

Abstracts with Program

15th International Geochemical Exploration Symposium

Reno, Nevada

April 29, 30, May 1, 1991

SCHEDULE OF EVENTS

Saturday April 97	
08:30-17:00	Biogeochemistry and Geomicrobiology in Mineral Exploration (Short Course)
00.30-17.00 Sunday April 98	bigeochemistry and Geomerobiology in Mineral Exploration (Short Course)
08:30 17:00	Biggagabamistry and Coomissibility in Niceral Exploration (Short Course)
08:00 12:00	The use of Soil Cases in Cases in Cases being I Walter (Workshop)
10:00 21:00	Paristration Open
10:00-21:00	Champagne Brunch in Zieffield Theatre Non bested
13:00 15:00	"Will State And Enderal Degulations Dut Mining and Exploration Out of Dusingson"
13.00-13.00	Sponsored by Wilderness impact research foundation Nameda Mining Association
	Profile Legal Foundation Moderated by Dr. Chaster F. Nicholo
14.00-21.00	Trade Fyhitian in Fyhihit Hall (and Dester Setur)
17:00-20:00	Sumprises Cocktail Recention in Exhibit Hall
19:00-22:00	AFC Outgoing Council Meeting
Monday April 29	The Outgoing Council Meeting
07:00-08:00	Coffee and doughnuts for Speakers in Speaker's Ready Room
07:00-16:00	Speaker's Ready Room Open
07:00-16:00	Registration Open
08:00-09:45	1A. New analytical T-chniques and Improved Methodologies
09:45-10:00	Break
10:00-11:45	1B. New Analytical Techniques and Improved Methodologies, continued
11:45-13:45	AEG Presidential Address Luncheon/AEG Annual General Meeting
13:45-15:00	2. The Triassic-Jurassic Magmatic Arc Mineral Systems. Western Nevada and Eastern
	California
15:00-15:30	Break
15:30-17:00	3. Geochemistry of Gold and Platinum Deposits
	Evening Presentations:
19:00-20:00	Presentation by Dr. J. Alan Coope, Director of Geochemistry, Newmont Exploration
	on "Monitoring Laboratory Performance with Standard Reference Samples - Newmonds
	Experience"
20:00-21:00	Presentation by Dr. Arthor G. Darnley, Project Leader, Geological Survey of Canada on
	"GLOBAL GEOCHEMICAL MAPPING: Recent Development in the International Geochemical
	Mapping Project"
Tuesday, April 30	
07:00-08:00	Coffee and doughnuts for Speakers in Speaker's Ready Room
07:00-16:00	Speaker's Ready Room Open
07:30-16:00	Registration Open
08:00-09:30	4A. Concealed Deposits, Case Histories
09:30-10:00	Break
10:00-12:00	4B. Concealed Deposits, Exploration Methods
12:00-13:30	Tuesday Luncheon
13:30-15:00	5A. Regional Mapping, Geochemical and Geophysical
15:00-15:30	Break
15:30-17:30	5B. Regional Mapping, Geochemical and Geophysical, continued
17:00-17:15	Buses Leave - Tahoe Queen Dinner, Paddle Wheeler Cruise
Wednesday, May 1	
07:00-08:00	Coffee and doughnuts for Speakers in Speaker's Ready Room
07:00-16:00	Speaker's Ready Room Open
07:30-15:30	Registration Open
08:00-09:30	6. Remote Sensing and Biogeochemistry in Exploration
09:30-10:00	Break
10:00-11:45	7. Gold Transport and Deposition, Primary Element Dispersion
11:45-13:30	Wednesday Luncheon
13:30-15:00	8A. General Technical Session
15:00-15:30	Break
15:50-17:00	ob. General recurrical Session, continuea
08.30 17.00	Statistical Treatment of Evalaration and D-111 Accor Data (Short Course)
08:30 17:00	Geophysical Data Interpretation for the Mineral Fundamentar Contents.
00.30-17.00	(Short Course)
Friday May 2	
08.30-17.00	Geophysical Data Interpretation for the Mineral Evolution Coolectet
00.00-17.00	(Short Course)
08.30-17.00	A Case Study and Comparison of Varying are Estimation Techniques (Short Course)
00.00-17.00	in case study and comparison of varying ore Estimation rechniques (Short Course)

Cover photo-Lucky Star mine, Bristol District, Nevada. Joe Tingley photo.

Steve Cook

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THE ASSOCIATION OF EXPLORATION GEOCHEMISTS

15TH INTERNATIONAL GEOCHEMICAL EXPLORATION SYMPOSIUM P.O. Box 9126, Reno, Nevada 89507

The Association of Exploration Geochemists welcomes you to their 15th International Geochemical Exploration Symposium. There are many interesting papers on the program and a full schedule of field trips, workshops, and short courses.

Please take special note of the many interesting products and services that our exhibitors have to offer and make them feel especially welcome.

Our guest program chairman has arranged a full and varied social program, and we urge you to attend our special party on Tuesday evening, a dinner cruise on Lake Tahoe on the paddle wheeler, the Tahoe Queen.

The symposium committee welcomes all of our visitors, both foreign and domestic, to the Reno area and we sincerely hope that your stay here will be both enjoyable and rewarding

Sincerely,

Harold F. Bonham Jr. General Chairman

Symposium Chairman Mr. Harold F. Bonham Nevada Bureau of Mines and Geology University of Nevada, Reno Reno, Nevada 89557-0088 702-784-6691

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SCHEDULE OF TECHNICAL SESSIONS

Monday, April 29

07:00-08:00 07:00-16:00 07:00-16:00	Coffee and Doughnuts for Speakers in Speaker's Ready Room Speaker's Room Open Registration
08:00-09:45	1A. New Analytical Techniques and Improved Methodologies
	Hall, G.E.M., Geological Survey of Canada, Ottawa, Canada
	Klusman, R.W., Colorado School of Mines, Golden, Colorado
08:00-08:15	Laser sampling ICP-MS: analysis of powdered geological materials by laser vaporization ICP-mass spectroscopy Broadhead, M.
08:15:08:30	ICP-MS analysis of trace metals and pathfinder metals by ICP-mass spectroscopy Broadhead. R. and Broadhead, M.
08:30-08:45	A fully automated system for solvent extraction and ICP analysis of geological material for gold-related trace elements <u>Caughlin. B.L.</u> , Blok, H., and Borgun, B.R.
08:45-09:00	Progress in application of ICP-mass spectrometry to analytical chemistry Hall, G.E.M.
09:00-09:15	Large fine fraction stream samplesa practical method to maximize catchment size, minimize nugget effect and allow detection of coarse or fine gold Hawkins, M.A.
09:15-09:30	Laboratory data: what the explorationist should look for to ensure reliability Johnson, W.M.
09:30-09:45	Stability of spectral interference correction factors in plasma emission spectroscopy <i>Paski, E.F.</i>
09:45-10:00	Break
10:00-11:45	1B. New Analytical Techniques and Improved Methodologies Henderson, W.B., Geochemical Services, Rocklin, California Lechler, P.J. University of Nevada, Reno, Nevada
10:00-10:15	To the geochemical prospecting of disseminated gold occurrences, New Zealand

- 10:15-10:30 The geochemical sampling and characterization program of the Nevada Bureau of Mines and Geology *Bonham, H.F.,Jr., Garside, L.J., <u>Price, J.G.</u>, Hsu, L.C., Lechler, P.J., and Desilets, M.O.*
- 10:30-10:45 Basal till sampling in the Abitibi area of Quebec: a geochemical data bank for exploration *Lasalle, P.*
- 10:45-11:00 Application of digital signal processing to mining exploration in central Alaska Lawrence. M., Rogers, M.D.G., and Henderson, W.B.
- 11:00-11:15 Prediction of soil anomaly productivity from sediments using geographical information system *Moon, C.J.*
- 11:15-11:30 Optimization of geological and geochemical sampling Shoji, T.
 11:30-11:45 Exploration for the Chinkuashih gold-copper deposits with iron sulfides in Taiwan
 - <u>Yu. B.S.</u> and Tan, L.P.
- 11:45-13:45 AEG Presidential Address Luncheon/AEG General Meeting

13:45-15:00	2. The Triassic-Jurassic magmatic arc of western Nevada and eastern California
	Price, J.G., University of Nevada, Reno, Nevada
	Raines, G.L., U.S. Geological Survey, Reno Office, Nevada
13:45-14:00	Triassic-Jurassic magmatic arc of western Nevada and eastern CaliforniaPart I: geology <u>Schweickert. R.A.</u> , Stewart, J.H., Dilles, J.H., Garside, L.J., Greene,
44.00 44.45	n.C., naruyinan, n.F., narwoou, D.S., and Sinberning, N.J.
14:00-14:15	mineral deposits <u>Doebrich, J.L.</u> , Garside, L.J. and Shawe, D.R.
14:15-14:30	Triassic-Jurassic magmatic arc of western Nevada and eastern CaliforniaPart III: stream sediment geochemistry <u>Turner. R.L.</u> and McCarthy, J.H., Jr.
14:30-14:45	Triassic-Jurassic magmatic arc of western Nevada and eastern CaliforniaPart IV: regional soil gas surveys McCarthy, J.H., Jr.
14:45-15:00	Triassic-Jurassic magmatic arc of western Nevada and eastern CaliforniaPart V: a model for the evaluation of Cenozoic basins for concealed mineral-systems <u>Sawatzky. D.L.</u> , Raines, G.L., Doebrich, J.L., Turner, R.L., Garside, L.J. and McCarthy, J.H., Jr.
15:00-15:30	Break
15:30-17:00	3. Geochemistry of gold and platinum deposits
	Mutschler, F.E., Eastern Washington University, Cheney, Washington
	Querol, F., Jete de Exploracion, Frenillo, Chinuanua, Mexico
15:30-15:45	in soils of the Toulameen ultra- mafic complex <u>Cook, S.J.</u> and Fletcher, W.K.
15:45-16:00	Pattern curves for gold contents distribution in lateritic profiles: application for geochemical exploration in tropical environments <u>Da Costa, M.L.</u> , Fonseca, L.R. and Costa, J.V.
16:00-16:15	High grade gold deposits of the Alleghany mining district. Sierra County,

- California *Wittkopp, R.W.*
- Aspects of the geology, geochemistry, and mineralogy of carbonate-hosted PGE occurrences <u>Lechler. P.J.</u>, Larson, L.T. and Hsu, L.C. Geology and mineral potential of the Occidental lode in the Comstock district, 16:15-16:30
- 16:30-16:45 Storey County, Nevada Nichols, C.E.
- Biogeochemistry of palladium Kothny, E.L. 16:45-17:00
- Monitoring laboratory performance with standard reference samples 19:00-20:00 Coope, J.A. 20:00-21:00 Recent Developments in the International Geochemical Mapping Project
- Darnley, A.G.

Tuesday, April 30

	01.00 00.00	Conee and Doughnuts for Speakers in Speakers heady hoom
	07:00-16:00	Speaker's Ready Room Open
	07:30-16:00	Registration
	08:00-09:30	4A. Concealed Deposits, Case History
		Jaacks, J.A., Westmont Mining, Inc., Denver, Colorado
		Nichols, C.E., Advanced Exploration, Sparks, Nevada
	08:00-08:15	Geochemical dispersion in lateritic regolith about the Mt. Gibbon Au deposits,
		western Australia, and implications to exploration for concealed mineral
		deposits Anand, R.R., Smith, R.E., Innes, J., Churchward, H.M., Brabham,
		G.R. and Birrell, R.D.
	08:15-08:30	Geologic setting and lithogeochemical characterization of two disparate precious
		metal prospects, western Turkey, Larson, L.T. and Erler, Y.A.
	08.30-08.45	Geology and exploration geochemistry of Miccene volcanic rocks at the Sleeper
	00.00 00.40	cold-silver mine Humboldt County Nevada Nash J T and Bartlett WM
	08.45.00.00	Element dispersion in alluvium covering gold deposits east of Osgood Mountain
James .	00.45-05.00	Getchell Trend Humboldt County Nevada Smith SM Detra D F
KIPYNU SO		Theobold DK and Theodorakes DM
A RAILING	A) 00.00 00.15	Filesophamical response to gold minoralization at Mt. Hamilton, White Pine
40) THAT IN	V 09-00-09-15	Soli geochemical response to gold mineralization at Mil. Hamilton, White The
1 the	, 00.15 00.20	Cooperational coll compling for deeply buried minoralized braceic piper, porthern
A VILL	09:15-09:30	
LAN'.	(n) M	h Anzona Weilich, R.J.
·	21/11	v
	09.30-10.00	Brook
	09.50-10.00	Dicak
		<u>`</u>
	10:00-12:00	4B. Concealed Deposits, Exploration Methods
	10.00 12.00	McCarthy, J.H., Jr., U.S. Geological Survey, Reno Office, Nevada
		Taufen, P.M., Western Mining Corp., Lakewood, Colorado
	40.00 40.45	
	10:00-10:15	A new enzyme partial leach enhances anomalies in pediment soils near buried)
	10:00-10:15	A new enzyme partial leach enhances anomalies in pediment soils near buried old deposits <i>Clark, J.R.</i> and <i>Russ, G.P.</i>
	10:00-10:15	A new enzyme partial leach enhances anomalies in pediment soils near buried gold deposits <u>Clark, J.R.</u> and Russ, G.P. Application of gas analysis of jasperoid inclusion fluid to exploration for micron-
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Savel in her -bot weather -wo level T	10:00-10:15 10:15-10:30 10:30-10:45 10:45-11:00 11:00-11:15 11:15-11:30	 A new enzyme partial leach enhances anomalies in pediment soils near buried gold deposits <u>Clark. J.R.</u> and Russ, G.P. Application of gas analysis of jasperoid inclusion fluid to exploration for micron-gold deposits <u>Graney. J.R.</u>, Keble, S.E. and Jones, H.D. Environmental conditions affecting concentrations of He and Co₂ in soil gases <i>Hinkle, M.E.</i> Potentials for the detection of volatile arsenic over gold deposits without surface expression <u>Klusman, R.W.</u> Suspended sediment geochemistry in exploration for polymetallic sulfide deposits (Au, Zn, Cu, Pb) in felsic metavolcanic rocks <u>Siegel, F.R.</u> and Roach, N.M. Gas analysis as a guide to centers of hydrothermal mineralization Norman, D.I. and Ruff, B.K.
Savele weather -bry weather -wo beneft T	10:00-10:15 10:15-10:30 10:30-10:45 10:45-11:00 11:00-11:15 11:15-11:30 11:30-11:45	 A new enzyme partial leach enhances anomalies in pediment soils near buried gold deposits <u>Clark. J.R.</u> and Russ, G.P. Application of gas analysis of jasperoid inclusion fluid to exploration for micron-gold deposits <u>Graney. J.R.</u>, Keble, S.E. and Jones, H.D. Environmental conditions affecting concentrations of He and Co₂ in soil gases <i>Hinkle, M.E.</i> Potentials for the detection of volatile arsenic over gold deposits without surface expression. <u>Klusman, R.W.</u> Suspended sediment geochemistry in exploration for polymetallic sulfide deposits (Au, Zn, Cu, Pb) in felsic metavolcanic rocks <u>Siegel, F.R.</u> and Roach, N.M. Gas analysis as a guide to centers of hydrothermal mineralization <u>Norman, D.I.</u> and Ruff, R.K. Hydrogeology and ground water multi-parametric hydrogeochemical analysis; an
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Savefle in her -bry weather -we level t	10:00-10:15 10:15-10:30 10:30-10:45 10:45-11:00 11:00-11:15 11:15-11:30 11:30-11:45 11:45-12:00	 A new enzyme partial leach enhances anomalies in pediment soils near buried gold deposits <u>Clark. J.R.</u> and Russ, G.P. Application of gas analysis of jasperoid inclusion fluid to exploration for micron-gold deposits <u>Graney. J.R.</u>, Keble, S.E. and Jones, H.D. Environmental conditions affecting concentrations of He and Co2 in soil gases <i>Hinkle, M.E.</i> Potentials for the detection of volatile arsenic over gold deposits without surface expression. <u>Klusman, R.W.</u> Suspended sediment geochemistry in exploration for polymetallic sulfide deposits (Au, Zn, Cu, Pb) in felsic metavolcanic rocks <u>Siegel, F.R.</u> and Roach, N.M. Gas analysis as a guide to centers of hydrothermal mineralization <u>Norman, D.I.</u> and Ruff, R.K. Hydrogeology and ground water multi-parametric hydrogeochemical analysis: an effective methodogy to detect buried mineral deposits and establish baseline water quality characteristics <i>Lluria, M.R.</i> Pediment exploration geochmistry: application of soil grids <u>Henderson, W.B.</u>, <i>Rogers M.D.G.</i> and <i>Putnam B.R. III</i>

12:00-13:30 Luncheon

13:30-15: 00	5A. Regional Mapping, Geochemical and Geophysical Krause, B.K., American Copper & Nickel Co., Wheat Ridge, Colorado
13:30-1 3:45	Geochemistry of rare earth elements in surface lateritic rocks: the Maicuru case Angelica, R.S. and Costa, M.I.
13:45-14:00	Integrated geochemical exploration for concealed tin deposits and "tin fertility index" as applied to the Bastar Granitoids, District-Bastar, Madllhya Pradesh, India Babu, T.M.
14:00-14:15	Geochemical atlas of North CarolinaNURE database and geochemical applications for state government Reid JC
14:15-14:30	Geochemical characteristics of epithermal precious metal mineralization in arid terranes of the Los Frailes-Karikari volcanic field, Potosi region, Bolivia <u>Schneider, A., Medina, A. and Riera, C.</u>
14:30-14:45	Geochemical and geophysical signatures at certain bulk mineable precious metals prospects in Nevada Henkle, W.R., Jr., Hyde, C.C. and Riera C
14:45-15:00	Inorganic geochemistry and magnetic susceptibility of soils over hydrocarbon deposits in the Krishna Basin, Lingala area, A.P., India <u>Sitaramayya, S.</u> , Shiva, K.P. and Rao, G. V.S.P.
15:00-15:30	Break
15:30-17:30	5B. Regional Mapping, Geochemical and Geophysical Callahan, J.E., Appalachian State University, Boone, North Carolina
15:30-15:45	Hadtke, A.S., Couger Metals International, Palo Alto, California Evaluation of lake-sediment geochemistry as an aid to regional mapping and anomaly identification, Granville Lake map sheet, Manitoba, Canada Amor. S.D.
15:45-16:00	Regional heavy mineral survey in the exploration for gold using regression and indicator kriging: Grenville Province, southwestern Quebec <u>Bellehumeur, C.</u> and Jebrak M
16:00-16:15	Regional sediment geochemical survey of south Africa <u>Labuschagne. L.S.</u> , Holdworth, R. and Stone, T.P.
16:15-16:30	Spatial analysis of geochemical, magnetic, and geological data near the Sewell Brook sulfide deposit, New Brunswick a practical application of geographic information system (GIS) technology and mineral exploration <u>Meresereau, T.G.</u> and Dixon, G.S.
16:30-1 <mark>6:45</mark>	Distribution and dispersion of the Huai Hin Laep Laei, northern Thailand Paoponosawan, P. and Eletcher, WK
16:45-17:00	Geologic mapping and geochemical sampling from a light aircraft inflighta progress report Sainsbury, C.L.
17:00-17:15	Multielement geochemical reconnaissance as an aid to target selection in Irish Caledonian terrains O'Connor, P.J. and Reiman, C.
17:15-17:30	Geochemical characteristics and retrogressive metamorphism of Archean metamorphic rocks of granulite facies in Zhanjiakou, Xuanhua area, Hebei province, China <i>Gao, M.</i>

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<u>Wednesday, May 1</u>

07:00-08:0 07:00-16:0 07:30-15:3	 Coffee and Doughnuts for Speakers in Speaker's Ready Room Speaker's Ready Room Open Begistration
08:00-09:30	6. Remote Sensing and Biogeochemistry in Exploration
	Dunn, C.E., Geological Survey of Canada, Ottawa, Canada
	Reeves, R., Prof. (Em), 4025 Lakeside Dr., Odessa, Texas
08:00-08	15 Diamondiferous kimberlite in Saskatchewana biogeochemical study Dunn, C.E.
08:15-08	30 An infield indicator for gold and other mineralization by the detection of Bacillius cereus. Imber B F
08:30-08	45 A new cost-effective biogeochemical method for gold exploration in tropical
	Southwest Pacific regions <u>McInnes. B.I.</u> , Kameko, L., Dunn, C.E. and
	Cameron, E.M.
08:45-09	00 Biogeochemical mapping of Sweden for exploration and environmental research Nilsson, C.A. and Selinus, O.
09:00-09	The determination of gold concentrations in humus and humic fractions by
W ANT TO THE T	charcoal adsorption preconcentration-instrumental neutron activation analysis
X IS I	(CA-INAA) and the investigation of their spatial relationship to subcropping gold
-hurriberty hold (1).	mineralization Perry. B.J., Van Loon, J.C., Spooner, E.T.C., Gorton, M.P. and Hancock B.G.V.
win terrisol Par 09:15-09	30 Gold exploration using analyses of balsam fir twigs: an example from eastern Nova
Min livelet	Scotia, Canada <u>Rogers. P.J.</u> and Dunn, C.E.
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09:30-10:00) Break
09:30-10:00) Break
10:00-11:4	 Break 7. Gold Transport and Deposition, Primary Element Dispersion
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10:00-10 10:00-10	 Break 7. Gold Transport and Deposition, Primary Element Dispersion Bloomstein, E.T., Sata Fe Pacific Mining Co., Albuquerque, New Mexico Rytuba, J.J., U.S. Geological Survey, Menlo Park, California Primary element dispersion patterns in a carbonate-hosted, epithermal, high-
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10:00-10 10:15-10	 Break 7. Gold Transport and Deposition, Primary Element Dispersion Bloomstein, E.T., Sata Fe Pacific Mining Co., Albuquerque, New Mexico Rytuba, J.J., U.S. Geological Survey, Menlo Park, California Primary element dispersion patterns in a carbonate-hosted, epithermal, high- grade, Au-Ag telluride system: Mayflower mine, Madison County, Montana, USA Cocker, M.D. Compositional controls on the gold contents of silicic volcanic rocks
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10:00-10 10:00-11:4 10:00-10 10:15-10 10:30-10	 Break 7. Gold Transport and Deposition, Primary Element Dispersion Bloomstein, E.T., Sata Fe Pacific Mining Co., Albuquerque, New Mexico Rytuba, J.J., U.S. Geological Survey, Menlo Park, California Primary element dispersion patterns in a carbonate-hosted, epithermal, high- grade, Au-Ag telluride system: Mayflower mine, Madison County, Montana, USA Cocker, M.D. Compositional controls on the gold contents of silicic volcanic rocks <u>Connors, K.A., Noble, D.C., Weiss, S.I.</u> and Bussey, S.D. A graphical approach to mineral-solution equilibria Deffeyes, K.S.
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10:00-11:4 10:00-11:4 10:15-10 10:30-10 10:45-11 11:00-11	 Break 7. Gold Transport and Deposition, Primary Element Dispersion Bloomstein, E.T., Sata Fe Pacific Mining Co., Albuquerque, New Mexico Rytuba, J.J., U.S. Geological Survey, Menlo Park, California Primary element dispersion patterns in a carbonate-hosted, epithermal, high- grade, Au-Ag telluride system: Mayflower mine, Madison County, Montana, USA Cocker, M.D. Compositional controls on the gold contents of silicic volcanic rocks <u>Connors, K.A., Noble, D.C., Weiss, S.I.</u> and Bussey, S.D. A graphical approach to mineral-solution equilibria Deffeyes, K.S. Silver concentrations in salt lake sediments as a potential exploration tool for gold in western Australia Lyons, W.B. Paleohydrothermal characteristics of ore formation from fluid inclusions data, San
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09:30-10:00 10:00-11:4 10:00-10 10:15-10 10:30-10 10:45-11 11:00-11	 Break 7. Gold Transport and Deposition, Primary Element Dispersion Bloomstein, E.T., Sata Fe Pacific Mining Co., Albuquerque, New Mexico Rytuba, J.J., U.S. Geological Survey, Menlo Park, California Primary element dispersion patterns in a carbonate-hosted, epithermal, high- grade, Au-Ag telluride system: Mayflower mine, Madison County, Montana, USA Cocker, M.D. Compositional controls on the gold contents of silicic volcanic rocks <u>Connors, K.A., Noble, D.C., Weiss, S.I. and Bussey, S.D.</u> A graphical approach to mineral-solution equilibria Deffeyes, K.S. Silver concentrations in salt lake sediments as a potential exploration tool for gold in western Australia Lyons, W.B. Paleohydrothermal characteristics of ore formation from fluid inclusions data, San Luis area, Frensnillo, Zac., Mexico <u>Querol, F., Paracios, H., Melchor, A.</u> and Herrera,A.
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10:00-11:4 10:00-11:4 10:00-10 10:15-10 10:30-10 10:45-11 11:00-11 11:15-11 11:30-11	 Break 7. Gold Transport and Deposition, Primary Element Dispersion Bloomstein, E.T., Sata Fe Pacific Mining Co., Albuquerque, New Mexico Rytuba, J.J., U.S. Geological Survey, Menlo Park, California Primary element dispersion patterns in a carbonate-hosted, epithermal, high- grade, Au-Ag telluride system: Mayflower mine, Madison County, Montana, USA Cocker, M.D. Compositional controls on the gold contents of silicic volcanic rocks <u>Connors, K.A., Noble, D.C., Weiss, S.I. and Bussey, S.D.</u> A graphical approach to mineral-solution equilibria Deffeyes, K.S. Silver concentrations in salt lake sediments as a potential exploration tool for gold in western Australia Lyons, W.B. Paleohydrothermal characteristics of ore formation from fluid inclusions data, San Luis area, Frensnillo, Zac., Mexico <u>Querol, F., Paracios, H., Melchor, A.</u> and Herrera,A. Distribution and behavior of gold in soils and tills at the Michel Plate mine, southern British Columbia <u>Sibbick, S.</u> and Fletcher, W.K. Indication of geochemical map confirmed by difference in bedrock
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11:45-13:30 Luncheon

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13:30-15:00	8A. General Technical Session Carlisle, D., University of California, Los Angeles, California
	Krauskopf, K.B., Prof. (Em.), Stanford University, Stanford, California
13:30-13:45	World-class gold depositsthe model success storywhere is the next Olympic Dam? <i>Mutschler, F.E.</i> and <i>Radtke, A.S.</i>
13:45-14:00	Behavior of rare-earth elements in CO2-rich geothermal systems, New Zealand Hopf, S.
14:00-14:15	Reconnaissance geochemical prospecting and geologic setting for mineralization in the Lesser Antilles volcanic arc, West Indies <u>Nielsen, R.L.</u> , Hite, J.B. and Ruckmick, J.C.
14:15-14:30	New dimensions for gold deposits in Turkey Ozkocak, M.O.
14:30-14:45	A geochemical investigation of the Hatu gold anomaly, Xinjiang-Uygur Autonomous Region, China <u>Smith. D.B.</u> , Theobald, P.K., Shen, S., Ren, T. and Hou. Z.
14:45-15:00	Ammonium geochemistry and its application to exploration for gold <u>Barsukov, V.L.</u> , Koserenko, S.V., Baranova, N.N., Bannicova, L.A. and Zhilina, E.I.
15:00-15:30	Break
15:30-17:00	8B. General Technical Session Paski, E.F., Bondar-Clegg and Co., Vancouver, British Columbia, Canada Smith. D.B., U.S. Geological Survey, Denver, Colorado
15:30-15:45	Exploration geochemistry of jaspeoids Nelson, C.E.
15:45-16:00	Styles of gold mineralization in the lower Paleozoic Meguma Group, Nova Scotia, Canada <u>Smith, P.K.</u> and Kontak, D.J.
16:00-16:15	Soil and rock mercury as a useful exploration tool for the Chinkuashih gold-

 copper deposit <u>Tan, L.P.</u> and Yu, B.S.
 16:15-16:30 A comparative study of Carlin-type gold deposits in W. China and Nevada, U.S.A. Tu, G.Z.

16:30-16:45	On regional geochemical anomalies and geochemical provinces Xie, X.
16:45-17:00	Geochemical criteria for uranium metallogenetic capacity of granitoids in South
	China Zhano, B.

Poster Sessions

08:00 Monday, March 29 to 17:00 Wednesday, April 1

<u>Booth</u>

- 101 A review of analytical techniques for analysis of complex nitrogen ions used in geochemical exploration *Desilets, M.O.*
- 102 Computer simulation of sample representativity in gold exploration *Lin, C.*
- 103 The use of cesium as a pathfinder element in gold exploration utilizing lithogeochemical and hydrogeochemical survey <u>Little. W.D.</u> and Ikramuddin, M.
- 104 Reductive coprecipitation--a selective preconcentration/separation method for the determination of trace metals for geochemical exploration <u>Niskavaara. H.J.</u> and *Kontas, E.H.*
- 105 Study on the rare-earth element geochemical halo of hydrothermally altered rocks related to gold ore deposits in the Jiaodong area, China *Yang, M.*
- 201 Gravity and magnetic studies of eastern California and western Nevada and relations to a volcanic-arc terrane *Ponce, D.A.*

Booth 301	Geochemical signature of the Comstock district, Storey County, Nevada <u>Hudson. D.M.</u> and
302 303	A regional exploration strategy for PGE and kimberlite in Mozambique Aswathanarayana, U. Composition of gas phase basic-ultrabasic intrusions and its connection with range of
	platinum-palladium copper-nickel ore-depositions Neruchev, S.
401	Soil and gas signatures over precious metal deposits in Nevada <u>McCarthy, J.H., Jr.</u> and Dietrich J.A
402	Geophysical, soil-gas, and geochemical evidence of a concealed, mineralized fault near W- and Sb-rich hot springs, Pumpernickel Valley, Nevada <u>Erdman. J.A.</u> , Hoover, D.B., McCarthy, J.H., Jr., Ficklin, W.H., Watterson, J.R., Lovering, T.G. and Owen, R.W.
403	Gold distribution at the Igarape Bahia lateritic gold deposit <u>Bliss. L.</u> , Machesky, M., Andrade, W., Kato, T. and Rose, A.
404	Groundwateran effective geochemical exploration sample for Australia gold deposits Giblin, A.
405	Geostatistical and GIS evaluation of biogeochemical and ecological data from three mineralized sites (Au, Cu-Ni and PGE), northeastern Minnesota: implication for mineral exploration in a boreal forest Zanko. L., Gokee, A. Dewey, B. Hauck S. and Paster, L.
406	Geochemical exploration marks of blind ore bodies in gold mining districts Li, H.
501	Geochemical exploration near Glen Innes, New South Wales, Australia Brooke, J.P.
502	Lithogeochemical studies of the Chitral area, Hindu Rush Range, Pakistan Afridi, A.G. and Ikramuddin, M.
503	Mineral resource potential in the Anchorage 1° by 3° Quadrangle, southern Alaska <u>Madden-McGuire, D.J.</u> and Winkler, G.R.
504	Reconnaissance guidelines for gold exploration in central Alaska <u>Light, T.D.</u> , Lee, G.K. and Moll, S.H.
505	Regional geochemical signatures of lode Au and Cu deposits in the western half of the Redding 1X2 degree quadrangle, northern California <u>Silberman.M.L.</u> , Hassemer, J.R. and Smith. S.M.
506	Development and testing of the CHIM electrogeochemical exploration method <u>Smith. D.B.</u> , Hoover, D.B. and Sanzolone, R.F.
507	Regional geochemical survey of buried regolith from drill samples over Archean terrane, Lake of the Woods County, northern Minnesota <u>Martin, D.P.</u> , Meyer, G.N., Dahl, D.A. and Cartwright, D.F.
508	The metallogenic and halo forming model of the polymetallic ore deposits and the geochemical prospecting prediction system in the Feng-Tai district, Shanxi province, China Fang, Weixian
509 510	Geochemical and geophysical methods of prospecting nonmetallic minerals Komov, I.L. Gold deposits and occurrences of the Amanos Mountain Range in the basin and range structure of Hatay, Turkey Ozkocak, M.O.
511	Gold-bearing antimony deposit of Afyon-Bayal-Doglat volcanic area, Turkey Ozkocak, M.O.
512	Drainage survey for Nb-Ta-Zr-Sn in arid conditions, Nugrus area, eastern Desert, Egypt <u>Mohamed. F.H.</u> , Morsy, M.A. Anwar, Y.M. and Saarger, R.
513	Correlation between the mineralogical and chemical composition of fine stream sediment: application to geochemical exploration in a tropical rain forest <u>Tosiani. T.</u> and Tapia, J.
514	Use of regional and detailed till geochemistry in exploration for tungsten in southern Finland Peuraniemi, V.J.
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701	Primary and secondary dispersion patterns associated with Mother Lode-type gold mineralization, Hudson District, Calaveras County, California <u>Chaffee. M.A.</u> and Kuhl, T.O.
702	Mobilization of gold into lake sediments from acid and alkaline mineralized environments in the southern Canadian shield <u>Schmitt. H.R.</u> , Cameron, E.M. and Hall, G.E.M.
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801	An evaluation of gold hydrogeochemistry as an exploration method in the Canadian Cordillera Ballantyne. S.D. and Hall, G.E.M.
802	Geochemical surveys over the Bell Springs deposit, Hog Ranch mine, Washoe County, Nevada <u>Bussey. S.D.</u> , Taufen, P.M., Suchomel, B.J. and Ward, M.
803	Distribution of gold in the ultramatic member of the Betts Cove ophiolite, Newfoundland, Canada Lavingne. J. and Hatton, K.
804	Lithogeohemistry and geological mapping in the Vermillion greenstone belt, Minnesota, as an aid to mineral exploration <u>Reichhoff, J.A.</u> , Hauck, S.A. and Southwick, D.L.
805	History and methods for discovery of the gold-rare metal object in the Northeast of the USSR Dobrotin, Y.R. and <u>Neruchev. S.</u>
806	Geochemical characteristic of Maysky gold deposit and Maysky ore cluster in northwestern part of Chukotka, the USSR <u>Dobrotin, Y.R.</u> and Volkov, A.V.
807	New pathfinders for gold-zinc exhalative mineralization identified by multielement geochemistry in the Ar Bjum zinc prospect (Hulayfah Proterozoic belt, Saudi Arabia) Salpeteur, I.
808	Sedimentological and geochemical controls of gold bearing paleoplacers from the Orapu basin, French Guyana <u>Salpeteur. I.</u> , Manier, E., Milesi, J.P. and Mercier, D.
809	Application of statistical pattern integration to appraisal of synthetic information of gold mineral resources in the northern Jiamushi block, Northeast China <u>Sun, Jigui</u> and Cheng, Qiuming
810	False drainage anomalies in a granite area, Kvaloya in Troms, Norwaya case study <u>Stendal, H</u> . and Peterson, M.D.
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813	Geochemical model for gold mineralization in south Devon, England, using raster-based GIS <i>Wang, C.L., Belete, K.</i> and <u>Moon. C.</u>
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FIELD TRIPS

Field trips listed below are described based on the best information available at the time of this announcement; some changes in stops may be made later. Trips are subject to cancellation if participant interest is low. Early registration will help ensure that you are included in your preferred choice of field trip. If your first choice of field trip is full or cancelled, you will be assigned your second or third choice as necessary. If reassigned you will be notified of the changes and given an opportunity to cancel with full refund. To ensure your registration is received and processed in time for a field trip, please register for field trips at least two weeks prior to the trip date. Costs are based on double occupancy of rooms. Travel to starting points and from ending points is the responsibility of the participant, and is not part of the trip cost. Rhodes Travel, the official travel agent for the meeting, can make these arrangements. Some trips may be physically demanding or require participants to supply hard hats or other safety equipment. Registration form must be accompanied by the full amount of the trip fee, in U.S. funds on a U.S. bank. Participants who cancel before April 15, 1991 will be charged 10% of the cost of the trip as a processing fee; after April 15 an additional 40% of the trip cost will be charged unless a replacement is available. Last minute cancellations can expect to pay the full cost of the trip.



PREMEETING

Hot Springs and Hot-Spring-Related Ore Deposits Leaders: F. W. Dickson and D. C. Noble

A three-day trip beginning in San Francisco on April 26 and ending in Reno on April 28. The trip will examine hot springs and hotspring-related ore deposits in northern California and Nevada. Stops include Sulphur Banks (Hg), McLaughlin (Au, Hg), Golconda (Mn, W), Sleeper mine (Au, Sb), Steamboat Hot Springs (Hg, Sb), Wind Mountain mine (Au). Cost \$250; includes bus transportation, two nights' lodging, two dinners, and three lunches.



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PREMEETING

GOLD/SILVER DEPOSITS OF CHILE

FIELD TRIP 2

A field conference co-sponsored by the Association of Exploration Geochemists and the Society of Economic Geologists. TRIP IS FULL

FIELD TRIP 4

PREMEETING

Geology and Geochemistry of the Carlin Trend Leaders: R. R. Craig and S. Long

A three-day trip beginning in Reno on April 26 and ending in Reno on April 28. The trip will study the geochemistry, geology, alteration, and mineralization of the major sedimentary rock-hosted, disseminated gold deposits of the Carlin Trend of northern Nevada. Stops will include Gold Quarry, Post, Genesis, Carlin, and Rain mines. Cost \$300; includes bus transportation, two nights' lodging, two dinners, and three lunches.

FIELD TRIP 5

POSTMEETING

Ore Deposits of Eastern Nevada

Leaders: W. R. Wilson, D. Durgin, and M. D. Dennis

A four-day trip beginning in Reno on May 2 and ending in Reno on May 5. The trip will examine gold and base metal mineralization at several operating mines in eastern Nevada. Stops will include Mt. Hamilton mine (gold skarn), Ward Mountain mine (base metal skarn), Robinson district (porphyry-related gold), Casino, Yankee, Winrock, and Easy Junior mines (sedimentary rock-hosted gold), and Bald Mountain mine (porphyry-related gold). Cost \$350; includes bus transportation, three nights' lodging, two dinners, and four lunches.

FIELD TRIP 6

POSTMEETING

Geochemical Relationships and Ore Deposits of the Osgood Mountains, Nevada

Leaders: J. V. Tingley and R. Madrid

A three-day trip beginning in Reno on May 2 and ending in Reno on May 4. The trip will examine geochemical relationships of gold deposits and tungsten skarn deposits in the Osgood Mountains. Stops include the Pinson, Getchell, and Chimney Creek gold mines and selected skarn tungsten mines. Discussions will include topics such as the mobility of cations in the supergene and hypogene environments, the geochemistry of metal-bearing veinsin the Osgood stock, and the importance of illite in gold exploration. Cost \$275; includes bus transportation, three lunches, two dinners, and two nights' lodging.



PREMEETING

Geology and Geochemistry of Gold Deposits of the Central Battle Mountain-Eureka Mineral Belt Leaders: P. Wotruba and S. Foo

Leaders. F. Wolluba and S. Foo

A three-day trip beginning in Reno on April 26 and ending in Reno on April 28. The trip will emphasize the geology and geochemistry of some of the porphyry-related and sedimentary rock-hosted, disseminated gold deposits of the central Battle Mountain-Eureka Mineral Belt. Stops will include the Gold Bar, Fortitude/Surprise, Cove, Gold Acres, and Elder Creek mines. Cost \$250; includes bus transportation, two nights' lodging, three lunches, and one dinner.



POSTMEETING

 $\overset{\leadsto}{ ext{Geochemical Signatures Over Several Nevada Precious}}$ Metal Deposits Concealed by Alluvium or Barren Rock Leader: H. McCarthy

A two-day trip beginning in Reno on May 2 and ending in Reno on May 3. The trip will concentrate on geochemical signatures over concealed deposits and the various sample media used in exploration. Stops include the Marigold and Rabbit Creek mines. Cost \$200; includes bus transportation, one night's lodging, two lunches, and one dinner.



POSTMEETING

Mineral Deposits of Montana Leader: R. W. Schafer

A four-day trip beginning in Bozeman, Montana on May 1 and ending in Helena, Montana on May 4. The trip will visit a spectrum of ore deposits and mines in western Montana that include a variety of geologic environments and mineral commodities. Stops include Stillwater platinum mine (underground tour); gold ± base metal mineralization hosted in breccia pipes at Golden Sunlight and Montana Tunnels; fracture-controlled gold mineralization in sedimentary rocks at the Beal mine; and porphyry-copper-style mineralization at Butte. Cost \$400; includes van transportation, three nights' lodging, three breakfasts, three lunches, and three dinners. Meeting travel agent can assist with Reno-Bozeman flight.



PREMEETING

Massive Sulfide and Gold Deposits of the Klamath Mountains.

Leaders: J. Danielson and M. L. Silberman

A four-day trip beginning in Reno on the afternoon of April 25 and ending in Reno on April 28. Stops will be made at a variety of massive sulfide and gold deposits typical of those found in the volcanic and sedimentary arc rocks of the eastern Klamath Mountains; additional stops will be made to show the nature and character of host rocks and intrusions that have been important in tectonic development and mineral endowment of the region. Mine visits include; Hayden Hill, Afterthought, Iron Mountain, Brown Bear, Reid, and Silver Falls-Chicago. Cost \$350; includes bus transportation, three nights' lodging, two dinners, and three lunches.

FIELD TRIP 15

POSTMEETING

Ore Deposits of the Republic and Wenatchee Areas, Washington

Leader: R. Tschauder

A 31/2-day trip beginning in Spokane on the afternoon of May 2 and ending in Spokane on May 5. The trip includes surface and underground visits to epithermal precious metal deposits located in early Tertiary grabens at the Republic and Wenatchee mining districts of northern Washington. Stops will include the Wenatchee-Cannon mine area, Republic district/Golden Promise mine, and Overlook mine. Cost \$350; includes van transportation, three nights' lodging, two dinners, three lunches. Limited to 15 participants.



PREMEETING

Western Nevada Mineral Deposits

Leaders: M. Fianacca and G. V. Albino

A three-day trip beginning in Reno on April 26 and ending in Reno on April 28. Emphasis will be on the geology and geochemistry of Cretaceous through Miocene mineralization relative to the structural evolution of western Nevada during this period. Stops will include Round Mountain, Cyprus Tonopah, Candelaria, and Santa Fe mines, as well as the Boss, Isabella, Talapoosa, and Washington Hill gold properties. Dinner scheduled for evening of April 25 in Reno. Cost \$300; includes bus transportation, two nights' lodging, three dinners, and three lunches.



SHORT COURSES

- POSTMEETING -

Statistical treatment of exploration and drill assay data.

Leader: Robin Young, Western Services Engineering, Inc. Thursday, May 2

Various statistical techniques will be presented using case study scenarios to provide the geologists with approaches to establishing the preferred methodology to sampling, sample preparation and assaying. Precious metal case studies will be used to illustrate techniques to define the presence of biased/erroneous data and methods commonly used to handle "high grade" values. Course attendees need not have any statistical background although it would be helpful. Disks with Lotus 1-2-3 compatible programs will be provided to registrants. Cost: \$230.00

- POSTMEETING -

 2^{A} case study and comparison of varying ore estimation techniques.

Leader: Robin Young, Western Services Engineering, Inc. Friday, May 3

A comparative analysis of reserve estimation techniques for a precious metal deposit will be presented. Specific attention will be given to the relationships between the ore reserve models and actual production results. Examples will include ore reserve estimates compiled by polygonal, inverse distance, and geostatistical methods. The effects of sample selection and weighting will be addressed to establish their impact on the estimation process. Though a statistical background is not required, it would be helpful. Cost: \$200.00

- PREMEETING -

Biogeochemistry and geomicrobiology in mineral exploration.

Leader: S. Clark Smith, Minerals Exploration Geochemistry Nancy L. Parduhn, Cereus Exploration Technology, Inc. Saturday and Sunday, April 27 and 28-short course and field trip.

Recent mineral exploration in the western U.S. has increasingly focused on terrains covered by exotic overburden with depths to bedrock often exceeding 100 feet. As part of this recent history, biogeochemistry and geomicrobiology have been important for targeting deep mineralization, especially in areas of significant pediment, alluvial, soil and glacial overburden.

The workshop will be a two-day event on the general use of biogeochemistry-geomicrobiology techniques with special attention to precious metal exploration for covered deposits in the Basin and Range. Classroom presentations will include theory, case histories, field methods, laboratory methods, and data interpretation. The second day will involve a hands-on field exercise in plant, soil, and bacterial sampling. Each participant will be given a bound classroom manual (100-200 pages). The evening poster session and beer party will include invited poster presentations illustrating recent microbiological and biogeochemical studies. The field trip will include one or more stops in the Virginia City and Talapoosa mining districts to demonstrate field and interpretational methods. A deli-lunch is included each day. Cost: \$450.00

- POSTMEETING -

A Geophysical data interpretation for the mineral exploration geologist

Leader: Jack Corbett, Ken Sweet and Ron Bell, Interpex Limited

Thursday and Friday, May 2 and 3.

This course focuses on the practical aspects of geophysical data interpretation for mineral exploration. It takes a handson approach to computer assisted interpretation of these data by using the latest in geophysical data interpretation software to interpret example data sets as well as model geological concepts.

The first day of the two-day course covers magnetic, gravity, and VLF-EM interpretation. Day 2 covers electromagnetic methods (MaxMin, transient EM, and CSAMT), electrical methods (IP, resistivity), as well as some nonconventional methods (radiometrics, seismic refraction, seismic reflection). The course is intended to give the exploration geologist an insight to the interpretation of project data so that he can relate these data to geological/ geochemical knowledge of a property.

There will be one computer for use by every two attendees. Each attendee will receive a course notebook as well as the data interpretation software. Cost: \$450.00



WORKSHOP

— PREMEETING —

The use of soil gases in geochemical exploration. Leader: Howard McCarthy, U.S. Geological Survey Sunday afternoon, April 28

A one-half day workshop will be held on the application of soil gases as indicators of concealed mineralization. Methods of gas sampling and analysis will be discussed and compared. Sampling methods will include direct sampling of soil air, soil sampling for degassing of absorbed gases and the used of collectors. Analytical methods will include gas chromatography, mass spectrometry and instruments for individual gases. Factors that affect gas migration (barometric pressure, temperature, and precipitation) will be discussed. Case histories of soil gas surveys over several base and precious metal deposits will be used to illustrate the advantages and shortcomings of soil gas methods. Cost: \$75.00

SOCIAL PROGRAM

Virginia City—Lake Tahoe tour Monday, April 29

This all day tour will visit historic Virginia City, a mining metropolis from the 1870s and home of the famous Comstock Lode. During the tour, the group may visit the old Victorian mansions, museums and churches, stroll along the wooden sidewalks, or browse through the many original saloons and antique shops. The tour will continue through Carson City, the state's capital, to Lake Tahoe, one of the world's largest and most beautiful montane lakes. Lunch will be at the Forest Restaurant at Harrah's Lake Tahoe hotel. Following lunch, a short time will be set aside for browsing, shopping, and enjoying the lakeside community. The return to Reno will follow a scenic route over the Mount Rose highway. Cost: \$40.00

Squaw Valley ski trip Monday, April 29 and Wednesday, May 1

A ski shuttle will be available for transportation to and from the worldfamous Squaw Valley Ski Resort. Cost: \$20.00, lift tickets are additional.

Tahoe Queen dinner paddle wheeler cruise Tuesday evening, April 30

Join the party for a lovely sunset dinner and dance cruise aboard the Tahoe Queen, a three-tiered Louisiana paddle wheeler sailing on Lake Tahoe. The ship departs from the south end of Lake Tahoe, sails into Emerald Bay, past the Vikingsholm castle, and then returns to the south shore. A full dinner will be served, and a live band will play for dancing and entertainment throughout the evening. Cost: \$60.00

Supplier Cocktail Reception Sunday evening, April 28

This cocktail reception will be hosted by the exhibiting suppliers, in the exhibits area. Registration and information packets will be available during this function.



AEG Presidential Address Luncheon Monday, April 29

This luncheon, to be held in Bally's Ziegfield Theater, will feature an address by AEG President, Dr. Donald D. Runnels. The cost of this luncheon is included in the general registration fee.

Tuesday and Wednesday Luncheons

These luncheons will feature no speakers. An additional charge of \$20.00 will be required for each of these meals.

Deli-style Lunches

As an alternative to the formal luncheons, catered lunches will be offered in the exhibit area Monday-Wednesday.

TO THE MULTIELEMENT GEOCHEMICAL PROSPECTING OF DISSEMINATED GOLD OCCURRENCES (NEW APPROACH)

ASADULIN, A.A.

1. Problem. Metasediment- and volcanic-hosted disseminated gold deposits are rather difficult ones for discovery. Usually there are no visual differences between ores and host rocks. The distribution and intensity of gold concentrations are extremely irregular. So the direct measurement of gold contents in rock even near orebody may not give positive results, thus gold mineralization will be missed. Therefore it is useful to apply some indirect geochemical indications. Here, the geochemical data processing by traditional approach gives unreliable results due to the lack of trace-elements which are accumulated by gold deposition.

2. Solution. The examination of probablity-statistic particularities of primary element dispersion around gold deposits and host metamorphosed formations shows the following: the majority of trace-elements have in the bulk of disseminated gold occurrences average contents commensurate with the local geochemical background. Nevertheless, the features of distribution of many elements in the ore-bearing zones and host rocks vary. It is due to the gold deposition processes which transform the geochemical field of the host rock formation without significant gain or loss of many elements. Thereby some special zone of internal redistribution of trace-elements exists. We consider this zone a kind of multidimensional analogy of so-called "subbackground halo". The anomalous (in traditional meaning) and subbackground haloes of elements compose the complex geochemical field of the gold occurrence. This field spread sufficiently beyound the outlines of orebodies, deposits and anomalous haloes of separate elements. Exposing such a field with application of our method is equivalent to exposing potentialy gold-bearing rocks.

3. Efficiency. a) More complete utilization of trace elements routine analisis results. b) Increasing of geochemical prediction reliability, especially when bedrocks are badly exposed or geological information is inadequate. c) Saving money with more accurate preliminary definition of the localities for detail search.

