

23rd International Applied Geochemistry Symposium
– - IAGS -

Oviedo, 14 – 19 June 2007



IAGS 2007 – Exploring our Environment

Program & Abstracts of the Symposium

Edited by Jorge Loredó Pérez

June, 2007

University of Oviedo, Spain

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WELLCOME TO IAGS 2007

The 23rd INTERNATIONAL APPLIED GEOCHEMISTRY SYMPOSIUM (IAGS) will be held in Oviedo (Spain) from 14th to 19th June 2007, organized by the Department of Mining and Exploration of the University of Oviedo (Spain) and co organized by the Geological and Mining Institute of Spain (IGME) and the Association of Applied Geochemists (AAG).

This event intends, on the basis of the presentation of results and discussions, to promote exchange of ideas about innovative technologies in the geochemical application and to advance in the exploration and the environment field.

In this proceedings book are included the abstracts of the oral and poster presentations corresponding to the different sessions of the symposium. A special edition of Geochemistry: Exploration, Environment, Analysis, the Journal of the Association of Applied Geochemists, will publish selected full papers presented on the Symposium.

We wish to thank a large number of people for their help organization and executing such as event. This includes participants, authors, session's chairman and Keynote speakers.

Special thanks are due to the Scientific Committee, Local Organizing Committee, Technical Advisory team and other individuals that helped during the preparation of the Symposium. Grateful thanks are also dedicated to all the institutions and Companies that sponsored and supported the Congress.

We wish all participants in the 23rd International Applied Geochemical Symposium, a beneficial meeting and a nice stay in Oviedo.

Jorge Loredó

A handwritten signature in black ink, appearing to read 'Jorge Loredó', written in a cursive style.

23rd IAGS Chairman

Organizing Committee

Jorge Loreda

Almudena Ordóñez

Teresa Bros

Aurora Otal

Rodrigo Álvarez

Juan Llamas

Manuel Viladevall

Alejandro Bel Lan

Juan Locutura

Eduardo de Miguel

Angel Cámara

Venue

The Symposium will be held at the Príncipe Felipe Auditorium, located in the centred of Oviedo. It is one of the most modern and best equipped multipurpose scenarios in Spain. The “Príncipe Felipe” Congress Palace and Auditorium offers enormous opportunities to the world of the business, with the opportunity to host events and meetings of many different types.



With a total capacity of over 3200 persons, the 4 great areas which make up the Palace: The Central Hall, with 2388 seats, formed by uniting the Principal and Multipurpose Halls, which can function independently or as one, the Symphony or Principal Hall, with 1450 seats, the Multipurpose Hall with 535 seats, and the Chamber with 404. Conferences and Exhibitions are complemented by the large common spaces such as the Great Foyer or Principal Entrance Hall and the Lobbies situated on the First and Second Floors, ideally laid out for the installation of Stands, Modules or Exhibitions with all the usual technical facilities. A total of more than 18000 square metres in almost 5000 square metres of construction are the disposal of professional congress organisers.

Keynote Speakers

The Organizing Committee wants to give thanks to the following keynote speakers for their unselfish collaboration.



Brenda Caughlin (PhD), Vice President of Technical Services, ALS Chemex.

With over twenty years experience in the industry, Brenda has an international reputation as a geochemical analyst. She is responsible for technical development and oversight of the global ALS Chemex group. She has a degree specialization in analytical spectroscopy and was

instrumental in developing ICP services at ALS and more recently, the integrated laboratory management system (GEMS) and client interface, Webtrieve, for the ALS Chemex group.



Clemens Reimann (born 1952) holds an M.Sc. in Mineralogy and Petrology from the University of Hamburg (Germany), a Ph.D. in Geosciences from Leoben Mining University, Austria, and a D.Sc. in Applied Geochemistry from the same university. He has worked as a lecturer in Mineralogy and Petrology and Environmental Sciences at Leoben Mining University, as an exploration geochemist in eastern Canada, in contract

research in environmental sciences in Austria and was chief of laboratory in an Austria cement company before joining the Geological Survey of Norway in 1991 as a senior geochemist. At present he is Chairman of the EuroGeoSurveys geochemistry expert group, acting Vice President of the IAGC, and associate editor of both, Applied Geochemistry and GEEA.



Paul Polito obtained his PhD in economic geology and exploration geochemistry from Adelaide University in 1999 after working on the Junction Archaean Au deposit in Western Australia and then worked with Kurt Kyser at Queen's University, Canada as a postdoctoral fellow until 2005. He has published on unconformity-related (Nabarlek, Jabiluka, Ranger, King River), sandstone-hosted (Westmoreland) and albitite-hosted (Valhalla) U deposits in northern Australia, sediment-hosted Zn-Pb-Ag-Cu deposits

(Century, Watson's Lode, HYC) in the Mount Isa and McArthur basins and VHMS Zn-Cu deposits (Triple 7, Trout Lake, Talbot, Harmin), in Manitoba, Canada. Paul is currently searching for world-class base metal deposits for Anglo American as their regional geochemist in the Africa, Asia, Australia division.



Ronald W. Klusman is an emeritus professor of Chemistry and Geochemistry at the Colorado School of Mines. He received a Bachelors degree in Chemistry from Indiana University in 1964 and completed a PhD degree in Geology and Geochemistry in 1969. He was an Assistant Professor of Geosciences at Purdue University from 1969 to 1972 when he joined the Colorado School of Mines as an Associate Professor of Chemistry and Geochemistry. He was promoted to Professor in 1977 and retired in 2001 but has continued with research in soil gas.

Principal research areas have been in geochemistry and remediation of acid drainage, sampling design, application of soil gas to petroleum, mineral, and geothermal exploration, and to environmental problems. Since 1994, gas exchange between soils and the atmosphere has been the primary focus, with support from NSF, various programs within DOE, and industry. Research and publication continues on the detection and quantification of gas leakage rates from CO₂ sequestration projects. He has more than 100 refereed publications, a book on the application of soil gas to exploration, several hundred reports and presentations.



Thomas Driesner was born 1965 in Wittingen, Northern Germany. Started to become interested in mineralogy and geology already during high school. Undergraduate studies in mineralogy and geology at the Technical University of Clausthal, Germany, later at University of Zurich, Switzerland. Diploma thesis on fluid processes during alpine metamorphism of ophicarbonates (1991, supervisor V. Trommsdorff).

Experimental and theoretical studies with Terry Seward at ETH Zurich leading to PhD thesis (1996) on the influence of dissolved salts and pressure on hydrogen and oxygen stable isotope fractionation in hydrothermal solutions. 1997/1998 postdoc at the Department of Chemical Engineering of the University of Tennessee and at Oak Ridge with theoretical studies on the thermodynamics of hydrothermal fluids and experimental studies on isotope fractionation. Since 1999 senior researcher in Chris Heinrich's group at ETH Zurich: field projects on hydrothermal ore deposits in Bulgaria, development of equation of state model for H₂O-NaCl, and together with Stephan Matthai and Sebastian Geiger development of novel simulation tools for "geologically realistic" hydrothermal fluid flow.

Program

In this program are showed the names of the people that will be make the oral presentations:

THURSDAY 14/06/2007		
CONFERENCE HALL		
9.30 -10.00	Opening Ceremony	Relevant Authorities
10.00-10.45	Keynote address: CONFERENCE HALL "Geochemical Atlas of Europe: A multi-media sampling survey for the establishment of geochemical baselines"	Clemens Reimann (Geological Survey of Norway)
10.45-11.15	Coffee & Poster placement	
	Session 1: CONFERENCE HALL <i>Classic mining districts: Exploration and environmental geochemistry in the shadow of headframes</i>	
CHAIRMEN	R. Howell (SRK Consulting. Cardiff) & J. Loredo (Univ. Oviedo)	
11.30-11.50	Exploration of porphyry copper deposits beneath transported overburden: soil sampling and passive collector devices trialled at the Toki District, II Region, Chile	Germán Ojeda (Chile University)
11.50-12.10	Geochemical assessment of abandoned mining lands: assigning value and seeking new opportunities	Rob Howell (SRK Consulting. Cardiff)
12.10-12.30	Dispersion patterns of gold and pathfinder elements in different modes of presence in soils: Pervomaysky area, Far East of Russia	Alexey Marchenko (A.P.Karpinsky Russian Geological Research Institute)
12.30-12.50	The Rio Tinto River Basin - a Remote Sensing Perspective	Phoebe Hauff (Spectral International, Inc. USA)
12.50-13.10	Geology and geochemistry of intrusive dikes and meta-sedimentary rocks from Workamba area, Tigray province, northern Ethiopia.	Solomon Gebresilassie (Ludwig-Maximilians University. Germany)
13,15 - 14.30	WELCOMING LUNCH (Sponsored by SGS)	

	Session 2: CONFERENCE HALL		Session 3: ROOM 1	
	<i>Mapping Geochemical Data (I)</i>		<i>Geochemistry in the industry sector: exploration and environmental applications (I)</i>	
CHAIRMEN	C. Reinman (Geological Survey of Norway) & A. Bel-Lan (Geological Survey of Spain)		Peter Winterburn (Anglo Research. South Africa) & J. Llamas (Madrid Politecniv Univ.)	
14.30-14.50	The history of low density geochemical mapping	Clemens Reimann (Geological Survey of Norway)	Exploration, Mining, Metallurgical and Environmental Sampling, Analysis & QA/QC Best Practice in a Global Mining Company.	Winterburn P.A. (Anglo Research. South Africa)
14.50-15.10	Low density geochemical mapping and the robustness of geochemical patterns	Clemens Reimann (Geological Survey of Norway)	The Application of portable XRF: Exploration, Evaluation and Mining.	Winterburn P.A. (Anglo Research. South Africa)
15.10-15.30	'Laterite' Geochemical Atlas for the deeply-weathered western Yilgarn Craton of Western Australia.	Robertson, I.D.M. (CRC LEME. Australia)	Exploration using Fluid Inclusions – the acoustic decrepitation technique. With examples from Hebei, China and El Penon, Chile.	Kingsley Burlinson (Burlinson Geochemical Services P/L. Australia)
15.30-15.50	Rock and Soil Environmental Geochemical Baseline Mapping: Collahuasi District, N. Chile.	Christopher J. Oates. (Anglo American. United Kingdom)	Using groundwater chemical and isotopic composition in the search for porphyry copper and base metal deposits: Examples from Chile and India	Patrice de Caritat (Geoscience Australia)
15.50-16.10	Soil geochemical mapping of the Rustenburg Layered Suite, Bushveld Complex, South Africa.	Strauss Schalk (Council for Geoscience. South Africa)	Stream sediment geochemical surveys in the Hauraki Goldfield, Coromandel Volcanic Zone, New Zealand: utilising mining company exploration data and a pilot survey to assist planning for national surveys.	Anthony B. Christie (GNS Science. New Zealand)
16.10-16.40	Coffee & POSTER SESSION (N° 1-15)			

CHAIRMEN	P. de Caritat (Geoscience Australia. Australia) & J. Locutura (Geological Survey of Spain)		A. B. Christie (GNS Science. New Zealand) & E. de Miguel (Politechnic Madrid University. Spain)	
16.40-17.10	Mapping anomaly residence in the regolith at small scales.	Robert Hough (CSIRO Exploration and Mining. Australia)	QA/QC insertion rate: is there an industry standard?	Armando Simón (AMEC International Chile)
17.10-17.30	National geochemical survey of Australia: Outline of a new initiative	Patrice de Caritat (Geoscience Australia. Australia)	Soil Geochemistry of the Denver, Colorado (USA) Urban Area	L. Graham Closs (Colorado School of Mines.USA)
17.30-17.50	Semi-quantitative mapping of heavy metal contaminated areas using infrared hyperspectral image data	Eunyoung Choe (Gwangju Institute of Science and Technology. Korea)	Innovative exploration in Nova Scotia: effective sampling and estimation of coarse gold deposits.	Peter John Rogers (Chavin Consulting Limited.Canada)
17.50-18.10	Stream sediments geochemical mapping survey in an island arc context, Bonaconanza Area (Dominican Republic)	A. Bel-Lan (IGME. Spain)	Post-depositional geochemistry of sediments in response to urbanization in Merimbula/Pambula estuaries, New South Wales, Australia	Fern Beavis (The Australian National University)
21,00	EVENING RECEPTION (offered by Oviedo's Council)			

FRIDAY 15/06/2007		
	Session 4: CONFERENCE HALL <i>Exploration case studies Symposium in honour of Dr. Eion Cameron (I)</i>	
CHAIRMEN	D. Kelley (Newmont Mining Corporation. USA) & J. García Iglesias (Univ. Oviedo)	
9.00-9.40	Keynote address Future Directions for Exploration Geochemistry in the Next 10-20 Years? A Peripheral Viewpoint	Ron Klusman (Colorado School of Mines. USA)
9.45-10.05	Targeting gold mineralisation through the cover in the Tanami Desert Region in Northern Australia	Lisa Worrall (CRC LEME. Australia)
10.05-10.25	A hydrologic and hydrogeochemical study of the regolith signature of gold mineralization in the Tanami Desert Region of Australia.	Dirk Kirste (CRC LEME. Australia)
10.25-10.45	Heavy mineral exploration for Uranium in Narigan area, Central Iran	Mohammad Yazdi (Shahid Beheshti University. Tehran-Iran)
10.45-11.05	Discovery of the sub-outcropping Kwaggashoek ultramafic body in the Bushveld basin, South Africa.	Kobus Elsenbroek (Council for Geoscience. South Africa)
11.05-11.30	Coffee & POSTER SESSION (Nº 16 - 30)	
CHAIRMEN	Ch. Butt (CSIRO Exploration & Mining. Australia) & O. Lavin (Newmont Mining. USA)	
11.30-11.50	The link between gold depletion zones and gold mineralization with examples from the gold province of Victoria, Australia: implication for Genesis and exploration	Ishai Goldberg (Lonex Pty Ltd. Australia)
11.50-12.10	Exploration for gold beneath a hypersaline playa lake – Eastern Goldfields, Western Australia.	Mark Pirlo (CRC & Barrick. Australia)
12.10-12.30	Geochemical expression of bedrock mineralization through deep cover – a comparison of exploration methods and sample depths, Curnamona Province, South Australia	Adrian Fabris (CRC LEME: Australia)
12.30-12.50	Collahuasi and District Alteration and Trace Element Geochemistry.	Esteban Urqueta (Anglo American Chile)
12.50-13.10	Genesis and exploration geochemistry of IOCG mineralization in the Mantoverde District, Chile.	Kyser Kurt (Queen's University.Canada)
13.10-13.30	Migration of arsenic from a Cu-W-As mine tailings area, Ylöjärvi Finland.	Ruskeenieni Timo (Geological Survey of Finland)

13.45-15.30	LUNCH			
15.30-16.15	Keynote address: CONFERENCE HALL		Thomas Driesner	
	Session 5: CONFERENCE HALL		Session 6: ROOM 1	
	<i>Exploration, Classic European mining districts & New technologies (I)</i>		<i>Commercial session for companies displaying trade stands (I)</i>	
CHAIRMEN	N. Radford (Newmont Mining Corp. Australia) & Pablo Higuera s (Univ. Castilla La Mancha, Spain)		Robert Ayuso (U.S. Geological Survey) & Nieves Roqueñi (Oviedo University)	
16.15-16.35	Mercury vapor dispersion from La Peña-El Terronal Mine (Asturias, Spain)	Pablo Higuera (Univ. Castilla La Mancha, Spain)	Definitive organic geochemical SGH signatures both identify and locate deeply buried targets to aid mineral exploration	Dale Sutherland (Activation Laboratories Ltd. Canada)
16.35-16.55	The use of factorial kriging analysis to distinguish natural from anthropogenic sources of trace metals in the topsoils of Lavrio, Greece.	Anna Korre (Imperial College London. U. K)	Leach Reduction of Solid waste with a Bauxsol™-based Concrete	Malcolm Clark (Southern Cross University . Australia)
16.55-17-25	Coffee & POSTER SESSION (Nº 31 - 45)			
17.25-17.45	Application of lake sediment studies for the evaluation of natural background values around the Talvivaara Ni-Cu-Zn deposit, Finland	Kirsti Loukola-Ruskeeniemi (Helsinki University of Technology. Finland)	reserved for companies	
17.45-18.05	The Corcoesto Gold Deposit	Lluís Boixet (Río Narcea Gold Mines. Spain)	reserved for companies	
18,05	AAG MEETING			

MONDAY 18/06/2007						
	Session 7: CONFERENCE HALL <i>Ore Deposit-Forming Systems: A Geochemical Perspective (I)</i>		Session 8: ROOM 1 <i>Hydro-bio geochemistry (I)</i>		Session 9: ROOM 2 <i>Data interpretation (I)</i>	
CHAIRMEN	D. Lentz (University of New Brunswick, Canada) & Carmen Conde (IGME, Spain)		C. Oates (Anglo American) & M. Viladevall (Barcelona Univ. Spain)		D. Cohen (University of New South Wales, Australia) & L. Graham Closs (Colorado School of Mines, USA)	
9.00-9.20	Uraniferous and thoriferous Y-REE-Nb granitic pegmatites in the Grenville Province: understanding distribution, age, and genesis to aid in exploration	D. Lentz (University of New Brunswick, Canada)	Acid Groundwaters in Southern Australia – new models for their formation and mineral exploration implications.	Gray, D. J., (CSIRO Exploration & Mining, Australia).	What is an anomaly? A comparison of fractal-based filters with band-pass wavelength filters for large datasets	Steve Ludington (U.S. Geological Survey)
9.20-9.40	Termitaria as a biogeochemical sampling medium for mineral exploration: the significance of species variations towards a representative and robust approach.	Anna E. Petts (University of Adelaide, Australia)	Methods for Nickel Sulphide exploration using Hydrogeochemistry.	David J. Gray (CSIRO Exploration & Mining, Australia)	Hot spring arsenic distribution in the Andes Cordillera (18-52oS)	J.L. Fernandez-Turiel (CSIC, Spain)
9.40-10.00	Coal Occurrences in Biga Peninsula, Northwestern Anatolia, Turkey	Maral Mehmet (Technical University of Istanbul, Turkey)	Regional hydrogeochemical exploration for Ni sulfides in the NE Yilgarn Craton, Western Australia.	Ryan R.P. Noble (CSIRO Exploration & Mining, Australia)	Deciphering multi-stage geochemical dispersion in complex regolith	Kenneth McQueen (CRC LEME, Australia)
10.00-10.20	Mass balance and geochemical anomalies related to the Mataralampi orogenic gold occurrence, Archaean Kuhmo greenstone belt, eastern Finland.	Pasi Eilu (Geological Survey, Finland)	Mineral Expression and Plant Species Differences at the Titania Prospect: Biogeochemical Sampling in the Tanami region, Northern Territory, Australia	Nathan Reid (University of Adelaide, Australia)	Quantitative minimum probability measures of exploration accuracy and geochemical contrast: comparing exploration techniques to maximize discovery.	C. Stanley (Acadia University, Canada)
10.20-11.00	Coffee & POSTER SESSION (Nº 46-60)					



11.00-11.40	Keynote address: CONFERENCE HALL			Paul Polito <i>(Anglo American. Australia)</i>		
	<i>Ore Deposit-Forming Systems: A Geochemical Perspective (II)</i>		<i>Hydro-bio geochemistry (II)</i>		<i>Data interpretation (II)</i>	
CHAIRMEN	Pasi Eilu (Geological Survey of Finland) & Thomas Driesner (ETH Zürich)		C. Dunn (Consulting Geochemist. Canadá) & R. Álvarez (Oviedo Univ. Spain)		R. Castroviejo (Politechnic Madrid Univ. Spain) & Sarala Pertti (Geological Survey of Finland)	
11.40-12.00	How ore grade 'laterite' Au deposits form in Western Australia: new insights into the processes of anomaly formation.	Ravi Anand (CRC LEME. Australia)	Biogeochemistry and geobotany of Pb-Zn gossans, northwest Queensland, Australia.	Bernd G Lottermoser (James Cook Univ. Australia)	Assessment of reactivity of sulphidic tailings and river sludges.	Dimitra Zaharaki (Technical University Crete. Greece)
12.00-12.20	Origin of the Urals VHMS deposits inferred from the Re-Os isotopic studies.	Svetlana Tessalina (Institut de Physique du Globe in Paris. France)	Application of a characterization methodology of dnapl contaminant episodes based on the integration of field and laboratory tools.	Manuel Viladevall (Barcelona Univ. Spain)	Lithogeochemistry and fluid flow in the epithermal Veta Rublo base metal-silver deposit, Chonta Mine (Huancavelica, Perú)	R. Castroviejo (Madrid Univ. Spain)
12.20-12.40	Tracing crustal contamination – a key aspect for IOCG and Ni-Cu deposits in SW Iberia	Fernando Tornos (IGME. Spain)	Hydrogeochemical processes in groundwater from the Salar of Pipanaco (Catamarca, NW Argentina)	J.L. Fernandez-Turiel (CSIC. Spain)	Characterization and Spatial Variability in Eshidiya phosphate, South Jordan: Statistical and Geostatistical Applications	M. Al-Hwaiti (Jordan)
12.40-13.00	The El Valle-Boinas Gold Deposit. Low-Temperature Hydrothermal Mineralization Hosted in Skarn.	Santiago G. Nistal (Kinbauri. Spain)	Assessment of Stream Water Quality and Chemistry around the Rapel Basin, Central Chile.	Anna Korre (Imperial College London.U. K)	Quaternary geological and till geochemical studies in verifying GIS-based prospectivity mapping in the Central Lapland Greenstone Belt, northern Finland.	Sarala Pertti (Geological Survey of Finland)
13.00 - 14.30	LUNCH					

	<i>Ore Deposit-Forming Systems: A Geochemical Perspective (III)</i>		<i>Hydro-bio geochemistry (III)</i>	
CHAIRMEN	F. Tornos (IGME. Spain) & Paul Polito (Anglo American. Australia)		C. Gleeson (Kinbauri Gold Corp. Canadá) & A. Puig (Codelco. Chile)	
14.30-14.50	Generation of free ions and hydrocarbon gaseous compounds from ore deposits beneath cover and migration mechanism to surface: experimental laboratory analogue models and empirical field results in Northern Chile	Brian Townley (University of Chile)	Hydrogeochemical characteristics of surface waters in areas with abandoned mercury mines in northern Spain.	Jorge Loredó (Univ. Oviedo. Spain)
14.50-15.10	The Geothermal Geochemistry of Western Turkey.	Füsün Servin Tut Haklıdır (TUBITAK-MRC Earth and Marine Sciences. Turkey)	Hydrogeochemical characteristics of groundwater in Günyüzü basin (Sivrihisar- Eskişehir) Western Turkey.	Muhterem Demiroğlu. (İstanbul Teknik Üniversitesi. İstanbul)
15.10-15.30	Gold mining-related and natural mercury in an orogenic greywacke terrane, South Island, New Zealand.	E. A. Holley (University of Otago. New Zealand).	Weathering – Alteration Geochemistry and Petrography of Canakkale – Tuzla Geothermal Area, Northwestern Turkey	Kepekçi Aykan (Technical University of Istanbul, Turkey)
15.30-15.50	Genesis of the Benato emerald deposit, Ianapera area, Southwestern Madagascar.	Prosper Andrianjakavah (Observatoire Midi-Pyrénées. France)	Zeolitisation Process in the Southwest Part of Keşan, Thrace, Turkey	Aktuna Zeynep (Technical University of Istanbul, Turkey)
16.00-16.30	Coffee & POSTER SESSION (Nº 61-75)			
21,30	OFFICIAL DINNER			

TUESDAY 19/06/2007				
CONFERENCE HALL				
9.00-9.40	Keynote Speaker: CONFERENCE HALL " Innovation and Development in Analytical Geochemistry – Is the Future as Bright as the Past? "			Brenda Caughlin (ALS Chemex)
	Session 10: CONFERENCE HALL <i>Litho geochemistry (I)</i>		Session 11: ROOM 1 <i>Analytical Geochemistry (I)</i>	
CHAIRMEN	C. Stanley (Acadia Univ.) & J.H. Elsenbroek (Council for Geoscience, South Africa)		G. Hall (Geological Survey of Canada) & A. Cámara (Politechnic Madrid Univ. Spain)	
9.45-10.05	Hydrothermal alteration zonation in regolith, Vera-Nancy epithermal gold deposit, Pajingo, Queensland, Australia.	D.M.K. Murphy (University of Western Australia)	Round-robin results for the analysis of vegetation in Canadian commercial geochemistry laboratories.	Gwendy E.M. Hall (Geological Survey of Canada)
10.05-10.25	Litho geochemical characterization of hydrothermal alteration associated with gold mineralization in the Golden Mile dolerite, Fimiston Superpit, Kalgoorlie, Western Australia.	V. O'Connor-Parsons (Cardero Resource Corp. Canada)	Method of Analysis of Superfine Fraction (MASF): A new effective geochemical technique for mineral exploration in covered terrains	Alexey Marchenko (St.-Petersburg State Mining Institute. Russia)
10.25-10.45	Mercury retention in a Smectitic clay.	P. Higuera (Univ. Castilla La Mancha. Spain)	The fundamentals of Aqua Regia digestion	Iain Dalrymple (Actlabs Pacific. Australia)
10.45-11.05	Supergene gold at the Golden Virgin Deposit, Western Australia	Robert Hough (CSIRO Exploration and Mining. Australia)	Field evaluation of waste rock geochemical reactivity, and its role in providing comprehensive dump characterization	J.V. Parshley (SRK Consulting. USA)
11.05-11.25	Geochemical controls on very coarse-grained Au mineralization within sheeted quartz veins at the mesothermal Callie Au deposit, Dead Bullock Soak, Northern Territory, Australia.	Clifford R Stanley (Acadia Univ. Canada)	The Effect of the Kizilcaören Complex Mineralization (Fluorite-Barite-Thorium-Rare Earth Elements) on Groundwaters in Kizilcaören (Beylikova) Eskisehir, NW, Turkey	Yüksel Örgün (İstanbul Teknik Üniversitesi. Turkey)
11.25-11.55	Coffee break & POSTER SESSION (Nº 76-88)			

	<i>Lithogeochemistry (II)</i>		<i>Analytical Geochemistry (II)</i>	
CHAIRMEN	R. G. Eppinger (U.S. Geological Survey) & F. J. Lillo (Rey J. Carlos Univ. Spain)		S. Cook (Cominco. Canadá) & J.L. Fdez. Turiel (CSIC. Spain)	
11.55-12.15	Use of the PGE in the Discrimination of Nickel Gossans	Reid R. Keays (Monash University. Australia)	Laboratory methods for microdiamond recovery.	Hugh A. F. de Souza (SGS Minerals Services. Canadá)
12.15-12.35	Detection of pegmatite-hosted Sn-Ta mineralization in southwest Western Australia using stream sediment geochemistry	Paul Morris (Geological Survey of Western Australia)	Application of a single extraction method to the determination of the organic mercury in sediments.	Rodolfo Fernández-Martínez (CIEMAT. Spain)
12.35-12.55	Trace element and Pb and S isotope results from tree cores over a Proterozoic VMS prospec.	Kurt Kyser (Queen's University. Canadá)	The use of Pb Isotopes to Trace the Source of Metals in Geogas	Wang Mingqi (China University of Geosciences)
12.55-13.15	Geochemical characteristics of barren and mineralized intrusives in the Geodo area, Taebaeksan Basin, South Korea: implications for adakite magmatism and Fe-Cu(-Au) mineralization.	Jung Woo Park (Korea Institute of Geoscience and Minerals)	A comparison of traditional and novel partial geochemical extractions at a Cu-Zn soil anomaly in Victoria, Australia.	Ryan R.P. Noble (CSIRO Exploration and Mining . Australia)
13.15-13.40	Application of the multidisciplinary methodology in the study of apatite for the diamond prospecting and potential evaluation	Vasyl N. Guliy (Ukrainian State Geological Research Institute)		
13.40-14.00	Geochemical exploration through bedrock: examples from the Carboniferous Maritimes Basin of Eastern Canada.	Peter John Rogers (Chavin Consulting Limited. Canada)		
14.00-15.30	LUNCH			

	Session 12: CONFERENCE HALL		Session 13: ROOM 1		Session 14: ROOM 2	
15.30-17.30	<i>Geochemistry in the government sector: exploration and environmental applications</i>		<i>Geochemistry and health</i>		<i>New technologies and miscellaneous paper</i>	
CHAIRMEN	P. Morris (Geological Survey of Western Australia) & A. García Cortés (Geological Survey of Spain)		O. C. Selinus (Geological Survey of Sweden) & A. Marchenco (A.P.Karpinsky Russian Geological Research Institute. Russia)		D. Gray (CSIRO. Australia) & A. Ordóñez (Univ. Oviedo)	
15.30-15.50	New Multi-element Regional Geochemistry Surveys of Northern Ireland.	Dermot Smyth (Geological Survey of Northern Ireland)	Spatial correlation between the prevalence of transmissible spongiform diseases and British soil geochemistry.	Anna Korre (Imperial College London.U. K)	SI (Saturation Index) Characteristics and Crystallization Mechanism of Hydromagnesite and Huntite in Salda Lake, Turkey	Suner Fikret (Technical University of Istanbul, Turkey)
15.50-16.10	Environmental and exploration geochemistry of sediment-hosted Zn-Pb-Ag massive sulfide deposits.	Karen D. Kelley (U.S. Geological Survey)	Heavy metals in the soils of Islam Shahr urban area, Iran.	Mohammad Yazdi (Shahid Beheshti University. Iran)	Early Stage Development of a Bauxsol™-based Grout for Treatment and Stabilisation of Acid Waste Rock	Malcolm Clark (Southern Cross University. Australia)
16.10-16.30	Indicator mineral and till geochemical signatures of the Broken Hammer Cu-(Ni)-PGE sharp-walled vein deposit, Sudbury, Canada	M. B. McClenaghan (Geological Survey of Canada)	Extraction of Astaxanthin from Shrimp waste by Chemical and Microbial Methods	Afra Saberi (Islamic Azad University.Irán)	Remote detection of whole rock geochemical alteration patterns – Implications for regional VMS exploration –	Frank van Ruitenbeek (Int. Inst.of Geo-information Science and Earth Observation. Netherlands)

6.30-16.50	Geochemical associations and its spatial patterns of variation in soil data from the Marrancos gold-silver mineralization: a pilot analysis.	A. P. Reis (University of Aveiro, Portugal)	The Potential Health Risks from Dust Exposure in the Middle East	Mark B. Lyles (US Navy Bureau of Medicine & Surgery, USA)	Reproducibility and correlation of geochemical anomalies by different sampling densities	Xueqiu Wang (Institute of Geophysical and Geochemical Exploration, China)
16.50-17.10	The Canadian Contribution to the North American Soil Geochemical Landscapes Project- A common environmental view of North America	A.N. Rencz (Geological Survey of Canada, Canada)	Natural radioactivity, toxic metals pollution and epidemiology in the Campania region (Italy)	Albanese Stefano (Università degli Studi di Napoli "Federico II, Italy)	The influence of sample preparation on the detection and discrimination of regolith material types and alteration mineralogy using spectral measurements in the visible and infrared.	Cajetan Phang (CSIRO Exploration and Mining, Australia)
17.10-17.30			Arsenic and other toxic elements in coal leachates of Korba: a review of Central India	V.K. Jena (Ravishankar Shukla University, India)	Effect of sulfide mineralogy on isotopic composition of sulfate: Implications for acid mine drainage (AMD) formation.	Nurgül Çelik Balci (Istanbul Technical University, Turkey)
17.30-17.50	Coffee Break					
17.50-18.30	CLOSURE CEREMONY					
18,30	SPANISH WINE					



23rd IAGS 2007
Exploring our Environment

Work shop (16 June 2007)

SATURDAY 16/06/2007 - WORKSHOPS -		
	WORKSHOP 1: Room 1	Cliff Stanley
9.30- 13.00 15.00- 18.30	Lithogeochemistry in Mineral Exploration: Principles and Practice of Molar Element Ratio Analysis	(Acadia University. Canada)

1. Lithogeochemistry in Mineral Exploration: Principles and Practice of Molar Element Ratio Analysis by Clifford R. Stanley.

Cost: 250 €

Content: The short course will be one day in duration. The morning will be devoted to presenting the theory, principles, assumptions, philosophy, and procedure of MER analysis. In the afternoon, a number of case histories will be presented that illustrate how MER analysis can be used in a variety of applications to solve geochemical problems of interest to the mining industry. In addition, the practical considerations of sampling, sample preparation and laboratory analysis for the variety of applications to which MER analysis can be applied will be discussed, including how it can be used in exploration for volcanic-, intrusion- and sediment-hosted deposits, how it can 'see through' metamorphism, how it can be applied in 'greenfields' and 'brownfields' exploration programs, and its use in environmental geochemistry.

NOTE: Participants are advised to bring a laptop computer with spreadsheet software, as we will practice some of the calculations required in MER analysis at the end of the day.

BRONZE SPONSOR





Posters List

The following posters have been numbered for making the presentations in the spaces indicated in the program. Their corresponding abstracts have been included in the different Technical Sessions:

1. Arsenic mineralogy and mobility at two historic gold mines, New Zealand. L. Haffert and D. Craw. University of Otago (New Zealand).
2. Geochemical Database for Historical Mining Areas in the Upper Salmon River Basin, Central Idaho. R. G. Eppinger et al. (U. S. Geological Survey).
3. Solid-phase control on the mobility of mercury and heavy metals in the old mining area of the Valle del Azogue (Almería, SE Spain). A. Navarro et al. (Barcelona University. Spain).
4. Influence of mining and smelting on chemical composition of soil around the abandoned Pb-Zn-Hg-Ag mine and Pb smelter in Litija, Slovenia. R. Sajn et al. (Geological Survey of Slovenia).
5. Recent results from a geochemical survey in the New South Wales part of the Thomson Orogen: Implications for mineral exploration. M. E. Lech and P. de Caritat (CRC LEME. Australia).
6. Weathering of mineralized volcanic rocks and the genesis of kaolinite deposits: Carolina Slate Belt, Southeastern USA. N. Foley. (U.S. Geological Survey)
7. Urban Geochemical Mapping in the city of Madrid. J. Locutura et al. (IGME. Spain).
8. Geochemical Exploration and Mapping in the Ossa Morena Zone (Spain). J. Locutura et al. (IGME. Spain).
9. Heavy mineral exploration at the Petäjälehto, northern Finland. P. Sarala et al. (Geological Survey of Finland).
10. Geochemical signatures of concealed kimberlites in the shallow groundwaters of wetlands: Case study in the Attawapiskat area, northern Canada. K. Brauneder et al. (University of Ottawa. Canada).
11. Regolith Characteristics of Cyprus. D. Cohen and N. Rutherford. (University of New South Wales. Australia).
12. The Khongor Porphyry Cu-Au Deposit Discovery by Low Density Fine Fraction Stream Sediment Exploration Geochemistry in the Gobi Desert, Mongolia. Cui Mao Pei. (Asia Gold Corp. Canada).
13. Using Hg in till for the delineation of buried VMS mineralization; Bathurst Mining Camp, New Brunswick, Canada. H. E. Campbell et al. (University of New Brunswick. Canada).
14. Geochemical Exploration of Pantanillo Prospect: An Au-Rich Porphyry and HS Epithermal system from Maricunga Belt, Northern Chile. S. Gamonal (Chile University).
15. Environmental quality assessment of the Guadiana estuarine sediments (SW Iberian Peninsula): evidence from a GIS study. J. Delgado and J.M. Nieto. (Huelva University. Spain).
16. The hydrothermal alteration halo at the Wallaby mesothermal gold deposit: genetic theories and exploration insight from stable isotopes. M. Pirlo et al. (Barrick Gold Australia).
17. Andsecondary sulphate precipitates in the gravel pits at Kumpuselkä and Kurkiselkä esker chain, northern Finland. T. Eskola and V. Peuraniemi. (University of Oulu. Finland).
18. The effects of catchment area to lake sediment composition. T. Eskola and V. Peuraniemi. (University of Oulu. Finland).
19. *Biobleaching of iron and copper sulphides and relationship with the generation of hydrocarbon gaseous compounds: applications to mining exploration.* R. Luca et al. (Universidad de Chile).
20. Determination of contaminant load transported by Meca River (Huelva, Spain). L. Galván et al. (Universidad de Huelva. Spain).

21. Factors controlling mobility of heavy metals and rare earth elements in a stream affected by mine drainages (NW Spain). B. Buil et al. (CIEMAT. Spain).
22. Geochemical identification of the sources of natural arsenic in groundwater of the Madrid Basin (Spain). J. Lillo et al. (Rey J. Carlos University. Spain).
23. Gold uptake in Australian plants - a preliminary experimental study. M.J. Lintern et al. (CRC LEME. Australia)
24. Historical trends in the metal content of river bed sediments of an Atlantic basin. R. Devesa et al. (Santiago University. Spain).
25. Hydrogeochemistry variations along the Tinto river course (SW Spain). Cánovas, C. Ruiz et al. (Huelva University. Spain).
26. Soil to plant (*Solanum tuberosum* L.) radionuclides transfer in the vicinity of an old uranium mine. F. P. Carvalho et al. (Technical Univ. of Lisboa. Portugal).
27. Phytoexploration signals: Does one sample represent an area, case study using *Melaleuca lasiandra*. N. Reid et al. (University of Adelaide. Australia).
28. Tellurium breath, tellurite Resistance and Reduction by Bacteria Isolated from Sarcheshme copper mine. V. Rashednia et al. (Islamic Azad University. Irán).
29. Geochemical characterization of gold-bearing mineralized zones and their dispersion patterns in Janisjarvi and Louhi areas, Karelia, North-West Russia. O. Savicheva and A. Marchenko (St.-Petersburg State Mining Institute. Russia).
30. Poplar trees used for the detection of hazardous elements: case history of the Ebro, Llobregat and Ter valleys (NE, Spain). M. Viladevall et al (Barcelona University. Spain).
31. Geochemical characterisation of the Catalanian coastal ranges (Barcelona-Gerona, NE Spain) using stream sediments. M. Viladevall et al (Barcelona University. Spain).
32. Antacid belches from northeastern Ontario: generation of high pH groundwaters and H₂ gas. J. A. Sader, et al., University of Ottawa. Canada.
33. Acid Groundwaters in Southern Australia – new models for their formation. D. J. Gray (CSIRO Exploration & Mining. Australia).
34. Back-arc shoshonitic magmatism in the Fuegian Andes, Argentina. M. González Guillot et al. (CONICET. Argentina).
35. Cu isotope composition as a tracer of ore-forming process. R. Krymsky et al. (VSEGEI. Russia).
36. Geochemistry of ancient vent deposits as record of the temporal and spatial evolution of expelled fluids: a case study from west Pyrenees. L. M. Agirrezabala (Euskal Herriko University. Spain).
37. Mid-Cretaceous hydrothermal petroleum generation and expulsion in the Basque-Cantabrian Basin (western Pyrenees). L. M. Agirrezabala et al. (Euskal Herriko University. Spain).
38. Pb-Sr-Nd isotope evolution and metal sources of Zn-Pb-Ag deposits, Brooks Range, Alaska. R. A. Ayuso and K. D. Kelley. (U.S. Geological Survey).
39. Rare earth, major, and trace element composition profiling of bedded chert and siliceous shale sequences across the Santonian-Campanian boundary in Western Venezuela. G. Garbán and M. Martínez. (University of Venezuela).



