# 18th INTERNATIONAL GEOCHEMICAL EXPLORATION SYMPOSIUM

JERUSALEM, ISRAEL, MAY 25 - 30, 1997



# PROGRAM, ABSTRACTS and LIST OF PARTICIPANTS







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Geological Survey of Israel

KENES - ORGANIZERS OF CONGRESSES AND TOUR OPERATORS LTD. P.O. Box 50006, Tel Aviv 61500, Israel Tel: 972 3 5140000; Fax: 972 3 5175674 / 5140077 E-mail: conventions@kenes.com Homepage: http://www.kenes.co.il

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### Dear Colleagues;

On behalf of the Association of Exploration Geochemists, we take great pleasure in welcoming you to the 18th International Geochemical Exploration Symposium. This scientific meeting is taking place in a unique historical setting and at a special time marking the 3000th anniversary of the establishment of Jerusalem.

As you will note from the program, both the subject content and the geographic distribution of the home countries of the participants, is somewhat different from those of former IGES meetings. This is particularly reflected in the continuing overlapping of what has been called the "sister fields" of geochemical exploration and environmental geochemistry. As a result, the agenda of lectures and posters includes an unusually wide variety of topics.

The field trips to the north and south of Israel are important parts of the meeting and will provide an excellent cross-section of the geology and historical aspects of the country.

We would like to thank David Garnett, Gwendy Hall and Fred Siegel of the AEG council for their ongoing support and advice in the planning and organization of this meeting. Our colleagues at the Geological Survey, particularly Dov Levitte, Naomi Porat, Ariel Heimann, Gidi Baer, Yossi Yechieli and Amihai Sneh are thanked for their assistance and cooperation.

Have a pleasant stay in Jerusalem and in the field, and a productive meeting.

Ron Bogoch and Moshe Shirav



"Geochemists in the field"

### G:\TAMMIGUR\GEOCHEM\final timetable.doc page 1of 1 lvetta 19/05/97 9:38 AM

SUNDAY May 25, 1997	MONDAY May 26, 1997	TUESDAY May 27, 1997	WEDNESDAY May 28, 1997	THURSDAY May 29, 1997	FRIDAY May 30, 1997		
May 25, 1997	10:30 - 11:00 Coffee Break	08:30 - 10:30 Session E ENVIRONMENTAL GEOCHEMISTRY I	08:30 - 10:30 Session G EXPLORATION GEOCHEMISTRY II	08:30 - 10:30 Session K GEOCHEMICAL MAPPING	09:00 - 10:30 Hall A Workshop A MODERN TECHNIQUES IN GEOCHEMICAL ANALYSES: AN UPDATE	09:00 - 10:30 Hall B Workshop B ENVIRONMENTAL AND LEGISLATIVE USES OF REGIONAL GEOCHEMICAL BASELINE DATA FOR SUSTAINABLE DEVELOPMENT	09:00 - 10:30 Hall C Workshop F GLOBAL GEOCHEMICAL BASELINES
	11:00 - 13:00 Session B EXPLORATION GEOCHEMISTRY I	11:00 - 13:00 Session F MITIGATION OF GEOCHEMICAL IMPACT ON THE ENVIRONMENT	11:00 - 13:00 Session H ADVANCES IN ANALYTICAL TECHNIQUES	Session L BIOGEO- CHEMISTRY	Workshop A continued	Workshop B continued	Workshop F continued
	13:00 - 14:30 Lunch Break		13:00 -14:30 Lunch Break				
	14:30 - 16:00	14:30	14:30 - 16:00	14:30 - 16:00			
	Session C HYDRO- GEOCHEMISTRY	HALF DAY TOUR OF JERUSALEM	Session I ARCHAEOLOGY AND GEOCHEMISTRY	Session M GEOCHEMISTRY OF RADON AND RADIOACTIVE TRACERS			
	16:00 - 16:30 Coffee Break		16:00 - 16:30 Coffee Break				
17:00 - 21:30	16:30 - 18:00		16:30 - 18:00	16:30 - 18:15			
REGISTRATION	Session D SAMPLING MEDIA		Session J ENVIRONMENTAL GEOCHEMISTRY II	Session N DATA PROCESSING			
Green grad	18:30 - 19:30		18:00 - 19:30	State Line Street	1. And the second		
	POSTER SESSION I		POSTER SESSION II				
21:00 Get Together Reception		20:00 Guided Tour of the Israel Museum followed by a Reception	20:30 AEG Festive Dinner (Optional)				

ALL SESSIONS WILL BE HELD IN HALL A UNLESS OTHERWISE SPECIFIED

# TIMETABLE

# **ORGANIZING COMMITTEE**

Ron Bogoch and Moshe Shirav Co-Chairmen, Geological Survey of Israel

Michael Beyth Earth Science Administration, Ministry of Energy and Infrastructure

Joe Brenner Geological Survey of Israel

Yuval Cohen Israel Oceanographic and Limnological Research, Haifa

Yigal Erel Hebrew University of Jerusalem

George Constantinou Director, Geological Survey Department, Cyprus

Shimon Feinstein Ben Gurion University of the Negev, Beer Sheva

Yehoshua Kolodny The Hebrew University of Jerusalem, Jerusalem

Joel Kronfeld Tel Aviv University

Yair Levi Rotem Amfert Negev Ltd. (Negev Phosphates)

Yoseph Nachmias PAMA (Energy Resources Development) Ltd.

Aryeh Nissenbaum The Weizmann Institute of Science, Rehovot

Naomi Porat Geological Survey of Israel

Steve Tandy Dead Sea Works Ltd.

# SPONSORS

GEOLOGICAL SURVEY OF ISRAEL ASSOCIATION OF EXPLORATION GEOCHEMISTS ISRAEL MINISTRY OF SCIENCE ISRAEL GEOLOGICAL SOCIETY BEN GURION UNIVERSITY OF THE NEGEV PHOENICIA AMERICA ISRAEL LTD. TAAVURA (ISRAEL) LTD. SANTA FE GOLD, U.S.A. THE ISRAEL MINERAL SCIENCE AND ENGINEERING ASSOCIATION EVEN VASID (ISRAEL) LTD.

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GEOLOGICAL SURVEY OF ISRAEL 30 Malkhe Israel St. Jerusalem 95501 Israel Tel: 972 2 5314256; Fax: 972 2 5380688

# WORKSHOPS

Workshops on selected topics will be held on Friday, May 30 at the Symposium venue from 09:00 to 13:00.

- MODERN TECHNIQUES IN GEOCHEMICAL ANALYSES: AN UPDATE
  Joe Brenner, Geological Survey of Israel
  Gwendy Hall, Geological Survey of Canada
- B. ENVIRONMENTAL AND LEGISLATIVE USES OF REGIONAL GEOCHEMICAL
  BASELINE DATA FOR SUSTAINABLE DEVELOPMENT
  Peter Simpson, British Geological Survey
- F. GLOBAL GEOCHEMICAL BASELINES Reijo Salminen, Geological Survey of Finland

Note:

Participation in the Workshops is not included in the Symposium Registration fee and separate registration is necessary.

# SOCIAL EVENTS

### SUNDAY, MAY 25, 1997

21:00 GET TOGETHER RECEPTION At the Jerusalem Renaissance Hotel.

### **TUESDAY, MAY 27, 1997**

### 14:30 HALF DAY TOUR - JERUSALEM THROUGH THE AGES

Please exchange your voucher at the hospitality desk no later than Monday, May 26, at 14:00. Bus departs from the Jerusalem Renaissance Hotel.

"He who has not seen Jerusalem in all its Glory has never seen a beautiful city ...".

A scenic ride through the beautiful gardens of the Knesset, the Israel Museum and the magnificent new Supreme Court building will lead to the Haas Promenade on the most impressive southern city slope, for a breath-taking view of ancient Jerusalem. Understand its topography and how it developed throughout the ages. Continue to the Jaffa Gate, one of Jerusalem's main gates from the Ottoman period. Walk along the narrow streets and alleyways of the oriental market to the rooftops of the Old City for an overview of the Christian, Jewish, Moslem and Armenian Quarters. Travel back in time as you walk to the Jewish Quarter to visit the Broad Wall, part of Jerusalem's walls from the First Temple period, built 2800 years ago by King Hezakaia. Continue to the Cardo built by Emperor Hadrian. Descend the route of the upper city dwellers to the Western Wall, the only link to the Second Temple (built 2000 years ago by King Herod the Great). View the most amazing sites unearthed at the southern wall excavation.

### 20:00 VISIT THE ISRAEL MUSEUM FOR A GUIDED TOUR FOLLOWED BY A RECEPTION.

Departure from the Jerusalem Renaissance Hotel at 19:30 hours. Proceed on foot to the Israel Museum (Approximately 20 minutes walk). Upon arrival, divide into groups for a guided tour of the Museum and join up again for an outdoor reception.

Please wear comfortable shoes and a warm jacket.

### WEDNESDAY, MAY 28, 1997

### 20:30 ASSOCIATION OF EXPLORATION GEOCHEMISTS (AEG) - FESTIVE DINNER (Optional)

At the "Little Jerusalem", The Ticho House.

Bus departs from the Jerusalem Renaissance Hotel at 20:00

Tickets can be purchased at the registration desk, up until the close of sessions on Tuesday, May 27. Price: \$30

# ACCOMPANYING PERSONS PROGRAM

Registered Accompanying Persons are invited to participate in Symposium social events and in the following tours:

### MONDAY, MAY 26, 1997

### DIG FOR A DAY - VISIT TO A KIBBUTZ

09:00 Bus departs from Jerusalem Renaissance Hotel

In a fascinating half-day tour, combine two of Israel's most exciting experiences: a chance to participate in a hands-on archaeological excavation, and a visit to a Kibbutz, the uniquely Israeli communal living settlement.

Descend the western slopes of the Judean Hills passing "Zora" Samson's home town and the Ela Valley, where David the young shepherd slew Goliath the Philistine. Arrive at Tel Marisha in the area of Beit Guvrin, the ancestral home of King Herod. Vast underground labyrinths of man-made rooms are being systematically cleaned and give evidence of underground industrial complexes dating from the Hellenistic period. Remains of olive oil production, weaving installations, water cisterns and baths confirm a high level of material culture. This site offers a wealth of discoveries and practical experience for those who want to dig but have limited time.

From the dig proceed to Kibbutz Beit Guvrin, where we tour and meet a member of the Kibbutz.

### **THURSDAY, MAY 29, 1997**

### DAVID'S CITY - CELEBRATING JERUSALEM'S 3000th ANNIVERSARY

09:00 Bus departs from Jerusalem Renaissance Hotel

Follow the path of the newly constructed Promenade along the Kidron Valley site of David's entry into Jerusalem. This breathtaking walk affords an opportunity to explore the majestic Tombs of the Mount of Olives. Descend to Area G where archaeological remains of the First Temple Period houses support the Biblical account of the early city's expansion. Climb down the restored Warren's Shaft where ancient construction methods can be seen. We conclude with a walk through King Hezekiah's famous Water Tunnel.

# GENERAL INFORMATION

### LOCATION

Jerusalem Renaissance Hotel 6 Wolfson St., Jerusalem Tel: 972 2 6528111; Fax: 972 2 6511824.

### **REGISTRATION / INFORMATION / HOSPITALITY / SECRETARIAT**

Jerusalem Renaissance Hotel May 25, Sunday From 17:00 - 21:30 May 26, Monday - May 30, Friday

From 08:00 throughout session hours.

### LANGUAGE

The official language of the Symposium is English.

### BADGES

Upon registering you received your Symposium kit, which includes your name badge. You are requested to wear your name badge during all Symposium sessions and events.

### **EXHIBITION**

Symposium participants are invited to view the exhibition. The exhibition will open on Monday, May 26. at 09:00 and will remain open during the session hours until 18:00 on Thursday, May 29.

### MAIL/MESSAGES/LOST AND FOUND/MEDICAL ASSISTANCE

Please apply to the Information Desk.

### PROJECTION

Speakers are requested to notify the Information Desk of their audio-visual requirements. Slides may be checked in the slide preview area prior to the presentation, and should be handed in to the projectionist in the hall 15 minutes prior to the session. Please remember to collect them immediately afterwards.

### SHOPPING HOURS

Department stores are usually open from 08:00 to 19:30. Small stores close for lunch from 13:00 to 16:00. Stores close on Friday at 14:00 and remain closed on Saturday.

### TRAVEL AND ACCOMMODATION

Kenes Tours will operate a desk during the Symposium. Participants requiring additional hotel accommodation in Israel, tours by motor coach or by chauffeured limousine, domestic flights, car rental, etc. should apply to this desk at their earliest convenience. Payment for any of these services can be made in travelers cheques, Eurocheques, foreign currency or major credit cards. Payment in local currency is subject to 17% VAT.

### POSTER DISPLAY

Special poster sessions have been added to the program and presenters should be available alongside their boards during these sessions. Please check the program for the exact dates of presentation. Posters should be mounted by 08:30 on the first designated day and should be removed at the end of the last session of the following day. The Organizers can accept no responsibility for posters left on display beyond this time. Pins are available in the Poster Display area.

### **OFFICIAL CARRIER**

El Al Israel Airlines is the official carrier of the Symposium.

### SYMPOSIUM PAPERS

Full papers presented at the 18th IGES will be published in a special issue of the Journal of Geochemical Exploration. after the usual review process. These papers must be submitted to:

Moshe Shirav (at the Geological Survey of Israel) by September 30, 1997.

### FLIGHT RECONFIRMATION

Participants flying EL AL Israel Airlines are requested to reconfirm their return flight at the Kenes Hospitality Desk no later than Tuesday, May 27, 1997.

Participants flying other airlines are requested to reconfirm their return flight directly with the respective Airline.

### ELECTRICITY

Electrical equipment in Israel is 220 volt A.C., single phase, 50 cycles. Some appliances require an adapter for the plug (can be purchased locally).

### FIELD TRIP D - Southern Israel - Eilat - Post Symposium

Sunday, June 1 - Wednesday, June 4, 1997

Stops will include salt diapir, Qumram site where the Dead Sea scrolls were discovered, Dead Sea Works and evaporation pans, radon measurement station, Timna area silicate-carbonate deposit, ancient Cu-mining sites, Eilat area, Au-As mineralization, Negev phosphorites, oil shale mining, Ramon erosional cirgue.

Tickets are available. You may register at the Hospitality desk up until Monday, May 26, at 15:00.

SCIENTIFIC PROGRAM

## MONDAY, MAY 26, 1997

### 09:00 - 10:30

### Session A OPENING CEREMONY AND PRESIDENTIAL ADDRESS

Ron Bogoch: Congress Co-Chairman Ehud Olmert: Mayor of Jerusalem Gideon Steinitz: Director: Geological Survey of Israel

PRESIDENTIAL ADDRESS David Garnett: AEG

10:30 Coffee Break

### 11:00 - 13:00

Hall A

### Session B EXPLORATION GEOCHEMISTRY I

Chairpersons:

I.D.M. Robertson, Australia Y. Levi, Israel

Keynote Lecture: EFFICIENCY OF CYANIDATION IN GOLD EXPLORATION USING SOILS T.A. Delaney, W.K. Fletcher, Vancouver BC, Canada

STREAM SEDIMENT EXPLORATION FOR GOLD AND SILVER IN NEVADA - APPLICATION OF AN OLD PROSPECTING METHOD USING MODERN ANALYTICAL TECHNIQUES J.V. Tingley, S.B. Castor, Reno NV, USA

SULFIDE AND SILICATE GEOCHEMISTRY IN THE BLEIDA ORE DEPOSIT: A GUIDE TO GEOCHEMICAL EXPLORATION

Y. Zinbi, B. Maamar, L. Maacha, R. Ziyadi, Casablanca, Morocco

REGIONAL GEOCHEMICAL EXPLORATION IN DEEPLY WEATHERED AND DESERT TERRAINS

X. Wang, D. Liu, Z. Cheng, X. Xie, Heibei, China

EXPLOITATION OF GOLD AND OTHER PRECIOUS METALS IN AN HISTORIC SEWAGE SLUDGE STOCKPILE, MELBOURNE, AUSTRALIA; DISTRIBUTION, EXTRACTION AND UTILISATION OF DEPLETED SLUDGE S.J. Reeves, I.R. Plimer, Melbourne VIC, Australia

EXPLORATION AND OCCURRENCES OF AU, PT AND PD IN THE POLISH ZECHSTEIN COPPER DEPOSITS (KUPFERSCHIEFER) Z. Sawlowicz, A. Piestrzynski, Krakow, Poland

13:00 Lunch Break

Hall A

### 14:30 - 16:00

### Session C HYDROGEOCHEMISTRY

Chairpersons:

R. Taraskevicius, Lithuania Y. Cohen, Israel

Keynote Lecture: THE CHEMISTRY OF THE DEAD SEA AND THE SURROUNDING THERMAL BRINES Y. Yehieli, I. Gavrieli, Israel

GEOCHEMICAL ATLAS OF GROUNDWATER AND ITS APPLICATION IN THE ENVIRONMENTAL SPHERE D. Bodis, J. Kordik, S. Rapant, I. Slaninka, Bratislava, Slovakia

CHEMISTRY OF INTERSTITIAL WATER FROM EOCENE CHALK OF AVDAT AQUIFER, NORTH-WESTERN NEGEV, ISRAEL Y. Livshitz, Beer Sheva, Israel

Keynote Lecture: GEOCHEMISTRY OF RIVERS: A PULSE FOR THE STATE OF THE ENVIRONMENT **E.M. Cameron**, G.E.M. Hall, K. Hattori, Ottawa ONT, Canada

16:00 Coffee Break

### 16:30 - 18:00

Hall A

### Session D SAMPLING MEDIA

Chairpersons: Z. Sawlowicz, Poland M. Matthews, Israel

Keynote Lecture: CARBONACEOUS SUBSTANCES IN SELECTED MINERAL DEPOSITS: IMPLICATIONS FOR GEOCHEMICAL EXPLORATION D.J. Mossman, Sackville NB, Canada

VARIATIONS OF SOIL SIGNAL AND SELECTIVE EXTRACTION OF GOLD IN DIFFERENT LATERITIC CONTEXTS **P. Freyssinet**, C. Greffie, Orleans, France

WHAT'S IN A SAMPLE? D.L. Garnett, Sydney NSW, Australia

TRANSPORTED OVERBURDEN, THE TIME FACTOR N.W. Radford, P. Burton, Perth WA, Darwin NA, Australia

CHEMICAL ELEMENT DIFFERENTATION IN THE COURSE OF ALLUVIAL LITHOGENESIS IN THE POLLUTED SVISLOCH RIVER, BELARUS V. Savchenko, Minsk, Belarus

Hall A

### 18:00 - 19:30

### POSTER SESSION I

PHYSICO-CHEMICAL CONDITIONS OF SALT SEDIMENTATION IN MODERN EVAPORITE BASINS

M.V. Charykova, V.V. Kurilenko, St Petersburg, Russia

DOLOMITIZATION, PRECURSOR OF HYDROTHERMAL-METASOMATIC MINERALIZATION IN THE JUDEAN DESERT, ISRAEL

A. Gilat, Y. Nathan, Jerusalem, Israel

MODELING OF DEEP GROUNDWATER CHEMISTRY IN THE HEBEI PLAIN, CHINA Y. Guo, Beijing, China

IDENTIFYING SOURCES OF SALINITY IN THE PLEISTOCENE COASTAL AQUIFER, MT. CARMEL REGION, ISRAEL

J. Guttman, J. Kronfeld, Ramat Aviv, Tel Aviv, Israel

PRESERVATION OF ARSENIC SPECIES IN NATURAL WATERS G.E.M. Hall, G. Gauthier, J.C. Pelchat, Ottawa ONT, Canada

MAGNETIC SUSCEPTIBILITY AS A PROXY PARAMETER FOR THE DETECTION OF POLLUTION OF SOILS AND SEDIMENTS: CONTAMINATION DUE TO EMISSION OF VEHICLES

V. Hoffmann, M. Knab, E. Appel, Tubingen, Germany

BIOGEOPHYSICAL-CHEMICAL INVESTIGATIONS OF THE FORGOTTEN DEPOSITS A.L. Kovalevskii, M.A. Nefed'ev, A.S. Odegov, G.V. Chervyakov, Ulan-Ude, Russia