4. Proposed usage. a) Retrospective recalculation of stored geochemical information to revise prospecting areas. b) Operative prediction of potential gold ore-bearing rocks based on made before model and current geochemical prospect data.

THE GEOCHEMICAL SAMPLING AND CHARACTERIZATION PROGRAM OF THE NEVADA BUREAU OF MINES AND GEOLOGY BONHAM,H.F.Jr.,GARSIDE,LJ.,<u>PRICEJ.G.</u>HSUL.C.,LECHLER,P.J., and

DESILETS.M.O.

The Nevada Bureau of Mines and Geology (NBMG) has instituted a geochemical sampling and characterization program that is designed to provide statewide coverage of background geochemical values for all major rock units, comparable in scope to the database currently available at NBMG for mineralized rocks. The program commenced in June 1990 with major financial assistance from Santa Fe Pacific Mining Co., Kennecott Exploration and Cordex Exploration Co. Three sampling projects were carried out during the summer and fall, 1990, two projects involved sampling the Paleozoic and Mesozoic rock units in the Winnemucca 30 by 60 minute quadrangle, and the third sampled the Preble Formation in the Osgood Mountain and Winnemucca quadrangles. Over 400 samples of unmineralized rocks were collected for the three separate projects and analyzed for 58 major and trace elements. Gold was determined by a combined fire assay-neutron activation technique with a detection limit of 0.1 ppb. Quality assurance for this program includes analyzing at least one check sample with every 20 unknowns as well as analyzing standard reference materials.

The initial project report on the Preble project was released as an open file report on 1 January 1991, and the other two project reports will be released to the general public on 1 January 1992.

ASER SAMPLING ICP-MS: ANALYSIS OF POWDERED GEOLOGICAL MATERIALS BY LASER VAPORIZATION ICP - MASS SPECTROSCOPY

BROADHEAD, M. Because of the complexity of the various minerals in rocks, ores, and soil samples, complete metals analysis can be an extremely difficult task. One of samples, complete metals analysis can be an exitemely difficult task. One of the most challenging problems in geochemical analysis is the preparation of a solution for analysis that is representative of the original sample. Traditional sample dissolution methods include: alkali fusions, fire assay fusions, mixed acid digestions including hydrofluoric acid, and bomb fusions, mixed acid digestions including hydrofluoric acid, and bomb digestions to prevent loss of volatile metal halides. Aside from the considerable time and effort required for the sample preparation techniques and the associated risk of contamination along the way, there are always worries of incomplete dissolution, loss of volatile metal halides and/or precipitation of insoluble analytes. As the number of elements to be analyzed grows, the complexity of the sample preparation step overshadows that of actual analytical measurements.

Laser vaporization is a new technique for direct solid sampling applications. A portion of a solid sample is volatilized by a high powered laser and the particulate material is transported to a ICP-MS. Here, ICP-mass spectrometry is used to provide a multi-element picture of the composition of the sample vapor. The volatilized materials transported to the ICP torch by a form of scroop where the material is transported to the ICP torch by a flow of argon, where the material is vaporized, atomized, and ionized for mass

spectrometrometric elemental analysis. This results in a simple mass spectra with characteristically high sensitivity, low background, and the availability of isotope information. The major advantage of this method is that the laser

of isotope information. The major advantage of this method is that the laser vaporizes all elements contained in the material that is vaporized. ICP-mass spectrometry is a extremely useful tool because of its wide elemental coverage, spectral simplicity, and absolute identification capabilities. Because the mass spectrum is comprised of known elemental isotopes with relatively few interfering molecular species, elemental identification is a straight forward process involving comparison of the measured isotopic ratios to the naturally occurring ratios. In this study, two methods of quantification were examined. First, 66 elements were determined semi - quantitatively with good accuracy. An average relative standard deviation of 15% was achieved. Second, Gold was analyzed quantitatively with excellent results. This method is an alternative method to fire assay in the analysis of high grade gold without the interferances that fire assay may have. interferances that fire assay may have.

ICP-MS: ANAYSIS OF TRACE METALS AND PATHFINDER METALS BY ICP-MASS SPECTROSCOPY

BROADHEAD, R. and BROADHEAD, M.

Geological surveys depend on trace analysis of various metals as indicators or pathfinders for locating ore bodies. This is especially useful in gold exploration. Metals such as As, Sb, Hg, Bi, Se, Te and Tl are especially important. Most of these metals are significant at sub ppb values. Unfortunately many of these metals produce serious errors at trace levels with conventional methods. Some methods produce acceptable results, but require much sample preparation and preconcentration prior to analyses and are subject to contamination in the process.

In the past 5 years, Inductively Coupled plasma Mass spectrometry (ICP-MS) has been proven to have great potential for the simultaneous determination of a wide range of trace metals without preconcentration or separation from the sample. matrix. The ICP-MS method combines the sensitivity of the Zeeman graphite furnace and the speed of a simultaneous ICP achieving a 10 - 100 fold increase in sensitivity over many other methods. In addition the ICP-MS is capable of determining different isotopes.

This paper compares samples prepared by the USGS as standard reference materials and is mainly concerned with the practical application of analyzing geochemical exploration samples.

A FULLY AUTOMATED SYSTEM FOR SOLVENT EXTRACTION AND ICP ANALYSIS OF GEOLOGICAL MATERIAL FOR GOLD-RELATED TRACE ELEMENTS

CAUCHLIN, B.L., BLOK, H. AND BORGUN, B.R. Multielement analysis has gained wide spread popularity within the exploration community. The geologist can now obtain a large amount of data for a given sample at a very

within the exploration of data for a given sample at a very low cost per element. In order to interpret this data, geologists are making use of increasingly powerful computer systems which allow them to quickly evaluate large sets of data for the presence of small correlations and/or anomalies. To ensure that the correlation or anomaly detected is a geological feature and not an artifact, data of the highest quality must be used. Laboratories are assisting the geologist by the development of new technologies, in particular automated systems, to produce high quality analytical data. Laboratory automation is highly reproducible and in general improves the accuracy and precision of data. Automation can thus help the geologist by improving data reliability, thereby enhancing the prospects of detecting small correlation has other advantages such as increasing productivity, reducing turnaround times and it may even reduce analytical costs. Chemex has developed an automated system for on-line enhancement of the section of an automated system is provided to the section of an automated system for on-line enhancement of the section of the system for on-line section of the section of the section of the section of the automated system for on-line section of the sectio

Chemex has developed an automated system for on-line solvent extraction which is used as the sample introduction system for a new breed of ICP spectrometer. Solvent extraction is used as a pre-concentration technique to improve sensitivity and eliminate interferences. It is particularly useful for gold and gold-related trace elements

particularly useful for gold and gold-related trace elements such as arsenic, antimony, mercury, and the base metals. Automation of the extraction is accomplished via flow injection. Analysis of the extracted solution is done with a multiple grating diode array spectrometer. The unique optical configuration of the spectrometer allows simultaneous acquisition of background and analytical signals. This is particularly advantageous when dealing with the transient signal from the flow injection system and the complex, varying background present in organic analysis. The fully automated system will be described. Digestion and extraction procedures and their efficiencies for various elements will be presented. Precision and accuracy of data obtained with the automated system will be compared with results from manual procedures.

A REVIEW OF ANALYTICAL TECHNIQUES FOR ANALYSIS OF COMPLEX NITROGEN IONS USED IN GEOCHEMICAL EXPLORATION

DESILETS, M.O. The recent use of complex nitrogen ions such as NO,", NO,", and NH, as pathfinders for hydrothermal platinum group metal deposits has demonstrated the need for a rapid, inexpensive technique for the analysis of these species in soil and rock samples.

A method involving a partial high temperature leach per-formed in sealed test tubes is compared with a variation on the classic Kjeldahl method and a new pyrohydrolysis method. The former two methods involve ion chromatographic finishes. A comparison is made of the relative concentrafinishes. A comparison is made of the relative concentra-tion and the stability of complex nitrogen species in solution over time for each technique. Results indicate that the high temperature leach developed by the Nevada Bureau of Mines and Geology is a rapid and cost efficient means of analysis for ions in soils and rocks.

means of analysis for ions in solis and rocks. A detailed study of the stability of complex nitrogen ions using the partial leach method mentioned above at 100°C, 120°C, 130°C, and autoclaved at various time regimes will be presented. In general results indicate that the time that the complex ion species are stable in solution increases with increasing temperature to a maximum of 4 to 5 days.

PROGRESS IN THE APPLICATION OF ICP-MASS SPECTROMETRY TO ANALYTICAL GEOCHEMISTRY

HALL, G.E.

The extremely variable composition of geological materials, particularly that of rocks and soils, poses an immense challenge to the accurate and precise multi-element determination of trace and ultra-trace level constituents. Hence, it is not surprising that numerous geoanalytical laboratories leapt with both feet into ICP-MS in its early days, with promises of such features as simple spectra with few interferences, wide linear dynamic range and detection limits in solution in the order of 0.01-0.1 ng ml⁻¹. Inevitably, we have since learned to temper enthusiasm with caution, as fundamental and applied studies of matrix-induced interferences have evolved. However, new doors have been opened in geoanalysis by this technique whose ultimate power is yet to be fully exploited.

Undoubtedly two of the most significant achievements to date lie in the determination of two groups of elements: precious metals and the REEs. The collective determination of Au and the PGEs (Pt, Pd, Rh, Ru, Ir, Os) by commercial laboratories has been the sole domain of NAA. Application of ICP-MS in this field offers the advantages of superior sensitivity for Pt, Pd and Ru and rapid turnaround time without the necessity of lengthy decay periods. This technique has also found a niche in the determination of Au, Pt and Pd following Pb fire assay where previously ICP-AES and AAS have dominated. As in other applications the critical factor affecting detection limits is the purity of the reagents used, not the sensitivity of ICP-MS. Biogeochemical exploration for Pt and Pd has now become a practical tool, owing to the reasonable quantity of sample required to attain adequate detection levels. This technique now reigns supreme in its proven ability to determine all REEs down to 1 ng g⁻¹ if a separation step is incorporated into the procedure. This capability together with abundance level detection of high field strength elements (e.g. Nb, Hf, Ta) is greatly facilitating tectonic interpretation studies.

The application of surface and ground waters in geochemical exploration is yet to be thoroughly evaluated but the ability of ICP-MS to analyse waters directly and adequately for many trace elements assures it a key role. Research is active currently into the introduction of gaseous hydrides into the ICP mass spectrometer in an effort to improve detection limits over those offered by ICP-AES.

These comprise some of the accomplishments reviewed in this presentation. Progress in the use of alternative sample introduction techniques and calibration strategies is also discussed.

LARGE, FINE FRACTION STREAM SAMPLES: - A PRACTICAL METHOD TO MAXIMIZE CATCHMENT SIZE, MINIMIZE NUGGET EFFECT AND ALLOW DETECTION OF COARSE OR FINE GOLD.

MAXIALLE CALORMENT SIZE, minimize moduli filter and allow DETECTION OF COARSE OR FINE GOLD. HAWKINS, M. A. The problems of collecting stream sediment samples which minimize the "nugget effect" and allow consistent detection of low but potentially significant concentrations of gold in sediments are well known and of long standing. With these problems in mind, an orientation stream sediment sampling program was undertaken in southeastern British columbia (Canada) during the summer of 1990. Panned concentrates were not collected during the course of the orientation program, as a prerequisite was that the sampling method should allow for detection not only of lode gold but also of very fine grained gold. BLEG sampling was considered, but rejected due to the non-availability of a suitable analytical facility in British Columbia and because of the logistical problems associated with transport of large samples in mountainous terrains.

associated with transport of tage of the samples 250 localities were sampled, and at each locality samples from both high energy and low energy sites were collected. Approximately 500g of -80 mesh sediment was collected on site and this was subsequently dried and sieved to -80 +150 mesh, -150 mesh and rarely to -270 mesh fractions. A 50g subsample fraction was submitted for rold analysis using bot -150 mesh and rarely to -270 mesh fractions. A 50g subsample of each fraction was submitted for gold analysis using hot bromide extraction, A.A. finish (detection limit lppb) and a 10g subsample was submitted for quantitative multi-element analysis by I.C.P. Sites returning elevated gold values were resampled and at this stage an additional 10g subsample was analyzed for gold by A.A. This was aimed at quantifying the variability of results due to sample size. The results of the orientation program revealed that for any given size fraction, far more gold "anomalies" were generated by sampling of higb energy sites than sampling of low energy sites, and that down stream dispersion of known

gold mineralization was greater in high energy sites. Only rarely did a low energy site return an "anomaly" not detected in sampling from the adjacent higher energy site. Only

in sampling from the adjacent higher energy site. In many cases, elevated gold values were detected in the finer fraction but not in the coarser fraction, but only rarely was the reverse encountered. This was true even of creeks draining coarse gold occurrences. Maximum downstream dispersion from source areas was usually returned from -150 mesh fraction collected from high energy sites. In repeat sampling of anomalous areas, the greatest variability between initial and followup results was evident in the -80 mesh fraction from low energy sites, especially when only 10g sub-samples were analyzed for gold. Results from -150 mesh fractions collected from high energy sites

when only 10g sub-samples were analyzed for gold. Results from -150 mesh fractions collected from high energy sites were reproducible within an order of magnitude. Sampling of large samples from high energy sites and submitting a 50g portion of the -150 mesh fraction for analysis is therefore suggested as a practical means of minimizing the "nugget effect", maximizing sample catchement area and obtaining reproducible results. The method is suitable for the detection of coarse or fine gold in a given attributes. catchment.

LABORATORY DATA; WHAT THE EXPLORATIONIST SHOULD LOOK FOR TO ENSURE RELIABILITY JOHNSON, W.M.

The mineral explorationist often receives thousands of individual analytical results from one project. If a 30 element optical emission spectrometer analysis was part of the analytical package this can jump to tens of thousands of numbers. The geochemist is faced with thousands of numbers. The geochemist is faced with having to interpret this information and it is critical that the data be reliable enough to ensure that this interpretation will not result in false anomalies or other problems that will complete the tables. other problems that will complicate an already complex task.

This will discuss what controls the paper explorationist should look for in the data sets reported by the laboratory in order that such problems need not be a concern. These internal laboratory controls should include both preparation and pulp duplicates, in-house laboratory and outside standards and reagent blanks. These controls should be run with all sample sets. In order to allow the explorationist/geochemist to assess the reliability of the data reported. the results obtained on all internal laboratory controls (including the accepted values of the standards) should accompany the reports received from the laboratory. Examples will be given of such controls and how to use them to evaluate the reliability of the data reported by the laboratory In addition, the discussion will include suggestions

as to how the exploration program can be structured to give some indication of the overall variance of the program, including the field sampling portion.

BASAL TILL SAMPLES IN THE ABITIBI AREA OF QUEBEC: A GEOCHEMICAL DATA BANK FOR EXPLORATION LASALLE, P.

8,000 samples of basal till were collected under varved clays in the Abitibi area of northwestern Quebec. Basal till is here defined as till collected at the interface between till and bedrock. Those samples were originally analyzed for Cu, Pb, Zn, Ni, Co, Mn, by atomic absorption. They were recently reanalyzed by neutron activation for Au, As, Sb, W and by x-ray fluorescence for Rb, Sr, Y, Zr, Nb, Mo. Color maps generated on Mac II and printed with H-P paint jet show broad correlation with bedrock units as they are known in the area. On a detailed scale, small bedrock units can be outlined by till geochemistry. Dispersal patterns match known ice-flow directions. Glacial transport is minimal because samples were collected at interface between till and bedrock. In conclusion, the basal till geochemistry in northwestern Quebec matches very closely the bedrock geology and is a good tool for exploration.

APPLICATIONS OF DIGITAL SIGNAL PROCESSING TO MINING EXPLORATION

EXPLORATION LAWRENCE, M., ROGERS, M.D.G. and HENDERSON, W.B. In the '60's, a group of engineers and mathematicians at Bell Labs invented the basic concepts and mathematics of Digital Signal Processing (DSP). Their problem was to extract useful information from noisy, incomplete, and sometimes ambiguous signals - in their case, satellite data communications. They developed numerous techniques including Fast Fourier Transforms, Digital Convolutional Filters, and numerical differentiators and integrators. The problem of finding mineral deposits is very analogous the available data is from analysis of surface or drilling

- the available data is from analysis of surface or drilling - the available data is from analysis of sufface of our first samples through fire assay or multi-element analysis. This data is believed to be useful to predict ore deposit locations. The data is noisy, incomplete, and often ambiguous due to geologic processes and sampling effects. The techniques developed at Bell Labs for extracting the maximum useful information can be applied. In this talk, we will consider these various algorithms,

how they work, what they do, and show some real-world results where mineral deposits can be located quickly and inexpensively through analysis of available data.

COMPUTER SIMULATION OF SAMPLE REPRESENTATIVITY IN GOLD EXPLORATION

LIN, Cunshan City, contents in replicated samples collected at the same site or from a bulk sample differ from each other notably. The difference becomes more significant as sample weight decreases. The explanation is that gold occurs in particle

mode of native gold which can not be ground into smaller size to increase the number of particles. The simulation is made to see to what extent size distribution and concentration of gold influence sampling representativity. Assumptions of the simulation are: 1. mother sample or population to be sampled is of 1000kg The mother sample or population to be sampled is of 1000kg which, after a single sampling, is reset to the initial weight and size distribution. 2. Gold particles are well mixed and the number of particles for each size fraction in subsample is proportional to the subsample weight and rounded to an integer. 3. Gold content is fully detected free from analytical errors. Table 1 is three distribution types of gold particles in mother samples and Table 2 and a nor are to the substance of the substance of the sample samples and the sample samples and the samples and table 2 and

types of gold particles in mother samples and Table 2 and 3 are parts of the simulation results. The simulation also involves coexistence of particle gold and soluble gold which is imitated by adding a sufficient proportion of 1-micron gold to a symmetrical population. Gold grains distribution as a simulated example is 793882780, 0, 2370, 4741, 9481, 4741, 2370, 0, 0 for 1, 2, 4, 8, 16, 32, 63, 125, 250 microns, respectively. This constructs a 16 ppb mother sample in which 50 percent of gold is soluble. Replicated subsamples of 1 gram all yield gold contents within 8.014 to 8.024 ppb. The simulation is extended to prospect areas constructed artificially where six ore deposits along two gold belts are sampled at 130*84 gridpoints under different gold occurrence.

occurrence.

Table 1. Frequency distribution of three types for gold grains in mother samples

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J						-	
Grain size	Distribut	ion ty	pes fo	r gold	grains	-	
in microns 1	Exponentia	1 Sy	mmetri	cal u	niform	-	
1 2 4 8 16 32 63 125 250	. 5010 . 2505 . 1253 . 0626 . 0313 . 0157 . 0078 . 0039 . 0019		. 021 . 0439 . 087 . 173 . 347 . 173 . 087 . 043 . 021	7 5 9 8 9 5 7 7	.1429 .1429 .1429 .1429 .1429 .1429 .1429 .1429 .0000 .0000		
Table 2. M subsamples ta	ledians of iken from s	gold c ame mo	ontents ther sa	s in SO Imples,	o repl: in ppb	icated	
Distribution types of	; Sub- sample		True d	ontent: ther sa	s of go mples	оld (ррь)	
particles	weight	1000	250	64	15	4	1
Exponential	10kg 1kg 100g 10g 1g	994 1032 266 34.4 .101	253 214 29.7 .593 .000	63.3 23.5 .483 .009 .000	18.8 .433 .007 .000 .000	1.18 .042 .000 .000 .000	. 036 . 000 . 000 . 000 . 000
Symmetrical	10kg 1kg 100g 100g 10g 1g	994 1031 265 33.6 .000	253 231 29.5 .000 .000	63.3 23.5 .420 .000 .000	18.8 .419 .000' .000 .000	2.02 .005 .000 .000 .000	.037 .000 .000 .000 .000
Uniform	10kg 1kg 100g 10g 1g	1000 999 992 909 331	250 250 258 290 . 000	63.9 63.9 58.5 .583 .000	16. 17.1 25.3 .000 .000	4.06 3.24 .006 .000 .000	. 909 . 331 . 000 . 000 . 000

Table 3. Maxima of gold contents in SOO replicated subsamples taken from same mother samples, in ppb.

Distribution types of	Sub- sample	True contents of gold in mother samples (ppb)					
gold particles	weight	1 1000	250	64	16	4	1
Exponential	10kg 1kg 100g 10g 1g	1010 1050 1840 17800 158000	253 392 1810 16000 158000	81.1 184 1780 15800 331	21 181 1580 15800 331	18.1 178 1580 1970 .647	18 158 1580 4.14 .000
Symmetrical	10kg 1kg 100g 10g 1g	1010 1050 1840 15800	253 392 1810 15800 158000	81 184 1780 1970 2530	21 181 1580 15800 158000	18.1 158 1580 1970 .000	17.8 158 25.3 .000 .000
Uniform	10kg 1 1kg 1 100g 1 100g 1 10g 1 19	1000 1000 1020 1160 2910	250 252 261 291 2860	64.2 66.8 87.2 291 2860	16.3 17.4 29.1 257 2530	4.07 5.81 28.6 253 41.4	1.16 2.91 28.6 4.14 .000

THE USE OF CESIUM AS A PATHFINDER ELEMENT IN GOLD EXPLORATION UTILIZING LITHOGEOCHEMICAL AND HYDROGEOCHEMICAL SURVEYS

SURVEYS <u>LITTLE, W.D.</u> and IKRAMUDDIN, M. Cesium is a lithophile element and is similar geochemically to K, Rb, and Tl; however, it is concentrated more in hydrothermal fluids because of its large size. In order to understand the behavior of Cs during hydrothermal processes and to explore the possibility of utilizing it as a pathfinder element in lithogeochemical and hydrogeochemical surveys, volcanic hosted gold deposits of the Republic mining district, northeastern Washington, were studied. One hundred twenty five samples of altered and unaltered volcanic rocks and quartz veins and thirty water samples from drianges in the area were analyzed for Cs, K, Rb, Tl, and Au. The concentrations of these elements were obtained by Zeeman and deuterium corrected electrothermal atomization techniques and flame atomic absorption.

All ALL The concentrations of these elements were obtined by Zeeman and deuterium corrected electrothermal atomization techniques and flame atomic absorption. The content of Cs in hydrothermally altered rocks is significantly higher than in unaltered volcanic rocks. The highly mineralized rocks and veins contain low K/Cs ratios. The ternary relationship between Cs, K, and Rb separates mineralized and unmineralized rocks into two distinct populations, highly mineralized rocks and veins falling near the Cs apex. The K/Cs ratios decrease in order from unaltered volcanics to altered volcanics and Au-bearing quartz veins. The water samples collected from the drianges below one of the mines contain higher concentrations of Cs and Au compared to the background samples. The data obtained in this study suggest that Cs and the K/Cs ratio can be used successfully in lithogeochemical and hydrogeochemical surveys to delineate gold deposits of hydrothermal origin.

hydrothermal origin.

PREDICTION OF SOIL ANOMALY PRODUCTIVITY FROM STREAM SEDIMENTS USING GEOGRAPHICAL INFORMATION SYSTEMS

PREDICTION OF SOIL ANOMALY PRODUCTIVITY FROM STREAM SEDIMENTS USING GEOGRAPHICAL INFORMATION SISTEMS MOON, C.J. The advent of Geographical Information Systems offers challenges and opportunities to the exploration geochemist. In particular, in geologically mapped areas there is the possibility of using stream sediment data to predict the productivity (size* metal concentration above background) of soil anomalies. Bonham- Carter, Rogers and Ellwood (1987) have demonstrated the use of regression analysis of catchment areas to highlight residuals after the elimination of background geological effects and Fe- Mn scavenging using digitised geology. The next stage is to develop an equation to relate these residuals to the productivity of the soils within the catchment. The most familiar equation relating soil to stream sediment chemistry for English speaking readers is that of Hawkes (1976) which is a current mass balance of the catchment. This appears to work well in areas of intense chemical weathering and uplift such as the case of the Bougainville copper deposit cited by Meyer, Theobald and Bloom (1979). This model is however unable to explain the differential mobility of elements. A more recent approach is that of Pan and Harris (1990) who bring two additional factors, distance of the soil anomaly from the sediment sample and element mobility, into contrast seen in stream sediments in areas of rapid uplift and clastic dispersion or flat peneplains. So a more generalised equation needs to be developed which also takes account of the geomorphological factors and the weathering regime in the area. Fortunately, more generalised equations are available in the fusion and a practical solution. This practical solution, the equation of Keal Dispersion Flow, contains empirical factors to modifierences in elemental mobility. These empirical factors are claulated by Waknoweyey, Shestakov and Mulin (1990) as a computer from the nearest slopes (geomorphological factors are claulated by measuring the productivity and using the

irregularities. The empirical factors are consistent for particular districts. After the empirical factors have been calculated, soil productivity can be computed from stream sediment anomalies of unknown origin. Examples of this approach will be shown from the U.K. Once soil productivity has been calculated it is possible to overlay it on digitised geology or geophysics using G.I.S. Spin-offs are that (i) it is possible to produce more precise estimates of sample spacing to detect anomalies of a particular broductivity and (ii) it is possible to produce more precise if stream sediment anomalies have been explained by soil data. Bonham- Carter, G.F., Rogers, P.J. and Elwocd, D.J. (1987) Catchment basin analysis applied to surficial getchemical data, Cobequid Highlands, Nova Scotia. J. Geoch. Expl. 29 259-278 Hawkes, H.E. (1976) The downstream dilution of stream sediment anomalies J. Geoch. Expl. 6 345-358 Meyer, K.T., Theobald, P.K. and Bloom, H. (1979) Stream Sediment for Metallic Ores G.S. Canada report 31 pp 411-434 Pan, G.C. and Harris, D.P. (1990) Quantitative analysis of anomalous sources and geochemical signatures in the Walker Lake guadrangle of Nevada and California. J. Geoch. Expl. 32 299-322 Shvarov, Y.V. (1990) The evaluation of lithochemital dissipation flows. Abs. Prague IGES p89

REDUCTIVE COPRECIPITATION - A SELECTIVE PRECONCENTRATION/

SEPARATION METHOD FOR THE DETERMINATION OF TRACE METALS FOR GEOCHEMICAL EXPLORATION

NISKAVAARA, H.J. and KONTAS, E.H.

In the determination of trace metals in geological and en-

vironmental samples the method of determination must be very sensitive to achieve low detection limits required. However in many cases separation and/or preconcentration of the analyte-elements has to be still used to remove the interfering matrix constituents and to lower the detection limits to achieve ppb-concentration levels.

The most frequently used separation/preconcentration methods involve solvent extraction, ion exchange, chelating resins etc. Coprecipitation using metal hydroxides, sulphides and various organic compounds is also used. In reductive coprecipitation a selected group of trace metals can be quantitatively reduced to elemental state together with a suitable collector using a reducing agent. All the elements which are electrochemically more noble than the collector can be coprecipitated. Most frequently used reducing agents are stannous chloride, sodium borohydride, hypophosphoric acid, sulphur dioxide, hydroxylamine hydrochloride, hydrazine and ascorbic acid. Tellurium is widely used as a collector but also As, Se, Hg etc has been used. The method has been mainly applied for separation/preconcentration of precious metals in geological materials but also for preconcentration of various elements in water, metal, glass and biological samples. The mechanism of coprecipitation may involve isomorphous solid solutions, mixed-crystal formation, formation of sparingly soluble compounds or adsorption.

With specified group of elements the separation/ preconcentration can be done very selectively and quantitatively by choosing a suitable reductant and collector. Stannous chloride and mercury has been used in the Geological Survey of Finland for the separation of Au (1), Pd (2), Te (3) and Ag, Se, Pt, Rh (4). By combining the separation with determination by graphite furnace atomic absorption spectrometry (GFAAS) extremely low detection limits can be achieved (eg. Au 0.2 ng/g, Pd 0.4 ng/g, Te 2 ng/g, Se 5 ng/g in geological samples). Annually about 70 000 determinations are done using this method. Daily up to 200 samples can be processed. In addition to these elements Sb , Bi and Cu can be separated by using sodium borohydride/potassium iodine as a reductant. All elements mentioned are important in the exploration of precious metals as target elements or ore indicating pathfinder elements (5). The method has been successfully applied to areal mapping and reconnaissance prospecting of gold and platinum group elements. In addition extensive studies on geochemistry of tellurium has been carried out.

The efficiency of coprecipitation is effected by the acid concentration of solutions, the amount of collector, the reductant and its concentration. The matrix of the sample effects also the results in two ways: by consuming the efficiency of the reductant (eg reduction of Fe^{34}) and promoting

the precipitation by nucleation.

In comparison to most frequently used collectors (eg Te) mercury has several advantages. Mercury is an ideal matrix for determinations with GFAAS because of its volatility the matrix can be volatilized in charring stage and no interferences due to matrix can be expected in analysis. During precipitation no heating and stirring is needed to promote the formation of stable precipitate. Many analytes make up compounds or amalgams with mercury therein promoting the recoveries. The precipitate is adsorbed very efficiently on the walls of borosilicate tubes. The separation of the precipitate can be done simply by centrifuging and pouring out the supernatant - no tedious filtration is required. After sample dissolution the whole procedure (precipitation, separation, rinsing and final dissolution of the precipitate) can be done in same centrifugal tubes - no extra contamination and losses are introduced.

1) E. Kontas, At. Spectrosc., 2 (1981) 59.

- E. Kontas, H. Niskavaara and J. Virtasalo, Geostand. Newsl. 10(1986), 169.
- 3) E. Kontas, H. Niskavaara and J. Virtasalo, Geostand.

Newsl. 14(1990),477.

- 4) H. Niskavaara and E. Kontas, Analytica Chimica Acta, 231 (1990).273.
- 5) P.Nurmi, P.Lestinen and H.Niskavaara, Geological Survey of Finland, Bulletin (1991), in press

STABILITY OF SPECTRAL INTERFERENCE CORRECTION FACTORS IN PLASMA EMISSION SPECTROSCOPY PASKL E.F.

The accuracy and precision attainable for an element at a given concentration is a function of factors such as: spectral line used, instrumental line broadening, optical system stability, sample introduction system, excitation source stability, concomitants and their concentrations, detector sensitivity, and measurement time. In geological materials, corrections for residual spectral overlap interferences may be on the order of five to ten times the analyte concentration. Therefore, detection limits for many trace elements are primarily a function of concomitant concentrations.

IEC (interelement correction) factors on echelle and Paschen-Runge spectrometers for 30 interferents on 24 analytes were examined. Changes in optical alignment, primarily due to temperature changes of the polychromator, produced significant changes in IEC factors. In some unfavorable cases a relative tripling of the IEC factor was observed. The factors on the echelle system were typically one fifth those of the Paschen-Runge. In all but two analyte-concomitant combinations, the echelle system showed significantly less IEC variation. In all cases studied IEC factor stability was directly related to the degree of spectral shoulder overlap within the spectrometer bandpass.

OPTIMIZATION OF GEOLOGICAL AND GEOCHEMICAL MAPPING SHOJI, T.

Mapping of alteration zones is essential for exploration of various mineral deposits. A map showing alteration zones is generally drawn on the basis of the mineralogy of collected specimens, which is usually given by means of powder X-ray diffraction. In this case, the result is accurate, but the cost of each datum is expensive, and the volume of data is small. On the contrary, the alteration charac-teristics of each specimen can be estimated from the chemical data by application of multivariate analysis, although mineralogy of a sufficient number of specimens is necessary. In this case, the accuracy is lower, but the cost is low, and the data volume is large. For the effective exploration, therefore, we must know an In get for the effective exploration, checked of the most an anomalian optimal number of the reference specimens whose mineralogy is determined. This problem has been solved using the prize-penalty function (Shoji, Mining Geol., <u>35</u>, 407-413, 1985), $G = N(1-\gamma\Sigma\pi_1, \phi_1)$, where G is gain of the system, and N, Y, $(\eta_1, 2)$, and $(\phi_{1,2})$ are number of specimens, penalty coefficient, matrix showing identification probability, and matrix showing penalty, respectively. The suffixes i and j indicate that a sample belonging to the group i is seemed to belong to the group j. The diagonal elements of both matrixes correspond to correct identification, while the other elements to wrong identification. If the identification probability matrix is diago-nal, then the identification is perfect. The large value of an element of the penalty matrix means serious misidentification. Each value of penalty coefficient, and the penalty matrix is given in accordance with the purpose of the exploration. The data used in this work are presented by MMAJ (Metal Mining Agency of Japan), who chemically analyzed 533 rock specimens from the Kushikino area neighboring the Hishikari gold deposit, southwestern Japan, and identified the constituent minerals of 349 specimens among them by X-ray diffraction technique. Six alteration zones are defined as follows: LA (least altered), SZ (smectite-zeolite), PC (propylitic), MC (mica-chlorite), AG (argillic), and KM (kaolinite-mica). Former three zones (LA, SZ, and PR) are products of regionally hydrothermal activity, while latter three (MC, AG, and KM) are associated with the gold mineralization. The cost ratio between X-ray diffraction and Chemical analysis is 5 for each specimen in this case. The values of the penalty coefficient and the penalty matrix are the most important in the analysis using the prize-penalty function. penalty coefficients and 3 penalty matrixes have been examined. In results it is concluded that the optimal number of reference specimens is less than 250 in the present case.

STUDY ON THE RARE EARTH ELEMENT GEOCHEMICAL HELO OF HYDRTHERMAL ALTERED ROCKS RELATED TO GOLD ORE DEPOSITS IN JIAODNG AREA, CHINA

YANG,Minzhi

I .Gold ore in jaodong Area occurs as lodes in Mesozic fractural belts trending in NE, NNE. The early Cretaccous Epoch is the main metallogenic interval (104-115my by K-Ar Method). Genetically, the gold deposits are mesothermal type (homogenization T.180-250°C) but dominated by mesothermal gold deposits (210-250°C). There are also epithermal types which are Ag-deposits or Au-Ag deposits. Four metallogenic stages can be recognized; 1.pyrite-quart; 2.pyrite-chalcopyrite-electrum-pyrite; 3.chalcopyrite-pyrite-spheleritegalena-Te, Au, Ag mineral; 4.pyrite-carbonate-quartz among which stages 2,3 are main ones. Gold occurs mainly as electrum (75-83%) and less Kustilite, native gold, calaverite, petzite, altate, vitreous silver etc. Gold veins are generally located in the fractures developed within granites and Archean plagioclase-amphivolite and leucogranulites. Quartz-pyrite-arciate rock, silicified-fractured rock, microcline-sericite granite, less barite rock and carbonate rock are the altered rocks adjaccant ore bodies. The altered rock bits related to gold deposits in Jiaodong Area are mainy distrbuted along compressional fractural zones and ductile zones striking in NE NNE. They can be divided from the west to the cast into four belts: 1.Zhaoyuan-Yexian granitic-altered rock belt. 2.Qixa plagioclase-

amphibolite-altered rock belt. 3.The middle Rushan granitic-altered rock belt. 4.The west Rushan albite-leucogranulite-altered rock belt.

II .Mineral-rock-geochemocal xoning of altered wall rocks. Three kinds of zoning can be recognized: 1.Fresh granite > microcline-sericite granite > sericite granite > pyrite-sericite granite > silicified-fracturedrock > gold vein with increase of Rb,Ba,Cs,Pb,Zn,Au,Ag,LREE and KO2,SiO2H2O⁺ and de crease of CaO to gold vein(in granite). 2.Fresh plagioclase-amphibolite - fuchsitzed plagioclase amphibolite - sericitizde plagioclase amphibilite sericite-quartz. rock sold vein with increase of SiO2, H2O*, K2O, CO2, HREE, Cu,Pb,Zn, Au and Ag and decrease of Fe2O3, FeO, MgO, CaO, Sr, Ba / Rb and V, Ni, Fe(in plagioclase-amphibolite). 3.Fresh albite-leucogranulite > silicifed and sericitized keucogranulite - gold vein with increase of K2O, H2O, Fe2O3, MgO, CO2, Eu, Total REE, Ti, V, Cr, Fe, Mn, Co, Ni, Ba, Au, Ag and derease of Sr(in leucogranulite).

III.REE pattern of the altered rocks in Jiaodong Area: 1.Gentle type: Total REE is inercased in the hydrothermal altered rocks adjacent to gold veins in plagioclase-amphibolote. 2.Eu-concentrated type: Eu is concentrated in the hydrothermal alterde rocks adjacet to gold veins in leucogranulites. 3.undulate type: HREE are increased in the hydrothermal altered rocks adjacent gold veins in granitic rocks with LREE concentratated in sericitized granite zones.

EXPLORATION FOR THE CHINKUASHIH GOLD-COPPER DEPOSITS WITH IRON SULFIDES IN TAIWAN YU,B.S. and TAN,L.P.

The iron sulfide minerals in the Chinkuashih gold-copper deposits of northeast Taiwan are marcasite and pyrite. Reniform marcasite occurs on the top of ore bodies. As approaching an ore body, the crystal size increases from <to >loam, Au content from <1 to 3ppm, Ag from 3 to 6ppm, Cu from <1 to 3ppm, Mn from 80 to 600ppm, and Pb from <0.3 to 3ppm 3ppm.

Pyrite is widely distributed in this area. Its Au, Ag, As, Cu, Ba, Mn, Pb, and Zn contents are distinguishable in different types of ores. Mn, Pb, and Zn contents are distinguishable in different types of ores. In gold-copper and copper-bearing gold zones, the pyrite is high in Cu content, up to 1.5%, averaging 4,000ppm. Arsenic contents vary from <300 to 3,000ppm in these zones, depending on the amount of enargite inclusions. In bonanzas, pyrite is typically high in Au, 6-30ppm, and Ag, 60-100ppm. The Ba, Pb, and Zn contents of pyrite in or near bonan-zas are irregular, from <300 to 10,000ppm, from 80 to 10,000ppm and from 60 to 3,000ppm, respectively, due to inclusions of barite, galena, and sphalerite, whereas the As and Mn contents range from 300 to 3,000ppm and from 600 to 1,000ppm. The size and crystal forms of nyrite are also useful for prospect-

3,000ppm and from 600 to 1,000ppm. The size and crystal forms of pyrite are also useful for prospect-ing. In barren areas, the pyrite is cubic in form and <2mm in size. From a gold-zone through a copper-bearing gold zone to a gold-copper zone, the sizes of pyrite increase from <1 to >40mm, and the crystal forms change from cube to combinations of cube and pyritohedron, pyri-

tohedron and octahedron, and octahedron. Heavy concentrates of stream sediments are composed of >90% of pyrite, In an unexplored area near Chinkuashih, the Ag, Au, Ba, Cu, Hg, Pb, Sn, and Zn anomalies in some of these concentrates may indicate mineralization. Silicified and argillized dacites and sandstones indicating mineralization were recently discovered.

TRIASSIC-JURASSIC MAGMATIC ARC OF WESTERN NEVADA AND EASTERN CALIFORNIA - PART II: MINERAL DEPOSITS DOERICH, J.L., GARSIDE, L.J., AND SHAWE, D.R. Mineral deposit studies in the Triassic-Jurassic magmatic arc of western Nevada and eastern California were conducted to characterize mineral deposits hosted by the arc complex and to evaluate the arc complex for volcanogenic massive sulfide (VKS) potential. Jurassic arc-related mineral deposit types within the complex include porphyry Cu, Cu skarn, Fe skarn, polymetallic replacement, polymetallic vein, and Al-silicate deposits. The majority of these jurassic deposits are related to the Yerington supersystem which comprises at least three individual mineral systems [Yerington-Pumpkin-Hollow(?), Ann Mason-Buckskin(?), MacArthur-Bear-Lagomarsino-Airport] each of which produced porphyry Cu and related skarn, replacement and vein deposits. Late Jurassic and Cretaceous deposit types hosted by the arc complex but associated with the emplacement of the Sierra Nevada Batholith include W skarns (Gardnerville district). W veins, a low F porphyry Mo deposit (Pine Nut deposit, Gardnerville district), and Au-Cu quartz-tourmaline veins (Meadow Izke and Peavine districts). Tertiary deposit types hosted by Triassic-Jurassic arc rocks include epithermal adularia-sericite and quartz-alunite veins (Ramsey and Peavine districts, respectively), and volcanogenic U deposits. Au-bearing polymetallic veins (e.g., the Lucky Boy and Pamlico districts), barite veins, and volcanic-hosted base-metal skarns are of uncertain age and probably formed during more than one metallogenic event and during more than one period of geologic time. The apparent absence of VKS deposits is a consequence of several factors relating to the geologic setting of the Triassic-Jurassic arc complex exposed in the study area. These are 1) the deminance of subaerial volcanism. 2) the absence of volcanism in deep restricted basins, and 3) the lack of submarine felsic volcanic centers. Most volcanic sequences were depo

TRIASSIC-JURASSIC MAGMATIC ARC OF WESTERN NEVADA AND EASTERN CALIFORNIA - PART IV: REGIONAL SOIL GAS SURVEYS IN SELECTED BASINS MCGARTHY,J.H., JR. Soil gas samples were taken at 1/2 to 1.0 mile intervals in six basins in west-central Nevada: Mason, Smith, Churchill and Soda Springs Valleys and in Pine Grove and Whiskey Flats. Closer spaced sampling (0.1 mile) was done along a traverse in the valley 1 mile east of the Lucky Boy mine, southern Wassuk Range, to test the possibility that the ore vein system might extend into the valley. In all, 338 soil gas samples were collected and analyzed for multiple gas species. Soil gases were collected at a depth of 0.75 meters and analyzed immediately using a truck-mounted mass spectrometer. Gas anomalies were found in all basins. Some of these anomalies were found to correlate with mineralized areas in adjacent ranges. Other anomalies occur in areas where no mines or prospects are known, and these may indicate mineralization in bedrock beneath the valley fill. Hydro-carbon gas anomalies (methane and propane) occur in alluvium above the projected strike of the Lucky boy Mine vein system suggesting front and beneath the basin fill. Gas anomalies for CO, and O₂ occur at 76 sites throughout the basins and may indicate oxidizing sulfide deposits at depth. One such example is found in northern Smith Valley between the Singates and Buckskin Ranges. Other hydrocarbon gas anomalies from basin fill deposits may reflect petroleum or natural gas deposits. . An apparent correlation of hydrocarbon gases with Mesozoic meta-

gas anomalies from Dasin fill deposits may reflect performed of natural gas deposits. An apparent correlation of hydrocarbon gases with Mesozoic meta-sedimentary rocks may indicate areas in the basins that are underlain by these rocks. Gas anomalies are also found over the projected strike of faults beneath basin fill. Soil gases may be useful indicators of concealed mineral deposits in basing

GRAVITY AND MAGNETIC STUDIES OF EASTERN CALIFORNIA AND WESTERN NEVADA AND RELATIONS TO A VOLCANIC-ARC TERRANE

PONCE, D.A. Gravity and magnetic data were analyzed in eastern California and west-Gravity and magnetic data were analyzed in eastern California and west-ern Nevada as part of an effort to help characterize the mineral re-source potential of a Triassic-Jurassic volcanic-arc terrane. Gravity data were particularly useful for providing information over covered areas in the Basin and Range province and magnetic data were used to define regional structures and to trace lithologic units beneath basins. A gravity procedure similar to that used in a statewide assess-ment of Nevada was used to determine the thickness of alluvial or vol-canic cover and help limit the areal size of potentially mineralized areas by excluding areas where basins are greater than about 1 km in depth. depth.

In general gravity data suggest that volcanic rocks along the Sierra In general gravity data suggest that volcanic rocks along the Sierra Nevada and especially in the western part of the study area are thin, much less than about 0.5 km. In the northwest part of the study area gravity data show that volcanic rocks near the crest of the Sierra Nevada Mountains thicken to about 2 km west of Verdi, Nevada. Gravity data reveal that alluvial valleys northwest of Lake Tahoe are relatively shallow, less than about 1 km in thickness. In the Nevada part of the Basin and Range province gravity data indicate that in general basins are relatively shallow, typically less than 2 km in thickness. These shallow, linear, and NNW-trending basins probably reflect a common Tertiary tectonic history. Deep basins occur in the northeastern part of study area at Mono Valley. Aeromagnetic and truck-mounted magnetic data were used to help deter-mine regional structure, subsurface geology, and to infer where marnetic

mine regional structure, subsurface geology, and to infer where magnetic sources are relatively shallow. In the western part of the study area high amplitude magnetic anomalies reflect strongly magnetic ultramafic

rocks that occur along the Melones and Bear Mountain fault zones. A large magnetic anomaly is associated with gabbro of the Pine Hill intru-sive complex along the west edge of the study area. In the central part of the study area arcuate east-west-trending aeromagnetic anomalies cor-relate with mapped Tertiary volcanic and Mesocoic granitic rocks. One of the more conspicuous east-west anomalies extends across the Desert Mountains at about lat 39° 10° N. This anomaly may reflect a pre-Tertiary basement feature related to moderately-magnetic granitic rocks or may be related to a belt of Tertiary volcanic rocks. East of Oreana Peak, truck-mounted magnetometer data reveal that Smith Valley is not underlain by Triassic-Jurassic volcanic-arc rocks but is probably under-lain by moderately-magnetic granitic rocks similar to those exposed in the adjacent Pine Nut Mountains. Although it is difficult to assign a particular geophysical signature to the volcanic-arc rock assemblage, gravity and magnetic data are a useful method to infer the extent of these rocks beneath Cenozoic cover and to exclude deep basins as possi-ble mineral exploration targets.

TRIASSIC-JURASSIC MAGMATIC ARC TERRAIN, WESTERN NEVADA AND EASTERN CALIFORNIA - PART V - A MODEL FOR THE EVALUATION OF CENOZOIC BASINS FOR CONCEALED MINERAL-SYSTEMS <u>SAWATZKY, D.L.</u> RAINES, G.L. DOEBRICH, J.L., TURNER, R.L., GARSIDE, L.J., and MCCARTHY, J.H., Jr. A computerized geologic information system based on several GIS computer programs provides data management, digitizing and plotting, and powerful GIS functions. These functions provide the analytic tools for spatial analyses of map databases for evaluation of mineral resources in basins. Databases were compiled from new data and several existing sources of digital data. These data sets include the geologic map of Newada and larger scale geologic maps, MEDS mines and prospects data, NURE and RASS stream sediment and soil geochemical data, NURE aeroradioactivity data, USGS aeromagnetic and gravity data, USGS DEM topographic data, AMT profile data, biogeochemical data, and soil gas data.

aeroradioactivity data, USGS aeromagnetic and gravity data, USGS DEM topographic data, AMT profile data, biogeochemical data, and soil gas data. The basin evaluation model is based on maps of pre-Cenozoic rocks, depth-to-basement, and maps of proximity to mines and prospects, geochemical anomalies, hydrothermal alteration, limonite anomalies, and radiometric anomalies. A digital subcrop map of pre-Cenozoic rocks was prepared by extrapolating basement geology beneath Cenozoic basins, utilizing known geologic relationships in the ranges, structural data relating to folding and faulting, and interpreting magnetic, gravity, and electrical geophysical data. Depth-to-basement is estimated from complex physical relationships among geology, topography, gravity and magnetic data. It is used to estimate the thickness of Cenozoic fill on basement rocks. The proximity maps show prospective areas around mines and prospects of size appropriate to the deposit types, and prospective areas around geochemical and geophysical anomalies, and hydrothermal alteration zones. zones

zones. The geologic, depth-to-basement, and proximity maps are combined by a linear weighting procedure to produce the evaluation model. The weights reflect the importance of each data type as a predictor of mineralization. Weights are determined intuitively, based on experience, or from statistical analysis of the distributions of the data. The result is a map of the areas favorable for mineralization at depths of less than one kilometer under Cenozoic cover rocks in the basins.

the basins. TRIASSIC-JURASSIC MAGMATIC ARC OF WESTERN NEVADA AND EASTERN CALIFORNIA - PART 1: GEOLOCY SCHWEICKERT:R.A., STEWART.J.H., DILLES,J.H., GARSIDE,L.J., GRENER,R.C. HARDYMAN,R.F., HARVOOD,D.S. AND SILBERLING,N.J. Hetavolcanic and metasedimentary rocks and plutons that represent a Middle Triassic to Jurassic magmatic arc crop out at scattered localities throughout a large region of western Nevada and eastern California. These rocks have recently been studied in an area extending northwestward from the Gillis Range near Walker Lake through Lake Tahoe to the northern Sierra Nevada near Bowman Lake and near Reno. Geologic relations of the arc have been complicated by the intrusion of younger Jurassic and Cretaceous plutons of the Sierra Nevada batholith, concealment beneath Cenozoic volcanic rocks, fragmentation by large magnitude Genozoic extension and strike-slip faulting, and burial beneath Neogene Basin fill. The Mesozoic strata can be separated into at least four strati-fragmentation by large magnitude Cenozoic volcanic rocks, transition from andesite to thyolite. These rocks were deposited in both subaerial and marine environments and locally are intercalated with shallow marine carbonate rocks. This package extends westward forn the Gillis Range to the Carson Gity area but does not occur in the northern Sierra Nevada. Coformably overlain, apparently conformably, by a third package of uppermost Triassic to lower Hiddle Jurassic (Bajocian) basinal siltstone, arglillite, and dark limestone. Shallow-marine to nonma-rich package is overlain, apparently conformably, by a third package of uppermost Triassic to lower Hiddle Jurassic of boy ong est package apparently rest unconformably upon the older units. Major-and tracelements analyses of volcanic units that include felsic ashflow tuff, dacite and andesite porphyry, fluvial conglomerate, and bydoyssal intrusions. In some areas, rocks of the youngest is arc developed along an active continental margin. Uncertainties about

but lack foliation. The extent, geometry, timing, and significance of the regional deformation are still being studied. The relation of the younger stratigraphic package to the regional deformation varies across the study area. For example, Middle and Middle(7) Jurassic volcanic rocks in the Yerington area appear to postdate the regional deformation. In contrast, in the northern Sierra Nevada, the youngest Middle(7) Jurassic units were involved in regional deformation together with older units. The oldest Mesozoic rocks in the study area are interpreted to have formed in a low-relief, shallow-marine to subaerial volcanic terrane during the Middle to Late Triassic. As volcanism wanned in the Late Triassic, subsidence occurred and one or more intra-arc or fringing basins developed. Continued subsidence and (or) sea-level

the Late Triassic, subsidence occurred and one or more intra-arc or fringing basins developed. Continued subsidence and (or) sea-level rise deepened and enlarged the basin(s) during most of the Early Jurassic, as basinal marine siltstone, mudstone, and limestone were deposited. Late in the Early Jurassic, the region shoaled and nommarine sedimentary deposits accumulated. Subsequently, Middle Triassic to Middle(?) Jurassic units were regionally deformed. At least locally, the deformed rocks were intruded by younger Middle Jurassic batholiths and were overlain by younger Middle(?) Jurassic volcanic sequences. An unresolved tectonic problem is whether major Mesozoic strike-slip or thrust faults proposed by various authors divide the Mesozoic units into different tectonostratigraphic terra-nes.