40. *The relationship between tectonics, granitoids and Mesozoic Au-Ag mineralization in the Hondo Collision Belt, South Korea.* Ch. Seon-Gyu et al. (Korea University).
41. *Arsenic and Cadmium presence in AMD-Affected river waters.* J. A. Grande et al. (Huelva University, Spain).
42. *An initiative for a new geochemical coverage of whole Spain by means of floodplain sediments.* A. García Cortés et al. (IGME, Spain).
43. *Applicability of Radon monitoring as a screening methodology for NAPL-contaminated sites.* E. de Miguel et al. (Madrid Polytechnic University, Spain).
44. *Application of Principal Components Analysis to Enhance Targets for Mineral Exploration.* F. Da Silva et al. (GIMEF, Portugal).
45. *Chemical, mineralogical and ceramic properties of Rhyolitic Tuff from Arabaalan – Elmalı (Biga) District (Biga Peninsula – Turkey).* A. Çalık and Y. Erçetin. (Çanakkale Onsekiz Mart University, Turkey).
46. *Extractable Cd, Cu, Pb and Zn in cultivated soils of Northern Zhejiang of China.* Z. Guohua et al. (Institute of Geophysical and Geochemical Exploration, China).
47. *Geochemistry of Tin and incompatible elements in the Jálama batholith (Central Iberian Zone).* C. Fernández-Leyva et al. (IGME, Spain).
48. *Heavy minerals distribution in bauxites, Los Pijiguaos, Venezuela.* W. Meléndez et al. (Venezuela University).
49. *Mineralization and Electron Probe Microanalyzer (EPMA) geochemical characterization of Primary Gold from the Bukit Koman Area (Raub), Pahang, Malaysia.* J. H. Abdul Aziz and T. G. Hoe. (University of Malaysia).
50. *Source apportionment of lead in the Guadiana River basin.* L. Martins et al. (IGM, Portugal).
51. *Using Selective Chemical Extraction to distinguish the variable signatures from the anomalous component introduced by an underlying Zn deposit.* C. Patinha et al. (University of Aveiro, Portugal).
52. *Thallium analysis in geological samples from La Peña-Terronal Mine (Asturias, Spain).* I. Higuera et al. (CIEMAT, Spain).
53. *An isotopic and fluid inclusion study of the polymetallic, sediment hosted Abra deposit, Western Australia.* S. Austen et al. (University of Southampton, UK).
54. *Geochemical assessment of the reactivity of tailings proposed for marine tailings disposal (MTD).* R. Matthies et al. (SRK Consulting, UK).
55. *Geochemical and mineralogical soil study of the Veramonte vineyard, Casablanca Valley, central coastal Chile.* J. Poblete et al. (University of Chile).
56. *Geochemistry and mineralogy of spoil heaps and mine wastes related to copper mining in Asturias (Northwestern Spain).* R. Álvarez et al. (Oviedo University, Spain).
57. *Geochemistry of Soils over a Buried Porphyry System, Atacama Desert, Chile.* C. Jorquera and P.A. Winterburn. (University of Chile).
58. *Gold dispersion in the calcrete zone, Girilambone region, western New South Wales, Australia.* K. McQueen et al. (Australian National University, Australia).
59. *Influence of ironworks, mining and metallurgy on distribution of chemical elements in the Stavnja valley (Central Bosnia and Herzegovina).* R. Sajin et al. (Geological Survey of Slovenia).
60. *Litho-geochemistry of the volcanic sequence hosting the Río Tinto ore deposit (Iberian Pyrite Belt, Spain).* C. Conde et al. (IGME, Spain).
61. *Metal element distribution in two river basins of contrasting lithology.* M.L. Iglesias et al. (Santiago de Compostela University, Spain).

62. The southern Nova Scotia wine terroir: A geological and pedological study of the cation exchange capacity and Ca/Mg ratios in vineyard soils. R. Cavalcanti de Albuquerque et al. (Acadia University, Canada).
63. Geoaccumulation index of heavy metals in estuaries of Autonomous Community of Cantabria (Spain). P. Blanco et al. (Cantabria University, Spain).
64. Geochemical study of element mobility from the au-tailing impoundment of Rodalquilar (Almería, SE Spain). A. Navarro et al. (Barcelona University, Spain).
65. Heavy metals in alluvial sediments of the river Drava (Slovenia and Croatia). R. Sajn et al. (Geological Survey of Slovenia).
66. Lithium Pegmatites Exploration in eastern Portugal using Statistical and Geoestatistical Analysis. R. Vieira et al. (GIMEF, Portugal).
67. Multivariate statistics of geochemical data for assessing anthropogenic soil pollution in Hg mine districts of Asturias (Spain). A. Ordóñez et al. (Oviedo University, Spain).
68. Early Cretaceous productive and barren granitoids in Gunbuk-Jindong area in Gyeongsang basin, South Korea: Petrogenesis, geochronology and implications for Cu (-Au) mineralization. J. W. Park et al. (Korea University).
69. Geochemical characteristics and mineral composition of the PGE-sulfide mineralization in the Mountain General'skaya massif, Kola Peninsula, North-West Russia. N. Kropacheva and A. Marchenko (St.-Petersburg State Mining Institute, Russia).
70. Statistical analysis of ballclays chemical composition from the Oliete basin (Teruel, NE Spain). S. Mesequer et al. (Jaume I University, Spain).
71. A New Soil Gold Map of Northern Ireland. D. Smyth (Geological Survey of Northern Ireland).
72. Geochemical Atlas of Eastern Barents Region. V. Chekushin et al. (S/C Mineral, Russia).
73. Geochemical Atlas of Italy. B. de Vivo et al. (Università degli Studi di Napoli "Federico II", Italy).
74. Modelling biogeochemical accumulation of trace elements in soils and vegetation. Y. Ma and A. W. Rate. (University of Western Australia).
75. Air Pollution Prediction Models of particles, As, Cd, Ni and Pb in a Highly Industrialised Area. A. B. Vicente-Forte et al. (University Jaume I of Castellón, Spain).
76. Anthropogenic and natural enrichment of As, Cr and Pb of the soils near the Stawell Gold Mine, Victoria, Australia. R. R. P. Noble and R. T. Watkins. (CRC LEEME, Australia).
77. Ecosystems health and geochemistry: concepts and methods applied to abandoned mine sites. J. Pastor and A. J. Hernández (Alcalá University, Spain).
78. Evaluation of an in vitro digestion protocol in human-health risk assessment. E. de Miguel et al. (Madrid Politecnico University, Spain).
79. Uranium uptake by potato plants (*Solanum tuberosum* L.): a study case in controlled field experiments. O. Neves et al. (Tecnico University of Lisboa, Portugal).
80. Geochemistry of soils and waters close to W-Au-Sb old mines from Sarzedas, Castelo Branco, central Portugal. P. Carvalho, et al. (Coimbra University, Portugal).
81. Detection of deeply buried mineralisation using ground conductivity and pH measurement. A. Mokhtari et al. (University of New South Wales, Australia).



82. Determination of Gold, Platinum and Palladium by Lead Collection Fire Assay and Axial Inductively Coupled Plasma Optical Emission Spectroscopy. N. Turner et al. (SGS Minerals Services. Canada).
83. *Documenting geochemical, physical, and thermodynamic changes associated with all possible geochemical reactions in rocks using Gale vector space: Metasomatic examples from diamondiferous kimberlites to Ni laterite deposits.* C. Stanley and D. M. K. Murphy (Acadia University. Australia).
84. *Geochemical and environmental characterization of pyritic tailings ponds.* C. Torres Vivas et al. (IGME. Spain).
85. Geochemical indicators as tools for water management in transboundary rivers. Application to Guadiana basin (Spain-Portugal). T. Bros et al. (Oviedo University. Spain).
86. *Removal of Pb, Cd, Zn, and Cu from aqueous solutions using lignite.* D. Pentari et al. (University of Crete. Greece).
87. *Visage: a new stereo viewing and compilation software tool for geologic woks.* S. García Cortés et al. (Oviedo University. Spain).



Founded in 1921 and publicly traded on the NYSE since 1925, Newmont is one of the largest gold producers in the world and a leader in international exploration and mine development with operations on five continents. Headquartered in Denver, Colorado, the company employs approximately 33,000 employees and contractors, the majority of whom work in Newmont's five core regions: Nevada, South America, Australia/New Zealand, Indonesia and Ghana.

In 2006, Newmont sold 7.4 million consolidated ounces of gold (5.9 million equity ounces) and grew reserves for the fifth consecutive year to 93.9 million ounces. Newmont is a Fortune 500 company, the only S&P 500 listed gold mining stock and maintains a "no gold hedging" philosophy.

Exploration remains a driver of Newmont's success and future. With over 100 exploration projects around the world, Newmont drilled more than 730,000 meters last year and continues to aggressively pursue near-mine and greenfield projects this year. Over the past 15 years, Newmont's exploration team has been successful in finding 14 greenfield and 12 near-mine discoveries partially through a variety of strategic joint ventures with local and international firms

Newmont is a founding member of the International Council on Mining & Metals (ICMM), an organization committed to the principles of sustainable development, stewardship of the environment, and partnership with host communities. Newmont's CEO, Wayne W. Murdy, served as ICMM chairman in 2006. Additionally, Newmont was one of the first gold mining companies to become certified under the International Cyanide Management Code, ensuring the responsible use of chemicals at our operations.

Pre Symposium Field Trip

Almaden (Hg), Rio Tinto (Cu), Las Cruces (Cu), Agua Blanca (Ni-Cu), Las Médulas (Au)

Madrid – Seville – Cáceres – Salamanca – León – Oviedo

Depart on 10th June at 8.30 a.m. from “Instituto Geológico y Minero” (C/ Río Rosas, 23. Madrid).

Arrival on 13th June to Oviedo in the evening.

Itinerary:

10th June: Visit to “Almaden Mine” and lunch in Almaden town. Departure to Seville where dinner and accommodation will take place.

11th June: visit to “Rio Tinto Mines”, lunch and visit to “Las Cruces Mine”. Back to Seville in the afternoon.

12th June: visit to “Agua Blanca Mine” and lunch in Cáceres town. Visit the old part of the town and departure to Salamanca where dinner and accommodation will take place.

13th June: visit the centre of the city and departure to “Las Médulas” (roman gold mines), lunch in the surrounding. Departure to Oviedo.

Cost: 750 €

SPONSOR OF SYMPOSIUM SACHELS





Social Program

. Thursday 14th June 2007:

WELCOMING LUNCH:

It will be held in the flat roof of the Auditorium Príncipe Felipe and it will be the first point of contact between the audience of the Symposium. This event is sponsorship by SGS minerals:

EVENING RECEPTION:

It will be held in a well-known place of the Oviedo centre (Trascorrales Square). We invite to all the attenders and their companions to participate in this event because it is a special opportunity to have the first contact between all of us in a relaxed and grateful environment.

. Friday 15th June 2007: TYPICAL DINNER

It will be the most informal event of the symposium. It will take place in a very typical asturian restaurant (sited in Gijón city), where we will taste the gastronomy and we will enjoy of asturian music and traditional dances.

. Monday 18th June 2007: OFFICIAL DINNER

This dinner will be the farewell of the symposium, it is considered a formal event so elegant clothes are required. It will be held in the *Reconquista Hotel*, an emblematic building of the XVIII century sited in the most central, residential and commercial zone of Oviedo.

The moments before the dinner will be livened up by an asturian bagpipes group, just as another show which will take place during it.

. Tuesday 19th June 2007. CLOSURE CEREMONY AND SPANISH WINE

The closure ceremony marks the end to the symposium and the Organizing Committee will be grateful to all the attendees for their participation with a Spanish wine.

Optional activities

The Organizing Committee proposes two interesting excursions for the weekend.

Saturday 16th June. GIJÓN

On Saturday, will take place an ideal excursion for people that want to pass the day in the coast, in Gijón, a seaside town considered as the second most important city of Asturias will be visited.



This trip will include a tour around the city as well as several visits; the ethnographic museum of Asturias, the botanical garden and the Art Centre. Cost: 80 €

Saturday 16th June.: CENTRAL -WEST COAST.

Departure from Oviedo to visit the sea museum in Luanco and route for the town.

Then, the most typical sea town of Asturias will be visited, Cudillero.

The tour continue to Salinas where is placed the "Philippe Cousteau" Anchor Museum. The trip will finish in Avilés where we will have lunch. Cost: 100 €



Saturday 16th June. THE BORDEAUX NATIONAL OPERA: GALA OF SOLOISTS AND ÉTOILES

The Campoamor theatre offers at 20.00 h. the Ballet of Bordeaux's Opera, directed by Charles Jude who will take part as dancer together with others outstanding dancers as Igor Yebra and Okxana Kucheruk.

Prizes:

- Stalls and mezzanine: 22,5 €
- Principal: 19 €
- Amphitheatre and General: 15,5 €

Sunday 17th June. CANGAS DE ONÍS - COVADONGA



For all those persons that prefer to know the most mountainous zone of Asturias, this excursion will be perfect. They will be able to observe spectacular views of the "Picos de Europa" and enjoy walking around this natural paradise. Furthermore, this trip includes a visit to the town where the typical asturian drink –

cider – is manufactured. Cost: 100€



Companions Program

The Accompanying Person's fee includes admission to the Welcome Reception and the typical dinner. Furthermore, on Friday 15th will take place a guided tour for Oviedo:



Visit to the Cathedral, Holly Chamber and the historic centre: "Foncalada fountain", "Umbrella's square", the town hill, The Fontán...

Walk for the centre to visiting several famous statues.



Anglo American recognises that the identification and successful development of new business projects forms an important part of its long term future. Its goal for the new millennium is to significantly expand its natural resources asset base through a combination of world-wide exploration for long life low cost projects and acquisitions.

Anglo American has always shown a commitment to grass roots exploration and adding value to existing assets through near-mine exploration. Its extensive, targeted exploration programme spans a broad range of geological environments and countries. The group currently has exploration offices in several countries in the Americas, as well as in Africa, Europe, Australia, India and the Pacific Rim. New mining business activities will continue to be international in scope and focused principally on base metals, given that precious metals exploration is conducted through the company's associates AngloGold and AngloPlatinum.

A vital component of the company's exploration philosophy is the employment of decentralised, multidisciplinary teams of high quality people. Additionally the company is committed to a well resourced and focused research and development programme, the main objective of which is to keep Anglo American at the forefront of exploration technology and practice.

Anglo American has a long history of working successfully in joint ventures and partnerships with governments and other companies. It has a track record of being sensitive to the needs of local communities and of meeting the requirements of environmental best practice in its exploration projects.

Local Information

Location

Oviedo is the capital of Asturias and it is sited in the North of Spain.

With about 216.000 inhabitants, it is considered the commercial and business core, just as the administrative and university centre of the province. The commerce is now the fundamental economic sector.

The old part of the city, house numerous historic buildings as the Cathedral and his Holy Chamber. In the surroundings are conserved many of the treasures of the Asturian Pre-Romanesque period, as S. Julián de los Prados, S. Miguel de Lillo and Sta. María del Naranco.

Oviedo is considered one of the most clean Spanish cities, as well as a very safe so you can take a walk quietly around the numerous parks and gardens that take up a big part of the city.

Climate

The climate in Oviedo is humid and mild. The temperatures are soft every year, with maximum values about 18.7º C in august and minimum values (7.4ºC) in January. The rainfall are constant too although they usually take place from October to April.

In June the temperatures are about 16 ºC, the days are larges and most of them are sunny and slightly rainy.

Banks Hours

The most of the banks are near to the Auditorium in the Fruela and Uría Street. They are opened only in the morning from 8.30 at 14.00 h Monday to Saturday. Sundays they are closed, but the cash machines are available 24h all days.

Telephones for travellers

ALSA is the name of the most important bus company in Asturias. It makes the corresponding services to the airport, to Madrid and it links many places in Asturias.

In the web page www.alsa.es is showed all information related to prizes, timetables and destinations.

If you prefer travel by train, RENFE is the company with service in Spain. It makes similar routs to the bus company. It has available too a web page www.renfe.es. In Oviedo the train station is located in the centred of the city, in the Uría Street.

The best method of transport inside the city is by taxi whose phone number is 985 25 25 00.

Oral and Poster Abstracts

The abstracts have been compiled in the different Technical Sessions. They are published in the form in which the authors submitted them. Their contents and opinions represent the point of view of the authors only.

Session I :
Classic mining districts

Exploration of porphyry copper deposits beneath transported overburden: soil sampling and passive collector devices trialled at the Toki District, II Region, Chile

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ABSTRACT

Chemical and biological oxidation processes that affect a sulphide deposit beneath transported overburden will generate free ions and hydrocarbon gaseous compounds that migrate to surface forming a real time geochemical contrast anomaly respect to background. Different techniques were trialled at the Toki Cluster, II Región, Chile. A systematic sample grid was undertaken over three porphyry copper deposits, Toki, Genoveva and Quetena, with a total coverage of 20 Km² at over 170 sample sites. Soil samples were taken for aqua regia, Enzyme Leach, MMI and SGH analysis, and passive collector devices (project FONDEF, University of Chile–Codelco) were inserted in the field and retrieved after over 100 days. Collector materials were analysed by ICP-MS and SGH. Raw data results, shows good correlation of collector device data with the location of ore deposits and the invoked real time processes. Soil sample based techniques show high variability, a partial response to the above mentioned processes, cloaked by other effects such as soil heterogeneity, contamination, hydrogeologic processes, among others.

Geochemical assessment of abandoned mining lands: assigning value and seeking new opportunities

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ABSTRACT

The current environment of high metal demand and exhaustion of historically important metal sources is leading mining companies to seek different sources of metals. The challenge for the applied geochemistry community is to identify such opportunities and find reliable methods that can be used to evaluate and recover the value. The closure and abandonment of mining areas is rarely due to complete consumption of a reliable resource but rather due to diminishing financial returns based on metal values, or social, political and environmental restrictions that lead to an uneconomic scenario for a resource unit.

In the assessment of a mining area there are several potential sources of economic value in an abandoned mine site exists including;

Previously unidentified resources in the mining area;

Mining of known In-Situ ore and stockpiled unprocessed ore;

Recovery of value from previously processed waste and previously cited “mine waste”;

Recovery of value from undeveloped resource, such as the processing of mine water to recover metals and valuable salts;

Recovery of new value from mining facilities such as mine sludge processed to recover ferric oxyhydroxides as a source of iron, pigments and trace metals;

Development of mine water resource for agricultural, industrial or even potable water.

In the case of the first two potential sources, unconventional or innovate methods of exploration may be required to identify these resources, additionally the development of water as a resource either for metal or salt recovery or as a source of useable water requires hydrogeochemical investigations. The successful development of these resources and value recovery often requires more efficient metallurgical circuits or new chemical and physical extraction procedures to recover value.

This presentation presents case study evaluations where value is identified in abandoned mine sites. Additionally modified and new technologies developed in the last decade are discussed for value recovery and geochemical factors that influence the financial assessment of abandoned mine lands.

Dispersion patterns of gold and pathfinder elements in different modes of presence in soils: Pervomaysky area, Far East of Russia

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Keywords: geochemical exploration for gold, soils geochemical sampling, dispersion patterns, different geochemical exploration techniques.

ABSTRACT

This presentation shows and discusses results of geochemical exploration for gold carried out in the Pervomaysky area situated in the Far East of Russia. Three geochemical methods were used: (1) routine lithogeochemical survey with the usage of soil and stream sediment sampling and determination of total contents of elements in soils (fraction < 1 mm); (2) lithogeochemical survey by means of Method of Analysis of Superfine Fraction (<10 mm) of soils (MASF); (3) soil sampling with sequential extraction and analysis of water-soluble forms of elements from soils and stream sediments. Contents of indicator elements were determined using ICP-AES and ICP-MS, and geochemical data processing and interpretation conducted with the help of original algorithms. The comparison of resulted geochemical data and maps obtained by these different techniques is discussed. It has been shown that most reliable prediction of gold mineralization can be distinguished by getting together data obtained by 2-nd and 3-rd geochemical techniques.

The Rio Tinto River Basin - a Remote Sensing Perspective

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Keywords: acid drainage, remote sensing, Rio Tinto River, hyperspectral, satellite sensor, reflectance spectroscopy.

ABSTRACT

The Rio Tinto River Basin in southwestern Spain is one of the best examples of severe acid drainage on the planet and indeed has been used as an analog for Mars (NASA MARTE Project). The highly acidic nature of the Rio Tinto River is a function of both anthropogenic and natural acid drainage, caused by dissolution of intense iron sulfide mineral concentrations in a world class, massive sulfide deposit at the source of the river. Remote sensing and field reflectance spectroscopy bring a unique perspective to this fascinating region. The authors routinely use hyperspectral and multispectral remote sensors including ASTER, SPOT, IKONOS, AVIRIS and SPECTIR to identify, characterize and monitor diagnostic minerals precipitated along the river banks, slag heaps and dumps. Extensive spectroscopy field work at the Rio Tinto River, in the pits, dumps, slag heaps and spring source areas has yielded a progression from very young iron sulfates (copiapite, melanterite, rhomboclase, szmolnokite, coquimbite, jarosite), to hydroxides (goethite) and more maturely oxidized oxides (hematite) that illustrate an oxidation cycle. Selected imagery will be applied to the Rio Tinto drainage illustrating the data that different spectral and spatial resolutions can provide for this application.

Geology and geochemistry of intrusive dikes and meta-sedimentary rocks from Workamba area, Tigray province, northern Ethiopia.

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Keywords: Ethiopia, Workamba, Rare earth elements, trace elements

ABSTRACT

The Workamba area, located in Tigray region, northern Ethiopia, is part of the Arabian-Nubian shield comprising low grade metasedimentary rocks, metavolcanic rocks, monzogranites and aplitic dikes. Monzogranites and aplitic dikes (~608 Ma) post date the metasediments which are sheared and metamorphosed to lower green schist facies.

Rare earth element patterns of the monzogranites and aplitic dikes normalized to chondrites are enriched in LREE as compared to HREE and show negative Ce anomaly. Their trace element pattern is characterized by peaks of Ba, U, La, Zr and Sr and troughs of Th, Nb, Pb and Nd. Such trace and REE patterns could be explained by crustal contamination of magmas. The negative Ce anomaly may suggest emplacement in marine environment. The Rb versus (Y+Nb) discrimination diagram indicates volcanic arc tectonic setting and is consistent with that of surrounding intrusives. The metasediments are slightly enriched in HREE than LREE indicating marine to sea water provenance.

Arsenic mineralogy and mobility at two historic gold mines, New Zealand

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Keywords: historic gold mining, arsenic trioxide, arsenopyrite, scorodite, kankite, arsenic mobility

ABSTRACT

The Phoenix Mine and the Blackwater Mine are historic gold mines hosted within the Otago schist and Greenland Group schist, respectively. No rehabilitation was undertaken after mine closure at either site. Processing residues include arsenopyrite rich tailings at the Phoenix Battery and arsenic trioxide (As₂O₃) at the Blackwater Mine site, where roasting of arsenopyrite ore took place. The presence of anthropogenic arsenic trioxide indicates that ore processing procedures have an important control on the available As source. In the vicinity of As rich mine residues hydrated iron arsenates precipitate, which have two major consequences. Firstly, the precipitate cements the ground in the vicinity of the roaster area, thereby creating an impermeable surface crust and preventing further dissolution of underlying As minerals. Secondly, formation of secondary arsenic minerals temporarily immobilizes some of the dissolved As, that is generated during nearby As mineral dissolution. In the downstream environment, As mobility is controlled by the solubility of hydrated iron arsenate.

Geochemical Database for Historical Mining Areas in the Upper Salmon River Basin, Central Idaho

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ABSTRACT

A geochemical database has been recently completed for samples from 644 sites from historical mining areas within the upper Salmon River drainage basin, Idaho, USA. The database comprises sample analytical and descriptive data, site descriptive data, and site photographs for areas visited between 1995 and 2005. The samples were collected primarily to gather new environmental geochemical data as part of mineral-environmental assessment studies undertaken in the region. Results contained in this database have been utilized as an aid to (1) land managers in selecting and prioritizing abandoned mine remediation projects, (2) addressing heavy metal concerns of private landowners living adjacent to sampled mines, (3) a Federal regional toxicological study, and (4) assessing pre-burn ecosystem conditions using samples and photographs collected prior to wildfires that swept through the region. Alternatively, these sensitive, multi-element analyses on a variety of sample media also could be useful for mineral exploration in the region.

Solid-phase control on the mobility of mercury and heavy metals at the old Azogue Mine (Almeria, SE Spain).

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Keywords: old mercury mine, mobility of mercury, mobility of heavy metals, pollution

ABSTRACT

The old Azogue mine is a low sulphidation epithermal ore deposit containing mainly cinnabar, stibnite, realgar and pyrite ores with 1.3% of mercury in a geological context of slates and dolomites (Table 1).

Soil in the old open pit and tailings shows high levels of Hg, As, Au, Ag, Pb, Zn and Ba (Table 2).

Element	Mean	Std. Deviation	Max.	Min.	Slates
Hg	13380.5	32039.8	110000	1	<1
Sb	14773.4	27232.1	96000	7.5	3.8
As	393.7	333.9	1200	19	50.8
Au	164	250.8	823	5	2
Ag	23.6	43.8	160	5	<0.3
Pb	67.2	105.5	276	2	47
Zn	555.8	464.3	2705	50	123
Ba	52096	110118.2	390010	200	460

Tabla 1.

Element	Mean	Std. Deviation	Max.	Min.	NCS
Hg	357.3	587.7	2300	1	<1
Sb	3117.7	6829.3	32000	19	22
As	353.9	399.6	1610	18	18
Au	49.0	98.6	480	5	<5
Ag	8.4	11.6	60	5	<5
Pb	361.4	601.7	2554.9	7	15
Zn	535.1	755.8	2970	50	90
Ba	16117	32264.6	170000	200	870

Table 2.

NCS: Non contaminated soils values

According to the column leach test, the contaminated soil shows the following: mercury mobility up to 67 µg/l, an arsenic concentration exceeding 300 µg/l, an iron content in the order of 1650 µg/l and sulphates between 80 to 299 mg/l.

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Session 2:
Mapping Geochemical Data

The history of low density geochemical mapping

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Keywords: global geochemical mapping, low-density sampling, continental scale

ABSTRACT

Low-density geochemical mapping (c. 1 site/200 km²) was first tested during the 1960ies in Africa. In the early 1980ies Shacklette published a low-density (c. 1 site/6000 km²) geochemical survey of the conterminous United States. His data are still among the most cited geoscience databases. In China pioneering work on low-density geochemical mapping was carried out over many years. In Europe the Nordkallot Project (1 site/30 km²) was a first and still careful test of the power of low density mapping for mineral exploration purposes. The geochemical atlas of Norway, based on overbank sediments, uses a sample density of 1 site/300 km². The same density was used in the Kola Ecogeochemistry Project. Barents Project and the Baltic Soil Survey used a sample density of 1 site/1000 km² and the latest success of low-density geochemical mapping in Europe has been the publication of the EuroGeoSurveys Geochemical Atlas of Europe (sample density 1 site/5000 km²). This paper will discuss the development and usefulness of low-density surveys. During the last 30 years several sub-continental to continental scale geochemical mapping projects have been carried out. The geochemical maps resulting from these surveys are based on very low sample densities from 1 site per 1000 km² to 1 site per 6000 km². Geochemists used to sample densities of 1 site per km² or higher and knowing the high local variation in geochemical signals often wonder whether such low density surveys can return any useful and reliable information. Are geochemical maps based on so few samples robust, i.e. would the same patterns emerge if the same area were re-sampled and re-mapped? This contribution will demonstrate the existence and the robustness of continental scale geochemical patterns, using published examples from different parts of the world.

Low density geochemical mapping and the robustness of geochemical patterns

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Keywords: global geochemical mapping, low density sampling, robustness, map patterns

ABSTRACT

During the last 30 years several sub-continental to continental scale geochemical mapping projects have been carried out. The geochemical maps resulting from these surveys are based on very low sample densities from 1 site per 1000 km² to 1 site per 6000 km². Geochemists used to sample densities of 1 site per km² or higher and knowing the high local variation in geochemical signals often wonder whether such low density surveys can return any useful and reliable information. Are geochemical maps based on so few samples robust, i.e. would the same patterns emerge if the same area were re-sampled and re-mapped? This contribution will demonstrate the existence and the robustness of continental scale geochemical patterns, using published examples from different parts of the world.

‘Laterite’ Geochemical Atlas for the deeply-weathered western Yilgarn Craton of Western Australia

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Keywords: Archaean, Yilgarn Craton, Western Australia, craton-scale laterite geochemistry, geochemical mapping.

ABSTRACT

The Atlas provides geochemical coverage at a sample spacing (9 km) sufficiently close to recognize regional geochemical trends, major lithologies and dispersion halos around significant bedrock mineralization. The extent of the coverage (approximately 400 000 km²) means the data are valuable for both exploration and environmental purposes. The sample medium is ferruginous nodules and pisoliths from lateritic residuum, its derived lag and ferruginous gravel selected from locally derived colluvium. All 3142 ‘laterite’ samples were analysed for a minimum of 53 elements by XRF, ICP-OES and ICP-MS, with selected samples analysed for PGE. Considerable care was taken in monitoring analytical quality throughout.

Significant results include increased Au abundances in the northeast of the survey area that not only cluster around known gold deposits, but extend beyond them, indicating the likelihood of more widespread mineralization in these areas. A chalcophile element index illustrates potential for Au and base metal mineralization in the westernmost part of the Yilgarn Craton, whereas a pegmatophile index shows a regional northwest trend parallel to regional structures. Chromium abundances in granitic terrain might indicate mafic–ultramafic remnants (some with anomalous Au) beyond known greenstone belts. A regional Hg anomaly trends northwest for more than 500 km. Anomalous As, Bi, Mo and Sb along the south margin of the craton may be related to Au mineralization. Because the dataset is very consistent, multivariate statistics can be used to highlight specific lithologies and locate target types

**Rock and Soil Environmental Geochemical Baseline Mapping:
Collahuasi District, N. Chile**

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Keywords: Baseline Geochemistry, Environment Geochemistry, Soil
Guideline Values

ABSTRACT

A geochemical baseline survey of the Collahuasi District, N. Chile has been completed based on systematic regional rock and soil sampling. The Collahuasi district hosts 3 major Cu porphyry centres, Rosaria, Ujina and Quebrada Blanca which are now being mined for Cu and Mo. 1100 samples were collected on a grid averaging 1-2 sq. kms. over an area of 1500 sq. km. and 74 chemical elements determined on whole rock samples by ICPMS and ICPOES and 65 elements on soils samples after aqua regia extraction. The rock and soil data have been compared to international soil guideline values for chemical elements from N. America and Europe and the ratio of the concentration in soils has been compared to that in rocks for all elements. The results show that even in pristine background samples some elements exceed all guidelines. This observation is critically important in using generic guideline values which should more fully take account of bedrock geology. The data also indicates that erosion has redistributed many elements including As, Pb, Cd, Ag and Hg with increase of levels by a factor of above x 10 (V).

**Soil geochemical mapping of the Rustenburg Layered Suite,
Bushveld Complex, South Africa.**

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Keywords: soil, geochemical mapping, Bushveld Complex, South Africa

ABSTRACT

The national geochemical soil mapping programme conducted by the Council for Geoscience in South Africa also covered the enormous Bushveld Complex. The Rustenburg Layered Suite, which constitutes the mafic-ultramafic portion of the complex, hosts up to 80% of the world's platinum reserves, 60% of the world's chromium reserves and significant reserves of palladium, vanadium and titanium. Since the geochemical data obtained from the soils is a direct reflection of the underlying rocks, geochemical mapping of sub-outcropping Rustenburg Layered Suite in areas of thick soil cover was attempted using the data. Geochemical mapping succeeded to establish 'new' trends which resulted in the remapping and re-evaluation of parts of the Rustenburg Layered Suite in the Western Limb of the Bushveld Complex. The results stressed the enormous value of regional geochemical mapping and modeling of sub-outcropping rocks in soil covered areas.

The challenges of Regional Geochemical Soil Sampling Programme in a tropical rain forest belt in Ghana, West Africa

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Keywords: Palaeo-proterozoic, Birimian, Ghana, rain forest.

ABSTRACT

A regional geochemical soil sampling programme on a 1 km²-grid under a EU-funded geological mapping project is currently in progress in selected areas in Ghana, West Africa. Of the four areas selected for the mapping and sampling project, one lies entirely in the tropical rain forest belt in the Palaeo-proterozoic Birimian in the Western part of the country, two in the savannah to the north and one in the transitional zone in the east between the savannah and the forest belt in the south. Apart from the usually stormy weather and/or torrential rains which effectively limits the period of active field work to only between the months of November and March each year, sampling within the tropical forest is also influenced greatly by choice, set up and movement of camp sites, sampling methodology, population distribution, “social capital” and general lack of signals on GPSs due to the thick forest canopy. The strict 1 km²-grid pattern, therefore, offer peculiar challenges at any stage and within various areas of the sampling programme which call for distinctive innovative measures.

Mapping anomaly residence in the regolith at small scales

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Keywords: Mineralogy, geochemistry, speciation, element mapping, pisoliths.

ABSTRACT

Understanding trace element residence and provenance of near-surface geochemical anomalies in heterogeneous regolith is crucial for both exploration and environmental geochemistry. Laser Ablation ICPMS transect analyses, Synchrotron based X-Ray Fluorescence and Proton Microprobe element mapping have been used to constrain element distributions and speciation variation within residual and transported iron oxide nodules from a typically complex regolith setting at the Moolart Well gold deposit. We have been able to spatially resolve the distribution of trace metals and relate these directly to the petrographic context displayed by the samples, including distinguishing transported from in-situ signatures of metal dispersion. This illustrates the potential of such studies to accurately establish true environmental background pre-mining, and is also promising in anomaly provenance analysis for mineral exploration.

National geochemical survey of Australia: Outline of a new initiative

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Keywords: Geochemistry, regolith, mineral exploration, energy resources

ABSTRACT

A new project aimed at unravelling the geochemical composition of Australia's regolith has recently been approved under the Australian Government's new Onshore Energy Security Initiative (OESI). The primary aim of the National Geochemical Survey of Australia (NGSA) will be to provide actual concentrations and distributions of elements useful in targeting energy resources (uranium, thorium, other elements indicative of hot granites, etc.). The project will complement other OESI projects focussing on airborne radiometrics, airborne electro-magnetics and geothermal resources. The NGSA project will adopt a cost-effective, ultra-low density, landscape-based sampling approach to select sampling sites. Collection, preparation and analysis of surface and near-surface transported regolith samples will closely follow protocols established during pilot projects recently carried out by Geoscience Australia and the Cooperative Research Centre for Landscape Environments and Mineral Exploration, which revealed strong bedrock signatures in those materials.

Semi-quantitative mapping of heavy metal contaminated areas using infrared hyperspectral image data

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Keywords: Absorption parameters, contamination, heavy metal, hyperspectral, mineral, semi-quantitative

ABSTRACT

Trace metals released by mining activities can be potentially toxic and harmful to the environment. These metals are easily adsorbed onto clays and metal oxide minerals in soils. Although metals are spectrally featureless in the visible and near-infrared part of the electromagnetic spectrum, the spectral signatures of minerals that bind heavy metals can be used for indirect detection and mapping using imaging spectrometer data. This paper describes semi-quantitative mapping of heavy metal contamination using spectral variation in clay and iron oxides due to heavy metals. Reflectance spectra were measured in a laboratory on stream sediment samples of the Rodalquilar mining area in Spain. Parameters such as absorption wavelength, depth and area were derived and linked to metal concentration levels in the stream sediments. The classification result of a HYMAP hyperspectral image based on the absorption parameters shows a profound match with the ground data. This technique is expected to support assessment of dispersion of heavy metal contamination and decision on optimal sampling point.

Stream sediments geochemical mapping survey in an island arc context, Bonao-Constanza Area (Dominican Republic).

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Keywords: Island arc, Dominican Republic, stream sediments, geochemical signature, geochemical anomaly, epithermal

ABSTRACT

This paper presents the main results and conclusions of a multielemental geochemical mapping on stream sediments carried out in the Bonao-Constanza area, Cordillera Central, Dominican Republic. The studied area covers 3.800 km². The area contains oceanic crust fragments, represented by the Loma Caribe and Complejo Duarte formations, volcanoplutonic fragments that include basic volcanics episodes, bimodal eventually, with a series of intrusive bodies of basic, intermediate and acid character, and sedimentary back-arc fragments. The hosted mineralizations are typical of this geotectonic setting: epithermal (Au, Ag), volcano-sedimentary massive sulphide (Cu-Zn), and laterite (Ni), on a peridotitic protolithe. The presence of the world class Pueblo Viejo Au orebody, a high sulfidization epithermal mineralization in a structure hosted by the Los Ranchos Fm is very significant. The <150 μ fraction of stream samples (1/5 km² sampling density) have been analysed by INAA and ICPAES for 48 determinands. Maps showing element by element distribution patterns have been prepared. The multivariant statistical treatment of the multielemental data has consisted in a principal components analysis and in a clustering or classification process. The first one defines the main geochemical associations that explain most of the geochemical variability, which could also be explained in terms of metallogenic and geological factors. Clustering of samples population has been achieved according with the internal structure of the geochemical data. This last procedure allows the definition of geochemical domains with contrast enough and with geological entity, in order to establish geochemical backgrounds with regional certitude. The geochemical signatures of the most prospective units (Los Ranchos Fm. and Tireo Fm.) and of the Pueblo Viejo (epithermal), Cerro Maimón (VMS) and El Higo (epithermal) have been established. Several prospective areas have been delineated. Those of most interest are located in the sedimentary back arc basin (Ba-Au, suggesting possible epithermal mineralizations), made up by the Cinturón de Peralta (Eocene). This feature suggests that hydrothermal activity is not restricted to the Upper Cretaceous and continues in the early Tertiary times, enlarging the prospective areas.

**Influence of mining and smelting on chemical composition of soil
around the abandoned Pb-Zn-Hg-Ag mine and Pb smelter in Litija,
Slovenia**

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Keywords: geochemistry, soil, heavy metals, geochemical mapping, Litija, Slovenia

ABSTRACT

A soil survey was undertaken in the abandoned mining region of Litija, central Slovenia. The objectives of the study were to assess the levels of soil contamination with respect to average concentrations of toxic elements in the region, to determine the associations between the different chemical elements and their spatial distribution. In this reason 120 topsoil and 120 bottom soil samples were collected in 30 km² area (grid 500 x 500 m). Analysis of 42 elements was performed.

Two geogenic and two anthropogenic geochemical associations were established on the basis of visually indicated similarity of geographical distribution of elemental patterns and with comparisons of basic and multivariate statistics. Study was focused on ten toxic elements (Pb, Zn, Cu, As, Cd, Mo, Ni, Co, Cr and Hg), some of which were present in soil with concentrations well above the global soil means. Pb, As and Hg, with topsoil medians of 120 mg kg⁻¹, 14 mg kg⁻¹ and 0.35 mg kg⁻¹ respectively, exceeded the means for Slovenian soils. According to Slovenian law and the New Dutchlist is the critical or action value of the analyzed elements exceeding in an area of 1.6 km².

**Recent results from a geochemical survey in the New South Wales
part of the Thomson Orogen: Implications for mineral exploration**

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Keywords: Regional geochemical mapping, regolith geochemistry

ABSTRACT

The Thomson regolith geochemical survey is a multi-agency collaborative project that aims to provide mineral explorers in northwestern NSW with an internally consistent background geochemical dataset. Transported regolith was sampled at 99 catchment outlet sites from the surface and at depth. Element concentrations were determined using XRF and ICP-MS on <75 µm and <180 µm fractions. Preliminary results suggest that higher concentrations of Cu, Sb and Pb are proximal to known mineralisation (1) in the west near outcrop of the Curnamona Province; (2) at the junction of the Koonenberry, Thomson and Lachlan crustal elements; and (3) in the east near the Cobar Basin. Low concentrations in many ore elements coincide with areas of thicker Great Australian Basin cover with no known mineral occurrences. Several anomalous concentrations occur well away from known mineralisation and deserve further investigation. Recent drilling near such an anomaly discovered sulfide mineralisation. Bedrock signatures are clearly detectable in some regolith geochemical patterns.