SCINTILLATION EMISSION SPECTRAL ANALYSIS (SESA) IN GEOCHEMICAL RESEARCHE AND ENVIRONMENTAL ASSESSMENT

A.L. Kovalevskii, S.I. Prokopchuk, Ulan-Ude, Irkutsk, Russia

THE HYDROBIOGEOCHEMICAL METHODS FOR EXPLORATION AND ECOLOGICAL INVESTIGATIONS

A.L. Kovalevskii, A.M. Plyusnin, Ulan-Ude, Russia

COMPARATIVE CHARACTERIZATION OF HUMIC ACIDS OF DIFFERENT ORIGIN E.V. Krechetova, Moscow, Russia

FORMATION AND RATIONAL UTILIZATION OF CONTEMPORARY EVAPORITE SEDIMENTATION BRINES

V.V. Kurilenko, M.V. Charykova, St Petersburg, Russia

DETERMINATION OF SOIL GEOCHEMICAL ANOMALIES BASED ON PHOTOMETRIC MEASUREMENTS OF VEGETATION

V.G. Surin, G.A. Ladner, E.V. Kuvaldin, St Petersburg, Russia

GRANULOMETRIC FRACTIONS OF COPPER AND ZINC IN LARGE INDUSTRIAL CITY SOILS D.V. Ladonin, Moscow, Russia

GEOCHEMICAL SIGNATURES OF ARCHAEOLOGICAL SITES WITH BLACK EARTH SOILS IN AMAZON REGION

M. Lima da Costa, D.C. Kern, Belem, Brazil

GEOCHEMICAL EVOLUTION OF LATERITIC Sn, Zr, Th, Nb Y AND REE-BEARING ORE BODY DERIVED FROM APOGRANITE: THE CASE OF PITINGA, AMAZONAS - BRAZIL A.M.C. Horbe, **M. Lima da Costa**, Belem-PA, Brazil

### 18:00 - 19:30

### **POSTER SESSION I (cont.)**

THE EFFECT OF URBANIZATION AND INDUSTRY ON CONTENTS OF SOME ELEMENTS IN ALLUVIAL SEDIMENTS IN POLAND J. Lis, Warsaw, Poland

RADIOGEOCHEMICAL MAPPING IN THE LITHUANIA J. Mazeika, R. Petrosius, Vilnius, Lithuania, (R. Taraskevicius presenting on behalf of J. Mazeika)

EVALUATION OF TERRA ROSSA GEOCHEMICAL BASELINES FROM CROATIAN KARST REGIONS

S. Miko, G. Durn, Zagreb, Croatia

GEOCHEMISTRY AND MINERALOGY OF THE ZAOSTROVSK BAUXITE-PHOSPHORITE DEPOSIT IN THE MIDDLE TIMAN (RUSSIA) L.E. Mordberg, St. Petersburg, Russia

ORGANO-MINERAL SPECIES OF METALS AND THEIR MIGRATION IN HUMID LANDSCAPES G.V. Motuzova, Moscow, Russia

TRACING MARINE SEDIMENT TRANSPORT USING RADIOCESIUM IN THE EASTERN MEDITERRANEAN

E. Ne'eman, J. Kronfeld, N. Lavi, V. Butenko, H. Koral, Tel Aviv, Israel, Istanbul, Turkey

# TUESDAY, MAY 27, 1997

08:30 - 10:30

### Session E ENVIRONMENTAL GEOCHEMISTRY I

Chairpersons:

J. Vesely, Czech Republic Y. Nachmias, Israel

Keynote Lecture:

CORRELATION OF NATURAL AND TECHNOGENIC MERCURY SOURCES BASED ON REGIONAL MAPPING AND MONITORING, BAIKAL POLYGON, SIBERIA **P.V. Koval**, G.V. Kalmychkov, V.F. Gelety, G.A. Leonova, V.I. Medvedev, L.D. Andrulaitis, Irkutsk, Russia

DEPOSITION AND IMPACT OF ELEMENTS EMITTED FROM FOUR POWER PLANTS IN THE WABAMUN LAKE AREA, ALBERTA, CANADA F. Goodarzi, Calgary, Alberta, Canada

A TALE OF TWO CITIES: URBAN GEOCHEMISTRY OF JERUSALEM AND HAIFA M. Shirav, N. Wolfson, S. Ilani, L. Halicz, Jerusalem, Israel

ENVIRONMENTAL GEOCHEMISTRY-GEOCHEMICAL EXPLORATION: LINKED PRINCIPLES AND PROCESSES; CONTRASTING PROBLEMS AND SOLUTIONS **F.R. Siegel**, J.H. Kravitz, Washington DC, Arlington VA, USA

URBAN ENVIRONMENTAL GEOCHEMISTRY IN A MEDIUM-SIZE INDUSTRIAL CITY IN NORTHERN SPAIN A. Ordonez, J. Loredo, J. Garcia-Iglesias, Oviedo, Spain

POTENTIAL USE OF PYRITE AS A CALCAREOUS SOIL AMENDMENT M.A. Castelo Branco, J. Santos, O. Moreira, S. Dias, V. Magalhaes, J.M. Vieira e Silva, Oeiras, Santarem, Coimbra, Portugal

10:30 Coffee Break

Hall A

### 11:00 - 13:00

Hall A

### Session F MITIGATION OF GEOCHEMICAL IMPACT ON THE ENVIRONMENT

Chairpersons:

W.L. Plueger, Germany L. Halicz, Israel

Keynote Lecture:

IMPACT OF MINING ACTIVITIES UPON THE ENVIRONMENT OF THE SLOVAK REPUBLIC: A CASE STUDY

A. Klukanova, S. Rapant, Bratislava, Slovakia

LEAD 207/206 RATIOS IN SEDIMENTS FROM THE COEUR D'ALENE AND SPOKANE AREA, IDAHO AND WASHINGTON, USA: EFFECT OF MINING ACTIVITIES ON LEAD ISOTOPIC COMPOSITION OF SEDIMENTS

M. Ikramuddin, S.E. Box, A.A. Bookstrom, Cheney WA, Spokane WA, USA

THE ROLE OF CHANNEL PROCESSES IN MITIGATION OF IMPACT FROM ZINC AND LEAD MINING IN UPPER SILESIA (SOUTH POLAND) D. Ciszewski, Krakow, Poland

AN APPROACH TO THE ENVIRONMENTAL IMPACT FROM "LA SOTERRANA" MERCURY MINE (ASTURIAS, SPAIN)

J. Loredo, C. Fernandez-Albarran, J. Garcia-Iglesias, Oviedo, Spain

GEOCHEMICAL PATTERNS OF As, Cd, Pb, Zn AND Cu IN STREAM SEDIMENTS AND SOILS FROM A MINING SITE IN TERMS OF AN ENVIRONMENTAL IMPACT ASSESSMENT P. Avila, J.M. Santos Oliveira, S.Mamede Infesta, Portugal

METHANE EMISSION MITIGATION FROM ISRAELI LANDFILS A.B. Lifshits, V.I. Gurvich, Moscow, Russia

# WEDNESDAY, MAY 28, 1997

### 08:30 - 10:30

Session G EXPLORATION GEOCHEMISTRY II

Chairpersons:

P. Freyssinet, France A. Nissenbaum, Israel

Keynote Lecture:

ORIGINS AND GEOCHEMICAL APPLICATIONS OF THE COMPONENTS OF SOILS OVERLYING THE BEASLEY CREEK GOLD DEPOSIT IN THE ARID NORTHEAST YILGARN OF WESTERN AUSTRALIA I.D.M. Robertson, Perth, WA, Australia

VERTICAL MIGRATION OF ELEMENTS FROM BLIND MINERAL DEPOSITS I. Goldberg, Sydney NSW, Australia

STREAM SEDIMENT GEOCHEMICAL RECONNAISSANCE SURVEY, EASTERN ERITREA M. Beyth, M. Shirav, Jerusalem, Israel

GEOCHEMICAL EXPLORATION FOR BURIED GOLD MINERALIZATION, KYZYL KUM DESERT, UZBEKISTAN

A.A. Kremenetsky, I.A. Kubantsev, A.A. Volokh, Moscow, Russia

REGIONAL ORIENTATION OF NEW GEOCHEMICAL METHODS FOR DELINEATING LARGE GEOCHEMICAL PATTERNS AROUND THE GIANT DEPOSITS IN CENTRAL KYZYLKUM DESERT TERRAIN, UZBEKISTAN

X. Xie, X. Wang, L. Xu, A.A. Kremenetsky, V.K. Kheifets, Heibei, China, Moscow, Russia, Tashkent, Uzbekistan

GEOCHEMICAL EXPLORATION OF KARST BAUXITE DEPOSITS BY AIRBORNE GAMMA-RAY SPECTROMETRY: STUDIES IN THE INTERNAL DINARIDES BAUXITE PROVINCE A. Dangic, M. Milojevic, Belgrade, Yugoslavia

METALLOGENY AND ECOLOGY OF RUSSIA: POSSIBILITIES PRESENTED BY A SET OF GEOLOGICAL AND GEOCHEMICAL MAPS AT A SCALE OF 1:5,000,000 E.K. Burenkov, A.A. Golovin, M.V. Kochetkov, A.F. Morozov, E.I. Filatov, Moscow, Russia

10:30 Coffee Break

Hall A

### 11:00 - 13:00

Hall A

### Session H ADVANCES IN ANALYTICAL TECHNIQUES

Chairpersons: S. Rapant, Slovakia J.B. Brenner, Israel

Keynote Lecture:

THE "ENZYME LEACH - SOME NEW DISCOVERIES OF BLIND DEPOSITS E.L. Hoffman, J.R. Clark, J.R. Yeager, P. Rogers, Ancaster ONT, Canada

COMPARISON OF ANALYTICAL RESULTS USING DIFFERENT SELECTIVE EXTRACTION SCHEMES

G.E.M. Hall, Ottawa ONT, Canada

A STUDY OF THE MEASURING OF IONIC CONDUCTIVITY OF SOIL IN SEARCH FOR CONCEALED ORE DEPOSITS

Xianrong Luo, Guilin Guangxi, China, (Z. Xuejin presenting on behalf of X. Luo)

SORPTION OF VOLATILE METALLIC COMPOUNDS ON ACTIVATED CARBON: APPLICATION TO THE EXPLORATION FOR CONCEALED DEPOSITS IN SOUTHERN SPAIN H. Pauwels, J.-C. Baubron, P. Freyssinet, M. Chesneau, Orleans, Vierzon, France

ACID INSOLUBLE CONCENTRATIONS OF ELEMENTS IN SEARCH FOR VOLCANIC-HOSTED MASSIVE SULPHIDE, DEPOSITS, ROSEBERY AREA, WESTERN TASMANIA, AUSTRALIA A. Pwa, J.C. van Moort, Tasmania, Australia

ARTIFICIAL SORBENTS FOR PROSPECTING DEEP BURIED DEPOSITS V. Lukashev, Minsk, Belarus

13:00 Lunch Break

### 14:30 - 16:00

### Session I ARCHAEOLOGY AND GEOCHEMISTRY

Chairpersons: A. El Goresy, Germany N. Porat, Israel

APPLICATION OF PLATINUM GROUP ELEMENT AND LEAD ISOTOPE GEOCHEMISTRY TO THE STUDY OF THE CORROSION PRODUCTS OF ARCHAEOLOGICAL ARTEFACTS TO CONSTRAIN PROVENANCE

W. Snoek, T. Sogona, I.R. Plimer, Melbourn VIC, Australia

ALLOY COMPOSITION OF BRONZE OBJECTS FROM CANAAN DURING THE MIDDLE BRONZE AGE

A. Rosenfeld, S. Illani, M. Dvorachek, Jerusalem, Israel

LEAD ISOTOPIC PROVENANCE OF EGYPTIAN SULPHIDE DEPOSITS, NEW KINGDOM GLASS, AND GALENA COSMETICS: A SEARCH FOR THE SOURCE ORES OF PHARAONIC ARTEFACTS

A. El Goresy, F. Tera, B. Schlick-Nolte, E. Pernicka, Heidelberg, Germany

PETROCHEMISTRY OF BALLAST STONES: A KEY TO THE HOME-PORT AND ROUTE OF A SUNKEN PHOENICIAN-PERIOD VESSEL A.E. Shimron, D. Avigad, Jerusalem, Tel Aviv, Israel

PALEOMORPHLOGY AS THE KEY FOR THE UNDERSTANDING OF ANCIENT MINE WORKINGS - IN THE TIMNA VILLEY AND IN RIO TINTO (SW SPAIN) B. Rothenberg, London, UK

16:00 Coffee Break

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### 16:30 - 18:00

Hall A

### Session J ENVIRONMENTAL GEOCHEMISTRY II

Chairpersons: F.R. Siegel, USA S. Ilani, Israel

ENVIRONMENTAL ASPECTS OF ASH DISPOSAL FROM AN OIL SHALE COMBUSTION PLANT S. Laichter, J. Nahmias, Israel

ENVIRONMENTAL-GEOCHEMICAL MAPPING IN SLOVAKIA S. Rapant, M. Raposova, Bratislava, Slovakia

THE GEOCHEMISTRY OF MACRO- AND MICROELEMENTS IN THE AGRICULTURAL LANDSCAPES OF SOUTH VIETNAM G.V. Motuzova, N.T. Hong Van, Moscow, Russia, Hanoi, Vietnam

HEAVY METAL CONTAMINATION OF THE MINSK, BOBRUYSK AND MOZYR ENVIRONMENT V. Lukashev, Minsk, Belarus

ECOLOGICAL-GEOCHEMICAL ESTIMATION OF ANTHROPOGENIC POLLUTION OF MOSCOW

E.K. Burenkov, L.N. Ginzburg, T.D. Zangieva, Moscow, Russia

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### 18:00 - 19:30

### **POSTER SESSION II**

NONBARRIER BIOGEOCHEMICAL EXPLORATION FOR PLATINOIDS A.L. Kovalevskii, Ulan-Ude, Russia

PLATINUM AND PALLADIUM IN THE "PLANT-SOIL-ROCK" SYSTEM A.L. Kovalevskii, O.M. Kovalevskaya, E.M. Tat'yankina, Ulan-Ude, Russia

SYSTEMATICS OF HEAVY METALS AND HYDROCARBON MIGRATION IN THE ELECTRIC FIELD

M.A. Nekrasova, V.A. Korolev, Moscow, Russia

THE SEQUENTIAL EXTRACTION OF METAL FORMS IN THE SOIL IN SOUTH OF POLAND B. Nowak, Sosnowiec, Poland

TOTAL AND PARTIAL CONTENTS OF SOME ELEMENTS IN SOILS OF THE BORDERLAND OF POLAND AND LITHUANIA

J. Lis, A. Pasieczna, R. Taraskevicius, Warsaw, Poland, Vilnius, Lithuania

RELATIONSHIP OF GEOCHEMICAL LANDSCAPE OF SOILS AND GEOLOGICAL BASEMENT IN LOWER SILESIAN COAL BASIN - SW POLAND A. Pasieczna, Warsaw, Poland

PROXY MAPPING OF FLY-ASH POLLUTION OF SOILS AROUND A COAL-BURNING POWER PLANT: A CASE STUDY IN THE CZECH REPUBLIC

A. Kapicka, E. Petrovsky, S. Ustjak, K. Machackova, Prague, Czech Republic

PROVENANCE OF HEAVY METALS IN FOREST SOILS OF AN OLD MINING REGION IN WESTERN GERMANY

G. Deissmann, W.L. Plueger, Aachen, Germany

RESEARCH OF CLAY SOIL MICROSTRUCTURAL INFLUENCE ON THE INTENSITY OF DIFFUSION-OSMOTIC TRANSPORT S.L. Polischuk, V.A. Korolev, V. Sokolov, Moscow, Russia

GEOCHRONOLOGY OF THE GROUNDWATER IN THE HAIFA BAY REGION, ISRAEL V. Rogojin, J. Kronfeld, I. Carmi, Tel Aviv, Rehovot, Israel

PECULIARITIES OF HEAVY METAL BEHAVIOUR IN ARID TECHNOGENIC LANDSCAPES L.K. Sadovnikova, Moscow, Russia

FOUR TYPES OF ALLUVIAL SEDIMENTS: APPLICATION FOR ENVIRONMENTAL ASSESSMENT

V. Savchenko, I. Samsonenko, Minsk, Belarus

METALLURGICAL REMAINS FROM EN-ZIQ AND BE'ER RESISIM, CENTRAL NEGEV, ISRAEL I. Segal, Jerusalem, Israel

A NEW TECHNIQUE FOR EVALUATING MERCURY ANOMALIES S.L. Shvartsev, Tomsk, Russia

ECOGEOCHEMICAL INVESTIGATIONS OF URBANIZED TERRITORIES IN LITHUANIA R. Taraskevicius, R. Zinkute, Vilnius, Lithuania

METAL OCCURRENCE IN SOILS DEVELOPED ON BASALTIC BEDROCK: THE INFLUENCE OF RAINFALL

N. Teutsch, Y. Erel, L. Halicz, O.C. Chadwick, Jerusalem, Israel

POLLUTION OF CZECH FRESHWATERS BY TRACE ELEMENTS J. Vesely, V. Majer, Prague, Czech Republic

### 18:00 - 19:30

### **POSTER SESSION II (cont.)**

GEOCHEMICAL MERCURY SURVEY IN THE AZOGUE VALLEY (BETIC AREA, MURCIA SE SPAIN)

M. Viladevall, X. Font, A. Navarro, Barcelona, Catalonia, Spain

RESULTS FROM THE MULTIDATASET ANALYSIS FOR THE DEVELOPMENT OF METALLOGENETIC/ECONOMIC MODELS AND EXPLORATION CRITERIA FOR GOLD DEPOSITS IN WESTERN EUROPE (MIDAS PROJECT): THE CATALONIAN COASTAL RANGES (NE SPAIN) APPLICATION

M. Viladevall, J.M. Carmona, X. Font, D. Perez, Barcelona, Spain

THE RATE OF MIGRATION OF A URANIUM DEPOSITION FRONT: AN EXAMPLE FROM THE UITENHAGE ACQUIFER J.C. Vogel, A.S. Talma, J. Kronfeld, Tel Aviv, Israel

GAMMA-RAY ANALYSIS OF THE SEDIMENTS OVERLYING THE HELEZ AND KOCHAV OIL FIELDS, ISRAEL

N.E. Yanaki, D. Ashery, J. Kronfeld, Tel Aviv, Israel

# THURSDAY, MAY 29, 1997

### 08:30 - 10:30

### Session K GEOCHEMICAL MAPPING

Chairpersons:

E. Petrovsky, Czech Republic S. Feinstein, Israel

Keynote Lecture:

REGOLITH GEOCHEMICAL MAPPING AS AN ADJUNCT TO GEOLOGICAL MAPPING AND EXPLORATION; EXAMPLES FROM THREE CONTIGUOUS PROTEROZOIC BASINS IN WESTERN AUSTRALIA

R. Davy, F. Pirajno, A. Sanders, P. Morris, Perth WA, Australia

DISTRIBUTION AND ABUNDANCE OF MOBILE FORMS OF METALS IN DIFFERENT SETTINGS AND THEIR IMPLICATIONS FOR MINERAL EXPLORATION IN CONCEALED TERRAINS X. Wang, Z. Cheng, D. Liu, Heibei, China

HIGH DENSITY REGIONAL GEOCHEMICAL MAPPING OF SOILS AND STREAM SEDIMENTS IN SOUTH AFRICA

M. Lombard, D. de Bruin, Pretoria, South Africa

RADARSAT DATA APPLICATIONS: RADAR BACKSCATTER OF GRANITIC FACIES, ZAER PLUTON, MOROCCO

A. Mahmood, S. Parashar, S. Srivastava, Saint-Hubert PC, Canada

LITHOGEOCHEMICAL MAP OF SLOVAKIA (1 : 500,000) K. Marsina, J. Lexa, Bratislava, Slovakia

MULTIPURPOSE GEOCHEMICAL MAPPING (1:1,000,000) AS A BASIS TO INTEGRATED ASSESSMENT OF NATURAL RESOURCES AND ECOLOGICAL PROBLEMS E.K. Burenkov, A.A. Golovin, L.V. Leonenko, E.I. Filatov, T.V. Chepkasova, Moscow, Russia

10:30 Coffee Break

Hall A

### 11:00 - 13:00

### Session L BIOGEOCHEMISTRY

Chairpersons:

L. Dejonghe, Belgium Y. Erel, Israel

Keynote Lecture: MINERAL EXPLORATION OF AURIFEROUS AREAS IN ARGENTINA AND MEXICO BY GEOMICROBIOLOGY L. Dejonghe, Brussels, Belgium