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TRIASSIC-JURASSIC MAGMATIC ARC OF WESTERN NEVADA AND EASTERN GALIFORNIA - PART III: Stream Sediment Geochemistry <u>TURNER R.L.</u>, McCARTHY,J.H., JR. Stream sediment sample were collected from 806 sites within the project area of about 10,000 mi². These samples were analyzed for 31 elements by an emission spectrographic method, and for As, Bi, Cd, Sb and Zn by more sensitive wet chemical methods. The data were statis-tically analyzed using an R-mode factor analysis technique. Three-tically analyzed using an R-mode factor analysis technique. Three-tically analyzed using an R-mode factor analysis (Cd, Zn, Ag, Pb, Cu & Mo), (Ni, CT, Co, Ba & Cu), (Bi & Cu), (Y, ZR, Be, La, B & Mo), and (As, Sb & Mo). In the second approach nine factors were produced with the major elements of (Mg, Sc, Fe, Co, V, Ca, Mn & Ti), (Ba, Sb, Sr, La & Be), (Zn, Cd & Cu), (Ni, Cr, Co & Ti), (Bi, Ga, Cu & As), (Zr, Y, V, La & Be), (As, Zn & Mo), (B, Be, Ca & Mo), and (Ag, Mo & Fb). In the last approach the data was separated into a lithologic data set of sevencen elements (Fe, Mg, Ca, Ti, Mn, B, Ba, Be, Co, Cr, La, Ni, Sc, Sr, V, Y & Zr) and an ore-metal data set of nine elements (Ag, Cu, Mo, Fb, As, Bi, Cd, Sb & Zn); factors were produced from these two data sets. The factors produced in the last approach were (Fe, Mg, Ti, Sc, V & Mn), (Y, Be, La& Zr), (Sr, Ca, Ba & Mg), (Ni, Cr, B & Co), (Zn, Cu, Cd & Ga), (Mo, Sb, As & Cd), (Si & Ga & As), and (Pb & Ag). Four factors are common in all approaches and overlap, almost totally, when plotted. Geochemical plots of three of the factors delineated three separate zones in the study area that appear to correlate with a general progression of age of intrusive and extrusive rocks in the area from the older rocks in the southeast to younger in the northwest. (largely lithopile) that differentiate lithologic units. The ore metal factors do not correlate well with the deposit types. Single element geochemical maps reveal groups of elements that appear to characterize different deposit in the drinage

A GEOCHEMICAL EXPLORATION STRATEGY FOR PGE, GOLD AND KIMBERLITES IN MOZAMBIQUE ASHATHABARAYANA.U.

Though the geologic environment of Mozambique closely parallel that of Zimbabwe and South Africa, the mineral potential of Mozambique largely remains unrealized due to lack of infrastructure, security problems, etc. The paper presents an innovative strategy of geochemical exploration for PGE (platinum group elements), gold and diamondiferous kimberlites, on the basis of mineral deposit modelling, and utilization of easily-determinable path-finder elements to trace the extensions of known occurrences and to locate new ones.

Platinum group elements (PGE), which are by far the most valuable metals in the Ni-Co-Cr-Pt assemblages, are known to occur in the gabbro-amorthosite complex of Tete Province in NW Mozambique (analogous to Bushveld Complex of South Africa?), layered mafic-ultramafic body of Mt Atchiza (analogous to the Great Dyke of Zimbabwe?), high HgO (20-25%) komatiites of Manica Province in western Mozambique (analogous to komatiites in the greenstone belts of South Africa and Zimbabwe), collision-related ophiolites (?) in the Mozambique Belt in northern Mozambique, etc. Among the FGE, Pt-Pd-Rh are more common in the layered intrusions and Os-Ir-Ru, in the chromitites of the ophiolite assemblages. Routine determination of FGE by neutron activation analysis is not feesible in Mozambique. Since a few measurements made in the area indicate a Ni/Pt ratio of about 400, it should be possible to make an order of magnitude estimation of FGE concentrations on the basis of Ni abundances. Thus, potential PGE areas in the Angonia region of the Tete Province (say, at Tsangano, long. 34'27', lat. 15'17'S) could be traced and assessed preliminarily using the easily-determinable Ni as a pathfinder. In some areas (say at Menchichula), Ni-Co-Cr anomalies coincide with Zn anomalies, though the two groups may not be genetically related. In such cases, both Ni and Zn could be used as nethfinders for PGE

The groups may not be seed as pathfinders for PGE. In Mozambiquem, gold occurs in several environments (such as iron formation-hosted, lateritic gold, sulphidic gold in the shear zones of Chifumbasi, long. 32^{57} , lat., $14^{10}(S)$, etc. Recent advances in the use of organics for the extraction of fine-grained gold (<10 μ m) in low concentrations (~1.5 g/t) have made lateritic gold an attractive proposition. Counting the number of grains in a fixed volume of sluiced material, and chromatographic method (which can detect gold at sub-ppm levels), can be used in the field. More accurate determinations of gold may be later used in the laboratory by AAS (available in Mozambique).



Apart from the identification of kimberlite-derived pyrope and picro-ilmenite in the loam, diamondifeous kimberlites could be identified on the basis of their geochemical finger-prints (MgO>10%, Cr> 500 ppm, Ni>485 ppm), in the Lunha River area of Maniamba graben. chromite fragments in soils near chromitite pods accounts for the high platinum content of the non-magnetic fractions of these soils.

With regard to choice of media for exploration, the magnetic heavy mineral fraction of C horizon soils would probably provide the best chance of detecting a platinum anomaly during reconnaissance overburden sampling. Subsequently, the greater contrast but more limited dispersion of platinum in the non-magnetic heavy mineral fraction, together with the association with chromiumrich/iron-poor chromite grains, may be most useful for tracing the platinum anomaly back to its bedrock source.

GEOCHEMICAL EXPLORATION FOR CHROMITITE-ASSOCIATED Pt DEPOSITS: DISTRIBUTION OF Pt IN SOILS OF THE TULAMEEN ULTRAMAFIC COMPLEX, SOUTHERN BRITISH COLUMBIA <u>COOK,S.J.</u> and FLETCHER, W.K. Exploration for chromitite-associated platinum deposits is barmered by a poor understanding of the distribution and

Exploration for chromitite-associated platinum deposits is hampered by a poor understanding of the distribution and behaviour of platinum in the surficial environment. This study investigates platinum content, residence sites and PGE mineralogy of soils developed on till and colluvium above an Alaskan-type ultramafic complex in southern British Columbia.

The Grasshopper Mountain platinum occurrences consist of massive-to-discontinuous pods and segregations of platinic chromitite in dunite of the Tulameen ultramafic complex. Representative soil profiles, stream sediments, and waters were sampled. Platinum content of the -212 μ fraction of soils and sediments was determined by fire assay-inductively coupled plasma spectroscopy. Selected samples were then examined in detail to determine platinum mineralogy and its distribution between different size, density and magnetic fractions.

distribution between different size, density and magnetic fractions. Except on colluvium platinum content of soils generally increase with depth. Concentrations in the $-212 \ \mu$ size fraction of C horizon soils range from 2 to 885 ppb and are closely related to estimates of soil-dunite content based on MgO values. For example, dunite colluvium (mean 24.2% MgO), local dunitic till (16.5% MgO), and exotic non-dunitic till (5.7% MgO) have median platinum concentrations of 88 ppb, 36 ppb, and 8 ppb, respectively. This trend is evident in all size and density fractions but the platinum content of heavy mineral concentrates (SG >3.3) is 10-20x greater than in the light minerals. In heavy mineral concentrates from nondunitic tills and dunitic tills remote from mineralization, platinum is most abundant in the magnetic fraction. However, as mineralization is approached the greatest concentrations of platinum, maximum 3225 ppb, are found in the non-magnetic fraction.

SEM-microprobe studies identified Pt-Fe-Ni-Cu alloys as free grains, and as inclusions in Mg-silicates and chromite. The chromite, which is generally most abundant in the magnetic fraction, occurs as both Cr-rich anhedral fragments and Fe-rich euhedral-subhedral crystals. The latter are relatively more important in the magnetic fraction whereas fragments are the principal form of chromite in the nonmagnetic fraction. They are interpreted as being fragments of the FGM bearing chromitite segregations whereas the euhedral crystals probably represent platinum-poor grains that occur throughout the dunite. The abundance of anhedral

PATTERN CURVES FOR GOLD CONTENTS DISTRIBUTION IN LATERITIC PROFILES: APPLICATION FOR GEOCHEMICAL EXPLORATION IN TROPICAL ENVIRONMENTS. DA COSTA, M.L., FONSECA, L.R. and COSTA, J.V.

The Brazilian Amazon region is rich on Tertiary and Quaternary lateritic covers, which are under a chemical unbalance to recent weathering processes that prevail in the region as a consequence of humid rain climate and its dense forest cover activity.

Laterites are geologically very important because of their wide distribution - obliterating primary rocks outcrop - and significative metalogenetical potential(Al, Fe, Mn, P, REE, Ti, Ni, Cu, Cr, Sn, kaolin). The major iron, aluminum and kaolin mines of the Earth of lateritic origin are in Amazon region. Mineral potential for gold has also been identified in the last years, where laterites are probably the source of great part of alluvionar gold deposits in Amazon region.

Amazon laterites are classified in two wide groups based on their evolution grade and period of formation: mature and immature laterites. Although the first are more favorable for mineral deposits formation, gold on the other hand, may be concentrated in anyone.

Mature lateritic profiles exhibit a thick clayey horizon(saprolitic only in the base), superposed by a gibbsitic(bauxite)/phosphatic horizon which can be directly concealed by a yellow clayey horizon and/or an aluminous-ferruginous crust.

Immature profiles, also exhibit a similar clayey horizon, overlaid by a concretionary/columnar ferruginous horizon, invariably covered by sandy-clayey yellow soil.

Gold shows its highest contents in the following horizons: bauxitic,

concretionary, feruginous, and also in middle and lower part of saprolite (figure 1). The distribution curve of gold contents in these profiles shows a characteristic sigmoidal pattern. It detaches a concavity highest contents) in concretionary horizon and convexity(lowest contents) in the zone between upper horizons and the top of saprolite. Gold contents in this zone are equivalent or lower than its contents in soils overlaying concretionary horizon/iron crust.

In Amazon region, where great part of lateritic profiles was truncated by erosive processes - reaching saprolitic clayey horizon - with subsequent tropical weathering giving rise to a new latosols development (similar those in the top of complete profiles), a clearly qualification of gold contents in this horizon becomes fundamental because it represents the more frequent sampling media in Amazon region. The young superimposed weathering processes promote a wider dispersion of gold, giving rise to smaller contents than those from ferruginous and latoscls horizons of the complete profiles. The result is that uninquered geochemist can disregard these low gold contents , which can be more significative than those from the top horizons of the complete profiles, eliminating probable interesting geochemical targets, indicated by low gold contents. In this way, 100 to 200 ppb gold in this latosol derived from clayey horizon may be more significative than 500 to 1000 ppb in the latosols derived brom top horizons of complete profiles. Therefore, in Brazilian Amazon like areas, is fundamental to distinghish soils derived from top of lateritic profiles from those derived from clavey horizon(saprolite).

GEOCHEMICAL SIGNATURE OF THE COMSTOCK DISTRICT, STOREY COUNTY, NEVADA HUDSON, D.M., AND SMITH, D.B. The Comstock district in western Nevada produced rich gold-silver ore

from stockwork quartz-adularia (calcie) veins, hosted mainly in Miocene andesitic rocks, of the Comstock, Silver City, and Occidental Lodes. Post-mineralization faulting of the Comstock Fault system has exposed many of the ore bodies and the accompanying hydrothermal alteration. Propylitization is the predominant wall rock alteration in the district. Propulsization is the predominant wall fock alteration in the district. Post-mineralization faulting has exposed, in the footwall of the Commstock Lode, areas of the deeper level sericitic and illitic alteration assemblages and preserved, in the hanging wall, areas of the higher level alunitic, kaolinitic, and illitic alteration assemblages.

Multi-element geochemical analyses of nearly 250 oxidized surface rock chip samples from the district were used to determine the geochemical signature of the different vein systeme used to determine the geometrical signature of the different vein systemes and to study the enrichment or depletion of elements in the wall rocks. Positive anomalies of gold and silver are restricted to the lodes. The Comstock Lode is also enriched in As, Cd, Hg, Mo, Pb, and Tl, with localized enrichment of B, Bi, Cu, Mn, Sb, Te, and Zn, and depletion of Ba, Co, F, and Ni when compared to Mn, Sb, Te, and Zn, and depletion of Ba, Co, F, and Ni when compared to unaltered rocks. The Occidental Lode shows general enrichment of As, Hg, and Tl, with localized enrichment of B, Bi, Cd, Pb, and Sb, and depletion of Ba, Co, F, and Ni. The northern Silver City Lode is similar geochem-ically to the Occidental Lode but appears to lack enrichment of Bi and Pb. The geochemical signature for regional propylitization shows little variation from unaltered rocks except for slight enrichment of F and locally Tl. Hydrothermally altered rocks (other than propylitization) in the hubbing unall of the Greatork Lode show constant of As in the hanging wall of the Comstock lode show general enrichment of As, B, F, Hg, Mo, Pb, Te, and Tl, with localized enrichment of Bi, Cd, and Sb, and strong depletion of Mn, Co, Ni, and Zn. Footwall sericitic and illitic alteration show enrichment of B, Pb, Tl, and Te, with very localized enrichment of As, Bi, Cd, Cu, Mo, and Sb, and depletion of Co, F, Mn, Ni, and Zn.

The most consistent indicator elements in the lodes appear to be Tl. Ag, Au, and As. In the hanging wall alteration the important indicator elements are Tl, Te, As, B, F, Hg, Mo, Pb, and Sb. The primary ores contain abundant sphalerite, chalcopyrite, and galena. Low levels of Zn, Cu, and Pb at the surface in oxidized ores may indicate supergene leaching of base metals. Supergene leaching may also account for the apparent broad depletion of Zn, Co, and Ni in the hydrothermally altered wall rocks.

BIOGEOCHEMISTRY OF PALLADIUM. KOTHNY, E. L.

Pd was suggested for the exploration of platinum group metals (FGM). Whenever possible, use of vegetation is more practical than drilling or sampling different soil horizons, especially in terrain of limited accessibility. After the discovery of PGM uptake by vegetation by Fuchs and Rose in 1974, the interest in the mechanisms of such translocation increased.

Gabbro, basalt and serpentine contain higher levels Gabbro, basalt and serpentine contain higher levels of Pd (mean of 15 ppb Pd). Soils derived from such rocks bear levels of 0.4 to about 100 ppb Pd. In ordinary soils and in laterites, Pd correlates with Mn. The global con-centration of Pd in soil is about 6 ppb Pd. The element is more mobile during the weathering cycle than Al, Fe, Ta, Nb, Sn, Au, and Pt, especially in presence of chlori-des and soluble organic chelants. Natural content in spring water is nearly 0.6 ug/m3; in oceanic water at 2000 m depth it is 0.07 ug/m3.Emissions into the environ-2000 m depth it is 0.07 ug/m3. Emissions into the environment are mostly from catalysts and smelters. The preparative methodology plays an important role

in the analytical recovery of traces of Pd. The metal in plants is the source of most Pd found in the biogenic chain, but it has no apparent physiological the biogenic chain, but inas hospital physiosystem physiosystem function. The biological absorption coefficient (BAC = content in dry tissue/content in soil) allows the study of the correlation plant/soil. Physiologically essential elements usually have BAC>0.1. The BAC found for Pd in some plant organs are ≥ 0.3 , which are comparable to those observed for Mn, Ca, Cu, and Ba. Pd does not correlate with Pt in different or the same plant species gro-wing in the same area. Correlations plant/soil for Pd are generally poor, possibly because the uptake of Pd is related to the soluble portion of the element in soil. Solubility is strongly influenced by presence of clay, hydrous ferric oxides, insoluble organic substances and pH. Uptake is variable and depends on plant organs. In general stems and leaves accumulate more than tips in leafy plants, whereas the opposite was observed with needles and tips of gymnosperms. For the same concentration in soil, uptake of Pd is about an order of magnitude lower than the corresponding uptake of Pt. The BAC's of Pd are variable with climate and growing stage.

In exploration biogeochemistry it is necessary to study the concentrating ability of a variety of vegeta-tion in places known to contain PGM mineralization. Plant organs showing highest contrasts in tissue or ash are targeted.

ASPECTS OF THE GEOLOGY, GEOCHEMISTRY, AND MINERALOGY OF

CARBONATE-HOSTED PGE OCCURRENCES <u>LECHLER, P.J.</u>, LARSON, L.T., AND HSU, L.C. For decades, the Boss Mine in southern Nevada was the only known example of carbonate-hosted PGE mineralization. Boss Boss Known example of Carbonate-nosted PGE mineralization. B Mine mineralization consists of Au-Ag-Pt-Pd-Cu-Ni ore hosted in brecciated Mississippian limestone. A genetic relationship to minor nearby igneous dikes has not been demonstrated. PGE mineralization within the Goodsprings district is restricted to the Boss Mine and other prospects along the NE-trending Ironside fault. The Goodsprings District is best known for its carbonate-hosted zinc mineralization.

Recently several additional carbonate-hosted PGE occurrences have been identified outside of the Goodsprings District. These include the Carr Fork and Iron Springs

occurrences in Utah and the Gibelini Mine in Nevada. At Carr Fork, in north-central Utah, Pt-Pd accompanies copper-gold skarn mineralization. Platinum values as high as 340 ppb and palladium as high as 960 ppb have been reported. Carr Fork is thought to be a distal product of the Force Pierbar courter

reported. Carr fork is thought to be a distal product of the Eocene Bingham copper system. At Iron Springs in southwestern Utah, Pd-bearing carbonate breccias occur as part of the iron skarn system produced by Cretaceous intermediate intrusives. Palladium produced by Cretaceous intermediate intrusives. Palladium Palladium occurs in concentrations as high as 300 ppb; other PGE are present at low concentrations.

Gibellini mineralization in central Nevada is characterized by Pt-bearing manganese ore which contains important amounts of Zn, V, Ni, and Co. Platinum concentrations of 200 - 650 ppb are common; other PGE are present in low concentrations. Gibellini is hosted in Upper Devonian limestone. Genetically related proximal igneous rocks are not evident.

Within an individual mining district the occurrence of hydrothermal PGE mineralization has been observed to be limited to a few closely associated mines or to a unique ore-controlling structure or particular mineral zone. Th This implies unique conditions related to transport, deposition, or available source rock.

This paper will focus on specific aspects of the geochemistry, mineralogy, and geologic settings of this rare class of PGE occurrence.

COMPOOSITION OFGAS PHASE IN BASIC-ULTRABASIC INTRUSIONS AND ITS CONECTION WITH RANGE OF PLATINUM-PALLADIUM COPPER-NICKEL ORE-DEPOSITION NERUCHEV.S.

Many foliate basic to ultrabasic rock intrusions occur in northern Siberia and Taimyr Peninsular. Comparative geology, petrography and geochemistry of some nickelifeous foliate intrusions have indicated much in common with respect to their geochmical type. However, ore mineral components were distributed in them under different processes, hence different extent of minerralization. These processes have affected a special fluid regime of intrusion.

We had focused our study on the Upper Talnah and Lower Pokin in-trusions near Norilsk as well as Bootankag and some other intrusions on the Taimyr Penninsular. These two regions are generally similar in the evolution of the Permian-Triassic trap magmatism. The intrusions under study are associated with deep fracture zones. The host rocks are mainly Late Carboniferous to Early Permian terrigenous scients are mainly late derivatives to barry relation to the more than the sender of the science ing dolerites and gabbro-diorites on the top of the section.

In the lower part of the intrusions except for the Lower Pokin, pegmatoid rocks with taxit texture occur. Horizones of impregnated ores and ore veinlets are restricted to the lower contact dolerites, taxit and picrite gabbro-dolerites of the Upper Talnah intrusions. Veins of commercially viable massive pentlandite-chalcopyrite-pyr-rhotite ores are continued to the bottom exo- and endocontacts. Massive ore bodies are formed under temperatures widely ranging between 1100°-1000° and 600°-300°C, the coldest mineral associations of Pt-Non-commercial, impregnated, and thin bodies of massive pentlandite chalcopyrite-phyrrhotite ores are associated with taxite and picrite gabbrodolerites of the Bootankag intrusion. The Lower Fokin intrusive rocks do not indicate sulfide mineralization.

The data obtained give evidence that 1) mineral potential of the intrusion is commercially viable under special hydrogen fluid conditions (high chlorine, boron, argon, helium) which seem to be secondary; 2) non-commercial intrusions are characterized by nitrogen fluids which have probably resulted from magmatic gases cooled under equilibrium setting; 3) ore-barren intrusives show nitrogen-methane and methane composition of the fluid due to cooling of magmatic gases and their mixing with cold gases of host rocks.

We suggest a regular relation between the type of fluid regime and mechanics of foliation of basic and ultrabasic magmas. High hydrogen sustained throughout the magmatic stage of intrusion promote silicate, basic to ultrabasic, liquation in magmas. The intrusions actively manifesting this process are commercially ore-bearing. Intrusions that show predominantly reduced fluids only at the early magmatic stage did not experience silicate liquation are ore-poor.

GEOLOGY AND MINERAL POTENTIAL OF THE OCCIDENTAL LODE IN THE COMSTOCK DISTRICT, STOREY COUNTY, NEVADA NICHOLS, C.E.

The Occidental lode (also called the Brunswick) trends northward about 1.5 miles southeast of Virginia City in Storey County, Nevada. The oldest rocks exposed in the Virginia City area are Jurassic and Cretaceous intrusives and extrusives ranging in composition from gabbro to granite (Hudson, 1986, unpubl. geol. map). On this lies some Oligocene tuffs and a thick sequence of Miocene volcanics dominated by extrusives, but numerous related intrusives are recognized. Contacts are rotated westward by several east-dipping normal faults from the Comstock fault eastward to the Occidental/Brunswick fault.

Ore in the Comstock district, including the Flowery and Occidental lodes, is hosted mainly by Miocene volcanics of the Alta Formation. The sequence is regionally propylitized to various mineral assemblages related to a long history of intrusives which extend well beyond the Comstock district as a whole. (Vikre, 1989, Econ. Geol. p. 1580).

Argillic alteration, mainly of illite and kaolinite, surround silicic cores of epithermal quartz which mark the outcrop of the lodes. These crop out as bold elongate knobs stained by the weathering of pyrite. Laterally the fissure-type vein filling degenerates to silicified and argillized stockwork which is sometimes altered beyond recognition of the original host rock fabric to a soft quartz-bearing clay. Criss, <u>et al</u> (1989, USGS Circ. 1035, p.13) was impressed by the pervasive nature

Criss, et al (1989, USGS Circ. 1035, p.13) was impressed by the pervasive nature of the alteration which crosses rock types. His oxygen isotope values indicate to the author that there are at least three intensive heat centers in the Comstock district: one on the Comstock lode, one on the Flowery deposit, and one on the Occidental lode. This conclusion is supported by fluid inclusion data of Vikre (1989, Econ. Geol., p. 1591). A number of intrusive plugs and dikes correlate with the Kate Peak Formation (Bonham, 1969, NBMG Bull. 70, p. 105), suggesting several heat centers of slightly differing ages.

The epithermal veins of the Comstock district are dominated by quartz and calcite in the major east-dipping normal faults. The wall rocks are altered to clay, especially in the hanging wall, and ore may occur in both the vein filling and the clays. The host rocks are mainly Miocene andesite flows, mostly of the Alta Formation.

The Occidental lode is very similar to the Comstock lode in structure, host rock, alteration, and mineralization. Previous mining in the Occidental was from the surface down - and only in the highest grade material - indicating a potential for establishing open pit reserves similar to those which were mined along the Comstock fault since 1920. From the Flowery lode to the Comstock, the ratio of silver to gold is typically in the range of 10:1 to 40:1. The grade of most of the major underground orebodies varied from approximately 0.5 to 2.0 oz/t Au.

Initial interest of Miramar in the Occidental lode is for medium-grade near-surface ore which could be leached at its Flowery mine operation. It is believed that there is good potential for additional ore on adjacent tracts.

Extensive sampling from the 350 level of the Occidental mine to the surface indicates a grade of better than 0.10 oz/t remains in the vein over a thickness of 10 to 30 feet and a strike length of approximately 1000 feet. The silver to gold ratio is roughly 35:1 and the dip of the vein averages about 45 degrees.

HIGH GRADE GOLD DEPOSITS OF THE ALLEGHANY MINING DISTRICT, SIERRA COUNTY, CALIFORNIA WITTKOPP,R.W.

WITTKOPP,R.W. The Alleghany Gold Mining District, located approximately 40 miles northeast of Grass Valley, California has long been known for its extremely rich high grade pockets of gold within quartz veins. Mineralized quartz veins occur along steeply dipping faults. Wall rocks include metamorphosed sedimentary and volcanic rocks of the Carboniferous Calaveras Group. High grade pockets of gold occur in narrow pipe shaped masses in the veins within 80-100 feet of serpentinite bodies. Characteristics of these ores which distinguish them

Characteristics of these ores which distinguish them from most of the Mother Lode deposits include: (1) abnormally large amounts of arsenopyrite; (2) tendency for gold to concentrate locally with gold : vein guartz ratios as high as 1:5; and (3) smaller amounts of base metals. Metallic 'gold is closely associated with arsenopyrite. Other ore minerals include galena, sphalerite, boulangerite, chalcopyrite, gersdorffite and the tellurides, altaite and hessite.

The average gold content of the Alleghany quartz veins is approximately 0.04 oz/ton. The key to discovering high grade pockets is a thorough understanding of both the types of structures and alteration associated with these pockets. Carbonate alteration is especially important. In addition to the presence of serpentine, wall rock composition appears to have an important relationship to the deposition of high grade. GEOCHEMICAL DISPERSION IN LATERITIC REGOLITH ABOUT THE MT. GIBSON AU DEPOSITS, WESTERN AUSTRALIA, AND IMPLICATIONS TO EXPLORATION FOR CONCEALED MINERAL DEPOSITS

ANAD, R.R., SMITH, R.E., INNES, J., CHURCHWARD, H.K., BRABHAM, G.R. and BIRRELL, R.D.

A regolith, landform, and geochemical orientation study about Au deposits at Mt. Gibson, in the semi arid part of the Yilgarn Block, clarifies landscape evolution and geochemical dispersion in terms of the dynamics famility of formation, preservation, and dimmating of the undulating lateritic weathering mantle. The relatively complex regolith and vegetation patterns are explained in terms of the distribution of (i) sub-areas of erosion of the lateritic mantle to the level of saprolite, (ii) sub-areas of essentially-complete lateritic mantle, and (iii) sub-areas characterized by depositional accumulation of detritus provided by the dismantling of the lateritic mantle upslope, commonly burying the essentially complete laterite weathering profile in the local foot slopes and lowlands.

The regolith units were mapped over the central 3-km by 5-km area, the regolith stratigraphy established, and units of the upper regolith the regolith stratigraphy escalismed, and units of the upper legislich were characterized in field profiles persographically, mineralogically, and chemically. An idealized regolith/landform facies model has been erected for use in predictions in appropriate terrain, and for planning and integrating follow-up research. Geochemical analyses of samples of lateritic residuum, which consists

of loose lateritic nodules overlying lateritic duricrust, collected systematically from surface, and from pit walls and drill holes where the systematically from surface, and from pit walls and drill holes where the unit occurred sub-surface, document the characteristics of the lateritic Au deposits. The orientation study together with published results of exploration, shows that the lateritic Au ore and the area peripheral to it is a multi-element, chalcophile, geochemical anomaly, measuring 1 to 1.5-km across and 6-km in length, with a Au Ag Pb As Bi Sb W association. Within the lateritic residuum, coincident highs of several of these elements in centres within the overall anomaly delineate a close genetic high budget within the overall anomaly delineate a close genetic

link with bedrock sulphide mineralization, quartz-sulphide veining, hydrothermal alteration (quartz-sericite - biotite-epidote) and deformation

Exploration drilling shows that, in some of the depositional regimes at Mt. Gibson, lateritic residuum occurs beneath up to 30-m or more of Quaternary, surficial sediments. Exploration trials show that it is feasible to explore for concealed mineral deposits by drilling for geochemical haloes in buried lateritic residuum, the extent of preservation of laterite subsurface being the key ingredient. A conceptual approach is discussed.

Geochemical haloes in laterite are desirable exploration targets Geochemical naices in laterite are desirable exploration trigets because they tend to be relatively consistent and large in comparison with individual mineral deposits in bedrock. The dispersion haloes also themselves can be important resources, as at Mt. Gibson, where the geochemical anomaly accounts for over 15 tonnes of Au (production combined with reserves).

GOLD DISTRIBUTION AT THE IGARAPÉ BAHIA LATERITIC GOLD

DEPOSIT, CARAJÁS REGION, BRAZIL <u>BLISS, L.</u>, MACHESKY, M., ANDRADE, W., KATO, T. and ROSE, A. Many gold deposits in highly weathered (lateritic) systems show enrichment near the surface. This indicates that gold is somehow mobilized in lateritic environments. Low chloride and sulfur concentrations in lateritic soil solutions rule out the generally accepted mobilization mechanisms. One proposed mechanism for gold mobilization is the uptake by vegetation. If this is true, vegetation is potentially a valuable exploration tool.

We are trying to determine possible mobilization processes at the Igarapé Bahia gold deposit in the Carajás region of Brazil. We are analyzing soil, water, and vegetation samples to determine the mechanisms of gold transport. The soils in this region are highly weathered (lateritic), and contain 20 to 60% iron. The saprolite extends to a depth of around 100 m. Gold is enriched in the upper 20 meters of the profile, generally showing a peak at around 10 m. Average gold content of the soil is about 7 ppm, but peaks can contain as much as 20 ppm. The soil is also enriched in Mn, Cu, Mo and Ag. Analyses of plant material show enriched gold values in vegetation above the orebody compared with a background area.

Preliminary field work was done in August, 1990. Additional field work will be done in January, 1991 to assess differences between rainy and dry season conditions. Soil samples of 0.5 g are being subjected to a sequential extraction technique which should determine the relative mobility of the gold species. The extraction technique isolates the following fractions:

1. Easily exchanged ions,

- 2 Chelateable ions,
- 3. Organic matter,
- Amorphous iron oxides, and Crystalline iron oxides.

Samples are then further concentrated using a methyl isobutyl ketone (MIBK) extraction. Difficulty has been encountered in the last step of the extraction procedure (crystalline iron oxides) due to the extremely high iron content of the soil. Knowing with which fraction the gold is associated will enable us to assess its mobility and availability for plant uptake.

A NEW ENZYME PARTIAL LEACH ENHANCES ANOMALIES IN PEDIMENT SOILS NEAR BURIED GOLD DEPOSITS

CLARK, J.R., RUSS, G.P. A partial leach has been developed which enhances trace-element anomalies in soils formed on overburden. An enzyme reaction preferentially leaches manganese oxide coatings on mineral grains. Glucose oxidase reacts with dextrose in the leach solution to produce trace amounts of hydrogen peroxide and gluconic acid. Hydrogen peroxide reduces and dissolves manganese dioxide, releasing trace elements trapped in the coatings. Gluconic acid

complexes the metals and holds them in solution. Once the products of the glucose oxidase-dextrose reaction are no longer being consumed, the enzyme reaction stops. The hydrogen peroxide concentration probably never exceeds 40 ppm, and sufficient gluconic acid is produced to complex the metals solubilized by the process. This self-limiting characteristic of the enzyme minimizes leaching of mineral substrates and is responsible for the enhanced contrast of trace element anomalies.

Soil samples collected in the vicinity of the Sleeper and Rabbit Creek deposits were analyzed with the enzyme leach. The Sleeper samples were collected along two traverses perpendicular to the strike of the Sleeper vein; one north and one south of the deposit. The Rabbit Creek soil samples were from three traverses across the deposit. Because many of the trace elements in the leach solutions were in the part-per-trillion range, analyses were made by inductively coupled plasma/mass spectrometry (ICP/MS).

Enzyme-leach anomalies at Sleeper have contrasts ranging from 2 to 50 times background. Anomalous trace metals in the Sleeper samples fall into two groups: Ag, Cd, Co, Cu, Ni, and Pb have maximum contrasts of less than five; As, Mo, Re, Se, V, and W have maximum contrast of greater than five. The high-contrast metals correlate with enzyme-leach anomalies of Br, Cl, and I. The association of these particular metals with halogens suggests transport to the surface as volatile halides or oxyhalides, formed under highly oxidizing conditions. Such conditions could occur in association with electrochemical cells resulting from the oxidation of a metal deposit. Silver and Pb form a symmetrical "rabbit ears" anomaly along the northern traverse, suggesting metal transport by an electrochemical gradient in the overburden. Although much more irregularly distributed, Cd, Co, Cu, and Ni possibly reflect migration along electrochemical gradients. Some of these anomalous trace elements (Ag, As, Mo, and Se) are strongly enriched in the deposit. Other trace metals, which are not strongly enriched in the deposit, may be anomalous because they are more mobile.

Results for the Rabbit Creek samples are not conclusive. Some anomalous samples from this deposit have a metal-halide association similar to that found near Sleeper, possibly reflecting high oxidation potentials at the bedrock-overburden contact at that site. The metal-halide anomalies at Rabbit Creek are not regularly distributed over or around the deposit. Other anomalous samples may result from dispersion from areas of low oxidation potential, or they may result from dispersion by some nonelectrochemical process.

GEOPHYSICAL, SOIL-GAS, AND GEOCHEMICAL EVIDENCE OF A CONCERLED, MIMERALIZED FAULT NERR W- AND SD-RICH HOT SPRINGS, PUMPERNICKEL VALLEY, NEVADA <u>ERDMAN, J.A.</u>, HOOVER, D.B., MCCARTHY, J.H., Jr., FICKLIN, W.H., WATTERSON, J.R., LOVERING, T.G., and OWEN, R.W. In 1988, audio-magnetotelluric (AMT) soundings; telluric and compared washingtonets; solid cas; telluric

In 1988, audio-magnetotelluric (AMT) soundings; telluric and gamma-ray measurements; soil-gas (CO, O, and hydrocarbons) determinationz; soil, pebble-coating, and sagebrush geochemical data; and Bacillus cereus spore counts in soils were obtained along two parallel traverses across a concealed mineralized fault in the Pumpernickel Valley, Nevada. These studies attempted to locate the source of Bi, Cd, and Ag anomalies in soils, and Cd and Au anomalies in big sagebrush (Artemisia tridentata) found in an earlier geochemical survey. The anomalies are in basin-fill deposits of the Pumpernickel Valley, east of outcropping precious- and base-metal mineralization along an exposed range-front fault in the Preble Formation of Lower Cambrian to Lower Ordovician age.

an exposed range-front fault in the Preble Formation of Lower Cambrian to Lower Ordovician age. In June 1988 multifrequency telluric traverses provided evidence of a buried fault subparallel to the exposed range-front fault. Two AMT soundings at the east ends of the traverses indicate that basement rocks east of the buried fault may be 350 m below the surface. Santa Fe Pacific Mining, Inc., drilled 213 m of fill east of the concealed fault. Subsequent controlled-source AMT soundings by the company confirmed the earlier geophysical evidence of deep fill. The most significant feature of the gamma-ray data is a potassium (⁴⁰K) anomaly centered over the inferred concealed fault. Potassium haloes around base- and precious-metal deposits are well known from standard geochemical studies, and there is ample evidence that gamma-ray methods are

deposits are well known from standard geochemical studies, and there is ample evidence that gamma-ray methods are important in gold exploration. In October 1988 soil gases, soils, pebbles, and big sagebrush were sampled along the two geophysical traverses. Concentrations of O_2 , CO_2 , and the hydrocarbon gases methane (CH₂⁺) and propane (C₂H₂⁺) showed marked changes over the informate fault. The bidgeoptheraper constitute inferred fault. The hydrocarbon-gas anomalies may result from thermal maturation of organic matter by hydrothermal solutions, as suggested in a report for one of the major sediment-hosted, epithermal gold deposits in the Carlin

setiment-nosted, percentral Nevada. Spore counts of Bacillus cereus ranged from less than 10 to 60,000 counts per gram of soil, with some anomalous samples from sites above the concealed fault.

samples from sites above the concealed fault. Residue from oxalic-acid leachate of surface pebbles showed the same metal anomalies found in the coarse fraction of the soils--in particular As, Sb, W, and Bi--but at much higher concentrations. Maximum Au concentrations of 150 ppb in soils and 33 ppb in sagebrush ash occur at sites on the exposed range-front fault; much lower Au anomalies were found in soil and sagebrush samples over the commalied family. Soil and sagebrush ash core the sites concealed fault. Soil Hg anomalies occur only at sites

near the range-front fault. Cadmium in soil and sagebrush appears to best delineate the concealed fault. We believe that a fault within the valley fill may be the conduit through which these metals and gases migrated to the surface.

surface. Condensate from a geothermal well and water from hot springs in valley fill, 300 m south of the nearest traverse, contained 15 μ g/L Sb and approximately 200 μ g/L W. These concentrations are very high compared to other hot springs sampled in the western United States. The association of Sb, W, As, and Hg with Au, Bi, and some of the base metals suggests a gold-skarn system, similar to skarn systems found along the Eureka-Battle

similar to skarn systems found along the Eureka-Battle Mountain mineral belt to the southeast.

GROUNDWATER - AN EFFECTIVE GEOCHEMICAL EXPLORATION SAMPLE FOR AUSTRALIAN GOLD DEPOSITS.

GIBLIN.A.M., MAZZUCCHELLI,R.H.

In large areas of inland Australia, concealment of bedrock by transported overburden inhibits the application of geochemical exploration techniques based on the analysis of surface sample media. In such areas, groundwaters that traverse the target are an active, present-day dispersing agent of all formations in their path, and as such constitute an effective geochemical sample medium that permits initial exploration in zones hitherto inaccessible to more conventional geological and geochemical techniques.

The advantages of groundwaters as geochemical sample media derive from their chemical reactivity with crustal rocks and soils, coupled with their physical mobility. This applies particularly in the subdued topography of the Yilgarn Block of Western Australia where the relicts of deep lateritic weathering profiles present large volumes of oxidised rock material to reactive groundwaters. Advantages also attach to water as an exploration sample that integrates the geochemistry of a larger volume of the upper crust than do single samples of rock or soil.

An example of the exploration value of groundwater geochemistry comes from a gold exploration program using groundwater geochemistry in the Grant's Patch and Bardoc areas, 50km NW of Kalgoorlie. The techniques used have been developed in a continuing CSIRO, Division of Exploration Geoscience project and apply the complete geochemistry of the water, not merely variations in the concentration of one particular target element. Principal groundwater geochemical properties that were applied were pH and redox potential, major ion composition and the trace element content.

Procedures for data interpretation included statistical analysis of chemical data and comparison of measured trace element concentrations with their thermodynamically calculated concentrations in model Australian groundwaters equilibrated with common ore minerals. In addition, the important relationship between the major ion composition of groundwater and aquifer minerals was investigated using major ion composition plots, normalised major ions, equilibrium with chemical precipitates such as carbonates, sulphates and carbonates, and products of groundwater alteration of silicate minerals.

Using these procedures, groundwater data from the Grant's Patch and Bardoc areas allowed sample sites to be sorted into three groups: those outside the influence of greenstones, the common host rock for Au mineralization in the Yilgarn Block; those in contact with greenstone ; and those that have contacted zones of Au enrichment,

For example, groundwaters from greenstone aquifers were characterised by detectable concentrations of trace elements such as Ni. Co and Cr, by higher concentrations of Mg relative to other major cations and by saturation of the groundwater with dolomite or magnesite rather than calcite, the common carbonate in non-matic aquiters.

Sample sites in zones of Au enrichment stand out because detectable concentrations of Au in groundwaters are unequivocal exploration indicators, as the baseline concentration of Au in barren zones is less than the analytical detection limit of 1 ng/l. Similarly, As, a well established geochemical pathfinder for Au in many environments, occurs in Yilgarn groundwaters at a background concentration of less than 0.5 ug/l. Groundwater As concentrations that are significantly higher are clearly indicative of flow paths that are locally enriched in As, and may thus signify proximity to gold mineralization.

APPLICATION OF GAS ANALYSIS OF JASPEROID INCLUSION FLUID TO

EXPLORATION FOR MICRON-GOLD DEPOSITS <u>GRANEY,J.R.</u>, KESLER,S.E., and JONES,H.D Quadrupole mass spectrometric analyses of inclusion fluid in jasperoid from the Carlin and Standard sediment-hosted jasperoid from the Carlin and Standard sediment-hosted micron-gold deposits were used to evaluate the importance of H₂S, CO₂ and other gases in the localization and formation of these deposits. Results indicate higher H₂S/CO₂ ratios and stronger H₂O-CO₂-N₂ correlations within mineralized jasperoids in both study areas. For each analysis, approximately 10 mg of -18 to +60 mesh jasperoid grains were crushed under vacuum. Released gases passed directly into an enclosed quadrupole source using path length and conduit diameter designed to minimize surface gas adsorption. By monitoring sixteen user-specified

path length and conduit diameter designed to minimize surface gas adsorption. By monitoring sixteen user-specified masses, simultaneous analysis of H₂O, CO₂, CO, CH₄, C₂H₆, C₃H₈, H₂, N₂, Ar, H₂S, and SO₂ was obtained. Jasperoid sampled included mineralized and barren Roberts Mountains Fm. and barren Vinnini Fm. from the Carlin mine area, as well as mineralized Prida Fm. and barren Natchez Pass Fm. from the Standard mine area. The gas analyses suggest that jasperoids from mineralized areas have higher H₂S/CO₂ ratios and more linear correlations between H₂O-CO₂ and H₂O-N₂ than do jasperoids from barren areas. Mole \aleph N₂ and Ar from both areas are similar with N₂/Ar ratios near that of air-saturated meteoric water, supporting the possible predominance of evolved meteoric water in these

fossil hydrothermal systems. In both study areas, primary chemical variation in potential ore hosts may exert some control on inclusion fluid composition. This is particularly true for the Standard data where all of the samples with high mole % H₂S and low CO₂(ave. value of 0.03 and 0.5 mole % respectively) are in ore-hosting Prida Fm., whereas the barren Natchez Pass Fm. contains higher mole % N₂ and CH₄. However, since a much wider range of H₂S and CO₂(0.005-0.025 and 0.2-1.5 mole % respectively) are seen in Roberts Mountains Fm. jasperoid at Carlin, host rock effects may be overridden in areas with high water/rock ratios. Since ore is mainly hosted by jasperoid at Standard, whereas jasperoid is not the major ore host at Carlin, caution must be used when comparisons are made between deposits with dissimilar when comparisons are made between deposits with dissimilar characteristics.

characteristics. Speciation and reaction progress calculations, using our gas analyses, show that fluids with high H_2S/CO_2 ratios(0.035 mole % H_2S and 0.50 mole % CO_2), such as those associated with mineralization in these deposits, may dissolve and deposit more gold than fluids with lower H_2S/CO_2 ratios(0.0029 mole % H_2S and 2.016 mole % CO_2), such as those in barren jasperoid. Calculations suggest that boiling would be a more efficient depositional mechanism than cooling and/or mixing with groundwater. High mole % N_2 , CO_2 , and CH_4 were found in several jasperoids, suggesting jasperoid may contain gas-rich fluid inclusions produced by a boiling/immiscibility process. These results suggest jasperoids associated with

These results suggest jasperoids associated with mineralization have high H_2S/CO_2 ratios, which reflect a strong gold-carrying capacity for the fluid; and $H_2O-CO_2-N_2$ contents indicative of boiling/immiscibility processes related to gold deposition. The $H_2S-CO_2-N_2$ relations are better defined at the jasperoid-dominant Standard deposit, perhaps reflecting mineralization in a smaller, less complex hydrothermal system than that which formed the Carlin deposit.

PEDIMENT EXPLORATION GEOCHEMISTRY: APPLICATION OF SOIL GRIDS

PEDIMENT EXPLORATION GEOCHEMISTRY: APPLICATION OF SOIL GRIDS HENDERSON, W.B., ROGERS, M.D.G. AND B.R. PUTNAM III Pediment exploration provides some of the remaining frontier area in the southwestern US for the discovery of new gold and mineral resources. Ore deposits lying in pediment areas are covered by both un-mineralized bedrock and overlying post-mineral, transported overburden. The transported overburden has presented limitations to surface sampling as it does not reflect local area bedrock compositions. To-date, only the application of geophysical techniques has advantaged pediment exploration. Recent advances in geochemistry and analytical techniques utilizing the Graphite Furnace - Atomic Absorption Spectro-photometer (GF-AA) and the ICP-Emission Spectrometer (ICP-ES) have allowed the lowering of stable detection limits to the ppt range for gold (GF-AA), and the iOP photometer (ICP-ES) have allow for analysis of low-level elemental concentrations not previously detectable in a cost-conscious procedure. Research indicates pediment solis contain minute concentrations of elements mobilized in groundwater and precipitated in the very near surface environment by redox reactions. These "mobile" metals are concentrated in the Fe- and Mn-Oxides, which act as sinks or metal traps. These very minute constituents by application of a selective, partial leach extraction technique. The application of a procedure modified from that published by Vists, et al (1984) using an ascortic acid - potassum iodide solution (the "AX" leach) allows the selective extraction of the mobile metals (signal), while deliberately not extraction of the detection of those elements introduced into the mear surface soils, which can reflect concentrations of mineralized material at depth. Results indicate the AX procedure achieves significant signal-to-noise ratios, with geochemical anomalies beiow 5 ppb

mineralized material at depth. Results indicate the AX procedure achieves significant signal-to-noise ratios, with geochemical anomalies below 5 ppb for Au, with a stable background well below 1 ppb. The resolution of these very low-level anomalies allows for the deciphering of meaningful geochemical signals in pediment areas where classical geochemical techniques cannot be utilized. Soil grid applications of the AX technique allows for the surface detection of geochemical nomalies positioned over structures cutting mineralized rock at depth. The results yield drill targets in areas otherwise left to blind drilling. Results to-date from a number of soil studies conducted along the Carlin trend, NV suggest that mineralization "blinded" by up to 1,100-ft of cover can be detected by this technique.

ENVIRONMENTAL CONDITIONS AFFECTING CONCENTRATIONS OF He AND CO2 IN SOIL GASES HINKLE, M.E.

The measurement of concentrations of volatile species in soil gases has potential use in geochemical exploration for concealed ore deposits. However, the interpretation of anomalies in surficial gases is not always straightforward. Soil-gas concentrations are dependent on both meteorological and environmental conditions.

Concentrations of He, CO_2 , O_2 , and N, and meteorological conditions were monitored for 10-14 months at seven conditions were monitored for 10-14 months at seven nonmineralized sites in both humid and dry environments: humid sites at Reston, Virginia, and at the summit of Kilauea volcano, Hawaii; two semi-arid sites near Denver, Colorado; and three arid sites in southwestern Utah. Most of the soil gases were extracted by a hollow probe from the interstitial pore spaces of soil at about 0.6 m depth; at one of the Denver sites gases were collected at depths of 2.0 1.2 0.6 and 0.3 m. Pain and growfall soil and air 2.0, 1.2, 0.6 and 0.3 m. Rain and snowfall, soil and air temperatures, barometric pressure, and relative humidity were monitored at all the sites. The sand, silt, and clay

content, and the organic carbon content of surficial soil were measured at each site.

Meteorological conditions affected He and CO₂ concentrations in the same way in all environments. However, these effects were modified by local environmental conditions.

Rain and snowfall had the greatest effect on concentrations of He and CO_2 at all the sites. Small concentrations of He and CO₂ at all the sites. Small amounts of rain and snow increased soil-gas concentrations by forming an impermeable barrier at the ground surface and trapping gases rising from below. Large amounts of rain and melted snow decrease concentrations by dissolving or displacing soil gases.

Soil and air temperatures affected both He and CO2 concentrations. He concentrations generally decreased as temperatures increased, supporting field observations that temperatures increased, supporting field observations that He concentrations are slightly lower on warm afternoons than on cool mornings. Subtle conditions such as the amount of sun or shade at a site may modify the effect of temperature on He concentrations.

Carbon dioxide concentrations were more affected by Carbon dioxide concentrations were more affected by temperature than were He concentrations. Carbon dioxide concentrations were always higher in the summer than in the winter, and were lowest when air temperatures were below freezing and when the ground was frozen. Concentrations rose rapidly when soil temperatures were above 10°C, suggesting that most soil-gas CO₂ probably originated from bacterial activity in the soil. Concentrations also bacterial activity in the soil. increased with depth.

The effects of barometric pressure on He and CO_2 concentrations were hard to decipher. At some sites below average He and CO_2 concentrations coincided with low barometric pressure, whereas concentrations ranged from very low to very high when barometric pressure was high. At other sites. He and CO_2 appeared unrelated to barometric At other sites, He and CO_2 appeared unrelated to barometric pressure changes.