Weathering of mineralized volcanic rocks and the genesis of kaolinite deposits: Carolina Slate Belt, Southeastern USA

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Keywords: kaolinite, Fe-oxide, trace metals, hydrothermal, saprolitization

ABSTRACT

Kaolinite deposits of the Carolina Slate Belt (e.g., Haile, SC) have diagnostic variations in trace element abundances (REE, Ga, As, Pb, Se, etc.) and radiogenic isotope (Nd-Sr-Pb) values. The clay deposits are derived from saprolitization of hydrothermally altered tuff (ca. 554 Ma) historically mined for gold in pyritic lenses. Geochemical and ion probe data indicate distinctive mineral assemblages produced by the combined effects of metasomatism, dissolution, precipitation, and sorbtion. Weathering of tuff resulted in clay rock (~35% kaolinite, ~45% quartz, ~20% sericite) with 4-36 ppm Ga, 0-7 ppm Se, 0-22 ppm As, layers of Fe-concretions and gossan (enriched by factors of 50 in Se and 25 in As), and silicastone (depleted by factors of 10). Al, Ga and REE are conserved in most rock types. Quantitative modeling suggests that the clay deposits consist of stable mineral assemblages that sequester trace metals of potential concern (e.g., As, Pb). Undisturbed clay deposits represent a relatively stable trace metal repository in the surface environment.

Urban Geochemical Mapping in the city of Madrid

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Keywords: urban geochemistry, Madrid, soils, dust geochemistry, contamination

ABSTRACT

The main objective of this study has been the geochemical characterization of the urban and peri-urban soils of Madrid. Other aims were the analysis of the spatial distribution of trace and major elements and the knowledge of their concentration levels, the definition of the element associations and of their source, natural or anthropogenic, and the classification of the urban space according to the levels of potentially harmful elements. Soils sampling density was 4 samples/km² (1.800 samples). Soil samples were tested both by near total/total methods (ICPAES and INAA) and partial ones, after aqua regia digestion (48 chemical elements). Total organic carbon, pH, mineral oils, and some organic pollutants have been also determined or analyzed. The content of elements in soils is mainly a function of their primary features (geological control) and of contaminants contribution, mainly by diffuse atmospheric contamination. Different sources of contamination have been recognized. A complementary geochemical study of components of soil dust has also been made by sweeping of roads and pavements (1sample/km²), and then performing total chemical analysis of the dust and an optical study under binocular lens. Treatment and graphic representation of geochemical data has allowed the definition of the main geochemical associations and their most probable origin (lithologic or anthropogenic, mainly from industrial sources or from traffic). The relationships between elements in soils and in aerosols, and the spatial structure (directional variograms) of their distribution patterns leads to a better understanding of the problems in the urban space and a deeper knowledge of the current state of urban contamination.

Geochemical Exploration and Mapping in the Ossa Morena Zone (Spain).

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Keywords: Ossa Morena, stream sediments geochemistry, heavy minerals, litho geochemistry, gold anomalies

ABSTRACT

This paper presents the methodology and main results of a geochemical survey of drainage sediments carried out in Badajoz (SW Spain). The study area has a surface of 6.250 km² and contains a very important shear zone structure (Shear zone of Badajoz-Córdoba, ZCBC) which connects the main part of the study area within the Ossa Morena zone (ZOM) and a lesser area within the Central Iberian zone (ZCI). The area has a great geologic complexity, and contains several magmatic episodes, some of them related to the Cadomian plutonism and volcanism, with character from ultrabasic to acid, volcanic rocks associated to Cambro-Ordovician rift, and several acid and intermediate hercynian plutonic intrusives. There is a great number of mineralisations, organized in Fe districts (skarns and VMS), Pb-Zn veins, Ba veins and beds (SEDEX), W-Sn-Bi veins in apical parts of granites, Zn,Pb,Cu (VMS deposits linked to Cadomian volcanism).

Samples from different media, stream sediments (1 s/km²), heavy mineral concentrates (1s/5 km², with mineralometric study and chemical analysis), complementary litho geochemical samples of the main lithostratigraphic units (120 samples), overbank sediments (70 samples (80-100 km² catchments), collected in this survey have all been analyzed by ICPAES and INAA for 54 chemical determinands. Geochemical data have lead to a wide understanding of the area from the geologic, metallogenic and even, environmental, point of view. The data show the great geochemical variability of backgrounds, and the strong relationship of distribution patterns with lithostratigraphic units, whose geochemical signatures are clearly set. The main results, from the prospecting side, are the large number of gold anomalies (stream and heavy minerals) related to the Serie Negra materials (Proterozoic shales and quartzites) and, probably, to structures crossing them, and to intrusives and Fe associated ores (IACOG affinities). Other interesting base metals anomalies related with phyllites-quartzites of Devonian age are probably due to stratiform or strata bound Zn-Cu-Pb mineralisations. Some multielemental treatments of data (ternary maps) allow to delineate some linear structures which support isolated strong anomalies, suggesting the presence of controlling structures.

Heavy mineral exploration at the Petäjälehto, northern Finland

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Keywords: gold, heavy minerals, till geochemistry, exploration, Central Lapland, Finland

ABSTRACT

The Petäjälehto target area is situated ca. 80 km to the north from the centre of Sodankylä municipality in northern Finland. The area situates in the northeastern part of the Central Lapland Greenstone Belt where the bedrock is composed of volcanic and sedimentary rocks of the Archaean basement. Surficial deposits are composed of Quaternary glacial deposits above the Tertiary weathering crust.

Anomalous gold and copper contents of the regional geochemical mapping of till completed in the 1985 and N-S-orientated magnetic anomalies of the airborne geophysical survey encouraged to enter an exploration for gold in the area. In addition, there was a lot of tales about big gold nuggets, which the old gold prospectors have found from the washed gravels on the streams near the Petäjälehto target area. The area is situated on the southern part of the Sotajoki-Tankavaara gold field in Finnish Lapland.

Present studies were carried out during the 2005-2006 in the area including detailed ground geophysical studies with VLF-R, magnetic and gravimetric measurements, some diamond drilling, bedrock outcrop and surficial boulder exploration and test pit excavations with stratigraphical and heavy mineral studies of till and detailed geochemical sampling of till.

The results of till geochemistry and heavy mineral analyses indicate that the Petäjälehto has highly potential for gold exploration. Gold contents in the fine till fraction (<0.06 mm) are anomalous, varying from 4-10 ppb at the several sampling sites in southern Petäjäselkä area. The thickness of glacial drift is here from 2-6 m and it is totally enriched in gold. Gold exists also as small nuggets with size varying in range 0.1-0.5 mm approximately. The number of nuggets can be even more than 20 in concentrated heavy mineral samples (ca. 20 kg). Due to unaccomplished analyses and studies, a location of mineralization in the bedrock is not detected at the moment. Assays of new bedrock, weathered bedrock, and till geochemical samples, and heavy mineral concentrates will be done during the spring 2007.

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**Exploration, Mining, Metallurgical and Environmental
Sampling, Analysis & QA/QC Best Practice in a Global Mining
Company**

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Keywords: Quality control, sampling, sample preparation, analysis, laboratory

ABSTRACT

In line with requirements of international mining codes, JORC, SAMREC, NI43-101 and mineral reserve and resource guidelines; sampling, sample preparation, analysis and QA/QC best practice has been developed and rigorously implemented within the Exploration and Base Metal divisions of AAPlc for geological exploration and ore resource & reserve definition over the last 6 years. The key aspects of the Anglo Best Practice include the use of matrix matched CRMS (MMCRM's); 5% inclusion of each QA/QC control sample; annual sampling, MM-CRM round robins and laboratory reviews; and mine laboratories adopting the spirit of ISO 17025. The reviews, carried out with full management and group audit support, have resulted in significant improvements to sampling and laboratory practises to a level whereby Best Practice is now commonplace. The same concepts are being extended to cover all environmental sample monitoring, as well as pre- and concurrent-mining geochemical baselines studies and, with adoption of the recommendations of AMIRA P754, to metal accounting with specific metallurgical CRM's allowing reconciliation from the initial ore reserve to final mine closure.

The Application of portable XRF: Exploration, Evaluation and Mining.

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Keywords: XRF, field analysis, QA/QC

ABSTRACT

Portable hand held XRF spectrometers, using both active and passive sources, have been evaluated and taken through to routine application in a variety of base metal exploration, evaluation and mining projects in AAplc. Spectrometers have been evaluated on Zn exploration projects in India and Namibia in addition to various mine sites including: oxide- and sulphide-Zn; lateritic- and sulphide-Ni; porphyry-Cu; and Cu-Pb-Zn sedimentary hosted mineralisation. The test work has been aimed at the systematic evaluation of accuracy, precision, sample representivity, sample presentation, method applicability and limitations. Whilst the technology has been successfully applied at some sites, constraining limitations in its general application include detection limit issues in exploration; and accuracy and precision issues in project evaluation and mining. One of the principle constraints identified is sample form, e.g., pulp, RC-chips, core, bench faces. This along with “application creep”, brought on by simplicity of operation, can result in misleading data and inappropriate application. However, simple sample preparation procedures; proper matrix matched calibrations and good QA/QC and business process controls can help ensure optimal application.

Exploration using Fluid Inclusions – the acoustic decrepitation technique. With examples from Hebei, China and El Penon, Chile.

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Keywords: fluid inclusions, decrepitation, epithermal, carbon dioxide, temperature

ABSTRACT

The use of fluid inclusions in exploration is frequently overlooked because conventional microthermometric measurements are slow, tedious and rarely definitive. However by using acoustic decrepitation, useful exploration data can be acquired quickly and reproducibly. The results can readily identify CO₂ rich inclusion fluids, in addition to providing relative temperatures of aqueous fluids to outline palaeo-thermal temperature gradients in hydrothermal quartz systems.

Samples from several gold mines in the Hebei province of China show that CO₂ rich fluids are quite rare in this region, in contrast with the common occurrence of very CO₂ rich fluids in typical archaean gold deposits. Because the microscopic studies on these deposits concentrated on the rare but prominent CO₂ rich inclusions, the deposits have been wrongly classified as being derived from CO₂ rich fluids, whereas acoustic decrepitation shows that those CO₂ rich fluids were merely minor phases of the overall hydrothermal system.

At the El Penon epithermal gold deposit in Chile, there are some CO₂ rich fluids present, indicating a deeper and higher pressure origin than is usual for epithermal deposits. Variations in the aqueous fluid temperatures of about 50 C suggest that mapping of paleo-thermal gradients can be done, which may help to outline favourable mineralised zones within the quartz system.

Using groundwater chemical and isotopic composition in the search for porphyry copper and base metal deposits: Examples from Chile and India

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Keywords: Hydrogeochemistry, mineral exploration

ABSTRACT

Groundwater can interact with mineralisation at depth and, under appropriate circumstances, retain and transport a chemical signature in the form of major, trace element and isotopic fingerprints. These can be used to vector back to their source and hence help locate ore bodies under regolith or rock cover. As part of mineral exploration campaigns carried out by Anglo American in Chile and India, groundwater samples were collected from bores and wells to evaluate the usefulness of hydrogeochemistry in mineral exploration. Comprehensive and high quality chemical and isotopic analyses were carried out and thermodynamic and reaction path modelling was undertaken. Major element concentrations, ratios and isotopes reflect evaporation, water-regolith-rock interaction and mixing processes. Gradients in (1) concentration of ore and related elements, and (2) saturation index of ore and alteration minerals may reflect proximity to mineralisation and be useful to vector toward mineralisation.

**Stream sediment geochemical surveys in the Hauraki Goldfield,
Coromandel Volcanic Zone, New Zealand: utilising mining company
exploration data and a pilot survey to assist planning for national
surveys**

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Keywords: stream sediments, geochemistry, database, REGCHEM, pilot survey, epithermal, gold, Thames, Hauraki Goldfield, Coromandel Volcanic Zone

ABSTRACT

REGCHEM, a database of mining company exploration data for New Zealand, is accessible via <http://maps.gns.cri.nz/website/minmap>. REGCHEM data have been used in GIS-based mineral resource assessment and gold prospectivity studies. However, inherent problems such as different sampling methods, analytical techniques and detection limits between surveys highlight the need for new national multielement geochemical surveys. To test methods for the national surveys, a pilot stream sediment geochemical survey was carried out in a 220 km² area near Thames in the Hauraki Goldfield. Seventy samples were analysed for 50 elements, mostly by XRF. Some regional patterns are apparent: 1. As, Cd, Cu, K₂O, Pb, Sb, Se, and Zn exhibit anomalous concentrations mainly in the western part of the study area related to Au-Ag-Zn-Pb-Cu epithermal quartz veins and porphyry Cu occurrences; 2. Hg is anomalous in southern samples reflecting cinnabar occurrences; and 3. Ba and U are anomalous in the eastern samples, probably related to rhyolitic rocks.

QA/QC insertion rate: is there an industry standard?

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Keywords: QA/QC, insertion rate, industry standard, exploration, mining.

ABSTRACT

There is no definite consensus in the mining industry about the existence of an industry standard for the QA/QC sample insertion rate, which has a clear economic significance in the budget of an exploration program. If a reasonably sound answer is required, the proper way to approach this problem is to inquire the industry. Three sources have been consulted: well known international QA/QC specialists, SEDAR-filed technical reports, and information in web sites and press releases published in the Internet by exploration and mining companies. This review demonstrates that there is a preference in the mining industry for total insertion rates of QA/QC samples close to 20%, including duplicates, standards, blanks and external checks.

Soil Geochemistry of the Denver, Colorado (USA) Urban Area

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Keywords: urban geochemical mapping; soils

ABSTRACT

In 2005, the U.S. Geological Survey and Colorado School of Mines conducted a geochemical survey of roadside soils in the Denver, Colorado (USA) metropolitan area. The top 12 cm of soil was collected at 497 sites uniformly distributed throughout 1165-km² of the urban area. Two size fractions, less than 2 mm and less than 250 μ m, of each sample were analyzed for the near-total concentration of 44 elements. The 2005 data set and geochemical maps were then compared to similar data and maps generated from 439 samples of <250- μ m roadside soils collected in 1972. Several elements, including Pb, Zn, As, Hg, Cd, Cu, and Sb, show elevated concentrations in the Denver area in both data sets compared to rural background concentrations. Lead exhibited the greatest decrease in concentration from 1972 to 2005, likely as a result of the phasing out of leaded gasoline beginning in the 1970s.

Innovative exploration in Nova Scotia: effective sampling and estimation of coarse gold deposits.

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Keywords: gold, estimation, exploration

ABSTRACT

The gold deposits of Nova Scotia have geochemical anomalies at all survey scales. However, once an anomalous area is defined, the bedrock needs to be assessed either by grab or drill core sampling using relatively small sized samples. Unfortunately coarse gold deposits are notorious for their defining property, multiple dispersed particles of precious metal. Evaluation studies usually require large bulk samples to do accurate grade estimation but these are prohibitively costly for early property exploration. Exploration sized samples usually yield high variance spotty values rendering decision making very difficult. The developed approach concerns the realisation that accurate estimation of coarse gold deposits is more a sampling and preparation issue rather than a statistical one. Progressive crushing with sieving and followed by an elutriation separation produces a gold bearing concentrate. The gold grains are also counted, processed through an image analysis system before analysis by Fire Assay. Comparison studies confirm this as a simple but cost effective treatment for small sized exploration samples will yield accurate and reproducible gold values.

Post-depositional geochemistry of sediments in response to urbanization in Merimbula/Pambula estuaries, New South Wales, Australia

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Keywords: Estuary, heavy metals, pollutant, remobilization, sediment geochemistry

ABSTRACT

In an arid country like Australia, coastal areas are undergoing rapid population growth. The impact on the environment is likely to be significant. Estuarine sediments can act as pollutant sinks. In the case of coastal estuaries, increased pollutant load into sediments via the air and water through storm water outflow, urban runoff, and increased sewage loads. Future disturbance of heavy metal contaminated sediments can be a serious problem if metals become remobilized. We used rare earth elements as a monitor of original sediment mixing in estuaries. Heavy metals such as Pb can then clearly be discriminated in terms of original and pollutant sources. This shows that heavy metal pollution correlates in proximity to urban development, rather than with original sediment type (such as clay-rich, sand-rich). In many industrialised regions, heavy metal pollution can be shown to be derived from contaminated rivers which also carry sediment into an estuary. In an Australian context, the source of metal pollution is directly attributable to local development within the vicinity of an estuary, as the river systems themselves are pristine.

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Future Directions for Exploration Geochemistry in the Next 10-20 Years? A Peripheral Viewpoint

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Keywords: mineral exploration, new methods, gases, isotopes, microbiology, computer modelling

ABSTRACT

The search for concealed deposits using geochemical methods must consider the future use of gases which reflect chemical and microbiological processes operating in the subsurface. Future research must explore new methodology beyond the well-known and valuable carbon dioxide/oxygen methods of Lovell. An overview of possible processes and transport mechanisms that may prove useful in future mineral exploration will be presented. The viewpoint will be from a geochemist who has become recently active in mineral exploration and has applied gas methods to understanding other subsurface geologic processes and their surface expression. The understanding of processes of gas generation, transport, attenuation and consumption has synergies that can be applied to mineral exploration. The focus will be on microbiological production and consumption, physical processes in transport, microbiological consumption and production in the unsaturated zone, and dissipation into the atmosphere using data generated in other applications. The effective application of these methods will require the future geochemical explorationist learn the basics in other fields of science, including microbiology, organic chemistry, and isotope geochemistry, as well as develop additional field observational skills.

Targeting gold mineralisation through the cover in the Tanami Desert Region in Northern Australia.

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Keywords: regolith, mineral exploration, geochemistry, geophysics

ABSTRACT

A number of significant gold deposits, including the world class Callie gold deposit, are located in the Tanami Desert Region in Northern Australia. Exploration of this region is hampered by the extensive development of regolith; comprised of both in situ and transported regolith materials. The oldest dated elements of the landscape are Cambrian and the oldest dated elements of the weathering profile are Permo-Carboniferous. The collaborative regolith research project “Exploring through the cover in the Tanami” has developed an understanding of the processes which have sculpted the landscape and formed regolith over these very long periods of time. By coupling this understanding with physical, chemical and biochemical datasets an effective mineral exploration strategy has been devised. Ultimately, the strategy integrates the interpretation of geophysical and geochemical data and enables the identification of preferred geochemical sampling media.

A hydrologic and hydrogeochemical study of the regolith signature of gold mineralization in the Tanami Desert Region of Australia.

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Keywords: regolith, mineral exploration, hydrogeochemistry

ABSTRACT

Finding gold mineralisation in areas where there are thick in situ and deposited accumulations of regolith is a significant challenge for the exploration industry. One of the most common techniques involves identifying geochemical anomalies in the sediment or bedrock medium. Another potential medium, and the primary source of anomalies in transported sediments, is the groundwater. This study details the results of a targeted investigation to identify the presence of a mineralisation signature in the groundwater overlying a known gold prospect. Water levels and samples were collected from a grid of piezometers to determine the hydrogeological and hydrogeochemical processes controlling the dispersion of gold and other elements associated with the mineralisation. The samples show a number of gold and arsenic highs that generally correlate with the subsurface distribution of mineralisation. This data coupled with data on the flow field and direction has resulted in a greater understanding of dispersion processes and anomaly formation in regolith.

Heavy mineral exploration for Uranium in Narigan area, Central Iran

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Keywords: Heavy mineral, U-bearing minerals, Narigan, Central Iran

ABSTRACT

Iran`s uranium deposits occur mainly in the Central Iran zone. Several uranium deposits have been discovered in this zone. The Narigan area is one of the important uranium mineralized area in this zone. The oldest rock units within the area are pyroclastic series of the Precambrian (Saghand formation) which has been intruded by a Narigan granite. The uranium bearing sequences in this area are contained in the plutonic to volcanic rocks of so called-Narigan granites. These rocks have been affected by pervasive alterations, mainly hematitization and silicification. The uranium mineralization followed mainly faults directions and alterations halos. Uranium mineralization in this area is hydrothermal type (probably vein-type). The aim of our project is to develop a regional exploration strategy for uranium in these igneous rocks. A grid-based sampling was planned following the results of the previous geochemical mapping at a scale of 1:100,000, integrated with geophysical data and alteration zones and outcrop of intrusive rocks. The following results are based on geological and heavy mineral explorations in 1:20000 scale of this area. The heavy mineral samples were collected from three different sizes of <20 mesh. The samples were collected according to conventional methods from 30-40 cm depth of stream sediments. Each sample was about 15 kg. The 22 samples were analysed for U-bearing and other heavy minerals such as xenotime, zircon, barite, monazite, sphene, allanite, epidote, pyrite, pyriteoxide, hematite, pyritelimonite and apatite. The data processing shows good anomaly for these minerals in the studied area (except for Xenotime and Allanite).

**Discovery of the sub-outcropping Kwaggashoek ultramafic body in
the
Bushveld basin, South Africa.**

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Keywords: discovery, ultramafic body, South Africa

ABSTRACT

The discovery of the sub-outcropping Kwaggashoek ultramafic body in the Bushveld basin, North-West Province of South Africa, is a direct result of the national geochemical soil mapping programme conducted by the CGS. The body was discovered during the verification and follow up of 'new' Ni-Cr anomalies, in 2006. The presence and extend of the sub-outcropping body were delineated during a geochemical soil follow up mapping programme. Lithosols were recovered from the anomalous area and analysed on XRD and SEM. The mineralogical composition of the lithosols confirmed the presence of an ultramafic body. The lithosol has a mineralogical composition of approximately 50% smectite, 36% olivine, 10% quartz and 4% kaolinite. Regional geochemical soil mapping on a grid of 1 sample per km² therefore proved to be a significant vector towards 'new' sub-outcropping ultramafic bodies in the Bushveld basin, South Africa.

The link between gold depletion zones and gold mineralization with examples from the gold province of Victoria, Australia: implication for Genesis and exploration

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ABSTRACT

Depletion zones of gold are found in many gold regions of the world, in scales of gold-bearing lodes and deposits. Depletion zones and gold mineralization are spatially linked and can be understood as unified geochemical systems. The large gold deposits in the Bendigo region of central Victoria (Australia) are examples of such systems. A regional lithogeochemical survey of a 3700 km² area was completed by IONEX Pty Ltd. Extensive areas with an anomalously low gold content, less than 0.5 ppb in all rock types (depletion zones), with 70% below regional background levels (average is 1.29 ppb), were detected in the vicinity of the known goldfield. The Bendigo goldfield itself is located within an enrichment zone (average value of 14 ppb in all rock types) extending for approximately 100 km². To the north is a depletion zone approximately 700-800 km². On the whole, this geochemical system occupies an area over 1000 km². The presence of extensive gold depletion zones adjacent to the major gold deposits of central Victoria suggests that these rocks could have been a source of the gold in those deposits. These findings provide possible new criteria for the appraisal of prospective regions, providing a rapid and low cost method for exploration.

Exploration for gold beneath a hypersaline playa lake – Eastern Goldfields, Western Australia

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Keywords: playa lake, hydrogeochemistry, spectral logging

ABSTRACT

Hypersaline playa lakes, such as those found throughout many arid areas of Australia, may be highly prospective for Au and other commodities. Residual and transported regolith, up to 120m deep, and saturated with hypersaline groundwater make all exploration techniques problematic. Application of groundwater hydrogeochemistry, coupled with spectral logging of regolith and partial-leach geochemical analysis of drilling samples has yielded encouraging results on Lake Carey in the Eastern Goldfields of Western Australia. Locating paleo-water tables and redox fronts in the saturated regolith using visible and short-wave infra-red spectral techniques is considered important in identifying regolith horizons that may be sampled to produce larger, more coherent geochemical anomalies. Developed in close collaboration with exploration geologists, this integrated approach to geochemical exploration is practical, efficient and effective for exploration in playa lake terrains.

Geochemical expression of bedrock mineralization through deep cover – a comparison of exploration methods and sample depths, Curnamona Province, South Australia

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Keywords: partial extraction geochemistry, CHIM, Curnamona Province, South Australia

ABSTRACT

An increasing requirement for new mineral deposit discoveries is the ability to see mineralization through thick cover. Large areas of the Proterozoic Curnamona Province in southern Australian are prospective for Pb-Zn and Cu-Au mineralization, however, much of it is under 10-150 m of Cenozoic fluvial, alluvial and lacustrine sediments. Soil surveys were conducted over mineralization covered by 40-100 m of sediment. Samples were collected from 10-25 cm and 60-300 cm (auger), with deeper samples taken within the zone of high soil moisture loss defined by the precipitation of calcium carbonate and gypsum. Samples were treated using the partial extractants MMI-M, weak cyanide, sodium hydroxide, magnesium chloride and the data compared to those obtained using a stronger digest (aqua regia). Results from both sampling intervals showed element responses that reflected changes in underlying geology and in some cases, to mineralization. Partial leaches consistently produced clearer anomalies compared with aqua regia digest. The electrochemical method, CHIM, gave an indication of highest-grade mineralization, although the anomalies were usually defined by single point elevated values.

Collahuasi and District Alteration and Trace Element Geochemistry

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ABSTRACT

The present study examines the nature and extent of the alteration haloes in the world-class porphyry Cu-Mo and epithermal Cu-Ag (-Au) cluster of the Collahuasi district, I Región, northern Chile. As alteration haloes constitute larger targets than the deposits themselves, especially in porphyry systems, a widely spaced lithogeochemical survey (1 x 1 km) is herein presented as a cost-effective exploration tool to vector towards the core of a mineralised centre. The geochemical signature of the major and best known porphyry system within the district was used to derive an anomalous trace element suite. This suite of pathfinders rendered a "prospectivity index" that was ultimately applied to the whole district. This index not only areally defines and vectors towards the main known mineralised hydrothermal centres within the district, but it also provided with several new exploration targets. Hence, the thorough study of the geochemical footprint of a known system can effectively be applied to target generation even at a district to regional scale.

Genesis and exploration geochemistry of IOCG mineralization in the Mantoverde District, Chile

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Keywords: IOCG, paragenesis, alteration, isotopes

ABSTRACT

Exploration for IOCG deposits has traditionally involved minimal input from geochemistry, due in part from the ill-defined nature of the fluids involved and the alteration associated with mineralization. Mineral paragenesis, alteration and geochemistry of country rocks, lag talus, showings and IOCG deposits in the Mantoverde District of northern Chile indicate that the rocks in the area exhibit a complex evolution. Early albitization, low-grade metamorphism, K-Fe metasomatism and hydrolysis, all preceded the emplacement of sulphide-bearing hematitic breccias and veins of the Cu ores. Molar element ratios and oxygen isotope geochemistry differentiate the least-altered from moderately-altered rocks and talus as well as the specific geochemical alteration associated with the ore stage. The Cu ore stage results from incursion of modified sea water mobilized by marginal basin inversion. The oxygen and sulphur isotopic compositions and trace elements of these fluids are recorded in the ores and concomitant alteration and can be used to guide exploration.

Migration of arsenic from a Cu-W-As mine tailings area, Ylöjärvi Finland

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Keywords: arsenic, mine tailings, migration, groundwater, surface water,
lake sediments, Ylöjärvi, Finland

ABSTRACT

The Ylöjärvi Cu-W-As mine was in operation in 1943-1966. The low-grade ore (0.75% Cu, 0.11% WO₃, 0.46% As) was hosted by a tourmaline breccia. The total production was about 4 Mt of ore leaving behind 4 Mt of tailings and waste rock. Almost 3 Mt was deposited in the tailings area and the rest was backfilled in the underground mine. Arsenic concentrate was recovered only few years meaning that most of the arsenic is still in the tailings sand. This has worried the local environmental authorities and, consequently, the tailings area and related watercourses have been studied and monitored since 1975. Within the EU LIFE supported RAMAS project all available data were reviewed and additional research was carried out to promote the modelling of arsenic transport, the assessment of risks and the planning of risk management actions. Arsenic was analysed from the tailings sand, dust, ground and surface waters and lake bottom sediments. The effects of mining activities are readily observable 7-8 km downstream where the arsenic concentrations in the sediment exceed 200 mg/kg. The present arsenic load from the tailings area is still 3-4 fold compared to the natural background level.

Geochemical signatures of concealed kimberlites in the shallow groundwaters of wetlands: Case study in the Attawapiskat area, northern Canada

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Keywords: diamond exploration, hydrogeochemistry, kimberlite, wetland, groundwater.

ABSTRACT

We examined shallow groundwaters in the Attawapiskat area where 17 diamondiferous kimberlites, including the Victor pipe, have been discovered. The kimberlites intruded Paleozoic limestones at ~170 Ma and were successively overlain by Quaternary glacial sediments, clayey marine sediments (Tyrrell Sea deposits) and peat up to 4 m in thickness. Peat-interstitial groundwater samples were collected along transects across 4 kimberlites covered by a ~10 m thick overburden. Waters overlying kimberlites are characterized by large variations in metal contents over short distances, as well as high Ca and K, and low Mg with respect to waters in background areas. They also show higher pH, up to ~6.5, and variable redox conditions due to a reduced and alkaline flux from the kimberlites. In contrast, the groundwater samples from background areas have a consistent redox state and a pH of ~3.7. $\delta^{13}\text{C}$ values of dissolved inorganic carbon are low, ranging from -15‰ to -25‰, indicating a contribution of CH₄, a gas commonly produced during kimberlite weathering. Our data suggest that the use of groundwater geochemistry is promising in the exploration for buried kimberlites in peatlands.

Regolith Characteristics of Cyprus

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Keywords: Regolith, Cyprus, Troodos, geochemical mapping

ABSTRACT

The geology and topography of Cyprus is dominated by two distinct terrains – the mafic to ultramafic Troodos Ophiolite Complex and the surrounding Mesozoic sequences of calcarenites, siltstones and carbonates. Residual regolith profiles >1m are only exposed in the upper regions of Troodos. Elsewhere the regolith is dominated by colluvium (some of which is recemented), alluvium or exposed C-horizon. Regolith geochemistry and mineralogy is largely controlled by the primary composition of lithologies of the two dominant terrains from which the regolith is derived. The regolith has been severely disturbed by combination of ongoing tectonic disturbances and human activity – especially the extensive terracing that has occurred from antiquity to the present. The Troodos area has also been affected by the mining and logging activities that span the last ~3,000 years. This study is part of a soil geochemical atlas of Cyprus, that is being developed using surface and sub-surface regolith samples collected from a 4700-site grid.

The Khongor Porphyry Cu-Au Deposit Discovery by Low Density Fine Fraction Stream Sediment Exploration Geochemistry in the Gobi Desert, Mongolia

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Keywords: fine fraction stream sediments, low density sampling, porphyry Cu-Au, discovery, orientation survey, Khongor, Gobi, Mongolia

ABSTRACT

In 2004, Asia Gold started a grass roots exploration program for porphyry copper and epithermal gold deposits on a 35,517 km² tenement block in the Gobi Desert of southern Mongolia. Asia Gold applied low density fine fraction stream sediment exploration geochemistry for evaluating the Cu and Au potential in this large and remote area.

Stream sediment orientation surveys were conducted at Yagaan (an epithermal Au prospect) and Khongor (a porphyry Cu-Au prospect) after its discovery. A test of two and three fractions (-63µm, -230µm and +1mm ~ -4mm) over known mineralization at both prospects was carried out to determine optimum methods for routine geochemical exploration in the West Gobi of south Mongolia. In the conditions of the Gobi Desert, the mineralized zones at both prospects can be easily detected by stream sediment surveys using fine fraction (-63µm) stream sediments and a density of 1 sample per 6 ~10 km². A gold threshold of 2ppb is used and 5ppb is considered significantly anomalous. The ICP-MS analytical method with a low detection limit (Au 0.2ppb) is required.

The Khongor porphyry Cu-Au mineralization was discovered by Asia Gold during a grass root geochemical reconnaissance exploration program on the company's West Gobi properties in June 2005. Follow-up geological investigation and initial rock chip sampling of the exposed copper-oxide mineralization outcrops revealed a system in excess of 2 km length and 150-200 m width. Continuous rock chip samples across outcropping copper oxide mineralization in the East Creek returned 126 meters with 0.42% Cu and 0.07g/t Au including 54m with 0.72% Cu and 0.13g/t Au. First phase drilling returned encouraging results including a best intercept of 50m with 1.0% Cu and 0.30g/t Au. Phase two and three drilling is ongoing.

**Using Hg in till for the delineation of buried VMS mineralization;
Bathurst Mining Camp, New Brunswick, Canada**

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Keywords: Mercury, till, exploration geochemistry, detection limits, CVAFS, DMA-80

ABSTRACT

A test of Hg as an effective exploration tool in an area of thin (<3m) glacial cover and low regional Hg values ($x = 21$ ppb) was conducted at a Zn-Pb-Cu-Ag-Au VMS deposit located in northern New Brunswick. A total of 240 till samples were collected in a 1km area overlying a mineralized zone dipping at 45 eastward from outcrop. The traditional ICP-MS analytical method (aqua regia digestion, detection limit 5ppb) was compared with an inexpensive pyrolysis, cold-vapour atomic fluorescence spectrometry (CVAFS) method (sample desiccation, detection limit 0.01ppb) using a Direct Mercury Analyzer (DMA-80).

Both Hg datasets are strongly correlative ($r_s = 0.90$), although the ICP-MS dataset averages 10% higher than the CVAFS values. There is a strong response over the shallow mineralized zone to the west of the survey, but Hg, Au, Ag and Pb till concentrations are laterally dispersed 200m down-ice of the deposit. Cu, As, and Zn values demonstrate topographic influence likely related to hydromorphic or colluvial redistribution. These results support the use of the CVAFS-DMA method for Hg determination as an effective technique for VMS exploration in glaciated areas.

**Geochemical Exploration of Pantanillo Prospect: An Au-Rich
Porphyry and HS Epithermal system from Maricunga Belt, Northern
Chile.**

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Keywords: Au-rich porphyry, steam-heated, Chile, Maricunga Belt.

ABSTRACT

The Pantanillo prospect, located in northern Chile, lies within the Maricunga metallogenic belt, host to numerous Au-rich porphyry and Ag-Au deposits of Miocene age. Pantanillo comprises two sectors of alteration and mineralization: Pantanillo Norte (PN) and Quebrada Pantanillo (QP). An andesitic-dacitic intrusive complex and coeval volcanics at PN, dated at 22 Ma, are overprinted by advanced-argillic alteration. In QP tuff units host hypogene advanced-argillic alteration, overlain by high-level advanced-argillic alteration of steam-heated origin, which are dated at 15 Ma. Soils samples collected in a systematic grid and analyzed by a population method, using a logarithmic transformation, have defined contrast anomalies of Au-Cu-Mo at PN and As-Ba-Fe-Hg-Pb-Sr at QP. Alteration mapping supported by short-wave infrared spectroscopy indicate the presence of alunite-kaolinite-opal in both systems. In conclusion, the different systems are interpreted as an Au-rich porphyry telescoped with HS epithermal roots at PN, and a HS epithermal system at QP.

Session 5:
*Exploration, Classic European mining districts &
New technologies*

Mercury vapor dispersion from La Peña-El Terronal Mine (Asturias, Spain)

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Keywords: Mercury, ZAAS-HFM, Asturias, mining environment.

ABSTRACT

The survey was carried out (summer 2005), in La Peña and El Terronal mercury mine, close to the city of Mieres (NW Spain), using a LUMEX RA-915+ analyzer for continuous Hg measurements, with detection limits of 2 ng·m⁻³. At the regional scale, the average Hg concentration in air corresponds to 119.28 ng·m⁻³, with 35,279 measurements. Background, eliminating values over 15 ng m⁻³ (5,721 values) was 6.05 ng·m⁻³. The identified sources of atmospheric mercury in La Peña-El Terronal mine are decommissioned rotary furnaces, dumps of calcines from the metallurgical plant, and a chimney-channel used to transport roasting smoke to the top of San Tirso Valley. Mercury contents of calcines reach 27,350 mg·Kg⁻¹, while soils into the chimney-channel have 18,000 mg·Kg⁻¹. The mean concentration of atmospheric mercury in the mine area was 3,708 ng·m⁻³, and the highest value was 74,418 ng·m⁻³, measured underneath the rotary furnaces at El Terronal. Near the calcines dump the values reached 17,479 ng·m⁻³, with schuetteite present on the soil surface. Values measured in the chimney were up to 18,081 ng·m⁻³.

The use of factorial kriging analysis to distinguish natural from anthropogenic sources of trace metals in the topsoils of Lavrio, Greece

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Keywords: soil geochemistry, trace element sources, mining

ABSTRACT

The Lavrio area has a history of Ag, Pb and Zn mining that spans three millennia. As such, the local topsoils have high concentrations of these elements due to both natural mineralisation and the deposition of mining waste. In order to provide environmental quality standards for metals in topsoils, it is desirable to know the natural background concentrations, i.e. the concentrations that would exist if there was no anthropogenic input. This paper describes the use of factorial kriging analysis to decompose the variance in the soil geochemistry according to various spatial scales and identify the main factors governing the distribution of the trace metals in the area. The dataset comprises 425 topsoil samples collected during 1992/1993 and analysed for 24 elements. The principal components were plotted in a GIS and compared with maps of geology, land use, relief, mineralisation and mining waste deposition. A significant proportion of the variance in lead and zinc was found to be attributable to mining activities

Application of lake sediment studies for the evaluation of natural background values around the Talvivaara Ni-Cu-Zn deposit, Finland

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Keywords: natural background, lake sediment, sulphide deposits, nickel, Talvivaara, Finland

ABSTRACT

Environmental impact of the Talvivaara black-shale-hosted Ni-Cu-Zn deposit has been monitored since the 1980s with hundreds of stream sediment and stream water samples. In March 1994, continuous undisturbed lake sediment cores were obtained from a total of seven lakes. Altogether 194 lake sediment samples were chemically analyzed using a combination of ICP-MS and ICP-AES methods. In addition, lake sediment samples collected in 2005 from one of the lakes situated in the black shale area, Lake Kolmisoppi, were dated by ²¹⁰Pb-method. The median values in lake sediments varies from 85 to 238 mg/kg Ni, 32 to 88 mg/kg Cu, and 569 to 928 mg/kg Zn in > 23 cm depth in different lakes in the black shale area. The highest heavy metal values and lowest pH are encountered in 9,000-year-old sediments in Lake Härkälampi. The abrupt isolation from the ice-dammed large lake immediately after the last Ice Age resulted in exposure of surrounding Ni-Cu-Zn-rich metamorphosed black shale to erosion in the absence of vegetation.

The Corcoesto Gold Deposit

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Keywords: Corcoesto, gold, soil geochemistry, dextral shear, extensional, silicification, arsenopyrite, quartz.

ABSTRACT

The Corcoesto gold deposit is located in Galicia in Northwestern Spain. In 2005, Kinbauri Gold Corporation signed an agreement with Rio Narcea Gold Mines to explore the property. Soil geochemistry has proven to be reliable in defining gold targets suitable for trenching and subsequent drilling. The deposit lies in a N30°E trending dextral shear band about 2km wide within an antiformal structure in the northwest part of the Schistose Domain of Galicia-Tras Os Montes, a strongly deformed medium grade metamorphic unit that consists of metasediments (paragneisses) of Precambrian to Devonian age and orthogneisses derived from Hercynian granites and migmatites. Gold mineralization in Corcoesto is related to extensional zones trending N70°E which represent second order dextral shears within the main (first order) N30°E dextral shear band. Higher grade gold mineralization is related to arsenopyrite bearing quartz veins that are frequently included in large zones of silicification that commonly contain disseminated arsenopyrite with sericitic and potassic alteration.