APPLICATION OF BIOGEOCHEMICAL METHODS TO EXPLORATION IN ULTRAMAFIC TERRAINS OF THE RIF AND ANTI-ATLAS OF MOROCCO

C.E. Dunn, R.R. Brooks, M. Leblanc, J. Edmondson, K. Targuisti, Ottawa ONT, Canada, Palmerston North, New Zealand, Montpellier, France, Liverpool, UK, Tetouan, Morocco

BIOGEOCHEMICAL EXPOLORATION USING *THOLAS* IN THE ANDEAN HIGHLAND (BOLIVIA AND ARGENTINA)

M. Viladevall, J. Ponce, R. Santivanez, J. Saavedra, I. Queralt, S. Lopez, R. Arganaraz, Barcelona, Salamanca, Spain, La Paz, Bolivia, Salta, Argentina

STRUCTURE AND METAL BINDING PROPERTIES OF SEDIMENTARY HUMIC SUBSTANCES IN RELATION TO THEIR ORIGIN M. Klavins, Riga, Latvia

ADSORPTION OF ZINC ONTO PEAT FROM PEATLANDS OF POLAND AND ISRAEL I. Twardowska, Y. Avnimelech, J. Kyzio, T. Goldrath, Zabrze, Poland, Haifa, Israel

THE MERCURY-BIOGEOCHEMICAL EXPLORATION A.L. Kovalevskii, A.V. Lbov, Ulan-Ude, Russia

NONBARRIER LITHOBIOGEOCHEMICAL EXPLORATION FOR PLATINOIDS A.L. Kovalevskii, Ulan-Ude, Russia

13:00 Lunch Break

Hall A

### 14:30 - 16:00

### Session M GEOCHEMISTRY OF RADON AND RADIOACTIVE TRACERS

Chairpersons: D. Bodis, Slovakia J. Kronfeld, Israel

Kevnote Lecture:

TRANSFER OF RADON AND PARENT NUCLIDES <sup>238</sup>U AND <sup>234</sup>U FROM SOILS OF MENDIP HILLS AREA, ENGLAND, TO THE WATER PHASE D.M. Bonotto, J.N. Andrews, Reading, UK, Rio Claro, Brazil

SOIL-GAS RADON ANOMALIES OVER FAULT ZONES IN THE BASEMENT COMPLEX OF SOUTHWESTERN NIGERIA T.R. Ajayi, A.A. Aluko, G.O. Omotade, Ile-Ife, Nigeria

MONITORING OF THE TECTONICALLY RELATED RADON FLUX IN ISRAEL G. Steinitz, U. Vulkan, B. Lang, Jerusalem, Yavne, Israel

### **SPECIAL LECTURE:**

ASPECTS OF GEOLEGAL MITIGATION OF ENVIRONMENTAL IMPACT FROM MINING AND ASSOCIATED WASTE IN THE UK J.K. Kwolek, Brighton, UK

16:00 Coffee Break

### 16:30 - 18:15

Hall A

### Session N DATA PROCESSING

Chairpersons: S. Miko, Croatia S. Tandy, Israel

Keynote Lecture:

PROBLEM-SOLVING OR PROBLEM-SEARCHING - A LOOK AT THE DATA PROCESSING HIERARCHY FROM ACQUISITION TO DECISION MAKING T.M. Dobush, G.M. Hollyer, Toronto ONT, Canada

GIS ANALYSIS OF THE EFFECTIVENESS OF THE COMBINATION OF QUANTITATIVE PETROGRAPHIC AND ROCK GEOCHEMICAL DATA: A CASE STUDY FROM THE YUBILEINYOE CU-AU DEPOSIT, WESTERN KAZAKHSTAN V.V. Shatov, C.J. Moon, St Petersburt, Russia, Leicester, UK

GEOCHEMICAL PROSPECTING USING STREAM-SEDIMENT SAMPLES FROM CENTRAL PORTUGAL: AN INTERPRETATIVE STUDY APPLYING MULTIVARIATE STATISTICS E. Ferreira da Silva, H. Garcia Pereira, A.J. Sousa, E. Cardoso Fonseca, Aveiro, Lisboa, Portugal

DATABASE "GRANITES OF THE MONGOL-OKHOTSK (MOZ) ZONE" AND ITS USE IN MINERAL EXPLORATION

P.V. Koval, V.I. Grebenshchikova, E.E. Lustenberg, P.J. Henney, Irkutsk, Russia, Nottingham, UK

AN INTEGRATED G.I.S. APPROACH TO UNDERSTANDING GEOCHEMICAL DISPERSION WITHIN THE LATERISED TERRAIN OF SOUTHEAST MALI A.D. Stewart, C.J. Moon, M. Langford, P.F. Fisher, Leicester, UK

# FRIDAY, MAY 30, 1997

### 09:00 - 13:00

### Workshop A MODERN TECHNIQUES IN GOCHEMICAL ANALYSES: AN UPDATE

J.B. Brenner, Israel G.E.M. Hall, Canada

- 10:30 Coffee Break
- 11:00 Workshop A (cont.)

### 09:00 - 13:00

Hall B

Hall C

Hall A

### Workshop B ENVIRONMENTAL AND LEGISLATIVE USES OF REGIONAL GEOCHEMICAL BASELINE DATA FOR SUSTAINABLE DEVELOPMENT

P.R. Simpson, UK

- 10:30 Coffee Break
- 11:00 Workshop B (cont.)

### 09:00 - 13:00

Workshop F GLOBAL GEOCHEMICAL BASELINES

R.K. Salminen, Finland

- 10:30 Coffee Break
- 11:00 Workshop F (cont.)

ABSTRACTS

The abstracts are presented in alphabetical order of the first author. Many of these were edited, and the results were returned to the authors for approval. There were, however, a few cases where electronic and other correspondence were affected by technical difficulties, and we apologize if any inadvertent meanings resulted. At the time of this writing (two weeks pre-Symposium), all authors whose abstracts are included in this volume expected to attend the Symposium. Since "last minute" travel difficulties do arise, there may be a few "absentee" abstracts.

Those who wish to submit full papers for publication in the Symposium issue of the Journal of Geochemical Exploration, should do so by the end of September, 1997, to:

Moshe Shirav Geological Survey of Israel 30 Malkhe Israel St., Jerusalem 95501 Israel

Instructions to authors of the JGE should be followed.

### SOIL-GAS RADON ANOMALIES OVER FAULT ZONES IN THE BASEMENT COMPLEX OF SOUTHWESTERN NIGERIA

### T.R. Ajayi, A.A. Aluko and G.O. Omotade

Dept. of Geology, Obafemi Awolowo University, Ile-Ife, Nigeria

Tropical rain forest areas are well-known for problems of geological mapping arising from poor outcrop conditions which are due to dense vegetation and thick overburden. The application of soil-gas radon measurements as a mapping tool using the EDA radon detector (model RD 200) was carried out over known and suspected fault zones in the northern and southern parts of Obafemi Awolowo University area, Ile-Ife, south western Nigeria. These faults zones are major linear structures within the migmatite-gneiss complex concealed by relatively thick overburden. Radon values range between 6 cpm and 153 cpm with an average of 53±10 cpm. The fault zones show high radon concentrations giving rise to narrow anomalies which confirm the presence of both faults trending in a NE-SW direction. The use of the radon technique provides a confirmation of its application as a useful, cheap and fast tool in geological and structural mapping in basement areas largely covered by relatively thick overburden.

### GEOCHEMICAL SIMULATION OF MASS TRANSPORT PROCESSES IN SOIL

Igor Z. Akoulenko and Evgeniy E. Kolomensky Geological Faculty, Moscow State University, Russia

Mathematical simulation methods are significant for hydrogeochemical investigations of fluidization and transportation. At present, determinative methods such as the method of final elements and the differential method are most often applied. These methods are used, for example, for a description of osmosis and diffusion processes in soils. However, these methods have certain inherent mathematical difficulties and the process of model construction is labour-consuming.

We suggest a method related to a class of discrete stochastic methods of mathematical simulation which enable the development of a wide spectrum of various hydro-geochemical models of mass transfer. This method is based on the theory of cellular automata and permits the simulation of several processes, including diffusion in rocks, using relatively simple approach.

Cellular automata are represented by discrete dynamic systems describing the behaviour of interacting particles in a simulated environment. The simulated space is considered as a uniform hexagonal grid, each unit of which can contain a particle. When moving the particles interact.

The evolution of the system is determined by a number of rules adequate for the fundamental laws of matter and energy conservation. Accordingly, the particle changes its own space position relative to the positions of the nearest particles. Thus, the laws of a system are locally determined at a microscopic level. The description of the behavior of the process as a whole, i.e., on a macrolevel, is executed by averaging a number of parameters obtained from the model area. By comparing results of mathematical and physical modeling of diffusion in clay, a high degree correlation of factors of diffusion and curviosity was shown. The results obtained from the imitation of diffusion may allow the application of cellular automata for simulation of other hydro-geological processes.

### GEOCHEMICAL PATTERNS OF As, Cd, Pb, Zn and Cu IN STREAM SEDIMENTS AND SOILS FROM A MINING SITE IN TERMS OF AN ENVIRONMENTAL IMPACT ASSESSMENT

### Paula Avila and J.M. Santos Oliveira

Instituto Geologico e Mineiro, 4465 S. Mamedc Infesta, Portugal

This study is part of a national multidisciplinary program to characterize sites influenced by abandoned mines is Portugal. It is being carried out on the sulphide-gold Jales Mine in the north of the country, with a multielement geochemical strategy leading to the determination of 20 trace elements in various materials of the secondary environment (stream sediments, alluvium and soils). This was considered suitable for a first approach to this type of environmental assessment (Birke and Rauch, 1993). As, Pb, Zn, Cd and Cu appear to be the most significant chemical elements from an environmental point of view, showing anomalous patterns which can mainly be assigned to the continuous erosion of some 5 million tons of fine-grained tailing material that resulted from ore dressing operations. Data interpretation, which was supported by some statistical-mathematical techniques, points to a partition of the heavy metals: strong association between Zn-Cd-As and links of Cu and Pb with the Mn-Fe pair. The same trends emerge from PCA and R-mode factor analysis, from which two significant factors account for 78% of the total variance. In the main stream draining materials from the mine site, significant enrichments of As, Pb, Zn and Cd contents in relation to their local and regional backgrounds are noted for distances up to 30 km from the polluting source. Similar patterns are obtained from mapping of factor scores and from a "pollution index" which was computed using the more harmful elements. In the alluvium sampled in tailing areas, strong enrichments in these elements (plus Cu) are delineated which persist in depth at least up to 35 cm from the surface. Some of these values lie in the range of contaminated soils (Alloway, 1993). Monitoring based on sampling undertaken during 95/96 winter and summer campaigns confirms the persistence of these anomalies. Agricultural soils collected in the proximity of the mine reveal subtle enrichments in As, Pb and Cd which appear to be controlled by the wind acting on surficial tailing material. Identical aspects can be traced in the upstream sediments collected near the tailings.

A first assessment points to the possibility of disastrous consequences to the environment surrounding the Jales Mine. Presumably, the abnormal concentrations of these harmful elements (which largely occur in mobile mineralogical phases - based on sequential chemical extractions) can be correlated with evidence of progressive vanishing of fish from the main river and of digestive problems in the cattle. These data require measures to remediate the situation.

### STREAM SEDIMENT GEOCHEMICAL RECONNAISSANCE SURVEY, EASTERN

### M. Beyth and M. Shirav

Geological Survey of Israel, Jerusalem, Isarel

Stream sediments were collected from small, well-defined tributaries in the high-grade para-schist and orthogneiss terrain of the eastern lowlands of Eritrea. The <100 mesh fraction was analysed using ICP-AES for a series of trace elements, and for gold and silver by ICP-MS. The aim of this work was to study the feasibility of this prospection method for this arid area. The number of samples was therefore limited, and the results are presented in preliminary geochemical maps.

The REE (Ce, La and Y) are high in most samples and correlate well among themselves. Arsenic values are generally low, while barium is apparently anomalous in a few samples. Traces of Au may indicate gold anomalies, and two samples are relatively enriched in silver (10 and 12 ppm). The possible presence of Ag-mineralization along the marginal faults of the Hargigio-Lahazin graben is thus indicated.

It therefore appears that earlier methods of sampling using the fine fraction of stream sediments in arid areas may serve as an important prospecting tool in this unknown and promising area.

### GEOCHEMICAL ATLAS OF GROUNDWATER AND ITS APPLICATION IN THE ENVIRONMENTAL SPHERE

# Dusan Bodis, Josef Kordik, Stanislav Rapant and Igor Slaninka

Geological Survey of Slovak Republic, Mlynska Dolina 1, 817 04 Bratislava, Slovakia

Geochemical maps are part of the series of synoptic maps enabling the acquisition of a global view of the earth's structure and of the processes which have a decisive influence upon the character of its surface, and accordingly upon the environment. The geochemical atlas of groundwaters of the Slovak Republic is part of this map series, produced by the GS SR staff between 1991 and 1995 within the framework of a national mapping program. This presents a regional overview of the distribution of elements, components and parameters in groundwaters, which are important in ecological and water management terms.

The hydrogeochemical mapping was based on the investigation of groundwater samples from the first aquifer (springs, wells, ?). Sampling density  $1/3 \text{ km}^2$ , and totaled 16.359 samples.

The following parameters were measured at the collection site: discharge,  $T_{H2O}$ , pH, conductivity, ZNK<sub>8,3</sub>, KNK<sub>4,5</sub> and dissolved O<sub>2</sub>. Part of samples submitted for trace elements analyses were filtered through a membrane filter (0.45 Om) and chemically stabilized; 32 elements were analyzed while

maintaining a continuous monitoring of the analysis quality. The results are presented in the geochemical atlas of groundwaters using the following forms: areal monoelemental maps, monoelemental single site maps, and basic statistical processing of the raw data.

The field and analytical data are stored at the GS SR in the Groundwater database and tied into the GIS allowing for the flexible manipulation of the data which can be tailored to the needs of the customer. The supplementary data were selected to take into consideration possible environmental applications. They mainly include the rock environment types for particular water circuits, the degree of anthropogenic influence, etc.

We herein present a few case studies with the environmental applications using the groundwater database. - application of areal and <u>site-point</u> monoelemental maps to delineate hazardous regions with anomalous contents of toxic elements. Application of statistical analysis to the distribution of arsenic and implementation of the GIS which allows a pinpointing of the highest concentrations of this element clustering in areas underlain by crystalline and Neogene volcanic rocks; these areas contain occurrences of mainly sulfidic mineralization, and of mining activity The areal distribution of anthropogenic anomalies relate mainly to the surroundings of thermal power plants.

- assessment of the <u>intensity</u>, <u>stage</u>, and grade of regional contamination of groundwaters in Slovakia. The highest degree of contamination of groundwaters is bound to the lowland areas with concentrated anthropogenic activities: these are characterized mainly by NO<sub>3</sub>, NH<sub>4</sub>, Cl, SO<sub>4</sub> anomalies and locally by areas with abandoned, or active mines with increased contents of Al, As, Cd, Cu and Hg.

### TRANSFER OF RADON AND PARENT NUCLIDES 238U AND 234U FROM SOILS OF MENDIP HILLS AREA, ENGLAND, TO THE WATER PHASE

D.M. Bonotto<sup>1</sup> and J.N. Andrews<sup>2</sup>

1 Universidade Estadual Paulista, Rio Claro, Brasil

2 In Memoriam, University of Reading, Reading, UK

Radon-222, a <sup>238</sup>U and <sup>226</sup>Ra progeny, is a naturally occurring radioactive gas produced continuously in soils, rocks, and minerals through  $\alpha$ -decay. Some of the radon escapes from the solid phase to the surrounding fluid phase, such as groundwater and air, where the partition coefficient between water and air (Ostwald coefficient) depends on the temperature and ionic strength of the liquid phase. The radioactivity in waters due to dissolved radon has been extensively studied in many areas where wells are used for domestic water supply, since although radon in water is not a well-documented health risk, it does contribute to radon in indoor air, which has been established as a health threat. The aim of this study was to evaluate the release of radon and their parent nuclides <sup>238</sup>U and <sup>234</sup>U from soils to the water phase, with the purpose of understanding the influence of several parameters which can affect the geochemical behaviour of these nuclides in natural systems. Laboratory time-scale experiments were conducted on soils occurring at Mendip Hills area, a karstic district in the southwest of England.

The rocks exposed in the district span a wide range in time from the Upper Paleozoic to the Ouaternary era, embracing two continental phases and two marine phases of deposition, and more recently a glacial epoch. Soils derived from limestone and sandstone belonging, respectively, to Lulsgate and Maesbury series, were sampled and aliquots between 400 and 700g were weighed and placed into 1000-ml glass bottles, fitted with inlet and outlet stopcocks, in order to perform the <sup>222</sup>Rn release experiment; then, they were immersed in a surrounding distilled water phase equilibrated with the atmosphere and at room temperature. After sealing during about 26 days, the <sup>222</sup>Rn was extracted by circulating a stream of radon-free air through the sample container to purge the water phase of its accumulated <sup>222</sup>Rn. The specific surface area of dried aliquots was evaluated, changing from 50.4 to  $61.6 \text{ cm}^2\text{g}^{-1}$ , where the values for the released radon were between 26 and 194 pCi, allowing to estimate emanation coefficients ranging from 0.1 to 0.2, within the context of other values reported elsewhere.

Soils derived from Carboniferous limestone and characterized by higher pH, exchangeable calcium, and U-content but lower  $^{234}U/^{823}U$  activity ratio provided the highest values for the released Rn, whereas the same trend was not observed for the dissolved U and its respective  $^{234}U/^{823}U$  activity ratio. Uranium is mobilized from rock matrix to horizons A and B in both soil profiles, where its enrichment is about 10 times in soil derived from Carboniferous limestone. The ratio of the weight of dissolved U per unit volume of solution to the weight of U adsorbed per unit weight of adsorbate remained constant in more acid soil profiles, independently of the etch solutions, but increased during etch with distilled water saturated by CO<sub>2</sub> at 1 atm in quasi-neutral soil profiles.

### GEOCHEMICAL ZONING OF SNOW COVER WITHIN URBAN TERRITORIES

### S. Bordon

Institute of the Geological Sciences, Minsk, Republic of Belarus

Seasonal snow cover is one of the components of natural landscapes that influence their geochemical characteristics. The geochemical peculiarities of the snow cover are being studied within regions exposed to other geochemical variations and data on anomalies in the snow cover within urban territories are presented. Snow melt-water is of primary significance in studies of the geochemical patterns.

The largest variation coefficients among major cations are for Na and K. Concentrations of trace elements in the snow cover depend on the technogenic load level. The geochemical series of trace elements arranged in order of decreasing the coefficient values is as follows:

### Y>W>Ni>Ga>Zz>Co=

Nb>Cr>Ti>Zn>Ba>Mn>Ge>Cu>Bi>Yb>Sn>Pb>Mo>Y

It is interesting to note that the highest values are for elements usually associated with the so-called "high tech" industries (Y, W and Ga). The element classification into categories according to their variation coefficients does not depend on the association of the element with any particular geochemical group. There is also no established relationship between the element category and its atomic weight.

### POTENTIAL USE OF PYRITE AS A CALCAREOUS SOIL AMENDMENT

M.A. Castelo Branco<sup>1</sup>, J. Santos<sup>2</sup>, O. Moreíra<sup>3</sup>, A. Oliveira<sup>1</sup>, F. Pereira<sup>1</sup>, L. Magalhăes<sup>2</sup>, S. Dias<sup>1</sup>, L.M. Fernandes<sup>1</sup>, J. Gama<sup>2</sup>, J.M. Vieira e Silva<sup>1</sup> and J. Ramalho Ribeiro<sup>3</sup>

. Kamamo Kibeno

1 Estação AgronÓmica Nacional, Oeiras, Portugal

2 Direoção Regional de Agricultura da Beira Litoral, Coimbora, Portugal

3 Estação Zootécnica Nacional, Santarém, Portugal

Degraded calcareous soils occupy some 10% of Portugal's area, and present severe fertility problems. The recuperation of these soils would result in good conditions for sustainable agriculture. Significant amounts of great copper ore tailings are present in Portugal and at present have no practical use. They are disposed off a tailings dam under a water cover, to avoid oxidation. Approximately 90% of the tailings consist of pyrite with very high sulphur (500 g/kg<sup>-1</sup>), iron (4!4 g/kg<sup>-1</sup>), and copper (3.3 g/kg<sup>-1</sup>).

Several trials were carried out on calcareous soils located in the mid-western coast of Portugal, in order to study the effect of the pyrite on the physical, chemical and mineralogical properties of the soil, on the risk of contamination of the soil and groundwater, and on a soil - plant - animal system.