The effects of relative humidity were also puzzling. various sites at various times, the relative humidity and He and CO₂ concentrations were directly related, inversely related, or completely unreleated. Because increased relative humidity often coincides with rainfall, gas

relative numinity often coincides with rainfall, gas concentration changes were probably due more to the amount of rainfall than to relative humidity. Soil-gas concentrations were affected by local conditions of soil type and organic content. Soil type affects the amount of pore space and moisture present in affects the amount of pore space and moisture present in the soil and therefore the soil-gas concentrations. Mean CO₂ concentrations at the sites were inversely related to the quantity of sand present. Organic matter affects soil-gas concentrations by modifying soil texture to increase permeability, thus permitting freer passage of gases through the soil. Sites where soil organic content was high had slightly lower oxygen concentrations than the sites with low organic content probably reflecting sites with low organic content, probably reflecting oxidation of the organic matter.

Understanding the effects of all the factors that affect soil-gas concentrations is important to planning soil-gas surveys. Because of their strong influence, environmental conditions should be monitored to properly interpret soilgas anomalies.

POTENTIAL FOR THE DETECTION OF VOLATILE ARSENIC OVER GOLD DEPOSITS WITHOUT SURFACE EXPRESSION KLUSMAN.R.W.

KLUSMAN,R.W. Arsenic is frequently associated with disseminated Au deposits as well as other types of ore bodies. The exploration for these deposits beneath alluvial or other cover, will present a challenge if the future rates of discovery are to keep pace with present rates of mining. The use of volatile species offers promise for use in future exploration programs. One of the elements which has considerable potential for use is As. The volatilization of As by bacteria and fungi in various forms has been responsible for cases of poisoning in the early 1900's. Arsenic has a relatively complex microbial geochemistry with microorganisms capable of both oxidizing reduced forms of As, and others capable of reducing oxidized forms. Enrich (1990) discusses the interactions of microbes with As in some detail. The microbial volatilization of As in an ore body has not been demonstrated, although the geochemistry suggests the reaction of most promise for application in exploration will occur at the interface between oxidizing and reduced ores. In this zone, the reduction of dissolved arganic carbon in groundwater toward the surface in the overlying oxidized materials. Several kilograms of minus 1/4 inch samples of As-containing oxidized and reduced ores were buried at depths of 4 meters in a ciay soli in a semi-and climate. The ores were wet with

toward the surface in the overlying oxidized materials. Several kilograms of minus 1/4 inch samples of As-containing oxidized and reduced ores were buried at depths of 4 meters in a clay soil in a semi-arid climate. The ores were wet with a liter of potato starch slurry inoculated with substrate from an anaerobic constructed wetland receiving acid minu drainage from an ore containing As. The drill holes were compacted as they were backfilled with clay. A proprietary collector was placed under an 8 inch diameter cone buried just below the surface above the ore and three collectors at horizontal distances of one meter from the surface locus of the buried ore. The collector is integrative and contains 30% hydrogen peroxide-soaked glass wool. The hydrogen peroxide adsorbs and oxidizes any volatile compounds, converting them to a stable oxidized form in solution. In the case of As, the stable idor in solution is arsenate ion. The arsenate ion is reduced to arsine gas and analyzed in the laboratory by quartz turnace atomic absorption. The experiments with ores buried in the clays initially produced no detectable As signal during a winter integrative period. The following spring a signal ranging from 50-180 nanograms of total As was collected over the reduced ores, while all but one of the oxidized ores produced total As signals of <50 nanograms. Laboratory control experiments under oxidizing conditions all produced total As signals of <50 nanograms. Three proprietary lide experiments have been done with the experimental collector. The first of these tailed due to technical reasons and initial inadequate analytical sensitivity for As. The second and third experiments stowed promising signs of being able to detect buried ore in a Au-Ag vein deposit and over a disseminated Au deposit. The collector did not detect volatile reduced As being produced in high As soils at the surface, suggesting that oxidized As in soils will not produce a signal.

GEOLOGIC SETTING AND LITHOGEOCHEMICAL CHARACTERIZATION OF GEOLOGIC SETTING AND LITHOGEOCHEMICAL CHARCELERIZATION OF TWO DISPARATE PRECIOUS METAL PROSPECTS, WESTERN TURKEY <u>LARSON, L. T.</u> and ERLER, Y. A. Kursunlu, some 5 km SW of the city of Salihli, and Orencik, about 10 km E of the town of Dagardi are but two of severa

several about 10 km E of the town of Dagardi are but two of several small antimony or mercury districts in western Turkey which exploration since 1987 has shown to be strongly anomalous with respect to precious metals. The deposits offer a broad-ly similar trace element lithogeochemical signature but occur in very distinctively different geological environ-ments. They offer, therefore, an opportunity to evaluate the efficacy of rock chip sampling as applied to differing geologic terrains. Orencik is in a melange terrain characterized by serpen-tinized ultramatics and gravwackes which have been thrust

tinized ultramafics and graywackes which have been thrust over Neogene fine-grained micritic limestones. Stibnite-

Orencik is in a melange terrain characterized by serpen-tinized ultramafics and graywackes which have been thrust over Neogene fine-grained micritic limestones. Stibnite-pyrite and gold metallization appears to be concentrated within silicified zones (jasperoids) and/or listwaenites as disseminations, pods and stockworks over thicknesses of a few meters along and immediately adjacent to an undulating very flat thrust fault--often where cut by high angle faults. The lithogeochemical signature of rocks which mega-scopically have been silicified or mineralized includes elevated Au (many assays in the 1 to 5 g/t range), Ag (often 2 to 9 g/t), As in the 200 to 1000 ppm range and Sb values from 100 to more than 10,000 ppm. Hg is low --usually less than 0.1 ppm. Tl and Se are usually less than 0.5 ppm but with occasional values up to 10 ppm with a unique Tl high of 85 ppm. Au/Ag correlation is good , and correlation of Au/Sb and Ag/Se at higher values is mediocre. Other direct elemental comparisons show a great deal of scatter. The Kursunlu prospect is a present day and a paleo hot spring occurrence located along the WNW-striking extensional graben fault between the schistose 'cover' rocks of the Mendares augen gneiss and schist massif and the Neogene age Gediz graben. Gold/silver are associated with stibnite, pyrite, arsenopyrite, marcasite, +/- cinnabar in silicified marble, chalcedonic stockwork veinlets and sinter, and breccia/microbreccia of unknown protolith in both hanging wall and footwall of a low angle (11-14^O, N-dipping) detach-ment-like fault near its intersection with the high angle basin-bounding structure. Rock chip samples provide a geo-chemical characterization with Au/Ag assays up to 8 and 35 g/t, respectively, As ranging from 100-4000 ppm , and Sb up to 9000+ppm. Mercury is very erratic and spotty but ranges from 0.1 to 72 ppm while Se, also spotty in distribution, is locally elevated to between 2 and 60 ppm. Selenium shows fair correlation with Au and good correlation buth Ag. Most Tl assay

GEOCHEMICAL EXPLORATION MARKS OF BLIND ORE BODIES IN GOLD MINING DIJTRICTS LI.Hui

The author summarized the marks of applied geochemical methods for blind ore bodies exploration in a series of typical gold mining districts in China through geochemical

pical gold mining districts in China through geochemical study of some typical gold deposits during the last decade. In this paper the research results of indicator elema-nt zoning order in some China's typical gold deposits are presented. An ideal zoning order of indicator element of China's hydrothermal vein type gold deposits is derived from an integrated comparison, i. e., from top to bottom : Hg_-Sb, F, (B,I)-As, Pb-Zn, Ag-Au,Cu-Mo, Bi, Mn, Co and Ni. The calculations of the zoning orders of the typical gold deposits are shown that there is no any retypical gold deposits are shown that there is no any raverse zoning order in all cases. Vertical variation regulations of the element assemb-

lage, ratios of the elements in pyrite and enclosure com-ponents are all very distinct at different elevations in typical gold deposits. There are both common features and particular ones for these vertical regulations in diffe-rent type gold deposits.From this, the geochemical marks for deep exploration are summarized at some gold mining districts in Guangxi and inner Mongolia Regions, Hebei and

Shandong Province. The study of primery halos in some typical gold deposits in China indicated that the primary halos of hydrother-mal gold deposits were well developed, in particular the front halos could extend several hundred meters away along front halos could extend several hundred meters away along with structures. The primary halos of gold deposits exhi-bit very distinct vertical zonation. Based on this, the geochemical anomaly evaluation marks looking for blind gold ores are obtained : Hg, Sb, B, As, and I are charac-teristic elements to the front halos of gold deposits. When the concentrations of Au and Ag in the anomaly are low, while higher anomalies of Hg, Sb, B and As occur, it means that there may be blind ores in the deep. If the concentrations of Au and Sb are quite low or no anomalies of them, but strong anomalies of Mo, Bi and Mn cocur, it means the tail halos of the orebody. Encouraging results have been obtained for the appli-cation of the above mentioned marks searching for more go-

cation of the above mentioned marks searching for more go-ld in the deep in typical gold mining districts in China.

HYDROGEOLOGY AND GROUND WATER MULTI-PARAMETRIC HYDROGEOCHEMICAL ANALYSIS: AN EFFECTIVE METHODOLOGY TO DETECT BURIED MINERAL DEPOSITS AND ESTABLISH BASELINE WATER QUALITY CHARACTERISTICS

LLURIA, M.R.

Mineral deposits contained within aquifer systems impact the chemical and physico-chemical characteristics of the ground water enclosing the rock mass hosting the ore. The specificity and intensity of the effect of the mineralization on the ground water chemistry is a function conditions prevailing in the aquifer system, the local hydraulics and the mineralogical and structural conditions of the rock units encompassing the mineralization. The detection, definition and interpretation of anomalous hydrogeochemical responses, after an effective screening of ambiental responses not related to the mineralization, constitutes a powerful exploration tool for concealed

constitutes a powerful exploration tool for concealed deposits. The technique can be also employed to assist in establishing the ground water quality baseline characteristics required to prepare an Environmental Impact Statement (EIS) for the mining operation. The hydrogeochemical technique developed is applicable to detection and definition of base metals, gold and coal deposits. Both the ground water sampling technique, and the suite of chemical and physico-chemical parameters to be determined differ not only with the chemistry of the ore, but with genetical type. An example of the latter is the difference in the hydrogeochemical response patterns of Mississippi Valley type zinc deposits and those of Volcanogenic Massive Sulphide zinc deposits. Ground water samples are collected from irrigation wells, domestic wells, industrial supply wells and springs.

wells, domestic wells, industrial supply wells and springs. wells, domestic wells, industrial supply wells and springs. Wellhead determinations are: pH, water temperature, oxidation-reduction potential (ORP), dissolved oxygen (DO), electrical conductivity (EC) and alkalinity. Based on the ore target and on local hydrogeologic conditions, other on-site analysis could be carried out. Filtered and un-filtered samples collected at the wellhead are sent to the laboratory after application of appropriate preservative measures: acidification, refrigeration or nitrogen blanketing. Inorganic analysis for major and trace level ground water dissolved chemical components determines their

ground water dissolved chemical components determines their presence and level of concentration. Organic chemical determinations are performed when applicable. Statistical and graphical processing of the data is carried out using various computer software packages capable of multiple correlation, factor and cluster analyses as well as analysis of normal and log-normal umulative plots of the chemical information Cumulative plots of the chemical information. Definition of mineralization targets is done using

Definition of mineralization targets is done using multi-parametric pattern analysis of the ground water chemical data. Screening of non-significant responses is done by hydrogeologic analysis. A typical response pattern for a volcanogenic massive copper-zinc sulphide deposit shows anomalous concentrations of copper, zinc, lead and iron in the ground water. Sulphide concentration, ORP and EC form positive peaks overlying the mineralization while the pH show low values. The hydraulic conductivity and the physico-chemical conditions prevailing in the aquifer control the volumetric extent and geometry of the plume. Advection and dispersivity contribute to the elongate shape of the individual chemical anomalies along the piezometric gradient, and molecular diffusion promotes their lateral spreading.

SOIL GAS SIGNATURES OVER PRECIOUS METAL DEPOSITS IN NEVADA <u>McCARTHY J.H.</u>, JR., DIETRICH, J.A. Soil gas studies were conducted over three sediment-hosted gold deposits along the Carlin Trend; the Betze, Rain, and Gnome deposits. All studies were done after drilling delineated the ore deposit but prior to stripping. Soil gases were sampled along linear traverses that extended across and beyond the limits of the ore deposits. Gases were sampled by driving a steel probe into the ground 0.75m and analyzed at the site, using a truck-mounted mass spectrometer. Anomalous concentrations of low molecular weight hydrocarbons-methane and propane best correlated with the mineralized zones. Positive CO₂ and negative 0₂ anomalies were found over the oxide ore at the Betze/Post deposit. Ammonia (NN^{*}₃) also correlated reasonably well with mineralized zones at the Rain and Gnome deposits. Hydrocarbons down the oxidized ore. Gas anomalies were low, commonly 2-3 times background and were not always repeatable. Despite this the results suggest that soil gas surveys may be useful in exploration for concealed mineral deposits. SOIL GAS SIGNATURES OVER PRECIOUS METAL DEPOSITS IN NEVADA

GEOLOGY AND EXPLORATION GEOCHEMISTRY OF MIOCENE VOLCANIC ROCKS AT THE SLEEPER GOLD-SILVER MINE, HUMBOLDT COUNTY, NEVADA <u>NASH, J. T.</u> and BARTLETT, M. W. The Sleeper gold-silver deposit is in a local Miocene volcanic field 40 km south of

the coeval McDermit calders complex. New information from mine exposures and drill cores clarify the geology of the covered and variably eroded Miocene section that is from 0 to >500 m thick at the mine. This section, unconformably overlying Mesozoic basement, consists of (1) 20-170 m of volcaniclastic lacustrine and fluvial sedimentary rocks; (2) 50-220 m of vesicular andesitic flow rocks; (3) 50 m of massive basalt and 0-40 m of lapilli tuff; and (4) 0-310 m of rhyolite porphyry flows. Quaternary fluvial and lacustrine alluvium 0 to >80 m thick disconformably overlies the Miocene volcanic rocks. The rhyolite porphyry, host for >90 percent of known ore in bonanza veins, stockwork fractures, and hydrothermal breccias, generally is of uniform composition but contains local zones of vesicular texture,

flow preccia, and variable phenocryst proportions. Where visible, flow banding dips at low angles and is parallel with layering. Peralkaline 15.6- and 16.1-Ma ashflow tuffs of the McDermitt volcanic field, more than 80 m thick 3 km northeast of the mine, were not found in the mine section and are deduced to be younger than the rhyolite porphyry. Concentrations of Ca, Cr, K, Nb, Ni, P, Sc, Th, Ti, V, Y, and Zr can be used to distinguish all but extremely altered rock units.

Exploration guides to the bonanza gold veins are more subtle than for the Exploration guides to the bonarize guid vens are individual of the first of the hybrid source of the rhyolite flow, having glassy groundmass, massive fabric and > 300 m thickness, clearly was important for open fractures, but alteration and geochemical criteria are less diagnostic. The rhyolite is devirtified and silicified in large areas peripheral to the deposit, but glassy groundmass persists in local zones to within 250 m of the western side of the orebody. Geochemical and mineralogical zonation in the deposit area is subtle, however, and provides few clues to the location of bonanza veins. Wide depletion halos of Ca. Na, Ba, and Sr in rhyolite would not be diagnostic in exploration. Rocks underlying the rhyolite are pervasively altered to clay-pyrite-carbonate mixtures that may be zoned outward from ore, but relations to ore stages are not defined. Locally intense acid-sulfate alteration zones formed after the ore. Pyritic veinlets and breccias having high Ag/Au ratios and anomalous As, Mo, and Se are present hundreds of meters from veins and comprise low-grade ore, but would not be a definitive indicator of the bocears using any interpretation present. definitive indicator of the bonanza vein environment in exploration. Visually identified banded opaline veinlets, located within 200 m of major veins, accompanied by narrow spikes high in Au and Au/Ag but low in base metal concentrations, are most diagnostic of nearby bonanza gold veins.

GAS ANALYSIS AS A GUIDE TO CENTERS OF HYDROTHERMAL MINERALIZATION

<u>NORMAN.D.I</u>. and RUFF,R.K. Boiling of hydrothermal fluids is a mechanism commonly associated with deposition of ore minerals. Boiling strips the fluids of relatively insoluble gases such as CO_2 , He, and N₂, and the gas phase will separate from the fluid and migrate to the surface. This gas plume may leave the only geochemical signature in rock well above the ore deposit in cases where hydrothermal fluids did not penetrate

the surface or were dispersed by ground waters. Evidence of a gas plume may be looked for in fluid inclusions and phyllosilicate minerals. Whole rock gas analysis utilizing a quadru-pole mass spectrometer has been performed on samples from the Copper Flat porphyry-Cu deposit, NM, and the Steeple Rock district, NM. At the Copper Flat deposit, thermal desorption of gases from alterationphyllosilicate minerals gave anomalous values that clearly outlined the blind ore body. The Steeple Rock district contains base-metal and precious-metal epithermal vein deposits with widespread alteration. Decrepitation and crushing of fluid inclusions from vein and jasper-oid samples release volatiles for gas analysis. Preliminary results suggest that gas anomalies are present. The Steeple Rock district is presently undergoing exploration and the relations of gas anomalies to ore remain to be proven by exploration drilling.

SUSPENDED SEDIMENT GEOCHEMISTRY IN EXPLORATION FOR FOLMMETALLIC SULFIDE DEPOSITS (Au, Zn, Cu, Pb) IN FELSIC METAVOLCANIC ROCKS, EASTERN FIELMONT, GEORGIA, U.S.A. <u>SIBCEL, F.R.</u> and ROACH, N.M. Suspended sediment was used successfully as a geochemical prospecting medium in the drainage near the Magruder mines, Lincoln County, Georgia. The mine area was opened as a gold producer sometime prior to 1850 and was mined irregularly until 1938 for Au, Cu, Zn, Pb and Ag from five distinct mineralized zones in felsic metavolcanic rocks. This mineralization is comprised quartz-hosted native Au and the primary mineralization is comprised quartz-hosted native Au and the principal gancue mineralization is comprised quartz-nosced matter an the principal gaugue minerals chalcopyrite, sphalerite, galena and pyrite. Frincipal gaugue minerals are quartz, sericite and chlorite but galmite and berrite are common (Carpenter et al., 1975). Twenty-four suspended sediment samples were collected in the field from about 1.7 km upstream to about 4.2 km downstream from the mineralization using a hand-operated vacuumfiltering system

filtering system. The suspended sediment was analysed for 35 chemical elements using DNA and AAS techniques. Table 1 gives the basic statistics for some of the elements evaluated. Of these, Au, Cu, Zn (Figure 1), and Ba are strong indicators of the mineralization but Bb and Yb also contribute to the multielement anomaly system. The downstream dispersion of the elements from the mineralization is Au < Fb = Ba < Cu = Yb < Zn. The strongest Au value (1290 ppb) in the samples is located at the first sample site downstream dispersion of strong concentrations of an indicator element (Zn, to 2300 ppm) extends to about 800 m from the mine area. Suspended mineral matter was shown to be an effective sampling medium in the openhemical ecoloration for cationate-bosted stratiform

Suspensed mineral matter was shown to be an effective sampling medium in the geochemical exploration for carbonate-hosted stratiform Zn-Pb mineralization (Siegel, 1990). On the basis of the results reported here, suspended sediment may be equally effective in geochemical exploration for Au-bearing polymetallic sulfide ones in felsic metavolcanic rocks in geomorphological and climatological regimes similar to that at the Magruder mines.

Element	x	6	Range
Auppob	409	306	51-1290
Znppn	1121	632	350-2300
Cu ppm	406	251	121- 958
Poppon	129	87	24- 370
Bappon	1000	797	300-3500
Yb ppm	3.8	0.6	2.7- 5.1
Fe 🖁	13.8	4.1	8.5-23.8

Table 1. Basic statistics

Figure 1. Downstream dispersions of suspensate indicator elements, the Magruder mines area, Georgia.



ELEMENT DISPERSION IN ALLUVIUM COVERING GOLD DEPOSITS EAST OF THE OSGOOD

ELEMENT DISPERSION IN ALLUVIUM COVERING GOLD DEPOSITS EASI OF THE OSCOOD MOUNTAINS, GETCHELL TREND, HUMBOLDT COUNTY, NEVADA <u>SMITH, S.M.</u>, DETRA, D.E., THEOBALD, P.K., and THEODORAKOS, P.M. U.S. Geological Survey, DFC, Box 25046, MS 973, Denver, CO 80225 Analyses of overburden drill cuttings from the vicinity of the Chimmey Creek, Rabbit Creek, and Pinson gold deposits reveal an apparent paleo-dispersion anomaly buried within the overburden section. These three sediment-hosted deposits are covered by 0-185 m of basin-fill alluvium in sediment-hosted deposits are covered by 0-10-2 m or Dasin-111 alloving in the valley east of the Osgood Mountains, in the Getchell gold trend of north-central Nevada. Exploration drilling and the development of these deposits has provided a unique opportunity to define three-dimensional element-dispersion patterns in the allovium over and away from the ore bodies and to study the geochemical and physical processes that produced these patterns.

these patterns. In this multidisciplinary study, reverse-circulation rotary drill cuttings of alluvium were obtained from 57 vertical exploration and development holes drilled by Gold Fields Mining Corporation, Santa Fe Pacific Mining, Inc., FirstMiss Gold, Inc., and Pinson Mining Company within a $67 \cdot km^2$ study area along the east side of the Osgood Mountains. Cuttings generally were sampled at 6-m intervals within the alluvial sequence, were sieved to obtain the fraction from -20 to +100 mesh, and then were ground to -100 mesh for analysis. Direct-current-arc atomic-emission spectrography was used to produce both total analyses and oxalic. then were ground to -100 mesh for analysis. Direct-current are atomic-emission spectrography was used to produce both total analyses and oxalic-acid partial-leach analyses for 35 elements. Gold and thallium analyses were performed by graphite furnace and flame atomic absorption spectrome-try, respectively. Results of these analyses show a distinct vertical and lateral distribution of elements and element suites within the alluvium of the study area. Both total and partial analyses detected anomalous element the study area. Both total and partial analyses detected anomalous element concentrations; however, these anomalous values were significantly enhanced in results from the partial analyses. This enhancement suggests that the metals may be concentrated in clast coatings. Vertical variations in the concentrations of major and minor elements may result from (1) lithologic variation within the alluvial sequence, (2) diagenetic alteration of the alluvium, and/or (3) water-rock reactions within the alluvium. For the most part, gold and base metals occur in low concentrations and do not demonstrate any systematic distribution with depth. Of the trace elements most part, gold and base metals occur in low concentrations and do not demonstrate any systematic distribution with depth. Of the trace elements determined, As, Ge, Sb, and W show the greatest vertical and lateral con-trasts in concentration and help delineate a depression-filling blanket near the base of the alluvium. A three-dimensional model of the data for this suite shows that the blanket has a fairly flat upper surface and a lower surface that conforms to the irregular surface topography of the bedrock. The blanket is apparently offset by normal faults within the alluvium and shows no spatial relationship to the present-day water table. These observations suggest that the As, Ge, Sb, and W suite may be a fossil geochemical anomaly that is largely unrelated to currently active element-dispersion processes in the basin. This blanket could have been created by (1) deposition of mineralized or metal-enriched clastic detricts derived from the Osgood Mountains to the west. (2) lateral and vertical percolation of fluids from a low-temperature hydrothermal system through the alluvium, or (3) migration down gradient along the bedrock-alluvium interface of a plume of ground water slightly enriched in trace elements. plume of ground water slightly enriched in trace elements.

SOIL GEOCHEMICAL RESPONSE TO GOLD MINERALIZATION AT MT. HAMILTON, WHITE PINE COUNTY, NEVADA <u>WAREFIELD, T.W., JAACKS, J.A., CLOSS, L.G.</u> Mineralization at Mt. Hamilton is comprised of complex overlapping precious metal epithermal and skarn systems. Outcrop is sparse over most of the property, and so a two-phased soil orientation survey was conducted to establish effective surficial geochemical exploration procedures. A total of one hundred and fifty-six soil samples were col-lected along three traverses and analyzed for Au, Ag, As, Sb, Hg, Mo, Cu, Pb, Zn, Fe, and Mn. In Phase 1, forty-six soil samples were collected along a traverse aligned perpendicular to subcropping precious metal epithermal mineralization to determine optimum sam-pling and analytical procedures. Four soil size fractions were evaluated: -30 to +80 mesh, -80 mesh, -80 to +200 mesh, and -200 mesh. Gold, As, Ag, Zn, Sb, and Pb were 'selected as the principal indicator elements for precious metal epi-thermal mineralization based on their response to the tar-geted subcropping precious metal epithermal mineralization. The -80+200 mesh fraction was found to provide optimum anomaly to background contrast. In Phase two one budged and ten soil samples were anomaly to background contrast.

In Phase two, one hundred and ten soil samples were collected along two additional traverses, designed to cover representative geologic and geomorphic settings found at Mt. Hamilton. Optimum sampling and analytical specifications determined in Phase 1 of the orientation survey were em-ployed throughout Phase 2. Four anomalous surface zones were delineated.

Two separate mineralized systems were recognized in the soils at Mt. Hamilton: epithermal mineralization charac-terized by a Au+Ag+As+Sb+Pb+Zn geochemical suite, and skarn terized by a Au+Ag+As+Sb+Pb+Zn geochemical suite, and skarn mineralization characterized by a W+Mo+Fe+Cu+Hg geochemical suite. Epithermal mineralization was hosted by grano-diorite, hornfels and jasperoid located along a fault zone cutting the Seligman stock. Skarn mineralization was hosted by flat-lying zones of skarn and hornfels. Multi-element soil geochemistry is a viable tool for ongoing property evaluation at Mt. Hamilton.

GEOCHEMICAL SOIL SAMPLING FOR DEEPLY BURIED MINERALIZED-BRECCIA PIPES, NORTHWESTERN ARIZONA WENRICH, KAREN J.

Solution-collapse breccia pipes extend up to 3000 ft vertically through Solution-collapse precia pipes extend up to solo Plateau in northwestern upper Paleozoic and Triassic rock of the Colorado Plateau in northwestern Arizona; their roots lie within the Mississippian Redwall Limestone. Uranium orebodies rich in other metals such as Ag, As, Co, Cu, Mo, Ni, Pb, V, and Zn, lie about 1000 ft (330 m) beneath the top of the Triassic Noenkopi Formation- or Permian Kaibab Limestone-capped plateau surfaces. Mineralized rock is rarely exposed in the sparse rock outcrops on the plateau surfaces. The breccia pipes are seldom more than 300 ft (100 m)

in diameter, although the collapsed cone exposed on the plateau surface can extend to one mile (1.5 km) in diameter. Such an enlargement is due can extend to one mile (1.5 km) in dimeter. Such an enlarge the set of the dissolution of Upper Permian gypsum and limestone beds within and immediately adjacent to the breccia pipes. In some areas these gypsum and limestone beds form unmineralized collapse structures that are not related to the more deeply-rooted breccia pipes. Hence, development of Insertione bees form unmineralized collapse structures that are not fracted to the more deeply-rooted breccia pipes. Hence, development of geochemical tools that can distinguish these unmineralized collapse structures, as well as the unmineralized breccia pipes, from the mineralized breccia pipes could significantly reduce drilling costs in exploration for breccia pipe orebodies.

Design and interpretation of soil-sampling surveys over breccia pipes are plagued with several complications: (1) Although most of the plateaus containing uranium orebodies are capped by either the Kaibab Limestone or the Moenkopi Formation their various members contain diverse lithologies. Thus, when one is downdropped into the other a trace-element depletion or enrichment is created over the pipe compared to the surrounding rock, independent of any upward migration of metals from an underlying orebody. The collection of true background samples is a continual problem in (2) (2) The contention of the background samples is a continual point in these soil surveys, due to the presence of the collapse come and ring fracture zone that surround the pipes, but are not always obvious in areas with little or no outcrop. The come and particularly the fracture zone permit upward migration of some metals creating a halo around the pipewhen samples believed to be background are within such a zone, spurious conclusions will be drawn.

conclusions will be drawn. Soil surveys were completed over 17 collapse structures in 1984. Because many of these surveys yielded encouraging results 37 more pipes were sampled in 1985 and 1986. Samples were taken from a depth of 4 in., which was presumably from the B horizon. The samples were dry sieved through 80 mesh and analyzed for 55 elements. Twenty samples were collected within the surface expression of each collapse structure and 16 outside of the structure-the outer 8 samples were a mile apart, and hence shand experiments true helescond walless they happen to lie within an outside of the structure--the outer 8 samples were a mile apart, and hence should constitute true background unless they happen to lie within an adjacent breccia pipe. These solution collapse breccia pipes do tend to cluster, and hence background samples overlapping into an adjacent pipe is a real problem. Anomalies that were present were rarely more than one standard deviation above the mean, which underscores the necessity for careful sampling and good analytical precision. Three of the surveyed collapse structures are known to be breccia

pipes containing an orebody or significant uranium-mineralized rock: (1)The SBF pipe shows very significant enrichment of As, Mo, Pb, Sb, and Zn in soils collected from within the collapse structure in contrast to those from outside of the topographic and structural rim. (2) The Mohawk Canyon pipe shows distinct soil depletions of As, Cu, Mo, and Pb within the ring fracture zone in contrast to outside of the mapped fractures. (3) The fracture zone in contrast to outside of the mapped fractures. (c) The Canyon pipe shows a distinct Ho enrichment within soils from inside the treeless zone, containing the delineated breccia pipe, in contrast to the surrounding forest; unfortunately many other metals commonly enriched within breccia pipe orebodies show no contrast between the two areas. Of the 51 other collapse structures studied several contain strikingly anomalous soil enrichments in such elements as Al, Ba, Co, Cr, Cu, Fe, Ca, Mg, Mn, Na, Pb, Tl, V, Y, and Zn. Several of the 51 structures contain element depletions, similar to the Mohawk Canyon pipe, and several show

element depletions, similar to the Mohawk Canyon pipe, and several show no contrast in metal content of soils from within the structure and outside. Mo and Zn show the most consistent enrichment over the most structures; in contrast U, which is not known to concentrate in an oxidizing environment, shows no anomalies in any collapse structure. Interpretation of geochemical soil surveys must be carefully integrated with the geological mapping. The variance in metal content of soils developed from different lithologic units within the Kaibab and Moenkopi sometimes exceeds that produced by metal enrichment from the underlying orebodies. Nevertheless, a circular metal anomaly caused by the downdropping of Moenkopi into Kaibab is useful information, that in rockless terrain may be a good indication of an underlying breccia pipe as opposed to a structure caused by minor shallow-seated collapse. These soil surveys appear to delineate many of the collapse structures, and promise to be a useful technique toward the location of good drilling targets. . targets.

GEOSTATISTICAL AND GIS EVALUATION OF BIOGEOCHEMICAL AND ECOLOGICAL DATA FROM THREE MINERALIZED SITES (AU & CU-NI-PGE), NORTHEASTERN MINNESOTA: IMPLICATIONS FOR MINERAL EXPLORATION IN A BOREAL FOREST ZANKO, L., GOKEE, A., DEWEY, B., HAUCK, S., PASTOR, J.

Detailed biogeochemical and ecological studies of vegetation were conducted in the boreal forest of northeastern Minnesota. These studies were implemented over three mineralized sites:

Raspberry Prospect: Archean (2.7 Ga) gold mineralization in the Shagawa Shear 1) Zone (SS2), Vermilion greenstone belt, 5 miles west of Ely, Minnesota; Spruce Road (SR): basal Cu-Ni mineralization of the Duluth Complex;

2)

South Filson Creek (SFC): "cloud zone" Cu-Ni-PGE mineralization of the Duluth 3) Complex.

The two Keweenawan age (1.1 Ga) Duluth Complex sites are 15 miles southeast of Ety. The SR site consists of low grade Cu-Ni sulfide mineralization at the basal contact of the Duluth Complex, whereas the SFC site has discreet, fracture-controlled secondary Cu-Ni-PGM "cloud zone" mineralization. Glacial overburden thickness at the three sites varies from 0-40 ft.

Over 1300 vegetation samples were collected from 17 plant species during 1989 and 1990 at the three sites. Sampling took place over two weeks in late August and early September of both years. Tissue samples (1100) submitted for multi-element INAA and DCP analysis included leaves, twigs, needles, and outer bark.

Analysis of 500 vegetation samples from the Raspberry site in 1989 shows Ables balsamea (balsam fir) twigs, Populus tremuloides (quaking aspen) leaves, Corylus comuta (beaked hazel) leaves and twigs, Acer spicatum (mountain maple) twigs, and Aster macrophyllus (large-leaved aster) leaves contain anomalous gold values. Many of the gold anomalies in vegetation overlie a zone of sericite-iron carbonate alteration associated with

the SSZ. A. balsamea twigs recollected in 1990 verify the gold anomaly. At the two Cu-Ni sites, 600 tissue samples from A. balsamea (twigs), Picea mariana (black spruce - twigs and bark), Pinus banksiana (jack pine - bark). Ledum groenlandicum (labrador tea - twigs), Chamaedaphne calyculata (leatherleat - twigs), Alnus crispa (green alder - twigs and leaves), Alnus rugosa (speckled alder - twigs and leaves), and A. macrophyllus (leaves) were analyzed for base and precious metals. Analytical results are pending.

Bacillus cereus spore counts and other measures of microbial activity in soils were used as bioindicators of natural metal enrichments. *B. cereus* counts, total carbon and nitrogen, nitrogen mineralization, and pH analyses were done on the A horizon of soils collected at 200 ft. intervals across each site. *B. cereus* counts ranged from 1,000 to 576,000 spores/gm soil, matching spatial variation of soil metal anomalies. Initial results indicate that *B. cereus* counts can be an effective indicator of concealed ore bodies in northern Minnesota. The effectiveness of other soil properties as biogeochemical prospecting tools is being evaluated.

Ecological characterization consisted of identification and quantification of tree, shrub, and herbal species present within 550 tree and herb bits and 1100 shrub plots. Geostatistical interpretation of the tree, shrub, and herb data will be used to map the various plant communities at each site as well as the spatia distribution of metals. A geographical information system (GIS) will be used to determine what spatial relationships exist between the geochemical, geological, ecological, anc geographical data. The ecological, nutrient uptake, geostatistical, and GIS studies are being used to better characterize and identify variables that affect metal uptake and concentration by boreal forest vegetation over metallic mineralization.

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LITHOGEOCHEMICAL STUDIES OF THE CHITRAL AREA, HINDU KUSH

AFRIDI, A.G. and <u>IKRAMUDDIN, M.</u> Lithogeochemical studies of the Chitral area were carried out in order to evaluate the mineral potential of northern Pakistan. The Chitral area lies in the central part of the Hindu Kush Mountains, which constitute the northwestern extension of the greater Himalayas. The area is underlain by a wide variety of metamorphic and sedimentary rocks, which are intruded by granites, pegmatites, quartz veins, and basic dikes.

One hundred and twenty samples of a variety of rocks were analyzed for λu , λg , λs , Sb, Cu, Mo, Pb, Zn, K, Rb, and Tl. The concentration of the trace elements is generally low in most of the rocks, with the exception of altered carbonates and some of the quartz veins associated with granites and and some of the quartz verns associated with granites and slates. The altered carbonate rocks have significantly higher concentrations of Au, Ag, As, Sb, Cu, Mo, Pb, Zn, and Tl. Several samples contain up to 1 ppm Au and more than 1% As. Some of the quartz verns in granitic rocks and in slates contain high contents of Au, Ag, As, Sb, and Tl, but the enrichment of these elements is not high enough to mine them profitably. A high grade vern sample containing the enrichment of these elements is not high enough to any them profitably. A high grade vein sample containing boulangerite, however, contains extremely high concentrations of Au (-30 ppm), Ag, Pb, As, and Sb. Thallium is significantly higher in hydrothermally altered carbonate rocks compared to the unaltered rocks. The Carbonate rocks compared to the unaltered rocks. The enrichment of Tl over K and Rb in hydrothermally altered rocks is demonstrated on a TI-K-Rb ternary diagram. mineralized rocks fall close to the TI apex, and the

The abundance of Ag, As, Sb, Cu, Mo, Pb, and Zn in altered carbonate rocks is more or less similar to the sediment hosted gold deposits of the western United States. The enrichment of Au and Tl, however, is not as high as in some of these deposits. The preliminary study suggests that Chitral area probably contains economically important gold deposits. Detailed lithogeochemical and pedogeochemical surveys of certain areas may prove to be useful in locating sediment hosted gold deposits.

MULTI-CYCLIC GLACIAL TRANSPORT - AN EXPLANATION FOR THE LONG-DISTANCE GLACIAL DISPERSAL OF CHROMITE FROM THE KEMI CHROMIUM ORE IN NORTHERN FINLAND

<u>ALAPIETI, T.T.</u>, FORSSTRÖM, L.E. and PEURANIEMI, V.J. About 30 chromite ore boulders had been found in the area east of Oulu, northern Finland, before mid-1960's. Following the tungsten and sulphide ore prospecting carried out by Rautaruukki Oy Exploration in the same area in the early 1980's, using heavy mineral till geochemistry, a decision was made to employ this method to reconsider the source of the old chromite ore boulders.

employ this method to reconsider the source of the old chromite ore boulders. Altogether 2251 samples were taken from a surficial part of the till and the heavy fraction was concentrated by sluicing and panning for chemical analysis by XRF. Selected samples were investigated mineralogically with the aid of scanning electron microscopy and an electron microprobe. As a result, a glacial dispersal train for chromite emerged which, by Finnish standards, is exceptionally long (Fig. 1). The coherent train has two branches at its head part. This is caused by the fact, that in addition to the



Fig. 1. Chromite train and chromitite boulders within the survey area.

Kemi layered intrusion and in particular the Kemi chromium ore within it the Penikat layered intrusion also contains dissemination of chromite. The chemical compositions of the analyzed chromite grains from till are similar to those from the Kemi chromium ore, which was found in 1959 and is one of the largest chromite deposits in the world (Alapieti et al. 1989). The other rock types of the area contain no chromite, so the source rock of the anomaly train is very clearly defined.

The longitudinal axis of the chromite train is not fully coincident with the deglacial ice flow directions, which are indicated by the drumlins of the area. Especially in the southern part of the area the directions of the drumlins de-viate clearly from the longitudinal axis of the chromite train. From this one can conclude that the anomaly indicates the dominant lee movement direction in the area while that shown by the drumlins is a short term flow direction. The anomaly train is also so long, 90 km in a coherent form and up to 130 km in a discontinuous form, that it must have been generated during successive glaciations. The fact that the suboutcrop of the Kemi chromium ore is broad will also have contributed to the length of the dispersal train, as also has the high resistance of chromite to chemical and mechanical weathering.

The last ice flow phases seem to have been more important for the dispersal of chromitite boulders, because that boulders are more scattered than the heavy mineral anomaly (Fig. 1). An explanation for this is most probably, that the boulders were transported in an englacial or suprajacial position. In this case they will have been moved a long distance even during the last deglacial ice flow phases, when the majority of the till material moving as a basal load had already been deposited.

References

Alapieti, T.T., Kujanpää, J., Lahtinen., and Papunen, H. (1989). The Kemi stratiform chromite deposit, northern Finland. Economic Geology 85, 1057 -1077

EVALUATION OF LAKE-SEDIMENT GEOCHEMISTRY AS AN AID TO REGIONAL MAPPING AND ANOMALY IDENTIFICATION, GRANVILLE LAKE MAP SHEET, MANITOBA, CANADA AMOR, STEPHEN D.

almost universal problem the interpretation in of geochemical surveys is the partitioning of analytical responses into components related to environmental processes, and components which are statistically responses into processes, and processes, and components subordinate but frequent frequently more important from economic point of view.

The dominant effects of such environmental processes may be seen in the composition of lake sediments from the Granville Lake map sheet, which covers approximately 140,000 square kilometres of of northern Manitoba, Canada. The area is underlain by a diverse assemblage of

Canada. The area is underlain by a diverse assemblage of Proterozoic rocks of the Churchill Province of the Canadian Shield, including a volcano-sedimentary belt in which nickel-copper, copper-zinc and gold deposits have been mined. Surficial deposits resulting from glaciation and deglaciation are ubiquitous in the area. As part of a regional lake-sediment sampling program carried out under the auspices of a Joint Federal/Provincial Mineral Development Agreement, 1293 lake sites were sampled in 1983. Factor analysis of the analytical data demonstrates that 73% of the total variance of twelve selected parameters (Zn, Cu, Ni, Co, Mn,As, Fe, Hg, L.O.L., U.F, V) can be accounted for by threeanalytical data demonstrates that 73% of the total variance of twelve selected parameters (Zn,Cu,Ni,Co,Mn, As,Fe,Hg,L.O.I.,U,F,V) can be accounted for by three factors. The first of these, which accounts for 50% of the total variation, is considered to represent the effects of sedimentation in Glacial Lake Agassiz, for three reasons: the close correlation, throughout the map sheet, of factor scores between samples in adjacent lakes; the observation that factor scores are highest in the southeast and lowest in the northwest, where Lake Agassiz clay is demonstrably thickest and thinnest respectively; and the strong loadings of elements with high ionic potential. The second factor accounts for a further 13% of the variation and is heavily loaded in favour of mercury and loss-on-ignition; this factor is interpreted to model organic complexing. Manganese, iron and zinc are strongly weighted in the third factor, which and zinc are strongly weighted in the third factor, which accounts for 10% of the total variation and probably represents precipitation of, and with, manganese and iron oxides and hydroxides.

In order to study that component of each element's variability that is not explained by the three environmental factors, and which is more likely to represent the effects of bedrock geology, the scores from the three factors were used as predictors for the original variables in multiple regression analysis. Examined individually, the regression residuals that represent this unexplained component show an interesting relationship to certain areas of known mineralization, particularly in the case of copper and uranium, and to nickel contamination caused by tailings from the nickel mines at Lynn Lake.

mines at Lynn Lake. An interesting paradox emerges when the data are used to "fingerprint" the major lithological groupings using multivariate classification procedures: although there is little or no evidence that any of the three factors descrbed above is related to bedrock geology, classification with raw values is as efficient as that achieved by using the regression residuals from factor
scores, although misclassifications are numerous in both cases. It is concluded that factor analysis offers a useful method of screening out environmental effects on lake sediments in order to highlight "statistical rarities" such as mineralization and pollution, but that it is less effective as an aid in regional mapping.

GEOCHEMISTRY OF RARE EARTH ELEMENTS IN SURFACE LATERITIC ROCKS: THE MAIGURU CASE. <u>ANGÉLIGA, R.S.</u> & GOSTA, M.L. Maiguru is a typical alkaline-ultramafic-carbonatite complex, emplaçad, in the Guidan Caston (action of the second secon

Maicuru is a typical arkailne-uitrematic-carbonalite complex, emplaced in the Gulana Craton (northern Brazil) and completely transformed on its upper part in a thick lateritic profile. The laterites are enriched in aluminum phosphates and specially titanium mineralization as anatase.

This paper deals with the rare earth elements mineralization strictly related to aluminum phosphates in the lateritic cover (ferruginous crust plus lateritic soll) from Malcuru.

The ferruginous crust occupies the central part of the complex, being differentiated into at least three main units, related to primary lithology: a magnetic crust (with abundant anatase) and a phosphatic crust, where the Al-phosphates domain. The soils border the central structure where one part derived from laterites and another from primary sikaline rocks. In isolated samples, REE contents reach up to 20.0 wt% of REE203 as crandallite-goyazite-florencite soil solution, where this last member domains. Mean contents of Σ REE are slightly greater in soils (1082 ppm) than in the crust (831 The ferruginous crust occupies the central part of

ppm). The chondrite normalized plot for crust and soil samples exhibits a strong fractionation of the REE (Fig. 1), with high (La/Lu)N mean values of 72 (crust) and 113 (soils) where the HREE are strongly depleted compared with the LREE, resembling alkaline rocks patterns



The figure also shows a widely range in REE contents for the ferruginous crust, while the soils exhibits a narrow zone variation, as a consequence of lateritic homogenizing ٥f

The forregimes clock, while the best statistic homogenizing processes. One of the most interesting features also observed in figure 1 is the presence of prominents positive and negative cerium anomalies in the ferruginous crust, where Ge/Gex ranges from 0.33 to 38.97. In the solis, these anomalies are less representative. Ytterblum negative anomalies are also evident while europium anomalies were not observed. Table 1 summarizes the main significant linear correlations between REE and other trace elements. Among the REE, Ge and Lu show more divergent correlations, the former due to its great mobility in lateritic environment and the latter probably due to low contents (analytical problems). Besides phosphor, Be and Sr show strong positive correlations with LREE and HREE, only in the crust (also related to the crandalite group). Yttrium exhibits better positive correlation with HREE than with LREE, both in crust and crandallite group). Yttrium exhibits better positive correlation with HREE than with LREE, both in crust and soils.

solis. The results show that the ferruginous crust and the solis are geochemically distinct lateritic material, where the crust must be prospected as rock, being the own mineralized bedrock, for example, for Ti, Fe, P, REE, resistates, what does not occur with the solis. The presence of anomalous concentrations of REE in laterites as in the parent rocks, outstanding the great importance of lateritization processes. Table 1 - Main linear correlation coeficients between REE and other trace elements in the ferruginous crust (84 samples and soils (22 samples) from Maicuru.

		Y	Sc	Ba	Sr	Nb	Tì	Zr
CRUST	LREE	.61	. 83	.79	.80	.73	.33	-
	HREE	.76	.68	. 82	. 85	.64	. 25	. 22
SOIL	LREE	.63	. 40	-	-	.64	. 56	-
	HREE	.75	. 52	-	.60	.61	.37	.43

INTEGRATED GEOCHEMICAL EXPLORATION FOR CONCEALED TIN DEPOSITS AND "TIN FERTILITY INDEX" AS APPLIED TO BASTAR GRANITOIDS, DISTRICT-BASTAR, MADHYA PRADESH, INDIA. BABU, T.M.

the multidisciplinary surveys carried out in parts of Bastar district of Madhya Pradesh forming a part of Central Indian shield, the integrated geochemical exploration methodology adopted for search of concealed tin deposits proved to be successful. To cover large areas where not much of information is available, regional stream sediment surveys have been carried out covering about 4200 sq km area. Trace elemental litho geochemical bed rock sampling led to ascertain the primary dispersion pattern of tin and associated elements. Study and assaying of heavy mineral concentrates obtained from stream sediments samples brought out the secondary geochemical landscape pattern. The integration of these studies could lead to demarcation of several anomalous target areas. Detailed geological and geochemical follow-up work in these target areas led to identification of tin fertile granites, stanniferous pegmatites and economically viable cassiterite enriched colluvial and alluvial placer resources. Systematic sampling of leaves, trunks, roots, fruits of the trees thriving on these tin fields and assaying of the ash brought to light that several flora (Shorea robusta, Emblica officinalis, Eugenia jambolana, Stepto guinaii) could absorb tin content from 125 ppm to as high as 700 ppm and possibly could be used as additional exploratory tools.

Thus the geochemical exploration with integrated approach of trace elemental lithogeochemistry, regional stream sediment sampling, heavy mineral concentrate analysis, soil geochemistry, different mineral fraction analysis and bio-geochemistry proved to be of great help in locating concealed ore concentration of economic importance.

The whole rock and trace element geochemistry of granites of Bastar correlates well with well known tin bearing granites of the world. The binary and ternary plots and other comparative studies indicate that certain distinct variations exist between tin fertile and normal granites. Broadly it can be concluded that the tin fertile granite has higher differentiation index, $K_20^{\%}$, Si $0_2^{\%}$, enrichment of certain trace elements like,

Sn, Nb, Ta, Li, B, Rb, Be and depletion in ferromagnesium constituents and related trace elements like Mn, Ti, Co, Ni, Cr, V and Sr.

Reviewing the geochemical characteristics of granitic rocks the "tin fertility index" (TFI) has been proposed to distinguish the tin bearing from the normal granites. The granitic rocks with high TFI tend to have saturated tin content and with detailed search are likely to yield tin deposits of economic importance.

REGIONAL HEAVY MINERAL SURVEY IN THE EXPLORATION FOR GOLD USING REGRESSION AND INDICATOR KRIGING: GRENVILLE PROVINCE, SOUTHWESTERN OUEBEC

BELLEHUMEUR, C. AND JEBRAK, M.

A geochemical reconnaissance heavy mineral survey has been carried out in the area of the Gatineau river valley, over a part of the Allochthonous Mono- and Polycyclic Belts of the Grenville Province, southwestern Quebec. Canada. The majority of samples shows gold concentrations below the detection limit and anomalies are erratic. To circumvent these problems and to present an accurate image of the gold-bearing potentiel of the area, we d regression and indicator kriging. use

The regression is performed among samples showing gold concentrations above the detection limit of 5 ppb. The regression of gold on chalcophile pathfinders (As, Se, Sb, Pb, and Hg) explains respectively 11% and 14% of gold variance for each belt. The equation infered from regression is applied to the whole data set and provided a gold estimation for each sampling point. Exploration targets are defined from highest gold concentrations estimated by regression.

Lithophile elements such U, Th. Y, and W, which are typical of resistant and dense minerals explain 4% and 10% of gold variance. This part of the geochemical signal is probably dependant of hydrodynamic conditions of streams.

Variograms of gold estimated by chalcophile elements only show shortest continuities (10 to 20 km) than those estimated by chalcophile and lithophile elements (15 to 60 km). Lithophile elements are influenced by regional geological conditions while chalcophile elements express more positively the influence of sulfide mineralizations, which are local phenomena. Continuities of the order of 10 to 20 km indicate that regional geochemichal survey can detect background variations of gold pathfinders.

Anomaly maps of gold predicted with regression indicate that the loss of information resulting from the using of chalcophile elements only, rather then all available elements did not mask any important anomaly, but has rather improved the resolution of these ones.

Spatial dispersion of gold transformed in an indicator variable is erratic, variograms showing very short continuities for the 6 ppb threshold and

Variagrams showing very short continuines for the 6 ppb threshold and pure nugget effects for 10 and 15 ppb thresholds. However, a local average of indicators permit to produce a probability map of exceeding 10 ppb. The joint examination of maps of gold estimated by regression and maps of indicator kriging permit to define exploration targets. These maps are more revealing of the gold potential of the area than gold raw data.