The hydrothermal alteration halo at the Wallaby mesothermal gold deposit: genetic theories and exploration insight from stable isotopes

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Keywords: stable isotopes; Yilgarn Craton; hydrothermal alteration

ABSTRACT

The Wallaby gold deposit, in the Eastern Goldfields of Australia's Yilgarn Craton, is a mesothermal gold deposit hosted in a dominantly mafic, polymict conglomerate. All of the economic gold mineralization occurs within a pipe-like alteration assemblage of hydrothermal magnetite-actinolite that surrounds a series of dominantly syenitic dykes. Within the pipe, a number of additional alteration assemblages, more closely related to gold mineralisation can be identified visually, spectrally and geochemically. Analysis of stable isotopes including ³⁴S, ¹⁸O and ¹³C from samples that can be confidently related to particular alteration assemblages suggest that multiple fluid sources were involved in the mineralization events. Additional information related to the redox state and temperature of the hydrothermal fluids may also be determined. Knowledge of the source of these mineralizing fluids allows structural fluid conduits in the region to be recognized, and when integrated with other geochemical data, exploration drilling targets can be better defined.

Session 6.
*Commercial session for companies displaying
trade stands*

Definitive organic geochemical SGH signatures both identify and locate deeply buried targets to aid mineral exploration

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Keywords: SGH, Soil Gas Hydrocarbons, Deep Penetrating Geochemistry, Exploration, Uranium, Gold, VMS, Nickel, Copper, SEDEX, Petroleum, Kimberlite

ABSTRACT

Analysis of surficial geochemical samples offers exploration geologists an efficient means of conducting exploration in areas where ore deposits may be buried by transported overburden or post-ore volcanic cover. SGH is a deep penetrating organic geochemistry that is used to analyze near surface samples, such as soil, rock, peat, lake bottom sediments, etc., to predict both the location and type of mineral targets buried below. The 162 organic compounds analyzed by the SGH method define a signature proven to be directly related to bacterial activity that is target specific, which is based on 10 years of research. As a result SGH can help reduce the area to be covered by drilling programs. Drilling budgets can then be much more efficiently used to test specific targets and thus limit the scope of expensive drilling operations. The organic geochemical anomalies have proven to be definitive and easily interpreted. The SGH case studies to be shown will include targets of uranium, gold, volcanic-massive sulfides (VMS), nickel, copper, SEDEX, petroleum and kimberlite formations.

Leach Reduction of Solid waste with a Bauxsol™-based Concrete

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Keywords: Bauxsol™, fluidity, grout, treatment, waste rock

ABSTRACT

Bauxsol™ is a material that contains substantial acid neutralising capacity and an extensive metal binding capacity, which has had successful applications in the treatment of acid rock drainage, sewage effluents and liquid industrial wastes. Consequently, the acid neutralising and metal binding characteristics of Bauxsol™ could combine with the cementation properties of ordinary Portland cement (OPC) to provide a treatment for solid waste. This paper investigates the development of a Bauxsol™-based concrete for the immobilisation of an industrial solid waste. Five waste samples (2 alkaline As-speiss and 3 acidic Hg contaminated samples) from an ore processing and smelting operation were provided for analysis and TCLP leach reduction. Alkaline As-speiss is an Fe-arsenide stabilisation of high As wastes developed by Noranda Ltd, Canada, but the As-speiss materials provided continue to leach Pb and As at unacceptable concentrations. Two varieties of the As-speiss material were present, a silvery-grey crystalline alloy consisting mainly of Fe₂As and Fe₃As with some Sb substitution (raw), and a black-grey friable material consisting of Na- and Ca-alumino-silicates, Na carbonates, possible NaSO₄, CaSO₄, FeSO₄, Al₂(SO₄)₃, or similar sulphates and galena (PbS; < 4 mm). The Hg-wastes were a wet sludge (cf. 60% moisture as a dilute sulphuric acid cf. 2M) and are produced in almost equal proportions from different points within the refining and smelting operation.

TCLP leaching of the As-speiss indicates that As (> 100 mg/l) and Pb (> 320 mg/l) are the primary contaminants and that Hg (> 13 mg/L) and Cu (up to 37 mg/l) were the contaminants of concern in the Hg-wastes. Because one waste stream set was alkaline and the other set acidic, neutralisation could be affected by combining the two waste streams. The As-speiss wastes were blended at a rate 2:1 raw:< 4 mm and the three Hg wastes were combined at a rate of 1:1:1. A composite near-neutral waste was made by combining the As-speiss waste (85%) with the Hg composite (15%) and this combined waste was made into bricks using a 1:1 mixture of Bauxsol™ and OPC, where the waste concentration varied from 20% to 66% of total dry mass. The reduction in leach potential (TCLP As 0.03 mg/l, Pb < 0.5 mg/l, Hg 0.013 mg/l, & Cu < 0.008 mg/l) from the Bauxsol™-based concrete blocks is far greater than the reduction that can be achieved by simple dilution alone. Moreover, physical strengths of the

blocks indicate that compressive fracture and slake reduction of the bricks is highly unlikely. These data would therefore indicate that Bauxsol™-based concretes can be used to reduce leach potentials in contaminated solid wastes and provide an alternative to disposal hazardous waste landfill sites.

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Oviedo, 14 – 19 June 2007

SESION 7
*Ore Deposit-Forming Systems: A Geochemical
Perspective.*

**Australian Uranium - A geochemical excursion through three
different deposit types from Australia's top end.**

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Keywords: uranium, Jabiluka, Nabarlek, Ranger, Valhalla, Westmoreland.

ABSTRACT

The formulation of ore deposit models and exploration methods is significantly enhanced when geochemistry is applied to a well constrained mineral paragenesis. Debate over the origin of the fluids that formed U deposits in Australia has recently been regenerated on the back of renewed interest in uranium exploration globally. Geochemistry more so than any other earth science discipline has been the tool of choice used by researchers to propose new models to help explorers find the next deposit. In most cases, this geochemistry has not been paragenetically constrained and the resulting interpretations have lead to flawed models. This talk will demonstrate that fluid inclusion, isotope and whole rock geochemical data from minerals collected from in and around all U deposits must be placed in a detailed paragenesis if fluid type and source is to be characterized and meaningful exploration models are required. Results from Jabiluka, Nabarlek, Ranger, King River, Westmoreland and Valhalla will be presented.

**Quantification of ore-forming hydrothermal processes by integrating
of field and fluid inclusion data with novel fluid flow simulations**

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Keywords: hydrothermal, epithermal, porphyry copper, fluid inclusion,
fluid flow modeling

ABSTRACT

Field data and conventional fluid inclusion microthermometry reveal important insight into the overall aspects of ore-forming hydrothermal processes. However, key parameters such as the metal concentration of the incoming fluid, the precipitation process and the transient evolution of the hydrothermal system often remain rather speculative.

This paper summarizes how metal concentrations in the hydrothermal fluid and their change during ore-formation can reliably be obtained from a combination of careful fluid inclusion petrography and LA-ICPMS analysis. Using an example of an epithermal base metal mineralization from Bulgaria, we demonstrate how these data can be combined with novel fluid flow simulation techniques to obtain a quantitative process reconstruction that naturally “predicts” many field observations (including ore grades). Finally, we outline potential applications in understanding the formation of porphyry copper deposits and epithermal Au-Ag veins.

Uraniferous and thoriferous Y-REE-Nb granitic pegmatites in the Grenville Province: understanding distribution, age, and genesis to aid in exploration

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Keywords: uranium, contact metasomatism, hybrid, pegmatite, Grenville

ABSTRACT

The U-Th-Y-REE-Nb-enriched granitic pegmatite and aplite dykes, including alaskitic leucogranites, in the Grenville Province formed late tectonically (1010-1040 Ma) with respect to the Ottawa Orogeny of the Grenville Orogenic Cycle, based on U-Pb (zircon, monazite, titanite) and Re-Os (molybdenite) ages. The former U mines in the Bancroft area has the youngest ages. The distribution of dykes and dyke swarms is typically controlled by later transpressional features within the overall higher grade (amphibolitic) Grenville Province; this is not unlike the Rossing-type deposit in Namibia. The enrichment of U and other elements is a function of the nature of the source region at depth within the Grenville and degree of fractionation during ascent of these magmas. Both biotite and feldspar compositions best reflect the fractionation history. However, contact metasomatism during emplacement (hybridization and skarnification), which can be empirically observed, are known to control saturation of rare-element minerals within these magmas, such that a hybridization index (CaO+MgO+FeOt) can be used to relate to saturation in uraninite etc.

Termitaria as a biogeochemical sampling medium for mineral exploration: the significance of species variations towards a representative and robust approach

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Keywords: termitaria, geochemistry, gold exploration, trace metal cycling

ABSTRACT

Termitaria are a widespread and abundant component of tropical savannah ecosystems in northern Australia. They are particularly prevalent in the regolith-dominated landscapes of the highly prospective Tanami region. This study examines the biogeochemistry of termite mounds (termitaria) at the Titania Au Prospect, which is situated proximal to a palaeodrainage system in the central Tanami. Multi-element chemistry of termitaria from species with the most abundant epigeal mounds; *Naustiterme triodae*, *Drepanotermes rubriceps*, and *Amitermes* spp, are characterised and compared. The mineralisation was expressed through transported regolith up to 15 metres in the geochemical character of the termitaria, most particularly as anomalously high values of As and other key ore indicator elements. These findings therefore show that termitaria can successfully delineate mineralisation, which reinforces the role that soil biota, such as termites, play in forming surface anomalies above mineralisation masked by transported regolith.

Coal Occurrences in Biga Peninsula, Northwestern Anatolia, Turkey

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Keywords: coal formation, geochemistry, Biga Peninsula, Turkey

ABSTRACT

In this study coal and clay formations, located in the central and eastern parts of Biga Peninsula, are evaluated and a formation model is postulated. Biga Peninsula is a very rich zone in terms of both metallic ores and industrial minerals. Most of the metallic deposits and industrial occurrences in the region have been known and mined throughout the history. This richness of the region is related to the volcanic and tectonic activities that have developed during different geological periods. These activities are the main reasons of weathering and alteration phenomenon. Various types of Tertiary (Miocene) lignite occurrences had been formed and alternated with volcano-sedimentary Bigadiç Formation in the field of study, which resides in the middle and eastern parts of Biga Peninsula. The focus of the study is to identify the geochemical properties of coal occurrences and the formation mechanism of the deposits.

**Mass balance and geochemical anomalies related to the Mataralampi
orogenic gold occurrence, Archaean Kuhmo greenstone belt, eastern
Finland**

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Keywords: Gold, alteration, mass balance, geochemical anomalies,
Archaean, Finland

ABSTRACT

Mataralampi is an orogenic, quartz porphyry hosted gold occurrence in the Neoarchaean Kuhmo greentone belt in eastern Finland. Alteration related to mineralisation is characterised by sericitisation, carbonation and sulphidation. During mineralisation, Al, Cr, Ni, P, Ti, and Zr were immobile, Ba, Bi, CO₂, Cu, K, Rb, S, Sb, Te, and W enriched and Li, Na and Sr depleted throughout the alteration halo. In addition, Ag, Au, Cd, Pb, and Zn were enriched in the proximal alteration zones and in the ore, and Fe, Ga, La, Mg, and V were only enriched within the ore. Mineralisation-related anomalies extending beyond the area drilled are defined by Bi, [CO₂/Ca]mol, S, Sb, and Te. The most consistent local anomalies are defined by the threshold values for Au at 45 ppb, Bi at 0.10 ppm, Sb at 0.07 ppm, Te at 45 ppb, and W at 14 ppm. Also Ag, Cd, Cu, Pb, and Zn define anomalies at Mataralampi, but these only occur inside the gold anomalies. Within the geochemical anomaly, only Sb defines any consistent trend across strike towards the known high grade lode at Mataralampi.

How ore grade 'laterite' Au deposits form in Western Australia: new insights into the processes of anomaly formation

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Keywords: anomaly formation, dispersion events, biogenic, mineralogy,
geochronology

ABSTRACT

'Laterite' Au deposits, generally containing 1-5 ppm Au, are concentrated in near surface ferruginous nodules and pisoliths. Many such deposits have no economic primary mineralisation directly underlying them. Gold anomalies in 'laterite' (ferruginous pisoliths and nodules) can be several kilometres long and less than a kilometre wide. These deposits are common in deeply weathered terrains of the Yilgarn Craton of Western Australia and similar terrains elsewhere in South America, India and West Africa. Data from many deposits in the Yilgarn Craton suggest three-stage local to distal hydromorphic, biogenic and, to a lesser degree, physical dispersion of Au, As, Cu, Pb, Bi and Sb in 'laterite' to form ore-grade deposits. Each dispersion event is characterised by a separate suite of elements which can be linked to the relative ages of pisolith formation in 'laterite', climatic history and groundwater regimes. Recognition of ferruginous pisolith types is essential for determining the origin of an anomaly. Detrital hematite-maghemite pisoliths preserve the multi-element geochemical signature (Au, Pb, As, Bi, Sb) of a nearby primary source, whereas goethitic authigenic pisoliths concentrate Au from distal sources. Element associations in the primary mineralisation (i.e. Au, Au-As-Cu or Au-Cu-As-Bi-Sb) determines the nature of element suite in the secondary Fe oxides. Large Au anomalies in 'laterites' do not necessarily imply underlying large primary Au deposits neither do they imply large distal Au deposits but could have been formed by concentration from a large number of very minor Au occurrences and deposits.

Origin of the Urals VHMS deposits inferred from the Re-Os isotopic studies

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Keywords: VHMS, sulphides, Re-Os, Urals

ABSTRACT

The Re and Os elemental and isotope composition have been studied within four distinctly different Urals VHMS deposits. The Os is enriched in first-stage high-temperature portions of hydrothermal systems and correlates with Co and Au contents. The Re has more affinity with lower temperature polymetallic assemblages and correlates positively with Zn and Mo. In general, the Re/Os and $^{187}\text{Os}/^{188}\text{Os}$ ratios decrease from the interior (hydrothermal-metasomatic ore facies) to the exterior (clastic and seafloor altered ore facies) of the hydrothermal system and reflect the progress of mixing between hydrothermal fluid and seawater. The $^{187}\text{Os}/^{188}\text{Os}$ isotopic composition of Devonian seawater was inferred from the initial Os isotopic composition of metalliferous sediments at the top of hydrothermal systems at ~ 0.2 . The magmatic fluid input into the hydrothermal system may be tested using the initial Os isotope composition, if the hydrothermal system stays closed since ore deposition. The radiogenic Os end-member of the Dergamish deposit may be identified with fluid coming from the subducted slab.

The Re-Os model ages for four studied deposits from different volcanic formations are similar (about 366 ± 5 Ma) and younger than presumed stratigraphic ages. This repetitive Re-Os model age corresponds to the closure of Urals paleocean and could be ascribed to the continuous on-going hydrothermal fluid flow through the massive sulphide deposits until this time.

Tracing crustal contamination – a key aspect for IOCG and Ni-Cu deposits in SW Iberia

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Keywords: geochemistry, isotopes, Ni, Cu, Au, Ossa Morena Zone, Iberia

ABSTRACT

Crustal contamination of juvenile magmas by water-bearing middle crustal metasedimentary rocks is a key feature for the formation of hydrothermal IOCG and magmatic Ni-Cu deposits in the Ossa Morena Zone, SW Iberia. Contamination favors the exsolution of a metal-rich brine from the crystallizing plutons and promotes the immiscibility of sulphide-rich magmas that later form the Aguablanca-like magmatic Ni-Cu deposits. Thus, tracing such contamination is critical for distinguishing potential ore-related intrusions from barren ones. Systematic lithogeochemical and isotopic (S, Sr, Nd, Pb, Os) analysis show that ore-bearing intrusions show widespread and variable indicators of interaction with crustal rocks, such as enrichment in SiO₂ and LILE and crustal isotopic values that mask the original juvenile ones. Barren intrusions, despite showing some contamination, keep the original signatures.

**The El Valle-Boinás Gold Deposit.
Low-Temperature Hydrothermal Mineralization Hosted in Skarn.**

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Keywords: El Valle-Boinás, Gold, Copper, Skarn, Low-Temperature, Hydrothermal, Porphyry.

ABSTRACT

El Valle-Boinás mine is located at the south part of the Rio Narcea Gold Belt. Folding, thrusting and normal faulting are common in the region. Late Hercynian intrusions invaded the sedimentary package producing contact metamorphism and introducing hydrothermal solutions. High angle normal faults trending northeast crosscut the previous lithologies and structures. Late subvolcanic dykes cut the system mainly along previous structures producing an epithermal episode. The geological situation is complicated by Alpine thrusting.

At El Valle-Boinás two types of gold mineralization occurs. The first is a mesothermal copper-gold skarn mineralization related to the granite intrusion developing calcic skarn related to the limestone units and magnesian skarn related to the dolomite units, and the second is a later epithermal event related to the subvolcanic dykes, producing silicification, argillitization, sericitization and oxidation. Jasperoids and jasperoids breccias formed by silicification of carbonate and skarn rocks are characterized by enrichments in Au, Ag, Cu, Bi, Te, As, Sb and Hg. A later supergene alteration is also present.

Generation of free ions and hydrocarbon gaseous compounds from ore deposits beneath cover and migration mechanism to surface: experimental laboratory analogue models and empirical field results in Northern Chile

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Keywords: Ore deposits beneath cover, migration processes, mineral exploration, Chile.

ABSTRACT

On going research at the University of Chile has dedicated over three years of experimental laboratory analogue work in an attempt to emulate real time processes that occur in a sulphide mineralised body beneath different types of unconsolidated overburden. Onset of oxidation and natural bacterial activity on primary sulphide mineralization occurs within a short period of time once sulphides are exposed to oxidising and water unsaturated conditions. Generation of free ions and hydrocarbon gaseous compounds were demonstrated by direct time integrated collection to adsorbent materials, both within column and in-vitro experiments. Different column experimental designs allowed testing of the effects of various types of overburden, different conditions of water saturation and of air and argon flow, to better understand the mechanisms governing migration to surface. Results indicate that gaseous flow, together with development of electrochemical cells, are the most important factors. Real time processes were tested empirically in the field, two cases to be presented, an exploration prospect in the Chug Chug Pampa, II Region, and the Inca de Oro porphyry copper, III Region, Chile.

The Geothermal Geochemistry of Western Turkey

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Keywords: Geothermal, geochemistry, western Anatolia

ABSTRACT

Western Anatolian is such a tectonically active region in Turkey which has large grabens (such as Gediz and Menderes Grabens) association with extensional tectonic. The region also has been represented with young volcanics (such as Kula Volcanics).

Geothermal reservoirs of the Aegean Region are generally composed of Permian limestones, Mesozoic limestones and marble levels of metamorphic Paleozoic. With this reason geothermal water sources affected by reservoir chemistry are of bicarbonate type and travertine deposits (such as Pamukkale) are shown around the source. Therefore, carbonate scaling problem has been occurred drill pipes and pipe-lines.

Although there are many high entalphy geothermal fields around Aegean region, these hot sources can't use effectively at present. It is especially important to using new technics on electricity production and house heating applications from geothermal energy around the world with energy saving around the world.

Gold mining-related and natural mercury in an orogenic greywacke terrane, South Island, New Zealand

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Keywords: Gold, mercury, amalgamation, cinnabar

ABSTRACT

Mercury amalgamation was used historically in ore processing at mesothermal Au mines in the South Island of New Zealand, an orogenic greywacke terrane. Small volumes of tailings and processing residues at these sites contain up to 1×10^3 mg/kg Hg, and waters are up to 8×10^{-7} mg/L Hg. Natural Hg enrichment of the Au vein systems was compared to residual amalgamation Hg, and to concentration of natural Hg during ore processing. South Island Au occurs as an Au-Ag-Hg alloy, up to 8.4 wt % Hg. Cinnabar (HgS) occurs rarely in veins and as detrital grains in Quaternary gravels hosting Au-Ag-Hg alloy. Warm spring precipitates contain up to 111 mg/kg Hg, and waters are 3×10^{-4} mg/L Hg. Mineralized schist in the Hyde Macraes shear zone contains 1×10^{-1} mg/kg Hg, relative to 1×10^{-2} mg/kg Hg in unmineralized schist. Processing waters at the active Macraes mine in this zone are up to 1×10^{-2} mg/L Hg, whereas adjacent surface waters are $< 1 \times 10^{-9}$ mg/L Hg. Cinnabar partially controls naturally-elevated Hg in the South Island, and experimental oxidation of HgS by dissolved O₂ resulted in 3.2×10^{-2} mg/L dissolved Hg.

Genesis of the Benato emerald deposit, Ianapera area, Southwestern Madagascar

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Keywords: mineralogy, fluid inclusion, SEM/EDS, emerald, Ianapera, Madagascar.

ABSTRACT

The recently commissioned Benato emerald deposit is hosted in migmatitic paragneisses of the Vohibory volcano-sedimentary Terrane. Emeralds are mainly found in phlogopite at the contact between pegmatite veins and ovoid-shaped mafic to ultramafic lenses (few tens of meters thick). The latter are mainly made up of tremolite with up to 7500 ppm Cr. Associated amphibolites contain Cr-poor pargasitic to hornblende amphiboles. Solid inclusions and solid-bearing fluid inclusions are abundant in the emeralds. Barite, monazite, pyrite, F-rich phlogopite, Fe- and Ce±Th-oxides, Mg±Fe±Mn-carbonates are the most common solids identified by SEM/EDS. Solids found in open fluid inclusion cavities consist mainly of carbonates, quartz and K-feldspar. Trapping conditions of FIAs are 450-750°C and 3.5-6.8 kbars. We propose that fluids traveling along shear zones transported Be as well as other magmatic elements such as B and REE as fluoride complexes, based on the high F content for phlogopites (up to 3.5 wt. % F). Pegmatites originating from proximal granites were probably the source of Be, whereas Cr was available at the mineralization site from chromites and tremolites in the ultramafic lenses.

Back-arc shoshonitic magmatism in the Fuegian Andes, Argentina

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Keywords: Fuegian Andes, shoshonites, K₂O increase.

ABSTRACT

New geochemical data have led to a different interpretation of the Cretaceous magmatism in the Fuegian Andes, Argentina. In this area, several isolated plutons outcrop, ranging from pyroxenites to syenites. They were previously considered as part of the arc-related, calc-alkaline Patagonian Batholith (PB), which outcrops to the south. They have a mildly alkaline shoshonitic affinity, and their location far from the arc axis, suggest a back-arc environment, allowing to be considered as a different geological unit. It has been proposed that these magmas generated under a similar tectonic regime than the PB, but at greater depths in the mantle (K-h model by Dickinson), thus, accounting for their high K₂O content and K₂O/Na₂O ratio. Additionally, there is an increase in K₂O for a given SiO₂ content in the shoshonitic rocks and some of their mafic minerals towards the north, accompanied by a volumetrically increase in syenites. These favor a model of magma generation at gradually greater depths as the slab sinks, acquiring higher K content with distance to the trench.

Cu isotope composition as a tracer of ore-forming process

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Keywords: copper isotope, ocean, sulfide

ABSTRACT

The basement of this study was a collection of samples represented different kind of ore bodies from modern hydrothermal field (13°N MAR) developed over ultrabasic basement. According to morphology the studied chimneys were represented by two-, three and polyzonal items. The study reveals essential variations of $\delta^{65}\text{Cu}$ within single zonal chimney, and between different chimneys as well. Moreover these variations by absolute value exceed difference in isotope composition between other ore fields (up to 3‰). Some connection between mineralogy of the ores and isotope composition was revealed – high-temperature monosulfides and polysulfides have lower $\delta^{65}\text{Cu}$ values whereas a complex sulfosalts and low-temperature oxy-hydroxides have positive $\delta^{65}\text{Cu}$. If this observation has a widespread character than the defined isotope differences between these fields could be explained by not only of the specific isotope composition of their metal sources but the temperature and degree of manifestations of secondary processes with oceanic water as well.

Geochemistry of ancient vent deposits as record of the temporal and spatial evolution of expelled fluids: a case study from west Pyrenees

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Keywords: geochemistry, hydrocarbon vent carbonates, Cretaceous

ABSTRACT

Occurrence of ^{13}C and ^{18}O depleted authigenic carbonates and associated chemosymbiotic fauna in a mid-Cretaceous deep-water siliciclastic succession of the Basque-Cantabrian Basin (west Pyrenees) suggests the syndepositional venting of hydrocarbon-rich hydrothermal fluids to the seafloor and their anaerobic and aerobic oxidation. Obtained $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ values from individual major carbonate phases of the paragenetic sequence, the organic content values of selected samples and their spatial distribution indicate: 1) a temporal overall evolution from warm to progressively hotter fluids, interpreted as the result of the burial process and the vertical temperature gradient of the hydrothermal system; 2) a horizontal evolution from hot, ^{13}C depleted organic-rich inner vent facies to warm, ^{13}C enriched organic-poor outer vent and host facies, which reflects horizontal gradients of both temperature and petroleum input in the system. Deduced gradients are in agreement with paleontological and petrological data from the studied vent deposits.

Mid-Cretaceous hydrothermal petroleum generation and expulsion in the Basque-Cantabrian Basin (western Pyrenees)

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Keywords: hydrothermal petroleum, Albian, Basque-Cantabrian Basin

ABSTRACT

Authigenic carbonates occur in Albian organic-rich, deep-water deposits (Black Flysh Group) in the northern margin of the Basque-Cantabrian Basin. Isotope geochemistry, petrology and paleontology of these carbonates indicate that they formed by anaerobic and aerobic oxidation of expelled hydrocarbon-rich hydrothermal fluids. Carbonate $\delta^{13}\text{C}$ values and a presence of common pyrobitumen-fills, oil-stains, oil inclusions and high TOC values suggest an petroleum source. Fluid paleotemperatures calculated from carbonate $\delta^{18}\text{O}$ signatures, assuming that the parent fluid is heated Albian seawater, range between 51°C and 109°C (inside of the oil-window). Pyrobitumen samples exhibit $\delta^{13}\text{C}_{\text{org}}$ signatures and $\delta^{13}\text{C}$ values for saturated, aromatics and NSO fractions that are very similar to the values of the host Black Flysch Group. This good geochemical correlation together with calculated fluid paleotemperatures suggest that vented petroleum was generated from the host unit organic matter by contact alteration with hydrothermal fluids at shallow depths.

**Pb-Sr-Nd isotope evolution and metal sources of Zn-Pb-Ag deposits,
Brooks Range, Alaska**

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Keywords: Pb-Sr-Nd isotopes, metal sources, Red Dog, zinc deposits,
Alaska

ABSTRACT

Pb-Sr-Nd isotope data were collected on Mississippian shale-hosted Zn-Pb-Ag Red Dog deposits (RD), other shale-hosted deposits near RD, and Zn-Pb-Ag sulfide and barite deposits from western and central Brooks Range (BR). Data were also obtained on Lower Mississippian to Upper Devonian Endicott Group (EG) in western BR (underlying the deposits), correlative (and older) rocks from the North Slope (NS), and Late Proterozoic rocks from southwestern BR that may represent basement of the deposits. Pb isotopes link the deposits to the EG from western BR and correlative rocks from the NS, suggesting an extensive hydrothermal system. The EG is a likely metal source and fluid conduit. In western BR, barite has Sr isotopes overlapping the Kuna Fm. (host of deposits) and the EG. Nd isotopes of the Kuna Fm. and EG in western BR, and basement from the NS also overlap and suggest derivation from an evolved, older crustal source. In central BR, barite has less radiogenic Sr than barite from the western BR and basement in the NS. Sr isotopes do not reflect a single fluid, or a unique mix of fluids in western and central BR linking all the deposits and occurrences.

Rare earth, major, and trace element composition profiling of bedded chert and siliceous shale sequences across the Santonian-Campanian boundary in Western Venezuela

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Keywords: REE patterns; Bedded Chert; Santonian-Campanian Boundary; Ftanita de Táchira Member; Colón Formation.

ABSTRACT

Rare earth element (REE), major, and trace element composition of bedded chert and siliceous shale sequences, across the Santonian-Campanian boundary in western Venezuela were examined. The boundary is characterized by the disappearance of bedded chert (Ftanita de Táchira Member-La Luna Formation), and the appearance of siliceous black shale sequences (Colón Formation). Bedded cherts were characterized by small positive Ce-anomalies ($Ce/Ce^* = 0,84-1,13$) large variations in negative Eu-anomalies ($Eu/Eu^* = 0,14-0,92$) and low LREE-depleted patterns ($Lan/Ybn = 0,72-1,34$). In contrast, overlying siliceous black shale exhibit a large variation in positive Eu-anomalies ($Eu/Eu^* = 0,90 - 2,03$), small positive Ce-anomalies ($Ce/Ce^* = 0,91 -1,12$) and low LREE-enrichment patterns ($Lan/Ybn = 1,40-2,50$). These geochemical features and Lan/Cen versus $Al_2O_3/(Al_2O_3+Fe_2O_3)$ discrimination diagram suggest a hemipelagic depositional environment for bedded cherts. In addition, bedded chert exhibit a clear depletion in some elements such as Ti, Zr, Hf, Rb, Sc when compared with element of the NASC (North American Shale Composite) suggesting a silica dilution effect. However, the high correlation coefficient between those elements implies that the detrital component in the Ftanita de Táchira Member cherts has a terrigenous provenance.

Stratigraphic variation in composition of some elements such as P, Ba and Sr suggests a primary productivity cycles that resulted from inferred paleo-upwelling zone associated with bedded chert and siliceous black shale deposition.

The relationship between tectonics, granitoids and Mesozoic Au-Ag mineralization in the Hongseong Collision Belt, South Korea

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Keywords: Hongseong Collision belt, Triassic high Ba-Sr granitoids, Au-Ag mineralization, Gyeonggi massif, South Korea

ABSTRACT

Extensive Mesozoic Au-Ag (~130 Ma) mineralization in the Gyeonggi massif of the Korean Peninsula is closely related to deep-seated granitoids. The Haemi area in the Hongseong collision belt (eastern extension of the Dabie-Sulu collision zone in the China craton) within the Gyeonggi massif contains abundant syn-post collisional granitoids with shoshonitic high Ba-Sr intermediate enclaves altogether intruded into the Precambrian metamorphic rocks. The granitoids are subdivided into high Ba-Sr, low Ba-Sr and highly evolved ones. They are high K- calc-alkaline, broadly meta-aluminous and display I-type affinities; however the highly evolved A-type granitoids are peraluminous. SHRIMP U-Pb dating of zircons from high Ba-Sr granitoid yielded 233 Ma age, synchronous with the collision age. Combined field, petrographical, geochemical and stable O-isotope evidences suggest formation of high and intermediate Ba-Sr granitoids by the process of mingling/mixing of magmas derived from an enriched upper mantle and lower crust; and the low Ba-Sr and highly evolved granitoids are typical of highly fractionated granites by advance fractionation of granitic magma free of two-component mixing. Processes such as magma mingling/mixing, fractionation, remelting, remobilization and subsequent concentration of ore forming elements along with the regional tectonics play a significant role in metallogenesis. A four stage collision-metallogeny-fluid flow (CMF) model is widely documented for the geodynamic setting of significant Mesozoic gold deposits in North China craton and also in the Dabie-Sulu collision zone in which the Triassic collision and subsequent extension tectonics along with change in P-T conditions have played a significant role. We envisage a similar genetic model for the Mesozoic Au-Ag mineralization in the Gyeonggi Massif.

Arsenic and Cadmium presence in AMD-Affected river waters

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Keywords: A.M.D., Arsenic, Cadmium, Iberian Pyrite Belt.

ABSTRACT

The present paper gathers the most relevant methodological aspects and contributions relative to the presence of Arsenic and Cadmium in watercourses undergoing AMD processes in the Iberian Pyrite Belt, from data obtained and processed under two research projects*.

Among the different elements contaminating these waters, Cadmium and Arsenic are the most toxic ones for humans. Institutions such as the World Health Organization, the European Union (Directive 98/83) or the US Environmental Protection Agency (USEPA) have set up a reduction of the maximum content of Arsenic in drinking water from 50 to 10 ppb.

In a first phase, described in this paper, the objective was, with an exhaustive analysis of the medium generating heavy metals in general, and Arsenic and Cadmium, in particular. The methodology applied for the achievement of the characterisation of the potential contaminant sources was the sampling of mine dump leachate from those mines which, due to their historic relevance and mineralogy, are susceptible of throwing important amounts of heavy metals.

The results clearly show the existence of AMD phenomena in the Iberian Pyrite Belt. It has been proved that Arsenic concentration is 10 times higher than the limit allowed for drinking water in 68 of the 75 water samples, and even 1000 higher at some points of 6 of the studied mines.

An initiative for a new geochemical coverage of whole Spain by means of floodplain sediments.

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Keywords: floodplain sediments, geochemical survey, Spain, environmental assessment

ABSTRACT

Although IGME has carried out during the late twenty five years several regional surveys based on stream sediments, there is not yet a geochemical coverage of the whole Spain. Floodplain sediment has been well validated as a geochemical media for the regional environmental assessment. So, as a first step to obtain such a coverage (other sampling media with higher resolution are planned for the future), IGME is going to initiate a floodplain sediments survey in catchment basins with surfaces between 2000-4000 km² (over 200 sampling points in Spain). The methodology to be used is mainly based on previous experiences made at a local scale and on an orientation survey which is now going on. The main problem posed by this type of sample is the quality of the sample itself. For that reasons, sampling plan and sampling activity will be made with the strong support of sedimentologists and Quaternary experts, and following the information provided by the recent Quaternary Map of Spain. Our country is, indeed, a good test site, because of its ample climatic and morphologic variability and the very varied character of the fluvial systems, from braided to meandering rivers. Samples will be collected in each site of the floodplain at two points, and in each one a top sample and a bottom sample will be systematically taken. At the same site, a stream sediment sample of the river channel will also be regularly collected. In industrial or mining areas, subsamples will be collected all along the sedimentary sequences (in each layer, if recognizable, or each 20 cm). After their preparation, samples will be analyzed by total and partial techniques (aqua regia) for 54 chemical determinands). Other parameters will be determined, as TOC, granulometric features, pH. In industrial regions with dense population, or in regions with intensive agriculture, some organic compounds (dioxins or organic pesticides) will also be analysed. In some areas, and at some special sites, geochronological characterization of layers is also foreseen. Quality control program will consist in duplicate sampling and the analysis of the 5% of the total samples. Previous studies, made in specific and problematic environments, show a good discrimination between near natural values in bottom layers and very polluted in upper ones, and indicate that the differences between them depend on the granulometric fraction which has been analyzed.

Application of a characterization methodology of dnapi contaminant episodes based on the integration of field and laboratory tools

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ABSTRACT

The studied zone is located in Torelló, 80 km to the North of Barcelona (Spain). The main economic activities are agriculture, cattle and industry. The contaminant episode was detected in 2000 by the Catalan Water Agency (Agència Catalana de l'Aigua, ACA) in a municipal water supply well in the alluvial aquifer associated to the Ges River. The initial concentration was 70 ug/l of PCE, greater than the parametric value of the European Directive 98/83/CEE.

In January 2001 the ACA closed the municipal well and carried out with the company TUBKAL INGENIERIA S.L. the first characterization and restoration studies of the affected aquifers. Pumping and water treatment system has allowed to control the contamination advancing.

At the same time, from 2005 our Group of Research on Economic and Environmental Geology and Hydrology (Grup de Recerca de Geologia Econòmica i Ambiental i Hidrologia, GEAH) of the University of Barcelona, is carrying out research studies with the aim to deep in the characterization of the episode, to model it mathematically and to study new rehabilitation proposals. Our studies have allowed us to identify the concurrence in some DNAPL focuses of heavy metals.

We have used hydrogeology, geophysics, and soil and vegetation tools to characterize the contaminant episode.

The geophysical tool was electrical tomography, and has allowed us to define the fissured marl-calcareous substrate morphology of the alluvial aquifer of the Ges River and also the geometry of its paleochannels. Gravels and sands form these paleochannels with high electrical resistivity and silt and sands of lower resistivity.

The soil geochemistry has permitted the study of the chemical variations of soil profiles in the zones in which the aquifer is not affected by the contamination, as well as in the affected zones. On the other hand, these tools have allowed determining in laboratory the sorption isotherms of PCE, TCE and DCE in these soil profiles.

Vegetation geochemistry has allowed us to study the capability of poplar trees of the Ges River and mycorrhizas associated with different plants to fix contaminants, as for example metals.

The different hydrogeological studies that we have carried out; the tests of slug, punctual dilution and tracer; as well as the integrated statistical analysis of these results with the geophysical results, have allowed us to characterize the hydraulic characteristics of the aquifer.

On the other hand, we have carried out from November 2005 field sampling surveys every two months, in order to study the chemical evolution of the episode, specially in the focuses and near of them. This has allowed us to identify that the original DNAPL compound in these focuses is mainly formed by PCE, with the current presence of TCE, DCE and VC in a lower degree.

The existence of anaerobical conditions in the right bank of the Ges River favors the biodegradation of these compounds, with the consequent increase in TCE concentration but, specially in cis-DCE, and in some cases in VC. This kind of process essentially occurs in the aquifer zones in which a predominance of silt-sandy materials takes place.

The presence of high nitrate and sulfate concentrations in the alluvial aquifer permit at the same time of the dehalogenation process, the existence of denitrification and sulfate reduction processes. The simultaneous presence of all these electron consuming reactions explains the slow DNAPL degradation processes. All these processes have been verified by means of microcosm laboratory experiments carried out in anaerobical conditions with soil and water samples of the Ges alluvial aquifer.

At the same time of the microcosm experiments, we have carried out laboratory experiments, in anaerobical and aerobical conditions, with Fe⁰, KMnO₄, nutrients, co-solvents and H₂, with the aim of determining the ability to accelerate the contaminant degradation processes.

All these studies have allowed us to identify the governing mechanisms and processes that are taken place as well as the preferential migration and degradation pathways of the organic contaminant compounds.

SESION 8.
Hydro-bio geochemistry

**Acid Groundwaters in Southern Australia – new models for their
formation and mineral exploration implications**

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Keywords: Hydrogeochemistry, Exploration, Acidity, Carbonate, Gold

ABSTRACT

There has been long debate over the cause of pervasive groundwater acidity (commonly down to pH 3) across the southern Yilgarn Craton and much of the Gawler Craton. The present “ferrolysis” model explains many characteristics and some processes but is unable to adequately explain the origin of the acidity. An alternative “top-down” model is described and evaluated: sequences of biochemically mediated reactions, followed by slow infiltration and evapo-transpiration, generate differing soil minerals and groundwater conditions depending on soil characteristics and vegetative cover. This model can explain a number of previously disparate and seemingly contradictory data, including: the geographical range of acidity and correlation with carbonate-rich soils; Br depletion and SO₄ enrichment in groundwaters (as demonstrated by elemental ratio modeling); over-saturation with respect to most primary and Fe-rich minerals for groundwaters in the lower regolith. This new model may have significant implications for use of exploration media such as soil carbonates, interpretation of depletion zones and for the stability of gossans in regolith.

Methods for Nickel Sulphide exploration using Hydrogeochemistry

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Keywords: Hydrogeochemistry, Exploration, Nickel, Sulphide

ABSTRACT

Computer simulations of groundwater chemistry will assist use of hydrogeochemistry for regional and prospect-scale exploration in deeply weathered terrains. Modelling of groundwater interactions with sulphidic rocks using Geochemists Workbench®, for both Ni-rich and Fe-rich sulphide systems has demonstrated major differences due to weathering. Deeper groundwaters (generally greater than 50 m depth) are controlled by alteration of pentlandite or pyrrhotite to violarite/pyrite, resulting in high pH, depletion of dissolved SO₄²⁻ and only very low concentrations of dissolved Ni. Iron- and Ni-dominated sulphide systems produced similar results, so that discriminating between barren and mineralized sulphides is difficult. In contrast, shallow groundwaters in contact with Ni sulphides may have Ni, Fe and SO₄²⁻ enrichment due to violarite oxidation and dissolution, with strong potential to distinguish Ni and Fe sulphide systems. Comparing the modeling to results from intensive groundwater sampling around the Harmony NiS deposit in central Western Australia indicate these simulations are useful in predicting the chemical compositions of groundwaters. Such comparisons are also important in fine-tuning computer modelling to better simulate weathering effects.