### ECOLOGICAL-GEOCHEMICAL ESTIMATION OF ANTHROPOGENIC POLLUTION OF MOSCOW

### E.K. Burenkov, L.N. Ginzburg and T.D. Zangieva IMGRE, Ministry of Natural Resources, Moscow, Russia

The authors have developed the methodical investigation system ECOSCAN to solve the complex of related geo-ecological and medicine-biological problems related to anthropogenic pollution of urban territories. The combination of related branches is made on a basis of spatial, analytical and computer approaches in the following chain: sources of pollution - atmospheric air - soil - plants - human activity. The system is based on an integral approach to the solution of the complex of related geo-ecological and medicine-biological problems of urban territories. The geoinformation system requires: (1) ecological-geochemical mapping; (2) determination of the degree of soil degradation and toxicity, (3) recovery of the disturbed environment; (4) estimation of pollution impact on population health. Integration of the results is made using a software package which estimates pollution intensity and classifies it according to types of pollution of each depositing medium, and indicates specific associations of pollutants which present one of the reasons for ecology-dependent diseases. The results of the complex ecological-geochemical investigations became the basis for the methods developed by the authors aimed at the recovery

of the environment and sanitation of population in large industrial centers. One of the most ecologically unfortunate districts of Moscow was used as a model for investigations.

### MULTIPURPOSE GEOCHEMICAL MAPPING (1:1,000,000) AS A BASIS FOR INTEGRATED ASSESSMENT OF NATURAL RESOURCES AND ECOLOGICAL PROBLEMS

E.K. Burenkov<sup>1</sup>, A.A. Golovin<sup>1</sup>, L.V. Leonenko<sup>2</sup>, E.I. Filatov<sup>1</sup> and T.V. Chepkasova<sup>2</sup> 1 IMGRE, Ministry of Natural Resources, Moscow, Russia 2 Ministry of Natural Resources, Moscow, Russia

A new technology of regional studies at a scale of 1:1,000,000, termed multipurpose geochemical mapping, is developed in Russia. The essence of the approach is as follows: (1) during the pre-survey stage, a multi-factor zonation of the territories to be surveyed is conducted (including landscape geochemistry, genetic features of the rock assemblages along with geophysical, metallogenic, hydrogeological, engineering geological and economic groups of parameters); (2) within the units specified, quasi-homogeneous representative "cells" (on the average, 1 cm<sup>2</sup> of the map sheet) are allocated; (3) sampling is carried out within the "cells" to determine a series of its characteristics; (4) a quantitative estimation of the obtained characteristics is prepared; (5) systematic plotting and publishing of the maps.

The resulting maps include: (a) structural-formational (tectonic structures and related rock assemblages); (b) landscape- geochemical; (c) economic functional zoning; (d) geochemical specialization; (e) integrated anomalous geochemical fields; (e) geochemical forecast map; (f) ecological geochemical map; (g) agro-geochemistry; (h) of the rational nature management, (i) ecological-hydrogeological; (j) ecological-engineering geological; (k) ecological geological.

The latter three maps are designed only for areas where a detailed ecological- geological assessment is required. Resulting estimates include: geochemistry and metallogenesis of the rock assemblages, mineral potential, ecological situation, soil fertility and the chemical pollution level of the arable horizon, recommendations for nature management. The opportunities of the approach are exemplified by the East Transbaikalia area, SE Siberia.

### METALLOGENY AND ECOLOGY OF RUSSIA: POSSIBILITIES PRESENTED BY SET OF GEOLOGICAL AND GEOCHEMICAL MAPS AT A SCALE OF 1:5,000,000

E.K. Burenkov<sup>1</sup>, A.A. Golovin<sup>1</sup>, M.V. Kochetkov<sup>2</sup>, A.F. Morozov<sup>1</sup>, and E.I. Filatov<sup>1</sup> 1 IMGRE, Ministry of Natural Resources, Moscow, Russia 2 Ministry of Natural Resources, Moscow, Russia

A recently published set of maps of the Russia (1:5,000,000) summarizes information on its tectonic, landscape, geochemical. geophysical, metallogenic, hydrogeological and engineering geological zoning and ecological situation of the geological environment. The set includes 12 maps: (1) structural-formational (tectonic structures and related rock assemblages), (2) gradients of gravity and magnetic field, (3) geochemical speciation of tectonic structures and related rock assemblages, (4) formation conditions of the supergene geochemical fields, (5) geochemical anomalies, (6) ecological landscape geochemistry, (7) ecological-hydrogeological (8) ecologicalengineering geological, (9) availability of ground water for domestic water supply, (10) sources of anthropogenic pollution, (11) ecologic-radiogeological, (12) ecological assessment of geological environments.

Each map includes a legend and explanatory note in English and Russian. Information on the location of known and potential metallogenic zones and mineral potential of the country is available for maps (1), (2), (3) and (5). All maps include information on the ecological situation of the geological environment. The set is a product of a systematic approach and enables the development of a federal strategy of mapping (e.g., multi-purpose, geochemical, geological, hydrogeological, engineering geological, and geophysical), and the development of the mineral base and environment protection measures.

### GEOCHEMISTRY OF RIVERS: A PULSE FOR THE STATE OF THE ENVIRONMENT

# Eion M. Cameron<sup>1,2</sup>, K iko Hattori<sup>2</sup> and Gwendy E.M. Hall<sup>1</sup>

1 Geological Survey of Canada

2 University of Ottawa, Ottawa, Canada

The geochemistry of rivers provides a continuous report on the condition of the environment in their watersheds. Studies by Veizer and others in Europe have shown a variety of pollutants and their effects, ranging from heavy metals to anions, to the generation of large fluxes of CO2. The Fraser River in British Columbia is the largest undammed river to cross the North American Cordillera. It is neither pristine nor heavily polluted. To support the economic activities within its basin, which include the largest salmon fishery in the world, forestry, pulp and paper, mining and tourism, there must be a careful balance between the needs and effects of these industries. The Fraser provides a section across a geologically varied orogen. The Rocky Mountains in the east comprise sedimentary rocks made from detritus derived from the Archean craton. As the river flows west it crosses accreted ensimatic terranes and then the young magmatic arc of the Coast Range. This varied geology provides a wide spread in Sr and Nd isotope ratios that can be used to unravel the transport dynamics of dissolved and particulate phases. Conservative dissolved elements reflect the composition of the entire upstream basin, whereas particulate phases represent the local environment (and hence can be considered as a complementary method of geochemical mapping). Although present in low concentrations, Mo added from a mining area can be traced several hundred kilometers downstream. Pulp mills add dissolved organic compounds and NaCl, but a steady decline in these inputs, as a result of improved mill processes, can be seen in secular changes in

the river chemistry. The effects of timber cutting are subtler and are yet to be fully explored. But these may include the generation of organic acids and  $CO_2$  from decaying timber slash, with the former solubilizing metals from the soils. As a byproduct of the research, hydrogeochemical applications to mineral exploration have been outlined, using highly sensitive ICP-MS analytical methods, including heavy metal and Se/S determinations.

### PHYSICO-CHEMICAL CONDITIONS OF SALT SEDIMENTATION IN MODERN EVAPORITE BASINS

### M.V. Charykova and V.V. Kurilenko Saint-Petersburg University, Russia

Consecutive crystallization of saline minerals is the result of evaporite concentration of natural waters. Solution composition and temperature regimes define the succession and masses of the solid phases. The solubility of the compound defines the possibility of its crystallization as an evaporite mineral or it dissolution, so that quantitative descriptions of such processes as evaporite sediment formation and its interaction with natural waters and brines demands knowledge of solubility diagrams over a large temperature range.

In the present paper, the authors:

- considered a thermodynamic algorithm and computer programs for calculation of solubility diagrams in the system Na<sup>+</sup>, K<sup>+</sup>, Mg<sup>2+</sup>, Ca<sup>2+</sup>// Cl<sup>-</sup>, SO<sub>4</sub><sup>2-</sup> - H<sub>2</sub>O. They are based on equations of chemical and phase equilibria and Pitzer's equations for the calculation of activity and osmotic coefficients;

- gathered data for the calculation of phase equilibria in the systems containing sulphates, chlorides, carbonates and hydrocarbonates of sodium, potassium, magnesium and calcium for a wide temperature range;

- calculated solubility diagrams of quaternary and quintenary water-salt systems modeling the composition of different natural brines. Calculated results agree with experimental ones at temperatures from  $-5^{\circ}$ C to  $35^{\circ}$ C;

- determined the temperatures of the crystallization of certain salts in different brines;

- considered algorithm and computer programs for the quantitative estimation of the saturation of solution or its aggressiveness to the saline minerals and for the description of the open water evaporation processes and drop in temperature;

- modeled processes of evaporite mineral formation in Kara-Bogaz-Gol and Sivash bays and Kuchuk mirabilite lake; - calculated curves of open evaporation of the Caspian Sea, Black Sea, Sea of Azov and Aral Sea waters at different temperatures.

### THE ROLE OF CHANNEL PROCESSES IN MITIGATION OF IMPACT FROM ZINC AND LEAD MINING IN UPPER SILESIA (SOUTH POLAND)

### Dariusz Ciszewski

Institute of Nature conservation, Krakow, Poland

Heavy metal pollutants discharged to a river accumulate rapidly within channel sediments but are more slowly incorporated into overbank sediments. Channel processes control the rate of the heavy metals accumulation and their distribution in alluvium. These processes play an important role in self-purification of river waters from heavy metals present as a solid phases, since they shorten the length of transport of the pollutants.

The role of channel processes in mitigating the impact from lead and zinc mines was investigated in channels of the Biala Przemsza, Sztola and Chechlo rivers, receiving mine waters from the largest lead and zinc mines in Poland. Bed sediments were sampled from 5-6 sites in each of the cross-sections situated in meander loops, pools and riffles or braided river reaches, at 11-18 points along investigated river courses. Grain-size distribution of the sediments was determined and the Zn, Cd, Pb, Cu, Ni, Mn, Fe and Ag content in the <1mm and <0.063 mm fractions was determined using AA spectroscopy.

The heavy metals, present in a solid phase, are basically associated with very fine particles transported from mines as suspended matter. Accumulation of the material derived from mines changes both the concentration of heavy metals and the content of silt and clay fractions in bed sediments and it is therefore relatively easy to identify in sand-bed channels. The highest concentrations of heavy metals in the <1 mm fraction occur at banks below the water table, in the frequently inundated parts of the floodplain and in the channel bars of the braided river reaches with low channel gradients. The accumulation of the fine particles, rich in pollutants, is facilitated by water plants (grass, moss) since in the overgrown sections, resistance to flow increases and velocity decreases.

The most rapid fall in heavy metal concentrations, downstream of the source of pollution, occurs in natural river reaches with the high rates of supply of the unpolluted sand material to the channel. This supply is caused by intensive erosion of the river bed and banks and results in "dilution" of the contaminated sediments by uncontaminated sand. This is particularly remarkable in laterally unstable river reaches where the river actively undercuts its banks.

It can be concluded that channelization works, especially shortening of a river and channel lining, which commonly lead to downcutting of the river channel, result in extension of the reach polluted by heavy metals and in downstream shifting of the zone of maximum heavy metal concentrations. Moreover, the length of the dispersal of pollutants along river courses seems to be shorter in rivers with natural flow amplitudes than in rivers with constant, artificially lowered amplitudes.

### GEOCHEMICAL EXPLORATION OF KARST BAUXITE DEPOSITS BYAIRBORNE GAMMA-RAY SPECTROMETRY: STUDIES IN THE INTERNAL DINARIDES BAUXITE PROVINCE

### Adam Dangic<sup>1</sup> and Milan Milojevic<sup>2</sup>

1 Faculty of Mining and Geology. Universitely of Belgrade, Djusina 7,

11000 Belgrade, Yugoslavia

2 Geoinstitute, 11000 Belgrade, Yugoslavia

Common karst bauxite deposits are relatively small and of simple structures and chemical composition. These features, together with the low geochemical mobility of major (Al, Si, Ti  $\pm$ Fe) and trace elements (Zr, V, Ga, etc.) make the common methods of geochemical exploration inapplicable for these deposits. On the other hand, a method of airborne gamma-ray spectrometric exploration (AGSE), using Th, U, and K as path-linder elements, seems to be effective. This was applied and critically analyzed in the bauxite province of the Internal Dinarides in the Mediterranean karst bauxite belt.

The Internal Dinarides province, in central parts of Balkan Peninsula, is characterized by the typical Mediterranean type of karst bauxite deposits. Bauxites, appearing in four areas are of Cretaceous age: they are red (iron-rich) and boehmitic in the Vlasenica (E Bosnia), Pocuta and Zlatibor (W Serbia) areas, and diasporic in the Grebnik area (SE Serbia). AGSE was carried out in 3 areas where bauxite is exploited (Vlasenica, Grebnik) and in any area with high-grade ores (Pocuta). The flight altitude was 100-150 m with intervals of parallel profiles at 250 m. A system with a GR-800 D spectrometer, scintillation detector with sets of Naj(T1) crystals (10x10x40 cm), and gamma-ray resolution 8.5-9.5% was used. Intensities of total gamma-ray emission and that related to Th and U (based on Bi-214 and Tl-208 emissions, respectively) and K<sup>40</sup> were measured.

In the Vlasenica area, numerous (including large) bauxite deposits (up to 10 million tons) occur on Triassic limestones overlain limestone-clayey-sandy formations. Bauxites contain Th, U and K as high as 40-70, 4-6, and nx1000 ppm, respectively. AGSE covered the entire area and detailed geochemical interpretations were carried out. Higher and multiple several anomalies were selected by discrimintions of intensity/distribution of Th and U/Th and K/Th ratios. Results of drilling confirmed Th and U/Th anomalies as good indicators of bauxite bodies and associated K/Th ratio as an indicator of bauxite hangingwall thickness.

In the Grebnik area, Cretaceous limestone formations with numerous bauxite deposits are associate with ultramafic suits. Contents of Th, U and K are nearly the same as in the Vlasenica area. Higher, intense AGSE anomalies of Th and U/Th and low values of K/Th coincide with bauxite outcrops.

In the Pocuta area, Triassic and Cretaceous limestones appear to contain bauxite with 8.5-11 ppm Th, 2.4-3.0 ppm U, and 1.1-1.6% K. AGSE anomalies are less intense and U/Th appears to be a possible indicator of bauxites.

These studies shown that AGSE may be successfully used in areas with karst bauxites of higher stage of bauxitization, even in areas with complex geological settings.

### REGOLITH GEOCHEMICAL MAPPING AS AN ADJUNCT TO GEOLOGICAL MAPPING AND EXPLORATION; EXAMPLES FROM THREE CONTIGUOUS PROTEROZOIC BASINS IN WESTERN AUSTRALIA

### **R. Davy, F. Pirajno, A. Sanders and P. Morris** Geological Survey of Western Australia, Perth, Australia 6004

Regional regolith mapping on the 1:250,000 scale and geochemical mapping at a nominal 1 sample/16 km<sup>2</sup> in the contiguous Proterozoic Padbury, Bryah and Yerrida Basins has been effective in distinguishing between, and assisting definition of, underlying bedrock. To achieve this, +450  $\mu$ m - 2 mm fractions of stream sediment and/or sheetwash were analysed for up to 48 elements using a multielement digest and ICP finish for most elements.

The area examined is approximately  $20,000 \text{ km}^2$ . The greater part of the area (>75%) is covered with surficial sediments including colluvium and lateritic nodules, whilst about 30% of the area lacks significant drainage channels. The area is desert and most sediment transport is effected during cyclonic flooding. Soils are skeletal, and colluvially modified, except in limited areas where eolian sand is prevalent. Most stream sediment and sheetwash samples give some indication of their lithologic derivation, exceptions being sediments from major, but ephemeral, river channels and plains, and eolian sands.

Exposure for many millions of years has resulted in extensive chemical weathering, though mechanical erosion is currently dominant. Alkali and alkaline earth elements are leached at the fresh rock weathering interface, with part redeposited in river calcrete and saline playas. Base metals are variably leached. Many elements of economic interest are retained in coarser fractions (which largely comprise altered lithic fragments and iron-rich debris), whilst rare earths, Th, Zn and Zr are concentrated in the finest fractions (clays and sand). The fraction analysed is therefore a compromise to achieve optimal information.

Geochemical mapping has assisted in the delineation of major rock units. A black sulphidic shale is marked in regolith by elevated Bi, Mo, Sb, Th, U and V. The presence of mafic rocks is shown by CaO>0.5%, together with Sc, V, and Ga; separation of varieties of tholeiite is effected by Cr, Ni, Pd and Mg (higher over high-Mg rocks), and Cu (higher over low-Mg tholeiites). Regolith in the youngest basin is generally iron-rich and characterised by enhanced Mn, P, As, Ba, F, Pb and Th, except in one area with no enrichment in Mn or F. A granitic derivation for one group is suggested by lack of Ti, whilst differences in granitic sources can be identified from variations in K, Ba, Sr and Y contents. The data reflect regional facies changes in sedimentary rocks and suggest additional areas underlain by mafic rocks.

Normalised concentration indices reflect known mineralization and indicate other prospective areas.

### MINERAL EXPLORATION OF AURIFEROUS AREAS IN ARGENTINA AND MEXICO BY GEOMICROBIOLOGY

### Leon Dejonghe

Geological Survey of Belgium, Brussels, Belgium

The use of a geomicrobiological method in the search for polymetallic and particularly Au mineralization has been tested on different types of mineralization in Argentina (4) and Mexico (6). The spatial occurrence of *Bacillus cereus* and anomalous metal concentrations in the soils suggests that the *B. cereus* content of chalcophile elements is selectively related to mineralization and may be to some extent proportional to the total content of chalcophile elements in subsurface mineralization.

A spatial interval or "offset" between elevated *B. cereus* content and high metal contents in mineralized soils was observed. Possible explanations are advanced (toxic effect, reduced bioavailibility).

Reproducibility of duplicate analyses during the same analytical session (in the same country) is good, especially for tests done on the same day. After several months of storage in Argentina and Mexico, samples were re-analyzed in Belgium for their *B. cereus* content. Opposite trends were observed on Argentinian and Mexican samples (*B. cereus* counts were observed to decrease with length of storage for Mexican samples and to increase for Argentinian samples). A possible explanation is the temperature variation during the time interval between sampling and soil analysis. It implies that analyses should be carried out within the identical climatic conditions that prevailed during sampling.

The geomicrobiological method is an attractive approach in countries where labour costs are low (cost per microbial analysis varies from 1 to 2 US\$ without taking wages into account). Furthermore, this technique does not require sophisticated analytical equipment and results may be available quickly (2 or 3 days). The technique can thus be used to help screen mineralized from non-mineralized areas and provide a focus for analyzing by classical geochemical methods only those soils from sites with high bacterial contents.

### EFFICIENCY OF CYANIDATION IN GOLD EXPLORATION USING SOILS

### T.A. Delaney\* and W.K. Fletcher

Geological Sciences, Dept. Earth Ocean Sciences, University of British Columbia, 6339 Stores Road, Vancouver, B.C. Canada, V6T IZ4

Cyanidation allows gold to be extracted from larger samples than is practical by fire assay and may thus provide both a simpler analytical procedure and better sample representativity. Here we compare recovery of gold by cyanidation and fire assay for the -212+106  $\mu$ m and -106+53  $\mu$ m light mineral fractions and the -53  $\mu$ m fraction of C-horizon soils from a variety of gold deposit types and weathering regimes in Canada and the U.S. Results for cyanidation and fire assay are strongly correlated and for many samples gold recovery by cyanidation is within ±20% of values reported by FA-AAS. Somewhat unexpectedly, there is good recovery of gold from unground light mineral fractions in which the gold is encapsulated rather than being present as free gold. Abundance and size distribution of the gold should be considered in deciding if cyanidation offers any real advantage over fire assay based methods.

\*Present address: Steffen, Robertson and Kirsten, 7175 West Jefferson Avenue, Suite 3000, Lakewood, Colorado 80235, USA.