GEOCHEMICAL EXPLORATION NEAR GLEN INNES, NEW SOUTH WALES, AUSTRALIA

BROOKE, J.P. An area of about 200 square miles near Glen Innes, N.S.W. has been geochemically surveyed. Semiquantitative spectrochemical analyses of

500 samples of stream sediment were completed; the samples were collected and analyzed for eight different elements. A statistical analysis of the data has disclosed the presence of numerous small anomalies. These are considered real, but their significance has not been determined.

Anomalies. These are considered real, out their significance has not been determined. The samples for analysis were collected throughout the area by the author and 4 assistants. The specimens were obtained at predetermined locations along major streams and tributaries. The sample density was 3 per square mile. This technique was a fast and convenient method to prospect the exploration area. Sample locations were designed to avoid bias in analysis. An attempt was made to sample major streams and tributaries at one mile intervals. Experimental difficulties made it impossible to complete all of the sampling; water depth and velocity, and absence of sediments prevented sampling at about 10% of the locations. The locations of the samples were submitted to the firm of Babcock and Wilcox in Regents Park, N.S.W. for preparation and analysis. Semiquantitative determinations of eight elements were completed with a Varian Techtran, Atomic Absorption Model AAS Spectrophotometer. The samples were dried and then the minus 80 mesh fraction was separated and retained for chemical analysis. The eight elements were Cu, Pb, Zn, Ag, Mo, Sn, Sb, and Bi.

Mo, Sn, Sb, and Bi.

retained for chemical analysis. The eight elements were Cu, Pb, Zn, Ag, Mo, Sn, Sb, and Bi. The data were analyzed by standard statistical techniques for anomalous values indicative of metalliferous deposits; a preliminary scanning of the data indicated no gross anomalies are present. The values were then searched for small anomalies. The study revealed two Sb, five Bi, five Cu, six Pb, four Ag, four Mo and six Zn anomalies. These included both multiple and single station anomalies. Based upon statistical parameters these values are probably real and not due to chance errors. Some anomalies have been eliminated as a result of replicate analyses completed on a selected sample. The significance of each of these anomalies might be determined with additional investigations. It is difficult to decide at this stage whether these anomalies are due to higher background, random fluctuations in trace element content or some concentration of economic mineralization. Detailed geochemical sampling might delineate and identify possible economic situations (if they exist). The economic potential of the individual sub-areas was determined by using the multicriteria decision-aid model: Electre. This is a decision making technique utilizing sensitivity analysis. A game matrix was constructed with the various trace element concentrations as the coordinates for the sub-areas. Utilizing the geochemical data, the program indicated that none of the sub-areas is preferred for additional exploration. The technique has potential use in allocating resources among competing needs; it can also help evaluate areas when different types of geological data are available for the analysis.

types of geological data are available for the analysis.

GLOBAL GEOCHEMICAL MAPPING: RECENT DEVELOPMENT IN THE INTERNATIONAL GEOCHEMICAL MAPPING PROJECT DARNLEY.A.G.

At a workshop in Helsinki in 1988, Kalevi Kauranne, Director of the Geological Survey of Finland, said "Geochemical maps represent the most urgent and important task within geology for today's human so-

This task is now being prusued under the sponsorship of the International Geological Correlation Program, as the International Geochenational Geological Correlation Program, as the international Geoche-mical Mapping Project, and also under the sponsorship of the Inter-national Association of Geochemistry and Cosmochemistry, by the Work-ing Group on Global Geochemical Mapping. Support for the concept of a globally consistent geochemical database is beginning to grow.

The project's history has been described in a recent special issue of the Journal of Geochemical Exploration (Nos 1/2. Vol. 39, 1990).

The purpose of this paper is to report on the progress being made. Over the past decade the most rapid progress in systematic geoche-mical mapping has been made in China where approximately 50 per cent of country has been surveyed for 40 elements. In Europe a geochemi-stry group involving most West European Geological Surveys, is working hard to develop an acceptable proposal for systematic mapping of that continent. In North America discussions to integrate and expand the current incomplete geochemical database are still at a preliminary stage

The international project currently provides an umbrella under which activities in 75 countries may be co-ordinated. The task of es-tablishing common approaches and procedures in being undertaken by five technical committees. The following preliminary recommendations

are a sample of topics under discussion. The field methods committee under A. Steenfelt is recommending the use of stream sediment as the principal sample medium; coverage of large areas with low sample density should have priority over coverlarge areas with low sample density should have priority over cover-age of smaller areas with high sample density. The analytical com-mittee under Xuejing Xie is recommending that for economic and en-vironmental purposes there should be a core of 46 "essential" ele-ments, including loss on ignition (LOI); detection limits must be below average crustal abundance values. "Total" concentrations of elements are essential; partial leaches are optional. The data mana-gement committee under N. Gustavsson recommends that a world index of surveys should be constructed around a displace using a PC environment. of surveys should be constructed around a database using a PC environment and a cheap general purpose database management program. The system should provide the users with simple search mechanisms, gra-phical displays and statistical summaries. The database management program should provide easy import/export features to gurantee data exchange to other current and future systems. The radiometric com-mittee under M. Tauchid recommends that the International Atomic Energy Agency should act as co-ordinating centre for radiometric Energy Agency should act as co-ordinating centre for radiometric data in order to: continue to make an inventory of regional radio-mentric surveys world-wide, provide assistance with levelling (this applies particularly to developing countries); disseminate project information on a regular basis, including details of gamma ray spectrometry calibration facilities; collect sub-sampled data after levelling. The global sampling committee under A. Bjorklund recmmends that the Earth's land surface should be subdivided into

some 5,000 cells. Composite overbank (delta, flood plain) sediment should be collected from some 1,000 large catchment areas of the globe as a first stage.

Expanded and refined recommendations will be prepared during 1991; all geochemists who wish to contribute to the discussions are encouraged to do so.

THE METALLOGENIC AND HALO-FORMING MODEL OF THE POLYMETALLIC ORE DEPOSITS AND THE GEOCHEMICAL PROSPECTING PREDICTION SYSTEM IN THE FENG-TAI DISTRICT, SHANXI PROVINCE, CHINA FANG.Weixuan

With the difficulties of finding ore deposit being increased, it is one of the most important direction of research in geoscience for us one of the most important direction of research in geostiente for us to discover hidden ore body. From 1985 to 1988, the program, which was concerned with the study of the metallogenic and halo-forming model for polymetallic ore deposits in the Feng-Tai district, had been carried out. Throughout the research and investigation, the geo chemical prospecting prediction system in the area had been set up. The system functions very well and we have made surprising benefits. In this article, four subjects are discussed: 1. the geological

and geochemical characteristics of the strats-bound polymetallic ore deposits in the Feng-Tai district, 2. the pattern of primary anomaly of mineral deposits, 3. the metallogenic and halo-forming model, 4. the geochemical prospecting prediction system and its functions.

GEOCHEMICAL CHARACTERISTICS AND RETROGRESSIVE METAMORPHISM OF ARCHEAN METAMORPHIC ROCKS OF GRANULITE FACIES IN ZHANGJIAKOU -XUANHUA AREA, HEBAI PROVINCE, CHINA GAO MAI

The crystalline basement of the North China Platform comprises the oldest metamorphic rock in China. Archean granulites of the Zhangjiakou -Xuanhua area in Hebei province are distributed along the northern margin of the Platform. Little previous geochemistry work had been done in this area. The geochemical characteristics of this area are similar to those of neighbouring areas. Widespreade retrogressive metamorphism caused geochemical changes in the rocks of this area. During retrogressive metamorphism fluids caused changes in mineral assemblages, major elements, trace elements and REE of granulite facies rocks. The retrograde rocks possess negative Eu anomalies, perhaps related to the fluids present during retrogressive metamorphism.

1. Chemical characteristics of most of samples indicate that they belong to a normal series. Metamorphic rocks have been returned topriginal rocks using the chemical method. se rocks belong to intermediate to basic volcanic rock series and probably to island arc tholeilte series

2. The rock samples that were influenced by retrogressive metamorphism to variable degree show neightive Eu anomalies, but those that were not influenced by retrogressive metamorphism show minor to medium positiveEu anomalies. Retrogressive saples are HREE-enriched. In some cases REE is higher than in un -retrograde rocks.

3. The rocks in this area were basically anhydrous during the period of granulite facies metamorphism, we believe that REE patterns were not strongly influenced during that period. After granulites formed, retrogressive metamorphism occured and large amounts of fluid poured into the rocks. These fluids perhaps contained a mixture of CO2, H2O and halogens. there are more water-bearing minerals in retrograde rocks. This perhaps result in a low CO2/H2O ratio. This kind of fluid probably is important in the mobility of REE. Eu is lost in retrograde rocks.

4. Rb-Sr contents of the two groups are obviously different. In the plot of Rb against Sr, the samples are in different areas. Most of the Rb-Sr composition points of retrograde amphibolite facies rocks all plot in the area limited by Rb/Sr =0.1 and Rb/Sr=1. But the points for un-retrograded rocks all plot in the area limited by Rb/Sr=0.01 and Rb/Sr=0.1 except one point. We consider that the contents of Rb and other large ion lithiphile elements would change with introduction of fluids and retrogressive metamorphism. More Rb is introduced than K. The content of Rb does not change very much during retrogressive metamorphism.

5. Rb-Sr isochron age of the granulite, about 2.8Ga, has been determined. The age of retrograde amphibolite facies rocks is, however, about 1.6-1.8Ga or less. This suggest that granulite facies metamorphism took place about 2.8Ga ago, and original rocks were formed earlier. The age of about 1.6-1.8Ga probably reprent the time of retrogressive metamorphism.

6. Retrogressive metamorphism in this areas is an important geological event. It is not simply the end of single granulite event but occurred as a seperate geological event. It influences all granulite facies rocks, causing them to retrogress and resulting in changes in the geochemical characteristics.

GEOCHEMICAL AND GEOPHYSICAL SIGNATURES AT CERTAIN BULK

GEOCHEMICAL AND GEOPHYSICAL SIGNATURES AT CERTAIN BULK MINEABLE PRECIOUS METALS PROSPECTS IN NEVADA <u>HENKLE, W.R., JR</u>, HYDE, C.C., and JOHN, T.W. Integrated geochemical and geophysical exploration tech-niques for bulk mineable gold ores are compared at two pros-pects and at one operating mine in Nevada. The prospects are both associated with recent or active hot springs systems. The operating mine is volcamic hosted multiple stockwork The operating mine is a volcanic hosted, multiple stockwork vein deposit

vein deposit. Total field magnetic and VLF/EM surveys were conducted, in conjunction with geochemical sampling at the properties . At each prospect, several magnetically depressed areas were located which coincided with positive VLF conductors and anomalous geochemical signatures. Magnetic lows result from the oxidation of syngenetic trace magnetite to epigen-etic hematite and limonite, by hydrothermal fluids. The VLF conductors result from presence of clays due to alteration, and sulfides due to deposition, by focused hydrothermal fluids along faults. Areas where geophysical and geochemical anomalies overlap are considered prospective. Prospect A is a clastic, sediment hosted target which is partially concealed beneath pediment gravels. Active and recent hot springs sinter attracted exploration attention to

the prospect. Rock chip sampling revealed presence of gold the prospect. NOCK only sampling revealed presence of gold in the system. Geophysical signatures indicate presence of mineralized faults, limited drilling and geochemical anal-ysis of cuttings supports this exploration hypothesis. Prospect B is a volcanic hosted target which is con-cealed beneath a thin pediment gravel. Scattered outcrops of recent hot springs sinter which yielded up to 150 ppb Au attracted exploration attaction to this promot, which is

attracted exploration attention to this prospect, which is found within a Known Geothermal Area.

Geophysical anomalies overlap with a + 1000 ppb Hg soils anomaly at this prospect. A bifrucating VLF conductor is present in the overlap area. Geochemical analysis of drill cuttings suggests the presence of an as yet undifined bulk

mineable target. The Flowery Gold Mine is a vlocanic hosted, Comstock Type, epithermal deposit. Mineralization occurred at and near the contact of an overlying fragmental volcanic rock package

the contact of an overlying fragmental volcanic rock package with an underlying shallow intrusive. Hydrothermal alteration occurred in three major stages at the deposit. The first stage was barren, but deposited widespread disseminated pyrite. The second stage involved focusing of silica and sulphur rich fluids along faults and fractures, and at the volcanic / plutonic contact. This re-sulted in formation of pyrite and guartz rich explosion breccias and stockwork vein systems. The third stage involv-ed deposition of guartz - adularia veins and stockworks which are gold bearing. The third stage mineralization occurred primarily within and adjacent to rocks which had been altered by the second stage mineralizing event.

Recent large scale rock chip sampling allowed definition Reveral prospective ore bearing zones at the property. VLF /EM surveys showed the presence of large conductors located more or less down dip of known outcrops of ore grade mineralization. The VLF conductors result from the presence of second stage, pyrite rich altered rock in the subsurface. Drilling has confirmed the presence of ore grade material at whallow depth shallow depth.

The combination of geochemical sampling, with VLF/EM and Magnetic surveys is a cost effective method of prospecting for bulk mineable ores in certain terranes in the Basin and Range Province.

GEOCHEMICAL AND GEOPHYSICAL METHODS OF PROSPECTING NON-METALLIC MINERALS KOMOV . I . L.

Non-metallic commercial minerals differ by their origin and produce inhomogeneous geochemical fields with some elements detected in small concentrations.

In prospection of non-metallic minerals geochemicst considers migration and redistribution of elements in the bodies under analysis. A methodic base of such an approach is built of geochemical anomalies of accessory elements used as tracers of needed minerali-zations. The existing technique permits to find even smallest concentrations of elements. The practice of geochemical prospection of non-metallic minerals shows various types and origins (up to sedimentary ones) to be accompanied by hypogenetic anomalies, whose parameters are higher than those of the bodies to find. The anomalies, just as in the case of ore-bodies, are as a rule obvious in the background fields of endogenous geochemical scattering. Geochemistry is seen as a tool to prospect the following types of

deposits:

1. Deposits of independent mineral phases: diamond, beryl, topaz, ruby, sapphyre, emerald, rock crystal, Iceland spar, asbestos, and graphite.

2. Deposits of minerals where some definite elements (F. P. B. S. K, and I) are used as parts of the composition of apatite, phosphate, A, and 1/ are used as parts of the Comparison and the second seco

or chemical properties. Examples of such materials are gem material (jadeite, nephrite), adsorbing and filling material (talc, gaize, etc.) pigments (glauconite, chalk, etc.). The three types of deposits possess specific features defined by

environmental conditions at the times of formation. A geochemist looks always for accessory elements (Cl, F, Hg, K, Na,) developing around the bodies to study. Deposits are surrounded by halos of elements brought in the vicinity of the body or carried out. There is always a striking rise in compositional dispersion of the elements.

Non-metallic minerals form by steps. Particular features of location of these deposits are defined by the composition of the primary rock (hyperbasites define asbestos, whereas quartzites and quartz define rock crystal formation). Anion-forming halos (Cl, F) of some elements (low-, medium-, and high-temperature Hg and oxide chromium) appeared as a consequence of multi-stage ore forming activity may be considered signs of active mineralization. Volumes of these zones and their border are to be taken as volumes of producing bodies. Geochemical prospection in these conditions should be aided by mine ralogical and decrepitognonic studies.

Combined application of mineralogical and geophysical methods is advisable in the search for diamond, emerald, graphite, asbestos, and rock crystals.

The producing regions of deposits classified in the second group are surrounded by anomalous concentrations of high contrast elements (P, F, Cl, Br) readily detectable by geochemical methods. Exogenetic deposits of S, K-salts and phosphates have important

lithologic-facial signs to further substantiate the usual enrichment of rock in P, K, and Br. Gamma spectrometry is a tool in the circum-stances to resolutely determine deposits of apatite, phosphate and fluorite. Remote-sensing nuclear-physical methods are applied to determine the economic value of deposits for mining chemical raw materials.

The third group deposits, unlike the other two, have producing and enclosing rocks not easily differentiated by geochemical methods. Nevertheless, geochemical prospection results very often in finding

geological formations that control the third group deposits. A non-direct interpretation of geochemical data correlating geo-logical and geochemical analyses is very useful in the circumstances. spectral minerals are to be found always deeper and deeper, the pro-spection being made efficient by geochemistry. Quantitative assess-ment of producing deposits, to a large extent, is a field of application of this science too.

In conditions of some areas route surveying of a territory fails to provide objective data making it possible to form an opinion or the prospectiveness of the areas under investigation with respect to finding non-metalliferous useful minerals may be doubtful. In this case, geophysical methods are used in combination with mineralogical-geochemical investigations.

A combination of various methods makes it possible to search for deposits, to determine the prospects of deep horizons and flanks of deposits and to evaluate the quality of minerals.

TITANIUM DEPOSITS OF KEHNUJ, SOUTHERN IRAN: REGIONAL GEOCHEMICAL EXPLORATION

KOUSARI,S., AZARM,F., SHAMSA,M., and ALAVI,M.

A regional geochemical exploration for titaniium deposits has been carried out by the geochemical Section of the Geological Survey of Iran in the Kehnuj area, ssouthern Iran during the spring 1985.

Based on the lithology and structural geology, Kehnuj is one of the most promissing area, where after reviewing previous reports a regional exploration has been done over 500 km² by a group of geo-chemists from the Geological Survey of Iran.

More than 500 geochemical and 100 heavy mineral samples were ana-lyzed dudring the field period at the vbase camp laboratory. The amount of titanium in the geochemical samples was measured by a developed calorimetry field method (F. Azarm, 1984). By this method, the amount of Ti (in ppm) is measured in the form of titanium oxide, which usually occurs in ilmenite, magnetite, titanomagnetite, rutile, etc. (nò titanium silicate minerals).

etc. (no titanium silicate minerals). The results of the regional geochemical exploration showed five anomaly zones two of which were chosen for semidigital exploration. The background values for titanium and ilmenite contents are 13,000 and 13,332 ppm and absolute anomaly for each is 56,001 and 129,718 ppm, respectively. The variation of gabbroic rocks including the assemblage of uralized gabbro, hornblende gabbro, and diabase swarm dikes are called as the high level gabbro. This assemblage is asso-ciated with ilmenite mineralization mostly in the western part of ciated with ilmenite mineralization mostly in the western part of Band-e-zyarat complex.

REGIONAL STREAM SEDIMENT GEOCHEMICAL SURVEY OF SOUTH AFRICA

REGIONAL STREAM SEDIMENT GEOCHEMICAL SURVEY OF SOUTH AFRICA <u>LABUSCHAGNELS</u>, HOLDSWORTH,R. and STONET.P. The Geological Survey of South Africa is since 1974 engaged in a regional stream sediment geochemical survey which will eventually cover the whole of the country totalling 1.22 x 10⁶ km². Sampling is done in first order streams where possible and at a density of 1/km². A high degree of efficiency of sample collection has been developed using helicopter-supported transport for speed and recently GPS (Global Postioning System) for improved accuracy of navigation. Up to the end of 1990 a total of 178 000 samples, representing 14 per cent of the country, has been collected for further processing at the Geological Survey. Because of the relatively aldw rate of the survey compared to for instance alrborne geophysical surveys, the programme is designed to give priority to areas of high exploration activity. Thus the programme commenced in the central Permo-Triassic Karoo basin when exploration for sandstone hosted uranium deposits peaked by the end of the seventies. During the last decade, the programme which hosts several major Cu, Pb, Zn and Ag deposits. During the 1990's the programme grogramme which hosts evenal threas constitute the most important gold source outside the depieting resources of an expensive to mine Witwatersrand gold-bearing reets. Regional geochemistry will undouttedly be ranked alongside other disciplines e.g. engineering geology, geophysics, etc. In optimizing future land use. Diversity in climate, topography and typical economic mineralization necessitates that orientation surveys be conducted prior to sampling the sub-regions. The optimum size fraction, a compromise between the bade decored based on based comparison the host orientation surves be conducted prior to sampling the based comparison the host orientation surves be conducted prior to sampling the sub-regions. The optimum size fraction, a compromise

surveys be conducted prior to sampling the sub-regions. The optimum size faction, a compromise between the yield after sieving and the best contrast between anomalous and background values, pathfinder elements, element mobility, scavenging elements etc. are established. In the northern Transvaai, where the programme is being carried out at present, the minus 75 µm fraction is used; Cr, Co, Ni and Cu are important pathfinders for PGM, Sb for some gold deposits and Ce and Y for permitting carthourating monarity events and REF deposits.

Cr. Cd, Ni and CU are important pathimeters for PGM, So for some good deposits and CU and if for pegmattites, carbonattikes, monazite versins and REE deposits. Analyses are done by multi-element simultaneous XRF using 22 fixed, 4 background and one scanner channels on powdered briquettes. Geochemical data are stored as ASCII files on an inhouse mini computer and are being used for the production of a large variety of geochemical survey is presently engaged in the construction of an in-house relational database which will combine data generated by the various geological disciplines. Geochemical data will in future be spatially correlated with lithergent transmission. with lithology, topography, mineralization, geophysics, etc. in interpretation.

THE METHOD AND APPLICATION OF THE MODEL OF GEOPHYSICAL AND GEOCHEMICAL MARKERS OF METALLIC DEPOSITS IN EASTERN HUBEI LI, Sezhuan

This paper bases on geophysical and geochemical exploration reuslts of some typical Fe, Cu and Au deposits in eastern Hubei province. It puts forward the method of metal ore deposits by the characteristic markers (primary marker, secondary marker, and combined mar-ker) of distribution probability of geophysical and geochemical pa-rameters in geological bodies. It establishes the typical geological-gephysical-geochemical markers and models (GGGMM) for contact metsomatic metal ore deposits. It also discusses the effective and applicable way of "CGGCMM". 1. "CGGGMM" is closely integrated with geophysics and geochemi

stry. Comparing with single geophysical model, it has the charact-erisic to determine single mineralized type of objective body. Comparing with simgle geochemical model, it can also determine the ac-curate shape, occurrence, space distribution character and consi-derable prospecting depth of blind ore bodies. Therefore, "CGGGMM" consists of higher exploration capacity, especially for the blind ore deposits.

 "CGGGMM" can be more imagined, complete and accurate to de-lineate the law of "GGG" characters in the geological bodies. Thus, we may use it for researching the metallogenetic types of ore deposits, metallogenetic epochs, metallogenetic structures, occur-rence of igneous bodies, facies division of igneous bodies and dis-

criminant metamorphic zones, etc. 3. On the basis of "CGGGMM" of various types of ore deposits, the best method content may be decided to explore respectively the various metal ore deposits and the systematic method of geophysical and geochemical exploration for prognosticating blind ore deposits. Finally this paper indicates the effective way to raise the pro-gnostic capacity for "CGGGMM".

RECONNAISSANCE GUIDELINES FOR GOLD EXPLORATION IN CENTRAL ALASKA

ALASNA <u>LIGHT, T.D.</u>, LEE, G.K., and MOLL, S.H. Distribution of gold-bearing samples from the Livengood (Tolovana) and parts of the Fairbanks and Rampart mining districts indicate that the concentration of gold is spatially related both to structural features and to Late Cretaceous and Tertiary felsic plutons.

Cretaceous and Tertiary felsic plutons. Central Alaska has long been known for numerous and often large placer deposits with little or no evident lode gold source. The US Geological Survey has compiled geochemical data for more than 300 gold-bearing localities in the Tolovana, northern Fairbanks, and eastern Rampart mining districts. These data have been processed using a Geographic Information System to define the geologic distribution of gold-bearing samples. Integration of digital geologic and topographic data permits potential source units to be established by removing alluvial deposits from the geologic map and exposing underlying units. In all from the geologic map and exposing underlying units. In all three mining districts, the gold-bearing samples are predominantly associated with argillite, phyllite, shale, siltstone, or micaceous schist. In addition, most of the localities from which gold-bearing samples were collected are within 5 km both of Late Cretaceous or Tertiary felsic plutone and of large thrust faults. The regional are within 5 km both of Late Cretaceous or Tertiary felsic plutons and of large thrust faults. The regional consistency of this spatial relationship suggests that there may also be a genetic association between the faults, the felsic plutons, and the distribution of the gold-bearing samples. Because the faults are not mineralized consistently near the plutons, it is probable that the source of some, and possibly most, of the gold was derived from the country rock. The local occurrence of gold within the plutons indicates that at least some of the gold was derived from the plutons. We envision a model wherein weakly mineralized solutions, thermally driven by latent plutonic heat, were enriched by circulation through clastic units that may have had a naturally elevated gold background. The resultant enriched solutions were channeled and reconcentrated along or adjacent to large-scale fault background. The resultant enriched solutions were channeled and reconcentrated along or adjacent to large-scale fault systems. The observed spatial relationship and possible genetic relationship suggest that regional exploration to define individual target areas should be directed toward those areas where Late Cretaceous and Tertiary felsic plutons occur near major faults.

MINERAL-RESOURCE POTENTIAL IN THE ANCHORAGE 1 by 3 QUADRANGLE, SOUTHERN ALASKA MADDEN-McGUIRE, D.J., and WINKLER, G.R.

The Anchorage quadrangle contains three major fault-bounded terranes that were accreted between mid-Cretaceous and early Tertiary time. The Peninsular terrane is bounded on the south by the Border Ranges fault. The ternane comprises intrusive and extrusive phases of an early Mesozoic intraoceanic magmatic arc and late Mesozoic marine sedimentary rocks deposited in forearc basins; all were intruded by voluminous composite plutons of Late Cretaceous and Paleocene age. Paleocene and younger nonmarine volcanic rocks and coal-bearing sedimentary rocks overlap both the Peninsular terrane and the Chugach terrane to the south. The Chugach terrane consists of Mesozoic polygenetic melange and accreted wedges of Upper Cretaceous flysch and minor metatuff. South of the Contact fault, the Prince William terrane consists of an accreted Paleogene deep-sea fan complex interbedded with minor tholeiitic basalt.

Gold has been produced from gold-quartz veins and related placer deposits in the Peninsular and Chugach terranes, primarily in the Willow Creek and Girdwood mining districts. Areas that include the mining districts are assigned the highest and most certain levels of potential for gold-quartz veins and goldplacer deposits in this quadrangle.

In the Willow Creek district (Peninsular terrane), high-sulfide gold-quartzcarbonate veins cut a 72 to 79 Ma pluton (recording multiple stages of alterations) and adjacent pelitic schist. Mineralization occurred at 66 Ma and 55 to 57 Ma. The extent of the high-potential gold-vein area is defined by the known mineral deposits, geologic contacts, and panned concentrates containing gold and enrichments in As, Ag, Sb, and Pb; stream sediments contain as much as 600 ppm

In the Girdwood district (Chugach terrane), Au and Ag are concentrated in quartz-carbonate veins in joints and shears within greenschist-facies metasedimentary rocks of Cretaceous age and within intrusive quartz diorite (53 Ma). Elsewhere in the Valdez Group of the Chugach terrane (in adjacent quadrangles), gold-quartz veins are younger than 34 Ma. Panned concentrates from Crow Creek and surrounding drainages contain gold and local enrichments in Ag, As, and Sb.

Moderate-potential areas occur in the Chugach terrane, near Harriman Fiord and the Coghill River. The areas expose gold-quartz veins in a mine, prospects, and outcrop. Several stream-sediment samples are enriched in Au (as much as

0.31 ppm) near Harriman Fiord. Another area of moderate potential for goldquartz veins is located between Mount Marcus Baker and the Border Ranges fault. This area exposes base-metal- and gold-enriched quartz veins; concentrates panned from glacio-fluvial deposits contain gold, arsenopyrite, chalcopyrite, sphalerite, and galena.

Podiform chromite is exposed in the Peninsular terrane, within fault-bounded ultramafic complexes near Eklutna and in the upper part of Wolverine Creek. Cumulate chromitite, with a moderate potential for Cr_2O_3 , occurs within deformed cumulate dunite and wehrlite. Adjacent outcrops of ultramafic rocks have a inderate potential for Cr_2O_3 but a lower level of certainty. Platinum-group elements are not particularly enriched in these rocks.

A moderate-potential, prospected, base-metal-rich area occurs in the southeastern corner of the quadrangle, between Kadin and Miners Lakes. Veins and massive-sulfide occurrences in the Prince William terrane are locally highly enriched in Zn, Cu, Pb, and Ag and panned concentrates contain chalcopyrite and sphalerite.

REGIONAL GEOCHEMICAL SURVEY OF BURIED REGOLITH FROM DRILL SAMPLES OVER ARCHEAN TERRANE, LAKE OF THE WOODS COUNTY,

REGIONAL GEOCHEMICAL SURVEY OF BURIED REGOLITH FROM DRILL SAMPLES OVER ARCHEAN TERRANE, LAKE OF THE WOODS COUNTY, NORTHERN MINNESOTA. <u>MARTIN,D.P.</u>, MEYER,G.N., DAHL,D.A., CARTWRIGHT,D.F. We conducted a reconnaissance overburden geochemical survey by applying common techniques to unusual sample types--buried older tills and underlying saprolites. Since the useful strata are buried beneath 50 to 150 ft. of exotic Koochiching lobe till, Rotasonic drilling of 31" dia. continuous, undisturbed core to a maximum depth of 330 ft. Was necessary. In summary, drilling at 20 sites across 700 square miles has 1) established parameters to correlate till units; 2) established background levels spanning different dispersal scales for the till units; 3) characterized the saprolite composition; 4) identified anomalous contents of Fb, Cu, and Au in saprolite and Hg in till that suggest nearby bedrock point sources; and most importantly 5) permitted a refined methodology for further exploration. The objective is to identify either point source bedrock mineral occurrences or local-scale (mining camp) geochemical anomalies in this region of few bedrock outcrops. Multiple tills were found to overlie a Cretaceous, tropical weathering zone which is up to 120 ft. thick on this Wabigon Subprovince, Superior Province granite-greenstone terrane. The older tills are geochemically very similar to their

terrane.

The older tills are geochemically very similar to their overlying and nearby late-Wisconsinan counterparts. More significant composition differences are observed in those

significant composition differences are observed in those tills which incorporated the most saprolite. Saprolite composition varies greatly, both across its internal stratigraphy and on different protoliths. Regional till stratigraphy was constructed from detailed descriptive logging, pebble counts, matrix carbonate content, and textural analyses. Whole rock, clay fraction, and 3.3 S.G. heavy minerals fractions of saprolite were analyzed to define its contribution to tills, which were similarly analyzed.

analyzed to define its contribution to tills, which were similarly analyzed. The till geochemistry falls into three general populations corresponding to young northeast provenance, older northeast provenance, and older northwest provenance. Within each, we recognize varying background end members caused by the continuum of glacial dispersal scales, here lumped as regional, local, and property dispersal. The regional background values change east to west, regardless of the till stratigraphic unit, for Fe, Na, Cu, Ni, Mo, Cr, V, Hg, Sb, Nb, Ga, and carbonate content. In addition, the three provenance populations have differing background levels, whose populations overlap, for carbonate content, weights of nonmagnetic and magnetic heavy minerals, and textural analyses. These populations are best shown by content, weights or nonmagnetic and magnetic neavy minerals, and textural analyses. These populations are best shown by plotting B vs. Hg, but also by Au, As, Pb, Mo, Sb, or P. False anomalies, such as the high background Se in northwest provenance tills or a high siderite content from saprolite, can be distinguished by use of this interpretation process.

In this region where supergene enrichment of either gold or base metals offers an attractive target, this geochemical method can now be used more confidently, especially in conjunction with geophysics, to explore for subcropping ore.

SPATIAL ANALYSIS OF GEOCHEMICAL, MAGNETIC AND GEOLOGICAL DATA NEAR THE SEWELL BROOK SULFIDE DEPOSIT, NEW BRUNSWICK - A PRACTICAL APPLICATION OF GEOCRAPHIC INFORMATION SYSTEMS(G.I.S.) TECHNOLOGY TO MINERAL EXPLORATION <u>MERSEREAU, T.G.</u> AND DIXON, G.S. The Sewell Brook sulfide deposit is a recently discovered Devonian age massive sulfide zone located approximately 130 kilometres southwest of Bathurst, New Brunswick, Canada. Intercepts of greater than forty per cent combined Pb-Zn over core lengths in excess of meters prompted a staking rush in which approximately 1000 claims were recorded in November-December, 1990.

December, 1990. The area was selected for spatial analysis because of the availability of comprehensive geochemical data including stream sediment and till analyses, as well as lithogeochemical analyses of outcrop.

analyses of outcrop. Recent geological mapping was digitized and high sensitivity airborne total field magnetic-gradiometer data were transferred to a personal computer for classification and subsequent spatial analysis with SPANS G.I.S. software. Stream sediment data available in digital format from the Geological Survey of Canada were also ported into the G.I.S. A resultant score map was prepared by plotting the resultants of Cu(ppm)/Cu threshold + Pb(ppm)/Pb threshold + Zn(ppm)/Zn threshold onto a digitized base map. Subsequent Voronoi

analysis of the data delineated areas of combined stream sediment Cu/Pb/Zn anomalies.

seqIment Cu/Pb/Zn anomalies. Analytical data from till samples collected by the New Brunswick Department of Natural Resources and Energy were modelled by adding the total of Cu(ppm) + Pb(ppm) at Sample sites. The resultant score map was contoured with a triangular irregular network(TIN) technique. Available lithogeochemical analyses were modelled by summing Cu(ppm) + Pb(ppm) + Zn(ppm) at each sample site and contouring the resultant. Geological mapping was digitized and input in the same sector.

summing Cu(ppm) + Pb(ppm) + Zn(ppm) at each sample site and contouring the resultant. Geological mapping was digitized and input into the G.I.S. where it was assigned topology for spatial analysis. A model was prepared by which the data base was queried for areas characterized by anomalous resultant scores in tills, stream sediments, lithogeochemical samples and which were situated within a magnetic field range and rock package similar to the Sewell Brook deposit. In addition to delineating the Sewell Brook deposit area, several other zones of high mineral potential were also outlined.

DRAINAGE SURVEY FOR Nb-Ta-Zr-Sn IN ARID CONDITIONS, NUGRUS AREA, EASTERN DESERT, EGYPT

MOHAMED, F.H., MORSY, M.A., ANWAR, Y., M. and SAAGER, R.

The study aims to conduct an orientation survey in order to select a suitable size fraction for sampling and analyses under the extremely arid conditions of Egypt. In addition, drainage survey is carried out as a systematic approach for the evaluation of the mineral potential in the area.

Orientation survey reveals that minus 1 mm fraction is preferred to minus 70 μ m fraction in the exploration for Nb-Ta-Zr-Sn mineralization in stream sediments. This is attributed to that the coarser (-1 mm) fraction is characterized by higher metal (Nb, Zr, Sn, and Rb) concentrations and a distinctly higher contrast between anomal-ous and background samples than the finer fraction. Drainage survey shows that the sediments are enriched in Nb, Zr, Sn, Zn, and Li. The probability plots for Nb, Li, Rb, Zn, Zr, Pb, Cu, Fe, K, Mn, and Mg explain that most of these elements have lognormal bimodal distribu-tions. The bimodal distribution patterns are either unmixed or mixed (overlapped). Two threshold values are obtained for each element having bim odal distribution with overlapped populations. The two estimated threshold values divide the data into three goups namely, ano-

malous, mixed, and background groups. The correlation matrix reveals two geochemical associations. the first association (Li, Rb, Zr, Zn, and K) is attributed to the weath-ering of the rare-metal bearing apogranites at the mouth of Wadi Abu Rusheid. The second association (Cu, Fe, Mn, and Mg) is related to the userbaring apogranites at the second association (Cu, Fe, Mn, and Mg) is related to the weathering of the mafic hornblende gneiss and the ophiolite melange units.

The geochemical maps of Nb, Zr, Sn, Li, Rb, Zn, and Pb exhibit spatial affinities. They indicate that abnormally high concentrations of all these elements are almost exclusively confined to the mouth of Wadi Abu Rusheid. The maps also reveal the presence of two anomalous zones which sofar have not been recognized, one at middle Wadi Sikait and the other at middle Wadi Nugrus. The two zones require further investigations.

MULTIELEMENT REGIONAL GEOCHEMICAL RECONNAISSANCE AS AN AID TO TARGET SELECTION IN IRISH CALEDONIA TERRAINS

<u>O'CONNOR, P.J.</u> and REIMANN, C. A regional geochemical reconnaissance, based upon the -150 µm fraction of active stream sediment, has been conducted by the Geological Survey of Ireland over Caledonian terrains. Thirty-eight chemcial elements (Ag, As, Au, Ba, Br, Cd, Ce, Co, Cr, Cu, Eu, Fe, Hf, Ir, La, Li, Lu, Mn, Mo, Na, Ni, Pb, Rb, Sb, Sc, Se, Sm, Sn, Ta, Te, Th, U, V, W, Yb, Zn and Zr) were determined by combined instrumental techniques (AAS and INAA). To date, the multielemental database for $\frac{1}{2}$ and $\frac{1$ some 2500 samples from these regions covers about 7,500 km².

Data analysis employed resistant non-parametric techniques (Exploratory Data Analysis) for objective selection of outlier values (anomalies) and class boundaries for each elemental distribution. Such techniques are considered more appropriate to the treatment of geochemical data where assumptions about normality are rarely, if ever, achieved. Class selection was based on the resistant selected order statistic as represented in the boxplot. Special EDA mapping symbols, designed to give equal weighting to all data values, were assigned to the relatively wide boxplot class intervals. None of the original data are redundant in the resulting geochemical maps and subtle re-gional variations can be recongnized in many instances which are directly correlatable with known bedrock mineralization.

rectly correlatable with known bedrock mineralization. The methodology was applied to data from two Caledonian terrains -- the Inishowen area of NW Ireland and the Leinster massif of Ire-land. A great diversity of metalliferous mineralization (Pb, Zn, Cu, Ba, Au, Ag, W, Li, Ta, U, Cr, Ni, Sb) is found in both terrains. The geochemical maps of Inishowen highlight the most prospective gold-bearing lithologies fairly effectively. In Leinster, the geochemical maps show the close spatial correlation of Li, Ta, U, and W with eramitic lithologies. the unceuvivocal volcanceries instaure of Cu. granitic lithologies, the unequivocal volcanogenic signature of Cu, Sb and Au, an ultramafic Cr-Ni associations of mineralized zones and new targets for detailed follow-up surveys. The geochemical patterns on the maps are also of assistance in constraining metallodefined genic models. It is concluded that EDA-based techniques offer a viable, alternative, method of geochemical mapping to those employed traditionally.

GOLD DEPOSITS AND OCCURRENCES OF THE AMANOS MOUNTAIN RANGE IN THE BASIN AND RANGE STRUCTURE OF HATAY, TURKEY OZKOCAK.M.O.

The Amanos Range, situated near the border between Turkey and Syria along Dead Sea Rift, is 25 km wide and 200 km long. This region consists essentially of Upper Cretaceous ophiolites, three-phased volcanics and Lower Paleozoic to Quaternary sediments. Upper Cretaceous Kizildag thrusting, Tertiary basin and range faulting, and Dead Sea Rift are major structural elements of the region. Between the Amanos Range oriented NNE-SSW and the Taurus Mountain Chain striking NE-SW

Kange oriented ANC-SSW and the fairus Hourtain thain striking MESW exist the intensely folded Neogene sediments. Kizildag thrusting and Hatay basin and range faulting have shap-ed local morphology and have influenced the formation of local gold mineralizations mostly proximal to the Antakya-Karasu graben. Out-side the boundaries of the graben, gold and silver as well as the base metals decrease obviously.

Two categories of gold potential are: gold deposit of Kisecik and gold occurrences.

The Kisecik deposit is situated 14 km NW of Antakya on the SE border of the Amanos Range between horst and graben. A joint venture, Nerco Minerals Co. (Vancouver-Wash-USA) and Yurttaslar Minig Opera-tions Industry and Trade Co. (Turkey) has in 1987 acquired explora-tion licenses. The exploitation right for a sector is realized and tion licenses. The exploitation right for a sector is realized and exploration continues in the other sectors. Mineralized area is form-ed entirely in ophiolitic rocks, mainly peridotites, dumites, gabbros, olivine-bearing gabbros, pyroxenites and sheeted dikes. Gold mineral-ization formed hydrothermally at 250°-300° coccurs along the fault in brecciated gabbros and in the diabase-diorite dikes. The veins strike generally E-W and dip 70°-90°. Gold in the form of genreally 5 to 20 micron-sized free grains is accompanied by pyrite, chalco-pyrite, arsenopyrite, hematite, sphalerite, quartz with an important hydrothermal alteration showing yellow, red, and white colors. Its guide is arsenic compounds. In the explored sector, 3,250,000 tons of ore with 6 gr/ton Au have been calculated. The production will be underground and open pit. Heap leach by cyanidation will be applied

of ore with 6 gr/ton Au have been calculated. The production will be underground and open pit. Heap leach by cyanidation will be applied to the poor ore of less than 4 gr/ton Au and agitation leach to the rich ore. The final production will be 1,500 kg of gold per year. Fifteen interesting areas for gold are reported in the Amanos Range, mostly situated on the borders of the range between the horst and graben and comprising very often realgar, orpiment, sulfur, pyr-ite,marcasite, chalcopyrite, sulfurous water and sinters. Frequency and location of the mineralizations of the Amanos R. remind the Humbol the parts.

remind the Humbolt Range, Midas structural zone and the Florida Canyon gold deposits, Pershing County, Nevada. The Kizildag thrust-ing and the basin and range faulting also remind the Antler thrust-ing and the Buckhorn basin and range faulting with gold and silver mine, Eureka County, Nevada.

Favorable geological features of the Amanos Range and related gold mineralizations and similarities with other important mineral-ized areas in the world indicate that large additional potential resources may exist in the Hatay region of Turkey.

GOLD-BEARING ANTIMONY DEPOSIT OF AFYON-BAYAT-DOGLAT VOLCANIC AREA. TURKEY OZKOCAK,M.O.

The antimony deposit of Doglat, situated at $30^{\circ}49'$ E and $39^{\circ}03'$ N, 45 km ENE of Afyon, on the Afyon-Ankara highway near the county of Bayat, is included in the Afyon zone of the Anatolides, which is a

bayat, is included in the high zone of the Anatorius, which is a typical shelf-type Paleozoic-Mesozoic sequence of the Taurides and forms the cover of the gneisses of the Menderes massif. The area consists of Paleozoic mica schists, marbles and Neogene volcanic rocks (andesites, dacites, and tuffs). Mica schists are encountered on the road from Doglat village to the Maden Tepe Hill. Marbles occur just above the mica schists and mineralization. Vol-canics, generally green colored because of propylitization, are em-Calics, generally green colored because of propylfization, are em-placed on the northern side of the big open pit. Dacitic and ande-sitic tuffs, outcrops of green and red opal, hydrothermal breccia and brecciated silics occur on the upper part of the volcanic rocks. A big fault zone trending E-W, dipping 80 N, about 2 km long and 500 m wide, dips under the volcanic rocks. Mineralized area, repre-

sented essentially by the big fault zone can be followed toward the westernside by thick silicified zones with a big quartz vein cut-ting the marbles; 1.5 km WSW exists Saphane Dagi (alumite mountain hill). Just on the eastern flank of Maden Tepe, along the fault zone are emplaced from the elevation of 1600 m to 1535 m, Georman shaft pit, open pit II and open pit I. These pits, explored with a drilling program of 2000 m, consist of a red-yellow colored, very frac-tured and friable alteration zone comprising Sb oxide (stibiconite), limonite, kaolinite, marble fragments, quartz lumps and lenses. Over the open pit zone occur marbles cut and intruded by Sb-oxide veins. On the floor of the open pit I is yet encountered antimony sulfide in the silicified rocks.

At the elevation of 1500 m occurs the water table which provides water supply for Doglat village. From the elevation of 1535 m downward exists a silicified zone about 100 m thick as a massive silica cap comprising brecciated structures, cavities, open fractures, small euhedral quarz crystals, pyrite in euhedral crystals, veinlets and assemblages, and rarely free gold in the form of fine grains. Beneath the silica cap occurs a gray-colored alteration zone with more or less carbonaceous matter comprising sericite, illite, quartz and quartz veins. Altered mica schists and quartz veins contain pyrite also in different forms, rearely free gold in fine grains, yellowish calcite, black samll ssurfaces of silver, and rarely small grains of sphalerite.

From the uppermost quartz vein to the floor of the open pit I, silver grades change from 0.5 g/ton, 5 gr/ton to 14 gr/ton. A big sample of 200 kg representing the oxide alteration zone assyed 118 ppb gold. From the German shaft pit to the floor of the open pit I, antimony oxide assays from 10%, 2% to 0.81% Sb with an average grade of 3.41% Sb. Below the water table no Sb sulfide is encountered.

In conslusion, hydrothermal aclutions seem to encounter the water table in the redox boundary and boil; precipitation of gold, silver and pyrite occurred as a result of changing thermodynamic conditions such as boiling, cooling, mixing, decrease in temperature and total sulfur, and increse in pH. Vapor phase ascending upwards gave anti-mony sulfide with small amount of gold and silver. Rising hydrothermal solutions altered the metamorphic schists to a reduced gray zone; as boiling continued, H,S exsolved to H,SO, causing extensive acid leaching and so antimony sulfide has been almost completely transformed into antimony oxide, pyrite into limonite, and finally oxide alteration zone occurred.

DISTRIBUTION AND DISPERSION OF GOLD IN SEDIMENTS OF THE HUAI HIN LAEP, LOEI, NORTHEASTERN THAILAND <u>PAOPONGSAWAN,P</u>. AND FLETCHER,W.K. Gold anomalies in drainage sediments are often erratic. This reflects both rarity of gold particles and hydraulic effects whereby gold is concentrated at favourable sites along the stream. This study investigates these factors in a stream in northeastern Thailand. The Huai Hin Laep. a third order stream during a perior

northeastern Thailand. The Huai Hin Laep, a third order stream, drains a region of gently rolling hills 40 km east of Loei. Gold mineralization is thought to be associated with quartz veins in the stream's headwaters. Climate is monsoonal with a rainy season from May to October and an annual rainfall of 1300 to 1500 mm. Soils are laterites and podzols that developed under a mixed evergreen forest. However, within the last decade the forest has been removed and land converted to agricultural use. Probably as a consequence of deforestation and increased soil erosion, stream sediments are claverich gravels containing only very minor amounts of are clay-rich gravels containing only very minor amounts of to fine sand.

are clay-rich gravels containing only very minor amounts of medium to fine sand. Bulk sediment samples, each consisting of approximately 40 kg of -12 mm material, were collected from bar and pavement sites along a 6 km study reach. Samples were wet sieved into eight size fractions. The five fractions between 420 μ and 53 μ were then processed to obtain heavy mineral concentrates (SG >3.3). Gold content of all fractions finer than 420 μ was determined by fire assay-atomic absorption. Concentrations of gold in the heavy mineral concentrates (SG >3.3). Gold content of all fractions finer than 420 μ was determined by fire assay-atomic absorption. Concentrations of gold in the heavy mineral concentrates typically range from 10,000 to 50,000 ppb (maximum 198,000 ppb) whereas the corresponding light mineral and -53 μ fractions almost always contain <5 ppb gold. Estimates of the median number of gold particles in the heavy mineral concentrates increase from less than one at 212-420 μ to seven in the 53-106 μ size range. However, because of dilution by the light mineral and -53 μ fractions, the probability of a 30 g (fire assay) sediment sample containing a particle of gold is very low and thirteen out of sixteen -150 μ sediment samples failed to detect the gold anomaly. Insofar as this results from dilution of the heavy mineral concentrate by large quantities of -53 μ sediment, failure of conventional sediment samples to reliably detect the anomaly is probably a consequence of deforestation. Despite the large size of the field samples, the rarity of gold particles causes its distribution along the study reach to be somewhat erratic. Nevertheless, it is apparent

reach to be somewhat erratic. Nevertheless, it is apparent that rather than following an ideal anomaly-dilution curve, whereby concentrations decrease downstream from the source, gold values increase downstream although abundance of heavy minerals remains more or less constant. We attribute this to the greater density of gold causing its more effective trapping during sediment transport. Trapping efficiency of bar and pavement sites for gold appears to be roughly similar and without the large differences in concentrations that have been reported elsewhere between high and low

that have been reported elsewhere between nign and low energy sites. With respect to exploration it is apparent that heavy mineral concentrates are much more reliable than conventional sediment samples in detecting the gold anomaly in the Huai Hin Laep. This has the advantage of requiring a low sample density but, because anomalies may increase downstream away from their source, careful interpretation is required during follow-up.

USE OF REGIONAL AND DETAILED TILL GEOCHEMISTRY IN EXPLORATION FOR TUNGSTEN IN SOUTHERN FINLAND PEURANIEMI, V. J.

Heavy mineral till geochemistry was selected as a regional prospecting method

Heavy mineral till geochemistry was selected as a regional prospecting method when tungsten exploration was initiated in the volcanic-sedimentary schist area of Hämeenlinna in southern Finland. Altogether 3500 heavy mineral till samples were gathered with a spade from a depth of 0.5-1 metre (C soll horizon) from an area of 2700 km², using a sparse sampling grid along the roads. Some deeper survey and sampling pits were also dug with a tractor excavator, mainly in ore-critical areas. A denser sampling grid was used in areas where ore boulders or mineralized outcrops were known to occur. The till samples (each of 8 1) were concentrated in the field by slucing with a riffle box and then panning. This method is cheaper than the earlier one, which used heavy liquids in the laboratory. The wet-sieved -2 mm fraction was concentrated, dried and sieved into two subfractions: -0.5 mm and 0.5-2 mm. Magnetite was then removed and weighed. The non-magnetic fraction was studied with a stereomicroscope under UV light and the number of scheelite grains present was counted. It was then divided into two parts, one to be stored for later mineralogical examination and the other to be sent to a chemical laboratory where the concentrations of 30 elements were analyzed by XRF.

to a chemical laboratory where the concentrations of 30 elements were analyzed by XRF. Conventional fine fraction till geochemistry was used in the detailed phase of the exploration, i.e. when looking for the source rock of the scheelite ore boulders or scheelite heavy mineral anomalies. The till samples were taken with a lightweight percussion drill from as deep as possible. In some places a very dense sampling grid was adopted (point spacing 5 m) in order to get an exact picture of the dispersal pattern. The results of the heavy mineral geochemistry showed that the sampling density used (0.5-2 samples/km²) was generally satisfactory, so at least one sampling point hit the dispersal train. One scheelite deposit known earlier from an outcrop (Hieronmäki), were not found by means of this regional sampling grid, however. The Hieronmäki scheelite deposit is located in the cover moraine area, where the giaciogenic dispersal found by conventional detailed till geochemistry was from 10-30 metres to 200 metres.