**Regional hydrogeochemical exploration for Ni sulfides in the NE
Yilgarn Craton, Western Australia.**

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Keywords: geochemical indices, mineral saturation, nickel weathering,
uranium

ABSTRACT

The hydrogeochemistry of the NE Yilgarn Craton of Western Australia has been examined to develop reliable regional vectors to NiS mineralization. Approximately 300 samples were collected and an additional 210 samples were added from previous work. Field measurements included pH, Eh, EC and T. Separate, field preserved sub-samples were collected for cation, anion, alkalinity and Au and PGE analysis (using carbon sorption). Nickel, Co, Pt, Pd and W are the best individual pathfinders for NiS mineralization. Chromium is the best indicator element for ultramafic rocks. Hydrogeochemical differentiation and targeting for NiS is improved with multielement indices. The indices, consistent with the model for groundwater evolution around weathering sulfides, delineate the sulfide signature independent of the type of water i.e. varied Eh and pH. The better performing indices are $(Ni+Co+W+Pt) - (Mo+Ba+Li+Al)$ and $(Ni+Co+W+Pt) - (pH-Eh+Fe+Mn)$ that use the mineralized and sulfide weathering signatures. Mineral saturation indices were not generally beneficial to Ni targeting, but show promise for U exploration.

Antacid belches from northeastern Ontario: generation of high pH groundwaters and H₂ gas

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ABSTRACT

Severely depleted $\delta D(H_2)$ values (-771 to -801 ‰) correlate with enrichments in $\delta D(H_2O)$ values of up to 8 ‰ from the local meteoric water line (LMWL) in groundwaters recovered from diatreme facies kimberlites in the Kirkland Lake district, northeastern Ontario, Canada. These $\delta D(H_2O)$ -enriched groundwaters are characterized by high pH (up to 12.45), hydroxide alkalinity, Eh close to the H₂-H₂O redox couple, and exsolution of H₂ gas. The shift from the LMWL shift suggests that groundwater—kimberlite reactions result in serpentinization, the release of Fe²⁺ from olivine and subsequent hydrolysis. Hydrolysis is likely a result of Fe²⁺ oxidation and the reduction of H₂O to H₂. Mass balance calculations on groundwater and gas δD data show that up to 0.814 moles H₂ gas/L H₂O have been produced. In addition, measured $\delta D(H_2)$ -(H₂O) fractionation indicates low temperature. This abiotic reduction of H₂O only will occur in a closed system in the absence of dissolved oxygen and low concentrations of dissolved inorganic carbon. Low groundwater ⁸⁷Sr/⁸⁶Sr isotopic ratios compared to groundwaters from the host mafic to felsic volcanics, and major ion data (high K, Ca, and low Mg) further indicate reaction within the kimberlite.

Mineral Expression and Plant Species Differences at the Titania Prospect: Biogeochemical Sampling in the Tanami region, Northern Territory, Australia

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Keywords: Biogeochemistry, phytoexploration.

ABSTRACT

The Titania Prospect in the Tanami region, Northern Territory, Australia, includes 600,000 ounces of gold mineralisation held by Newmont Australia. The prospect is adjacent to a large palaeodrainage system and mineralisation is masked by ~15m of transported cover. Biogeochemical sampling over this prospect was conducted in October 2005 with the aims of 'rediscovering' the deposit using biogeochemical techniques and seeing which species best reflected the chemical signature of the buried mineralisation. The soft spinifex (*Triodia pungens*) picked up all of the key ore indicator elements and best delineated the ore body. Several other plant species delineated the ore body but their distribution was limited. The bulk chemistry of the several plant species sampled was compared at adjacent sites to determine the uptake properties of these desert plants. It was found that baseline elemental levels varied between species. It is inferred that the variation is related to differences in rooting depth.

Hydrogeochemical processes in groundwater from the Salar of Pipanaco (Catamarca, NW Argentina)

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Keywords: Groundwater, Hydrogeochemistry, Pipanaco, Catamarca

ABSTRACT

The hydrological basin of the Salar of Pipanaco is mainly located in the South of Catamarca Province (NW Argentina). It is a typical and large (17,200 km²) endorheic basin of tectonic origin situated in the Eastern Andes that has been dissected in the South by the Colorado River during the Plio-Quaternary. Climate is arid and the recharge is by the precipitation in the high surrounding mountains (El Manchao, 4,552 m.a.s.l.). Thermal artesian wells as well as new perforations exploited by new agricultural initiatives have been sampled in the western margin of the Salar of Pipanaco. New wells show the extents of several tens of kilometers to the north of the geothermal field. Hydrochemical results (major ions and 57 trace elements) allow to us fingerprint the origin of the groundwater and its path by the eastern margin of the Salar which is very affected by the real tectonics (it is a very active seismic area). Groundwater quality is excellent but must be managed carefully to avoid the overexploitation because of the low recharge.

Biogeochemistry and geobotany of Pb-Zn gossans, northwest Queensland, Australia

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Keywords: Gossans, biogeochemistry, Australia

ABSTRACT

The aims of the study were to investigate the biogeochemistry and geobotany of plants growing on gossanous outcrops of Pb-Zn sulfide ores in the Mount Isa Inlier, northwest Queensland, Australia. The ferruginous, jaspersy, Mn oxide-stained gossans are characterised by major Pb and Zn, minor As and Cu, and traces of Ag, Ba, Be, Bi, Cd, Ce, Co, La, Mo, Sb, Sr, U and W. Distinct botanical communities grow on acidic soils at the gossan sites. The above-ground biomass of plant species accumulate Zn and to a lesser degree other metals on gossanous soils compared to background sites. Lead bioavailability appears to be constrained by the presence of the poorly soluble Pb phases plumbogummite and plumbojarosite. However, plant species are still able to grow on substrates with elevated bioavailable Pb concentrations (as determined by DTPA extractions), suggesting that some plants actively exclude Pb. Such metal excluding plant species may be used for the rehabilitation of metalliferous mine sites in the region.

Application of a characterization methodology of dnapl contaminant episodes based on the integration of field and laboratory tools

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All these studies have allowed us to identify the governing mechanisms and processes that are taken place as well as the preferential migration and degradation pathways of the organic contaminant compounds.

Hydrogeochemical characteristics of surface waters in areas with abandoned mercury mines in northern Spain.

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ABSTRACT

Asturias in northern Spain is a metallogenetic Hg province, with important mines as “La Peña - El Terronal” and “La Soterraña”, located in Central Asturias, have been operative until the 1970's. The legacy of these mining operations remains currently in the form of abandoned mines and spoil heaps, where polluted water flows to reach the surface watercourses in the area. The potential of these abandoned mines to pollute the environment is enhanced by the presence of As-rich minerals in the ore. An exhaustive sampling of surface waters at the mine sites, upstream and downstream the mine operations and spoil heap areas, has been carried out. Hg has been measured by a direct mercury analyser, and major and minor elements were determined by inductively coupled plasma atomic emission spectrometry (ICP-AES) and flame atomic emission spectrometry (FAES). A Supervised Pattern Recognition study was applied to physico-chemical data. Linear Discriminant Analysis was designed to develop a set of canonical discriminant functions which can help to extract significant differences in water composition. The study revealed significant differences among samples according to As contents. The systematic monitoring accomplished in the area of abandoned mine works makes evident the presence of anthropogenic hydrogeochemical anomalies, represented by high concentrations of total As. The weathering of As-bearing minerals in abandoned mines and spoil heaps results in the transport of dissolved As to superficial watercourses. At the scale of the mining district, total As concentration increases from average values lower than 0.2 mg.l⁻¹, upstream of the mine works, to values up to 57 mg.l⁻¹ at the bottom of a spoil heap. Mine water and spoil heap leachates are incorporated to streams and rivers where dilution is effective, but in order to keep the objectives of water quality demanded on the Water Framework Directive, pollution from anthropogenic sources, including abandoned mine sites and spoil heaps, must be removed at the source before dilution.

Assessment of Stream Water Quality and Chemistry around the Rapel Basin, Central Chile

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Keywords: stream water quality, principal factor analysis, mining, agriculture

ABSTRACT

During the low-flow season in 2006, 94 stream water samples were collected from the Rapel Basin, Central Chile, to assess the processes that influence their geochemistry. Rigorous univariate statistical analysis was performed before using a subset of the original variables for multivariate analysis. Two principal factor analysis (PFA) approaches were used: a robust PFA, which considered the multivariate outliers; and a conventional PFA, in which the outliers were removed. For both PFAs, around 70% of the total variance was explained by four factors with similar elemental associations. However, their interpretation was more difficult for the robust PFA. The elements associated with each factor confirmed that several processes act simultaneously, due to the various industries in the Basin. The first factor was linked to As, Mo and Na which are associated with the geology of the mountains and the agricultural and mining activities in the central depression. The association of HCO₃⁻, NO₃⁻ and Si in the second factor reflected the influence of agriculture on the water chemistry.

Hydrogeochemical characteristics of groundwater in Günyüzü basin (Sivrihisar- Eskişehir) Western Turkey

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Keywords: Günyüzü Basin, groundwater, hydrogeochemistry, aquifer, isotope

ABSTRACT

Groundwater is mostly the unique water source in semiarid regions of Turkey. The study area is located in the Günyüzü basin. The basin covers an area of 500 km² with an annual average precipitation of 393 mm. The study area comprises Mesozoic metamorphic rocks, Eocene granitic rocks, Neogene sedimentary rocks and recent alluvium. Marbles is main aquifers within the studied area, which take places at the top of impermeable metamorphic basement. Neogene limestones, conglomerates and alluvium other important aquifers. 9 groundwater samples were taken from springs and wells in dry and wet seasons, chosen in order to represent aquifer characteristics. The groundwater have PH values ranging from 6.59 to 7.56, and temperatures (T) changes 14 - 35°C, The cation and anion permutation of the samples are mostly in rCa > rMg > rNa > rK and rHCO₃ > rSO₄ > rCl form, respectively. These results indicate that most of these groundwaters are located within the marbles and limestones. δ¹⁸O (‰ -11,2 - ‰ -8,9) and δ²H (‰ -79 - ‰ -60) isotope values shows that all waters (thermal and cold) are meteoric origin. The EC-tritium relationship indicates the existence of water with different origins. These groups that have high EC and low ³H (0 – 4 TU) values represent the deep circulating water. Low EC and high ³H (4-10 TU) values represent the shallow circulating waters where these waters mix in various proportions

**Weathering – Alteration Geochemistry and Petrography of Canakkale
– Tuzla Geothermal Area, Northwestern Turkey**

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Keywords: Weathering, Alteration, Tuzla, Canakkale, Turkey

ABSTRACT

In this study, weathering and alteration phenomenon that occurs around Canakkale – Tuzla geothermal field is to be inspected in terms of geochemical and petrographical aspects. The study area is located in Biga Peninsula – Ezine Zone. Zone's core consists of Permo Carboniferous – Triassic metamorphites and Upper Oligocene plutonics. These formations were overlaid by Middle Miocene volcanics and pyroclastics. These two volcanic formations are separated from each other with a tectonic contact, Tuzla Fault. Two Miocene aged Rhyolite domes are present in the area cutting the previous formations. Above all these formations Miocene – Pliocene aged sedimentary rocks and Quaternary alluvions are present. Fresh and altered rock samples from around Tuzla geothermal area were collected and studied by petrographical and geochemical methods. The results show that weathering – alteration process in Tuzla geothermal area has occurred continually with multi-stage developments indicated by differing geochemical behaviour and rock textural characteristics.

Zeolitisation Process in the Southwest Part of Ke?an, Thrace, Turkey

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Keywords: zeolite formation, volcanic rocks, Thrace, Turkey

ABSTRACT

In this study, the formation of zeolites in the Southwest of Ke?an were investigated. In this region, Upper Eocene Ke?an Formation which consists of mainly sandstone and shale were observed at the bottom. Early Middle- Oligocene Yenimuhacir Formation is conformably overlies the Ke?an Formation. Sandstone, marl and andesitic and dasitic tuffs are the main lithologies in the Yenimuhacir Formation. The tuffs contain mordenite type zeolites mainly. Clinoptilolite- heuylandite type formations were determined. The Miocene- Pliocene Ergene Formation were overlain these units. Zeolites are very common in Yenimuhacir Formation. The formation types can be classified as a) tuffs without zeolite, b) partial zeolitisation in cavities of volcanic rocks, c) tuffs rich of zeolite. This region contains economic zeolites. The studies show successively rapid and short term periods are responsible for the clinoptilolite-heuylandite formations in volcanic rocks. There is also another possible zeolitisation period due to the chemical character of the solutions.

**Andecondary sulphate precipitates in the gravel pits at Kumpuselkä
and Kurkiselkä esker chain, northern Finland**

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Keywords: Precipitates, acidic groundwater, esker chain, till .

ABSTRACT

White and yellowish precipitates were found on the floor in gravel pits in esker chain during summers 2004-2006 in Kiiminki, northern Finland. Kumpuselkä and Kurkiselkä esker chain is located in the schist area containing mica schists with quartz veins, which are locally enriched in Cu, Au, Zn, Pb and Bi. Thin till bed lies between the esker gravel and a bed-rock surface. Precipitates were only found as small grains on till surface and also attached to brushwood and around small pebbles in Kumpuselkä. In Kurkiselkä the precipitates were discovered in the gravel pile, occurring as thin layers. Groundwater ponds measured in summer 2006 were very acidic (Kumpuselkä pH 3.7 – 3.8 and Kurkiselkä pH 4.8). Also the till material is very acidic. Precipitates are composed of secondary sulphates, such as potassium aluminium sulphate, and are easily dissolved into water. Precipitates are formed when primary sulphide minerals are exposed to chemical weathering, causing dissolution of Fe and S to groundwater and rising capillary to ground surface in dry seasons.

The effects of catchment area to lake sediment composition

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Keywords: Lake sediments, catchment area, Pb.

ABSTRACT

Lake sediments were analyzed from three lakes in environmentally different areas in northern Finland. Lake Martinlampi is a small lake in forest area with no immediate human impact nearby and Lakes Pyykösjärvi and Kuivasjärvi are situated near roads with heavy traffic and population center near the city of Oulu. Lake Martinlampi lies in mica schist area with hummocky moraine and peat Quaternary deposits. Lake Kuivasjärvi and Lake Pyykösjärvi are lying in a granite area with deltaic sand, till and peat Quaternary deposits. Sediments in Martinlampi show high contents of Pb and Zn with Pb values rising upwards. The source of these elements in all probability are the Pb – Zn –mineralization in bedrock, Pb – Zn boulder train and anomalous Pb and Zn contents in till in the catchment area of the lake. Lead content is rising also in upper parts of sediments in Kuivasjärvi and Pyykösjärvi, which could be partly explained by anthropogenic sources. Mineralizations are not known in the catchment area of Kuivasjärvi and Pyykösjärvi.

Bioleaching of iron and copper sulphides and relationship with the generation of hydrocarbon gaseous compounds: applications to mining exploration

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Keywords: Bioleaching, hydrocarbon gases, Acidithiobacillus ferrooxidans, Mineral exploration

ABSTRACT

Two experimental phases of in vitro sulphide bioleaching have been carried out for a period of 90 days each. In each experimental phase three different mineral samples were used: pyrite and chalcopyrite concentrates and copper sulphide mineralised rock from the El Teniente mine (1 % Cu). These were exposed to a culture of Acidithiobacillus ferrooxidans or a natural bacteria community previously obtained from the acid leaching of El Teniente ore in columns. Bacteria cultures in sealed experiments were provided optimal feeding and growth conditions, with the injection of analytical air (99.999% pure), to avoid contamination of ambient hydrocarbon gaseous compounds. Experiments were kept under constant agitation and at fixed temperature between 30 – 35°C. Hydrocarbon gaseous compounds generated from bacterial activity were forced through a closed chamber with absorbent material, placed from the start for a time integrated collection. Gaseous compounds were analysed by the SGH (Actlabs Laboratories). Results show that sulphide oxidation bioleaching processes have an influence on the generation of some specific hydrocarbon gaseous compounds.

**Determination of contaminant load transported by Meca River
(Huelva, Spain).**

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Keywords: Acid mine drainage (AMD), Odiel river, Meca river, heavy metal, hydrological model SWAT.

ABSTRACT

Acid mine drainage (AMD) is the main contaminant source in the Odiel river basin (SW Spain), which is located on the Iberian Pyrite Belt (IPB) materials. The main objective of this study is the determination of the contaminant load transported by the Meca river, a tributary of the Odiel. The Meca river is severely contaminated by AMD coming from Tharsis mine, located in the northern area of the watershed. It is regulated by a reservoir which water has a pH close to 4 and high contents of Al and other toxic metals. By means of several samplings the quality of water has been obtained. Due to the shortage of stream flow gauges, a hydrological model (SWAT, Soil and Water Assessment Tool) is used to obtain flow rate data. The contamination load is calculated from the correlation between contaminant concentration and flow rate. The results show that the Meca River transports enormous quantities of dissolved contaminants: 2100 t y⁻¹ of Al, 635 t y⁻¹ of Zn and minor quantities of other metals.

**Factors controlling mobility of heavy metals and rare earth elements
in a stream affected by mine drainages (NW Spain)**

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Keywords: mine drainages, heavy metals, rare earth elements

ABSTRACT

A stream affected by mine drainages from several abandoned and active coal mines located in the Bierzo carboniferous basin (León, NW Spain) have been investigated. A comprehensive analysis of sediments and water was performed to understand the main processes which control the attenuation of contaminant elements and rare earth elements under conditions of high-level pollutant input. The waters show pH values close to neutral, significant sulphate contents and medium-low metallic and rare earth element contents. The precipitation of secondary Fe(III) minerals has reduced the aqueous concentration of metals and rare earth elements mainly by adsorption processes. The neutral pH conditions originated by the presence of carbonates in the environment favour the above processes. The REE are not strongly fractionated during these precipitation processes, except for Ce and Sm, as it shows the “convex” shape of the REE distribution patterns in the precipitates, typical of acid waters. Finally, the dilution processes contribute to the heavy metals attenuation in the stream, although its effect is greater at the major ions.

Geochemical identification of the sources of natural arsenic in groundwater of the Madrid Basin (Spain)

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Keywords: Arsenic, groundwater, geochemistry, detrital aquifer, Madrid Basin.

ABSTRACT

A geochemical and mineralogical study has been carried out in order to identify the sources of natural arsenic occurring in groundwater in the Madrid Tertiary Detrital Aquifer. 72 samples of terrigenous rocks from a 402 m-deep well (drilled by the Canal de Isabel II to supply drinking water) were analyzed by XRF and INAA for major and trace elements, and by XRD and SEM-EDAX for mineralogy. In addition, trace elements analyses (ICP-MS) were performed on selective extractions (Fe and Mn oxide dissolution by acid attack). Arsenic content in the rock samples is low (up to 10.3 ppm, mean: 3.92 ppm) and is positively correlated with Fe₂O₃(total), TiO₂, MgO, Al₂O₃, CaO, Cs, Sc, Hf and U, and negatively correlated with SiO₂. This is consistent with an arsenic affinity for the clay-rich beds. Moreover, the selective extractions and mineralogical data show that most of the arsenic in the solid phase occurs in Fe-Mn oxides-(oxyhydroxides). Even if it was not detected in the clays, sorption of some arsenic in these minerals must not be ruled out.

**Geochemistry of soils and waters close to W-Au-Sb old mines from
Sarzedas, Castelo Branco, central Portugal**

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Keywords: Soils, waters, contaminations, coatings, W-Au-Sb
mineralizations, Sarzedas

ABSTRACT

In Sarzedas area, the Cambrian schist-metagraywacke complex predominates and is penetrated by W-Au-Sb quartz veins and Sb-Au felsitic diques which were exploited for W, Au, and Sb in Gatas-Santa and Pomar-Galdins.

Soils and waters from Sarzedas area present contamination due to the past mining activities and host rock. Soils in Gatas-Santa and Pomar-Galdins must not be used for agriculture, human residence, commerce and industry due to their high Sb, Sn, W and As contents. Organic matter, clays and iron hydroxides and oxides in soils adsorbed metallic elements. Waters show high Fe and Mn contents and some of them also have high Sb contents due to mining activities. These waters must not be used for human consumption, but may be used for irrigation. Coatings on fragments from the waste rock consist of goethite and symplectite. Goethite contains inclusions of arsenopyrite and stibnite and adsorbed As and Sb. Symplectite adsorbed S and P. Therefore, coatings decreased contamination.

Gold uptake in Australian plants - a preliminary experimental study

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Keywords: biogeochemistry, Acacia, Eucalyptus, vegetation.

ABSTRACT

One of the reasons for the success of phytogeochemistry in mineral exploration in the Northern Hemisphere is the presence of vast boreal forests consisting of monocultures of a few species. Australia, on the other hand, has an extremely diverse flora dominated, in the arid interior, by spinifex, acacia and eucalypts so it can be difficult to find a consistent plant sample medium. How should data be compared from a phytogeochemical survey using different plants? A preliminary hydroponic experiment was designed to look at metal uptake in two species of Australian plants that appear to adsorb Au in the natural environment. Gold concentration in each plant organ and Au concentration in the applied treatment solution showed a linear trend over several orders of magnitude but differences between the two species have sampling implications for mineral exploration. Plant parts were examined by SEM and PIXE (proton induced X-ray emission) for Au and other elements, and images showed the specific location and the particulate form of metals within the plant. Several hundred ppm (mg/kg, dry weight) of Au was found in plant parts when a separate portion was digested in acid and analysed by ICP MS.

Historical trends in the metal content of river bed sediments of an Atlantic basin

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Keywords: heavy metal, cores, Pb210

ABSTRACT

During recent years, several studies have been dedicated to the geochemistry of metals in the Anllóns basin (NW Spain). In such studies, evidences of anthropogenic contamination were found. So, As levels higher than 260 mg·kg⁻¹ were found in the superficial layers, as well as P (>2300 mg·kg⁻¹), Cu (>60 mg·kg⁻¹) and Zn (>280 mg·kg⁻¹), exceeding highly the values expected for the crust. To investigate the historical trend of the total metal content, seven cores were taken along the watercourse with a Livingstone probe, and the following elements were determined: Pb, Cr, Mn, Co, Cd, Cu, Ni, Fe, Al, Zn, As and P. The core 5, located at the mouth of the river, was submitted to dating by using Pb210, as it is the end point of the basin and accumulates the whole erosive processes and, in consequence, the pollution phenomena of the basin. The concentration of most of the metals remained unchanged in time, except for P, which increased in the last decades due to the agricultural activities and As, which showed a decrease since the closing of the gold mine of the area.

Hydrogeochemistry variations along the Tinto river course (SW Spain)

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Keywords: Acid Mine Drainage, metal pollution, Tinto river, attenuation processes.

ABSTRACT

The Tinto river (SW Spain) drains the Iberian Pyrite Belt (IPB), which hosts one of the largest massive sulphide deposits in the world. The mining of this deposit, since at least 4500 years ago, has provoked an extreme acidity and metal pollution of Tinto river water. As a consequence of this metal transport, sediments of Ria de Huelva estuary show an anomalously high metal content. In order to assess the hydrochemical changes on Tinto water along its course, several samplings were carried out in 2005 and 2006 during low and high flow conditions. Physico-chemical properties were measured in situ and samples were collected, acidified, filtered and cooled until the arrival to the laboratory, where several elements (sulphates, As, Ba, Ca, Cd, Co, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Si, Zn, etc.) were determined by ICP-OES. Results proved that Tinto river is one of the most polluted river in the world. The degree of metal pollution decreases downstream, although variations depend on each element.

Soil to plant (*Solanum tuberosum* L.) radionuclides transfer in the vicinity of an old uranium mine

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Keywords: Soil-plant radionuclide transfer, uranium series radionuclides, *Solanum tuberosum* L., uranium mining impact

ABSTRACT

The uranium mine of Cunha Baixa, near Mangualde, Portugal, was in activity since 1970 till 1993. Due to past mining activities, some irrigation wells in the agriculture area display acidic water with enhanced radionuclides concentrations. In this area, field plots for experimental growth of plants were delimited and submitted to different treatment: irrigation with water containing high radionuclide concentrations and irrigation with water containing low radionuclide concentrations. Agricultural practices were controlled and soil and irrigation water radioactivity was measured. Crops of potatoes (*Solanum tuberosum* L.) were harvested and analysed for alpha emitting radionuclides of the uranium series. Results show a clear uptake of radionuclides by potatoes; this was particularly enhanced in the plots irrigated with the most contaminated water. However, the radionuclides were mostly concentrated in the potato tuber skin being the risk for human health decreased by potato peeling. The contribution of radionuclides in irrigation water versus radionuclides in soil to the uptake by plants is discussed.

Phytoexploration signals: Does one sample represent an area, case study using *Melaleuca lasiandra*.

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Keywords: Biogeochemistry, phytoexploration, bioaccumulation.

ABSTRACT

The Titania Prospect in the Tanami region, Northern Territory, Australia, includes 600,000 ounces of gold mineralisation held by Newmont Australia. The prospect is located adjacent to a large palaeodrainage system and mineralisation is masked by ~15m of transported cover. To test for spatial homogeneity-heterogeneity, and therefore representativeness of single point samples, 24 *Melaleuca lasiandra* leaf samples were collected from 24 plants within a 100 m diameter at the prospect. There was little variation in ore related elements (As, Au, Ce, Cr, Cu, La, Mo, S, Zn) within this sample array. The greatest variability occurred within the more 'essential' or 'bioavailable' elements such as Mg, Mn, P. The implications of this study are that with a 100 m sample spacing one plant sample will give the same result as many plant samples, or an amalgamation of several plant samples. It is concluded that 100 m spaced sampling of *M. lasiandra* can provide a representative expression of substrate anomalies in regolith dominated region

**Tellurium breath, tellurite Resistance and Reduction by Bacteria
Isolated from Sarcheshme copper mine.**

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ABSTRACT

Tellurium compounds can be found in high concentrations in land and water near sites of waste discharge of industrial manufacturing processes. Potassium tellurite (K_2TeO_3) is toxic to many microorganisms at concentrations as low as 1mg/ml. ten species of facultative anaerobic bacteria isolated from sarcheshme copper mine demonstrated high-level resistance to tellurite and accumulation of metallic tellurium crystals. High-level resistance was observed for Basil and cocoas grown with certain organic carbon sources, implying that tellurite reduction is not essential to confer tellurite resistance.

Level of adsorption determine by atomic adsorption and spectrophotometer (DDTC method).the level of tellurite concentration in the bacteria cell detected by TEM and SEM.

In the anaerobic condition tellurite reduce by azetobacter.In this case tellurite is the electron acceptor. In the anaerobic condition azetobacter can only growth in presence of tellurite.

Poplar trees used for the detection of hazardous elements: case history of the Ebro, Llobregat and Ter valleys (NE, Spain).

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Keywords: Biogeochemistry, Poplar trees, aquifers contamination, principal component analysis.

ABSTRACT

Poplar trees were used to detect water pollution in given stretches of the rivers Ebro, Llobregat and Ges, a tributary of the river Ter (NE Spain). Between 1954 and 1996 the chemical factory (Erkimia) discharged more than 950.000 t of solid waste from Chlorine and Polyphosphate production into the Flix dam in the Ebro River. These wastes contain high levels of Hg, Cd, U, Cr, R.E and F, some of which contaminated the lower reaches of the river at Ascó, where poplar leaves were sampled.

In the 1960s extensive sand and gravel extraction was carried out in the lower terraces of the river Llobregat, resulting in a large number of pits that were subsequently filled with industrial and urban waste. Some poplar trees were sampled to detect the composition of the waste in these pits at Sant Feliu near Barcelona.

Chemical industries near the river Ges at Torello discharged liquid waste into wells, resulting in considerable contamination of the aquifers. Some poplar trees were sampled in the terraces of the river to pinpoint the location of the contamination.

The three areas (table 1) show that the average content in Co, Cr, Fe, Na, Mn, Zn and Pb of the poplar leaves is higher at Sant Feliu than at Ascó and Torelló; Hg and Cd are higher at Ascó than at Sant Feliu and Torelló and the levels of Cu and Ni are higher at Torelló than at Sant Feliu and Ascó.

The principal component analysis (PCA) shows three principal factors (see table 2):

F1: The Mn/Co/Na/Sb/Zn/Pb association has a high load at Sant Feliu. This suggests urban and industrial contamination.

F2: The + Cu/Fe association has a high to medium load at Torello and the - Cd/Hg association has a high load at Ascó. The Cd and Hg constitutes

evidence of major contamination (Erkimia factory) and the Fe and Cu indicates major contamination in the aquifer at Torelló.

F3: The Ni/(Zn, Fe, Cd) association has a very high load in one sample at Torelló (Table 2) and a medium load at Torello 4, 6 and 7. This association has a medium load at Ascó 4 and 7.

	Co	Cr	Fe	Hg	Na	Sb	Zn	Cu	Mn	Ni	Pb	Cd
Ascó 1	2.0	0.8	0.02	0.11	1000	0.05	79	6.0	45	0.9	0.5	1.1
Ascó 2	1.1	1.4	0.04	0.28	122	0.07	45	13.0	51	0.9	0.5	0.1
Ascó 3	1.3	0.7	0.02	0.34	655	0.04	204	5.0	55	0.9	1.0	2.3
Ascó 4	1.3	0.8	0.02	0.43	129	0.05	230	11.0	34	2.0	0.5	1.2
Ascó 5	2.2	0.8	0.02	0.48	150	0.05	221	10.0	44	1.0	1.0	2.1
Ascó 6	1.3	0.5	0.02	0.38	150	0.03	111	4.0	77	0.9	1.0	1.6
Ascó 7	1.2	0.5	0.02	0.16	111	0.05	85	6.0	34	0.9	0.5	0.1
Ascó 8	1.4	0.4	0.02	0.05	1140	0.04	68	5.0	43	0.9	0.5	1.1
Ascó 9	2.0	0.5	0.02	0.43	140	0.07	145	4.0	69	0.9	0.5	2.6
Ascó 10	1.6	0.7	0.01	0.85	333	0.05	247	9.0	42	2.0	0.5	0.7
Ascó 11	1.1	0.7	0.02	0.54	244	0.06	111	6.0	14	0.9	1.0	1.3
Ascó 12	1.4	0.8	0.02	0.65	105	0.03	111	6.0	46	1.0	1.0	0.1
Sant Fel. 1	5.3	1.2	0.03	0.05	1470	0.23	500	8.0	214	1.0	2.0	0.5
Sant Fel. 2	3.8	1.0	0.03	0.45	1280	0.30	450	9.0	200	0.9	1.8	0.5
Sant Fel. 3	5.2	1.8	0.03	0.47	1790	0.30	800	8.0	150	1.0	2.0	0.5
Sant Fel. 4	3.1	1.1	0.04	0.05	1510	0.38	270	10.8	213	0.9	3.6	0.1
Sant Fel. 5	2.9	1.1	0.03	0.05	1460	0.30	390	10.8	171	0.9	3.6	0.1
Sant Fel. 6	3.9	0.8	0.03	0.32	2020	0.27	360	9.0	190	0.9	3.6	0.1
Sant Fel. 7	3.7	0.1	0.03	0.05	867	0.32	310	7.2	149	1.4	1.8	0.1
Torelló 1	0.9	0.9	0.02	0.05	213	0.07	215	7.0	35	1.0	1.0	0.6
Torelló 1	1.2	0.7	0.02	0.05	114	0.08	160	13.0	37	2.0	0.5	1.7
Torelló 2	1.7	0.7	0.02	0.05	299	0.11	170	12.0	24	1.0	0.5	0.6
Torelló 3	1.3	0.6	0.02	0.05	294	0.09	80	7.0	43	0.9	0.5	0.7
Torelló 4	1.4	0.9	0.03	0.05	323	0.12	130	11.0	27	0.9	0.5	0.1
Torelló 5	1.0	0.6	0.03	0.05	244	0.07	102	9.0	24	0.9	0.5	0.1
Torelló 6	1.4	0.4	0.02	0.05	200	0.08	54	15.0	15	2.0	0.5	0.1
Torelló 7	1.7	0.6	0.02	0.05	120	0.09	82	15.0	27	2.0	0.5	0.1
Torelló 8	1.5	0.7	0.02	0.05	102	0.08	135	14.0	20	1.0	0.5	0.1
Torelló 9	1.8	0.7	0.03	0.05	279	0.09	54	8.0	17	1.0	1.0	0.1
Torelló 10	2.3	0.7	0.03	0.05	364	0.12	130	7.0	27	2.0	0.5	0.1
Torelló 11	1.5	0.9	0.02	0.05	161	0.08	490	8.0	96	5.0	0.5	1.2
Torelló 12	1.4	0.6	0.03	0.10	602	0.13	64	7.0	30	1.0	0.5	0.1
Torelló 13	1.6	0.7	0.02	0.05	589	0.10	91	7.0	26	1.0	0.5	0.9
Torelló 14	0.9	1.1	0.04	0.05	115	0.10	81	10.0	21	0.9	1.0	0.1
Average	2.0	0.8	0.02	0.21	550	0.12	199	8.7	68	1.26	1.1	0.7

Table 1 (all elements in ppm except Fe in %)

	Co	Cr	Hg	Na	Sb	Zn	Ni	Cu	Mn	Pb	Cd	Fe	R
F 1	0.92	0.53	-0.02	0.9	0.88	0.86	-0.07	-0.08	0.95	0.85	-0.12	0.46	-0.13
F 2	0.03	0.32	-0.66	-0.09	0.32	-0.05	0.03	0.76	0.03	0.17	-0.68	0.66	0.04
F 3	-0.01	0.02	-0.33	-0.28	-0.13	0.37	0.89	0.17	-0.01	-0.2	0.31	-0.37	0.05
F 4	0.06	0.44	0.26	0.05	-0.09	0.22	0.07	0.17	-0.16	-0.26	-0.12	0.01	0.9

Table 2 (R: random numbers)

Geochemical characterisation of the Catalonian coastal ranges (Barcelona-Gerona, NE Spain) using stream sediments.

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Keywords: multi-element geochemistry, streams sediments, univariable statistics, Catalonian Coastal Ranges

ABSTRACT

The Catalonian Coastal Ranges (CCR) form part of the Hercynian chain made up of siliciclastic materials of Cambrian to Carboniferous age affected by regional and contact metamorphism. This contact metamorphism was produced by a large granitic batholite composed of granodiorites and tonalites and small intrusions of leucogranites.

The CCR are located between the Mediterranean and the Ebro basins in the NE of the Iberian Peninsula (Spain).

The geochemical characterisation of a major part of the CCR (2,640 km²) was undertaken between 1982 and 1995 and the method used consisted in stream sediments with a sample density of two samples/sq Km. Other methods included biogeochemistry (using evergreen oaks and pines) and water streams for fluoride and were used at local level.

The stream sediment samples once dried at a temperature not exceeding 50°C were sieved and the fractions lower than 80 mesh (ASTM) were analysed by conventional EAA after aqua regia digestion in the laboratories of the University of Barcelona. The elements analysed included Pb, Zn, Cd, Cu, Ag, Co, Ni, Mn and Fe. As, Sb, Hg and Bi were analysed by EAA using hydrides. In some areas, these elements were complemented by Au, RE, W, U, Th and Cr using INAA (Acltlabs, laboratories)

The results of the analyses were processed using a univariable (Figure 1) and multivariable statistical treatment. These results were incorporated in different maps as geochemical background and anomalies.

The geochemical stream sediments revealed a composition of slate, phyllites and granites of the CRR and also large anomalies in Pb, Zn, Cu and Cd in several areas of the CRR associated with Ordovician to Silurian volcano sedimentary events, with Cu, Zn, Fe in Cambrian volcano sedimentary phenomena, and with Pb-Zn (Cu) lodes in granites.

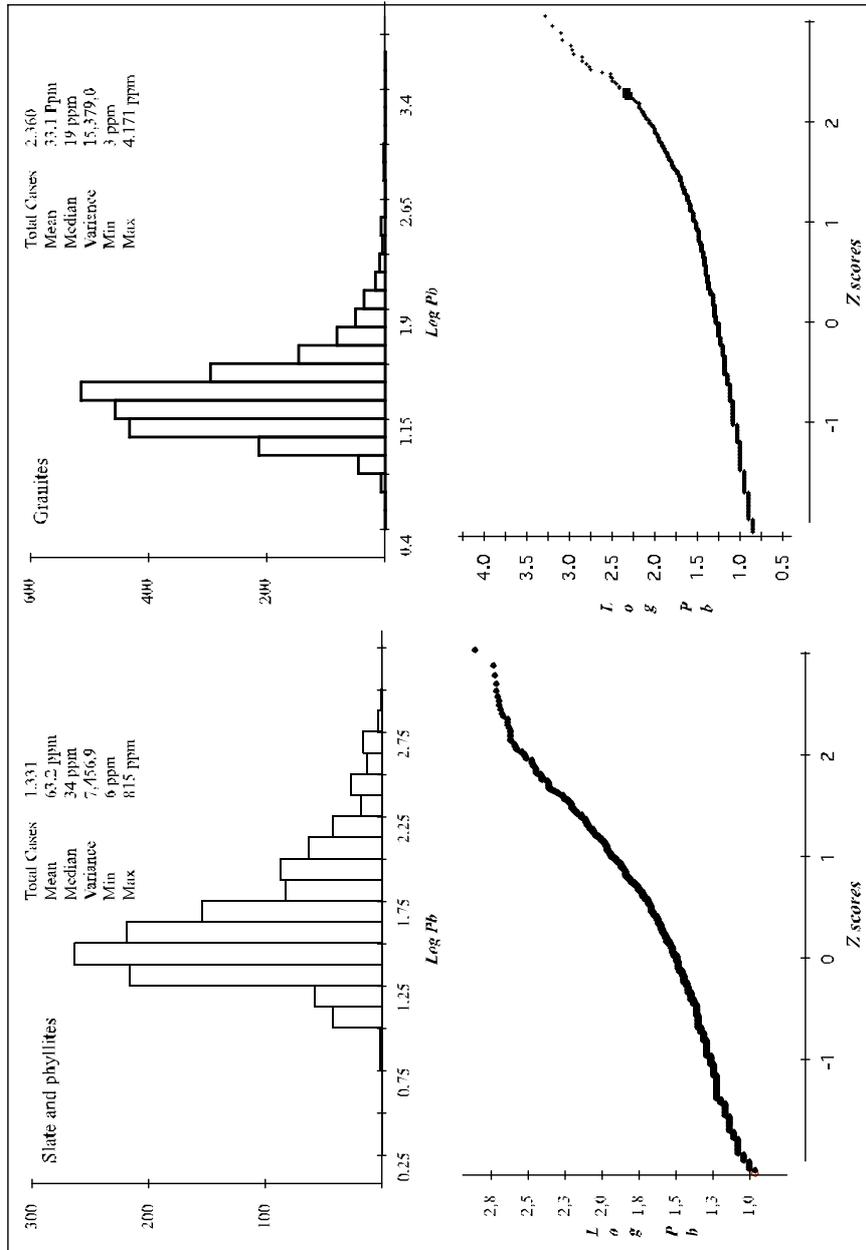


Figure 1. Univariable statistic of lead in CCR.

Geochemical characterization of gold-bearing mineralized zones and their dispersion patterns in Janisjarvi and Louhi areas, Karelia, North-West Russia

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Keywords: gold-bearing mineralization, indicator elements, geochemical types of mineralization, dispersion patterns.