### PROVENANCE OF HEAVY METALS IN FOREST SOILS OF AN OLD MINING REGION IN WESTERN GERMANY

### Guido Deissmann and Walter L. Pluger

Institute of Mineralogy and Economic Geology, Aachen University of Technology, Wullnerstr. 2, D-52056 Aachen Germany

The Northern Eifel is part of the Rhenish massif and one of the oldest mining regions in Germany. In this area, adjacent to the Netherlands and Belgium, mining and smelting of mainly Post-Variscan lead-zinc ores dates back to Celtic and Roman times. Heavy metal contamination of soils and stream sediments is a widespread feature in this area. In the study presented here an attempt was made to distinguish between geogenic and anthropogenic heavy metal enrichment in forest soils and to outline the major anthropogenic sources of heavy metals such as metal mining, processing and smelting, traffic, or the utilisation of coal and lignite in power plants. In general, lead, zinc and cadmium are mainly enriched in the upper soil horizons rich in organic matter (up to 2000 ppm Pb, 1000 ppm Zn, and 10 ppm Cd). The mineral soils are mostly uncontaminated and contain natural background concentrations of the respective metals. elevated lead concentrations up to 1000 ppm in mineral soils are restricted to soil profiles developed on Triassic sandstones, which are host rocks of various lead-zinc deposits. The contents of arsenic, cobalt, nickel, chromium in all soils are comparatively low and in the range of the geogenic background, taking into account the concentrations in the respective bedrocks. Investigations of lead-isotopic composition, geochemical pathfinder elements and heavy-metal bearing minerals and particles indicate that the use of leaded fuel is the predominant source for anthropogenic lead in the soils. Contamination with zinc and cadmium can be attributed to base-metal smelting, production of iron and steel as well as lignite and coal burning and traffic.In general, a significant contribution to soil contamination from base-metal smelters can only be found relatively close to the respective sites (i.e. in a distance up to 5km). In forested areas on Triassic sandstones, the increase in lead content from the top soil to the mineral soil, the occurrence of sphalcrite, load suiphates and lead phosphates as well as the lead isotopic composition of the mineral soil, which is in close agreement with data for Post-Varisean lead-zinc ores, point out a geogenic heavy metal enrichment in these soils. In spite of the soil contamination with comparatively mobile anthropogenic heavy metals and the acidification of forest soils due to
atmospheric deposition of acids, until now, the mobilisation of heavy metals from soils does not lead to an increase in metal concentrations in groundwaters that exceed German drinking water standards. An exception are some groundwaters in Triassic sandstones, where oxidation of natural occurring iron and base-metal sulphides results in slightly acidic and sulphate-rich groundwaters that contain lead concentrations up to 100  $\mu$ g/L.

# PROBLEM-SOLVING OR PROBLEM-SEARCHING -A LOOK AT THE DATA PROCESSING HIERARCHY FROM ACQUISITION TO DECISION MAKING

### Tim M. Dobush and Greg M. Hollyer Geosoft Incorporated, Toronto, Canada

The objective of the Geoscientist is to evaluate potential targets and to effectively reach decisions regarding the viability of these targets. In the past decade, increasing volumes of multidisciplinary data have made computers an integral tool in allowing the Geoscientist to build on their geological experience and knowledge to make decisions.

Today, personal computers (Pcs) are accepted as playing an important role in the decision-making process - helping the Geoscientist (or someone within their organization) progress through a hierarchical series of tasks:

• Accessing data acquired from field surveys and/or historical sources and storing it in a manageable format that allows for easy current and future use.

• Processing data and transforming it into useful information.

• Analyzing this information in context of the Geoscientist's experience - thereby helping to build the knowledge that is required at the decision-making stage.

Historically, the fragmented nature of DOS programs has forced us to use individual software solutions to address each of these tasks. In the DOS environment, each task was well constrained and generally addressed with a particular software program. A major frustration, however, was the lack of standard data formats which led to wasted resources as data and information had to be moved from one software system to another.

Paradoxically, the introduction of new operating systems, such as Windows 3.11/95/NT, only amplified this frustration. While common Graphical User Interfaces (GUIs) were intended to help software systems converge and lead to single software solutions, they have not yet achieved this outcome. Compounding the absence of such a unified software system is the proliferation of software "solutions" that give the perception of solving problems but that, in fact, work quite differently. Rather than helping the Geoscientist address specific problems, these software systems are engineered in reverse - effectively representing "solutions trying to find the problem".

The purpose of this paper is to review the data processing hierarchy to understand the scope and relevance of data, information and knowledge in terms of the Geoscientist's decision-making process. From this, we can clearly differentiate the approaches of the various software systems and the implications these software systems have on this data processing hierarchy. By focusing on the need to get knowledge from data, we examine how the Geoscientist can ultimately find "solutions that address the problem".

# APPLICATION OF BIOGEOCHEMICAL METHODS TO EXPLORATION IN ULTRAMAFIC TERRAINS OF THE RIF AND ANTI-ATLAS OF MOROCCO

Colin E. Dunn<sup>1</sup>, Robert R. Brooks<sup>2</sup>, Marc Leblanc<sup>3</sup>, John Edmondson<sup>4</sup> and Kamal Targuisti<sup>5</sup>

1 Geological Survey of Canada, Ottawa, Canada.

2 Massey University, Palmerston North, New Zealand

3 Universite de Montpellier, Montpellier, France

4 National Museums and Galleries, Liverpool, UK

5 Universit' Abdelmalek Essaadi, Touan, Morocco.

There have been few biogeochemical studies in North Africa, partly because there is the perception that the vegetation is too sparse and varied. An expedition, sponsored largely by the National Geographic Society, visited two areas of ultramafic rocks in Morocco in order to (1) document the flora; (2) determine if any plant species are sufficiently widespread to be used for biogeochemical exploration; and (3) determine if the more common species can accumulate ore-forming metals.

In the Anti-Atlas mountains of southern Morocco a 'boutonniere' of serpentinized ultramafic rocks outcrops in the Bou Azzer-Bleda region, south of Ouarzazate. Some precious metal enrichment is associated with mineralization currently exploited for Co/Ni arsenides, Cu-sulphides, and Cr minerals (oxides and carbonates). The arid climate supports a sparse development of hardy shrubs, dominated by the perennial 'daisy' Anvillea garcinii, goat-root (Ononis natrix), morning glory (Convolvulus trabutiamus), lavender (Lavandula multifida), and sagebrush (Artemisia herbaalba). These species, and others of more local occurrence, were collected for multi-element analysis. Some of the highest metal concentrations (e.g., 359 ppb Au in ash) occurred in the goat-root, but the yellow daisy Anvillea is the most common species, and therefore the most suitable for biogeochemical surveys in this area. Test transects over zones of known mineralization were conducted to sample Anvillea and soils. In general, the vegetation gave a sharper anomaly to background ratio of the main commodity metals, and defined zones of Co-enrichment in the substrate not identified from the soil analyses.

In the more temperate Mediterranean climate of northern Morocco, outcrops of ultramafic rocks occur on the seaward side of the Rif mountains. There has been little exploitation of several zones of Ni/Cr-rich mineralization. Compared to the Anti-Atlas, this environment is wetter and supports a much denser vegetation cover. It is dominated by a shrub heather (*Erica arborea*), pistache (*Pistacia terebinthus*) and lavender (*Lavandula stoechas*). Of these plants, the heather generally contains the highest levels of metals, although the pistache is the most sensitive species to the presence of Cu-rich zones. At a zone of Au-bearing Ni/Cr mineralization, the heather yielded the highest concentration of Au, with up to 195 ppb Au in ash.

# LEAD ISOTOPIC PROVENANCE OF EGYPTIAN SULPHIDE DEPOSITS, NEW KINDGOM GLASS, AND GALENA COSMETICS: A SEARCH FOR THE SOURCE ORES OF PHARAONIC ARTIFACTS

### A. El Goresy, F. Tera, B. Schlick-Nolte and E. Pernicka Max-Planck-Institut fur Kemphysik, Heidelberg

We carried out mineralogical and lead isotopic investigations of four galena deposits (Um Gheig, Zug El Babar, Gabal Rossas, and Ranga) in the Egyptian Eastern Desert, Also a detailed chemical and lead isotopic survey of Ancient Egyptian Ramesside glass unearthed from the Lisht site was conducted. A major question is if glass-making industry actually existed in ancient Egypt or if the glass workshops were only confined to glass working of imported pigmented or unpigmented raw glass. Our studies aimed to shed light on this long standing question, scrutinise the nature of the opacifier in the leaded yellow Ancient Egyptian Ramesside glass, and to explore if the lead opacifier in the yellow leaded glass originated from Egyptian galena deposits or was imported. Furthermore, with the isotopic data set of the Egyptian galena deposits it should be possible to cheek if the Ancient Egyptian galena cosmetics (Kohl) studied by Brill et al. (1974) were exploited from the galena deposits in the Eastern Desert. Our investigations indicate: (1) The Pb-isotopic composition of Ranga galena is clearly different from the other three lead deposits plots at clearly higher  $^{208}\text{Pb}/^{206}\text{Pb}$  and  $^{207}\text{Pb}/^{206}\text{Pb}$  ratios ( $^{208}\text{Pb}/^{206}\text{Pb} = 2.073284$ ;  $^{207}$ Pb/ $^{206}$ Pb = 0.8402325) thus indicating an isotopically and genetically different source than the other three deposits (<sup>208</sup>Pb/<sup>206</sup>Pb from 2.029042 to 2.033526 and <sup>207</sup>Pb/<sup>206</sup>Pb from 0.8183581 to 0.8237877). (2) None of the galena cosmetics derive from the four deposits studied here. Cosmetics sample 240 (Brill et al., 1974) most likely originates from the Ranga deposit that was apparently not exploited by the ancient Egyptians. Hence, it must be considered as a modern galena cosmetic (Kohl). (3) The Lisht glasses differ isotopically from the galena cosmetics indicating different galena sources. (4) The opacifier added during the glass making process of the Lisht glass was not, as generally accepted, Pb<sub>2</sub>Sb<sub>2</sub>O<sub>7</sub>, but a mixture of lead and antimony compounds (presumably oxides). (5) The Ramesside Lisht glasses are isotopically different from the 18<sup>th</sup> Dynasty glasses analysed by Lilyquist et al. (1993). The data points of the two groups of glasses indicate a bimodal distribution in well separated fields: Lisht: <sup>208</sup>Pb/<sup>206</sup>Pb = 2.084033 - 2.128028;  ${}^{207}\text{Pb}/{}^{206}\text{Pb} = 0.8430528 - 0.8746428;$ 18<sup>th</sup> dynasty:  ${}^{208}\text{Pb}/{}^{206}\text{Pb}$ : 2.01877 - 2.07912;  ${}^{207}\text{Pb}/{}^{206}\text{Pb}$ : 0.8088 - 0.83805 indicating different ore sources for the opacifiers (or glasses) in the 18th Dynasty and Ramesside Period.

# GEOCHEMICAL PROSPECTING USING STREAM-SEDIMENT SAMPLES FROM CENTRAL PORTUGAL: AN INTERPRETATIVE STUDY APPLYING MULTIVARIATE STATISTICS

# E. Ferreira da Silva<sup>1</sup>, H.G. Pereira<sup>2</sup>, A.J. Sousa<sup>2</sup>, E. Cardoso Fonseca<sup>2</sup>

1 Dep. Geociencias, Unv. de Aveiro, Aveiro, Portugal 2 CVRM/IST, Lisboa, Portugal

In the Fornos de Algodres area (Central Portugal), a geochemical stream-sediment survey was conducted in order to detected economic geochemical anomalies. A total of 892 stream-sediment samples were collected, dried and sieved to minus 80 mesh, and analysed by AAS for Fe, Mn, Cu, Zn, Pb, Co, Ni, Ag, Ba, Li, and by FRX for W, Sn, Nb.

Most of the area is occupied by Hercynian granitoids ranging in composition from hornblende granodiorites, through biotite and two-micas granites to muscovite-bearing granites. On a broader scale, the Fornos de Algodres complex can be envisaged as a segment of the Iberian Variscan Folt Belt that forms northwest, west and central Spain and the greater part of Portugal.

The occurrence of important economic deposits of tin and tungsten in close spatial and temporal associations with the Variscan granitoids can be found.

An exploratory statistical study by Factorial Analysis identifies the presence of three groups of elements, the first W - Sn - Nb, the second Li - Ba and the third Cu - Pb - Zn. A set of multivariate statistical methods were combined to provide insight on the sub-populations that occur in the area and results were interpreted on lithological grounds, accounting for new mineralization and tailings from exhausted ancient exploitations.

# VARIATIONS OF SOIL SIGNAL AND SELECTIVE EXTRACTION OF GOLD IN DIFFERENT LATERITIC CONTEXTS

### Ph. Freyssinet and C. Greffie

BRGM, Research Division, BP 6009, 45060 Orleans, France

An understanding of the geochemical environment is essential for the efficient application of geochemical soil surveys. In tropical zones, the paleoclimatic and paleoweathering conditions play an important role in the soil dispersion processes and especially in the variations of the gold signal in soils.

The aim of this study was to compare the variation of gold signal in different paleoclimatic zones of Africa and Amazonia. Gold mass balance calculations were estimated for soil horizons in various weathering profiles, using the average gold content in the saprolite as a reference. By calculating the absolute gold gain or loss, it was possible to normalise and compare the variation of gold signal in surface horizons of various types of tropical weathering profile.

Results show that in savannah zones, where the weathering profiles are capped by a ferruginous duricrust, the gold mass balance is generally negative. The opposite situation is found in rainforest systems, where gold shows absolute enrichment in recent yellow latosols. An intermediate stage is found in the gravelly latosols of the humid savannah zones of Amazonia and West Africa where the nodules represent the remnants of ancient duricrust and the clay matrix developed under the present humid tropical climate; the gold mass balance of these soils shows intermediate values between the negative ones of duricrust profiles and the positive ones of recent yellow rainforest latosols.

Selective extractions were performed on these different types of weathering profile to determine the gold distribution in the organic and mineralogical phases; sodium hydrochlorite (NaOCl), hydroxylamine hydrochloride and citrate bicarbonate dithionite (CBD) were respectively used to dissolve organic matter, Mn-oxides and Fe-oxides. Here the results show that: (a) in the duricrust profile, only 1 to 3% of gold is extracted by the NaOCl solution, despite the lack of organic matter - the rest of gold is probably in a metallic form and is not removed by the different leaching solutions: (b) in the humic layer of rainforest soils organically-bound gold constitutes 85% of the total gold in the dispersion halo and is up to 30% richer than the primary mineralization - about 2-8% of gold is also removed by NaOCl solutions in the underlying ferruginous horizons and the saprolite, where there is no detectable organic carbon.

The gold mass balance appears to be related to the amount of non-metallic gold in the soil. Remobilized gold in duricrust profiles reprecipitates as secondary gold or is leached out. Under more humid conditions, gold is reconcentrated in the clay matrix and a large amount is trapped as organically-bound gold or adsorbed on minerals.

# WHAT'S IN A SAMPLE?

### David Garnett

Becquerel Laboratories, Sydney, Australia

Most analytical samples contain many thousands of grains and the influence of any one grain on the final value reported is normally subdued. However, coarse-grained samples generally contribute far fewer individual grains to the final portion selected for analysis, so each has the potential to have a significant impact on the geochemistry of the sample as a whole. In order to investigate the degree of variability of such samples, iron-rich, desert varnished chips were collected from the surface in the vicinity of a calcrete-covered zinc deposit at Kantienpan, north-western Cape Province, South Africa.

Sixty sample points yielded a total of 223 chips, each of which was analysed separately. Chips ranged in weight from less than 0.1g to 24 g. Each was classified according to external appearance and was then hand pulverised. Colour of the resultant powder was recorded, before weighing, mixed acid digest and analysis for a range of elements by atomic absorption spectrophotometry. Since the weights of all chips were known, it was possible to calculate weighted average values for each sample site, in order to predict what value would have been reported from a normal composite sample. While these weighted average values would have located the target deposit, it was instructive to note the wide range of values of individual grains at a single sample site. Sampling of such material offers great potential for enhancement of subtle geochemical signals in covered areas, but it also has the potential to generate even greater confusion if sampling is not carried out with care.

# DOLOMITIZATION, PRECURSOR OF HYDROTHERMAL-METASOMATIC MINERALIZATION IN THE JUDEAN DESERT, ISRAEL

A. Gilat and Y. Nathan Geological Survey of Israel, Jerusalem, Isarel

Dolomitization in the Judean Desert is the result of hydrothermal-metasomatic activity along faults related to the Dead Sea transform. Isotope studies indicate that that the fluids were moderately hot during dolomitization, at least 60° - 120° C. These fluids used shear- and fracture zones adjacent to strike-slip faults as feeder systems.

The order of events appears to be: (a) dolomitization; (b)baritization; (c) calcitization, silicification, precipitation of halite and gypsum together with a wide spectrum of trace elements. The fluids mobilized trace elements from the surrounding and subsurface rocks. Uranium could be traced to the near-by phosphorite rocks. No concentraction of metals occurred during dolomitization and very little during baritization.

Since most mineralization occurrences are small (and particularly metallic mineralization), the large scale of dolomitization over thousands hundreds of square meters, is useful as pathfinder. Many mineralized bodies were located and their connection to strike slip faults and shear zones was established.

The mineralization is characterized by enrichment in U, Th, REE, and noble metals. Eu and in places Ce are anomalously enriched in relation to the other REE. Gangue minerals include dolomite, most of which has been replaced by barite, plus calcite, halite and gypsum.

### VERTICAL MIGRATION OF ELEMENTS FROM BLIND MINERAL DEPOSITS

### Issai Goldberg,

IONEX Pty Limited, Sydney NSW 2060, Australia

Exploration for blind ore deposits constitutes an outstanding potential opportunity on every continent. In geochemistry, some success has been achieved using the selective extraction of mobile and weakly-bonded occurrences of elements (MWBE). (Antropova et al., 1992). Case studies report the location of MWBE anomalies above mineral deposits occurring at depths of up to 500 m of more. The content of MWBE in an anomaly seems only slightly dependent on the depth of the "source deposit". MWBE anomalies seem to occur regardless of the mineral composition, age, genesis, or morphology of their "source deposits". These anomalies also seem to occur regardless of the nature and composition of the "source deposit" host rocks, their physical properties, tectonic disturbance, moisture content, or the presence and nature of younger

overlying unconsolidated material. Characteristics of MWBE anomalies suggest that a new form of essentially vertical mobile element migration exists ("jet-like", Ryss et al., 1987).

The velocity of migration is an important aspect and has been the subject of preliminary investigations. An extensive series of experiments has been completed on the diffusion of copper through heterogeneous media (purified quartz sand/ electrolyte). The distribution of copper velocities shows a narrow maximum, representing the normal range of velocity, and a long tail, representing "fast ions" of low concentration. In field experiments, the apparent velocity of migration was some five orders of magnitude faster than a normal diffusion front calculated using a diffusion coefficient of  $D = 10^{-6}$ cm<sup>2</sup>/second. Another feature of the migration of elements at very low levels of concentration is the development of advancing "tongues" of material, observed in quasihomogenous media. The phenomenon is also seen in "fast ion" anomalies, and is similar to "fingering", when microcomponents move through real media (Feder, 1991).

Rapid migration of elements at very low levels of concentrations, and the emergence of "tongues" ahead of migrating fronts, seem compatible with a convective mechanism for element migration. There is a growing body of data which support this suggestion.

The development of far more sensitive analytical procedures, and the selection of particular forms of elements or groups of forms elements - may eventually enable geochemical and petrological "mapping" to significant depths below the surface. In addition to providing a major benefit to mineral exploration, this could have other important advantages, for example in the prediction of volcanic and earthquake activity.

### DEPOSITION AND IMPACT OF ELEMENTS EMITTED FROM FOUR POWER PLANTS IN THE WABAMUN LAKE AREA, ALBERTA, CANADA

#### F. Goodarzi

Geological Survey of Canada, 3303-33rd St. N.W., Calgary, Alberta, Canada T2L 2A7

The aerial deposition of particles and elements emitted from four coal-fired generating stations in the Wabamun Lake area, Alberta has been monitored by a network of 36 moss traps. There have been seven periods for which the moss has been collected and analyzed. The results show that the deposition rate of emitted elements is small. Downwind traps, within 15-20 km of the power plants, show the greatest impact.

The impacted particles are grouped into geogenic and anthropogenic using their morphology and chemical signature.

The rate of deposition of particles and elements has not been uniform sometimes depending on seasonal effects and local activities. High values of Th and U registered at one trap was due to fugitive ash from an up wind ash disposal site. A high copper value at another trap was due to spring time application of fertilizer close to the trap.