Another scheelite prospect (Vahervuori) also situated in the cover moraine area, was found in the form of a one-sample heavy mineral anomaly. A narrow, coherent fan-shaped tungsten anomaly 600 metres long was located in The fine fraction of the till as a result of the detailed prospecting. One of largest and most intensive scheelite anomalies ever found in Finland

occurs around Lake Tömäjärvi. The area can be regarded as a ground moraine with a moderate thickness of till. The small drumlin field nearby is indicative of an active ice flow.

Tungsten content was highest in the fine fraction of some of the sieved till samples from Tömäjärvi and in the coarser fractions of some others. Thus the behaviour of scheelite in the face of glacial milling differs from that of sulphide minerals, which are very quickly ground to a fine grain size, as also seen at Tömäjärvi. The influence of sampling density on the form and size of the predicted heavy mineral anomaly could also be tested at Tömäjärvi. The the predicted heavy mineral anomaly could also be tested at Tömäjärvi. The heavy mineral survey revealed a clear scheelite dispersal train in the active-ice hummocky moraine area of Kanajärvi, whereas the dispersal pattern in the fine fraction of the till was quite incoherent. Several promising scheelite occurrences were found as a result of geochemical exploration. The scheelite deposits of the Hämeenlinna area are mainly of two types: I. Scheelite in skarn rocks within basic volcanics, and 2. Scheelite disseminations and parallel bands in basic volcanics. It may be said on the strength of this research that the Hämeanlinna volcanite area is one of the principal tungstern provinces in the Hämeenlinna volcanite area is one of the principal tungsten provinces in

GEOCHEMICAL ATLAS OF NORTH CAROLINA -- NURE DATABASE AND GEOCHEMICAL APPLICATIONS FOR STATE GOVERNMENT REID, J.C.

The North Carolina Geological Survey (NCGS) is preparing a geochemical atlas of North Carolina using the National Uranium Resource Evaluation (NURE) data. Before termination of the NURE program sampling of nearly the entire state (49,097 square miles of land area) was completed and geochemical analyses were performed.

The NURE data is applicable to mineral exploration, agriculture, waste disposal siting issues, health, and environmental studies. Applications in state government include resource surveys to assist mineral exploration by seeking geochemical anomalies and areas of mineralization. Agriculture seeks to identify areas with favorable (or unfavorable) conditions for plant growth, disease, and crop productivity. Trace elements such as cobalt, copper, chrome, iron, manganese, zinc, and molybdenum must be present within narrow ranges in soils for optimum growth and productivity. Trace elements as a contributing factor to disease are of concern to health professionals. Industry can make use of pH and conductivity water data to site plants which require specific water quality. The North Carolina NURE database consists of stream sediment

samples, ground water samples, and stream water analyses. The statewide database consists of 6,744 stream sediment sites, 5,778 ground water sample sites, and 295 stream water sites. Neuron activation analyses were provided for U, Br, Cl, F, Mn, Na, Al, V, Dy, in groundwater and stream water, and for U, Th, Hf, Ce, Fe, Mn, Na, Sc, Ti, V, Al, Dy, Eu, La, Sm, Yb, and Lu in stream sediments. Supplemental analyses by other techniques are reported U (extractable), Ag, As, Ba, Be, Ca, Co, Cr, Cu, K, Li, Mg, Mo, Nb, Ni, P, Pb, Se, Sn, Sr, W, Y, and Zn were performed on 4,619 sediment samples. A small subset of 334 samples was analyzed for gold.

The initial goal is to make available the statewide NURE data with minimal interpretation to enable prospective users to modify and manipulate the data for their end use without bias.

The atlas maps for each of the elements are computer generated at the state's geographic information system (Center for Geographic Information and Analysis) with the assistance of the Division of Statistics and Information Services. The maps in the atlas are point maps. Each sample is represented by a symbol corresponding to a quartile class. Openfile reports will transmit sample and analytical data for state regions. Data is tentatively planned to be available on disks in spreadsheet format for personal computers.

Plans are underway to assign samples to state geologic map unit names using a GIS system to determine statistically valid background and anomaly values. Subsequent publications are envisioned to make this geochemical data available to a wide spectrum of interdisciplinary users. Major interpretive efforts are planned.

GEOLOGIC MAPPING AND GEOCHEMICAL SAMPLING FROM A LIGHT AIRCRAFT IN FLIGHT -A PROGRESS REPORT SAINSBURY, C. L.

SAINSBURY, C. L. Typical results of 18 years of contract mineral exploration using a Super Cub in flight to do both geologic mapping and geochemical sampling of soils, stream sediments and vegetation will be discussed-methods first revealed to the exploration industry in a paper presented at the Third International Exploration Symposium in London in 1972. Several hundred dependable geologic quadrangle maps were prepared by the writer working all alone in the aircraft, ranging from west Texas throughout many of the western States to and through the Brooks Range in northern Alaska. Examples of typical geologic maps will be shown. Data will be presented from a geobotanical exploration for uranium

in Alaska in which hundreds of conifer tops were collected while the aircraft remained airborne over a northern spruce and birch forest so dense as to prevent even helicopter landings. Although the explored uranium-rich granite was covered by moraine and outwash gravels, ashed Conifer tops above the deposit contained more than six times the back-ground values of uranium (12 ppm versus less than 2). Sampling devices and retrieval systems for use with both the light aircraft and helicopter will be shown, including a "momentum" sampler

for use with the helicopter which allows soil samples to be taken near a predetermined depth beneath dense vegetation cover. If time permits, spectrometer charts will be shown from a test area

in California showing that even saturated soils and rocks do not perceptibly effect airborne gamma-ray count. The tremendous advantages gained from rapid airborne geologic map

ping prior to both radiometric and magnetic surveys will be briefly dis-cussed. Such mapping greatly facilitates the interpretation of such surveys. All maps and charts displayed will be taken from in-house work done by AirSamplex Corporation.

At the conclusion of the presentation, all the existing patents held by the writer and assigned to AirSamplex Corporation will be opened to the exploration industry for unrestricted international use.

GEOCHEMICAL CHARACTERISTICS OF EPITHERMAL PRECIOUS METAL MINERALIZATION IN ARID TERRAINES OF THE LOS FRAILES-KARIKARI VOLCANIC FIELD, POTOSI REGION, BOLIVIA SCHNEIDER, A., MEDINA, A., RIERA C.

Epithermal volcanic and carbonate hosted environments of the Los Frailes-Karikari region are currently subject of a major joint exploration program of the German and the Bolivian

joint exploration program of the German and the Bolivian Geological Survey. The volcanic field forms part of the tin-silver province of the Eastern Cordillera for which Bolivia is famous. Wellknown is the historic Cerro Rico at Potosi which has been the worlds largest silver resource. The project area encompasses 15.000 km² of the largest volcanic province in the Eastern Cordillera of the Central Andes, which is composed of mesetaforming ashflow tuffs erupted from underlying acid eruptive centres and isolated resurgent calderas.

erupted from underlying sold eruptive centres and isolated resurgent calderas. Bulk mineable epithermal potential lies within the higher, less eroded sections of the volcanic cover rocks which were intruded by acid to intermediate stocks and flow dome complexes as well as in carbonaceous sections of the Cretaceous.

Cretaceous. In the arid terrains of the Central Andes specific strategies are required in order to explore succesfully a complex polymetallic epithermal environment. Here, apart from Ag and Au, elements such as Sb-Bi-Sn-Pb-Zn-U may occur not only as pathfinders but also as mineable ore. Stibnite, native bismuth, colloform tin and uranium may form easily within the near surface environment, while Pb-Zn are principal components of all epithermal sulfide and sulfosalt phases. phases.

These strategies include an extensive geochemical survey, TM Landsat imagery, geological mapping and interpretation and geophysical exploration. The geochemical exploration program included the base and

The geochemical exploration program included the base and precious metals and Sb, As, Sn, Bi, Tl, Hg, W, Ba, Mn, Li, Mo, B and Be. Sampling methods applied included stream sediments, water, soils and rocks. Sampling tests demonstrated the poor sorting and transportation of the still coarse sediments within a reduced and only periodically active drainage system within the arid volcanic terraines of Bolivia.

Preliminar results indicate that the Bolivian epithermal environments are Ag dominated with Sb, Pb, Bi and Au as possible economic byproducts. Stream sediment results show distinct dispersion halos

Stream sediment results show distinct dispersion halos for elements such as Ba, Ag, Sb, Pb and partly Au, within about 3-8km of the potential zone. Water analysis are indicative for Sb, Li, B, Zn and Au, in part 10 km away from altered areas. Rock geochemistry from potential areas show distinct relationships between Au-Ag and Tl and enrichment levels in Li, As, Bi, W and Hg. Sn is however in general not a good indicator as this element can be present in all types of hydrothermal environments.

of hydrothermal environments. Basemetals too are not a good indicator for epithermal mineralization and levels for Cu, Zn, Co, Ni, Cd in the volcanic areas are generally lower than "Clarke Values".

REGIONAL GEOCHEMICAL SIGNATURES OF LODE AU AND CU DEPOSITS IN THE WESTERN HALF OF THE REDDING 1 X 2 DEGREE QUADRANGLE, NORTHERN CALIFORNIA

SILBERMAN, M.L., HASSEMER, J.R., and SMITH, S.M.

GEOLOGY:

The western half of the Redding quadrangle contains parts of two physiographic provinces: the Coast Ranges, and the Klamath Mountains. Both provinces consist of a series of accreted tectono-stratigraphic terranes of island arc and oceanic rocks. The terranes are separated by eastward dipping thrust faults, many of which contain ultramafic intrusions and gabbro plutons that are parts of ophiolite complexes. Both provinces contain meta-sedimentary and meta-volcanic rocks, but only the Klamath Mountains are intruded by granitic plutons and associated hypabyssal rocks.

MINERAL DEPOSITS.

Lode gold deposits occur throughout the Klamath Mountains, but most production has come primarily from the eastern part of the Province. The most common lode deposits are metamorphic type gold-quartz fissure veins, similar to those along the Mother Lode Belt. Host rocks similar to those along the mother Lode Belt. Nost rocks include meta-sedimentary, meta-volcanic and granitic rocks. Significant by-product Au has been won from volcanogenic massive sulfide deposits; in addition, scarn deposits have also produced Au. Sold-bearing quartz veins are associated with granitic intrusions. Particularly in the more productive districts, hypabyssal intrusions related to the plutons are intimately associated with and

in many cases host the veins. Cu, with significant Zn, Pb, Ag, and Au is found mainly in volcanogenic massive sulfide deposits hosted in felsic meta-volcanic rocks in island arc terranes. The eastern part of the province contains most of the larger

deposits, although smaller ones occur throughout the region where meta-volcanic rocks are present. Copper also occurs in base- metal-rich quartz veins, and with Cu-sulfides disseminated in serpentinite and diorite. Many these deposits are also Au-bearing. of

In the Coast Ranges Province, Au and Ag occur as components of Cu-, Zn-, Pb- bearing massive sulfide deposits hosted in meta-volcanic or meta-sedimentary rocks of the Franciscan Assemblage. They also occur within quartz veins and are associated with Cu sulfides disseminated in serpentinite and diorite. Small gold-bearing quartz veins are also found in sandstone, shale, and glaucophane schist. GEOCHEMISTRY OF DEPOSITS:

Regional stream-sediment geochemical sampling, both within and outside of areas containing known Cu and Au deposits, complimented by detailed study of the geochemistry of lode Au deposits and reconnaissance study of massive sulfide Cu deposits is in progress. Trace-element associations in the Au-bearing quartz veir varies from district to district. Quartz veins hosted in the same lithologies have similar overall trace metal assemblages, but differ in some element concentrations and assemblages, but differ in some element concentrations and ratios. The volcanogenic massive sulfide deposits also have overall geochemical similarity, but differ in some element concentrations. Many elements, including important indicators such as As, Ag, Zn, Hg, and Au occur in both Au and Cu deposits. Cu, Pb and Zn also occur in both deposit types, although contents are much higher in the massive sulfides.

STREAM SEDIMENT GEOCHEMISTRY:

STREAM SEVIENT DECOMPTIONS: Drientation stream-sediment sampling was carried out within the French Gulch-Deadwood and Canyon Creek-East Fork mining districts, two of the larger Au producers in the Klamath Mountains (1 million and 200 thousand ounces, respectively). Both districts contain metamorphic. fissure- vein-type, Au-bearing quartz veins. At French Bulch high As content is associated with Au in the quartz Build night as content is associated with Hu in the quartz veins, which are hosted in argilits, greywacke and hypabyssal intrusive rocks. At Canyon Creek moderately high As, Pb and Zn, and strongly anomalous Hg are associated with Au in quartz veins hosted in amphibolite and schist. In both districts Ag is associated with Au in

The veins, but in variable and inconsistant amounts. Samples of -80 mesh stream-sediment samples from both districts are anomalous in Au (up to 2 and 5 ppm, respectively). Elevated As and Hg contents in the sediments delineate Au-bearing areas at French Gulch, and are accompanied by weak to moderate anomalies of Ag, Mo, Pb, and Zn. At Canyon Creek, Fe, Hg, and to a lesser extent As in the sediments correlate with Au occurrence, and are accompanied by weak to moderate anomalies of Cu, Pb, Zn, and other elements.

Drientation stream-sediment samples in the briefficient of Fernander and the second sec bearing, and produced significant by-product Au.

Inspection of regional stream-sediment data from the western Redding guadrangle and surrounding areas indicate that areas containing lode gold deposits have -80 mesh stream-sediment anomalies of Au, As, Hg and also Cu and Zn. Areas containing Cu deposits have anomalies of Cu, Zn, Pb, Au and Ag. An overlap occurs in anomalies that signify the presence of Au and Cu deposits.

The stream sediment data in western Redding delineate extensions to known areas of occurrence of Cu and Au deposits, and also indicate anomalies in areas where no known deposits occur. The strongest anomalies appear to cluster along certain terrane boundary thrust faults, particularly the Coast Ranges Thrust, which forms the boundary between the Klamath Mountains and the Coast Ranges. The data are suggestive of significant metal flux of metal concentrations still within them.

INORGANIC GEOCHEMISTRY AND MAGNETIC SUSCEPTIBILITY OF SOILS OVER HYDROCARBON DEPOSITS IN THE KRISHNA BASIN, LINGALA AREA, A.P. INDIA

SITARAMAYYA, S., SHIVA KUMAR PATIL., RAO, G.V.S.P.

An orientation geochemical survey was undetaken to study the magnetic susceptibility of soils in relation to the known occurrences of hydro-carbon deposits in the Lingala area of the Krishna-Godavari Basin. carbon deposits in the Lingula area of the Krishna-Godavit bashin The Oil and Natural Gas Commission, India, located some oil and natural gas deposits both on-shore and off-shore in this region. Hydrocarbon deposits occur in the Eocene sandstones in structural as well as stratigraphic traps. Some of the pools are associated with basement ridges, which are found at a depth of about 2000

m. Soil samples were collected in a 1 km square grid over an area of 120 sq.km. Diethylenetriaminepentaacetic acid (DTPA) soil extract-ions with a two hour contact time were used for determining the Fe, Mn, Cr, Cu and Zn contents. This was done to understand the migration of the chelated metal content of the soils. All the elements studied have indicated a negative anomaly area where the values are below background and all the producing wells are located in this area. These low values rise abruptly near the boundary and fall to background values outside these areas. The distribution of iron values indicate compact anomalous areas with

sharp boundaries compared to other elements.

Magnetic susceptibility of the soils was determined and magnetic susceptibility anomaly maps were prepared using this data. Magnetite was separated from part of the sample. A bi-log graph showing magnetite weight per cent versus magnetic volume susceptibility indi-cated that most of the magnetic susceptibility is due to magnetite

The magnetic susceptibility distribution map is similar to the Fe anomaly map. Low values (less than background) are found over hydrocarbon pools compared to the areas outside. The location of the anomalous values coincides with the distribution of DTPA - extractable Fe values.

ctable Fe values. A multiparametric anomaly map seems to enhance the reliability of the interpretation as all the productive wells fall within the anomalous zone and all the barren wells fall outside this zone. From the data obtained it is inferred that the hydrocarbons migrate upwards, chelate the metals in the surface soils and migrate to the periphery depleting the DTPA - extractable metals in the centre. Reduction and mobilization of Fe and Mn oxides also takes place and these migrate to the periphery along with other chelated metals where the hydrocarbons get oxidised and dump their metal content. Authigenic magnetite forms and accumulates near the peri-phery in the soils. That hydrocarbons with their associated metal content are available over the oil pool is indicated by the high metal content in the plants. Though a higher metal content is extra-cted by the DTPA from soil samples near the periphery apparently all this is not available to the plants. These two soil methods are reliable prospecting methods capable

of locating even small oil pools in stratigraphic traps and are cost and time-effective.

DEVELOPMENT AND TESTING OF THE CHIN ELECTROGEOCHEMICAL EXPLORATION METHOD

SMITH, D.B., HOOVER, D.B., and SANZOLONE, R.F.

EXPLORATION METHOD <u>SMITH, D.E.</u>, HOUVER, D.B., and SANZOLONE, R.F. The CHIM electrogeochemical exploration technique was developed in the Soviet Union approximately twenty years ago and has become a routine mineral exploration tool in that country. CHIM is an acronym for the Russian phrase "chastichnoe izvlechenniye mettalov" which means "partial extraction of metals". The method is claimed to be particularly effective in the exploration for concealed mineral deposits which are not detectable by other geochemical or geophysical techniques. Soviet explorationists cite case histories in which concealed mineral deposits have been found through several hundred meters of barren cover in a variety of geologic settings. The basics of the CHIM method are relatively simple. A stable, high-voltage direct current source provides current to an anode and an array of special collector cathodes. Current to the individual collector cathodes is in the fange of 0.1 to 0.5 amperes and collection times range from 6-48 hrs. The anode may be an iron, steel, or carbon rod. The collector cathodes consist of a graphite or titanium rod inside a cylinder containing a solution of nitric acid. Electrical contact with the base of the cylinder. Mobile cations from soil in the vicinity of the cylinder are collected in the nitric acid or on the inner rod during passage of the current. Upon cessation of the electric current, the cathodes are retrieved and both the nitric acid solution and the graphite or titanium rod are analyzed for metallic elements that accumulated under the influence of the electric field. The U.S. Geological Survey is in the process of developing CHIM capabilities and testing the technique on a number of mineral deposit types. Early work consisted of developing and testing electronics, testing electrode designs, and testing different types of low-permeability membranes in the laboratory. This work was successfully completed and the first field tests were begun at the Kokomo mine near Cent

1990. The current field system obtains power from a trailer-mounted 15-KW, 400-Hz diesel generator and a Zonge Engineering I.P. transmitter using 50-1,000 V and 0.2-4.3 amperes; the transmitter is mounted in a pick-up truck. Direct-current output goes to a multichannel ampere-hour meter having 31 ancde and 31 cathode positions to monitor the total charge transfer during a run. Current from the meter is adjusted for individual collector electrodes in an optional rheostat bank and distributed through multi-conductor cables to the electrodes. Cathodes for the field test consist of a titanium or graphite rod suspended in 4N nitric acid housed in a PVC body. A parchment membrane through which current passes is held in place on the base of the unit with an O-ring. O-ring.

O-ring. The field tests at the Kokomo mine were conducted over a 2-meter wide vein containing Cu, Pb, and Zn sulfides and precious metals. The vein is covered by approximately 3 meters of colluvial material. Standard geochemical soil sampling showed only weak anomalies in Cu and Zn above the vein, with anomaly-to-background ratios of about 2. The CHIM method showed anomalies for these same elements with anomaly-to-background ratios of about 20.

CORRELATION BETWEEN THE MINERALOGICAL AND CHEMICAL COMPOSI-TION OF FINE STREAM SEDIMENT: APPLICATION TO GEOCHEMICAL EXPLORATION IN A TROPICAL RAIN FOREST.

<u>TOSIANI, T</u>, and TAPICAL KAIN FOREST. <u>TOSIANI, T</u>, and TAPICA, J. In tropical rain forests, where the chemical weathering reaches a high degree, the major mineralogical phases present in the stream sediment are clays, quartz, iron and manganese secondary oxides, and organic matter. Because the silt-clay fraction of sediments is able to concentrate and transport elements associated to since the silt (Silveray iraction of sequences is able to concentrate and transport elements associated to mineral deposits, it is common in the geochemical prospecting literature to recommend that the grain size of the sediment to be analyzed should be less than 100-mesh. However, little attention is paid to the relation between the chemical and mineralogical composition of the stream sediments and their bydrodynamical environment of deposition

mineralogical composition of the stream sediments and their hydrodynamical environment of deposition. In this work we define two types of fine sediments in relation to its hydrodynamical environment of deposition. The first are the silt and clay sampled in the stream bottom, associated to high hydrodynamical energy (samples BS); and the other is the silt and clay deposited from suspended material when the stream energy decrease (samples DS). Eighteen BS samples and 36 DS samples, both sieved to -230-mesh, were taken from streams and rivers that drain different lithologies. The analytical results show that the BS and DS samples

different lithologies. The analytical results show that the BS and DS samples have quite different chemical composition despite to the fact that they are composed by the same mineralogical phases. The BS samples show a low concentration of absorbers phases (clay and oxides) and total and extractable Cu, Co, Ni and Cr, with high concentration of zircon and quartz. On the other hand, the DS samples have the highest average of absorbers phases and transition elements, and the lowest concentration of zircon and quartz. Both type of samples can be discriminated by the proportions of Fe₂O₃, SiO₂ and Al₂O₃, which are correlated with their mineralogical composition estimated by X-ray diffraction.

Differences in proportions of mineralogical phases of the fine sediment samples (Fe-Mn oxides, clays, quartz and zircon) are the result of differences in the sources areas and hydrodynamical characteristics of site of deposition. and hydrodynamical characteristics of site of deposition. During geochemical sampling of fine sediments it is impossible to take all samples in the same hydrodynamical condition and from the same source, it is necessary to check how many populations are present in function of the mineralogical phases, and determine the proportion of absorber phases, clays and oxides, with respect the inert phase guartz before any interpretation.

GEOCHEMICAL FEATURES AND EXPLORATION GUIDES OF Se AND Te IN THE HETAI GOLD MINE WANG, M.Q.

Se and Te exist in almost all gold deposits (Boyle, 1979). Due to analytical difficulty, however, systematic research on geochemical features of Se and Te in the gold deposits in China has hardly been carried out. The Hetai gold mine in Guangdong, discovered in 1984, is a Jiaojia-type (altered host) gold mine. Gold ore bodies occur in large mylonite belts and are hosted in quartz schist. Quartz, sericite and feldspar are the main gangue minerals. Pyrite and chalcopyrite are the main opaque minerals. The majority of natural gold grains are less than 0.01 mm in size.

226 samples, including 75 samples of the orebodies from gold de-posits and 101 systematic drill core samples (one sample/1-10 m) and 50 samples of soil from the Gaocheng gold deposit which locates to the north of the Hetai gold mine and is the largest gold deposit in this area, were collected in 1987. For all samples, Au was determined by AAS and Se and Te by AFS.

The results suggest: (1) In the samples from orebodies the con-tents of Se and Te show strongly positive correlations with the Au content and Se-Te show strongly positive correlation. (2) Se and Te in the rock are good guides to prospect for gold deposits in this area. (3) The anomaly of Te in the soil can be found only on the exposed gold ore bodies and no anomaly of Se in soil can be found both on blind and exposed gold orebodies. (4) The decrease in the contents of Se and Te and the Te/Se ratio in the orebodies of different gold deposits from the north to the south may indicate that gold mineralization is stronger in the north than in the south in this area.

DIAMONDIFEROUS KIMBERLITE IN SASKATCHEWAN - A BIOGEOCHEMICAL STUDY DUNN, C.E.

The news that an outcrop of kimberlite had been discovered in central Saskatchewan was first released late in 1988. This announcement was particularly surprising in that the kimberlite occurs in an area of low mineral potential where Phanerozoic sediments are 1000 m thick. Furthermore, glacial deposits are known to be up to 300 m thick in this part of the province. The flurry of land-staking and exploration activity following the discovery led to evaluation of methods appropriate for finding more kimberlite pipes, perhaps concealed by substantial thickness of sedimentary rock and/or overburden. Subsequently, more kimberlite has been found and two macro-diamonds, up to 4 mm in diameter, have been reported.

Most kimberlites are characterized by high contents of: a) elements compatible with ultramafic rocks - Mg, Cr, Ni, Co; and b) 'incompatible' elements that are considerably more concentrated than is usual in ultramafic rocks - especially K, P, Zr, Nb, Sr, Ba, Rb, Cs and the light rare-earth elements. Data on the biogeochemical response to kimberlites are scarce. Therefore a study was conducted to determine if enrichment of elements could be detected in trees and shrubs growing over kimberlite and thereby assist in the discovery of other kimberlite pipes.

The three most common species in the study area are aspen (Populus tremuloides), dogwood (Cornus stolonifera) and hazelnut (Corylus cornuta). Twigs of each were collected at 32 sites from the vicinity of the Sturgeon Lake kimberlite. Samples were ashed at 470°C and analyzed by INAA, ICP and ICP/MS for more than 50 elements.

Three elements exhibit a strong spatial association with respect to the kimberlite: a) Ni enrichment occurs in dogwood; b) Sr levels in all three species are higher over the kimberlite than the surrounding sediments; and c) Rb mimics the Sr pattern, but with a striking difference of concentrations over the kimberlite (up to 290 ppm Rb) relative to samples from over the surrounding Cretaceous sediments (10 - 20 ppm Rb). Rubidium is an alkali metal which is extremely soluble, especially as a carbonate. Carbonate veining is characteristic of the kimberlite, therefore Rb could be mobilized as a carbonate from the kimberlite (where it may be substituting for K in phlogopite) and transported in solution until it is absorbed by plants in the acidic environment around their roots.

In this environment the recognition of relative enrichments of Rb, Sr, and Ni in vegetation may assist in detecting kimberlites at shallow depth, especially if there is any upward movement of groundwaters.

FIELD REFLECTANCE SPECTROSCOPY APPLIED TO PRECIOUS MINERAL DEPOSIT EXPLORATION

HAUFF, P.L., Kruse, F.A., and COCKS, T.

Short Wave Infrared Spectroscopy (SWIR) was established during the 1970's as a technique that could be used to identify hydrothermal alteration zone minerals by the work of Graham Hunt, John Salisbury and colleagues. Instrumental developments in the past decade have made it possible to transport this technique into the field and apply it to mineral exploration.

The SWIR method is most effective with clay minerals such as illite, kaolinite, smectite, and dickite; with the sulfates like alunite and jarosite; and with the carbonates such as dolomite, calcite and siderite. All these species are commonly seen in hydrothermal alteration zones and each have distinctive SWIR (1.2 - 2.5 µm) absorption bands. Digital feature extraction software has been developed allowing identification and characterization of features from carbonate, sulfate and hydroxyl-bearing minerals in the 2.0 to 2.5 µm region; from water and hydroxyl features, near 1.4 µm and from water features at 1.9 µm. The software has the additional capability of comparing unknown spectra against a data base of characterized minerals from known deposits.

The distribution of these minerals and changes in their structural ordering (reflecting changes in temperature and/or fluid chemistry) can be diagnostic of zones in a deposit. Degree of ordering or "crystallinity" can be numerically classified and appears to be based on changes in peak and feature profiles as they deviate from calibrated "end member" profiles. In this method the 10Å X-ray diffraction peak of illite and 7Å peak of kaolinite are deconvolved and the resulting components assigned a numerical value based on the asymmetry of the peak profile. For each mineral these values are plotted against similar asymmetry values calculated from the SWIR 2.2 µm (hydroxyl) feature. The resulting Crystallinity Index (C.I.) can be used to map changes in crystallinity of the target mineral using the SWIR data.

In the selected sediment hosted deposits we have observed, especially those that are fracture controlled, illites increase in order as the ore zone is approached and show a 2M polytype or high degree of ordering within the ore zones. In the volcanic hosted deposits we have investigated there is a very distinctive, well ordered 1M illite polytype associated with the ore zones, and less well ordered illites outside of the ore zones. This illite has also been seen in a volcanic hosted base metal deposit. Even the subtle, hydrothermal overprinting in the metamorphic hosted greenschist facies deposits can apparently be discriminated using the C.I. method.

To be effective as an exploration tool, this method must be transportable to the field. With the recent development in Australia of a truly portable high resolution, field SWIR spectrometer, it is now possible to compute the C.I. insitu. Generic examples of type deposits will be used to illustrate the method using spectra collected with the field instrument.

AN INFIELD INDICATOR FOR GOLD AND OTHER MINERALIZATION BY THE DETECTION OF <u>BACILLUS</u> <u>CEREUS</u> IMBER, B.E.

The development of an immunologically based (ELISA) field kit allowing the identification of potential gold deposits in twelve hours is described. A simple three step colour reaction has been developed that detects spore protein from the spores of <u>Bacillus cereus</u>. This organism has previously been shown to be an indicator of princerlization in ceneral (Watterson et al. 1984). Our organism has previously been shown to be an indicator of mineralization in general (Watterson <u>et al.</u>, 1984). Our data will describe specific responses to gold both in the laboratory and in the field. Experiments evaluating the specific nature of the sporulation process in the presence of Au will be discussed. Field data showing correlations with gold mineralization will also be presented. Field data from several Canadian locations will be presented that compares the GOLD PROBETM method with conventional exploration techniques as well as some less often used biological methods.

A NEW, COST-EFFECTIVE BIOGEOCHEMICAL METHOD FOR GOLD EXPLORATION IN TROPICAL SOUTHWEST PACIFIC REGIONS

<u>MCINNES, B.I., DUNN, C.E., KAMEKO, L., and CAMERON, E.M.</u> Biogeochemical prospecting has been used as an exploration method for mineral deposits worldwide, particularly in boreal forests and semi-arid regions, and papers have been published

method for mineral deposits worldwide, particularly in boreal forests and semi-arid regions, and papers have been published on work in tropical areas. The work presented here extends biogeochemical gold exploration to equatorial regions. After investigation of several plant species, a small- to moderate-size tree species was chosen because it is abundant and has a widespread distribution. Astronidium/Astronia may be useful) is present throughout the southwest Pacific region bordered by Sumatra and the Malay Peninsula, Philippines, Marshall Islands, east to Fiji and Tahiti, south to New Hebrides and throughout Papua New Guinea and the Solomon Islands. Density of this species is ca. 1/100 m² on Simberi and Lihir Islands P.N.G.. It may not occur at elevations greater than about 1000 m. As a biogeochemical survey medium, <u>A. palauense</u> has the following desirable characteristics: (i) it is easy to identify and is well known to indigenous peoples; (ii) its bark is plentiful and easy to obtain; the ashed bark reliably indicates gold concentrations in the substrate. Arsenic, too, can be used in combination with gold to ascertain the strength of the anomaly; (iii) the root system reaches at least 4 m depth, allowing greater penetration than surface samples of soil. This is particularly important in volcanic terranes where geochemical targets are buried by post-mineralization volcanic eruption or debris flows; (iv) the areal distribution of the root system (up to 5 m radius) samples a large volume of soil (ca. 100 m²), which effectively eliminates the 'nugget effect'. Biogeochemical surveys can be conducted in 25% of the time effect'

Biogeochemical surveys can be conducted in 25% of the time and at approximately 50% of the cost of conventional soil sampling surveys. Sampling time is approximately 6 minutes per site compared with 15 minutes per 1 m deep augured soil sample and 20 minutes per 2 m deep soil sample. The low-weight of bark samples (0.1 to 0.2 kg/vegetation sample vs. 0.5 to 2 kg/soil sample) enables fewer personnel to cover large areas kg/soil sample) enables fewer personnel to cover large areas more quickly. This is particularly advantageous in high relief tropical areas. The bark can be dried and ashed on site quickly and inexpensively with minimal capital requirements. Depending on the setup, 200-500 samples can be processed in 2 to 4 days. Shipping costs to the analytical laboratory are reduced because <1 g of ash is required for high precision, multi-element (Au, As + 32 elements) instrumental neutron activation analysis.

Field tests on Simberi and Lihir Islands, P.N.G., show that reconnaissance biogeochemical surveys have a high level of reliability for identification of prospects.

BIOGEOCHEMICAL MAPPING OF SWEDEN FOR EXPLORATION AND ENVIRONMENTAL RESEARCH

NILSSON, C.A. and SELINUS, O.S.

A national *biogeochemici* mapping programme is carried out by the Geological Survey of Sweden (SGU). Replacing inorganic stream sediments, plant roots from stream banks and aquatic mosses are sampled. These reflect the contents of heavy metals in stream water. Research has shown that roots and mosses respond closely to chemical back-ground variations related to different bedrock types. They also reflect in a sensitive way the effects of pollution.

Aerial parts of plants do not, in general, respond to high heavy metal concentration in the growth medium. This is due to the fact that plants have physiological barriers between roots and aboveground parts protecting them from uptake of toxic levels of heavy metals into the vital reproductive organs.

In the national programme the sampling density is 16 samples per 100 km² and each sample point represents a drainage area. The geo-chemical patterns are primarily related to the geochemistry of the bedrock. Superimposed on these patterns are, however, patterns re-lated to human influence such as airborne pollution and agriculture. An important aspect is also the effect of acid rain on the mobilization of heavy metals in our environment. Knowledge of such patterns is essential for the environmental control programme and for selecting anmalous patterns of significance for mineral exploration.

The anthropogenic patterns must be distinguished from the natural patterns in order to make the geochemical exploration efficient. This is crucial in all types of geochemical exploration. Therefore, we will also demonstrate statistical methods in order to distinguish between these patterns.

The mapping programme is very cost efficient and shows not only regional ore provinces but also individual ores and mineralizations. We will show examples of this from gold exploration and exploration for massivessulphide deposits. Studies have also shown that the method can be used in widely different climatic conditions such as desert areas as well as tropical areas.

THE DETERMINATION OF GOLD CONCENTRATIONS IN HUMUS AND HUMIC FRACTIONS BY CHARCOAL ADSORPTION PRECONCENTRATION-INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS (CA-INAA), AND THE INVESTIGATION OF THEIR SPATIAL RELATIONSHIPS TO SUBCROPPING GOLD MINERALIZATION.

PERRY, B.J., VAN LOON, J.C., SPOONER, E.T.C., GORTON, M.P., and HANCOCK, R.G.V.

The success rate for humus geochemical exploration for gold on the Canadian Shield has proven to be disappointing. Reliable detection of subcropping gold mineralization through the use of total gold concentrations in exploration humus samples has not been achieved. Field "anomalies" very often have no relation to underlying mineralization. Consequently, orebodies are being missed and exploration funds are being wasted on false anomalies. The presence of <u>exotic</u> gold in humus developed on glacially transported overburden tends to mask the weaker *bona fide* biogeochemical indigenous gold signature of an underlying gold deposit. Total gold methods, e.g. neutron activation analysis of pressed humus sample briquettes, cannot discriminate between the exotic gold component and the indigenous gold component. This paper presents new, cost effective methodology for the determination of indigenous gold concentrations in exploration humus samples. The spatial relationship between gold concentration and proximity to subcropping gold mineralization covered by glacially transported overburden is investigated for the three classic humic fractions, a general humic substances extract, aqua regia extractable gold, and weak HCl extractable gold.

The results indicate that gold concentrations in some organic fractions of exploration humus samples collected from areas overlying mineralization are enhanced compared to gold concentrations in the same fractions from areas not overlying subcropping gold mineralization. When biogeochemical communication exists between the surface environment and significant subcropping gold mineralization, the biogeochemical gold signal of subcropping gold deposits can be readily detected in the humic extract, humic acid, fulvic acid and weak HCI extractable gold fractions even though the mineralization may be covered by glacially transported overburden containing exotic gold particles.

However, the importance of the natural variability of organic matter concentrations in exploration humus samples must be recognized and taken into account. Loss on ignition studies (219 humus samples collected from 179 sites on 5 exploration properties) show that the natural variation in organic matter concentrations between 1.0 g subsamples is small within the -80 mesh fraction of individual exploration humus samples (average $Cv_{within-}$ sample n=24 miplicate subsamples was 0.02). However, the natural variability of organic matter

concentrations in exploration humus samples is significant both within-site (average Cv within-site n=20 sites was 0.23) and within-property (average Cv within-property n=5 properties was 0.41). In order to validly compare gold concentrations carried in the organic fractions of exploration humus samples, the gold concentration determined for each fraction must be normalized to a common concentration of organic matter. Normalization to 100% ashable organic content is convenient.

Gold concentrations in humus, humin, humic extract solution, fulvic acid solution, humic acid solution and 1.2M HCl humus extract solution can be determined satisfactorily by activated charcoal adsorption preconcentration of the gold in these fractions followed by instrumental neutron activation analysis of the gold bearing charcoal (CA-INAA) by the procedures developed herein. For humin, humic extracts, humic acid solutions, fulvic acid solutions and 1.2M HCl extracts, the activated charcoal adsorption gold preconcentration procedure increases the gold concentrations 100 fold, and also reduces the concentration of sodium relative to the concentration of gold. The decreased relative sodium concentration results in much lower detection limits than is achievable by direct INAA.

Humus, humin, humic extract, humic acid, fulvic acid and 1.2M HCl extractable fractions each can indicate the presence of subcropping gold mineralization at the Echo Bay study site. However, significant differences in within-site precisions obtained during the determination of gold concentrations in the various fractions suggest differences in their relative reliability for indicating the presence of significant subcropping gold mineralization. Within-site precision in the humic extract fraction and in the fulvic acid fraction (Cvaverage site (humic extract) = 0.74 and Cvaverage site (fulvic acid) = 0.89) were much better than the within-site precision obtained for total (aqua regia extractable) gold in the -80 mesh fraction (Cvaverage site (humus) = 1.37). The poorer site representivity diminishes the reliability of using total gold concentration in the -80 mesh humus fraction as an indicator of subcropping gold mineralization. The humic extract fraction indicated the highest number of spatially correct anomalous sites (2 sites over the ore zone, 1 site adjacent), thus giving a comparatively stronger indication of the underlying gold mineralization than the five other fractions. The combination of better within-site precision and stronger anomaly definition provided by gold concentrations in the humic extract fraction suggests that the humic extract fraction should be a preferred sampling medium in the task of detecting subcropping gold mineralization in areas of glacially transported overburden.

GOLD EXPLORATION USING ANALYSES OF BALSAM FIR TWIGS: AN EXAMPLE FROM EASTERN NOVA SCOTIA, CANADA

<u>ROGERS, P. J.</u> and DUNN, C. E. Samples of twig and bark tissues of several trees and shrubs were collected throughout 5000 km2 of Eastern Nova Scotia at a sampling density of 1 per 8km2. Results from balsam fir twigs (<u>Abies balsamea</u>) demonstrate the application of reconnaissance level biogeochemistry to mineral exploration for gold and other metals. Detailed surveys help to identify the locations of Au-rich zones.

The study area is underlain by Meguma Group (MG) metasediments of Cambro-Ordovician age intruded by 370 Ma (Devonian) granitoid rocks. Most significant Au producers are found in the metasediments, especially the upper Goldenville Formation. The Au deposits contain native gold with arsenopyrite and carbonate in quartz veins found along a series of NE trending anticlines and synclines. Zones of silicic, carbonate and phyllic alteration surround these deposits.

In June 1987 vegetation samples were collected at 650 sites spaced at 2 km intervals along all driveable roads and tracks. The last five years of twig growth were collected at least 50 m away from roads to minimize possible contamination. All samples were air dried, the needles removed and the twigs ashed at 470°C. The 0.5-1.0 g ash samples were analysed for 35 elements using Instrumental Neutron Activation.

Areas with enrichment of Au and As in twigs coincide with known gold districts and detail gold bearing shear zones. In addition Sb, Rb, Cs and W are enriched over granitoid bodies. The fir twig chemistry also indicates previously unsuspected Au potential in the contact aureoles of the granitoids and in Carboniferous Horton Group rocks in the north of the area. Anomalous groupings of Ba and Cr are seen along the Minas Geofracture. Results from a factor analysis of the regional dataset indicates an Fe-Hf-Sc-REE-As-Co grouping as Factor 1 and Au-Br-Rb-Cs-Sb-Sr-Zn as Factor 2.

At Millshaft, Cameron Flowage and Diamond Lake up to 20m of till cover is found in three discrete till sheets. In all three areas the twig tissues outline gold dispersion trains as coherent anomalous patterns for several elements including Au, As and Cs. This contrasts with the erratic response often noted in the commercial soil and till surveys. At the Millshaft grid values of up to 70 ppb Au are found in twigs over an area of structural disturbance as yet untested by drilling.

Vegetation samples were also collected from two boggy areas suspected to overlie potential gold bearing structures in bedrock. Low shrubs from the Mcgregor Lake bog yielded values of 22 to 36 ppb Au, which are elevated when compared to the 10 to 20 ppb Au background. Samples from the Como Lake contained 55 to 85 ppb Au associated with Cs and weak Co enrichment, suggesting this area as a potential target.

DETAILED STUDY ON THE BIOGEOCHEMICAL MEASUREMENT EXPLORATION WANG, Zhengyang and LIU, Jiancheng

In this study, a new thory system of biogeochemistry has benn preliminarily established. The most significant aspects of the regular pattern about the elements in plants are diacussed in detail. Based on a fundamental hypothesis, an important analytical formula, reflecting the relationship between the trace element contents in plant and those available from underground, has been reasoned out, which is expressed in the form $P = Mo[1-e^{-s_{i}(s_{i}+s_{i})}]$. Except for the basic formula, a data treatment method, called "Normalized Data Process", has been derived from the element contents in the plants directly obtained undergound, so the rule we had which forbade different species of plants to be used as sampling in some region is now got rid of. Also from this formula, a judging method, named "Double Parameter Principle", is presented along with the concrete and precise of plants. A developed working program and its related techniques have also been mentioned.

PRIMARY AND SECONDARY DISPERSION PATTERNS ASSOCIATED WITH MOTHER LODE-TYPE GOLD MINERALIZATION, HODSON DISTRICT, CALAVERAS COUNTY, CALIFORNIA

CHAFFEE, M.A. AND KUHL, T.O. The Hodson district lies along the West Gold Belt, about 17 km west of the main Mother Lode Gold Belt and the town of Angels Camp. Rocks in the area consist of two major units: (1) metasedimentary rocks comprising mainly tuffaceous wackes and carbonaceous slates and phyllites, and (2) metavolcanic rocks comprising flows, tuffs, and agglomerates mainly of andesitic basalt to basaltic composition. Rocks in the region have been metamorphosed to greenschist facies. The entire area has been intensely faulted; the Mother Lode-type, goldpyrite deposits are in or near quartz veins associated with some of these faults, mainly the large Hodson fault, which trends northwest and has many splays. The three orebodies in the district contain zones of altered rock that surround

the Au-bearing mineralized structures. The extent and mineralogy of these zones varies with each host lithology and orebody. Typical alteration assemblages include quartz, sericite, pyrite, calcite, ankerite, and mariposite in the metavolcanic unit, and quartz, sericite, and pyrite, plus bleaching, in the metasedimentary unit.

A total of 300 samples of core and cuttings were collected from drill holes on three sections, each of which transects an orebody. Analyses for 37 elements (Ag, AI, As, Au, Ba, Ca, Cd, Ce, Co, Cr, Cu, Fe, Ga, Hg, K, La, Li, Mg, Mn, Mo, Na, Nb, Ni, P, Pb, S, Sb, Sc, Si, Sr, Te, Ti, TI, V, W, Y, and Zn) and for loss-on-ignition (LOI) at 925°C were evaluated.

Pathfinder elements with positive anomalies spatially associated with anomalous Au zones include Ag, As, Hg, K, S, Sb, Sr, Tl, and W, plus LOI. Elements with negative anomalies in the same zones include Al, Ba, Cu, Fe, Ga, Li, Mn, Mo, Na, P, Sc, Te, Ti, V, and Y, and Zn. Elements with the broadest anomalies include Ag, As, K, Li, S, Sr, Sb, Ti, TI, and W; those for As, W, and Li extend farthest (at least 60 m) from mineralized structures. These three elements thus should be especially useful in delineating the outermost manifestations of alteration associated with blind Au mineralization in this district.

Chemical abundances are useful in distinguishing rock lithologies, particularly where the rocks have been strongly attered. Elements that seem to best discriminate lithology, mainly below the weathered zone, include Cd, Ce, Co, Nd, and Pb.

Chemical weathering has overprinted and modified primary hydrothermal zoning. Samples with low concentrations of Ca, Mg, and S generally define those areas most affected by weathering. Elements locally enriched in weathered rocks include Ag, As, Au, Ce, La, Ni, Pb, Te, and W. Cadmium, Cu, and Zn are locally enriched secondarily near the base of the zone of weathering.

PRIMARY ELEMENT DISPERSION PATTERNS IN A CARBONATE-HOSTED, EPITHERMAL, HIGH-GRADE, Au-Ag TELLURIDE SYSTEM: MAYFLOWER MINE, MADISON COUNTY, MONTANA, U.S.A. COCKER, M.D.

High-grade, Au-Ag telluride mineralization in the Mayflower nigh-grade, Au-Ag teriuride mineralization in the Mayflower mine occurs in hydrothermally altered carbonates of the Middle Cambrian Meagher Formation. Primary element dispersion patterns and hydrothermal alteration zoning suggest that the mineralization and alteration were principally guided by detrital guartz-bearing, paleo-tidal channels in the vertical to overturned Meagher Formation where this unit is cut by the detrital quartz-bearing, paleo-tidal Channels in the vertical to overturned Meagher Formation where this unit is cut by the Late Cretaceous to Paleocene Mayflower fault. Proximity of the Mayflower mineralization to the deep-seated, Mayflower fault and lateral geochemical zoning along strike of the Meagher Formation away from the fault suggests that the Mayflower fault acted as a source conduit for the hydrothermal fluids. With increasing distance from the Mayflower fault, Cu, Pb, Ag, Au and V decrease, Mn and MgO increase, and Hg, Tl, As, and Zn tend to remain the same or show a slight increase. Vertical zoning is evident by an increase in base-metals and Ag to the presently explored depth of 670 m. Alteration and geochemistry is zoned relative to the paleo-tidal channels with: 1) a central zone of quartz, adularia and roscoelite anomalous in Te, V, Zn, Mo, and Pb: 2) a proximal zone of quartz and adularia; and 3) a distal zone of hydrothermal dolomite with anomalous Mn. The quartz-adularia and dolomite zones show significant increases in SiO₂ and K,O and MgO respectively relative to unaltered carbonates of the Meagher Formation. Anomalous Mn. The quartz-adularia and 2. High-grade, gold and silver mineralization is best developed in and adjacent to zone 1. The major controls on element dispersion are principally: 1) lithologic (permeable, paleo-tidal channels, reactive carbonates and hydrothermal alteration), 2) structural (deep-seated, Mayflower fault as a fluid conduit), and 2) distance from source (lateral along strike and vertical along paleo-tidal channels) that may also reflect changes in the chemistry, pressure and temperature of the hydrothermal fluids.

COMPOSITIONAL CONTROLS ON THE GOLD CONTENTS OF SILICIC VOLCANIC ROCKS <u>CONNORS, K. A.</u>, NOBLE, D. C., WEISS, S. I. and BUSSEY, S. D. 79 volcanic rocks, mostly from the Western U.S., were carefully selected: 1) to sample a wide range of silicic to intermediate magma compositions and 2) to represent as closely as possible the composition of the magmas when erupted. Nonhydrated glasses of dense hydrated glassy rocks were analyzed in preference to devitrified materials. Gold contents were determined by XRAL Activation Services using neutron activation-fire assay concentration methods (Rowe and Simon, 1968) with a detection limit of 0.1 pb. with a detection limit of 0.1 ppb.