ABSTRACT

In Janisjarvi area, situated in Southern Karelia, the Au-bearing mineralized zones Janis and Alattu were studied. It has been shown that principal indicators of gold mineralization are Au, Ag, Bi, Cu, Pb, Zn, and As. In Alattu prospect, two ore-related associations were revealed: 1) early Au-As and 2) sequential Zn-Pb-Ag-Cu-Bi with Au. In Janis prospect, the Au-Ag-Bi-W-Sn-Pb association is mostly enriched with gold. There are definite links between contents of these groups of metals and mineral composition of mineralized rocks. In Louhi area, situated in the White Sea Belt of Northern Karelia, perspective types of mineralization, located in the Archean metamorphic sequences, are supposed to be generated by late hydrothermal metasomatic processes of Svecofennian age. Four principal geochemical types of mineralization have been distinguished: 1) Au, Bi, Ag with minor Cu and Pb; 2) Cu, Ni, Co; 3) Pt, Pd, Cu, Ag; 4) Pb, Zn, Cd, Cu, Ag. Dispersion patterns of these groups of elements in tills are geochemical pathfinders to related mineralization in bedrock.

Antacid belches from northeastern Ontario: generation of high pH groundwaters and H₂ gas

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ABSTRACT

Severely depleted $\delta D(H_2)$ values (-771 to -801 ‰) correlate with enrichments in $\delta D(H_2O)$ values of up to 8 ‰ from the local meteoric water line (LMWL) in groundwaters recovered from diatreme facies kimberlites in the Kirkland Lake district, northeastern Ontario, Canada. These $\delta D(H_2O)$ -enriched groundwaters are characterized by high pH (up to 12.45), hydroxide alkalinity, Eh close to the H₂-H₂O redox couple, and exsolution of H₂ gas. The shift from the LMWL shift suggests that groundwater—kimberlite reactions result in serpentinization, the release of Fe²⁺ from olivine and subsequent hydrolysis. Hydrolysis is likely a result of Fe²⁺ oxidation and the reduction of H₂O to H₂. Mass balance calculations on groundwater and gas δD data show that up to 0.814 moles H₂ gas/L H₂O have been produced. In addition, measured $\delta D(H_2)$ -(H₂O) fractionation indicates low temperature. This abiotic reduction of H₂O only will occur in a closed system in the absence of dissolved oxygen and low concentrations of dissolved inorganic carbon. Low groundwater ⁸⁷Sr/⁸⁶Sr isotopic ratios compared to groundwaters from the host mafic to felsic volcanics, and major ion data (high K, Ca, and low Mg) further indicate reaction within the kimberlite.

Acid Groundwaters in Southern Australia – new models for their formation

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Keywords:

Hydrogeochemistry, Acidity, Carbonate, Gold

ABSTRACT

Southern Australia appears unique with regards to saline groundwater with pervasive acidity (commonly down to pH 3). Previous explanations of this effect centered on various potential “ferrolysis” effects, whereby dissolved Fe²⁺ is released at the base of weathering, and oxidizes higher up in the profile, generating acidity. However, we have found this model is unable to adequately explain the origin of the acidity. An alternative “top-down” model is described and evaluated: sequences of biochemically mediated reactions, followed by slow infiltration and evapo-transpiration, generate differing soil minerals and groundwater conditions depending on soil characteristics and vegetative cover. This model explains a number of previously disparate and seemingly contradictory data, including: the geographical range of acidity and correlation with carbonate-rich soils; bromide depletion and SO₄ enrichment in groundwaters (as demonstrated by elemental ratio modeling); over-saturation with respect to most primary and Fe-rich minerals for groundwaters in the lower regolith. The strengths and weaknesses, and implications for 4D modeling of regolith/groundwater processes are discussed.

Session 9.
Data interpretation

What is an anomaly? A comparison of fractal-based filters with band-pass wavelength filters for large datasets

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Keywords: geochemistry, fractal, band-pass, anomaly, threshold

ABSTRACT

In the context of regional geochemistry, the character of the background is scale dependent. Defining thresholds for datasets that cover large heterogenous areas is a complex problem. Two appropriate methods for construction of a complex background are based on the spatial frequency structure of grid surfaces: 1) band-pass wavelength filters originally developed for potential field data, and 2) irregular wavelength filters chosen by fractal analysis of the power spectrum of the map.

When used to analyze a large (>10,000 sample sites) dataset for arsenic from the northern Great Basin, the chief differences between background surfaces created with these two methods are near the margins of the area of interest, where the surface is not fully constrained. Both methods are effective at identifying very small amplitude anomalies away from the margins of the study area. Two less sophisticated methods are also effective at constructing backgrounds for this dataset: 1) calculation of the slope and 2) averaging with a large (50 km) radius.

Hot spring arsenic distribution in the Andes Cordillera (18-52oS)

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Keywords: Arsenic, Hot spring, Andes, Argentina, Chile

ABSTRACT

One of the most extensive areas around the world where the low quality of groundwater due to the presence of high concentrations of arsenic of natural origin is a major concern is Argentina-Chile. The exhaustive knowledge of the geological, hydrogeological, and geochemical setting can be very effective to define an alternative strategy to mitigate the arsenic problem in water. The magnitude and extension of the arsenic affected areas is not well known. In order to understand the source of the arsenic, the development of a database of thermal waters in the Andean region is in progress. We present in this work the assessment of more than 360 hot springs and wells located in the Andes between 14 and 52oS of latitude. This information comes from projects carried out by our team in the area and from references. The hot waters with higher concentrations of arsenic (50-30,000 µg/l) are mainly located in volcanic areas with hydrothermal activity of the Andes Cordillera between 14 and 28oS.

Deciphering multi-stage geochemical dispersion in complex regolith

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Keywords: element dispersion history, regolith dating, weathering regimes

ABSTRACT

Geochemical dispersion is commonly a multi-stage process, particularly in areas of variably preserved ancient regolith where weathering has occurred under a wide range of contrasting conditions (i.e. most of Australia). Understanding this complex dispersion history can assist mineral exploration by improving anomaly recognition and interpretation. Ages have been determined for weathering profiles over Cu-Au deposits in key regolith-landform settings of the Cobar region of western New South Wales using palaeomagnetic, $^{40}\text{Ar}/^{39}\text{Ar}$, ^{18}O and relative dating techniques. Target and pathfinder element distributions, their host minerals and dispersion patterns investigated within this temporal framework indicate distinct differences related to different weathering regimes through the Cainozoic. Major controls are pH, groundwater chemistry (particularly chloride and sulfate concentrations) biological activity and the relative dominance of chemical versus mechanical dispersion, reflecting the landscape evolution at particular sites.

**Quantitative minimum probability measures of exploration accuracy
and geochemical contrast: comparing exploration techniques to
maximize discovery**

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Keywords: exploration performance, minimum probability, partial digestion, selective extraction.

ABSTRACT

Hypergeometric statistics have been used to establish a quantitative measure of accuracy (the minimum hypergeometric probability - MHP) for geochemical exploration techniques over known mineral showings. An alternative, complementary measure of exploration performance is geochemical contrast; it is analogous to measuring the precision of a geochemical result. Using the same philosophy as the MHP technique, the minimum Student's t probability (MTP) can be used to quantify geochemical contrast. The Student's t probability describes the random chance that anomalous and background samples derive from the same distribution. For low probabilities, the background and anomalous concentrations are very different, and high geochemical contrast exists. Thus, this approach can be used to quantitatively compare the geochemical contrast of rival exploration techniques. Because the MHP and MTP measures are probabilities, their joint probability collectively rates the performance of exploration techniques. An example dataset from the Navan carbonate-hosted Pb-Zn deposit, Ireland, illustrates how these two exploration performance measures can be used to identify a superior exploration technique.

Assessment of reactivity of sulphidic tailings and river sludges

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Keywords: tailings reactivity, contamination risk

ABSTRACT

The aim of this paper is the assessment of reactivity of sulphidic tailings disposed of in a tailings dam in Serbia as well as river sludges and therefore the estimation of risk for surface- and groundwater. The assessment was carried out according to AMIRA protocol using a conventional free draining leach column system, weekly wet-dry cycles and a monthly flushing cycle. The AMIRA protocol was slightly modified to enhance permeability of the waste mass. Deionised water and simulated acid rain were used as leaching agents. Parameters monitored provide information on a range of geochemical issues including sulphide reactivity, oxidation kinetics, metal solubility and the overall leaching behaviour of the wastes. The experimental results covering a period of more than 12 months show increased solubility for a number of heavy metals and sulphates and therefore the risk for contamination of surface- and groundwater is considered high. Finally, factors affecting long term reactivity of hazardous wastes in abandoned disposal sites are discussed.

Characterization and Spatial Variability in Eshidiya phosphate, South Jordan: Statistical and Geostatistical Applications

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Keywords: spatial variability, geostatistics, phosphate, variogram, Jordan.

ABSTRACT

A total of 81 boreholes were drilled through the exploration, prospect and development of the non-coquina area, Eshidiya mine district. The obtained data from each hole consisted of the P₂O₅ wt % and other constituents and the survey data including X, Y, Z coordinates for the three productive phosphatic beds A1, A2 and A3. These data are considered as variables. Due to the presence of different mineralogical and geochemical patterns in the studied phosphates, statistical and geostatistical analysis were applied to each data set to find out the geochemical features pertaining to the three productive phosphatic beds A1, A2 and A3. Every variable was subjected to the same analytical treatment, in order to (1) determine the type of distribution and calculate the statistical parameters, (2) calculate correlation coefficients to extract the inter-elemental relationships, (3) determine the spatial variability by constructing experimental semivariograms and fitting hypothetical models to them (variographic analysis) (4) prepare contour maps based on kriged estimates and their standard deviations. Furthermore, an attempt has been made to discern the presence of any possible groupings present either in variables or in samples using cluster and factor analyses.

**Lithogeochemistry and fluid flow in the epithermal Veta Rublo
base metal-silver deposit, Chonta Mine (Huancavelica, Perú)TP¹**

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Keywords: epithermal, lithogeochemistry, metal ratios, fluid flow.

ABSTRACT

The Chonta Mine (75°00'30" W & 13°04'30"S, 4495 to 5000 m abs), owned by Compañía Minera Caudalosa, operates a polymetallic Zn-Pb-Cu-Ag vein system of the low sulphidation epithermal type, hosted by cenozoic volcanics of dacitic to andesitic composition (Domos de Lava Formation). Veta Rublo, one of the main veins of the system, is worked underground to nearly 300 m. It strikes 60-80° NE and dips 60-70° SE; its width varies between 0.30 and 2.20m, and it crops out along ~1 km, but is continued along strike by other veins, as Veta Caudalosa, for some 5 km. Typical metal contents are 7% Zn, 5% Pb, 0.4% Cu and 3 oz/t Ag, with quartz, sericite, sphalerite, galena, pyrite, chalcopyrite, fahlore as main minerals, and minor carbonate and sulphosalts.

The Rublo vein has been the subject of a lithogeochemical study. Its metal contents have been systematically analysed (4 840 samples), compared, and related to their spatial distribution along the structure, to depict the evolution. Metal ratios (as ln) have been used to show fluid chemistry variations of the evolving hydrothermal system. These variations can be related to the directions of fluid flow, under the assumptions that (i) metal precipitation will not begin until the metal reaches saturation in the hydrothermal solution; (ii) saturation and therefore precipitation will be enhanced by cooling, and this is favored by flow of the fluids to shallower levels or by lateral flow away from the source; pressure drops or other changes related to this process may act in the same way; (iii) the temperature, and therefore the time, of precipitation of a particular metal depends not only on its solubility, but also on its concentration: the precipitation of an undersaturated metal will be delayed, as compared with the saturated metal.

Under these assumptions, the resulting picture (e.g. Fig. 1 for lnZn/lnCu – other metal ratios' pictures are similar) suggests a consistent upward flow of the hydrothermal fluids, progressing from the center and from both sides of the structure –arrows– and selectively precipitating Zn and Pb at lower levels, with a relative Cu enrichment at higher levels. This distribution could be explained by the relatively poor Cu concentration of the original solutions (Zn/Cu>15, Pb/Cu>10), which would prevent the precipitation of this metal until its saturation threshold is reached, at shallower levels.

¹ Projects AL05_PID_0021 (Universidad Politécnica de Madrid) and ALFA II 0459FA (European Union). The support of Compañía Minera Caudalosa and its staff is gratefully acknowledged.

Some requirements, which have been tested, must be fulfilled for these assumptions to be applied. The picture might be chaotic and the method unreliable, should different hydrothermal events be superimposed in the same structure and be unconsciously bulk sampled together. To prevent this, a preliminary underground reconnaissance and vein mapping have been carried out. Factor analysis of all the data is consistent with a single main event related to about 90% of the overall metal content (Factor 1, Fig. 2), and fits with the space distribution of metal ratios –compare Figs. 1 & 2-, while there seems to be a second, unimportant, event represented by Factor 2 (supergene silver enrichment?). Additional processes, as boiling, can also enhance precipitation; a fluid inclusion study is being carried out as well, to check the (palaeo)thermal history of the vein, and its consistency with the litho-geochemical picture discussed above.

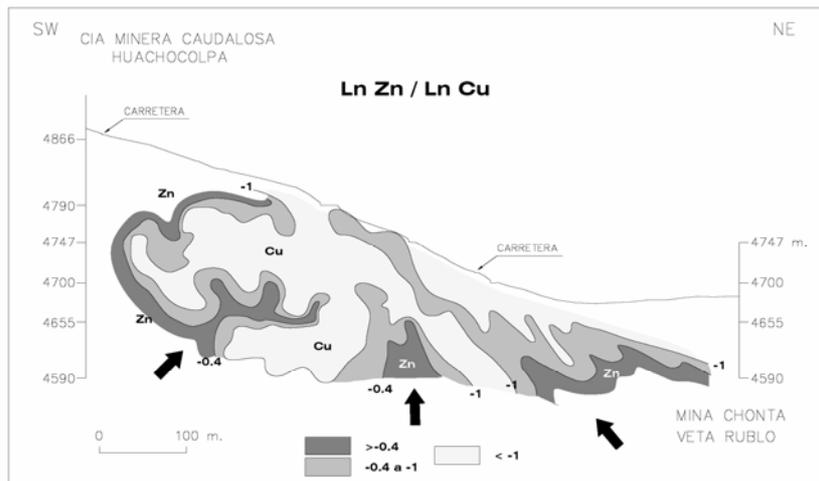


Figure 1. Metal ratios $\ln\text{Zn}/\ln\text{Cu}$

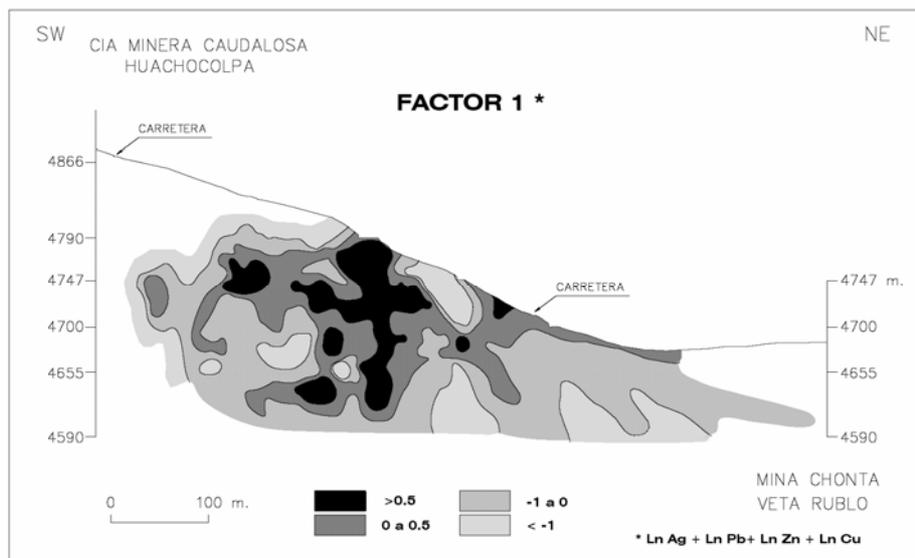


Figure 2. Spatial distribution of Factor 1 (isolines)

Quaternary geological and till geochemical studies in verifying GIS-based prospectivity mapping in the Central Lapland Greenstone Belt, northern Finland

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Keywords: gold, till geochemistry, prospectivity, Central Lapland, Finland

ABSTRACT

During the last decade Au exploration has been very intensive in Finland. Particularly the Central Lapland Greenstone Belt has been in the centre of investigations of foreign exploration companies and the Geological Survey of Finland (GTK). The whole area is proven to have potential for Au mineralization and many Au occurrences and deposits have been already found including three Au mines, Saattopora (1988-1995), Pahtavaara (in operation) and Suurikuusikko (under construction). Of those deposits, Pahtavaara and Suurikuusikko were found by GTK by using till geochemical methods.

GIS based prospectivity analysis is one of the most promising methods for defining the best target areas inside a large exploration area. The main aim is to integrate data from various sources to generate a single response theme, a mineral potential or a prospectivity map by using GIS software with Spatial Analyst and Modelling extensions. High-resolution airborne multi-element geophysical survey data, radiometric, magnetic and electromagnetic ground survey datasets and a nationwide till geochemical dataset (resolution 1 sample/4 km²) are used in the analysis.

Based on the prospectivity mapping many target areas potential for Au exploration have been found in the Central Lapland Greenstone area. Four target areas of them (Vuomanperänmaa, Nuttiot, Petäjäselkä and Lauttaselkä) have been selected for detailed studies. The aim has been to verify and analyse the results of the prospectivity mapping with a detailed fieldwork and geochemical sampling.

Preliminary results of the till geochemistry and heavy mineral analyses indicate that the modelling of prospectivity is an effective method in Au exploration. For example, in detailed studies Au contents at till at the several sampling sites of the Petäjäselkä target area are strongly anomalous (from 200 ppb to 900 ppb). Glacial transport distance of till material is quite short: the distal tail for the anomalous Au contents was only about 100 m from the bedrock source (shear zone hosted Au mineralization). Also, in the Nuttiot target area, where 2-4 gold nuggets per heavy mineral sample (20 kg per sample) in several test pits are found, the transport distance seems to be short.

Assays of bedrock, weathered bedrock and till geochemical samples, and heavy mineral concentrates are incomplete at the moment writing this abstract. The final results will be in use during the early spring 2007. Further studies are ongoing in the target areas including detailed till sampling and diamond drilling.

Geoaccumulation index of heavy metals in estuaries of Autonomous Community of Cantabria (Spain)

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Keywords: Geoaccumulation, heavy metals, sediments.

ABSTRACT

In the Autonomous Community of Cantabria (North of Spain), the highest percentage of population and industry is concentrated along the coastal strip. This fact turns out to be an important antropic pressure over the estuaries of the region. To show the correlation between the industrial activity and the quality state of the estuarine systems, 84 samples of surface sediments were taken along the main estuaries of the Community. The analyzed parameters were the Cd, Cu, Cr, Hg, Ni, Pb and Zn concentrations, determining the pollution grade by Müller's geoaccumulation index (1979). The highest pollution indexes were registered in Suances estuary with I.G. values = 6 (very strongly polluted) for Cd and Zn. On the other hand, San Vicente's estuary didn't show any pollution at all. I. G. = 0 for four of the seven metals analyzed, not showing in any case an I.G. level higher than 2 (slightly polluted).

Geochemical study of element mobility from tailings at the former Rodalquilar gold mine (Almería, SE Spain).

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Keywords: old gold mine, tailings, element mobility, geochemistry

ABSTRACT

The old Rodalquilar mine is a high sulphidation epithermal Au-Ag-Cu ore deposit. The mine was worked irregularly until 1985. Between 1943 and 1966 cyanide leaching was used in treatment of ores producing more than $3 \cdot 10^6$ cubic meters of tailings.

Studies of soils in tailings, and of stream sediments in the Rodalquilar Valley and on the beach (Playa del Playazo), show contents of As, Cu, Pb and Zn that exceed the Dutch norm (Table 1).

(ppm)	As	Cd	Co	Cr	Cu	Hg	Mo	Ni	Pb	Se	Zn
Average	520.6	0.8	4.1	43.9	143.5	0.3	3.2	14.7	670.7	14.5	340.1
Maximum	1410.0	4.6	11.0	90.0	957.3	3.0	5.5	43.2	8743.6	36.0	1869.7
Minimum	61.3	0.3	-	-	53.9	-	1.6	-	131.2	-	76.1
Std. Deviation	322.3	0.9	2.8	25.0	205.9	0.9	1.0	12.6	1543.8	9.8	445.3

Table 1

Groundwater of the Rodalquilar valley also shows high levels of different elements that exceed the Spanish norm for drinking water (table 2).

	Au	Al	Cd	Cu	Ni	As	Se	Sb	Pb	Fe	Mn	Zn	Cr
AS-2	1	60	-	83	645	6.3	25	2.7	2.9	1300	1750	108	34
AS-4	0.1	-	-	10	4	1.6	8	6.4	0.3	500	10	99	13
AS-5	0.1	30	-	10	-	2.8	4	6.3	0.8	1000	3	33	13
AS-6	0.2	2890	5	65	119	16.5	-	2.4	22.3	76300	416	125	6
AS-7	0.1	90	0.2	18	39	13	-	2.4	1.6	10200	115	191	10
AS-9	-	40	2.4	22	42	2.1	-	2.7	21.7	46100	624	297	-
AS-10	-	-	-	14	4	-	-	3.1	8.4	5500	70	83	-
AS-11	0.2	350	-	21	4	224	-	3.9	8.2	800	45	79	11
AS-12	0.1	130	-	17	-	-	-	2.6	1.7	300	107	67	16
SNDW	*	200			20	10	10	5	10	200	50	*	*

Table 2. Groundwater content ($\mu\text{g/l}$) and Spanish norm for drinking water (SNDW)

The column leach test concludes that As is derived from arsenopyrites and arsenical pyrites; Fe from jarosites and pyrites and Pb from anglesite.

Heavy metals in alluvial sediments of the river Drava (Slovenia and Croatia)

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Keywords: geochemistry, alluvial sediments, heavy metals, river Drava

ABSTRACT

The objective of this study was to obtain the geochemical data, especially the content of heavy metals in top soil and bottom soil horizons in the valley of the river Drava. Research work has been focused on downstream from the Austrian-Slovenian border to the confluence of Mura and Drava Rivers. In order to define the outspread pollution the samples were collected perpendicularly to the river Drava flow on each side of the border. 333 samples were collected in 44 soil profiles and analysis of 42 elements was performed.

Preliminary data processing has shown that primary pollution, which is the consequence of historical mining and smelting in Carinthia, has a huge (enormous) influence on chemical composition of alluvial sediments of the river Drava. Sediments of the upper stream area are less polluted with heavy metals due to the stronger river erosion. However the content of heavy metals increases significantly after the river spreading into the alluvial plains of Pannonian Basin. High content of heavy metals is also significant before the confluence of the Drava and the Danube, which is proven by geochemical sampling in the past.

Lithium Pegmatites Exploration in eastern Portugal using Statistical and Geoestatistical Analysis

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Keywords: lithium, pegmatite, stream sediments, statistic, Portugal

ABSTRACT

One of the objectives of this study was to define the spatial continuity of the lithium element and incorporate it into an estimation procedure in order to describe its variability regarding the geology as a tool to prospecting new orebodies. Based on 2529 stream sediment samples an exploratory statistical analysis was carried out which revealed a positively skewed distribution, with a relatively high coefficient of variation (1.0) and which does not compare either to a normal or lognormal distribution. Although in the presence of several outliers the variogram, calculations have established the directions of maximum (N55°W) and minimum (N35°E) continuity which were fitted by nested spherical models. Ordinary kriging was carried out as the interpolation technique. A map with the lithium estimates was combined with the geological map and highlight new possible mineral exploration targets. Major geochemical trends were revealed and show to match well with lepidolite, spodumene and petalite-bearing pegmatites intruded in metasediments.

Early Cretaceous productive and barren granitoids in Gunbuk-Jindong area in Gyeongsang basin, South Korea: Petrogenesis, geochronology and implications for Cu (-Au) mineralization

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Keywords: adakite, Cretaceous granite, Gyeongsang basin, Gunbuk granitoids, Cu(-Au) mineralization.

ABSTRACT

The Gunbuk-Jindong area in the southwestern part of the Gyeongsang basin in South Korea consists of spatially related gabbro, quartz diorite, granodiorite and granite that are intruded into Cretaceous sedimentary rocks of Jindong formation. Majority of Cu (-Au) deposits are located in the region of the Gunbuk granitoids (northern part) whereas the region around the Jindong granitoids (southern part) is almost barren. Mafic enclaves with spectacular magma mixing/mingling textures are present in the Gunbuk granitoids. The mafic enclaves and the host granitoids have geochemical features similar to slab-derived adakites such as high Al₂O₃, and Sr contents, high Sr/Y and La/Yb, but low Y and Yb contents. The Rb-Sr isotopic age of 97.0±8.4 Ma with an initial Sr ratio of 0.7046 recommend that the magma has mantle signature and intruded during Early Cretaceous. In contrast, the Jindong granitoids have low Sr and high Y contents and are typical of calc-alkaline I-type granitoids. The geochemical and tectonic features reveal that adakite-like signatures of the Gunbuk granitoids were generated by the interaction of subducted slab-derived adakitic melts (caused by the thermal effect of ridge subduction) and calc-alkaline magmas. Numerous vein-type Cu (-Au) ore deposits are associated with the Gunbuk granitoids and have features (geochemistry, alteration patterns, vein mineralogy and stable isotope characteristics) similar to the parental magmas of Cu (-Au) deposits associated with adakites. Hence a close genetic relationship existed between the adakitic magmas and associated Cu (-Au) mineralization. The Gunbuk granitoids are considered as the associated pluton of the proximal-type Cu (-Au) Gunbuk ore deposits.

Geochemical characteristics and mineral composition of the PGE-sulfide mineralization in the Mountain Generalskaya massif, Kola Peninsula, North-West Russia

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Keywords: PGE-sulfide mineralization, geochemical characteristics, indicator elements, platinum group minerals.

ABSTRACT

Results of geochemical, mineralogical, and petrographic studies of typical samples of rocks and ores from the Mountain Generalskaya massif are presented. Methods of instrumental analyses (XRFA, ICP-AES, ICP-MS, AAA) were applied to studying chemical composition and contents of trace elements. Methods of optical and electron microscope studies of polished sections were used for determination of sulfides and platinum group minerals. It has been shown, that high contents of S, Cu, Ni, Co, Te, Pd, Bi, Pt, As, Au, and Ag are typical for mineralized gabbro-norites, whereas P, Ti, V, and Mn contents are relatively low. The main associations of indicator elements have been determined, including indicators of the PGE-bearing sulfide mineralization (Pt, Pd, Te, Bi, Cu, Ag, As) and related sulfide nickel-cobalt mineralization (S, Ni, Co). The detected platinum group minerals belong to tellurobismuthides, arsenides, sulfoarsenides, etc., and the relationship of mineral and chemical compositions of the studied samples is discussed.

Statistical analysis of ballclays chemical composition from the Oliete basin (Teruel, NE Spain)

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Keywords: Oliete basin, ball clays, Ceramic Industry, Cluster analysis.

ABSTRACT

The Oliete basin (Lower Cretaceous, ENE Teruel, Spain) is one of the most important areas for the supply of ball clays for the production of red and white stoneware in the Spanish ceramic industry of tiles for walls and floors. The mineralogical assemblage of the studied material are: + kaolinite, + illite, + quartz, ± other minor components (including calcite, dolomite, siderite, pyrite, hematite, feldspars and smectite in very low amounts). The performed statistical analysis of chemical data included: descriptive statistics and cluster analysis. The cluster analysis of chemical data provided 3 main groups: C3 with the higher mean SiO₂ contents (66%) and the lower mean Al₂O₃ contents (20%), C2 with lower SiO₂ content (48%) and higher mean Al₂O₃ content (28%), and C1 with medium values for SiO₂ and Al₂O₃ mean contents. The main applications of these materials are refractories, white ceramics and stoneware red ceramics and stoneware, and heavy ceramics (including red earthenware, bricks and roof tiles), and components of white Portland cement and aluminous cement.

Session 10:
Litogeochemistry

Hydrothermal alteration zonation in regolith, Vera-Nancy epithermal gold deposit, Pajingo, Queensland, Australia

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Keywords: alteration, low sulphidation, weathering, metasomatism, regolith

ABSTRACT

The mineralogy and geochemistry of regolith at the Carboniferous Vera-Nancy low-sulphidation epithermal Au deposit can be used to discriminate weathered, hydrothermally altered and unaltered rocks. Bedrock zoning about the quartz vein consists of proximal silica-pyrite alteration (quartz-pyrite-siderite-illite), distal argillic alteration (illite-kaolinite-ankerite), and regionally-extensive 'background' propylitic alteration (chlorite-calcite-albite-quartz) in andesite. Deep weathering products are kaolinite, quartz and Fe-oxy-hydroxide minerals, with subordinate amounts of illite, interstratified clays, and smectite. Elevated concentrations of Au, As, Sb and Mo readily identify silica-pyrite alteration in regolith. Regolith developed from propylitic alteration contains smectite and interstratified chlorite-smectite. Regolith developed over argillic and silica-pyrite alteration zones contains illite and illite-smectite (I-S). The I-S is illite-rich, and both nearest-neighbour (R1 – ISISISIS) and long range (R3 – IISIIIS) ordering exist. Finally, larger kaolinite crystal thicknesses (50-60 nm) occur over argillic and silica-pyrite alteration zones than over propylitic alteration zones (< 40 nm).

**Lithogeochemical characterization of hydrothermal alteration
associated with gold mineralization in the Golden Mile dolerite,
Fimiston Superpit, Kalgoorlie, Western Australia**

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Keywords: Golden Mile, dolerite, Fimiston, orogenic lode gold, molar
element ratios, lithogeochemistry, hydrothermal alteration, alteration
indices

ABSTRACT

The Fimiston Superpit, Australia's largest gold mine, is an orogenic lode gold deposit hosted primarily by the Golden Mile dolerite, a thick differentiated mafic sill with a >25 km strike length. In this mature mining camp, exploration potential is significant, but is likely deep. Development of lithogeochemical exploration parameters that describe the nature and quantify the intensity of hydrothermal alteration about Au mineralization will provide advantage in future exploration. Mineralogical and geochemical analyses indicate that proximal hydrothermal alteration about the Au veins consists of a muscovite-pyrite-ankerite-albite assemblage produced by K, S, CO₂, Na and H₂O metasomatism; distal alteration consists of a chlorite-calcite assemblage produced by only H₂O and CO₂ metasomatism. The amounts of the various metasomatic additions associated with hydrothermal alteration are very much dependent on the initial host rock composition. Molar element ratio alteration indices have been identified that are specific to each style of alteration but independent of host rock composition, and can be used as exploration parameters to discover additional resources.

Mercury vapor dispersion from La Peña-El Terronal Mine (Asturias, Spain)

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Keywords: Mercury, ZAAS-HFM, Asturias, mining environment.

ABSTRACT

The survey was carried out (summer 2005), in La Peña and El Terronal mercury mine, close to the city of Mieres (NW Spain), using a LUMEX RA-915+ analyzer for continuous Hg measurements, with detection limits of 2 ng·m⁻³. At the regional scale, the average Hg concentration in air corresponds to 119.28 ng·m⁻³, with 35,279 measurements. Background, eliminating values over 15 ng m⁻³ (5,721 values) was 6.05 ng·m⁻³. The identified sources of atmospheric mercury in La Peña-El Terronal mine are decommissioned rotary furnaces, dumps of calcines from the metallurgical plant, and a chimney-channel used to transport roasting smoke to the top of San Tirso Valley. Mercury contents of calcines reach 27,350 mg·Kg⁻¹, while soils into the chimney-channel have 18,000 mg·Kg⁻¹. The mean concentration of atmospheric mercury in the mine area was 3,708 ng·m⁻³, and the highest value was 74,418 ng·m⁻³, measured underneath the rotary furnaces at El Terronal. Near the calcines dump the values reached 17,479 ng·m⁻³, with schuetteite present on the soil surface. Values measured in the chimney were up to 18,081 ng·m⁻³.

Supergene gold at the Golden Virgin Deposit, Western Australia

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Keywords: supergene enrichment, mineralogy, exploration, nanoscience.

ABSTRACT

The Golden Virgin pit, south of Southern Cross in Western Australia, is a small gold deposit where primary mineralisation occurs as thin high grade quartz veins, blanketed by up to 30 m of weathered cover. The veins near the base of the pit contain visible primary Au in the quartz and have weathered fracture surfaces lined with different generations of secondary iron oxides, clays and sulphates, together with a rich population of supergene Au crystals. This supergene Au occurs as nanoplates of ultra thin, euhedral, single, pure crystals. These crystals are found to be closely associated with salt crystals and intergrown with barite, supporting the premise they were precipitated from the saline and slightly acid groundwater. This gold occurrence points to rapid deposition of supergene gold rather than formation over prolonged timescales.

**Geochemical controls on very coarse-grained Au mineralization
within sheeted quartz veins at the mesothermal Callie Au deposit,
Dead Bullock Soak, Northern Territory, Australia**

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Keywords: gold nuggets, orogenic gold, oxidation-reduction, Fe trap

ABSTRACT

Quartz veins cutting fine-grained, carbonaceous, Fe-rich clastic sedimentary rocks host extremely coarse-grained gold mineralization in the Callie Au deposit. Low temperature quartz-chlorite-calcite veins are largely barren of coarse gold nuggets, whereas higher temperature quartz-albite-K-spar-chlorite-biotite-apatite-calcite-epidote veins contain abundant coarse gold nuggets spatially associated with epidote and calcite. These nuggets occur at vein intersections with coarse-grained Ti-rich laminae at the tops of turbidite beds (E Bouma facies) that underwent textural inversion during metamorphism. These laminae now contain poikiloblastic ilmenite that has been partially replaced by rutile, probably by the metasomatic reaction: $\text{FeTiO}_3 + 2 \text{H}^+ \rightarrow \text{TiO}_2 + \text{Fe}^{+2} + \text{H}_2\text{O}$. This liberated Fe⁺² that migrated into adjacent vein fractures and underwent oxidation, triggering epidote precipitation and acting as the redox couple to cause reduction and precipitation of Au. Oxidation of organic carbon to carbonate may also have acted as a redox couple for Au precipitation, and is responsible for the development of de-carbonized corridors surrounding high density regions (anticline axial planes) of high temperature sheeted quartz veins.

Use of the PGE in the Discrimination of Nickel Gossans

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Keywords: Platinum metals; nickel gossans; discrimination

ABSTRACT

Prolonged chemical weathering of Ni sulfide mineralization, hosted by komatiitic rocks in Western Australia, has often led to the production of ferruginous material that is indistinguishable from the products of lateritization or the weathering of rocks containing iron sulfides using standard chemical screens. (The most useful chemical screen for Ni gossans in Western Australia is Ni-Cu-Co-Cr-Zn-Mn, which can be successfully used in 90% of cases to discriminate Ni gossans from the Fe-rich weathering products of other rocks). The Pd and Ir contents of komatiitic rocks in Western Australia vary from 1 to 1000 ppb and 2 to 400 ppb, respectively, as their Ni contents vary from 0.2 to 10 wt % Ni; the correlations between the three metals is excellent. Iridium was completely immobile and Pd only slightly mobile during the weathering of the Ni sulfide-bearing rocks. As rocks with no Ni sulfides in them generally have very low Pd and Ir contents, these PGE are 100% successful in discriminating Ni gossans from other Fe-rich weathering products.

**Detection of pegmatite-hosted Sn-Ta mineralization in southwest
Western Australia using stream sediment geochemistry**

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Keywords: Stream sediment, Greenbushes, pegmatite, geochemistry

ABSTRACT

The Early Proterozoic Greenbushes Sn-Ta-Li deposit in the SW of Western Australia is the world's largest producer of tantalum and spodumene. A pilot project has been carried out to determine if stream sediment chemistry can detect known mineralization. The project has involved analysis of the organic-rich <180 µm, and quartz-dominated < 0.5 mm and < 2 mm fractions of sediment from streams directly draining the deposit, and from areas of no known mineralization. Using the latter to determine background levels, pegmatite-hosted mineralization is indicated by anomalous Li + Ta in the < 180 µm fraction using a Na₄P₂O₇ digest, Li + Sn for an aqua regia digest of the < 0.5 mm fraction, and Li + Ta for fusion + acid digest of the < 2 mm fraction. The pilot study has shown the effectiveness of using stream sediment chemistry for mineral exploration in an environmentally sensitive area, as well as highlighting the likelihood of pegmatite-hosted mineralization along the extension of a regional shear zone.

Trace element and Pb and S isotope results from tree cores over a Proterozoic VMS prospect.

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Keywords: Zinc, copper, lead, sulphur isotopes, tree geochemistry.

ABSTRACT

Tree cores from black spruce trees (*Picea Mariana*) growing in thinly developed, humic soils were sampled over the Proterozoic Harmin VMS Zn-Cu prospect, Manitoba to discriminate mineralised bodies buried ca. 45 – 60 m below Phanerozoic cover from background signals. Pre-1935 heartwood from the trees was analysed by LA-ICP-MS for trace element geochemistry and by solution digestion ICP-MS for S and Pb isotope analysis in an effort to see through post-smelter contamination in the district. The LA-ICP-MS identified anomalous levels of Zn, Cu, Cd and Co above the mineralized zone and another alteration zone not known to be associated with Zn-Cu mineralisation. Samples over the mineralized zone were found to have low $^{207}\text{Pb}/^{204}\text{Pb}$, $^{206}\text{Pb}/^{204}\text{Pb}$ values and low $\delta^{34}\text{S}$ values that are comparable to the Pb and S isotope values from Zn-ore in the district. In contrast, background samples had higher $^{207}\text{Pb}/^{204}\text{Pb}$, $^{206}\text{Pb}/^{204}\text{Pb}$ values and higher $\delta^{34}\text{S}$ values that reflect background soils and barren sulphide bodies.

Geochemical characteristics of barren and mineralized intrusives in the Geodo area, Taebaeksan Basin, South Korea: implications for adakite magmatism and Fe-Cu(-Au) mineralization

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Keywords: productive granitoids, adakite, Taebaegsan basin, Geodo skarn ore deposit, Fe-Cu(-Au) Mineralization.

ABSTRACT

The Taebaegsan basin within the Korean Peninsula encloses a variety of ore-deposit types such as veins, skarns, carbonate replacement ore, carlin-like ores, and alaskite, pegmatite and greisen ores from Early to Late Cretaceous. The Geodo Fe-Cu(-Au) skarn deposit in this basin host significant ore minerals such as magnetite, chalcopyrite, native gold and electrum. A range of intrusives are spatially related to this deposit which is noted for exclusive Cu mineralization in Taebaegsan basin, including granodiorite, quartz-monzodiorite, and two-mica granite. The quartz-monzodiorite and granodiorite show features of I-type, magnetite series granite and have high Fe₂O₃/FeO ratio. The granodiorites display adakite-like geochemical signatures such as high Sr/Y (23-43) and LaN/YbN (16-40) ratios, low Y (13-24) and Yb (1.1-2.0), highly fractionated HREEs and absence of Eu anomaly. They also host significant Early Cretaceous (~100 Ma) Fe-Cu(-Au) mineralization. However, the quartz-monzodiorite is less evolved than the granodiorite. The two-mica granite display features of s-type, ilmenite series magmatism and represents the evolution of magma under a reduced environment and is more or less barren. In short, the granodiorite has adakite-like geochemical signatures, oxidized environment of magma generation and are chemically similar to many Fe-Cu-Au skarn related granites. The composition of skarn minerals in the Geodo Fe-Cu(-Au) deposit spatially associated with granodiorite suggests the mineralization under oxidized environment. It is widely documented that the adakite-type magmas are often associated with Cu-Au mineralization under high oxygen fugacities. We interpret here that the significant Fe-Cu(-Au) mineralization in the Geodo area in the Taebaegsan basin is the effect of adakite-like magmatism of the granodiorite.

Application of the multidisciplinary methodology in the study of apatite for the diamond prospecting and potential evaluation

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Keywords: diamond, exploration, apatite.