# DEPENDENCE OF RADIOCESIUM DISTRIBUTION ON THE LANDSCAPE-GEOCHEMICAL CONDITIONS IN AREAS OF LOW-LEVEL BACKGROUND GLOBAL POLLUTION

### Andrei G. Grigoriev

All-Russian Geological Research Institute (VSEGEI), St. Petersburg, Russia

The distribution of technogenic radioelements in areas exposed to high-level pollution, as a result of accidents at Nuclear Power Stations or other catastrophic events, is examined in detail and described in many papers. The low-level background distribution of the radionuclides, connected with global reductions, has been investigated to a lesser extent, and information in not detailed. The area of our investigation in situated in the northwestern part of Russia to the north of the Ladoga Lake. This area is a typical region of the global reductions of technogenic radionuclides, and especially the characteristic technogenic isotope Cs-137, the distribution of which is related to the landscape and to geochemical conditions.

Radioactivity of soils depends on the distribution of Cs-137 and increases from sandy to clay soils, soils with high contents of organic matter, and reaches the maximum value in peats. When testing the average values of the radioactivity and its variances, significant distinctions between samples at the five percents level were obtained between sands and soils with low ash content (peat, plant residues).

Distribution of Cs-137 also depends on the landscape characteristics. Comparison of homogeneous sets of analytical data does not show significant differences within them, but displays some distinctions between their mean values. Areas without wood and bush vegetation, such as glades, roads, bogs, etc., usually can be united in one group, and their contamination is approximately 25-30% higher than the average level. Forest areas, including swampy ones, are combined in the second group. An intermediate situation is typical for forest margins. Such distribution of Cs can be explained by the accumulation of soluble forms of Cs-137 in vegetable tissues. These forms can be directly input from the atmosphere, as well as through root system from the ground. The investigation of radiocesium distribution shows that Cs-contents and surface are not relief-dependent. That proved to be true by comparing homogeneous sets for which no significant distinctions were revealed.

Our data show that in areas of global background pollution, as a result of redistribution of technogenic radionuclides, there is significant accumulation in soils, enriched with organic substances, and also in open areas (deprived of wood and bush vegetation). Thus, the best collectors are bogs with soils characterized by low ash content.

# IDENTIFYING SOURCES OF SALINITY IN THE PLEISTOCENE COASTAL AQUIFER, MT. CARMEL REGION, ISRAEL

# Joseph Guttman<sup>1</sup> and Joel Kronfeld<sup>2</sup>

1 TAHAL Consulting Engineering. Ltd, Tel-Aviv 2 Department of Geophysics and Planetary Sciences, Tel-Aviv University, Ramat-Aviv, 69978, Israel

The Coastal Plain aquifer at Magan Michael has been exhibiting increasing salinity. Likewise, the nearby major spring system of Nahal Taninim has also been experiencing a steady rise in its chlorinity. Isotopic studies from wells indicate that much of the recharge from of the Pleistocene sandy aquifer is from drainage from the juxtaposed Cenomanian carbonate aquifer of Mt. Carmel as well as the infiltration of rain. The Cenomanian carbonate aquifer also feeds the Taninim springs. The dominant salinization process affecting the Coastal Plain aquifer at Kibbutz Magan Michael is the downward leakage of recirculated fishpond water. The isotopic signature of this contaminating water source is clearly different than that of the natural replenishment of the region. The heavier hydrogen, carbon, and oxygen isotopic composition reflects the evaporative processes that it has experienced. The higher strontium isotopic ration reflects the sea spray derived salt that is accumulated in the fish ponds In addition, the isotopic profile, from water taken at varying depths within the T/4 observation well, shows evidence that upwelling brines are also contaminating the discharge of the Taninim spring system. The brines are isotopically heavier, with high Sr concentrations and lower Sr-87/Sr-86 ratios.

### MODELING OF DEEP GROUNDWATER CHEMISTRY IN THE HEBEI PLAIN, CHINA

#### Yonghai Guo

Beijing Research Institute of Uranium Geology, P.O.Box 9818, Beijing 100029, P.R. China

Sodium-bicarbonate waters are very common in the deep Quaternary system of the Hebei Plain. The main characteristics of the waters are that the pH values are higher (8.2-8.9) and the concentrations of total dissolved solids are lower (<1.5g/l). In solution, the sodium ion accounts for more than 85 percent of the total milliequivalents of cations, and the bicarbonate (plus carbonate) ion account for more than 50 percent of the total applied waters to irrigation. This often leads to harmful environmental effects of soil hardening and crop death when the waters are used for irrigation. This paper, taking the Boding - Cangzhou hydrogeological section in the Hebei Plain as an example, firstly analyses the chemical properties and distribution regularities of the sodium-bicarbonate waters, and then studies the trend of dissolution and precipitation of minerals and simulates the geochemical reactions between water and rock leading to the origin of this water type.

### **Mass Balance Model**

The Mass Balance Model is based on the principle of a balanced chemical reaction in the form: initial solution composition + reaction phases = final solution + product phases.

In this model, the K, Na, Ca, Mg, Cl, S, C, Fe, Al, Si and F are considered as the main elements. According to the mineralogical characteristics of the study area and the conditions of the groundwater, the calcite, dolomite, gypsum, albite, kaolinite, fluorite, biotite, siderite, pyrite, quartz, halite, CO<sub>2</sub> and Ca-Na cation exchange are selected to be the plausible phases. The redox reactions are also considered. The model is solved as an inverse problem by means of the computer program NETPATH.

### **Modeling Results**

- The sodium-bicarbonate waters originated from the evolution of calcium (magnesium) bicarbonate waters in a piedmont recharge area.

- The groundwater system, - from "open" to "closed", is the main environmental condition for the origin of sodium bicarbonate water.

- Dissolution of albite, precipitation of calcite and dolomite, and calcium-sodium cation exchange are the dominant hydrogeochemical reactions leading to the origin of sodium bicarbonate waters.

# COMPARISON OF ANALYTICAL RESULTS USING DIFFERENT SELECTIVE EXTRACTION SCHEMES

### Gwendy E.M. Hall

Geological Survey of Canada, Ottawa, Canada

Selective extraction schemes, where operationally-defined phases are dissolved using a sequence of suitable chemical reagents, are employed in the analysis of soils and sediments to provide information as to the binding sites of elements (metals and non-metals). The scheme originally used by Tessier has been widely applied in the field of environmental geochemistry to, for example, study the partitioning of metals with depth in lake sediment cores and, together with pore water data, to estimate the degree of diagenesis and historical input. The use of sequential extraction has also been prevalent in the field of exploration geochemistry, with particular focus recently on the specific dissolution of the so-called 'scavenger' phases: the humic and fulvic component and amorphous Fe and Mn oxyhydroxides. An enormous database is now being established, within the exploration community worldwide, comprising metal and non-metal concentrations held in these various labile forms in sediments (stream and lake) and soils (A, B and C horizons). Thus, it would seem important that data derived for exploration purposes be compatible with those obtained by implementation of protocols (such as Tessier's) used in the sister discipline of environmental geochemistry. It also appears logical that some consensus be achieved on the selection of reference materials used to examine precision and, to a certain extent, accuracy. This paper compares results obtained by the GSC sequential extraction scheme with those recently published in the literature using Tessier's method on the soil standard reference materials NIST 2709-2711 and CCRMP SO 1-4. These samples are being promoted as particularly suitable for quality control in selective extractions, whether the medium under investigation be soils or sediments. This paper goes on to compare the efficacy of extraction of Hg bound in sediments in humic and fulvic complexes using two popular leach solutions: 0.1 M Na<sub>4</sub>P<sub>2</sub>O<sub>7</sub> and 0.5 M NaOH. While the pyrophosphate leach is being adopted widely in exploration geochemistry, the sodium hydroxide reagent remains that suggested by the International Humic Substances Society and is prominent in environmental studies in sediment analysis. Results presented here suggest that more research is needed into the exact nature of phases purportedly extracted by selective leaches and into associated artifacts of extraction such as readsorption phenomema.

### PRESERVATION OF ARSENIC SPECIES IN NATURAL WATERS

### Gwendy E.M. Hall, Gilles Gauthier and J.C. Pelchat Geological Survey of Canada, Ottawa, Canada

The coupling of high performance liquid chromatography (HPLC) with the sensitive technique of inductively coupled plasma mass spectrometry (ICP-MS) allows for the determination of As species in waters, such as inorganic As, monomethylarsonic acid and dimethylarsinic acid (Thomas and Sniatecki, 1995). While the recent literature demonstrates the evaluation of this instrumentation for As, providing expected figures of merit such as detection limit, accuracy and precision, there is an absence of information on methods to preserve the distribution of As species during the period between collection and analysis. Preservation is of particular concern in work carried out by the Geological Survey of Canada (GSC) as sample sites of interest are often in remote locations (e.g., in the Arctic regions) and shipping under refridgeration can be extremely awkward. At the GSC, chromatographic separations of As III and As V were performed using the Cetac microcolumn, ANX 1606-As, a proprietary anion exchange resin. Initial testing of the system with spiked amounts of sodium arsenite and arsenate revealed a startling phenomenon. Distilled deionised water, at room temperature, spiked with As V (at 0.5 and 5 ppb) alone or mixed with As III showed that reduction to As III was occurring within hours. It was confirmed that this apparent conversion was not due to preferential precipitation or adsorption to container walls of As V. The reaction was further verified by independent analyses using hydride generation quartz tube atomic absorption spectrometry at a pH of 5 (only As III forms the hydride) and in 1M HCl after reduction with KI (total inorganic As). Conversion of As V to As III was also evident using Ottawa River instead of deionised water. No correlation was found with change in dissolved oxygen, organic C or pH. The cause of this reaction remains to be identified but it negates the use of spiking as a test for preservation of As species. A natural water sufficiently concentrated in As (total As of 21 ppb) was located near Ottawa for the study. A large sample was taken, filtered on-site at 0.45 µm, and treated various ways. Results, discussed in this paper, show that storage in the cold remains the method of choice to preserve the distribution of As III, As V and organic As. Although addition of HNO3 or HCl, to a final concentration of 0.1%, preserves the As distribution from day 1 to day 30 without refridgeration, it causes an initial increase in As III and to a lesser extent, As V, at the expense of organically bound As.

Thomas, P. and Sniatecki, 1995, J. Anal. At. Spectrom. 10, 615-618 (and references therein).

# THE "ENZYME LEACH" - SOME NEW DISCOVERIES OF BLIND DEPOSITS.

# Eric L. Hoffman, J. Robert Clark, James R. Yeager and P. Rogers

Activation Laboratories Ltd., Ancaster, Ontario and ACTLABS Inc., Wheat Ridge, CO

The problem when trying to perform geochemical exploration in terrains that are deeply covered by transported overburden is that the overburden is usually exotic to the bedrock that it covers. In other areas mineral deposits occur beneath deep sections of unmineralized bedrock, which masks the underlying ore. Conventional chemical analysis would reveal only the composition of the overburden or bedrock unit closest to the surface and would not give any indication of underlying mineral deposits. In the past, drilling has been the only means of collecting useful geochemical samples in areas of extensive overburden. An inexpensive means was needed for gathering meaningful geochemical data from overburden that would provide some indication of the existence of a buried mineralized body.

Trace elements released by oxidation of sulfide-mineral deposits in the bedrock will migrate up through overburden by such means as diffusion of volatile compounds, capillary action, and electrochemical processes. However, the amount of these bedrock-related trace elements is typically a very small component of the total concentration of these elements in the overburden. The goal is to determine the amount of a trace element that has been added to the overburden rather than the total amount in the overburden sample. Upon reaching the near surface environment, many of the trace elements migrating through overburden will be trapped in manganese and iron oxide coating, which form coatings on mineral grains in the soils. One of the most effective traps for trace elements migrating toward the surface is amorphous manganese dioxide, which is usually a very small component of the total manganese oxide phases in the soil sample.

A selective leach has been developed that employs an enzyme reaction to preferentially dissolve amorphous manganese dioxide. When all the amorphous manganese dioxide in the sample has been reacted, the enzyme reaction slows dramatically, and the leaching action ceases. Because the enzyme leach is self limiting, there is very little leaching of the mineral substrates in the sample. Thus, the background concentrations for many elements determined are extremely low and the anomaly/background contrast is dramatically enhanced.

This paper will describe how the process works, the types of anomalies obtained and how to interpret the anomalies. Several case histories of recent drilling successes will be shown.

### MAGNETIC SUSCEPTIBILITY AS A PROXY PARAMETER FOR THE DETECTION OF POLLUTION OF SOILS AND SEDIMENTS: CONTAMINATION DUE TO EMISSION OF VEHICLES

### V. Hoffmann, M. Knab and E. Appel

Institut für Geologie und Palaeontologie, Abtl. Geophsik, Universitaet Tüebingen, 72076 Tüebingen, Germany

Recent studies have shown that under certain conditions, magnetic susceptibility can be used as a proxy-parameter for the detection of pollution such as heavy metals or even PAH's in sediments or soils. Very often, spherical particles of anthropogenic origin (e.g., in fly-ash) containing a magnetite-like phase were found to be responsible for the enhancement of the magnetic signal. Emissions of vehicles represent another important source of inorganic (particles in exhaust fumes, heavy metals) and organic (PAH, PCDD/F, BTX, etc.) contaminants resulting in a strong decrease of air and soil quality in areas near roads and highways. Since the introduction of Pb-free petrol and catalyzers, the Pb-output is decreasing strongly; on the other, hand noble-metal particles (Pt, Ro, ...?) are emitted as new pollutants with (up to now) unknown consequences for the soil quality. The aims of our study are to trace the distributions and concentration gradients of contaminants being emitted in soils along roads and highways carrying appreciable traffic. The concentration and possible accumulation of these pollutants in deeper soil-layers are also being investigated. Magnetic susceptibility was used for the pollution-mapping already in the field (Bartington-bridge). The distribution of the susceptibility values very clearly represent the polluted areas which are strongly influenced by: traffic frequency, topography on the road-sides, meteorological conditions (e.g., wind directions) and others. The present and future directions of this study are to establish relations between the magnetic signal and various types of inorganic contaminants as well as to investigate the magnetic phases responsible for the enhanced magnetic signal (chemical composition, grain size, shape, etc.).

# GEOCHEMICAL EVOLUTION OF LATERITC Sn, Zr, Th, Nb, Y AND REE - BEARING ORE BODY DERIVED FROM APOGRANITE: THE CASE OF PITINGA, AMAZONAS - BRAZIL

A.M.C. Horbe<sup>1</sup> and M.L. da Costa<sup>2</sup>

1 Departamento de Geociencias - Universidade deo Amazonas, Av. Gal. Rodrigo O.J. Ramos, 3000 - Japiim, 69077-000, Manaus - AM - Brazil 2 Centro de Geociencias - Universidade Federal do Para, CP 1611, Campus Universitario do Guama, 66075-900, Belem - PA - Brazil

The Pitinga region, located 250 km from Manaus in the Amazonas state, northern Brazil contains primary and supergene mineralization of Sn, Zr, Th, Nb, Y and REE. The principal ore body of supergene mineralization (Serra do Masdeira), is represented by a 20 m thick lateritic profile in which seven horizons were identified (from bottom to top): parent rock, saprolite, argillaceous mottled, bauxitic, concretionary, colluvial and latosol. The parent rock is a porphyritic alkaline-granite containing albite, quartz, Kfeldspar, lepidolite, riebeckite, fluorite, cryolite, zircon, hematite, cassiterite, thorite, xenotime, pyrochlore, columbite, bastnaesite and fluorcerite. The saprolitic horizon constitutes more than half of the entire profile and displays a massive structure crossed by a network of fractures. Kaolinite and quartz are the main minerals. The argillaceous mottled horizon is reddish in color and contains less kaolinite but more gibbsite than the saprolitic horizons. The bauxitic horizon occurs outside of the main portion of Serra do Madeira. The concretionary horizons is composed of fragments of the bauxitic horizon and of an old iron crust. Colluvial material occurs on the slope of the Serra do Madeira, with a composition similar to that of the argillaceous mottled horizon. The latosol, which covers the concretionary and colluvial horizons has high contents of quartz, kaolinite and gibbsite and lesser hematite+goethite.

The bulk chemical composition of the lateritic profile when compared to parent rocks shows higher contents in Al<sub>2</sub>O<sub>3</sub>, Fe<sub>2</sub>O<sub>3</sub>, Sn, Zr, Th and Nb (which relate to the higher contents of kaolinite, gibbsite, hematite, goethite, cassiterite, zircon, thorite and columbite), and lower amounts of SiO<sub>2</sub>, FeO, CaO, Na<sub>2</sub>O, K<sub>2</sub>O, F, Pb, Rb and U (due to the presence of remnant quartz, K-feldspar, plagioclase, riebeckite/ arfvedsonite and biotite in the lateritic portion). Y, P and REE have the lowest values in the saprolitic and argillaceous mottled horizon and are highest in the latosol. The REE minerals are represented by xenotime, thorite, bastnaesite, fluorcerite and probably churchite and ytriofluorite. The large variety of REE minerals is responsible for the irregular pattern in the distribution of the REE in the profile. The iso-zirconium mass balance shows that the profile developed iso-volumetrically in the saprolitic and argillaceous mottled horizons while the colluvial and latosol horizons were reduced in volume. Alkalis, F and Rb are strongly leached; Si, Fe<sup>2+</sup>, Mn, P, Y, LREE and Pb are moderately leached; Sn, Zr, Nb, Th, Hf, Ga, HREE and Ta are relatively enriched and Al.  $Fe^{3+}$  and Ti are strongly enriched.

# LEAD 207/206 RATIOS IN SEDIMENTS FROM THE COEUR D'ALENE AND SPOKANE AREA, IDAHO AND WASHINGTON, USA: EFFECT OF MINING ACTIVITIES ON LEAD ISOTOPIC COMPOSITION OF SEDIMENTS

Mohammed Ikramuddin<sup>1</sup>, Stephen E. Box<sup>2</sup> and Arthur A. Bookstrom<sup>2</sup>

1 Department of Geology, Eastern Washington University, Cheney; WA 99004, USA

2 U.S. Geological Survey, 904 W. Riverside Avenue, Spokane, WA 99201, USA

In order to evaluate the effect of mining activities on the lead isotopic composition of sediments from rivers and lakes in the Coeur d'Alene-Spokane area, Idaho and Washington, about 125 samples of contaminated and uncontaminated sediments (including the subsurface samples from the Coeur d'Alene River) were analyzed for isotopic composition of lead by inductively coupled plasma mass spectrometry. This study concentrates on <sup>207</sup>Pb/<sup>206</sup>Pb ratio as a tracer of <sup>207</sup>Pb/<sup>206</sup>Pb ratios in The contamination. tailings contaminated (mining) sediments of the Coeur d'Alene River and Lake Coeur d'Alene (50 km downstream) are identical to those in the Coeur d'Alene mining district ore reported by several workers, but distinctly higher than the ratios in uncontaminated pre-mining sediments and sediments from several other areas which have not been affected by mining activities. Sediments from the Spokane River downstream of Lake Coeur d'Alene (from 65-120 km downstream of mining district) contain high <sup>207</sup>Pb/<sup>206</sup>Pb ratios but exhibit a wide variation indicating different degrees of contamination. Some of the pre-mining subsurface samples from the Coeur d'Alene River also contain high and variable ratios as a result of leaching of lead downward from tailings contaminated sediments. The mean <sup>207</sup>Pb/<sup>206</sup>Pb ratios and the ranges for contaminated and uncontaminated sediments are given in the table.

		<sup>207</sup> Pb/ <sup>206</sup> Pb
Location	Mean	Range
Coeur d'Alene area:		
Ore, Coeur d'Alene mining district	0.945	
Mining sediments, Coeur d'Alene River	0.946	0.940-0.951
Mining sediments, Lake Coeur d'Alene	0.944	0.943-0.947
Uncontaminated pre-mining sediments, Coeur d'Alene River	0.850*	
Uncontaminated sediments, St. Joe River	0.826	0.819-0.834
Spokane area:		
Contaminated sediments, Spokane River	0.926	0.875-0.943
Uncontaminated sediments, Spokane River	0.828	
Uncontaminated sediments, Little Spokane River	0.824	0.823-0.825
Uncontaminated sediments, Hangman Creek	0.823	0.822-0826

\*Approximate value; analysis of additional samples in progress

The Coeur d'Alene-Spokane area appears to be very suitable for application of lead isotopes to trace contamination in sediments, as the uncontaminated and contaminated sediments have distinctly different isotopic signatures. Preliminary lead isotopic data obtained on some drinking water wells from the city of Spokane indicate that Pb from the Coeur d'Alene mining district is entering the Spokane aquifer along the Spokane River, almost 100 km downstream from the mining district.