Silicic volcanic rocks as a group contain less gold than shown in much of the geochemical literature. Most samples have less than 1.0 ppb, and many contain only 0.1 to 0.3 ppb Au. Subalkaline high-silica rhyolites and peraluminous rhyolites have only slightly higher values 0.2 and 0.1 ppb, respectively. Lower silica rhyolites have only slightly higher values (mean 0.3 ppb). The highest gold contents are in peralkaline rhyolites (0.2 to 4.5 ppb, mean 1.0 ppb) and in subalkaline ferrorhyolite (0.4 to 1.0 ppb, mean 0.7 ppb). This pattern is well illustrated on a plot of FeO versus CaO (Warshaw and Smith, 1988). Intermediate tocks, in general, appear to have higher gold contents than silicic rocks, and tholeitic andesites (icelandites) appear to be digher in gold than calc-alkaline types. The gold in many of the specimens appears to be concentrated in the ground-mass rather than the phenocryst fraction. A phenocryst-rich vitrophyre of the Soldier Meadow Tuff, NW Nevada, contains 0.6 ppb Au. whereas nonhydrated glass separated from the rock contains 0.9 ppb Au. The relatively high gold contents of sold within the groundmass. An important control of the gold contents of silicic rocks appears to be melt structure. Network-modifying cations, particularly Fe⁺⁺ and Na⁺, depolymerize fe-rich and peralkaline melts, markedly reducing the partition coefficients between the silica melt and coexisting crystal and liquid phases. Our data suggest that crystal fractionation will increase the gold contents of paralkaline rhyolites in a manner generally accepted for the elevated Fe, Zr, Nb, REE, etc., contents of such rocks. High-silica tubalkaline inglosus rocks and magmas appears to be poor sources of gold dort formation of elements, apparently including gold, are not readily and possibly very important control of gold contents of many rocks may perhaps be to degree and timing of separation of a sulfide melt phase. The very low gold contents of magmas responsible for gold-enriched mafic august by thypotites and/or magmas may

A GRAPHICAL APPROACH TO MINERAL-SOLUTION EQUILIBRIA

A GRAPHICAL APPROACH TO MINERAL-SOLUTION EQUILIBRIA DEFFEYES, K.S. The familiar Eh-pH and other potential-potential diagrams need to be turned inside out. Using conserved properties as axes and contouring the potentials on the interior of the diagram emphasizes that the potentials, like Eh and pH, are usually symptoms and not causes. Following Redlich's useage, the conserved properties are called <u>coordinates</u> and the potentials forces. Coordinates and the potentials forces. Coordinates, in this sense, are those properties which are conserved on mixing of two solutions. They are inde-pendent of pressure and temperature. Examples of coor-dinates are 1) the sum of silver (in all dissolved forms) per kilogram of water, 2) alkalinity, and 3) the sum of all sulfur species per kilogram of water. On graphs using these coordinates, vector sums work and the lever rule correctly describes the mixing of solutions. Forces are independent of the volume of solution; they can often be measured by inserting a probe into a large, and unknown, volume. Examples of forces are gas pres-sures, voltages across an electrode pair (Eh and pH), solid phase solubilities, and absorbance of light or sound. These diagrams associate one force as a master variable

sound. These diagrams associate one force as a master variable with each coordinate. A typical choice would associate Ag⁺ activity, as a force, with the sum of all silver, as a coordinate. In addition to the two coordinates on the page, any number of additional coordinates can be held constant. In effect, the page is a two-dimensional slice through a miltidimensional system. Specifying that the solution is in equilibrium with a solid always results in eliminating one force and one coordinate. The electrosolution is in equilibrium with a solid always results in eliminating one force and one coordinate. The electro-neutrality requirement can be handled through an appro-priate definition of alkalinity. Equilibration with a gas volume, as during boiling, results in an apparent equi-librium constant incorporating Henry's Law. A set of simultaneous nonlinear equations result, one for each coordinate. Roots of the equations are found in order to produce contours of chemical species sume or products of

coordinate. Notes of the equations are found in order to produce contours of chemical species, sums or products of species, gas pressures, or electrode voltages. Even a relatively slow personal computer finds results fast enough to stay ahead of a pen plotter. Modern workstations can compute "what-if" diagrams rapidly on the Workstations can compute "What-if" diagrams rapidly on the screen. Examples of geologically interesting diagrams include the solubility of gold in the presence of iron oxide and pyrite, and mixing of a gold bisulfide solution with oxygenated water. An example from extractive metallurgy optimizes the cyanidation of silver sulfide.

MATHEMATICAL GEOLOGY STUDY ON GEOCHEMICAL FEATURE OF PRIMARY AN MINERALIZATION IN ZHAO YIE GOLD BELT SHANDONG PROVINCE

GUO, Guangyu, LIN, Zhouhong, ZHANG, Junling, ZHU, Xuewen and CONG, Guixin

The gold deposit belongs to mesothermal-filling type including two classes as gold-bearing quartz vein and gold-bearing altered-fractured granite. The gold mineralization may be classified into two stages. First, the hydrothermal (T=360 ° -420°C PH=7.23) migrated along the fractures, subjected the granite to sericitization and silicification alteration mainly by diffussive metasomatism and slightly mineralization. The average content of gold in sericite-quartz rock is 0.0252 g/ t. Second, the area which close compresso-shearing were developed, accompanied by the opening-filling of the hydrothermal (T = 200 ° -320°C, PH = 6.16-6.61) by filtration migration. Because the pulsation, inheritance and attenuation of structural activity, gold mineralization is possessed with polystage characteristice. In the first phase fractures were filled with auriferous pyrite-milky quartz vein, veinlet and stock work. Electrum and minor native gold are contained within crystals and cracks of pyrite and quartz. Gold enrichment is around 0.07-5.44 g / t, with that over 3 g/t made up 7.32% in this mineralization phase and 2.33% in the second stage. Gold resource of this phase accounts for 6.08% of the total resource of this area. For the second phase, fractures filled with smoky quartz pyrite vein, veinlet and stock work developed locally some section of the first. Gold exhibite as electuem and less native gold existing within the crystals, fissures and cracks of pyrite, pyrrhotite and quartz, gold enrichment is high, its content general is 1.19-130.97 g/ t; gold grade over 3 g/ t makes up 88.76% in this mineralization phase and 35.62% in the whole stage, provided gold resource 76.52% of the total deposit resource. Third phase, fractures were filled with auriferous quartz (calcite) and polymetallic sulphile vein, veinlet and stock work. Gold in electrum, kiistelite existed within crystals, fissures and cracks of pyrite, chalcopyrite, galena, sphalerite, purrhotite, colulite, arsenopyrite, quartz, calcite minerals. Gold conent general is 0.1-38.5 g / t, gold grade over 3 g/t makes up 38.24% in this phase and 8.10% in the whole stage, provided gold resource 17.4% of the total resource.

The optimum geochemistry mark associations determined are given below:

1. First phase gold mineralization

Au-Ag-W

2. Second phase gold mineralization

Au-Ag-Bi-Te

- 3. Third phase gold mineralization
- (1).Au-Ag-Cu-Bi-As-Se
- (2).Au-Ag-Cu-Pb-As-Bi-Zn-W

Make use of multivariate regression analysis analogue for the optimum element geochemistry model are given below:

 $\hat{ln}Au = 1.0454 \hat{ln}Ag + 0.4223 \hat{ln}Te - 0.5353$

The experience model of the primary halo of gold mineralization established by the geochemistrical and geomathematics analysis of the orebody and its primary halo shows that within the halo of hanging wall, the orebody can be seen from the horizons of Te-Ag, Te-Ag-Cu and Te-Ag-Cu-Au-As-Mn associations at 2.3-3.8m, 1.6-2.3m and 1-1.3m depth respectively. On the other hand, for the halo right on the top of orebody, gold orebody also can be seen in some depth down from the following element associtions respectively, Cu-Pb, 320-1200m; Ag-As-Cu-Pb, 290-320m; Au-Te-Ag-As-Cu-Pb,95-290m and finally, Mn-Au-Te-Ag-As-Cu-Pb, 0-95m.

Using multivariate discriminant analysis established the distinction model for the halo on the top of the orebody and the halo beneath the orebody:

 $\hat{Y} = 0.0685 \ in(Ag \cdot As) - 0.0182 \ in(Au \cdot Te) - 0.0203 \ inCu$

-0.1046 lnMn

The disciminant critical value $Y_{1} = -0.4960$

According to the geochemistry teatures of the primary gold mineralization given in the paper, especially the soil geochemistry comprehensive criterion and anomaly ore-causing evaluation model established from the optimum geochemistry feature and the associations effective exploration result and economic benefit have been made in the area.

TRANSPORT AND DEPOSITION OF GOLD IN SULFIDE-BEARING SOLUTIONS KOSERENKO, S.V., BARANOVA, N.N., ZOTOV, A.V. and KOLPAKOVA, N.N. Experimental investigation on the solubility of gold under conditons modeling the high temperature mineral-formation and determination of

concentrations of Au. Ag, Sb, Te, and S in the fluid inclusions in quartz of various types of gold deposits permit us to establish the prevailing mode of gold occurrence in natural hydrothermal solutions. In fluid inclusion solutions of quartz in early mineral associa-tion with chloride ions at 400-500°C and 500 to 1500 atm gold is pre-

sent in the AuCl; complex within a broad range of oxygen fugacity and chloride ion concentration.

A great variety of concentration values of S (to 0.1M), Sb (10- -10^{-4} M, As $(10^{-2} \cdot 10^{-4}$ M), and Te $(10^{-1} \cdot 10^{-4}$ M) were detected in fluid inclusions in quartz of main mineral association. A tansformation of AuCl, complexes into hydrosulfide and sulfur-bearing bimetallic complex compounds with As and Sb may take place. The possibility of their formation has been demonstrated experimentally. High concentration of Te compounds could play an impodrtant role in deposition of gold from hydrothermal solutions.

Mechanisms of gold precipitation in hydrothermal conditions are discussed on the basis of experimental data and investigation of natural mineral association with special attention to coprecipita-tion processes on the example of sulfide of iron.

Intensive coprecipitation of gold by sulfide mineral phases was observed within the concentration range typical of natural hydrothermal solutions. The most intensive coprecipitation is found within the near-neutral solutions. Temperature increase as well as the sulfide-ions concentration increase result in the decrease of coprecipitation intensity.

Obtained experimental data indicate that the chemical sorption mechanism of gold-sulfide coprecipitation result in the formation of unstable chemical compounds of gold-sulfide type. The aging of these compounds leads to the formation of stable sulfide and gold in finely dispersed form.

Gold-bearing sulfides were studied by proton magnetic resonance technique. The presence of hydrogen-containing atomic group (OH', HS', or HS',) in their composition was established. The "coprecipitation capacity" of sulfides in relation to gold is determined at the precapacity of suffices in feation to got is detained to the source of hydrogen group in its composition. Gold in Au form is con-sidered to substitute for metallic ion in cation sublattice of suffide phase in association with simultaneous substitution of hydrogen containing groups for sulfur in amion sublattice according to Me^{*} --> Au^{*}; OH --> S¹. The stability of Au-sulfide compounds is revealed to vary in a broad interval of values.

SILVER CONCENTRATIONS IN SALT LAKE SEDIMENTS AS A POTENTIAL EXPLORATION TOOL FOR GOLD IN WESTERN AUSTRALIA

LYONS, W. B.

Compared to vein gold, the concentrations of Ag in gold deposits in the highly weathered zone of the Yilgarn Block, Western Australia are extremely low, in many speculated that the source of this very fine gold in the weathered zone is of secondary origin. The the weathered zone is of secondary origin. The groundwater in this region of Australia has extremely high Cl- concentrations and in many cases is of very low pH (i.e. 2.8 - 4.0). Mann (1984) has argued that these groundwaters first solubilize and initially transport both Au and Ag through the regolith. Later the Au is thought to be precipitated via reduction of ferrous iron, whereas the Ag is not and it is further transported in the ground water system. Thus, gold is Thus, gold is separated and purified by the removal of silver. This process apparently is more common in granitic and gneissic terrain compared to in more basic rock regions of the Yilgarn Block.

If Mann (1984) is correct, high concentrations relative to crustal abundances, of Ag should be observed in geologic material down the hydrologic gradient from these Au deposits. The shallow water aquifers usually discharge into continental playas. These playas are geomorphologic depressions that are related to former surface paleo drainages, probably developed in the Tertiary when the climate was much wetter. We have analyzed surface sediment samples from a number of playas in drainages where gold mining has taken place, as well as in drainages where no mining has occurred. There are three lakes with Ag concentrations greater than 1.0 ugg^{-1} . These are Lakes Goongarrie, Annean and Yarra Yarra. Four other Lakes, Wallambin, Grace, King and Moore, have values between $0.8 - 1.0 \text{ ugg}^{-1}$. Because the average shale value for Ag is only 0.07 ugg⁻¹, these sediments can be thought of as "enriched" in silver. The highest value of 3.1 ugg⁻¹ in Annean is in an area where gold mining is presently taking place. It is possible that Ag concentrations in playa sediments combined with shallow groundwater hydrologic studies could be utilized as an exploration tool in Western Australia.

PRIMARY DISPERSION AROUND EPITHERMAL Hg- Sb DEPOSITS AND Au PROSPECTS IN THE HALIKOY AREA OF WEST TURKEY OZKAN, H.M.

IN THE HALIKOY AREA OF WEST TURKEY OZKAN, H.M. The Halikoy district is the major Hg producing area in Turkey and also has significant Sb output. It is situated on the southern side of the Kocuk Menderes Graben and the deposits are hosted in the graben bounding faults. Mercury deposits are found along the >15km long and 30m wide Halikoy Fault structure, which moves gneiss over schist, However, current production is only at the Halikoy mine. Approximately 1km to the south and sub- parallel to the Halikoy structure is the Emirli Fault which is host to most of the stibnite ineralization, although some stibnite is hosted in siliceous breccias to the west of the Emirli Mine. Underground sampling at the Halikoy Mine demonstrates that the mineralization is anomalous in As, Sb, Pb and Zn, as well as Hg, in schists within 20m of the fault although the base metal enrichment is minor relative to As or Hg. Elemental zonation with depth is unknown at present although preliminary depths of deposition, based on fluid inclusion data, will be presented. The situation at Emirli is much more complex with several zones of mineralization within the 300m schist section. Antimony is significantly enriched for 20m around the mined structures which also contain anomalous As, Pb, Cu, Ag and Au; the economic stibnite is associated with dolomitisation. With the exception of Pb, the base

metals are enriched in the upper structures, suggesting more than one phase of mineralization. Lithium presents a very different picture and is diagnostic of siliceous breccias. Fluid inclusion data will be presented to compare with the elemental zonation. Although the Halikoy and Emirli structures are sub- parallel it appears that they may have had very different histories of mineralization.

PALEOHYDROTHERMAL CHARACTERISTICS OF ORE FORMATION, FROM FLUID INCLUSION DATA, SAN LUIS AREA, PRESNILLO, ZAC., MEXICO QUEROL, F., PALACIOS, H., MELCHOR, A. and HERRERA, H.

The San Luis area is located SE of the old Fresnillo Mining District. A fluid inclusion study was conducted on vein material from the area in order to compare with other geologic data to understand the physical-chemcial characteristics of the hydrothermal paleosystem as well as the mechanism of precipitation of the ore. The fluid inclusion study consisted of petrography of the inclusions and the deter-mination of freezing and homogenization temperatures of more than 1,000 inclusions from samples of the different mining levels of the From First stands from samples of the different mining revers of the Santo Nino, San Richado, Santa Elena, Santa Cruz, San Emetrio, and Santa Ana veins as well as samples of present surface veinlets. Mea-surements indicate that most of the inclusions are two-phase liquid + gas with about 20 volk of gas phase at 25° C. T, and T, measured mostly on primary inclusions of the San Ricardo vein show ranges of 180° to 260°C and 0° to 8.5°C, respectively. Similar ranges were obtained from the Santo Nino vein by nrevious authors and in all obtained from the Santo Nino vein by previous authors and in all other veins by us. From the thermometric analysis, fluid inclusion petrography and the distribution of grade in the veins we conclude that the hydrothermal paleosystem in the San Luis area was practically isothermal laterally along the veins with a variable gradient at depth that averages 6 C/100 m; the paleosruface was calculated to be +100 m above the present-day surface. The massive precipitation of sulphides and sulphosalts coincided with sharp changes in the values of T, and T, the locations of these changes are represented by synforms in the isotherms and also are the *loci* of the highest absolute values of T, that is, of the highest equivalent salini-ties. This behavior is interpreted as zones along the vein sites, where high hydrodynamic flow existed that produced open boiling of solutions and consequently accelarated escape of gases and precipitation of the metals. Inside these microsystems one can see zoning represented by increase in gold with depth and increase in silver to the top. This research technique and the results presented have proven valuable in modeling the drill hole data and increase the success of exploration for new ore shoots.

SUPERGENE OXIDATION OF BONANZA Au-Ag VEINS AT THE SLEEPER DEPOSIT, NEVADA, U.S.A.: IMPLICATIONS FOR HYDROGEOCHEMICAL EXPLORATION IN THE GREAT BASIN SAUNDERS, J.A.

SAUNDERS, J.A. Supergene gold of high fineness, cerargyrite (AgCl), and alunite occur in veinlets and vugs in the upper 30 m of bonanza Au-Ag veins at the Sleeper deposit, Nevada. Gold and silver were leached from the primary electrum under acidic conditions caused by iron-sulfide oxidation. In addition, post-ore hydrothermal alteration associated with addition, post-ore hydrothermal alteration associated with hot-spring systems along high angle Basin and Range faults may have caused similar Au-Ag leaching on a local scale. Gold and silver were solubilized primarily as the chloride complexes AuCl, and AgCl, respectively. Downward migration of the chloride-rich waters containing these species resulted in the reduction of the AuCl, complex and gold precipitation, whereas the associated cerargyrite most likely precipitated due to dilution. Data from this study and descriptions of historic deposits suggests that cerargyrite is a common oxidation product of shallow Au-Ag deposits in the Great Basin Region. Hence, the solubility cerargyrite is a common oxidation product of shallow Au-Ag deposits in the Great Basin Region. Hence, the solubility of cerargyrite probably controls the silver content in shallow ground waters in the vicinity of oxidized deposits. Shallow ground water within the arid basins of the region is commonly saline due to evapotranspiration and dissolution of evaporite minerals, which increases the solubility of silver due to chloride complexing. Chemical modeling using the computer program SOLMINEQ.88 indicates silver contents in the low ppm range are possible in typical saline shallow ground waters of the Great Basin if: 1) ground waters equilibrate with cerargyrite, and 2) specific absorption of Ag-chloride species on silicate and Pe-oxyhydroxide surfaces is negligible. Therefore, hydrogeochemical surveys, Ag-chiofide species on sinicate and re-oxynyroxide surfaces is negligible. Therefore, hydrogeochemical surveys, emphasizing the silver content of shallow ground waters, may be a useful approach in exploring for shallow Au-Ag deposits buried by alluvium along the margins of basins.

MOBILIZATION OF GOLD INTO LAKE SEDIMENTS FROM ACID AND ALKALINE MINERALIZED ENVIRONMENTS IN THE SOUTHERN CANADIAN SHIELD

SCHMITT.H.R., CAMERON.E.M. and HALL.G.E.M. To be an effective indicator of mineralization for lake sediment surveys in the Canadian Solicil, it is necessary that an element migrate in solution or be adsorbed on suspensates. Given the low relief and disorganized drainage patterns of this region, dispersion in clastic form restricts the migration of metals and/or gives erratic distributions. Organicrich profundal lake sediments often contain anomalous Au contents in the vicinity of Au mineralization, suggesting that Au may enter lakes in mobile form and be fixed in these of Au sediments. This study investigated whether there is significant dispersion and mobility for Au, which is used to an increasing degree within the Canadian Shield as an indicator element for gold mineralization.

Mineralization, till, humus, vegetation, drainage and lake sediments, and water were collected from Napier Lake, Ontario; PAP Lake, Saskatchewan; and Foster Lake Manitoba. The areas lie in the glaciated boreal forest of the Canadian Shield and contain Au-quartz vein mineralization

Glacial erosion of primary mineralization and subsequent biogeochemical dispersion have enhanced the availability of Au for hydrogeochemical transport to lakes. Significant dissolution and transport of Au was found under oxidizing conditions varying from acid to alkaline. Waters from drill holes penetrating mineralization contain up to 400 ng L⁻¹ Au. Surface waters overlying or near mineralization collected from bogs, seeps, ponds and streams contain up to 13.3 ng L⁻¹ Au. Lake waters contain up to 1.1 ng L⁻¹ Au. Suspensates > 1 μ m filtered from lake waters at two sites contained Au contents equivalent to 0.17 ng L⁻¹ and 0.039 ng L⁻¹. The contents of Au in solution or as suspensates in lake and stream waters are relatively small, but are sufficient to provide an annual flux of Au into lake environments which far exceed the amount required to generate anomalous Au contents in profundal lake sediments. The study confirms that Au is dissolved during the oxidation of Au-bearing mineralization, till and vegetation, and that it disperses into solution and adsorbed on suspensates. that it disperses into solution and adsorbed on suspensates.

The source of anomalous Au in lake sediments can be traced to bedrock by combining detailed hydrogeochemical sampling for Au with till or biogeochemical sampling. Natural water samples of 1 L volume where Au is extracted into MIBK and analyzed by GFAAS permits detection levels for Au of 0.5 ng L⁻¹, which is below the content of Au found in waters from mineralized areas.

DISTRIBUTION AND BEHAVIOR OF GOLD IN SOILS AND TILLS AT THE NICKEL PLATE MINE, SOUTHERN BRITISH COLUMBIA SIBBICK, S. AND FLETCHER, W.K.

In order to provide better criteria for the design and interpretation of geochemical surveys for gold in glaciated terrain we have studied the distribution and behavior of gold in tills and soils at the Nickel Plate mine, British Columbia.

The deposit, in which gold occurs as <25 micron blebs associated with arsenopyrite in garnet-pyroxene skarns, is in the subalpine zone close to the southern limit of the Thompson Plateau. During the last glaciation the Cordilleran ice sheet moved south-southwest across the region and deposited a stony basal till. Soils on the till are eutric brunisols and grey luvisols with carbonate-rich C horizons. A dispersion train with anomalous concentrations of gold in tills and soils extends 1.5 kilometres downice of the deposit.

More than 300 soil and till samples were collected across the anomalous dispersion train. Gold content of humus samples and the -212 micron fraction of soils and tills were determined by instrumental neutron activation and fire assayatomic absorption, respectively. Selected samples were then examined in detail to determine the distribution of gold between different size and density fractions.

Despite erratic variability, gold content of the -212 micron fraction generally decreases from 200-400 ppb close to the minesite to <50 ppb at distal sites. At most sites there is also a twofold increase of gold values down the soil profile. Studies of individual samples show that the gold content of the -420+212, -212+106, -106+53 and -53 micron fractions is roughly constant. However, because of its abundance, the -53 micron fraction contains more than 70% of the gold. Amenability of gold in this fraction to cyanidation suggests that it is largely present as free gold. For size fractions >53 microns the contribution of the heavy mineral fraction (S.G. > 3.3) to the total gold content increases with decreasing grain size.

Distribution of gold between size and density fractions is consistent with its release from the bedrock or pre-glacial regolith by glacial abrasion. The bulk of the gold was incorporated into the fine fractions of the till at or close to the source. However, differences between downice dilution ratios for gold in different heavy mineral size fractions suggest that communition of host minerals continued to transfer gold to the finer size fractions during glacial transport. Textural evidence indicates that there has not been much post-glacial or pedological modification of the till. The increase in gold values down soil profiles is therefore attributed to its original distribution in the till and indicates that some vertical mixing occurred during glacial transport.

With regard to exploration, B and C horizon samples provide the best anomaly contrast. Estimates of the abundance of gold particles in different size fractions indicate that the nugget effect, which causes erratic gold values in the -212 micron fraction, can be reduced by analysis of 30 grams of -53 micron material. This results from the transfer of fine grained gold in the Nickel Plate deposit to fine fractions of the till during glacial abrasion and transport.

sions) are used for geochemical prospecting. In this study the thermodynamic criteria have been obtained by numerical modeling of hydrothermal ore-forming system based on the program of Gibbs Free Energy minimization. The method of reaction progress () has been used in the calculations.

The alteration process may be described on a broad scale in terms of irreversible thermodynamic model based on the local equilibrium assumption.

The thermodynamic model of individual hydrothermal system may be described as 16-component H, O, K, Na, Ca, Mg, Al, Si, Fe, C, Cl, S, Au, Ag, Zn, Pb at $T = 150-300^{\circ}C$, including 78 aqueous speciess and 31 solid phases (minerals).

The initial fluid composition was calculated by accumulating a large data base of analyses of inclusions and reaction progress () between mineralds and fluid.

Numerial physicochemical parameters, revealing the evolution of individual system of fluid-rock interaction, are the results of theoretical simulation. Process of metal deposition, the details of the mineralogical zonation and alteration halos at the deposit were regarded as an investigation object.

The calculations have shown that there is a concrete relation between gold transport, fluid's composition and mineralogical zona-

NUMERICAL MODELING OF Au-MINERALIZATION: GUIDELINES FOR EXPLORATION WOITSEKHOVSKAYA,M. and BORISOV,M. mmon petrological indicators for Au-mineralization (e.g.

sulfi dation equilibria, pH-dependent silicate assemblage, fluid inclu-

tion. The solubility of gold as Au(HS), complex and the transition Au(HS); --> AuHS' are most important. The concrete ratio redox-potential of the system and the activity

of total sufur may control and identify the Au-mineralization.

Published experiments on solubility of gold (e.g., Seward, 1973, 1984; Renders and Seward, 1989), observations in the field (Hannington and Scott, 1989) and the results of simulation in this study have shown a good correlation.

INDICATION OF GEOCHEMICAL MAP CONFIRMED BY DIFFERENCE IN BEDROCK

<u>ZUPANCIC.N.</u>, PIRC.S., PROHIC.F. and MISIC.M. The 8,000 sq. kms of Istria and Slovenian Littoral (NW Yugoslavia) consisting of karstified Jurassic, Cretaceous and Paleogene limeconsisting of karstified Jurassic, Cretaceous and Paleogene Imme-stones and Eocene flysch developed in two basins were mapped geochemically in 1989 on a 5x5 kms regular grid. The samples were taken from the upper 15 cm of topsoil. On flysch areals where surface drainage exists (it is absent on limestones) also stream sediment was collected. 7 major and 12 trace elements were deter-mined by emission spectroscopy. The resulting geochemical map indicates varying concentrations of Ca in soils on different rocks. A very high Ca content (about 10 percent) is found in soils on the rocks of the southern flysch basin, whereas low Ca content (2 percent) is found in soils on limestones and on clastic rocks of the northern flysch basin. Ca content is low in soils on limestone as a result of soil genesis: limestone weathers chemically and calcium is washed out owing to the karst regime. In contrast, flysch rocks weather also physically and calcium is never entirely washed out, because owing to thicker carbonate detritus dissolving water is less effective. The difference in mean calcium between the

two flysch basins was indicated also by stream sediment samples. Statistical significance at the 5 percent level was established by the analysis of variance.

Our hypothesis that calcium distribution in the two sample materials is a result of different calcite contents of rocks in the two flysch basins was tested by additional research. In the two flysch basins in four traverses fresh coarse (sandstones) and fine rocks (siltstone and marl) were sampled, sa well as their weathered equivalents and the soil on them. The examined sandstones of the southern basin contain about 3.5 times more Ca than the correspond-ing norks of the northern basin. ing rocks of the northern basin. Corresponding fine grained rocks contain 4 times more Ca on the average. In weathered rocks the difference is even bigger, those of the southern basin contain 14 times more Ca than those of the northern basin. In the soil of the traverses about 6 times more Ca was found in southern than in contain 1 northern localities.

X-ray examination showed that the calcarenite and sandstone samples of the southern flysch basin contain more than 40 percent of calcite. In the sandstones of the northern basin only about 15 percent calcite was found. Marls of the southern basin contain an average of 40 percent of calcite, whereas the corresponding silt-stones of the northern basin only 15. During the weathering of flysch rocks the calcite contents decreases, and the difference between the two basins become even more prominent. In the northern basin no calcite is left in soil nor in weathered rocks, while in the southern basin the calcite content is up to 35 percent in the examined soils and up to 40 percent in weathered rocks. This additional analysis confirmed the lithologic difference

indicated by both sample media of the geochemical map, the soil and the stream sediment.

THE RADIOACTIVITY CONTENTS OF SPANISH COALS

ALVAREZ, M.C., DOPICO, T., LOREDO, J. and GARCIA IGLESIAS, J. The radioactivity of terrestrial crust materials is mainly due to the presence of K-40 and the radionuclides which constitute the three natural radioactive series (Th-232, U-238 and U-235). As sedimentary rocks, the coals have contents in these

natural radionuclides very similar to their average contents in the terrestrial crust; sometimes, the lignites an exception and they can have high contents constitute in some radionuclides (uranium frequently). In most cases have been confirmed the existence on the coals of a radioactive equilibrium for each natural radioactive serie.

In the present work, the contents in potasium, thorium and uranium in samples from different spanish coal deposits have been determined. The radiometric technique applied for the geochemical determinations has been the gamma-spectrometry by use of a detector probe with crystal of NaI (T1) -introduced in a lead shield- and multichannel analyzer.

Data obtained from spanish coals are compared to data from another coals corresponding to different parts of the world, and provided that the distribution of the natural radionuclides in coals are controled by various and complex factors; a genetic interpretation is attempted on the basis of the geochemical data.

AN EVALUATION OF GOLD HYDROGEOCHEMISTRY AS AN EXPLORATION METHOD IN THE CANADIAN CORDILLERA <u>BALLANTYNE, S.B.</u> and HALL, G.E.M. Hydrogeochemical prospecting techniques are not commonly used in the Canadian Cordillera. There is a recognized need for high quality hydrogeochemical data as well as a better knowledge of dispersion characteristics within the wide range of climatic-physiographic conditions and lithotectonic terrains of the region. Currently gold and associated pathfinder element hydrogeochemistry is being evaluated as an exploration technique in the search for precious metal deposits. Seepage, spring, stream, lake and mine waters have been collected for the gold hydrogeochemical data base. In addition other pertinent parameters such as pH, alkalinity, SO, and pathfinder element concentrations have been determined.

The objectives of this investigation are to compare gold concentrations in waters from unglaciated and glaciated areas; study the gold distribution in natural waters in the vicinity study the gold distribution in natural waters in the vicinity of known precious metal deposits; examine the link between known lode deposits and their associated placer gold deposits by measuring present day gold-in-water concentrations; compare the gold hydrogeochemical response to that of stream silts and outcrops; assess the reliability of gold hydrogeochemical sampling by monitoring stream water anomalies for seasonal and Sampling by monitoring bit of the second sec

The recommended analytical procedure involves filtering, acidification with bromine-hydrochloric acid solution to desorb gold from the container, preconcentration of gold by evaporation and analysis by graphite furnace atomic absorption spectrometry (GFASS). Fractical detection limits range from 0.1 to 1 ppt depending upon the sample volume. Stream waters from the unglaciated placer gold districts of 60 Mile and Klondike, Yukon contained anomalous gold concentrations from 0.6 - 2.1 ppt at pH 7.2 - 8.2. In the glaciated lode and placer gold district of Atlin, British Columbia, a pond water contained 1.1 ppt gold at pH 7.5. A regional orientation survey involved stream water sampling in northwestern British Columbia. A seasonal and year-to-year variability study of Au in the Graham Creek drainage system was also established. Regional survey samples showed a variable pH in the range of 5.8 - 7.6. Fifteen percent of the samples contained gold concentrations greater than 1 ppt, with a range from 0.1 to 4.4 ppt.

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4.4 ppt.

4.4 ppt. The Graham Creek drainage study began in 1985 when anomalous concentrations of 1.1 and 2.5 ppt gold were measured. Since then, maximum gold concentrations found in each collection have varied from 7.0 ppt in July of 1987 to 0.6 ppt in June 1989. Positive hydrogeochemical gold responses correlate uplu with stream sediment gold anomalies and correlate well with stream sediment gold anomalies and delineate new areas of gold potential.

North of Stewart, British Columbia, in the Brucejack Lake epithermal-mesothermal Ag-Au camp detailed pond and stream epithermal-mesothermal Ag-Au camp detailed pond and stream waters indicated a maximum 2.2 ppt Au anomaly which outlined a new bedrock gold discovery. The Kerr copper-gold porphyry deposit shows intense and extensive phyllic alteration. Spring, stream and pond waters have pH levels averaging 4.2. Gold anomalies reach 10.4 ppt while copper contents are over 2000 ppb. Oxidation and leaching of mineralization and transport of sulphur, copper and gold in solution caused this deposit to be overlooked in favour of other exploration targets. Hydrogeochemical sampling could have successfully outlined some drill targets.

AMMONTHM GEOCHEMISTRY AND ITS APPLICATION TO EXPLORATION FOR GOLD BARSUKOV, V.L., KOSERENKO, S.V., BARANOVA, N.N., BANNICOVA, L.A. and ZHILINA, E.I

Nitrogen as well as its reduced form ammonium ion are essential constituents of natural hydrothermal solutions. The last ten years are available a lot of investigations on geochemistry of nitrogen on the base and precious metal deposits. The interests on geochemistry of nitrogen are connected with the possibility of using the obtained data in solution of some genetical problems and in exploration geochmistry.

Contents of nitrogen (ammonium) in the main minerals of near to ore metasomatites of gold-silver and gold-sulfide deposits have been determined by using a set of techniques (EFR, IRS, CHN-analysis, and colorimetry determination). The most concentrations were developed in micas (to 0.8%) and K-feldspars (to 0.06%).

Ammonium contents in fluid inclusions in quartz of ore bodies have been determined. A great variety of values from 0.42 to 0.07 mol/kg H₀ were detected. Maximum concentrations were found in quartz of the productive mineral association.

Elemental composition and nitrogen content of organic matter separated from samples of host rocks and near to ore metasomatites have been sstudied. It was established that metamorphogenic transformation of the organic matter of host rocks was accompanied with a minor decrease in the nitrogen content. At the same time the nitrogen content (ammonium) in mices is increased, i.e., nitrogen is redistributed between the organic and mineral components of the rocks. A considerable growth of the oxidation degree of the organic matter and loss of nitrogen is noticed near the ore metasomatic zones. Permanent nature of the mentioned phenomena makes it possible to suppose that the basic source of the nitrogen of the hydrothermal solutions is the organic matter of the host rocks.

GEOCHEMICAL SURVEYS OVER THE BELL SPRINGS DEPOSIT, HOG RANCH MINE, WASHOE COUNTY, NEVADA

BUSSEY, S.D., TAUFEN, P.M., SUCHOMEL, B.J., and WARD, M. The Bell Springs deposit is a bulk tonnage, low grade gold deposit that formed in a hot spring environment. The deposit is hosted by high silica, weakly peralkaline rhyolite ash flows and rheomorphic tuff of mid-Miocene age. Ore grade mineralization occurs over an area 1500 X 1500 ft, and exhibits NE and NW structural controls.

The mineralized horizon, which is exposed on the southern side of the deposit, is stratabound in nature. It consists of silicified tuff with up to 30% adularia cut by irregular chalcedonic veins and breccias. Mineralization is concentrated in the upper portion of the rheomorphic tuff which is strongly flow banded with abundant lithophysae and spherulitic devitrification textures. The silicified zones are surrounded by a zone of nearly massive illite-smectite clay that is barren of any gold mineralization. Most of the deposit is oxidized but local unoxidized zones contain up to 5% of an arsenic-rich pyrite.

An orientation sampling traverse was completed across the Bell Springs mineralization comprising 66 soils. To examine the effect of grain size on anomaly expression, these soils were screened into six mesh size fractions: +10, 10+35, -35+80, -80+120, -120+200, and -200. All fractions were analyzed by low-detection-limit acid digestion/organic extraction procedures, with instrumental determinations by ICP or graphite furnace. Analyses were completed for Au, As, Ag, Bi, Cd, Cu, Ga, Hg, Mo, Pb, Sb, Se, Te, Tl, and Zn.

Twenty-five stream sediment samples were collected from a drainage crossing mineralization and from a nearby tributary. Sediment size fractions of -200 mesh and -10+200 mesh were analyzed by the same procedures used for soils. In addition, a BLEG (bulk leachable gold via cyanide leach) Au determination was completed on the bulk -10 mesh sediment.

Anomalous values of Au, Ag, As, Sb, and Mo in all analyzed soils size fractions indicate the underlying ore at Bell Springs. Anomalous Sb and As values extend over about three times the area covered by Au and Ag values on the profile sampled, providing a much broader anomaly in these elements. Fine fraction stream sediments provide the best-defined Au anomalies in drainage. A multi-element expression comprised of Au, As, Sb, and Mo reinforces anomalous Au values in drainages and constitutes a useful multi-element "factor" for the Bell Springs mineralization.

HISTORY AND METHODS FOR DISCOVERY OF THE GOLD-RARE METAL OBJECT IN THE NORTHEAST OF THE USSR

DOBROTIN, Y. and NERUCHEV, S.

The gold-rare metal ores were found in the boundary of volcanicstructure isolated from Ohotsko-Chukotsky volcanic belt. Intrusion (25X3 km) is located in the central part of it. Ore field extends along he Eastern endomorphic zone of intrusion near the deep fault which has an important role in the ore's genesis. Ore bodies are presented with quartz-little sulphide veins which are located in the metasomatically changed zones in granodiorite. Landscape is presented with block stone and stone stream deposits on the abrupt slopes.

In 1960's, in accordance with the panned sampling results, pros-pectings of gold (scale 1:25,000) were made twice in the limits of Eastern contact intrusion zone. The main direction of prospecting dealt with the exocontact zone of intrusion containing many quartz and quartz-sulphide veins. Exploration methods were presented only with field routes and short trenches. Parameters of ore veins as a whole were limited. It resulted in the conclusion about the nullperspectives for gold ores in this area.

In 1970's, in accordance with the results of dispersion trains prospecting (scale 1:20,000, network-500 m) the central area of the volcanic structure was marked as an ore-geochemcial cluster. The contrast dispersion trains of gold and indicator-elements of gold ore on the peripheral intrusion zone allowed us to pay attention to it again.

In the summer of 1987 the inspection of anomaly dispersion trains' area was made in the limits of the endo- and exo-contact zone. Lithochemical sampling of water sheds and dispersion trains recosampling (network 100 m) had been carried out in the process of prospecting routes. This work resulted in the determination of a limited area of 6 km' in the peripheral zone intrusion enabling lithochemical prospecting (1:10,000) without traditional mapping (1:50,000). It leads to saving in the one-year work of the team and in the analysis of several thousands of geochemical samples.

Analysis of contrast geochemical field obtained in the result of lithochemical mapping (1:10,000) played a decisive role for concealed ores assessment. The halos of Ag, As, and Sb are predominant in the endocontact zone; the interior, near-fault zone contains more contrast Bi, Mo, and W halos; in the interim zone Au, Ba ones are predominant Au and Ba existing with the negative correlation. Stable association of Au-Bi-Mo exists in all three zones in spite of the different geochemical spectrums. This distribution of elements relalative to the mineralizing deep fault makes it possible to propose an ore model and to organize an exploration according to this model.

GEOCHEMICAL CHARACTERISTICS OF MAYSKY GOLD DEPOSIT AND MAYSKY ORE CLUSTER IN NORTHWESTERN PART OF CHUKOTKA (USSR)

DOBROTIN, Y.R. AND VOLKOV, A.V.

The I.I.Maysky gold deposit is located in the northwestern part of Chukotka region (Magadan district, USSR). The area consists of folded Chukotka Triassic terregene rocks and peripheral Cretaceous Ohotsko-Chukotsky volcanic rocks of the Pacific volcanic belt. Joint ventures were organized in 1990 with Severovostokzoloto

USSR), Placer Dome, Inc., (Canda-USSA) and Bering Straits Trading (o. (USSR). The deposit was discovered in 1972 (Grigorov, S.A. and Samorukov, N.M.) by use of lithochemica data to locate secondary halos. The deposit was explored by trenching, core drilling, and underground excavations. Geochemical anomalies of the ore deposit and ore clusters were recognized by studies of dispersion trains, secondary halos, and use of primary lithochemistry. Country rocks of the 10 km² ore district are sandstones and shales (T₁) folded in brachyanticline cut by meridional and lateral faults and intruded by a set of acidic dikes (K₂). Ore bodies in crushed zones of variable size average about 12 g/ton of Au. More than 20 ore bodies average 2.4 m in thickness, length 200-1300 m, and dip 40° to 80°. About 90 X of the gold is in arsenopyrite as fine grains disseminated through the matrix. The coefficient of variation ranges from 40 to 60 X.

The Maysky ore cluster shows a concentrically zoned geochemical structure. The spatial and energetic center of the system is in a differentiated granitoid intrusive with halos and zones mineralization containing tungsten, molybdenum, and tin. Halos and mineralization of arsenic, tin, and gold are closely associated with the margins of the intrusive. The next zone outward has no mineralization or halos. The Maysky gold deposit and several other smaller gold-silver deposits are in the frontal belt.

Factors were calculated by a computer program, with multiplied values of elements associated with high grade ore, (Pb, As, Sb, Hg, Ag, Li) in the numerator, and multiplied values of elements not so closely associated (Ni, Co, Cr, V Mn) in the denominator. These proved useful in locating high grade ore bodies. All the geochemical data were processed by similar computer' programs. As a result, ore bodies could be classified according to geochemical similarities to the main ore bodies. However, geochemical similarity did not always coincide with mineralogical and visual simularities. It proved possible to calculate factors for different levelsof mineraliztion and exploration. For example, a negative correlation was found between intensities of mineralization and the set of elements removed during mineral deposition.

GEOLOGY AND GEOCHEMISTRY OF THE BIRIMIAN GOLD DEPOSITS OF GHANA DZIGBODI-ADJIMAH,K.

The primary gold occurrences of the Birimian system (ca 2100 Ma) of the West Africa make the region a major gold province in the world. Birimian lithofacies is characterized by subaqueous and fine-grain sedimentation with contemporaneous bimodal volcanic activity. On the metasediments, phyllites and metagraywackes abound whilst the predominant metavolcanic rocks are of tholeiitic basalt compostion. Komatiltes are unknown.

The gold-belts are represented by 5 parallel, evenly spaced and over 300 km-long volcanic belts separated by basins of pyroclastics and metasediments. The most predominent of the belts are the Ashanti volcanic greenstone belt hosting the Ashanti Goldfields Corporation mine at Obuasi (over 800 mt Au since 1986), the Prestea and Marlu goldfields at Prestea and Bogosu, respectively (ca 300 mt Au since 1885), and the Konongo goldfields at Konongo and Obenemasi (50 mt u, since 1901). One grades range from 2 to over 30 gm Au per mt

Au since 1901). Ore grades range from 2 to over 30 gm Au per mt. The auriferous quartz veins, forming the major orebodies, are associated with deeply penetrating and laterally extensive fissure or shear zones located at the contact between the metasediments and metavolcanics. Modally the veins consist of 95-98 per cent quartz; calcitic carbonate, green Fe-bearing sericite, carbonaceous partings and sulfides being the other constituents. The gold is associated with calcite vein filling in fractured quartz veins and lenses. Native gold occurs with sulfides, sulfosalts and fahlores. Wolframite, scheelite and tellurides are unknown. Rutile with anatase and cryptocrystalline and granular masses of leucoxene constitute the only oxides, banded iron-formations (BIF's) being absent. Vein constituents include pyrrite with marcasite, gold, arsenopyrite, sphalerite, aurostibnite, bornite, bournonite, tetrahedrite, boulangerite, galena, and jamesonite.

The most noticeable hydrothermal alteration pattern along the ore channels include carbonatization, sericitization, silicification, and sulfidization. Carbonate alteration is intense and reaches over 50 per cent of mode in the metavolcanic rocks. At least three generations of carbonates are recognized in the rocks. Microprobe analysis of the early-carbonate shows high proportions of Fe with subordinate Ca, Mn, and Mg. The late-carbonate is, howeverr, predominantly calcitic in composition. Sericitization is also prevalent along the ore channels with green mica (previously thought to be fuchsite) forming conspicuous bands along the graphitic phyllites and in the auriferous quartz veins. A qualitative microprobe investigation of this material reveals no trace of chromite but rather the presence of Fe. Whole rock chemcial analyses of the rocks suggest the removal of silica and the addition of sulfur.

Preliminary fluid inclusion investigations reveal homogenization temperatures of 350°C during mineral deposition at 140 bars. The ore fluids contain graphitic inclusions along with CO, as gas and aqueous rich-inclusions. Salinities of ore fluids are, however, yet to be determined.

Ore textures, on the other hand, suggest that ore mineralization took place in several phases and in some occasions higher temperature paragenesses follow lower temperature associations. These observations together with the presence of pentlandite-bearing pyrrhotite along fractures in some early-formed sulfides suggest that ore mineralization is a multi-phase event and that ore fluids are derived from depth, probably powered by a seismic sosurce.

It thus appears that models based on geochemical results may be missleading as some of these results tend to represent either average values or the final episode in a mineralization that took place in several stages.

APPLICATION OF THE TECHNIQUE IN PHASE ANALYSIS OF TRACE ELEMENTS IN GEOLOGICAL EXPLORATION GONG.Meiling

The technique of phase analysis of trace elements is derived from normal phase analysis and partial extraction techniques. The principal task of it is to find out the mode of occurrence of elements which is below 100 ppm in content. It serves mainly for discovering the forming mechanism of the geochemical exploration anomaly.

Individual element, on hypergene conditions, has its own rule of displacement and deposition in different regional landscapes.

Using the technique in phase analysis of trace elements, and looking for the features of elemental contents at various phase in the samples of geochemical anomaly, simulataneously considering the different regional landscapes, especially the geological conditions and sampling medium, the original existing states of elements can be presumed; thus providing significant evidence for find-out of the mechanism of anomaly formation.

On the basis of study on phase features of a great deal of elements with known anomalies the method of phase analysis of various elements and the evolution standards of acobariand acomaly star made

and the evaluation standards of geochemical anomaly are made. We have some examples of phase analysis of various elements in different geochemical anomalies, such as Pb, Zn, Cu, Sn, Ni, Co, Au, Ag, Hg, and Mo. Each one of them has its own evaluation standard. With the application of the technique more than 60 anomalies with high accuracy have been fulfilled in Shanxi and Gansu provinces and Xinjiang Uighur Autonomous Region in the past five years.

BEHAVIOUR OF RARE EARTH ELEMENTS IN CO2-RICH GEOTHERMAL SYSTEMS, NEW ZEALAND

HOPF, S.

Rare earth element (REE) behaviour during low temperature hydrothermal alteration in the Broadlands, Kawerau and Tauhara geothermal systems in the North Island of New Zealand has been measured by INAA. The REE compositions of hydrothermally altered rocks have been normalised against fresh rhyolitic/dacitic lavas from the Taupo Volcanic Zone to distinguish between primary REE variations and the effects of alteration.

Alteration assemblages formed by near neutral chloride fluids in the deeper portion of the systems have relatively consistent REE trends, typically subparallel to those of fresh lavas. The consistency of these patterns suggests that there was only limited mobility of REE during alteration in this zone. The variation in absolute abundance of REE is interpreted to be either a primary feature, or the result of dilution or concentration due to volume changes during alteration. However, exceptions to this behaviour are illite-rich samples, which show a broad-spectrum enrichment in REE, above that which could be acounted for by primary variations and density differences, and silicified rocks which are characterised by weakly enriched LREE, depleted MREE and discordant concave trends.

In the upper portions of the systems, where boiling takes place, CO₂-rich vapours mix with cooler groundwaters to produce acid fluids and associated atteration assemblages that show a range in REE patterns. In general, the altered rocks display an overall depletion in REE, and patterns that are markedly different from those of unaltered rock, suggesting that the REE have been selectively mobilised during alteration. REE trends of altered rocks may have either steep positive slopes and highly fractionated HREE, or silicified samples may have negative slopes with slightly depleted middle HREE. Large negative Eu anomalies occur in samples that are relatively depleted in LREE, and strong negative Ce anomalies are present in samples with enriched HREE. The depletion in Ce may have resulted from the oxidation of Ce³⁺ to Ce⁴⁺, which probably cannot be accepted into the crystal structure of the alteration phases. The broad depletion in REE in these rocks suggests that during alteration by acid fluids (pH 2-6) the REE preferentially partition into the fluid phase and

are removed in solution.

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SECONDARY GEOCHEMISTRY OF GOLD IN TUANJIEGOU, NORTHEASTERN CHINA: ITS CONTRIBUTION TO THE FORMATION OF PLACER GOLD HOU.Zhihui

nou, chinui Taking rock, soil, plant and natural water to be a long chain in the Tuanjiegou district, northeastern China. The geochemical behavior of gold in this long chain was studied, especially the changes of gold in secondary environment and its contribution to the formation of placer gold were addressed.

High concentrations of gold were discovered in Late Proterozoic schists and Mesozoic granites outcropping arround the headwaters of the Tuanjiegou stream in which placer gold deposits occur. A partial the huanjegod stream in which place gold deposits occur and place of extraction technique was used to determine the occurrence forms of gold in the rocks. The result showed that gold in the rocks was main-ly in mobile forms which were easily dissolved and transported in the secondary environment. The soil-forming process and biological cycle of deep-rooted plants brought about the redistribution of gold. Con-sequently a lot of gold was carried out from the soil into the slopesequently a lot of gold was carried out from the soll into the slope-water and stream. Analyses revealed that more than 60% of the gold in soll was taken into new environments (slope-water and stream). The chemical changes such as pH and Fe-Mm oxides in the secondary environ-ment resulted in the precipitation and enrichment of gold. This geo-chemical behavior of gold contributed a lot to the formation of placer gold which is quite different in particle size, shape, fineness, and trace metal contents from the primary gold.

RESEARCH ON COMPREHESIVE, GEOCHEMICAL EXPLORATION METHODS FOR OIL AND GAS AND ITS EFFECT IN BAISE BASIN, GUANGXI AUTONOMOUS REGION, CHINA

JIA.Guoxiang, LUAN, Jisean, CHEN, Yuanrong, ZHANG, Maozhong, ZHU, Qisheng, and DONG, Pin Controlled by the northwest-woutheast trending Youjiang fault, Baise Basin developed as a Cenozoic intracontinetal faulted depression on

Basin developed as a cenozoic intracontinetal faulted depression on the base of the Mid-Traissic folding of Indo-China period. In the Basin, the northwest, eastwest, and northeast trending criscross faults restrict evolution, transportion, and accumula-tion of oil and gas in the Tertiary. This research on comprehensive, geochemical exploration method for oil and gas and its effect almed geochemicial exploration method for oil and gas and its ellect almost at prospecting for oil and gas fields in unknown regions, delineat-ing their distribution and scale, the comprehensive, geochemical evaluation for various types of structural traps in the prospective areas, and narrowed the prospecting target and enhanced the possibi-lity of successful prospecting effectively. The result of this study shows that in the Baise Baisin, through

the comprehensive, geochemical methods, such as acidolysis hydrocarbon of soil sample (cl-c5), secondary carbonate of soil (c), soil halogen (i), soil conductivity (Ks) and soil absobed phase mercury (Hg). The element and index anomalies in the first four ways form semi-trapped halo effect.