ABSTRACT

Based on inclusion studies, the most useful indicator minerals for assessing diamond-potential are garnet, chromite, ilmenite. However, some perspective diamond objects are poor in the traditional indicator minerals. In order to estimate possibility to use apatite for exploration purpose we studied distribution of phosphorus in kimberlites, lamproites, etc., as well as morphology, character of surface of apatite crystals and grains, its chemical compositions in rocks of different genetic types. On the basis of the data obtained it was inferred that apatite has perspective as an indicator mineral. Phosphorus is common component in primary diamond-bearing rocks, and a number of morphological and chemical peculiarities of apatite can be use to distinguish its primary genetic type in placers and determine possible locations of its source. It is suggested to use a complex of the spectroscopic characteristics of apatite for the pathfinder search of perspective diamond-bearing objects.

**Geochemical exploration through bedrock: examples from the
Carboniferous Maritimes Basin of Eastern Canada.**

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Keywords: partial extraction, cover rocks, buried mineralisation

ABSTRACT

In Canada most applications of partial extraction geochemistry have been in areas with thick sheets of glacial drift cover. Few studies have addressed the situation when bedrock cover masks buried mineralisation. In Nova Scotia the traditional methods of soil, till, stream sediment -80 mesh and heavy minerals, lake sediments and several vegetation media all easily locate most deposits which outcrop at surface within the Maritimes Basin. Multi media studies at Yava Pb and Jubilee Pb-Zn all show anomalous response in these media but to a varying degree. The exception which proves the rule is at the Canfield Creek Cu-Ag deposit which was found using wildcat drilling of a geologist's hunch and which lies beneath 100m of bedrock sediments and has no surface geochemical expression at all. Partial Extraction soil technology produces a clear resolution of the location of the Canfield Creek deposit and the broad ore controlling processes not easily seen by other methods. Studies at the Jubilee deposit at outcrop and then progressively down strike and under cover were able to locate the ore zone beneath a cover of 200m of anhydrite.

**Geochemical and mineralogical soil study of the Veramonte vineyard,
Casablanca Valley, central coastal Chile**

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ABSTRACT

The results of a pilot geochemical study of soils from four 70 cm deep pits within the Veramonte Vineyard, Casablanca Valley, central coast of Chile, are presented. A total of 3 to 4 samples from different soil horizons were taken from each pit. Each sample was ambient dried and sieved to the 60-80, 80-120, 120-200 and <200 mesh fractions, for independent analysis of subsamples. Soils are developed from surrounding weathered tonalitic and granodioritic biotite and amphibole Jurassic intrusives. Major and trace elements were analysed by ICP-AES (4 acid digestion). Mineralogical characterisation and measurement of pH and Eh were performed on separate subsamples from each size fraction. Average soil pH values are near neutral (~ 6) and Eh average values are low (~ 273 mV); biotite is the most common mineral (25%) and most minerals show high degrees of oxidation with abundant limonite and clay mineral coatings. Upper soil levels (10 cm) are organic-rich, showing bad granulometric selection; deeper soil levels are formed by gravely, coarse, medium and fine sands, silts and clays (10 – 45 cm), beneath 45 cm, in the C horizon, abundant granitoid blocks occur. Different soil levels show nutrient cation differences (K⁺, Ca²⁺, Fe²⁺, Mg²⁺, Mn²⁺, Zn²⁺) and differences of colour. Soil differences within the vineyard may have implications to grape production and quality; to wine properties; to land selection criteria, and to characterisation of “Terroir”.

Geochemistry and mineralogy of mine wastes derived from copper mining in Asturias (NW Spain)

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Keywords: mine wastes, copper mining, Asturias.

ABSTRACT

Since prehistoric times (1500 B.C.) and up to the middle of the last century, Cu was intermittently mined in Asturias. A total amount of 21 Asturian Cu mine sites are documented, being the second half of the XIX century the most productive period. The three most significant mines were the “Aramo” mine, located in Riosa (south-centre of Asturias) and the “El Milagro” and “Delfina” mines, at the East of the region. The mineralization exploited in these mines fit to the epithermal genetic model, as the ore is filling fractures and karstic voids in carboniferous limestones and dolostones, constituting generally high-grade but reduced areas. In order to assess the environmental effects of abandoned metalliferous mines in Asturias, the aim of this study is to characterize the mineralogy and geochemistry of the mine wastes accumulated in spoil heaps. More than 20 different ore minerals (Cu, Fe, As, Sb, Ni, Hg and Co species, mainly sulphides, arsenides and carbonates), were identified. Mine wastes have proven to contain up to 9263 mg·kg⁻¹ Cu, 1100 mg·kg⁻¹ As, 549 mg·kg⁻¹ Co and 840 mg·kg⁻¹ Ni.

Geochemistry of Soils over a Buried Porphyry System, Atacama Desert, Chile.

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Keywords: Porphyry Cu, Atacama Desert, Chile, Soil geochemistry, SDP

ABSTRACT

Detailed soil sampling was undertaken in alluvial gravels over a buried (~170m) weakly mineralised porphyry system in the Atacama Desert of N. Chile. Soil samples sieved to $-250\mu\text{m}$ were analysed for: multiple elements by aqua regia ICP-MS; pH; N₂, conductivity and organic gases by SDP of the $-2\mu\text{m}$ clay fraction. To ensure a stable geochemical background sampling was carried out parallel to the direction of gravel transport with the results defining a distinct Na-K-B-N₂-Cs-Li-Ag-Conductivity anomaly above the mineralised porphyry system. Anomaly formation is believed to be related to ground water movement vertically through fractures in the gravels. The restricted lateral and irregular distribution of the anomalous elements limits the applicability of such techniques on a regional basis. No distinct porphyry element suite was identified possibly reflecting the low metal tenor of the mineralisation. SDP analysis produced a distinct single compound C₂H₆ anomaly, however this is considered to represent interference of N-compounds (e.g. NO) during analysis.

**Gold dispersion in the calcrete zone, Girilambone region,
western New South Wales, Australia**

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Keywords: calcrete, gold dispersion, exploration, regolith

ABSTRACT

Regolith carbonate (calcrete) occurs in many semi-arid areas and in Australia it has been successfully used as a sampling medium in geochemical exploration for gold. This association of gold with calcrete is thought to reflect concentration of organically mobilized gold in carbonate saturated groundwater zones. In the Girilambone region of western New South Wales dispersed calcite-dolomite occurs within a zone of variable thickness in the upper 10 m of the regolith. The highest gold concentration in a profile is not necessarily associated with the position of maximum calcrete development. Typically it is at the top of the calcrete-bearing zone. The association of gold with calcrete in this region appears to reflect a chemical environment within both transported and in situ regolith that is conducive to precipitation of both carbonate and mobilized gold, rather than a direct control on gold fixation by calcrete. Sampling the regolith carbonate zone, particularly the upper part, should be as effective for detecting mobilized gold anomalies as sampling the calcrete itself.

**Influence of ironworks, mining and metallurgy on distribution of
chemical elements in the Stavnja valley (Central Bosnia and
Herzegovina)**

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Keywords: ironworks, pollution, soil, sediments, attic dust, Vares, Bosnia
and Herzegovina

ABSTRACT

The objective of this work is the study of the distribution of chemical elements in soil, stream sediments, alluvial sediments and attic dust in the Stavnja valley (Central Bosnia and Herzegovina) for the identification of anthropogenic and geogenic element sources in an old metallurgic area. Samples of topsoil (0-5), bottom soil (20-30 cm), stream sediments and attic dust were collected along the river Stavnja valley (cca 30 km) and analyzed on 42 elements.

For anthropogenically distributed elements (Ag, Fe, As, Bi, Cd, Cu, Mo, Mn, Pb, Sb, Sn, W, Zn, Hg) is important that the concentrations in attic dust several times exceed the concentrations in soil and stream sediments. Higher concentrations above elements are determined around ironworks therewith in autochthonous soils concentration decrease by distance along the valley of the river Stavnja, what is consequence of transportation of air pollution. Extremely high values in alluvial sediments of underflow the river is consequence of river transportation.

Lithogeochemistry of the volcanic sequence hosting the Río Tinto ore deposit (Iberian Pyrite Belt, Spain).

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Keywords: Río Tinto, lithogeochemistry, volcanic rocks, immobile-element, massive sulphides, IPB, Spain.

ABSTRACT

The complex geological setting of the Rio Tinto mine makes difficult to define its general stratigraphic sequence and the nature of the ore hosting rocks. Based on geological data and immobile-element ratios, two main volcanic units have been identified. The lower Mafic-Siliciclastic Unit consists of basaltic-andesite and high Ti-Zr basalt that show a tholeiitic affinity. The overlying Felsic Unit hosts the massive sulphides and is volumetrically dominant. It is formed by massive and volcanoclastic rocks with dacitic to rhyodacitic composition. HREE, Al, Y, Zr, Ti and Yb contents of all the felsic rocks are similar, suggesting that they derived from a single magmatic pulse. Thus, the geochemical data support that the volcanoclastic rocks interbedded with the massive ones are not exotic distal aprons but product of the synvolcanic erosion of the coetaneous sills and domes. All these rocks have been affected by a widespread hydrothermal alteration related with the formation of the massive sulphides. The TiO₂ vs. Zr plot suggests that both the mafic and felsic rocks have had an analogous alteration, dominated by chloritic and sericitic assemblages.

Metal element distribution in two river basins of contrasting lithology

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Keywords: Geochemical exploration, soil use, discriminant analysis,
watersheds

ABSTRACT

122 surface soil samples (0-2 cm) were taken from two sub-basins of the Anllóns river, a half from schist (the Anllóns upstream watershed), and the other half from gabbros (the river Grande basin). In each basin samples were distributed between culture soils (23%), forested soils (29%), pasture (20 %), road talus (14 %) and river banks (14 %). The total element concentrations were determined by Energy Dispersion XR Fluorescence Spectrometry. The river Anllóns basin has a more complex geochemical composition than the river Grande basin. After a complete statistical study, we can conclude that lithology is the main factor that differentiates the distribution of the metallic elements in soils, whereas the soil use does not affect the element distribution. Discriminant analysis shows that the main elements that differentiate the basins are Rb, Cr, Mn, Cu, Zn, Nb, Zr and Ni. Also, correlation analysis indicates that, in the two basins, the elements Al, Cr, Ni, Cu, Ga are positively related to Fe. Additionally, Y or Ti are related to Fe in the the Grande basin and the Anllóns basin, respectively.

The southern Nova Scotia wine terroir: A geological and pedological study of the cation exchange capacity and Ca/Mg ratios in vineyard soils

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Keywords: wine terroir, cation exchange capacity, Ca/Mg ratio, Nova Scotia

ABSTRACT

Terroir involves five environmental factors that affect wine grapes (meteorology, geology, pedology, physiography and viticulture). Variations in terroir explain why different vineyards produce wine of different quality and taste when identical grapes and processing methods are employed. The complex bedrock geology, pedology, and surficial geology of southern Nova Scotia influence the local terroir, leading to the production of diverse wine in the region. Variations in cation exchange capacity (CEC) exist among the vineyards studied. The LaHave Valley exhibits high CEC variations as some vineyards occur on thin local tills derived from sulphide-rich metasedimentary rocks, whereas others occur on drumlins derived from less sulphidic regional sources. The Annapolis Valley also exhibits high CEC variation due to its complex bedrock and surficial geology. Ca/Mg ratios, which control the extent of pedon development, have been used to compare the soils in NS with those in other wine regions. The Ca/Mg ratios in southern Nova Scotia range 4 to 6, and are comparable to ratios in other well known wine regions, such as the Sonoma Valley, California.

Session 11:
Analytical geochemistry

Innovation and Development in Analytical Geochemistry – Is the Future as Bright as the Past?

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ABSTRACT

In this presentation I am going to talk about innovation and development of analytical geochemistry with an emphasis on activities in the commercial laboratory sector. To understand where we are going, it is useful to review the history of where we have come from. The development of analytical instrumentation for elemental analysis and the commercial laboratory business are closely tied stories. Overlaid on this is the role played by Geological Surveys and government research organizations in exploring new techniques, new instruments, new methods and most importantly disseminating this information. The vigour of the last fifty years can be contrasted with the current state of the industry where we see funding cuts to government agencies, stagnation in the development of instrumentation for elemental analysis and a decrease in information sharing. However companies and industries do not survive without innovation. In the second half to the presentation, I will cover some of the new ways technical developments are happening.

Round-robin results for the analysis of vegetation in Canadian commercial geochemistry laboratories

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Keywords: analysis, vegetation, plant, digestion, ICP-MS

ABSTRACT

Ten milled vegetation samples (spruce, alder, wild pear) and six control reference materials (e.g. NIST's 1575a pine needles) were sent to four Canadian commercial laboratories for different elemental analytical packages. These included: oxidizing digestion of the dry material (\pm HF) followed by ICP-MS; analysis of the dry pellet by instrumental neutron activation; digestion of the ashed material followed by ICP-MS; and fire assay for Au, Pt and Pd on several enriched samples collected at the Rottenstone Deposit (Sask). The samples were submitted blind, in triplicate and randomized. Emphasis was put on analysis of the dry rather than the ashed material to judge (1) whether the various digestions used were adequate to decompose the organic components and thus liberate elements of interest, and (2) if today's generation of ICP-MS has the necessary sensitivity to analyse this type of sample. This paper discusses these results and provides recommendations to both analytical laboratories and geoscientists wishing to use biogeochemistry in mineral exploration.

Dispersion patterns of gold and pathfinder elements in different modes of presence in soils: Pervomaysky area, Far East of Russia

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Keywords: geochemical exploration for gold, soils geochemical sampling, dispersion patterns, different geochemical exploration techniques.

ABSTRACT

This presentation shows and discusses results of geochemical exploration for gold carried out in the Pervomaysky area situated in the Far East of Russia. Three geochemical methods were used: (1) routine lithogeochemical survey with the usage of soil and stream sediment sampling and determination of total contents of elements in soils (fraction < 1 mm); (2) lithogeochemical survey by means of Method of Analysis of Superfine Fraction (<10 mm) of soils (MASF); (3) soil sampling with sequential extraction and analysis of water-soluble forms of elements from soils and stream sediments. Contents of indicator elements were determined using ICP-AES and ICP-MS, and geochemical data processing and interpretation conducted with the help of original algorithms. The comparison of resulted geochemical data and maps obtained by these different techniques is discussed. It has been shown that most reliable prediction of gold mineralization can be distinguished by getting together data obtained by 2-nd and 3-rd geochemical techniques.

The fundamentals of Aqua Regia digestion

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Keywords:

ABSTRACT

Aqua regia has been employed for hundreds of years for the total dissolution of Au, Cu and Ag. Its ability to both oxidize and retain gold in solution has seen it employed for geochemical exploration, particularly in surface environments. However, there remain questions surrounding the ability of the digestion method to determine accurate and precise analytical results. A central composite design (CCD) is used to evaluate the effect of varying the reaction conditions and to examine how the leach effectively operates. The detrimental influence of sulfides, organic material and carbonate are examined evaluated as is the ability of the leach to return certified values over a range of concentrations. There has also been a trend towards using aqua regia digestion as a means of determining the concentration of large suites of elements from geological samples. A CCD is also presented to examine the extraction of many other elements from a range of geological materials. The use of optimal reaction conditions combined with appropriate sample preparation makes aqua regia digestion a powerful tool for the evaluation of many elements, not just Au.

Field evaluation of waste rock geochemical reactivity, and its role in providing comprehensive dump characterization

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ABSTRACT

A common concern in mine closure when considering geochemical characterization is the assessment of how representative a sample set is of overall geochemical conditions within a given unit such as a waste rock dump. Traditionally an approach that requires a minimum number of samples proportional to tonnage or volume has been applied or a variable intensity sampling grid, either regular or irregular in distribution has been applied. Although both approaches have gained acceptance there are limitations in both that compromise the overall integrity of a sampling campaign.

Selecting a random number of samples proportional to overall waste rock mass or volume has the inherent risk that some units may not be sampled, particularly small units that could exert a stronger control over drainage water quality than a more dominant rock type that was chemically less reactive. Similarly development of a grid approach may be biased towards material dumped at a particular time or sample material segregated on the dump. In addition the full assessment of validity cannot often be made until after sample analysis possibly resulting in additional expense and delay in having to re sample under represented units so as to provide an adequate coverage.

Such issues prompted the authors to develop a campaign strategy in the sampling of waste rock that utilizes geological and mineralogical mapping with semi-quantitative geochemical field reactivity testing. This provides a rapid characterization of not only the geological characteristics of the units comprising the dump but also allows the evaluation of variation in geochemical reactivity within each of the major rock units. Thus, by a field method an adequate laboratory sample set can be collected that fully characterizes the geological components of the dump and the range of variable geochemical reactivity observed for each of the geological components.

The methodology will be illustrated by recent waste rock evaluation studies conducted in Idaho (Atlanta) and Nevada (Tonopah and Robinson)

The Effect of the Kızılcaören Complex Mineralization (Fluorite-Barite-Thorium-Rare Earth Elements) on Groundwaters in Kızılcaören (Beylikova) Eskisehir, NW, Turkey

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Keywords: Fluoride, groundwaters, REE, radioactivity

ABSTRACT

The current study is carried out to investigate the effect of the Kızılcaören complex mineralization (Fluorite-Barite-Thorium-Rare Earth Elements) on the groundwaters in the Kızılcaören area. The complex mineralization is located at approximately 2 km south of the Kızılcaören area where dental fluorosis is common. 34 groundwater samples were taken from the mining area and its vicinity. The samples were analyzed for major and minor hydrogeochemical parameters along with natural radioactivity levels (gross-alpha (α) and -beta (β) activities). The results indicate that the groundwaters in the region can be classified as Ca-HCO₃, Ca-Na-HCO₃, Ca-Mg-HCO₃ type of water in the decreasing order, respectively. The major cation (Ca²⁺, Mg²⁺, Na⁺) and anion (HCO₃⁻, SO₄⁼ and Cl⁻) concentrations of the samples are below the WHO and US EPA drinking water guidelines. The concentration of Ba, F, U, Rare Earth Elements (La, Ce, Y) in the groundwater samples from the mining area are significantly higher than those taken from the pristine water samples. This is especially true for the fluoride concentration. The fluoride concentration of the samples taken from the mining area and its near vicinity are higher than 1.0 mg L⁻¹. The gross- α and - β activity concentrations ranged from 0.006 to 0.12 Bq L⁻¹ and from 0.007 to 0.146 Bq L⁻¹, respectively. The highest gross- α and - β activity values were determined in the samples from the mining area. Our results suggest that the mineralization dominantly controls the fluoride concentration relative to Ba, U, La, Ce and Y in the groundwaters.

Laboratory methods for microdiamond recovery

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Keywords: Microdiamonds, caustic fusion, kimberlites

ABSTRACT

The use of microdiamond data to predict the diamond grade of kimberlite bodies prior to the extraction of mini-bulk or bulk samples has become an intrinsic part of diamond exploration. Whereas the extraction of kimberlite indicator minerals from soils and tills has been described in considerable detail there is very little published on methods for microdiamond recovery. The aim here is to compare current methods used for microdiamond extraction and to describe in some detail the method most commonly used. This uses NaOH fusion to dissolve kimberlite rock leaving a residue of refractory minerals and diamond. The residue is further reduced by a variety of techniques to under 5g from an initial starting weight of about 8 kg. Stringent precautions are required to prevent microdiamond loss and the quality control measures through sample spiking are described. The petrography of kimberlites and other diamond bearing rocks can vary considerably, and caustic fusion methods need to be adjusted to successfully dissolve difficult matrices.

Application of a single extraction method to the determination of the organic mercury in sediments

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Keywords: organic mercury, extraction, sediments.

ABSTRACT

Monitoring organic mercury concentrations in natural sediments and their variability over space and time are of environmental concern. This work describes a rapid and simple method for determination of the organic mercury fraction in natural sediments. The proposed method is based on a previous single digestion stage using a CuBr₂ solution in HNO₃ media to release quantitatively the organic mercury compounds from the solid matrix, followed by its selective extraction into dichlorometane. After the separation of the organic phase, a reextraction into aqueous media using a N-acetyl-L-Cysteine solution allows the direct determination of the extracted organic mercury by electrothermal atomic absorption spectrometry with the direct mercury analyser DMA-80. Reagent concentrations and time were optimised for the different steps. The method was validated by the analysis of CRM-580 estuarine sediment certified reference material.

The use of Pb Isotopes to Trace the Source of Metals in Geogas

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Keywords: Geogas survey, Pb isotopes, source of metal in geogas

ABSTRACT

Geogas phenomenon has been attested since the use of aquatic collectors and ICP/MS analysis (Wang, in press). People doubt the geogas, however, because of uncertainty of its formation mechanism. The study where the geogas metals came from is helpful to understand the formation mechanism of geogas. Using the active method with a liquid collector and ICP-MS, over 40 elements in geogas samples were analyzed in the IGGE Central Lab. The samples following elemental determination were then analyzed for Pb isotopes by HP4500 ICP-MS through optimizing the operating parameters in Xiamen University (Zhuang et al., 1999). The Pb isotopes in loess, red layer, wallrocks, mineralized rocks and ores were determined by VG?354 spectrometer in the Institute of Geology and Geophysics, CAS. The Jiaolongzhang polymetallic deposit is covered by transported loess (50-80 m) and red soil (20-70 m). The test results on Line 48 in the deposit show that 'gaseous' forms of elements do exist in soil gas and can be used as a powerful mineral exploration technique. The Pb isotopes in geogas give evidence that some metals in anomalous samples might originate from deep orebodies and therefore, support that geogas survey can play an important role in mineral exploration in overburden.

**A comparison of traditional and novel partial geochemical
extractions at a Cu-Zn soil anomaly in Victoria, Australia.**

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Keywords: exploration performance, minimum probability, partial
digestion, selective extraction.

ABSTRACT

Partial geochemical extractions have been used as geochemical exploration tools to detect soil anomalies associated with buried mineralization. High geochemical contrasts are common in such surveys, but their exploration accuracy has been questioned. Two near-total digestions (four acid, aqua regia), and eight partial digestions (LocatOre® - a bacteria-moderated leach, hydroxylamine hydrochloride, Mehlich 1 - weak HCl and H₂SO₄, deionized water, and four new geochemical extractions) have been tested using of thirty <63 µm soil samples from Wartook, Victoria, Australia with known Cu and Zn anomalies to assess the exploration accuracy and geochemical contrast of the partial leaches. Minimum probability statistics were used to quantitatively compare the performance levels of each digestion/element. All partial extractions exhibit elevated Cu and Zn concentrations in the anomalous zone, but the four new partial leaches, and the Mehlich 1 and hydroxylamine hydrochloride digests, exhibit the best exploration accuracy and geochemical contrast. Results indicate that many (most?) partial extraction techniques may be effective in exploring for hydromorphically dispersed element concentrations.

**Applicability of Radon monitoring as a screening methodology for
NAPL-contaminated sites**

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Keywords: Radon; NAPL; Emanometry; site characterization;
prospecting.

ABSTRACT

Screening methodologies aim at improving the knowledge about subsurface contamination processes before expensive intrusive operations, i.e. drilling and core-sampling the vadose zone and installing wells to collect samples of groundwater and free-phase product, are implemented. Field tests carried out at a landfill above a lindane plume and at an asphalt plant suggest that radon monitoring can be effectively used to locate the boundaries of subsurface accumulations of NAPLs. Reductions of ^{222}Rn activity above pools of NAPLs due to radon's preferential partition into the organic phase, and higher-than-background signals near the boundaries of the free phase plume (where dissolved uranium precipitates in the reducing environment generated by hydrocarbons) have been spatially analyzed and resolved to yield the surface contour of two different NAPL source zones in two widely different geologic settings.

Application of Principal Components Analysis to Enhance Targets for Mineral Exploration

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Keywords: stream sediments, PCA, multivariate analysis, Portugal

ABSTRACT

The dataset available for this study consists of stream sediments collected over a time span of a year and analysed for 34 elements under the same analytical method. The principal components analysis results for the PC12 plan show that a strongly inter-correlated group consisting of TiO₂, MgO, Ba, Fe₂O₃, Ni, Co, Cr, Y and V is associated with the positive part of the first component (PC1) and have an inverse relationship with Na₂O, P₂O₅, K₂O, Li, Be and Sn related to granitic rocks. The first group of elements also shows to be orthogonal to either Si and Al₂O₃ which relate to the second component (PC2). The PC1 outlines the lithological variation in the area where the first group of elements can be associated with the metasediments while the second one to the granitic terrains. The elements in the PC13 plan keeps roughly the same position regarding the PC1 but a orthogonal non-correlated group composed by As, W, Cd, Bi and Ag crops out linking this third component (PC3) to possibly gold and tungsten bearing mineralization (skarns and veins).

Chemical, mineralogical and ceramic properties of Rhyolitic Tuff from Arabaalan – Elmalı (Biga) District (Biga Peninsula – Turkey)

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Keywords: Rhyolitic tuff, ceramic properties, floor tiles, the Biga Peninsula.

ABSTRACT

Rhyolitic tuff is an important preferential raw material because it is used as alkaline and silica containing materials. Additional to that, It is easy to exploit, and is cheaper than many other raw materials. Rhyolitic tuffs crop out in the Arabaalan – Elmalı district (Southeast of Biga village, the Biga Peninsula) were investigated in order to assess their potential in the ceramic industry. The Parent rock types of this raw material are Early - Middle aged, calcalkalen Biga volcanics are composed of mainly rhyolite – rhyodacite lava, tuff, ignimbrite and perlite at the base and andesite lavas above.

Chemical and mineralogical analyses were performed on representative samples by XRD and XRF methodologies. The chemical analyses generally show high silica, low alumina and low iron contents. Total alkali content of the Arabaalan rhyolitic tuff is about 4.96 – 8.02 %. The main mineralogical association consists of quartz, sanidine, albite and biotite with kaolinite, montmorillonite, illite and opaque mineral. Sericite and calcite exist as secondary mineral.

Colour measurement, viscosity, firing shrinkage, water absorption was tested by mineralogical and the thermal analysis techniques (TG – DTA) and their firing behaviour were investigated. From these studies it was understood that the Arabaalan - Elmalı rhyolitic tuff could be used for ceramic industry, floor tiles.

Extractable Cd, Cu,Pb and Zn in cultivated soils of Northern Zhejiang of China

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Keywords: extractable content; cadmium; copper; lead; zinc; soil;Zhejiang

ABSTRACT

105 soil samples were collected from farm lands in Northern Zhejiang. Soil samples were air-dried and sieved with 0.84mm nylon screen. Extractable Cd,Cu,Pb,Zn of soils were determined with ICP-OES after extracted by 0.1M HCl for acid soils and neutral soils(pH \geq 7.5), and 0.1M DTPA for calcareous soil(pH \geq 7.5). Total concentration of these heavy metals, soil pH and organic carbon were also determined. It was found that extractable value and extractibility (referred to extractable value v.s. its total content) of soil heavy metals varied greatly due to change of physiognomy, soil type as well as soil parent material. It was presented that extractable contents of Cd,Cu,Pb and Zn increased respectively with its total concentration in soils. The extractibility of each of them were related to soil acidity and organic carbon content. The results showed the extractibility of these heavy metals decreased with soil alkalization and increased with enrichment of organic carbon in soils.

Geochemistry of Tin and incompatible elements in the Jálama batholith (Centraliberian Zone)

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Keywords: Granite, Geochemistry, Incompatible elements, Sn, W.

ABSTRACT

The granite batholith of Jálama (Central Iberian Zone) is one of numerous granites with associated Sn-W mineralisation in the Hesperian Massif. The Sn and/or W mineralisations are basically present in the form of cassiterite and/or wolframite in intragranitic quartz veins. Three granitic units have been established: inhomogeneous granitoids, porphyry granites and leucogranites. These facies show enrichment in Sn and other incompatible elements with the differentiation, from inhomogeneous granitoids to leucogranites. However, in the leucogranites the contents of Sn, W and other incompatible elements exhibit relatively large variations for the same grade of differentiation, involving the existence of leucogranites impoverished and enriched in these elements. The low content of these elements in some leucogranites is certainly due to the segregation from the magma of an aqueous melt enriched in Sn-W. As a consequence of this, an impoverishment of these elements in the last stages of magmatic consolidation occurred. Sn and W concentrates in the final aqueous phase would give rise to mineralization of these elements.

Heavy minerals distribution in bauxites, Los Pijiguaos, Venezuela

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Keywords: Bauxite, heavy minerals, magnetic, trace elements.

ABSTRACT

A study of heavy minerals in bauxites was carried out in Los Pijiguaos ore deposit Venezuela; it was concentrated from top to 16 m depth in the soil profiles. The heavy minerals were separated by using bromoform and they were fractionated magnetically by using a Franz isodinamic. Then it was sieved to 2000, 1000, 500, 250, 125 and 63 μm and extractable (HCl 12M) trace elements was determined. The heavy minerals were dominated by the 0.4 Ampere fraction (ilmenite) which have a grain-size distribution between 250 and 63 μm ; the very magnetic fraction (magnetite) which tends to have a larger grain-size than ilmenite. The non-magnetic fraction is dominated by zircon with a grain-size smaller than 125 μm . On the other hand the 0.8 Ampere fraction (hematite) is associated to coarse sand and it is situated at top of the profile. It is possible that magnetite become in hematite during extreme weathering at top of the profile. The chemical analysis showed two different elemental groups. The first integrated by Mo, Fe, P, V, Ga, Ce and Al which are controlled by hematite and magnetite. The second is formed by Ti, Zn, Co, Mn, Nb, La and is controlled by ilmenite.

Mineralization and Electron Probe Microanalyzer (Epma) geochemical characterization of Primary Gold from the Bukit Koman Area (Raub), Pahang, Malaysia

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Keywords: EPMA, primary gold, mineralization, fineness values

ABSTRACT

The Bukit Koman area is one of the most important gold mining areas in Peninsular Malaysia. This area lies in the western side of Second Gold Belt of Peninsular Malaysia. Rock types in this area occur in a complex of lithology of sedimentary and metasedimentary rocks which are part of Raub Group and Lipis Group. Normally gold occur in fractures of quartz veins formed by faults and joints that is hosted in strongly deformed shale, carbonaceous slate, siltstone and black limestone. There are four types of fault consists of compression, tension, minor oblique and major oblique faults that controls gold mineralization in this area. Gold (as electrum) in quartz veins are mainly associated with pyrite (FeS₂), arsenopyrite (FeAsS), chalcopyrite (CuFeS₂), stibnite (Sb₂S₃), scheelite (CaWO₄), galena (PbS), famatinite (Cu₃SbS₄), bournonite (PbCuSbS₃), stistaite (SnSb) and zircon (ZrSiO₄). Gold grains panned from the vicinity of the quartz veins range in size from 20-90 μm. Based on the EPMA data, gold (Au) composition and fineness values for the primary gold show some distinctive values that reflecting the different episodes of gold mineralization in this area.

Source apportionment of lead in the Guadiana River basin

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Keywords: Lead, geochemistry, biochemistry, lead isotopes, Guadiana
basin, environment.

ABSTRACT

Results will be presented of a multidisciplinary environmental study (UTPIA) of the Lower Guadiana River basin and contiguous coastal waters, carried out by a joint Portuguese-Spanish team, to characterize the distribution and apportionment of heavy metals, especially lead. Chemical, biochemical and lead isotope data for waters, soils, sediments, plants and bivalves were used to track the principal pollution pathways: from terrestrial source to marine sink. Coupled water-bivalve studies indicate strong, seasonal changes in the geographic input of lead from different, abandoned Iberian Pyrite Belt massive sulphide mines, located in the upper part of the catchment. Downstream, there is a mixing of mine-related lead with isotopically distinctive lead from other anthropogenic sources related to the industrialised and populated areas of the Guadiana estuary. The flux of IPB lead can be traced into the marine environment where specific enzyme-lead studies (ALAD) can demonstrate an important toxicological effect on marine bivalve ecosystems. A risk assessment evaluation of the data is now being carried out to provide a baseline for public health awareness and intervention.

Using Selective Chemical Extraction to distinguish the variable signatures from the anomalous component introduced by an underlying Zn deposit

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Keywords: spatial distribution patterns, selective extraction, Zn mine, Portugal

ABSTRACT

Sequential extractions of metals can be useful to study metal distribution and identify mechanical/hydromorphic dispersion anomalies. This study concerns the application of selective extraction in soil samples and aims to identify spatial patterns of variation enhancing the main bearing-phases in soils samples collected in Preguiça and Vila Ruiva mine. These mines are considered as Zn enriched gossans, located in a carbonated environment. In order to identify the metal bearing phases, 180 samples were submitted to sequential chemical extraction using solvents of increasingly strength. The fractionation of Zn, Cu, Pb, As, Fe and Mn in highly weathered soils was investigated using operationally defined fractions; exchangeable, Mn oxides, amorphous Fe oxides, sulphides, crystalline Fe oxides and residual fraction. At Preguiça mine, crystalline Fe oxides and residual phases are the dominant hosts of Zn while at Vila Ruiva mine the exchangeable, amorphous Fe oxides, crystalline Fe oxides and residual fraction are the main bearing phases for the element.

Thallium analysis in geological samples from La Peña-Terronal Mine (Asturias, Spain)

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Keywords: Thallium, mass spectrometry, isotope dilution, mining
environment.

ABSTRACT

Due to its high toxicity, thallium has been considered by the US Environmental Protection Agency as one of the priority pollutants to be controlled [1]. While being a highly toxic element, Tl has been studied to a much lesser degree than other toxic elements, mainly because Tl is often undetected by classical analytical methods [2]. In addition, there are only a limited group of reference materials (RM) with a certified content of Tl.

Tl is a rare and dispersed element that occurs mainly in sulfur-containing ores. Thus, it is a potential pollutant to surrounding environment, if Tl-rich mineral and/or their industrial wastes are not properly disposed.

In this communication, a Mass Spectrometry (MS) analytical procedure has been developed in order to determine Tl in geological samples from La Peña-Terronal Mine, a mercury deposit in the northwestern margin of the Asturian Central Coal Basin (Spain), with cinnabar, metacinnabar and native mercury, and with presence of arsenic sulfides like orpiment, realgar and As-rich pyrite.

In order to validate the developed procedure, Isotope Dilution technique has been applied to some selected samples.

An isotopic and fluid inclusion study of the polymetallic, sediment-hosted Abra deposit, Western Australia.

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Keywords: lead, copper, gold, isotopes, fluid inclusion, basin fluids.

ABSTRACT

Sr, Pb, S, O, H and C isotopes and fluid inclusion data from the Abra Pb-Cu-Au-Zn deposit are presented. Pb isotopes suggest mineralization occurred over a 25-30 Ma year period. The upper barite-galena-hematite-magnetite mineralization appears to have formed just before the lower chalcopyrite-magnetite-chlorite stringer mineralization. Sr isotopes are highly radiogenic, indicating inheritance from sedimentary rocks. Thus the metals were likely derived from basin sediments. A S vs Sr isotope plot indicates involvement of modified marine fluids. $\delta^{34}\text{S}$ values are very high for barite and sulphides and a closed basin system may have prevailed. O and H isotopes indicate that the ore-fluid was an evolved basinal brine derived from seawater. S and O isotope geothermometry indicates mineralization formed from 270 to 360°C. Cooler temperatures are recorded in the upper mineralized zone. Fluid inclusion temperatures range from 162 to 250°C, indicating entrapment at >4 km. Fluid inclusion salinities range from 5.8 to 19.8. The isotope and fluid inclusion data suggest that mixing between two fluids may have triggered mineralisation.

Geochemical assessment of the reactivity of tailings proposed for marine tailings disposal (MTD)

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Keywords: Geochemistry, Static Testing, Kinetic Testing, Seawater Leaching, Marine Tailings Disposal, Greenland

ABSTRACT

A geochemical study has been completed on tailings of Nalunaq Gold Mine (Greenland) to evaluate the potential of the tailings material to generate acidity and deleterious leachate and the impact this may have on marine environments.

Static testing methods whole rock digestion, Acid-Base Accounting, Net Acid Generation along with X-Ray Diffraction, Scattered Electron Microscopy and optical microscopy has been undertaken.

Due to the uncertain of these tests a range of kinetic tests has been undertaken to evaluate the rates of mobilisation of contaminants and reduction in buffering capacities. In addition to the standard ASTM D5744 humidity cell test for tailings a parallel jar test was undertaken to evaluate the leaching characteristics in the marine environment. Samples were maintained permanently submerged in either de-ionized water or seawater and exposed to a range of temperatures (5°C,32°C, ambient) with or without day light exposure.

Despite the fine grain size of the sample material, that would promote acid generation from the sulfide minerals, there was little evidence of acid generation from the sample over the 20 week test period. This may be due to the fact that the majority of the sulfides minerals occurred as inclusions in inert minerals or due to the excess of lime that remains with the sample following the cyanidation gold extraction process. However, temperature and rinsing medium affected significantly leachate chemistry.

The parameters arsenic, cadmium, chromium, copper, nickel, lead, antimony and zinc along with cobalt and iron were identified as of special concern due to their enrichment in the tailing and potential to be leached and consequently bioavailable.

Session 12:
*Geochemistry in the government sector:
exploration and environmental applications*

New Multi-element Regional Geochemistry Surveys of Northern Ireland

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Keywords: Tellus, regional geochemistry, soil, stream sediment, stream water, multi-element, Au, PGE

ABSTRACT

The Tellus Project is a new ground geochemical and airborne geophysical survey of Northern Ireland for the purpose of geological mapping, mineral exploration and environmental characterisation. The geochemical program comprises new multi-element surveys of soils (63 analytes), stream sediments (62 analytes) and stream waters (55 analytes) at a density of c.1 site per 2km² in the rural environment and 4 sites per km² for soils in the urban areas of Belfast and Londonderry. Two composite soil samples have been analysed per site, at 5 to 20cm and 35 to 50cm depth intervals. A reconnaissance lithogeochemical program has also been completed. Au and PGE have been analysed in all three media and with the addition of the multi-element datasets new anomalies and distribution patterns have been mapped. These patterns and anomalies can be interpreted in relation to geological, mineralization, agricultural, and anthropogenic sources. Numerous precious and base metal anomalies have been identified in under explored areas which will lead to reappraisals of mineral prospectivity.

Environmental and exploration geochemistry of sediment-hosted Zn-Pb-Ag massive sulfide deposits

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Keywords: sediment-hosted zinc, thallium, Alaska

ABSTRACT

Sediment-hosted Zn-Pb-Ag massive sulfide deposits (SHMS) are numerous in northern Alaska, USA. In addition to Zn, Pb, and Ag, mineralized zones are characterized by anomalous concentrations of As, Cd, Ge, and Sb as well as some pathfinder elements that have not traditionally been used to delineate SHMS-type deposits, namely Tl, U, and P. These elements are reflective of alteration minerals and/or minerals that occur distal from base metal ore zones, and therefore, they are potentially useful for remotely detecting mineralization. The Tl resides largely in pyrite whereas U and P may be hosted in hydrothermal apatite deposited during alteration. Recent studies suggest that this geochemical signature translates to surficial samples (stream sediment and water). In particular, stream sediment samples from drainages near the SHMS deposits contain anomalous concentrations of Tl (>1.3 ppm), U (7.1 to 18.1 ppm) and P (4,040 ppm). Acidic stream water samples with high Zn concentrations have as much as 89 ppb Tl and 20 ppb U.