### PROXY MAPPING OF FLY-ASH POLLUTION OF SOILS AROUND A COAL-BURNING POWER PLANT: A CASE STUDY IN THE CZECH REPUBLIC

# A. Kapicka<sup>1</sup>, E. Petrovsky<sup>1</sup>, S. Ustjak<sup>2</sup> and K. Machackova<sup>3</sup>

 Geophysical Institute, Bocni II, 141 31 Prague 4, Czech Republic
Research institute of Crop Production Prague, Department of Ecotoxicology Chomutov, Czech Republic
Inst. of Environmental Studies, Charles Univ., Prague, Czech Republic

A novel method of outlining areas of different pollution impact due to fly-ash atmospheric deposition is reported.

Magnetic mapping based on measurements of magnetic susceptibility of surface soils around a coal-burning power plant can help us in estimating areas with high level of pollution due to fly-ashes. Magnetic susceptibility is a direct measure of concentration of ferrimagnetic minerals, among which the most frequent, magnetite, is produced from pyrite during coal combustion. Pilot field magnetic measurements were carried out on sites belonging to a standard network used for chemical analysis of soils. Contour maps will be presented, showing relationships between this magnetic parameter and contents of several toxic elements, e.g., Cr, Co and, in part Pb. Benefits and disadvantages of measurements of magnetic susceptibility of soils for pollution mapping will be discussed.

### ZONATION OF THE RUSSIAN TERRAIN BASED ON THE DEGREE OF RADON HAZARD

### M.G. Kharlamov, V.A. Maksimovsky and A.P. Karpinsky All-Russian Geological Research Institute (VSEGEI), St. Petersburg, Russia

Radon is of major importance in human exposure to ionizing radiation. Most of the radiation dose is received in living accommodations and industrial premises. Radon n the air is largely derived from underlying geological hosts and its presence in the rock mass results from many factors. Thus depending on the area, these factors have features which depend on the geological setting, the concentration of radioelements in rocks, soils and underground waters, emanating factors, etc. A 1:10,000,000 scale map showing the zonation of the territory of Russia based on the degree of radon hazard (edited by A.A. Smyslov and M.G. Kharlamov) was completed at VSEGEI in 1992.

During the compilation, the authors collected, generalized and analysed available data on the distribution of uranium, radium and radon in rocks, ores, soils and underground waters within Russia and contiguous countries. Radiogeochemical maps at 1:2,500,000 and 1:10,000,000 scales compiled at VSEGEI with the participation of other organizations under the direction of A.A. Smyslov were used as the basis for the proposed zonation. Supplementary material was used as well.

Three categories of potential radon hazard are distinguished: (1) unhazardous (conventionally unhazardous) - no or little rocks producing radon occur in the geological section and the rock mass is undisturbed; (2) potentially hazardous - potentially hazardous rocks occur, or formations highly suitable for hosting uranium are overlapped by a cover of screening rocks of various thickness; (3) hazardous extensive distribution of rocks with high potential as hosts for radioactive elements, deposits of uranium and uraniferous ores, and the presence of areas of emerging of flows are recorded. Areas characterized by the widespread presence of radon producing sources (uranium deposits, etc.) and the presence of high radon concentrations in the air of living accommodations and industrial premises, may be also classified as hazardous. Hazardous, potentially hazardous and unhazardous areas are distinguished on the basis of this qualitative gradation of radon hazards in Russia.

# STRUCTURE AND METAL BINDING PROPERTIES OF SEDIMENTARY HUMIC SUBSTANCES IN RELATION TO THEIR ORIGIN

### **M.** Klavins

University of Latvia, Faculty of Geography and Earth Sciences, Raina bovd. 19, LV 1586, Riga, Latvia.

Humic substances (HS) are recognized as the main component of natural organic matter (NOM) in soil, waters and different sediments of water bodies. Due to multifunctional structures, HS may be regarded as the major metal binding component of NOM. The metal speciation, their transport characteristics and fate are largely determined by the presence, amount and properties of HS. Considering this, the aim of this study is to compare properties of HS isolated from sediments of different water bodies, and particularly their ability to interact with trace metals. HS were isolated from sediments of lakes and rivers with different trophic states in Latvia. The isolated HS was characterized by their elemental, functional composition, their UV, IR, fluorescence and EPR spectra. The molecular mass of HS and their metal binding ability has been determined and complex forming properties of HS of different origin has been studied.

# IMPACT OF MINING ACTIVITIES UPON THE ENVIRONMENT OF THE SLOVAK REPUBLIC: A CASE STUDY

### Alena Klukanova and Stanislav Rapant Geological Survey of Slovak Republic, Mlynska Dolina 1, 817 04 Bratislava, Slovakia

Slovakia is a country with long-lasting extensive mining activity from Middle Ages. Mining activity inflicts considerable damages to the environment, and increased exploitation together with inappropriate processing technologies worsen the situation. Although a recent reduction in mining intensity has apparently curtailed the propagation of these negative effects, the remnants of mining operations will likely be felt in our environment for decades to come. We are presently engaged on research into the impacts of mining on the environment, especially in those areas with declining mining operations and/or in the surroundings of abandoned mineral deposits.

The most serious hazards are the dewatering of large rock complexes and subsequent reduction in yields of water resources, large mined-out areas left at the surface, or vast undermined areas and accumulations of large amounts of contaminated materials in dumps, or tailings. Secondary processes, such as vertical and/or horizontal movements and following landscape changes, land subsidence, and landslides go hand in hand with the mining activities.

Contamination of surface and ground waters with highly mineralised mine waters, and with compounds leached from dumps or tailings, pose another problem. Harmful contaminants derived from such sources enter the surface streams in soluble or insoluble forms. These settle out in stream beds, dissolve gradually and enter the environment in a form of increased contents of hazardous substances over long periods of time. Underground mining often involved stockpiling at the surface, sometimes characterized by increased radioactivity and therefore, potentially hazardous to the environment.

Monitoring of the impacts mining activity upon the environment is part of the Slovak national monitoring network of the environment. The result provide information on possible remedies or on a balance between the exploitation of industrial materials and the damage to the environment. This method should be maintained to prevent further serious damages due to mining, its inadequate prolongation, or inappropriate and chaotic closure of mining activities. This paper will present one case history from the area of a base metal mine in the Banská Štiavnica ore district, and another from an underground coal mine in the Slovakian Handlová-Cigel' brown coal region.

The Banská Štiavnica precious and base metal ore district is one the largest in the Carpatian arc. It is situated in the central zone of a large andesite stratovolcano, including a caldera, a resurgent horst and an extensive subvolcanic intrusive complex. An extensive precious and base metal epithermal vein system dominates, but barren high sulfide systems, magnetite skarns and skarn/porphyry Cu±Au, Mo, and disseminated base metal mineralization are also present. The first written record of mining is from 1217. Long lasting extensive mining activity contributed towards a large number of dumps, tailing ponds, excavated areas and polluted streams and soils.

The Handlová-Cigel' region contains the Neogene undeground brown coal mine. Coal seams lie at depths ranging from 100 to 400 m, overlain by a complex of volcano-sedimentary rocks. The deposit as a whole is situated above the local erosional base. It is entered by horizontal galleries and gravitationally dewatered. Mining activity began at the beginning of the century with a present annual production of  $\sim$ 1 mil. ton per year. The coal contains high concentrations of toxic elements, especially As, Cd, Hg, F and S.

# CORRELATION OF NATURAL AND TECHNOGENIC MERCURY SOURCES BASED ON REGIONAL MAPPING AND MONITORING, BAIKAL POLYGON, SIBERIA

### P.V. Koval, G.V. Kalmychkov, V.F. Gelety,

**G.A. Leonova, V.I. Medvedev and L.D. Andrulaitis** Vinogradov Institute of Geochemistry, P.O.Box 4019, Irkutsk-33, 664033, Russia Sosnovgeologiya Survey, Gogol Str., 55, Irkutsk, 664039, Russia

The Baikal polygon occupies the entire Lake Baikal watershed and the adjacent areas drained by the Angara and the Lena rivers, including the well-known Irkutsk and Bratsk man-made water reservoirs. It is characterized by large varieties of landscape, geology, mineralization and technogenic pollution. The main anthropogenic Hg-sources occur in Irkutsk-Cheremkhovo industrial zone with chemical industry using Hg in its technology (Usolie-Sibirskoe, Sayansk,

Zima). Along with those, some Hg occurrences and anomalies related to faults are known in the region.

In the last decade, a set of geochemical studies have been carried out: geochemical multimedia (stream sediment, soils, bedrock, water, snow, plants) mapping the Baikal geoecological polygon (110, 000 sq. km, 1 site per approximately 100 sq. km) and Irkutsk and Osa districts (about 6,000 sq. km, 1 site per 13-16 sq. km); soil and snow regional geochemical monitoring profiles; geochemical study of water reservoirs and surroundings of some industrial enterprises. The XR-radiometric (detection limit 2 ppb), AAA (detection limit 1 ppb), and AAA with preliminary chemical concentration on sorbent (detection limit 0.02 ppb) methods were used for Hg analysis. This made it possible to provide the first assessment of Hg distribution in the main natural media (ppb): bedrock - 11; stream sediment - 21; alluvial soil - 29; Baikal bottom sediment - 66; snow water -0.12; bottom sediment of the Irkutsk water reservoir - 3; bottom sediment in Bratsk water reservoir - 3-600; plankton of Bratsk water reservoir - 1.3-65; algae - 0.6-65; fish of Bratsk water reservoir - 18-200. Three typical Hg distributions in sediment profiles were recognized in the Bratsk water reservoir: increasing concentration from bottom to surface; irregular with 1-2 maxima; decreasing concentration from bottom to surface. The second one is typical for sites of high technogenic pollution. Many Hg anomalies, in some cases exceeding the maximum concentration limit, were identified in all media under study. Comparative analysis made classification of anomalies possible: (i) bedrock related natural anomalies, (ii) fault-related natural anomalies and Baikal rift zone anomaly, (iii) technogenic halos of enterprises and settlements, (iv) technogenic anomalies in dispersion flows (sedimentary bars). Some technogenic anomalies appear to be similar to small "deposits", and will remain for a long time after closing the Hg technology industries. The Hg chemical time bomb problem can be the reality for Baikal region.

This work was supported by the Russian program "Global Change of Environment and Climate" and the Irkutsk Nature Protection Committee.

## DATABASE "GRANITES OF THE MONGOL-OKHOTSK (MOZ) ZONE" AND ITS USE IN MINERAL EXPLORATION

P.V. Koval<sup>1</sup>, V.I. Grebenshchikova<sup>1</sup>, E.E. Lustenberg<sup>1</sup> and P.J. Hennev<sup>2</sup>

1 Vinogradov Institute of Geochemistry, Irkutsk, Russia,

2 British Geological Survey, Nottingham, UK

The MOZ forms an arcuate belt, up to 1000 km wide stretching from Central Mongolia, over 3000 km east, to the Sea of Okhotsk. The extensive suite of granitoid magmas and related variable economic mineralization were formed during the Mesozoic with 150,000 sq.km. of granitic rocks. The results of the data analysis for a geochemical relational database to hold the MOZ, land-based datasets currently managed by the IGC, are presented in full in the form of a geochemical data model. The data covered the previous 30 years work, including more than 800 granite massifs, and are still being accumulated. Relational database is a model allowing concurrent access to multiple data files via common fields. The database management systems (DBMS) PARADOX 5.0 have been used. The entity relationship diagram technology has been used for constructing the database model. Forty three entities were identified. Every record (row) in every table has a unique key.

Sometimes the geological samples code is used for this aim. but in common case it is a key code. The results of analysis of rock, mineral and fluid description correspond to the geographical location (latitude, longitude). It allows to use (plot) this data in the different geographical projections and use GIS technology mapping. The value of every non-digital field in each table belongs to it's own domain set of values (not freely text string). That's why it is possible to obtain the correct answer to the query, which contained qualitative parameter. These domain sets are the tables too, and in common case they describe the domain values in detail. The referential integrity between tables is supported. Data base makes it possible to provide generalization and analysis of geochemical data related to metallogeny on a new informational level which in based upon a concept of ore bearing potential of granitoid geochemical types and the ore productivity of intrusions. A general hierarchical metallogenic scheme has been developed as follows: total metallogenic assessment and identification of metallogenic provinces within the region; investigation of endogenic metallogenic zonation and regional ore exploration based upon observed relationships of mineralization with granitoid and magmatic geochemical and lithological zonation; study and characterization of mineralization related to particular magmatic associations; investigations of promising intrusions and potential deposits. Special attention has to be paid to granitoids of heightened alkalinity first of all to subalkaline series with particular interest to porphyry mineralization (Cu, Mo, Au, Ag, Pb, Zn related to granitoids of trachyandesite and latite series). This project was supported by INTAS (Reference number A-92-4) and RFBR (grant 96-05-64941).

### BIOGEOPHYSICAL-CHEMICAL INVESTIGATIONS OF FORGOTTEN DEPOSITS

# A.L. Kovalevskii, M.A. Nefed'ev, A.S. Odegov and G.V Chervyakov

Buryat Geological institute, Siberian Division of the Russian Academy of Sciences, Ulan-Ude, 670047, Russia

Deposits of precious metals have been objects of exploitation and exploitation from ancient times (more than 10,000 years ago). Their "exploration" first began by hand-picking of native metals and massive ore fragments from the surface, in river banks, in small rivers and in temporal water courses along valley bottoms which erode ore bodies. Mining of ancient deposits sometimes continued for thousands of years. Lower horizons of certain of these deposits are exploited to day by shafts to 2-3 km depth. The oldest methods of prospecting for ores were visual, geobotanical and biogeophysical (i.e., dowsing), the latter already known in Egypt 4000 years ago and in China 2000 years ago.

Our investigations were carried out in two forgotten ore regions using biogeophysical (simple and resonance with metallic frames, pendulums and needles), nonbarrier biogeochemical (20 elements) and various geophysical methods. The anomalies derived from different origins, and resulted in complex biogeophysical and chemical fields. These corresponded to the presence of precious metals. polymetallic and fluorite ore bodies in mineralized zones 1-30 m wide. Larger deposits (100-300 x 150-400 m) consist of mineralized stockworks and systems with linear, arc-like and circular geological structures. The Dzhida-Vitim tectonic lineament (active from the Archaen till today) is more 1200 km in length. It is remarkable that numerous old indications of forgotten ore localities were not noted during various geological mapping and prospecting programs at different scales.

The present study began in 1984 and has yielded reveal thousands of local biogeochemical anomalies (35 elements) and hundreds of local biogeophysical anomalies ( Pt, Ag, Au, Pb). Of practical interest are the Pt, Ag, Au, and fluorite anomalies.

Selected examples demonstrating the effective use nontraditional toponimic, ethnic, archaeological, biogeochemical, biogeophysical, prospecting-exploiting and other methods will be presented.

# SCINTILLATION EMISSION SPECTRAL ANALYSIS (SESA) IN GEOCHEMICAL RESEARCH AND ENVIRONMENTAL ASSESSMENT

### A.L. Kovalevskii<sup>1</sup> and S.I. Prokopchuk<sup>2</sup>

 Buryat Geological institute, Siberian Division of the Russian Academy of Sciences, Ulan-Ude, 670047, Russia
Institute of Geochemistry, Siberian Division of the Russian Academy of Sciences, Irkutsk, 670047, Russia

Scintillation emission spectral analysis (SESA) registers the analytical lines from light flashes of different elements. SESA is a sensitive analytical method yielding data on the chemical composition of minerals. It is suitable for analyses of samples of 0.1-1.0 g containing particles (of the studied elements) in sizes of 2-4 mkm, and in certain cases, as small as 0.3-1 mkm. Automated SESA apparatus was used to determine Au, As, Ag, Pt, Ir, Os, Pd, Rh, Ru, Nb, Ta, Ti, Zr and Pb, without chemical preparation of powdered samples. Three selected elements 2-5 particle sizes are determined simultaneously. SESA has been successfully applied for the past 15 years and is now being used for environmental analytical chemistry such as the rapid determination of As and Pb particles in smoke, dust, soil, plants and foods. More than 150,000 various samples, including approximately 20,000 samples of plant ash have been measured (Kovalevskii and Prokopchuk, 1977-1994, in Russian; Kovalevskii and Prokopchuk, 1981-1995 in English). The method is apparently not used western and developing . countries.

Our experience indicates that SESA can be widely applied for large-scale analyses in geochemical, mineralogical and environmental investigations. It may be especially important in detailed mapping of highly polluted localities with irregular distributions of the toxic elements.

### MERCURY-BIOGEOCHEMICAL EXPLORATION

A.L. Kovalevskii and A.V. Lbov

Buryat Geological Institute, Siberian Division of the Russian Academy of Sciences, Ulan-Ude, 670047, Russia

The greater depth sensitivity of the mercurybiogeochemical method is due to the upward migration of gaseous forms of mercury through loose cover with thicknesses of up to 2000 m and the formation of above-ore secondary haloes. Indications of mineralization by mercury-biogeochemical haloes (MBH) is explained by intensive absorption by plants of various migratorial forms of mercury: dissolved (in underground waters), absorbed, saline and particularly, vaporous. Results of our study of some 50,000 samples of plant ash, soil, rock and ore in 38 various deposits and ore occurrences (Kovalevskii, 1983-1996 in Russian; Kovalevksii, 1984-1996 in English) and close to 70,000 samples studied by P.I.Radchenko, yield the following conclusions).

1. In plant ash, the MBH of mercury deposits exceed background (5-50 ppb) by factors of up to 6000 times; in polymetallic, fluorite and antimony deposits, by up to 100-300 times; and in Mo, W, Fe, Mn, Cu, Ag, Au, B, Sr, Ba deposits - by up to 20-80 times. As a rule, the MBH are significantly more intensive and wide than soil-geochemical and primary lithogeochemical haloes of mercury.

2. The MBH usually do not coincide with the nonmercury ore bodies, but are included in wide anomalous biogeochemical halos of other elements. In most cases, the MBH zones are wider and more intensive than the other biogeochemical halo-forming elements.

3. In non-mercury deposits, the MBH often coincide with the biogeochemical haloes of As, Sb, Cd, Zn, Ag, Au, Pb, Tl, Ba, B, F, suggesting their migration with vaporous mercury.

4. MBH sometimes forms wide and long anomalies which coincide with known ore-bearing deep-seated faults.

### HYDROBIOGEOCHEMICAL METHODS FOR EXPLORATION AND ECOLOGICAL INVESTIGATIONS

### A.L. Kovalevskii and A.M. Plyusnin

Buryat Geological Institute, Siberian Division of the Russian Academy of Sciences, Ulan-Ude, 670047, Russia

The hydrobiogeochemical model of element accumulation by plants has practical significance when lower parts of root systems reach the upper horizon of underground waters (Kovalevskii, 1991, in Russian, Kovalevskii, 1993, in English). In arid regions, plant depths reach depths of 20-70 m. The hydrobiogeochemical model may be used in the exploration for most metal and non-metal deposits, including oil and gas, as well as in environmental studies. In migrating waters, elements are transported as dissolved ions controlled to some extent by the telluric currents. This model has significance for mapping natural and anthropogenic pollution by toxic chemical elements in the root-zone of underground waters. Hydrogeochemical sampling should be accompanied by biogeochemical techniques.

Two case studies are presented. The first involved the definition and contouring of hydrobiogeochemical data in ephemeral valleys which drain the  $0.3 \times 0.6$  km Zharchikha Mo-bearing stockwork at in Buryatia. The effective plants used were potato (*Solanium tuberosum*) and wheat (*Triticum vulgare*).

The second study was carried out in the steppe landscapes of the Mukhorshibir region, Buryat Republic. Here, biogeochemical sampling near two drill cores containing high values of Ag, yielded strong anomalies of Ag and Sr in the roots of undersized steppe plants, as well as "statistically trustworthy" anomalies of Cu, Pb, Zn, Co, Ni, Rb.

# NONBARRIER BIOGEOCHEMICAL EXPLORATION

#### A.L. Kovalevskii

Buryat Geological institute, Siberian Division of the Russian Academy of Sciences Ulan-Ude, 670047, Russia

Nonbarrier biogeochemical exploration (NBE) makes use of rare nonbarrier bio-objects of plants to determine ore elements and their indicators (Kovalevskii, 1978-1996, in Russian; Kovalevskii, 1981-1995, in English). Its practical use is dependent on the determination of the quantitative barrier characteristics of the bio-objects of living organisms and availability of tables describing the presence of 24 indicator elements in some 100-500 plants and bio-objects (Kovalevskii, 1991, in Russian; Kovalevskii, 1995, in English).