Along the margins of oil and gas fields and accumulation, there are ring-like anomalies. The low value region in the larger annular anomaring-like anomalies. The low value region in the larger annual anoma-ies and semi-closed area mainly represents the extent (boundary) and distribution of the large oil-bearing trap structures and oil-and-gas fields, and the small annular anomalies reflect the distribution of the small-scale oil-bearing trap structures and oil and gas fields. on the contrary, mercury anomalies are massive, approxiately stripped and the higher value regions of anomaly represent the central part

and the higher value regions of an answery representation. The comprehensive geochemical way is used in various type of oil and gas fields of different areas, and the comprehensive geocehemical anomalies always have four characteristics, i.e., locality, direction,

anomalies always have four characteristics, i.e., locality, direction, assemblage, and similarity. We used the shape, feature, and distribution rule of anomalies of the comprehensive geochemical method mentioned above and discovered the No.2-6 comprehensive anomalies at grade 1 in the Leigong uplifted area, through the examination of drilling at Lei No. 1-5 for those anomalies. Industrious oil flow has been found in the wells at Lei No. 1, 3, and 5. It has been proved thoroughly that this comprehensive geochemical method can not only prospect effectively for oil and gas field in unknown area, but also determine effectively the oil-bearing property at the structural traps in the exploration areas. property at the structural traps in the exploration areas.

DISTRIBUTION OF GOLD IN THE ULTRAMAFIC MEMBER OF THE BETTS COVE OPHIOLITE COMPLEX, NEWFOUNDLAND, CANADA.

<u>IAVIONE, J</u>. and HATTORI, K. Au-quartz vein mineralization on the Baie Verte Peninsula, Western Newfoundland, preferentially occurs in and adjacent to carbonatized ophiolitic ultramafic rocks. The southern part of the Betts Cove Ophiolite untramatic place of distribution of Au with progressive carbonatization of ultramatic rocks and to determine the temporal relationship between deformation, metasomatism, and Au-introduction. The ultramafic member of the Betts Cove Ophiolite forms a northeast trending fault bounded belt approximately 9 km long.

The southern part of the belt is 750 m wide and consists of partially serpentinized layered cumulate rocks that are cut by serpentinite, talc-carbonate shear zones. To the north, the belt narrows to between 75 and 350 metres where the dominant quartz veins occur within talc-carbonate rocks in the northern part of the belt. There is no known Au-quartz veins in the southern part.

A complete spectrum of metasomatic products were recognized during detailed mapping in the southern area. These range from partially serpentinized ultramafic rocks to talc-carbonate-magnetite-hematite rocks. Chemical analyses in this area consisted of 115 whole rock Au determinations and 63 whole rock major and selected trace element determinations. Au

0.88 ppb (s.d=1.37, n=12) in partially serpentinized ultramafic rocks, .75 ppb (s.d=1.88, n=37 in serpentinite, 4.61 ppb (s.d=2.21, n=36) in carbonatized serpentinite; 1.59 ppb (s.d=6.91, n=17) in talc-carbonate-magnetite, and 203.38 ppb (s.d=358.20, n=13) in talc-carbonate-magnetite + hematite. There is no difference in major and trace element contents There is no difference in major and trace element contents between high- and low-Au talc-carbonate rock samples. In thin sections of anomalous Au samples, magnetite is corroded and replaced by magnesite. Hematite occurs within carbonate grains indicating its formation during carbonatization.

Serpentine in the partially scrpentinized ultramafic rocks is evenly distributed in otherwise fresh and undeformed layered rocks. Its occurrence may be attributed to displacement and emplacement of the ophiolite. In contrast, scrpentinite and talc-carbonate schists occur in shear zones that have also affected Silurian felsic volcanic rocks. This indicates that deformation and metasomatism which resulted in talc-carbonate formation postdated initial hydration. The distribution of Au and the occurrence of hematite in magnesite indicates Au concentration during carbonatization and hematite formation. The disseminated nature of the gold enrichment and the occurrence Au-quartz veins within talc-carbonate to the north suggest that this occurrence may represent a precursor to Au-vein formation.

GEOCHEMICAL EXPLORATION FOR GOLD LL Shanfang and YU, Jinsheng

This paper presents a review of geochemical gold exploration (both research and production work) performed by various units affiliated to the Ministry of Geology and Mineral Resources, which covers high-sensitivity laboratory and in-site analytical methods for gold, geological standard reference samples of gold, modes of occurrence of gold, research and application of conventional as well as nonconventional geochemical gold exploration methods, and effects of geochemical gold exploration, with emphatic description given to the obvious advances in this field. In China, geochemical gold exploration starts with the "strategic scanning" at relatively large sampling intervals in a large area or in some tectonic unit favorable for mineralization, which is followed by the compilation of regional geochemical maps at the scale of 1:200,000 in conformity with the international sheet division. As the detectivity of gold reaches 90 percent or more, the low background area, high background area, regional anomaly and the variation in intensity and dimensions of the anomalous concentration center all appear distinctly in the map, thus revealing large quantities of direct information on gold prospecting. By means of anomaly examination and further geochemical work, the target areas could be successively reduced and, through geological work and drilling examination, many gold occurrences and deposits might be discovered. Over sixty economic gold deposits have been found mainly on the basis of geochemical data. It is pointed out that in 1980s gold prospecting is most effective in geochemical exploration for metallic deposits.

Several cases of successful geochemical gold exploration are enumerated, and some examples are given concerning the application of such nonconventional methods as geochemical gas survey, electro-geochemical metal-extracting method and hydro-electrochemical method to the prospecting for gold.

Finally, the paper points out that geochemical exploration has been generally accepted as the most effective ore prospecting method in search for gold deposits, especially for micro-disseminated gold deposits which are almost irrecognizable to the naked eve.

MULTISTAGES OF GOLD MOBILIZATION IN MIGMATIZED HYDROTHERMAL GOLD DEPOSITS LIU, ENHUAI

earches about the source, migration, precipitation and Many previous res Many previous researches about the source, migration, interprietion and enrichment of gold in migmatized hydrothermal gold deposits have been undertaken, but rarely mentioned is the multistages of gold mobilization and its mechanism in geochemistry researches. Based on researches into the micro-analysis and chemistry thermodynamics, the auther is of the opinion that there are three stages of gold mobilization which are as follows

1) Early stage of gold mobilization. This stage happens in the period. of the formation of source bed. The primary Au-bearing geological forma-tion by volcanism is turned into gold source bed through widespread metamorphism, resulting in the early gold mobilization and unhomogeneous dis-

 Major stage of gold mobilization. This stage takes place in the period of migmatization and granitization. A lot of gold is reseased from "gold carriers" and migrated with ore-forming fluids into upper shear zone, forming gold orebodies when the "gold carriers" change into "gold-free minerals" during the period of migmatization, granitization, the process of widespread alkali-metasomatism. Two types of gold mobi-lization can be divided into volume mobilization and zoned one.

 Late stage of gold mobilization. This stage is very important for gold mineralization within gold-guartz veins and auriferous silicification zones, leading to further enrichment of gold and formation of ore shoots, although the distance of gold moved is considered to be not too much.

The extent of gold mobilization depending on the gold occurrence, the characteristics of ore-forming fluids and the scale of shear zones may be discribed by the heat of formation and free energy.

WORLD CLASS GOLD DEPOSITS-THE MODEL SUCCESS STORY-WHERE IS

WORLD CLASS GOLD DEPOSITS—THE MODEL OF COMPARISON OF THE NEXT OF A DEPOSITS—THE MODEL OF COMPARISON OF THE NEXT OF A DEPOSIT OF A DEPOS

Western Australia); (3) porphyry Cu-Au (Bingham, Utah); (4) epithermal vein-disseminated Au (Cripple Creek, Colorado; Ladolam, Papua New Guinea); (5) sediment-bosted Au-Ag (Carlin rend, Nevada); (6) Muruntau metaclastic-hosted Au (Muruntau, USSR); (7) Olympic Dam Ca-U-Au (Olympic Dam, South Australia).

The development of empirical and genetic models for each of these deposit-types has led to the discovery of other deposits sharing attributes with the prototype deposit. For example, the Bingham porphyry copper deposit was recognized as a viable resource in the early 1900s, and since that time more than 400 other porphyry copper deposits have been discovered, at least four of which have the potential to become world class gold producers. Recognition of the Carlin deposit in the early 1960s was rapidly followed by new discoveries which have delineared a merupart of all 000 terms rapidly followed by

bechtigter version and east rout of which have the products to exclude worm class goud producers. Recognition of the Carlin deposits in the early 1960s was rapidly followed by new discoveries which have delineated a resource of >1,000 tonnes gold along the Carlin ternd and discovery of more than 40 other deposits in western North America. The Carlin sediment-hosted Au-Ag model is being actively applied to prospects world wide. The Olympic Dam Cu-U-Au-Ag (Fe, REE) deposit is the newest entry to the list of world class gold deposit models. Antibutes of Olympic Dam and similar systems suggest the following exploration guides for the discovery of blind Olympic Dam-type deposits: (1) deeply penetrating crustal flaws which may be expressed as geophysical linearnents; (2) tectonic environments characterized by rifting and anorogenic conditions; (3) coeval plutonic-volcanic rocks of the peralkaline granite-synenite-gabbro (tanorthosite) assemblage; (4) peripheral pervasive redox, carbonatic, and alkali-metasomatism alteration, and by REE, halogen, Ba, etc. geochemical halos. Using these criteria, we suggest that promising Olympic Dam-type prospects occur in such diverse locales as the McArthur basin, Northerm Territory, Australia; the intractatoric basins, Northwest Territories, Canada; the anorogenic granite-rhyolite province of the mid-continent United States; the Saint Lawrence rift, Canada; the Seal Lake, Labrador and Gardar, Greenland alkaline rock provinces; the Highlands of Scotland; and the East European craton.

EXPLORATION GEOCHEMISTRY OF JASPEROIDS

NELSON, C.E. Carlin-type disseminated precious metal mineralization is

NELSON, C.E. Carlin-type disseminated precious metal mineralization is typically accompanied by jasperoid, a distinctive alteration product formed by intense silicification of marine sediments. Jasperoids are resistant to erosion and are typically enriched in Au. Ag. As. Sb and Hg. A 45-element database has been constructed for close to 400 samples collected from 6 ore deposits and 4 barren Carlin-type systems. These data were used to compare jasperoid from barren both groups show similar enrichment in Au. Ag, As. Sb and Hg. Apparently, jasperoid enrichment in Au. Ag, As. Sb and Hg. Apparently, jasperoid marken in an epithermal suite indicates only that an epithermal process was responsible for alteration. A precious metal deposit may or may not be present. Disciminant analysis provides a more reliable tool for separating barren from mineralized systems. An eight-element function derived from the 45-element database is 90 percent effective at identifying jasperoids collected from mineralized systems. This function has been tested on close to thirty additional prospects and several additional orebodies. All of the ore deposits are reliably identified, including those where the jasperoid overlies deep ore (e.g. Post). Discriminant analysis, appropriately applied, provides a powerful new exploration tool for Carlin-type gold deposits.

RECONNAISSANCE GEOCHEMICAL PROSPECTING AND GEOLOGIC SETTING FOR MINERALIZATION IN THE LESSER ANTILLES VOLCANIC ARC - WEST INDIES <u>NIELSEN, R.L.</u>, HITE, J.B., and RUCKMICK, J.C. Islands of the Lesser Antilles in the eastern Caribbean Sea lie

Islands of the Lesser Antilles in the eastern Caribbean Sea he along two sub-parallel volcanic arcs of slightly different ages. An outer eastern arc includes the islands of St. Martin, Antigua, eastern Guadaloupe and parts of Dominica, Martinique, The Grenadines, and Grenada and formed by active magmatism in Eocene through mid-Miocene time. The inner or western arc is late Miocene, Pliocene and Recent in age and includes the active or dormant volcanoes of St. Kitts, Montserrat, Dominica, Martinique, St. Vincent and Grenada. The two arcs coincide in the south half of the lesser Antillas chain and diverge in the north. Lesser Antilles chain and diverge in the north. The older arc consists of marine mafic to andesitic pyroclastic rocks and associated sediments that have been weakly metamorphosed, folded, faulted and intruded by shallow plutons of rhyolite, quartz latite, granodiorite and diorite. The younger arc consists mainly of composite andesitic volcanoes with some basaltic pyroclastic cones and maars.

Results of geologic surveys and extensive rock chip, soil and stream-silt geochemical sampling suggest the volcanic arcs exhibit

several styles of mineralization and hydrothermal alteration: 1) Stratabound, layered volcanogenic exhalative sulfides in tuffaceous marine rocks with elevated silver base metal, arsenic, and berium values.

 2) Bulk disseminated, stockworks, breccia-hosted, and limestone replacement sulfide mineralization in cupolas and margins of highlevel dioritic intrusions; copper, gold and iron values are elevated.

a) Quartz veins and pyritic disseminations in and around rhyolite dikes, and domes that intrude pyroclastric rocks with elevated arsenic, antimony, mercury and precious metal values.
4) Near surface solfataric alteration and fine pyrite mineralization along faults and within permeable pyroclastic breccia units on the flanks of the young andesitic volcanoes; arsenic, antimony, and mercury values are elevated.
Economic potential of the mineralization is not yet defined.

Most high metal values and associated ore targets generally are located in poorly exposed and partly covered volcanic rocks of the older volcanic arc.

NEW DIMENSIONS FOR GOLD DEPOSITS IN TURKEY OZKOCAK, M.O.

During gelogical periods, Turkey has undergone intense magmatic tectonic evolution. Various magmatic activities occurred and different kinds of intrusive and volcanic rocks took form; thrusts, thrust faults, big fault zones, subduction and collision zones, basin and range structures have been the principal elements of the intense structural evolution.

Volcanic, intrusive and geothermal areas, affected by important tectonic activities, have a heat source at the depth and an important permanent high heat flow. Neogene volcanic rocks of Western Anatolia and volcanic systems

of Cretaceous, Eocene and Oligocene ages of Eastern Black Sea Coast exhibit very spectacular and important auriferous base metal and gold deposits which have drawn attention of the world known big mining companies.

Combined structure consisting of North Anatolian fault and Anatolian plate moving toward the north and entering in contact with the plate of Pontids by this big fault favors the formation of gold deposits. Pre- and post-plutonic volcanic rocks show clearly the presence of the heat source of long period.

Southeastern Anatolia thrusting zone representing the collision between Arabic block and Anatolian plate constitutes very favorable structure for gold formation. Along this structure distribute some gold and silver occurrences and favorable areas as Malatya-Poturge with extensive pyrophylitization and silicification as in Pueblo Viejo gold and silver deposit of Dominican Republic. Smaller simil-ar structures are numerous in Turkey. Basin and range structures such as Western Anatolia, Hatay, etc.

constitute important potential areas for gold exploration. Many antimony deposits related to or not related to magmatic

systems are auriferous. Because Sb occurs at surface or in shallower levels of the epithermal gold deposits, all Sb deposits warrant detailed gold exploration. Hg and As which generally accompany Au are also numerous in Turkey. High heat flow and high angle large faults of geothermal areas

of Anatolia favor gold leaching and deposition to form gold deposits. In some geothermal areas, such as Bolu-Seben and Nevsehir-Kozakli, geothermal brines yielded 100 ppb Au. There is an obvious relation between geothermal resources and gold deposits in Western Anatolia; petroleum discoveries are for the moment only as indications. In the Eastern and Southeastern Anatolia, petroleum and geothermal resources are widespread; gold occurrences are not so numerous as in the Western Anatolia. In fact, gold exploration in the East is not so frequent. High heat flow, high geothermal gradient and temper-ture up to 150°C in the petroliferous areas can creat additional possibilities. Moreover, asphaltites of Southeastern Anatolia as-say 0.35% Ni, Co, V, Mo; data for gold and silver are not yet sufficient.

Formation of sepiolite deposits especially close to the important faults indicates low heat hydrothermal alteration. Similarly, magnesite. talc, opal, chalcedony, chromium minerals such as kaeme-rerite, uvarovite, smaragdite are products of low heat hydrothermal alteration of ultrabasic rocks. Zeolitization and scapolitization in ophiolites are also very important. These alterations are also

worth to be checked for gold exploration. In conclusion, important epithermal conditions have reigned in Turkey with intense magmatic and tectonic evolution which provides actually with important geothermal resources and frequent earth-quakes. In addition to gold and silver discoveries to date, several hundred new deposits may be discovered in Turkey.

LITHOGEOCHEMISTRY AND GEOLOGICAL MAPPING IN THE VERMILION GREENSTONE BELT, MINNESOTA, AS AN AID TO MINERAL EXPLORATION <u>REICHHOFF, J. A.</u>, HAUCK, S.A., SOUTHWICK, D. L.

The Vermilion greenstone belt in northern Minnesota is a complex tectonic assemblage of late Archean volcanic and sedimentary rocks that consists of the classic Vermilion district, where iron ore has been mined for more than a century, and its subsurface extensions to the west beneath glacial cover. Several cycles of mineral exploration for commodities other than iron have occurred in the belt over the years, generally without success; perhaps the most intensive of these has been in the last decade, following the general recognition that the Vermilion greenstone bett is tectonically a part of the very productive Shebandowan-Wawa-Abitibi subprovince of the Superior Province of Canada. To assist industry with the difficult task of conducting exploration in this poorly exposed region of Minnesota, the State has conducted regional mapping projects aimed at providing the geological, geophysical, and geochemical framework required for mineral potential assessment and strategic planning. The lithogeochemistry and mapping project described here is designed to provide regional data on rock compositions within the Vermilion areenstone belt.

Recent geological mapping, supported by detailed aeromagnetic mapping and shallow drilling in poorly exposed areas, has led to the recognition of at least three volcanic-sedimentary cycles in the Vermilion greenstone belt. These are: (1) a dominantly calc-alkalic sequence that includes rocks south of the Mud Creek and Wolf Lake faults in the Vermilion district and southeast of the Bear River fault in northeast Itasca County; (2) a dominantly tholeiitic sequence that includes rocks north and northwest of these faults; and (3) a mixed volcanic sequence of unknown stratotectonic affinity (in the "Virginia horn") that lies south of sequence (1) and is separated from it by intrusive granitic rocks of the Giants Range batholith.

Approximately 275 rock samples have been collected from these three volcanic sequences and analyzed for major elements; minor elements, and trace elements (70 elements total). These data form an analytically consistent set that characterizes the lithogeochemistry of the volcanic sequences and facilitates comparisons, correlations and petrochemical interpretations of them. The data also provide the statistical background on the distribution of metal background concentrations, and pathfinder elemental associations in the rocks that is necessary for meaningful interpretation of the more than 6,200 partial rock analyses that have accumulated over the past century from academic and exploration activities in the Vermilion greenstone belt.

Products of the lithogeochemistry project will be: 1) a generalized regional geologic map of the central part of the Vermilion greenstone belt that shows sample locations for the 275 new 70-element rock analyses; (2) a computer file (electronic) of the new analytical data; (3) a computer file (electronic) of the archival analytical data; and (4) a report that describes methodologies and provides interpretations.

NEW PATHFINDERS FOR GOLD-ZINC EXHALATIVE MINERALIZATION IDENTIFIED BY MULTI-ELEMENT GEOCHEMISTRY IN THE AR RJUM ZINC PROSPECT (HULAYPAH PROTEROZOIC BELT, SAUDI ARABIA) SALPETEUR, I.

SALPETEUR, I. Multi-element geochemical analysis of drill-hole-, trench- and soil-samples collected in the vicinity of the sedimentary exhalative zinc-gold mineralization at Ar Rjum in the Central Arabian Shield were subjected to systematic and comparative study of inter-element correlations, accompanied by lithogeochemical mapping based on cluster analysis of the data. Results reveal (1) new pathfinders (Y/Ti, P) for mineralization below the surface, (2) the slightly discordant character of the Cu-2n-Ag-Au mineralization in relation to the dolomite market of the Cu-Zu-again mineralization in relation to the dolomite market layer, (3) the presence of an eight-meter-wide high-grade polymetallic halo at depth, which disappears towards the surface, (4) the presence of a low-grade Zn halo (grading more than 1,000 ppm Zn, more than 500 ppm Cu, and 8 ppm Mo) extending for 20 m into the black shale at the hanging wall of the mineralization; and (5) local K/Na alteration resulting from partial Na leaching at the footwall.

Comparison with data collected at the surface (phase-1 soil geochemistry on a 25 x 100 m grid) shows that the Ag and Au signals become very attenuated and erratic, whereas Cu, Pb, Zn and Mo satisfactorily mark the mineralized layer.

Further soil geochemistry over an area of 16 km² (phase 2) demonstrates the existence of an Au-Cu-Zn-Pb anomaly, over 1,500 m demonstrates the existence of an Au-cu-cu-ro anomaly, over 1,300 a long and extending into one of the trenches. Several less-contrasted anomalies were also discovered during phase 2. A clear geochemical relationship between gold and the yttrium/titanium ratio exists; paleogeographically, a submarine exhalative model explains the mineralization.

SEDIMENTOLOGICAL AND GEOCHEMICAL CONTROLS OF GOLD BEARING PALEOPLACERS FROM THE ORAPU BASIN, FRENCH GUYANA

<u>SALPTER, I.</u>, MANIER, E., MILESI, J.P., MERCIER, D. Several gold anomalies in soils covering Archean basement rocks were discovered during a BRGM gold regional exploration in Northern French Guyana in 1987.

A preliminary sedimentological study of the Archean sedimentary source rocks indicates a regional correlation between the main gold anomalies and debris flows facies (according to the Miall classification 1977) filling intracratonic basins.

Multielement geochemistry from channel sampling of these primary rocks define cyclic variations of Fe. Ti. Cr. Ce. P and Au, which correspond to plurimetric to decametric alternation of matrix suspended gravels (GMS of Miall 1977) and crudely bedded gravels (GM of Miall).

The richest gold intersections occur where the average pebble size and the percentage of quartz pebbles are highest. This debris flow (GMS) is typically depleted in Fe, Ti and enriched in Ce, Zn (partly inherited from gahnite).



Average SiO, (%), Au (ppb), Zn (ppm) grade in a typical debris Average Jus, (a), au (ppp), at (ppm), grave in a (ppical of [fow sequence (St: cross-bedded sands; Gt: trough cross-bedded gravel; Gms: mssive matrix supported gravel Gm: crudely bedded pebbly gravel)

BIOGEOCHEMICAL SURVEY FOR HYDROCARBONS IN THE KAZA AREA, KRISHNA DELTA, A.P., INDIA

SITARAMAYYA, S., RANGANATHAN, K.

A biogeochemical survey was undertaken in the Kaza area, Krishna Delta, on the east coast of India, where proved deposits of oil and natural gas deposits occur in the Eocene sandstones and limestones.

Soil samples and twig samples of Acacia Arabica tree, which occurs widely in this area, were collected with a sample density of one sample for one sq.km. The area is covered predominantly by black cotton soils with occasional patches of silt and fine sand. The area experiences a hot humid climate with seas onal rains in the monsoon months of June to October.

the monscon months of June to October. Soil Diethylenetriaminepentaacetic acid (DTPA) extractions with a two hour contact time were prepared for all the samples and the elements Fe, Mn, Cu and Zn were estimated. The anomaly maps prepared using this data indicate that the soils contain less than background values of all the elements over the hydrocarbon pools. The values increase abruptly near the periphery of the anomalous region and the high values occur in discontinuous patches around the anomalous areas and contain less than region and the nigh values occur in discontinuous patches around the anomalous areas and gradually merge with background values outside. The shape and size of the anomalous areas vary with the element. Fe distribution map shows a compact area which is more or less has the shape and size of the oil pool. The Mn, Cu and Cn anomalous areas have irregular shapes, but all the productive wells are located in the negative anomaly region. A multi-element map showing the superimposed common anomalous areas invariably contain the productive wells. contain the productive wells.

Soil samples in a profile across an anomalous area were used in studying the effect of the contact time on the amount of metal extracts by the DTPA. Soil samples were kept in contact with

DTPA for half an hour, one hour and two hours. These extractions were used for the estimation of Fe, Mn, Cu and Zn. Extraction with two hours contact time contained the maximum metal content. All the metals have shown low values over the oil pool with an abrupt rise in values near the periphery. The extracts with half abrupt rise in values near the periphery. The extracts with half hour contact time have less elemental content compared to the pre-vious one but contain relatively high values in the middle over the hydrocarbon pools and low values near the periphery. This is in contrast to the previous type of distribution. Apparently lateral migration of these chelated compounds is taking place and their Is in control to the previous ope of distribution, appendix, and migration of these chelated compounds is taking place and their increasing oxidation and immobilization has resulted in the accumulaincreasing octation and immoving the periphery of the pool, part of which is extracted by the DTPA with two hour contact time. This

which is extracted by the DTPA with two hour contact time. This fraction is obviously not available to the plants. The plant ash samples were analysed for Fe, Mn, Cu, Zn and Cr. The anomaly maps indicate that high values of all the elements prevail over the hydrocarbon pools. The distribution of Fe, as in the previous case, is more compact and regular whereas the other elements have irregular elongated shapes. However in all these cases the productive wells fall in the anomalous regions. A multi-element anomaly map has brought this out much more clea-rly. All the productive wells invariable fall in the superimposed common anomaly areas. common anomaly areas.

Apparently the high values of metals in the plant material are derived by absorbing the chelates which are easily available to the plant and can be extracted by the DTPA with less than half an hour contact time.

A + ... garithmic graph showing the relationship between the DTPAextractable soil Fe (with two hour contact time) versus relative accumulation (plant Fe/Soil Fe) has indicated a linear negative relationship proving that the tree Acacia Arobica is suitable for use in the biogeochemical surveys in this area.

The biogeochemical survey using Acacia Arobica tree has proved to be very reliable. This method is time-and cost-effective and is a very sensitive guide to hydrocarbon deposits.

A GEOCHEMICAL INVESTIGATION OF THE HATU GOLD ANOMALY, XINJIANG-UYGUR AUTONOMOUS REGION, CHINA

SMITH, D.B., THEOBALD, P.K, SHEN, Shiquan, REN, Tianxian, and HOU, Zihui The Hatu mining district is located to the west of the The Hatu mining district is located to the West of the Junggar Basin in the northwest corner of Xinjiang-Uygur Autonomous Region in northwest China. The climate is semiarid to arid and wind erosion predominates. Over several years preceding 1987, the 7th Geological Brigade conducted a regional sóil survey of the Hatu district. Samples were collected on a 200 by 500 meter grid and then composited prior to chemical analysis to comprise a density of one sample per square kilometer. The survey delineated a series of south-south-set-trending gold anomalies hormalous gold sample per square kilometer. The survey delineated a series of south-southeast-trending gold anomalies. Anomalous gold values range from 5 ppb to more than 700 ppb. The most prominent of these anomalies, termed the Hatu anomaly, is more than 30 km long and about 5 km wide. The mining town of Hatu and the economic gold deposits of Qigu 1 and Qigu 2 are located at the northern end of this anomaly. The other major anomalies are similarly situated over and to the south of known lode gold occurrences. The axis of the Hatu anomaly, as well as the axes of the other smaller anomalies, cuts across mapped structure and stratigraphy in the district, but is parallel to the speculation of eclian dispersion of gold. The alternative interpretation, that the anomalies reflected additional primary gold occurrences, was not reflected additional primary gold occurrences, was not consistent with existing knowledge of the known occurrences and geology. In 1987, a cooperative project between the U.S. Geological Survey and the Institute of Geophysical and Geochemical Exploration was initiated to evaluate the origin this gold anomaly. The investigation led to the identification of three types of

of gold in heavy-mineral concentrates derived from stream sediments that were collected along the axis of the Hatu anomaly: (1) free gold, (2) gold in pyrite, and (3) gold included in quartz. Gold in quartz was only observed within

included in quartz. Gold in quartz was only observed within 2 km of Qiqu 1. Free gold, the dominant type, composed up to 1 percent by weight of some of the samples. The size of the gold particles and the number of gold particles in the concentrates did not decrease uniformly with distance from Qiqu 1 as would be expected from eolian or fluvial dispersion from a point source. Instead, both the size and amount of gold increased significantly at a distance of 3.5 km from Qiqu 1 with the increase continuing to approximately 5.5 km from Qiqu 1. The mean intermediate diameter of gold particles increased from 0.1 mm to approximately 0.25 mm and the gold particle content increased from approximately 0.3 marticles per kilogram of sample to almost 8 particles per

the gold particle content increased from approximately 0.3 particles per kilogram of sample to almost 8 particles per kilogram of sample. The morphology of the gold changed from a delicate filigree texture near Qigu 1 to coarse, blocky particles in the southern part of the anomaly. It is concluded that the Hatu anomaly is caused primarily by alluvial dispersion of free gold from local point sources along the anomaly. Any eolian dispersion is restricted to very fine- grained (+/-2 micrometers) gold included in sulfide minerals or guartz grains and is only significant within 1 or 2 kilometers of the deposit. An additional implication of this study is that the entire anomalous area is a target for undiscovered lode gold deposits.

STYLES OF GOLD MINERALIZATION IN THE LOWER PALEOZOIC MEGUMA GROUP, NOVA SCOTIA, CANADA: REALITY OF LARGE TONNAGE GOLD DEPOSITS SMITH, P.K. and KONTAK, D.J.

Recent geological studies, coincident with extensive surface and underground exploration and development at several gold districts in the Lower Paleozoic Meguma Group, have concluded that several distinct styles

of gold mineralization occur throughout the region. Historical production (1.2 million oz. Au) from 60 gold districts came mainly from three quartz vein systems: (1) bedding-parallel veins (- 15 cm wide), (2) cross-cutting or angular veins (-30 cm wide) and (3) stockwork vein systems (-3 m wide). In addition, disseminated mineralization in wall rocks was mined locally at several deposits. However, the recent discovery of bulk mineable 1.05 at several deposits. However, the recent discovery of bilk minesite 1.05 million tonnes at 2.63 grams per tonne (Northern Miner Magazine, 1990), disseminated gold mineralization in vein-free, thick, hydrothermally altered argillites at Moose River (Touquoy Zone) and 28.9 million tonnes at 2.59 grams per tonne (company prass release, Dec. 19, 1990) amenable to open pit mining at Upper Seal Harbour, has led to speculation of similar mineable reserves throughout the Meguma Group.

The geological history of the Meguma Terrare encompasses regional deformation and metamorphism (greenschist to amphibolite facies) of the Meguma Group turbiditic sedimentary rocks during the mid- to late Devonian, followed by persluminous gramitoid plutonism (370 Ma) with contact metamorphism, and heterogenous brittle and ductile shear deformation.

High grade, quartz vein hosted, gold ore shoots are commonly developed at along the intersection of cross-cutting brittle structures (such as kink bands) and bedding. These secondary structures typically display a consistent NW trend, although dip angles may vary. Examination of minor these minor structures allows for reliable prediction of both position and geometry of these ore shoots. Both high grade ore shoots and low grade disseminated mineralization occur within a single deposit. Native gold (containing an average of 4 wt. X Ag) in these deposits

occurs in a wide array of sites and grain size ranges from $<1\mu$ to coarse nuggets weighing several ounces. Besides the ubiquitous base metal (Cu, Pb, Zn) association, Bi, Sb, Te and W frequently display localized anomalous enrichment. In vein-type deposits, gold characteristically occurs with late-stage, massive, white quartz in all vein types, either associated with sulphides or as minor wall-rock disseminations adjacent to vein margins. In disseminated deposits, gold occurs either with sulphides or in isolation.

or in isolation. Hydrothermal alteration, manifest by silica, carbonate, sulphide and sericite replacement, is a common feature of all Meguma gold deposits. Silica and carbonate form wide, irregular halos surrounding the gold districts, whereas sulphides and sericite are generally restricted to mineralized zones. Whole-rock geochemistry indicates corresponding element enrichment for each of the alteration types. Stable and radiogenic isotopic studies suggest that although the ore-forming fluids have interacted with Meguma Group lithologies, an additional reservoir is required to account for the isotopic signatures. The only lithology in the Meguma Terrane which could satisfy a single source for Meguma gold mineralization is the Liscomb gneiss which structurally underlies the Meguma Terup. Meguma Group.

FALSE DRAINAGE ANOMALIES IN A GRANITE AREA, KVALØYA IN TROMS, NORWAY - A CASE STUDY. STENDAL, H. and PETERSEN, M.D.

A regional overbank sediment sampling survey representing large drainage areas in northern Norway revealed several anomalous geochemical regions. Several areas in Troms Fylke were anomalous in Ti, Nb, Sn, Th, W, Y and Zr. One of these areas was a subregion on Kvaløya, which was chosen as a detailed follow-up study to confirm the overbank sampling anomalies and finding the source causing the anomaly values. The anomaly values in the overbank sediment samples were 3-20 times higher than the average background

In the oversank sediment samples were 5-20 times higher than the average background values for the whole region. The target area (100 km²) consists of a medium-grained granite (Ersfjord granite) containing quartz and feldspars associated with epidote, biotite and accessories of sphene, zircon and apatite. The granite is in certain zones (up to 200 m wide) mylonitised. These fine-grained mylonites are rich in epidote and are enhanced in fine-grained sphene and areas and a set of the set of the set of the set. zirco

A detailed follow-up study was carried out in a drainage catchment area (6 km²) collecting stream sediments (-100 um fraction), heavy mineral concentrates and rock

samples. These sample media were investigated geochemically and mineralogically. The drainage sediments (stream sediment and heavy mineral concentrate) are all highly anomalous especially in Nb, Ti, Y, Zr and light REE (La, Ce). The lithogeochemical results do not give any indication of mineralization or especially high values in any of the target

to not give all indicator of internation of especially studied and of the earger rocks except for a small enhancement in the mylonitic rocks. The drainage samples were also mineralogically studied aiming to find out which minerals gave the anomalous values. Apart from the contents of quartz and feldspar the stream sediment and the heavy heavy mineral are similar in mineralogy with epidote as the dominating factor associated with several vol.% of sphene and fine-grained zircon.

The geochemical values of the drainage samples are up to ten times (Nb, Y and Zr) higher in the stream sediment samples than the average contents of the rock samples. Sphene, zircon and apatite are geochemically confirmed by Ti, Ca, P_{2O_5} and Z. The enhanced values of light REE (La and Ce) and Nb are due to spene and Y due to zircon. It is concluded that the anomalies obtained both by overbank sediment sampling and the

follow-up drainage sampling are false anomalies and not related to any particular mineralization. The fine-grained sphene and zircon are naturally concentrated in the fine fraction of the sample media. The mineralogical studies have showed that the mineral assemblage of the drainage sediments and the rock types are similar in composition. This case study shows that the other anomalous areas in the same elements on a regional

scale should be taken up to consideration before any other follow-up study is established.

APPLICATION OF STATISTICAL PATTERN INTEGRATION TO APPRAISAL OF SYN-THETIC INFORMATION OF GOLD MINERAL RESOURCES IN THE NORTHERN JIAMU-SHI BLOCK, NORTHEAST CHINA

SUN, Jigui and CHENG, Qiuming

This paper describes a comprehensive study of the regional tectonic outline of the northern Jiamushi block, Northeast China, based on its synthetic information such as geology, geophysical and geochemical prospecting, and remote sensing. Referring gold anomalies to mineralized objects, the authors apply the method of "statistical pattern integration" to mineralized objects proposed by Agterberg (1989, Canada) to calculate quantitatively the control weights of geological factors on gold mineralization and to reveal the distribution laws of gold deposits in this area.

EXPERIMENTAL RESEARCH FOR RELATIONSHIP BETWEEN SHEAR ZONE AND GOLD DEPOSITS SUN.Shenglong

Many gold deposits relate closely to shear zone in place. To explore their internal relationship, the author used the ground diabase pow-der to mix homogeneously with gold-bearing pyrite powder (8 ppm) as a sample. The sample was made into a cylinder SHAPE .5 cm in diameter and 5 cm in height. The tests were performed with a high-temperature and high-ressure triaxis experimental system in the laboratory of Changchun University of Earth Sciences, China. The sample was heated to 950° C for 9 hours and 30 minutes. After heating 5 hours, the axile pressure was increased from 1 to 5.3 bar. The compressing stress around the sample was 2 kbar. After the tests polished sections were made

Observation on the sections by naked eyes shows that pyrite was liberated from the melted diabase. The pyrites exist in four types: (1) as small balls in the porcelain and as fine veins around it; (2) as narrow stripes in the upper shearing surface, the argles of shearing surfaces with the directions of axile pressure are 30° and 60° , respectively; (3) as heap bodies at the bottom of the sample; (4) shearas small balls with diameter ranging from 0.15 to 0.05 cm near the bottom. Observation under microscope shows that a few drops of pyrite were distributed along the lower shearing surface. The small pyrite balls at the bottom was analyzed by electronprobe and were found to contain 198 ppm gold.

According to these results, the author suggests that the model as follow: The gold-bearing rocks were melted. The gold and sufides, be-cause of their density, are concentrated downward but stay at the bottom of the magma chamber. The depth of the shearing zone developed is just the same as gold-bearing sulfides are concentrated. So the geologic conditions for both to coexist are the same. The squeezing actions that forced the sulfides into the shear zone are the first condition for both existence. In the field, the factors such as depth, attitude and time of a shear zone should be considered when one tries to research the relationship between shear zone and gold deposit. The author believes that shear zone with the characteristics at greater depth, high angle as well as the Precambrian age is favorable for gold mineralization.

As an example, the author will discuss the features of Jiapigou gold camp, Jilin Province, China which occurs in a shear zone and is also suitable for the model.

APPLICATION OF REGIONAL GEOCHEMICAL DATA TO AGRICULTURE AND ENDEMIC DISEASE

SUN, Tianyu and LI, Jiehua

This paper presents a study of the application of regional geochemi-cal data to agriculture and endemic disease. The study was carried out in the 1:200,000 Qinglong and Sanhaiguan Quadrangles in Hebei Province, China. Analyses for rock soil, and stream sediment could regionally reflect or/and represent the concentration tendency of the elements in soil, which elucidates that from the regional angle, the geochemical data got with stream sediment survey can be applied to agriculture and endemic disease. Comparison of yields of main crops in recent years and the mortar-

ity of some endemic diseases with the geochemical distribution of elements reveals that peanut, wheat, and Chinese sorghum have low yields in the areas deficient in B, Co, Mo, and Zn; the high death rate of esophagus cancer occurs in the areas deficient in Mo; and the high mortarity of diabates and hypertension is found in the areas deficient in Cr.

The environmental geochemical maps of B, Co, Cr, Cu, Mo, and Zn, marked "deficient area", "potentially deficient area" and "potential-ly excessive area", were compiled according to the results mentioned above.

SOIL AND ROCK MERCURY AS A USEFUL EXPLORATION TOOL FOR THE CHINKUASHIH GOLD-COPPER DEPOSITS TAN,L.P. and YU,B.S.

TW,L.P. and YU,B.S. The Fleistocene Chinkuashih deposits in Taiwan produced 100 tons of gold and 100,000 tons of enargite and luzonite copper in the last 90 years. The 4,000 soil samples collected within an area of 3 km² show a range of 20 to 1,840,000 ppb Hg, averaging 2,428 ppb. For the mercury in mineralized areas, the ranges are 3,000-1,8640,000 ppb over breccia pipes, 200-10,000 ppb over gold-copper veins, and 200-4,400 ppb over gold veins, analyzed by the gold-film method, Of these samples, 67% has less than 300 ppb Hg, but 12% more than 100,000ppb. The mercury occurs mainly in cinnabar but less commonly in the native form. The soil mercury detects mineralizations better than the cold-extractable copper and the total copper, and is also more useful than geological and geophysical prospectings. The recent soil mercury exploration has discovered high-grade orebodies in a marginal area after previous intensive explorations in the Chinkusshih district. The 3,000 surface and underground ore/rock samples show good correlation between Hg and Au. High-grade gold ores have high Hg contents, and high Hg contents also occur in the barren rocks 100-200 m over orebodies, which do not show signs of hydrothermal alteration. show signs of hydrothermal alteration.

ON THE QUALITY STANDARD OF MAIFANSHI (MAIFANSHITE, MAIFAN-STONE) TAO.Z.Z.

Maifanshi is a kind of Chinese Medical Stones. It is very useful for human race, plants and animals. We have found more than 40 locations in China. But we do not know that which is better or worse, and so we are looking forward to the quality standard for maifanshi since 1985. And now, it is provided by us. In short, there are four functions, two indexes and the norm of the rare earth elements (REE) in other. Four functions are dissolubility, absorption, adjustabili-ty, and the incremental dissolved oxygen (D0).

Two indexes are as follow: a).The contents of elements (including profitable and ha-mful elements-P.E. & H.E.) in maifanshi, P.E. are not less than the Clarke value, but H.E. are not more than the Clarke value.

b). The contents of P.E. in maifanshi's solution, first the solution must be in keeping with the sanitary standard for drinking water(China 1986-GB5749-85), then one item(P.E. or P.E.-compound) must achiev the standard of drinking natural mineral water(China 1988-GB8537-87), perhaps more than two items must be close to it. The norm of REE is that: The contents of REE in maifanshi

must be 200-700ppm or more than 700ppm. It must be pointed out that the maifanshi must not contain independent-minerals of REE except the carbonate-minerals of REE, which are not soluble in water.

It has been found that the contents of REE for human tis-sues and body fluids are as follows:

eleme	ntcont	contents(ppm)			
	female	male			
هت	<1.1932<7.8762	<1.1702			
Ce	1.2185 1.239	1.1885 1.209			
Y	<11475.0954<14431.7644	<13170.2097<16120.1957			
Pr	<0.1	127			
Nd	<0.5	5892			
Sm	<0.2	24			
Eu	<0.2	251			
Gđ	<0.2	212			
Tb	<0.1	1106			
Dy	<0.2	2			
Ho	<0.2	223			
Er	<0.	132			
Th	<0.1	1226			
Yъ	<0.2	21			
Lu	<0.0	0526			

According to the quality standard, maifanshi may be divied three kinds: (A).First rate; (B).Second rate; (C).Third rate.

A COMPARATIVE STUDY OF CARLIN-TYPE GOLD DEPOSITS IN W. CHINA AND IN NEVADA, USA AND IMPLICATION FOR MINERAL EXPLORATION TU.G.Z.

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In both SW Qinling and SW Guizhou, China, the Carlin-type Au deposits are well developed. Besides, in both these districts, metallogeneic belts of Au-Hg-As-Tl can be distinguished, as is the case with the Carlin trends in Nevada, USA. In many respcts, such as the geologic setting, the ore-hosting sedimentary rocks, the ore and gangue mine-ral assemblages, the wall rock alteration, the trace element and the stable isotope geochemistry, the Chinese and the Nevadan Carlin-type gold deposits are quite similar. In SW Qinling and SW Guiahou, the ore-hosting rocks are Paleozoic

and Triassic unmetamorphosed fine-grained clastic sedimentary rocks, chert and carbonates. The volcanic and coarse-grained clastic rock intercalations are scarcely met. The Au deposits therein are stratabound, but the structural control of ore bodies can be clearly observed, with ores confining to fracture zones mostly in anticlinal axial parts or along faults. The tectonic setting of SW Qinling is that of a miogeosyncline, while that of SW Guizhou, a platform regime.

The Au ores in SW Qinling and SW Guizhou are characterized by disseminated mineralization in the altered fractue zone. The wall rock alteration is mainly manifested in silicification, argillation, and sericitization, with the development of various carbonates. The mineral assemblage is quite similar in the sedimentary rock-hosted Au ores in SW Qinling and SW Guizhou, China and at Carlin, Nevada. The Hg, Sb, As, Tl, Pb, Zn, Cu trace element patterns and the S and O geochemistry of the ore from the above-mentioned deposits are also similar.

However, if the metallogenic belts or trends are taken into consideration, or if the mechanism of ore formation is considered, important differences between the Chinese and the Nevadan deposits can be found. Firstly, although a number of Tl minerals have been observ-ed at Carlin, no Tl ore deposit has ever been found in the Carlin trends. In SW Guizhou, nevertheless, important lorandite (TLASS,) deposit with industrial significance was lately discovered. Secondly, in the Carlin trends, no U deposits have ever been reported, but in both SW Qinling and SW Guizhou there are U deposits. Therefore, the metallogenic belts in the latter case should include U besides Au, Hg, Sb, As, and Tl. The co-existence of independent Tl and U deposits in association with Carlin-type Au deposits in the same metallogenic belts is a fact which should not be neglected in mineral exploration. Thirdly, field and laboratory observations show that the heat sources which were possibly related to the activation, transportation and enore substances in the Phanerozoic sedimentary beds are richment of not the Tertiary extrusive or intrusive rocks, as they are absent in both SW Qinling and SW Guizhou. Instead, the high paleothermal gradient and structural distubance might have played an important role in ore formation in these metallogenic belts.

GEOCHEMIOCAL MODEL FOR GOLD MINERALIZATION IN SOUTH DEVON, ENGLAND USING RASTER BASED G.I.S.

WANG, C.L., BELETE, K. and MOON, C.J.

A number of discrete gold anomalies have been discovered within Low-er Devonian sediments and volcanics in South Devon, largely by the British Geological Survey. The studies to date indicate that the alluvial gold grains are enriched in PGE and of ambiguous origin. We have attempted to investigate the potential of the area by modeling

the known occurrences and using the results in a Geographical Information System.

Possible origins for the gold are:

1. Associated with acid to intermediate volcanics within the Lower Devonian

2. Thrust related mineralization similar to that seen in North

Cornwall 3. Control by the Permian unconformity

4. Related to NW-SE strike slip faulting All occurrences seem substantially modified by Tertiary and Recent weathering.

The geochemical singnatures of the four possible models differ, for example:

model 1 is expected to be anomalous in Ba, Zn, Mn

model 2 in As, Pb, Cu, and Ag Model 3 in Pd, Se, Cu

model 4 in Cu, Pb, Ag It is possible to ask the G.I.S. to search the regional database for catchments which have a combination of the elements and geology in a particular model and assign a probability of a deposit in that catchment. Interrogating the database in this way allows a great deal of flexibility in modeling and geologist input.

ON REGIONAL GEOCHMICAL ANOMALIES AND GEOCHEMICAL PROVINCES

XIE. X.

Als, A. The large amount of information accumulated from many regional and national geochemical mapping programs carried out in the past 20 years in the world has shown a hierarchy of geochemical anomalies, from local ones(various types of primary and secondary halos, fans and trains) to regional and then to provincial scale anomalies. Such concept is very useful in successively reducing the target areas and efficiently leading the follow up work to locate new mineral demonsity deposits

The dimension of regional geochemical anomalies will be several km² to hundreds of km². The threshold values of such anomalies may be lower than the local anomalies surrounding mineral deposits. Such anomalies may be connected with the regional syngenetic or epigenetic concentration of certain elements in magmatic, sedimentary or metamorphic rocks during mineral forming process. Weathering process transmits such regional patterns in surface loose materials. A hierarchy of regional patterns in surface environments will be formed in soils, drainage sediments, waters and vegetables. Large amount of regional geochemical anomalies in stream sediment and other types of surface materials has been discovered during the implementation of China's Regional Geochemistry-National Reconnaissance Project. They have been important clues for many new discoveries of economic mineral deposits. Geochemical province was defines by Hawkes and Webb in 1962 as a relative large segment of the earth crust in which the chemical composition is significantly different from the average. Some geochemical provinces may reflect the primitive

the chemical composition is significantly different from the average. Some geochemical provinces may reflect the primitive compositional variation of the earth crust. Others may be the result of large scale differentiation by sedimentary process and reconstruction of sedimentary rocks to magmatic rocks. The dimension of geochemical provinces will be several thousands or several tens of thousands of square kilometers with threshold values still lower than the regional geochemical anomalies geochemical anomalies.

Though geochemical provinces were mentioned again and again in literature and standard textbooks of exploration again in literature and standard textbooks of exploration geochemistry, but their characteristics and even their existence at all were supported only by very meager evidences. Perhaps it is now time to explore this concept by studying and summarizing the large amount of substantial facts obtained from regional or national geochemical mapping covering very large areas. B. Bolviken gave proves of the existence of geochemical provinces in Scandinavia. England and Wales, Alaska and West Germany. The dimension of such provinces mentioned in Bolviken's paper is from 15,000 to 50,000 km2. Since recently, we have the geochemical maps of 60 elements obtained by ultra low density sampling of soil covering the whole territory of China (Soil Background Study Project). We have for the first time the good chance to delineate geochemical provinces of many elements in China and correlate them with known metallogenic provinces. The examples mentioned in this paper are only the result of the beginning of a long-term research work dealing with this beginning of a long-term research work dealing with this subject.

GEOCHEMICAL CRITERIA FOR URANIUM METALLOGENETIC CAPACITY OF GRANITOIDS IN SOUTH CHINA ZHANG, B.

The granice-type uranium deposits are widespread in South China and of great economic significances. The uranium deposits of the granite-type occur either *inside* of the uranium-productive granite plutons or *in* the country rocks within the contact zones.

Based on the geochemical, isotopic and perrographic studies of the 11 granite plutons to which uranium deposits are related (called productive granites) and 27 granites to which no uranium deposits are related (called non-productive granites) in South China, we come to the following geochemical criteria to characterize the uranium productive granites:

1. The average uranium contents of the productive granites in South China is 9.94 ppm based on 906 analyses, which is 2.5 times higher than that of the granitic rocks of the whole world (4.0 ppm). However, this value is not distinctive, which is close to the average uranium content of the non-productive granites (9.80 ppm averaging from 27

3. All of the productive granites in South China show the characteristics of multiple-cycle and multiple-stage granitic composites. The factors of crystalline concentration (Ke) of the productive granites are greater than 1.5. 4. The productive granites have relatively low average Th/U ratios (3.63). Generally, with the evolution of the productive granitic composites, the Th/U ratios increase steadily. To the latest stage, the Th/U ratios decrease suddenly, showing a sharp turn on the Th/U vs U diagram, which is called "Th/U turn". The sharp "Th/U turn" cannot be observed in the non-productive granitic composites.

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5. In the productive granites, large portion of uranium exists in uraninite (> 33% of the uranium content), and in the fractures and interstices (> 15% of the uranium content; called absorbed uranium) in or between the rock-forming minerals, which is considered as the active uranium. However, the most uranium atoms in the non-productive granite enter the crystal lattices of the glossary minerals as the form called structural uranium, or fixed uranium.

6. The low K/Rb ratio (< 200) is another feature of the productive granites. On the U-K/Rb diagram, the samples of the productive granites are plotted in the area of K/Rb < 200 and U > 10 ppm.

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