Indicator mineral and till geochemical signatures of the Broken Hammer Cu-(Ni)-PGE sharp-walled vein deposit, Sudbury, Canada

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Keywords: PGE exploration, indicator minerals, sperrylite, drift prospecting

ABSTRACT

Ni-Cu-PGE deposits have a characteristic suite of indicator minerals, however, little research has been carried out to determine which minerals may be useful for surficial sediment sampling. To partly address this need, the Geological Survey of Canada is examining indicator minerals that characterize the Broken Hammer footwall deposit, a sharp-walled Cu-(Ni)-PGE vein hosted in Sudbury breccia, and its associated glacial dispersal train. Till and bedrock samples were collected from the deposit area to determine indicator mineral and trace element signatures indicative of the deposit and to establish practical methods for indicator mineral recovery from glacial sediments that can be routinely applied in exploration in the region. Deposit ore minerals include chalcopyrite-digenite, emplectite, pyrite, galena, sperrylite, and michenerite. Overlying and just down-ice of mineralization, till contains 100s of visible gold and sperrylite grains. Till geochemistry reveals similar patterns for gold and PGE. Historically, till sampling has not been used for base metal exploration in the Sudbury Basin, however, this study demonstrates that till sampling can be a useful exploration method in the region for the lucrative Cu-Ni-PGE deposits in the Sudbury footwall environment.

Geochemical associations and its spatial patterns of variation in soil data from the Marrancos gold-silver mineralization: a pilot analysis

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Keywords: gold, soil, principal components analysis, geostatistics

ABSTRACT

Marrancos mineralization, located in Marrancos village, near Braga city, northern Portugal, is hosted by a NE-SW quartz breccia in a hornfels belt formed after the intrusion of a granitoid on Silurian metasediments. This NE-SW quartz breccia is spatially related to a major shear zone, the WNW-ESE Vigo-Régua shear zone. Gold occurs mostly as electrum that is hosted by sulphides (essentially arsenopyrite).

Several attempts were made to explore Au-Ag (in the sixties and again in the eighties) and one attempt to explore Sn-W during the first half of the 20th century (World War II).

Presently, under the scope of a research project, financed by the Portuguese government, the area is being re-evaluated using new sample media and more sensible analytical methods. This is a preliminary study that uses Principal Component Analysis and Geostatistics (Ordinary Kriging) to identify reliable associations between chemical elements in the soil, and estimate spatial patterns of variation for such associations. A special emphasis was given to the associations Au-Ag and W-Sn since they were the elements of interest in this area.

The Canadian Contribution to the North American Soil Geochemical Landscapes Project- A common environmental view of North America

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Keywords: soil geochemistry, geochemical background, sampling protocols.

ABSTRACT

The North American Soil Geochemical Landscapes Project is the first North American multi-national, multi-agency collaboration of its kind. It will lead to an understanding of the linkages between soil geochemistry and environmental and human health and provide systematic data on continental-scale background variation. In addition, a continentally applicable protocols manual and easy access to user-friendly data will be available for interpretation in the context of a wide range of applications, issues and disciplines. This Project will support the prediction of a wide range of the properties, functions, and capacities of soils and their parent materials that are relevant to land-use planning, international agreements, and environmental and health issues. The survey sites will be located on a spatially balanced array, some 6,180 sites (1 site per 1,600 km²) will be sampled in Canada. The Canadian core protocols will employ a standardized field record for benchmark data, topographic information, vegetation, soil classification, physical properties, and parent materials, together with standardized sampling of the 0-5 cm "human health layer", and the O-, A-, B-, and C-horizons. On various horizons either or both the <2 mm and <63 µm fractions will be studied using combinations of total, aqua regia and water extractions.

Natural radioactivity, toxic metals pollution and epidemiology in the Campania region (Italy)

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Keywords: geochemistry, toxic metals, radioactivity, epidemiology, cancer

ABSTRACT

Values distribution of the standardized mortality ratio (SMR) for a wide range of neoplasm types have been compared to the distribution of metallic harmful elements (As, Cd, Co, Cr, Cu, Hg, Ni, Pb, Se, Sb, Tl, V, Zn) and radioactivity in soil and sediments of the Campania region (Italy). Distribution maps produced for gamma-ray spectrometry data (^{40}K , ^{238}U , ^{232}Th) and for harmful elements clearly show a correspondence of higher regional values with the occurrence of alkalic volcanic rocks (Roccamonfina, Campi Flegrei, Somma–Vesuvius, fissural sources of Campania Ignimbrites) in the central-western part of the region, which is also the most anthropized. In these latter area, the standardized mortality ratio (SMR), expressed as a percentage, calculated on the overall regional population for lung cancer and leukaemia is always above 110, implying that the naturally occurring radio-elements and the intense anthropic pressure on the environment could be one of the possible cause of increased cancer risk.

New Multi-element Regional Geochemistry Surveys of Northern Ireland

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Keywords: Tellus, regional geochemistry, soil, stream sediment, stream water, multi-element, Au, PGE

ABSTRACT

The Tellus Project is a new ground geochemical and airborne geophysical survey of Northern Ireland for the purpose of geological mapping, mineral exploration and environmental characterisation. The geochemical program comprises new multi-element surveys of soils (63 analytes), stream sediments (62 analytes) and stream waters (55 analytes) at a density of c.1 site per 2km² in the rural environment and 4 sites per km² for soils in the urban areas of Belfast and Londonderry. Two composite soil samples have been analysed per site, at 5 to 20cm and 35 to 50cm depth intervals. A reconnaissance lithogeochemical program has also been completed. Au and PGE have been analysed in all three media and with the addition of the multi-element datasets new anomalies and distribution patterns have been mapped. These patterns and anomalies can be interpreted in relation to geological, mineralization, agricultural, and anthropogenic sources. Numerous precious and base metal anomalies have been identified in under explored areas which will lead to reappraisals of mineral prospectivity.

Environmental quality assessment of the Guadiana estuarine sediments (SW Iberian Peninsula): evidence from a GIS study

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Keywords: Guadiana Estuary, GIS, Sediment quality, Heavy metals.

ABSTRACT

The lower section of the Guadiana river drains the central-western sector Iberian Pyrite Belt, one of the most important provinces of polymetallic sulphide deposits. In order to evaluate the environmental quality of Guadiana estuary, a total of 89 surface sediment samples were collected from the estuarine main channel and adjacent marshes. All samples were analysed for major and trace elements using ICP-AES. Multivariate statistics and GIS techniques were applied to identify elements influenced by human activities (mining, industrial development, etc.). Principal component analysis (PCA) classified the elements in two groups: the first one predominantly derived from natural sources (Al, Fe, Mn, Co, Cr and Ni), and the second being influenced by human activities (As, Cd, Cu, Pb and Zn). These later elements were found in relatively high concentrations near the coastal localities, as confirmed by the GIS mapping. This technique has been a powerful tool to map the distribution of elements in the study area, and to help in the identification of the possible sources of these contaminants.

Geochemical Atlas of Eastern Barents Region.

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Keywords: Geochemical surveys, Soils, Stream waters, Bryophyta, Baseline studies, Heavy metals, Russia, Finland

ABSTRACT

A regional environmental geochemical survey covering the northwestern part of Russia and Finland (1.5 mill. km² area) was carried out in 1999-2004. Organic and minerogenic soil, stream water and terrestrial moss samples were collected from 1362 sites. Both total and aqua regia extractable element concentrations were determined from <2 mm fraction of minerogenic samples and total concentrations from organic samples. Altogether 190 geochemical maps together with maps showing basic information such as geology, topography, vegetation zones, soil types, metallogeny etc. were published as Geochemical Atlas of Eastern Barents Region. The geochemical maps show distribution of 48 elements and other parameters. The results from moss and organic soil layer show clear anthropogenic contamination due to human activities such as Ni and Cu smelting in Kola area or dense population and heavy industry in Leningrad region. On the other hand, geological variety and control most of the distribution of elements in the surficial deposits.

Geochemical Atlas of Italy

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Keywords: atlas, geochemistry, environment, Italy, Multifractal IDW.

ABSTRACT

The Geochemical Atlas of Italy addresses the need for a large scale geochemical mapping based on FOREGS procedures. In the framework of the FOREGS Global Terrestrial Network, Italy was divided in 21 cells and sub-cells but, to compile the Geochemical Atlas of Italy, the sampling was complimented with further 7 sub-cells in southern Italy, for a total of 28 cells. Stream waters (W), stream sediments (S), floodplain sediments (F), topsoils (T) and subsoils (C) have been collected in two phases in 58 locations. In both sampling phases were strictly followed FOREGS procedures. The geochemical data used for the FOREGS project and the new data from sub-cells of southern Italy have been processed using ArcView GISTM and a new Multifractal IDW method available in the software GeoDASTM. Interpolated maps have been overlaid by dots and have been classified by statistic graphs, for a total production of 360 maps. Data show that, even, at large scale, the distribution of some elements reflects the major geo-lithological Italy structures.

Modelling biogeochemical accumulation of trace elements in soils and vegetation

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Keywords: biogeochemistry, soil, vegetation, trace elements, mass balance

ABSTRACT

Biological processes could, over long time spans (~10⁶ yrs), accumulate anomalous concentrations of trace elements in soils and vegetation over mineralised ore bodies. Modelling this biogeochemical accumulation in soils and vegetation could help in the search for buried ore bodies. We present a conceptual model of trace element biogeochemical cycling using mainly Australian examples. This model considers the important factors that would lead to the formation of anomalous concentrations in soil and vegetation through biological deep uptake of buried mineralisation. Similar outcomes were achieved when this conceptual model was compared to previous work on a simple mass-balance model. Further, a substantial result from our modelling suggests that soil anomalies may be transient geological features, forming and dispersing as a result of the relative sizes of the accumulative and loss fluxes. Based on these results we are now developing a model that incorporates some rate expressions and feedback loops.

Session 13:
Geochemistry and health

**Spatial correlation between the prevalence of transmissible
spongiform diseases and British soil geochemistry**

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Keywords: Transmissible spongiform encephalopathies, soil, trace
element geochemistry

ABSTRACT

Transmissible spongiform encephalopathies (TSEs) are fatal neurological conditions affecting several mammals, including scrapie (sheep and goats), BSE (cows), and CJD (humans). They are believed to be due to the misfolding of the prion protein to an infectious pathological isoform. Outbreaks are often attributed to contaminated feed and genetic susceptibility. However, the implication of Cu and Mn in the pathology of the disease, as well as its apparent clustering, have suggested an environmental link with trace elements. Nevertheless, studies of soils at regional scales have failed to verify an environmental risk factor, and no link has been established between the occurrence of the different TSEs. This study uses geostatistics to investigate the correlations between the TSE prevalence and soil geochemistry across the UK at different spatial scales. An increasing N-S trend in scrapie and BSE occurrence may be linked with increasing pH and organic carbon, and decreasing iodine levels. However, this trend also coincides with the density of dairy farming.

Heavy metals in the soils of Islam Shahr urban area, Iran

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Keywords: Heavy metals, urban area, Islam Shar, South of Tehran

ABSTRACT

Islam Shahr is relatively small city in the south of Tehran (10km), Iran. It is located within the Recent Alluvium Formation of Tehran alluvials. This formation is associated with heterogeneous to poorly sorted clays and silts. The overall objective of this study was to better understand the nature of soil contamination in this area, including three aspects: (1) to investigate the main sources of heavy metal contamination in the area; (2) to determine contamination trends and pollutant types in the area; and (3) to find a proper evaluation approach to metal contamination in this area. Such information should be useful for enhancing safe park areas in the Islam Shahr area while minimizing adverse effects of soil contamination on human health.

In most geochemical studies, element concentrations are usually normalised to the contents of a common reference or background, thus enabling the calculation of the enrichment or depletion of elements against a baseline. Since early work on soil geochemistry of Islam Shahr is not available, the elemental compositions of these soils were normalised using average upper continental crust values. In this study, 25 samples were analysed by ICP for Al, Co, Cr, Cu, Pb, Zn, Ag, Cd, Hg, As, Se. The concentration of Ag, Cd, Hg, As, Se is less than detection limit. Among the 11 metals evaluated, copper contamination was most severe particularly in the area close to industrial and suburbs with agricultural activities. Data processing shows the average concentrations of Cu, Cr, Co, Pb and Zn were higher than the upper continental crust background levels. Industrial activities in the urban areas and application of agricultural chemicals were the main contamination sources of these heavy metals. The closer to the suburb and urban areas, the more increase of heavy metal concentrations in the soil is, especially in the central parts of the city. The Islam Shar is new developed city during the 15 years ago, thus such contaminations are high for this short period.

Extraction of Astaxanthin from Shrimp waste by Chemical and Microbial Methods

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Keywords: Astaxanthin, Extraction, Shrimp waste, Method.

ABSTRACT

The carotenoid pigments specifically Astaxanthin has many significant applications in food, pharmaceutical and cosmetic industries. Our goal was to research about extraction of these pigments (Astaxanthin from a certain Persian Gulf shrimp species waste *Penaeus semisulcatus*), purification and identification of the pigment by chemical and microbial methods. Microbial fermentation was obtained by inoculation of two *Lactobacillus* species in the medium culture containing shrimp waste powder by the intervention of Lactose sugar, yeast extract, the composition of Both and the coolage (-20oC).

The carotenoid pigments were extracted by an organic solvent system. After purification of Astaxanthin with the TLC method (thin layer chromatography) by spectrophotometer, NMR and IR analysis the presence of Astaxanthin was recognized in this specific species of Persian Gulf shrimp. Results obtained from this study showed that the coolage at (- 20oC) not only does not have an amplifying effect on the production of Astaxanthin but also slightly reduces this effect. Also the effect of intervention of Lactose sugar showed more effectiveness in producing Astaxanthin than yeast extract or more than with the presence of both. The results also indicated that there is not much difference in the ability of producing the pigment by comparing both *Lb. plantarum* and *Lb. acidophilus*. Also results showed the microbial method of extraction of Astaxanthin is more effective than chemical method.

The Potential Health Risks from Dust Exposure in the Middle East

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Keywords:

ABSTRACT

In the Middle East, dust and sand storms are a persistent problem and can be inhaled into the mouth, nasal pharynx, and lungs. The chronic and acute pulmonary effects of this dust inhalation have not been well studied nor has the dust been effectively characterized. Experiments were designed to study this dust as to its physical, chemical, and biological characteristics for its potential to cause adverse health effects. Samples were collected and processed and analysis conducted. Characterization of biologic flora of the dust, including bacteria, fungi and viruses, was performed. Data indicates that the mineralized dust is primarily composed of calcium and magnesium sulfates and carbonates with a variety of trace metals constituting approximately 1% of the total dust exposure. Microbial analysis reveals a significant biodiversity of which ~30% are human pathogens. The level of TSP mass constitutes an excessive exposure to micro-particulates including PM 2.5. These results suggest that further research is warranted as to potential health risks both acute and chronic.

Natural radioactivity, toxic metals pollution and epidemiology in the Campania region (Italy)

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Keywords: geochemistry, toxic metals, radioactivity, epidemiology, cancer

ABSTRACT

Values distribution of the standardized mortality ratio (SMR) for a wide range of neoplasm types have been compared to the distribution of metallic harmful elements (As, Cd, Co, Cr, Cu, Hg, Ni, Pb, Se, Sb, Tl, V, Zn) and radioactivity in soil and sediments of the Campania region (Italy). Distribution maps produced for gamma-ray spectrometry data (^{40}K , ^{238}U , ^{232}Th) and for harmful elements clearly show a correspondence of higher regional values with the occurrence of alkalic volcanic rocks (Roccamonfina, Campi Flegrei, Somma–Vesuvius, fissural sources of Campania Ignimbrites) in the central-western part of the region, which is also the most anthropized. In these latter area, the standardized mortality ratio (SMR), expressed as a percentage, calculated on the overall regional population for lung cancer and leukaemia is always above 110, implying that the naturally occurring radio-elements and the intense anthropic pressure on the environment could be one of the possible cause of increased cancer risk.

Arsenic and other toxic elements in coal leachates of Korba: a review of Central India

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Keywords: Arsenic, Flouride, Coal leachates.

ABSTRACT

Arsenic in bituminous coal occurs primarily in pyrite form and, to a lesser extent, in organic portions of the coal. A small fraction of this arsenic is emitted during coal mining and combustion. The coalphile affinity of As is like that for Ge or S. Korba city has rich deposits of coal for which it is also known as the land of Black Diamonds. It is estimated that coal deposits cover an area of 155 km². Total 12 (7 Open and 5 underground) coalmines are in operation, producing » 35 MT coal per year. The thermal power plants of capacity 4000 MKW and aluminum plant of capacity 1 million ton/year are in the operation. The amounts of coal consumed are estimated to be » 16 MT per year. The gradual digging of the mines deeper, the mines are flooded, thus creating everlasting problems in mining the coal. The depth of the shafts reached > 200 meters, and the manual pumps, drills, horse-driven pumps, or even the magnificent mining works – heritage shafts were not sufficient to pump the water out of the mines. Thus, several coal mines water reservoirs are originated. These waters are used for domestic purposes. They are found to be contaminated with heavy metals i.e. As, Se, Hg, Pb, etc. The contamination extent of the coal mines lechates with arsenic and other metals are discussed.

Air Pollution Prediction Models of particles, As, Cd, Ni and Pb in a Highly Industrialised Area.

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Keywords: Air Pollution, Ambient Air, Prediction Models, Public Health, TSP, PM10, Heavy Metals.

ABSTRACT

A study was carried out of TSP, PM10, As, Cd, Ni and Pb concentration levels in ambient air in a highly industrialised area in the ceramic cluster of Castellón during five years (2001-2005). The origin of the contamination in this area is both natural and anthropogenic. The natural origin is due to the resuspension of mineral materials from the surrounding mountains and from the long-range transport of materials from North Africa. The anthropogenic contamination sources that stand out include the non-metallic mineral material industries (ceramic production), chemical industries (colour, frit and enamel manufacturing) as well as vehicular traffic. The objective of this study was the elaboration of a series of mathematical models with the aim of short-term prediction of these contaminants that depend on some known variables. The goal is to provide a useful instrument to alert the population facing possible episodes of high concentrations of atmospheric pollution.

**Anthropogenic and natural enrichment of As, Cr and Pb of the soils
near the Stawell Gold Mine, Victoria, Australia.**

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Keywords: bioavailable, geochemical background, health risk
assessment, partial extraction

ABSTRACT

The Stawell Gold Mine (SGM) operation in NW Victoria, Australia, mines sulfides that contain high concentrations of As and metals. The project aimed to understand the dispersion and enrichment of potentially hazardous elements around the mine site. Fifty surface soil samples were collected near SGM (<15 km) and analysed by ICP-MS/OES following bioavailable and four-acid extractions. Soils near SGM show greater levels of As, Cr and Pb than background, which is attributed to natural enrichment due to a geochemical halo associated with mineralization, and anthropogenic enrichment due to mining, agriculture and other human activities. Dispersion from the ore processing is < 500 m, with the most enriched soils close to the town and unrelated to current mining. The bioavailable As, Cr and Pb, soil ingestion rates and Risk Reference Doses were used to estimate health risks. The maximum bioavailable As would pose a risk at average ingestion rates. Soil-eating disorders would exceed the safe daily consumption limits for As, and potentially Cr and Pb. Small children are not typically exposed to soil everyday, few have soil eating disorders, and therefore the health risk from the soils around SGM is minimal.

**Ecosystems health and geochemistry: concepts and methods
applied to abandoned mine sites**

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Keywords: heavy metals, pastures, punctate pollution

ABSTRACT

This study is based on the premise that the good health of an ecosystem is essential for its sustainable development, introducing a new terminology for understanding pollution. Thus, the health of ecosystems is defined as an emerging science, or systematic approach, to prevent, diagnose and predict management features and establish relationships between the health of ecosystems and humans. It is within this framework that our experimental study was conducted on three sites situated in abandoned mines in the central Iberian Peninsula. The ecosystems present are mainly those of grazing pastures although cereals are also cultivated. In each of these settings, we find that soils contain more than one heavy metal in their top layers, particularly Cu, Zn, Pb and Cd. This pollution is punctate and affects both the plant populations of the sites and their consumers, with the possible transfer of pollutants to the river or groundwater systems, depending on the type of soil and geomorphological factors. We describe the protocol used to evaluate the health status of these ecosystems in terms of effects involving the geochemistry of the heavy metals they contain.

Evaluation of an in vitro digestion protocol in human-health risk assessment

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Keywords: Bioaccessibility; In vitro digestion; Risk assessment; extraction.

ABSTRACT

Human health risk assessments, based on the combined evaluation of (a) the toxicity of the chemicals included in the analysis by exposure route, and (b) the site and population-specific levels of exposure to those chemicals, are increasingly being employed to assess the potential health impact of exposure to contaminated soils and other particulate materials. Implicit in the model is the assumption of 100 % absorption efficiency (i.e. bioaccessibility) of the amount of trace elements extracted with aqua regia or similar digestion protocols, a fact that could lead to an overestimate of risk. In this paper, the results of an in vitro digestion model that – through use of saliva, gastric juice and intestinal juice as extraction agents and adjustment of pH, temperature and residence time in the human body - simulates the decomposition of a solid matrix in the gastro-intestinal tract are compared to those of standard extraction protocols for playground sand, and the implications for the assessment of risk are discussed.

Uranium uptake by potato plants (*Solanum tuberosum* L.): a study case in controlled field experiments

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Keywords: Uranium uptake, contaminated water, *Solanum tuberosum* L.,
Cunha Baixa mine site, human health

ABSTRACT

Hazardous effects of uranium on Human health arising from ingestion of contaminated drinking water and, through the food chain via crop plants, animal feed and animal products. Some agricultural soils nearby Cunha Baixa mine area (Central Portugal), which are irrigated with uranium-contaminated water, present an environmental concern due to chemical element toxicity. The uranium uptake by potato plants (*Solanum tuberosum* L.) from two soils with different uranium levels (45 and 128 mg/kg) irrigated with contaminated and non-contaminated water (>100 mg/L and < 20 mg/L, respectively) has been studied in controlled field experiments. The uranium in the potato tuber ranged between 13.2 and 110.5 mg/kg (fresh weight) and was concentrated in the potato outer membrane (90-96%). Therefore, the inhabitants of Cunha Baixa mine area can minimize the total uranium daily intake by peeling the potato before consumption.

Session 14:
New technologies and miscellaneous papers

**Remote detection of whole rock geochemical alteration patterns
– Implications for regional VMS exploration –**

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Keywords: hydrothermal alteration; whole rock geochemistry; reflectance spectroscopy; volcanic massif sulphide mineralization

ABSTRACT

Studying regional-scale geochemical alteration patterns can be used for reconstructing fossil hydrothermal alteration systems and for indicating areas favorable for massive sulfide deposition. The distribution of the relative concentrations of Fe, Mg, K, Na, and Ca, and Si indicate the presence of various the alteration zones. High-temperature chlorite-quartz alteration zones underlying VMS mineralization and crosscutting the stratigraphy contain relatively high concentrations of Fe and Mg concentrations. Low and medium-temperature feldspar-sericite-quartz alteration zones (sub)parallel to the stratigraphy contain lower concentrations of Fe and Mg and are in varying degrees enriched in K and Si. Comparison with mineralogical interpretations of reflectance spectra from whole rock samples showed that the various alteration zones have unique spectral properties and that they can be differentiated using spectral reflectance data. Spectrally detected white mica minerals were used to further subdivide the geochemically defined zonation [1]. The various white micas could also be mapped using airborne optical systems and allowed reconstruction of hydrothermal alteration systems associated with VMS mineralization on a regional scale at high spatial resolution.

Leach Reduction of Solid waste with a Bauxsol™-based Concrete

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Keywords: Bauxsol™, fluidity, grout, treatment, waste rock

ABSTRACT

Bauxsol™ is a material that contains substantial acid neutralising capacity and an extensive metal binding capacity, which has had successful applications in the treatment of acid rock drainage, sewage effluents and liquid industrial wastes. Consequently, the acid neutralising and metal binding characteristics of Bauxsol™ could combine with the cementation properties of ordinary Portland cement (OPC) to provide a treatment for solid waste. This paper investigates the development of a Bauxsol™-based concrete for the immobilisation of an industrial solid waste. Five waste samples (2 alkaline As-speiss and 3 acidic Hg contaminated samples) from an ore processing and smelting operation were provided for analysis and TCLP leach reduction. Alkaline As-speiss is an Fe-arsenide stabilisation of high As wastes developed by Noranda Ltd, Canada, but the As-speiss materials provided continue to leach Pb and As at unacceptable concentrations. Two varieties of the As-speiss material were present, a silvery-grey crystalline alloy consisting mainly of Fe₂As and Fe₃As with some Sb substitution (raw), and a black-grey friable material consisting of Na- and Ca-alumino-silicates, Na carbonates, possible NaSO₄, CaSO₄, FeSO₄, Al₂(SO₄)₃, or similar sulphates and galena (PbS; < 4 mm). The Hg-wastes were a wet sludge (cf. 60% moisture as a dilute sulphuric acid cf. 2M) and are produced in almost equal proportions from different points within the refining and smelting operation.

TCLP leaching of the As-speiss indicates that As (> 100 mg/l) and Pb (> 320 mg/l) are the primary contaminants and that Hg (> 13 mg/L) and Cu (up to 37 mg/l) were the contaminants of concern in the Hg-wastes. Because one waste stream set was alkaline and the other set acidic, neutralisation could be affected by combining the two waste streams. The As-speiss wastes were blended at a rate 2:1 raw:< 4 mm and the three Hg wastes were combined at a rate of 1:1:1. A composite near-neutral waste was made by combining the As-speiss waste (85%) with the Hg composite (15%) and this combined waste was made into bricks using a 1:1 mixture of Bauxsol™ and OPC, where the waste concentration varied from 20% to 66% of total dry mass. The reduction in leach potential (TCLP As 0.03 mg/l, Pb < 0.5 mg/l, Hg 0.013 mg/l, & Cu < 0.008 mg/l) from the Bauxsol™-based concrete blocks is far greater than the reduction that can be achieved by simple dilution alone. Moreover, physical strengths of the

blocks indicate that compressive fracture and slake reduction of the bricks is highly unlikely. These data would therefore indicate that Bauxsol™-based concretes can be used to reduce leach potentials in contaminated solid wastes and provide an alternative to disposal hazardous waste landfill sites.

**Reproducibility and correlation of geochemical anomalies by
different sampling densities**

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Keywords: Reproducibility, correlation, sampling density, geochemical anomaly

ABSTRACT

In the interest of time and cost, wide-spaced geochemical sampling is used to delineate large-scale geochemical anomalies for mineral districts in large unexplored desert terrains of northwestern China. The premise is the large-scale anomalies must be reproducible by the follow-up surveys. A study area of 6400 km² in northwestern China was selected to investigate the reproducibility of geochemical anomalies by different sampling densities. In this area, 64 samples were collected at a density of 1 sample per 100km², 260 samples at a density of 1 sample per 25km² and 1690 samples at a density of 1 sample per 4km². The results show that 1) the background values and average values are very consistent by 3 sampling densities, 2) large-scale geochemical patterns of U, Au and Cu are very similar and reproducible, 3) 1 sample per 100km² and per 25 km² can only delineates large geochemical anomalies such as geochemical provinces of U and Au, whereas 1 sample per 4km² can delineate both large and small anomalies.

The influence of sample preparation on the detection and discrimination of regolith material types and alteration mineralogy using spectral measurements in the visible and infrared.

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Keywords: Pulps and chips, reflectance spectroscopy, visible, near and shortwave infrared.

ABSTRACT

Reflectance spectroscopy in the visible, near and shortwave infrared (350 - 2500nm) is capable of providing mineralogical information to enhance the value of geological data derived from drillcore, pulps and chips. An investigation into the spectral behaviour of dry chips and pulps of regolith materials reveals that there is a fundamental difference in the hull or background shape of spectra for pulps and chips of the same sample. The albedo, or brightness of the spectrum for pulps is much higher than that for chips, indicative of more surface scattering in the pulp samples. Pulping appears to affect the kaolinite crystallinity as shown by the Kaolinite crystallinity index (KCI). Spectra from chip samples commonly have better developed absorption features. This indicates that for more effective identification of minerals and discrimination of subtle changes in alteration mineralogy, chips are the preferred medium. Overall, consistency in the use of the sample medium becomes important, especially for sample comparisons.

**Effect of sulfide mineralogy on isotopic composition of sulfate:
Implications for acid mine drainage (AMD) formation**

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Keywords: Acidithiobacillus ferrooxidans, stable isotopes, sulfide minerals, AMD

ABSTRACT

Sulfide mineral weathering is the main source of acid generation in mining environments, known as acid mine drainage (AMD). Oxidation of sulfide minerals under earth surface conditions often produces sulfate and acid. Determination the source of weathering and in turn acid production is critically important to develop the proper rehabilitation strategies. Stable isotopes (O, S) provide important insights into the formational conditions of acid mine drainage because, in addition to iron, the elements oxygen, and sulfur are the most important ones involved in this process. In order to investigate the effect of sulfide mineralogy on isotopic composition of sulfate in AMD sites, we conducted a series of metal sulfide oxidation experiments in the laboratory. The experiments were conducted biologically and abiotically, under aerobic and anaerobic conditions, with varying $\delta^{18}\text{O}_{\text{H}_2\text{O}}$ values. Parent sulfur minerals used in these experiments included pyrite (FeS_2) and sphalerite (ZnS), galena (PbS) and elemental sulphur (S^0). Biological experiments were conducted at pH ~ 2.2 in the presence of the sulfide oxidizing bacterium, *Acidithiobacillus ferrooxidans*. The results for S^0 and ZnS experiments indicate H_2O as the sole source of oxygen for sulfate. Biological and abiotic PbS experiments did not produce sulphate. Oxygen isotope enrichment factors ($\epsilon_{(\text{SO}_4\text{-H}_2\text{O})}$) of 4 ‰ and 9 ‰ were estimated for the biological and abiotic FeS_2 and ZnS experiments under aerobic and anaerobic conditions, respectively. Aerobic biological S^0 experiments also produced 9 ‰ enrichment factor. These results suggest that $\delta^{18}\text{O}_{\text{H}_2\text{O}}$ from the aerobic and anaerobic sphalerite and the aerobic S^0 experiments were each enriched in ^{18}O by ~5 ‰ compared to FeS_2 experiments. The $\delta^{34}\text{S}_{\text{SO}_4}$ from aerobic and anaerobic FeS_2 experiments closely reflect the parent $\delta^{34}\text{S}_{\text{FeS}_2}$ value. In contrast to FeS_2 experiments, the $\delta^{34}\text{S}_{\text{SO}_4}$ from anaerobic ZnS experiments showed ~-3 ‰ enrichments relative to the parent $\delta^{34}\text{S}_{\text{ZnS}}$ value. Our experimental results suggest that sulfide mineralogy (monosulfides vs. disulfides) may have influence on the $\delta(^{18}\text{O}, ^{34}\text{S})_{\text{SO}_4}$ values.

SI (Saturation Index) Characteristics and Crystallization Mechanism of Hydromagnesite and Huntite in Salda Lake, Turkey

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Keywords: Hydromagnesite, Huntite, Saturation Index, Salda Lake, Turkey

ABSTRACT

Hydromagnesite one of the sedimentary deposits in Salda Lake Basin, is developed under the control of active tectonics regime. Systematic host rock, lake water and hydromagnesite sampling were carried out. Macro, micro, XRD and chemical investigations were also done in detail. Formation and crystallization mechanism and hydromagnesite's SI values were evaluated. Hydromagnesite development is considered in different phases, because it has showed various characteristics in different areas. Hydromagnesite levels exhibit tectonic influences in and around the lake. Therefore, the levels seem to exhibit secondary formation properties. Resolving and re-differentiation sedimentation processes probably improve in periods of lake water chemistry especially Ca/Mg proportional changes, and also SI variations indicate the mentioned precipitation mechanism. It is thought that hydromagnesite formation, which is existed by results of determined developments and multiphase sedimentation, could be originated from probable crack zones on the lake bottom.

Detection of deeply buried mineralisation using ground conductivity and pH measurement

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Keywords: Transported regolith, anomaly detection, Mandamah, selective extraction, conductivity.

ABSTRACT

Exploration of deeply buried mineralization in transported regolith is a major challenge for exploration. Ground conductivity measurement (GCM), soil pH, EC and selective geochemical extraction patterns have been examined in the upper 2m of transported regolith over the Mandamah Cu-Au deposit in NSW, Australia. Mineralization is buried under 45 m of transported cover and a further 30 m of saprolite. The transported unit contains sand, clay and gravel layers over an irregular erosional unconformity. The GCM results displayed consistent conductivity lows over mineralisation, and elevated conductivity and Na contents adjacent to mineralisation. Ammonium acetate extraction geochemistry demonstrates a vertical and lateral zonation of cations around mineralisation, that is consistent with an H⁺ source at depth and moderation by exchange on clays, precipitation of salts and carbonates in a semi-arid environment. The use of GCM at Mandamah has shown potential as a rapid, low-cost and reliable method for detecting variations in soil geochemistry related to the presence of deeply buried mineralization.

**Determination of Gold, Platinum and Palladium by Lead Collection
Fire Assay and Axial Inductively Coupled Plasma Optical Emission
Spectroscopy**

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Keywords: Fire assay, gold, platinum, palladium, ICP-OES, analysis

ABSTRACT

The accurate determination of gold, platinum and palladium concentrations in exploration samples is critical in determining future mining and resource plans. There is a constant demand for lower levels of detection and faster reporting of results. The work presented here details the development of a new method for the determination of gold, platinum and palladium using a lead collection fire assay, combined with inductively coupled plasma optical emission spectroscopy (ICP-OES). The axial mode of the ICP-OES is used to provide an efficient analysis with low detection limits (1ppb for all three elements), and wide dynamic ranges (up to 600ppm for each element). Validation data is shown for reference standard values and a comparison of low-level samples determined using inductively coupled plasma mass spectrometry (ICP-MS) is made. The correction of potential interferences using spectral fitting techniques is discussed. The method is certified to the ISO17025 standard.

Documenting geochemical, physical, and thermodynamic changes associated with all possible geochemical reactions in rocks using Gale vector space: Metasomatic examples from diamondiferous kimberlites to Ni laterite deposits

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Keywords: Gale space, metasomatism, hydrothermal alteration, weathering, balanced chemical reactions.

ABSTRACT

Metasomatic reactions associated with many geological processes (e.g., hydrothermal alteration, diagenesis, weathering) are typically difficult to confidently identify because some reactants and products are soluble species and may be added or removed by the fluid. As a result, a large number of different geochemical reactions may be responsible for a set of observed mineralogic changes. Determining which reaction operated to produce the observed changes in mineral assemblage may thus be intractable without other geochemical, physical, or thermodynamic constraints. Matrices of row and column vectors may be used to describe both the compositions of minerals and aqueous species, and the coefficients of these minerals and species in geochemical reactions. The row space of the null space of a minerals/species composition matrix (the 'Gale' space) hosts radial vectors defining all possible reactions among the minerals and species under consideration. Chemical, physical and thermodynamic properties of each of these reactions can be plotted in a radial coordinate system over this Gale space to identify what reactions satisfy a given set of constraints. Examples from several case histories illustrate the use of Gale space to identify specific geochemical reactions.

Geochemical and environmental characterization of pyritic tailings ponds

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Keywords: geochemical characterization, tailings ponds, composite samples, acid-base accounting, sequential extractions, heavy metals.

ABSTRACT

Land degradation from abandoned old mine workings is well known in most countries. There are many references to environmental damage from such sites, however few systematic surveys and impact assessments have been carried out in order to obtain valuable information, therefore the true scope of the problem is not accurately known. One of the first steps for the remediation or reclamation of tailings disposal sites should be their characterisation for ranking priorities. The GEOLOGICAL SURVEY OF SPAIN (IGME) is presently developing the Project “Geochemical characterization and environmental behaviour of tailing ponds at different environmental conditions”. The aim of this project is to test and validate a methodology, already used in other environments, to investigate geochemical and mineralogical processes in mine tailings ponds. Knowledge about oxidation processes, acid-base accounting and secondary minerals formation is being achieved. For this purpose, three tailings dumps have been selected, in order to carry out physical, geochemical and mineralogical characterization, as well as the heavy metal content using a seven-step sequential extraction. Multiple samples are obtained from the surface of each dump in open pitholes and from the subsurface, using a percussion drilling equipment. In parallel, other study is being carried out focused on the average properties tailings dumps surfaces. For this purpose, a screening method based on composite sampling of the tailings pond surface is being tried out, to evaluate her usefulness for huge amount of mine tailings ponds sampling and screening as well as for future ranking in a preliminary decision making strategy for tailings ponds management.

Geochemical indicators as tools for water management in transboundary rivers. Application to Guadiana basin (Spain-Portugal).

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ABSTRACT

To manage water at basin level according to the philosophy of the EU Water Framework Directive, technical and scientific measures must be applied to achieve an effective environmental management and protection. Of all applying necessary measures, the development of specific geochemical indicators is considered. In relation to basin waters uses, these elements represent a fundamental source of information for water quality studies and a useful tool for water management. The selected geochemical indicators should be exclusives and they must define with precision the characteristics of the corresponding study zone.

Specific geochemical indicators were selected for the Guadiana basin, located in a semi-arid region of Southern Europe. This transnational basin which begins in Spain continues beyond the frontier by Portuguese territory to finally follow the Spanish/Portuguese border up to flow into the Atlantic Ocean.

Due to climatic conditions it shows a non-compensated and critical water balance. While water quantity is influenced by natural climatic and hydrological factors, water quality is completely dependent on human activities, as available water resources which are reduced by pollution processes.

The problems associated to the pollution and shortage of its resources, are further compounded by the transboundary character of the basin which make the water management difficult.

Visage: a new stereo viewing and compilation software tool for geologic works

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ABSTRACT

A new software tool, called VISAGE, for aerial image stereo viewing and geologic cartographic compilation, is presented. This tool has been designed on a modular basis. The already developed main module, is the stereoscopic viewer of epipolar images. This nucleus has been programmed in C++ under .Net environment, using also the free distribution OpenGL library. This stereoscopic module virtually recreates a classic stereoscope, that is, the work is done directly in 3D on the computer. Different technologies for stereoscopic vision have been implemented through a new library developed by us, named GLSV (Graphics Library Stereo Vision). It allows VISAGE to work with different stereoscopic devices, like anaglyphs and shutter glasses (dual stream and interlaced formats), as well as the projection in the classroom by means of double projector using polarized light.

A module for manual stereo compilation has been added to the main one. It allows creation and edition of graphical entities. Many of these entities codify different geologic structures and geographical features with the specialized geological symbology (folds, faults, thrusts, etc.). In addition, they can be exported towards CAD systems using DXF standard files. It is also possible the exportation of the results in raster formats.

Future works will be the development of new modules for the epipolar image pair generation from the original images, and image and vector georeferencing. The use of several mathematical algorithms, will take into account different capture sensors and image geometries available to the user.

In the short term, the importation of external 3D vector maps in dxf format will be available. These vector maps will be overlaid on the 3D viewing photographic model and could be updated in the system to add new entities or check the existing ones. A graphical control for map layers will make easier the visualization handling of different kind of information. This task will remarkably benefit from the 3D working concept of the main

module. Other improvements related to image processing and geologic interpretation will follow in the future.

Removal of Pb, Cd, Zn, and Cu from aqueous solutions using lignite

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Keywords: heavy metals, removal, adsorption, lignite.

ABSTRACT

The removal of metal ions (Pb, Cd, Zn, and Cu) from spiked aqueous solutions using four lignite samples of different quality, from different areas in Greece, was investigated. Cation exchange capacity, humic and fulvic acid content, and the BET specific surface area of the samples were determined, proximate and ultimate analyses were conducted and the mineralogy of their low temperature ash was studied. Kinetic experiments were carried out and the equilibrium in all cases was achieved within approximately 45min. Sorption isotherm studies were conducted by varying the initial concentration of the elements from 10 to 1000ppm. Competitive adsorption of the elements was investigated using a solution that contained 100ppm of each element.

It was observed that the use of the four different lignite samples was considerably effective in removing Pb, Cd, Zn, and Cu ions from aqueous solutions, with the sample MT2 being the most effective. Among the elements, Pb appeared to have the strongest affinity based on a weight uptake by lignite samples. The same behavior was observed during the competitive adsorption experiments. Attempt is made to correlate the adsorption behavior for the lignite samples with the mineralogy of their low temperature ash and the content in humic and fulvic acids.

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