NBE was applied in the USSR in the 1970's and 1980's at large scales, and more recently in detail at scales to 1:500-1:2,000, and termed nonbarrier biogeochemical prospecting (NBP). The few examples of NBP are concerned with the veined deposits of U, W, Be, CaF<sub>2</sub>, Ag, Au, Pt (Kovalevskii, 1972-1994; Kovalevskii and Kovalevskaja, 1979, 1982, in Russian; Kovalevskii, 1973-1996, in English). NBP may detect and enable contouring of hidden ore bodies under loose cover reaching 30 m in thickness, and is useful in determining hidden ore-bearing structures in areas with plant covers. The most important advantage of NBE and NBP compared to soil-geochemical exploration is their potential to detect deeply covered mineralization.

NBE and NBP should be applied to ecologicalbiogeochemical investigations as provide objective information on natural and anthropogenic pollution by toxic elements. The technologies involved in NBE and NBP could also be applied to biological cleaning of polluted soils, including the special growing of plant-hyperaccumulators (terminology of R.R. Brooks), their ashing and extraction of the pollutant metals using mobile melting equipment.

# NONBARRIER LITHOBIOGEOCHEMICAL EXPLORATION FOR PLATINOIDS

### A.L. Kovalevskii

Buryat Geological Institute, Siberian Division of the Russian Academy of Sciences, Ulan-Ude, 670047, Russia

Studies involving lithobiogeochemical exploration for platinoids began after unexpected discovery in 1987 of biogeochemical anomalies of Pt and Pd in a known silver-bearing field. The platinoid mineralization occurs in a deep tectonic seem (Gil'bery zone) within syenitic rocks (Kovalevskii, 1990, 1993, 1994, in Russian; Kovalevskii, 1994, 1996, in English). The most important geochemical feature in the region of the south taiga (pine forest - *Pinus silvestris*) is a more intensive leaching of Pt and Pd from soils and upper horizons of loose cover compared to Cu, Ag, Au, Pb, Zn, Cd, Hg. Because of this, the platinoids mineralization was not detected by soil sampling at a depth of 0.5-1.5 m. In the plant nutrition horizon, the Pt and Pd uptake is situated in elluvium at a depth of 1.0-2.5 m and more.

The following recommendations should be applied to further research in this field: (1) Only strongly indicative bio-objects which are nonbarrier to platinoids should be used; (2) Cross-profile sampling; (3) Plants should be sampled in profile with 10-20 m steps, and 1-3 m steps when "supposed ore biogeochemical anomalies" (SOBA) of any platinoid is indicated; (4) High-sensitivity analytical methods for Pt, Pd, Ir, Rh, Os; (5) During biogeochemical prospecting, indicator elements such as Cu, Ag, Au, Zn, Cd, Hg, Pb, Sn, As, Sb should first be determined to detect possible Pt-metal hosts; (6) Biogeochemical profiling and mapping should accompany other methods for deep sources (geophysical, biogeophysical, hydrogeochemical, atmogeochemical, etc.); (7) Use trenching in the SOBA after initial lithogeochemical sampling, including heavy concentrates; (8) When choosing areas for lithobiogeochemical exploration for platinoids, their possible occurrence as "cloak" and "pocket" deposits due to secondary biohydrogenic enrichment, should be considered.

### PLATINUM AND PALLADIUM IN THE "PLANT-SOIL-ROCK" SYSTEM

# A.L. Kovalevskii, O.M. Kovalevskaya and E.M. Tat'yankinam

Buryat Geological Institute, Siberian Division of the Russian Academy of Sciences, Ulan-Ude, 670047, Russia

Pt and Pd behavior in the "plant-soil-rock" system were examined in the south taiga of the Buryatia and Irkutsk districts. The Gil'bery deep fault zone is located in the central part of the Dzhida-Vitim seam which is more than 1200 km length. Over 8000 analyses of plant ash and close to 2000 soil and rock samples were carried out.

The platinoids-bearing area is ~30 km in length and 11 km wide, and is part of the precious metal biogeochemical province containing elevated contents of Pt, Pd, Ag, Au in plants.

The following features of Pt and Pd biogeochemistry were noted: (1) The average relative contents of Pt in four nonbarrier bio-objects of pine (Pinus silvestris) vary from 0.91 to 1.05 (cork of living pines, stumps; old, usually rotten wood of stumps; cones from forest litter); (2) The pine nutrition horizon for Pt and Pd occurs in elluvium at depths of 2 to 5 m, but not in soils from which the metals are leached; (3) The plant-rock coefficient - PRC≈1.0 for Pt and Pd, similar to most other measured elements; (4) Hundreds of local nonbarrier biogeochemical anomalies of Pt and Pd exceed background by 10-4,500 times are usually monoelemental. Anomaly widths are 1-20 m, and anomalies of Pt generally do not coincide with those of Pd; (5) Three forms of anomaly thickenings are present: (a) rhythmically alternating anomalies of Pt and Pd totaling hundreds of meters in width; (b) Pd anomalies; (c) one Pt anomaly 20-80 m in width exceeding local background by 10-100 times. (6) The most intensive biogeochemical anomalies of Pt exceeded the local background 100-4,500 times are very local (1-10 m width).

We thank the Jordge Soros International Science Foundation for grants NYQ000 and NYQ300.

# COMPARATIVE CHARACTERIZATION OF HUMIC ACIDS OF DIFFERENT ORIGIN

### **Elena Krechetova**

The Laboratory of Environmental Biogeochemistry, V.I. Vernadsky Institute of Geochemistry and Analytical Chemistry of Russian Academy of Sciences, GSP-1, 117975 Moscow, B-334, Russia

Humic acids (HA) were isolated using method applied for the investigation of soil humic acids in oil shales (11 samples), sapropels (4 samples from Belorussian lakes of different types and 5 samples from different depths of 1 Estonian lake), sea deposits (5 samples from 2 columns of the Black Sea). Then properties of the humic acids of different origin were studied. Elemental composition of humic acids and their derivates from other 3 groups, the degree of hydrolysis, ulutraviolet spectra in visible and infrared regions, content and composition of aminoacids, content of functional groups, molecular-mass distribution by gelchromatograph, termogramms and others, were determined. This allows a comparison with data of soil humic acids.

Data on properties of soil HA were taken from sources in the literature. Humic acids of oil shales, sapropels and sea deposits have common fields on diagrams of atomic ratios (H/C and O/C) and the row characteristics are also proximal. They have similar elemental composition: 51-55% carbon, 5.3-6.3% hydrogen; however, the quantity of nitrogen in the HA of sapropels is greater in the HA of the oil shales . 1.5-3.2%. All HA have negative oxidation rates (-0.2-0.6 -HA of sapropels). HA of all groups contain some of the aminoacids (AA). In the hydrolysis of HA, the yield of aminoacids is 1.2-2.5% for HA of oil shales, and approximately 10-16% for HA of sea deposits and sapropels. Similar contents of AA was found in the soil HA. All HA is polydispersional (3-5 fractions with MW from 2000 to 140,000) and there are no distinctions between HA of different groups.

At the infrared spectra, HA of the oil shales, sea deposits and sapropels are similar and have no adsorption near 1650-1610 cm<sup>-1</sup> (C=C bonds), except for the spectra of non-hydrolized residues of the HA of sea deposits and sapropels. The highest yields of non-hydrolized nitrogen are in the Ha of oil shales (72-86%), as compared to approximately 40% in the other HA. All HA have no maximum absorption at any wavelength in the ultraviolet and visible spectra. They have low optical density (E0.001%465 nm, 1 cm 0.01-0.04 = for HA of oil shales and sapropels, 0.03-0.05 for HA of sea deposits). Thus, we have concluded soil HA have considerable quantities of aromatic structures, HA of sea deposits and sapropels consist mainly of aliphatic structures, and HA of oil shales have largely alicyclic structures.

## GEOCHEMICAL EXPLORATION FOR BURIED GOLD MINERALIZATION, KYZYL KUM DESERT, UZBEKISTAN

### A.A. Kremenetsky, I.A. Kubantsev and A.A. Volokh, IMGRE, 15 Veresaeva Str., Moscow 121357 Russia

Studies were conducted in the Kyzyl Kum gold province, one of the largest in the world. A gold giant, the Muruntau deposit, occurs there along with a dozen smaller economic gold deposits. Post-magmatic hydrothermal mineralization is hosted by a metamorphosed black shale sequence. Endogenous mineral and geochemical zoning of the mineralization is quite distinct. About 80% of the ore-hosting bedrock is blanketed by marine and continental sediments of Mz-Cz age (up to 500 m thick), and thin (10-15 m, less frequently up to 50 m) proluvial and eolian drift. Supergene processes and the soil profile are typical of cold deserts. As established experimentally, a qualitative relationship exists between the endogeneous zonal pattern and its signatures in the supergene profile of the cover, including soils. Hydromorphic and gaseous components of the supergene field differ: gold and associated elements in soil gas mark the axial parts of the permeable neotectonic zones, whereas hydromorphic species constitute a trellis pattern in a vertical cross-section and low-contrast anomalies occur in soils of wider extent relative to those in the soil gas.

Our concept of geochemical exploration involves two sampling media: soils (S) with determination of the mobile species, and soil air (SA); the most informative chemical elements are Au, Ag, As and Hg. Results of 3-stage studies conducted in the Kyzyl Kum during 1993-1996 are discussed: (I) Reconnaissance survey (profiles trending along and across major structures); distance between the sampling points about 1 km; total length of profiles 500 km. Sampling media (S and SA) was conducted in cooperation with Chinese specialists (Wang et al., 1996). Three ore nodes are contoured within the blanketed area: Kokpatas, Muruntau and Daughyz. (II) Within the Daughiz ore node, a medium-scale S-survey (extractable forms) was conducted (average dimensions of the sampling grid: 200x3000 m grid). Several new zones of high potential for non-eroded gold sulphide mineralization were contoured. (III) Within the anomalies, a detailed SA-survey was carried out (200x50 m grid); recommendations were given for drilling targets. This work was supported financially by RFBR, project 95-05-14802.

Wang, X., Cheng, Zh., Liu, D. and Xie, X., 1996. Wide-spaced geochemical mapping in concealed terrains. 30th IGC, Abst., vol. 3, p. 41.

# FORMATION AND RATIONAL UTILIZATION OF CONTEMPORARY EVAPORITE SEDIMENTATION BRINES

### V.V. Kurilenko and M.V. Charykova St. Petersburg State University, Russia

The purpose of this report is to present a theoretical generalization and quantitative characterization of the processes determining evaporite sedimentation in contemporary salt bearing basins (carbonate-, sulphate- and chloride-types) of the littoral-sea and continental origin. Saline-lake reservoir evolution is determined by successive transformations firstly into salt-bearing basins and then into a basins of underground salt-brines with closed conditions of their source, storage and exit. Further hydrogeological evolution of basins initiates lateral movements of salt-brines and activates diagenetic and hypergenetic transformations in "rock-water" systems which result in the substitution of intermediate minerals by more stable ones. At the same time, geochemical and hydrogeochemical zones develop. Under the influence of hydrodynamic factors, substitution zones gradually move in the direction of convective mass transportation. The number of substitution zones is reduced until a monominerallic system is formed. We consider this process as the hydrogeomorfism of saline deposits. A quantitative estimate of the processes determining evaporite sedimentation in salt-bearing basins is based a study of the inner structure and properties of the "rock-water" system using miltivariate statistics. The modeling and prediction of physicochemical polythermal interaction of solid and liquid phases in different hydrochemical systems are determined on the basis of thermodynamic equilibria methods applying Pitzer equations and a quantitative evaluation of hydrogeomorphic process is developed by mathematical mass transportation theory.

The following contemporary basins are used as examples: littoral-sea salt-accumulation of the sulphate (Kara-Bogas-Gol gulf); primary continental salt-accumulation of sulphate (Kutchuk lake) and soda type (Tanatar lake); secondary continental salt-accumulation of chloride-type (Baskunchak lake). Quantitative estimation of their water-salt balance is cited as well as principles of lithological-mineralogical and hydrochemical regional definition of salt deposits and salt brines. The role of surface and underground features forming hydrochemical types of basins is determined and principles of rational exploitation of the deposits are underlined, in particular, the expediency of excluding extensive methods of working the salt deposits.

### ASPECTS OF GEOLEGAL MITIGATION OF ENVIRONMENTAL IMPACT FROM MINING AND ASSOCIATED WASTE IN THE UK

#### Julian Kwolek

Burt Brill & Cardens, Solicitors, Brighton, England

Mining is a type of development in the United Kingdom which can have significant environmental impacts involving visual intrusions, dust (control), noise, blasting, traffic and hydrology. The process of mineral extraction, processing, smelting and refining can never approximate to becoming environmentally neutral, but the areas of impact can be ameliorated sometimes to a high degree by long term monitoring from the initiation of a project to the phases of a restored or remedial mine and/or refinery.

Before an authority will grant a "licence" to proceed, the evaluation and codification of all environmental impacts likely to arise from mining must be incorporated in an independent Environmental Assessment. Such assessments were given legal effect in the UK planning system through the Town and Country Planning (Assessment of Environmental Effects) Regulations 1988 in response to EC Directive 85/337/EEC. The regulations were amended in 1994, and the Schedule I and II Projects are discussed. Aspects of environmental impacts from non ferrous mining and open cast and deep coal mining are outlined involving the three well known principles of (I) Polluter Pays; (ii) Precautionary; and (iii) BATNEEC.

The geolegal implications of environmental impact mitigation are discussed and cover interalia the potential impact of minewater biologically and on other water users with associated civil and criminal liability in English law. The problem of abandoned mines in also addressed in the UK and the legal mitigation that may be required to ameliorate the expensive effects for industry, e.g., Wheal Jane Mine.

This paper also considers the application of English Common law to geolegal mitigation of these impacts and referral is made to the important Cambridge Water Co. case which incorporated aspects of trespass, the rule of Rylands V Fletcher, and nuisance; as well as principles involving smoke, dust, noise and vibration and fumes. Relevant UK and EEC legislation is highlighted including mines and quarries, Environmental Protection Act 1990, the Water Acts, Health & Safety, and the all important Environmental Act 1995 which proposes that authorities should be responsible for investigating land and controlled waters for contamination and tracing the polluter to pay, and that migration pathways of substance should be investigated.

The effects of colliery spoil disposal, tip combustion and the rarer structural failure, together with subsidence, and the effect of PHE's and methane emissions are geolegally reviewed. One of the paper's conclusions is that in the UK increasing environmental legislation and associated liabilities will require ever increasing vigilance and involvement of environmental professionals, including geolawyers, in the mineral industry.

### GRANULOMETRIC FRACTIONATION OF COPPER AND ZINC IN LARGE INDUSTRIAL CITY SOILS

#### **Dmitriv V. Ladonin**

Soil Chemistry Chair, Soil Science Department, Lomonosov Moscow State University, Moscow, Russia

Twenty-one upper layer soil samples were taken from various districts of Moscow, and contents of humus, pH, cation exchange capacity, total content of copper and zinc were determined. These soils have a number of features which distinguish them from natural landscape soils. In general, they have elevated contents of organic carbon, cationic exchange capacities and high pH. Cu and Zn values indicate pollution: average Cu = 310 ppm (range 30 - 1500 ppm); average Zn = 690 ppm (30 - 4000 ppm).

Different grain-size fractions of the solids were prepared by centrifuge following ultra sound disagregation: >50  $\mu$ m, 5-50  $\mu$ m, 1-5  $\mu$ m and <1 $\mu$ m. The humus, Cu and Zn contents (1 n. NHO<sub>3</sub> extraction) were determined in each fraction. Although the finest fraction does not generally exceed 3%, the soils have a rather high cation exchange capacity, related to the elevated organic material contents. Most of the Cu and Zn are present as mineral components in the coarse- to medium-size fractions. The role of humus as a host for Cu increases in the finer fractions, where it exceeds the Zn-content by a factor or more than 10. The formation of humic films on the surface of clay particles can interfere with the adsorption of zinc.

### ENVIRONMENTAL ASPECT OF ASH DISPOSAL FROM AN OIL SHALE COMBUSTION PLANT

### S. Laichter and J. Nachmias

PAMA (Energy Resources Development) Ltd.

The characteristics of Israeli combusted oil shale, the geological environmental and climatological aspects of the disposal area, made the disposal of the ash feasible and safe. According to the EPA Toxicity measurement procedure, the Israeli ash is declared non-toxic.

The ability of water retention by the ash in a pile is constant at a value of 50%. This feature limits the maximum water penetration to 10 cm, even at a 50 mm hourly storm. In addition to the ash characteristics, a layer of marl will cover the ash piles, whose penetration characteristics are  $3\times10^{-8}$  cm/sec. The disposal area is underiain by a 40 m layer of unpermeable chalk.

The area is arid, with a yearly average rainfall of 100 mm. In order to avoid dust during transportation, the roads are sprayed with water.

# METHANE EMISSION MITIGATION FROM ISRAELI LANDFILLS

### Alexander B. Lifshits and Vladimir I. Gurvich

Geopolis, CSC, Shipilovskaya str. 64-1-290, 115682, Moscow, Russia

Landfilling is the main method of domestic solid waste (DSW) disposal in Israel. This technology will dominate in the near future according to the environmental policy of the government. Waste recycling is planned to be developed in parallel with landfilling. About 2.7 million tons of DSW is produced in Israel annually, and its main features are a high content of organic material (OM=65-75%) and high initial humidity (50-55%). OM of DSW in landfills is converted by a microorganism into landfill gas. The main components of landfill gas are methane and carbon dioxide, generally in equal amounts. Based on a theoretical estimate, the gas potential of Israeli DSW is about 200-250 m<sup>3</sup>/t, while the duration of gas potential realization is around 10-20 years. According to our estimate, landfill gas emmision in Israel is about 150-200 mln.m<sup>3</sup>/year (including 53-71 thous, tons of methane).

The free release of landfill gas to the atmosphere leads to at least two unwanted consequences: (1) large scale environmental damage, and (2) loss of bio-energy. Technology which prevents both negative effects is available and involves landfill gas extraction and utilization. This technology is realized by special gas extraction wells which are connected by pipelines to compression and utilization modules. Usually gas utilization schemes are completed by electricity or heat production.

The technology is cost-effective even if only 50% of generated landfill gas is utilized. Thus, taking the average price for one ton of hydrocarbon gas equal to  $\sim$ \$200, the total income from 50% landfill gas extraction and utilization technology implementation in Israel will be  $5-7\times10^6$  US dollars and only half or less of the negative environmental impact will result.

These estimates are based on theoretical data and field observations undertaken in different regions of the world. To check and refine these figures for Israel conditions, a gas geochemical investigation of typical local landfill sites is required. The technology of gas geochemical investigation for landfills was developed by the Geopolis Consulting engineers company and was successfully implemented by the authors and proved to be cost-effective at a number of landfill sites in Russia and Italy.

### GEOCHEMICAL SIGNATURES OF ARCHAEOLOGICAL SITES WITH BLACK EARTH SOILS IN AMAZON REGION

# Marcondes Lima da Costa<sup>1</sup> and Dirse Clara Kern<sup>2</sup>

1 Federal University of Para/Geosciences Center

2 Museu Paraense Emilio Goeldi, Brazil

The dense tropical forest of the Amazon region conceals several small areas (1 to 4 ha) containing black earth soils bearing archaeological lithic artifacts and ceramic fragments. Archaeological investigations in these areas in the last two decades showed that in the past, c.a. 11,200 years, the areas were relatively well occupied by primitive peoples, the paleoindians. Considering these black earths as products of pre-historic human occupation, the authors studied them and their ceramic fragments using techniques of geochemistry investigations, in order to evaluate the human contribution to these soils and to the soil of the Amazon region as whole. For this paper we selected a typical black earth site, Manduquinha, located in the Tropical Rain Forest Reserve of Caxiuana, in the Lower Amazon with support of Scientific Station Ferreira Penna of Museu Paraense Emilio Geoldi. Geochemical and archaeological samples were collected in a grid at 5 m intervals. At each station, the Ao, Al, A2, A3, and B<sub>1</sub> soil horizons were sampled (total of 1433 samples). The sampling stations for archaeological artifacts took in account anomalous areas of phosphate and 14 sites were excavated until the B horizon. The soil samples were sieved to <200 mesh and analyzed for major (P2O5, CaO, MgO, K2O, Fe2O3, SiO<sub>2</sub>, TiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>), trace elements (ionic Zn, Mn, Fe, Ca, Mg, K, Al, H+Al, P, and As, Se, Cd, Co, Cu, Mn, Pb, Zn, U, F, Cl, Ba, Zr, Ga, Y, Nb, Sr, Cr, B, V, Sc) and organic C. The minerals were determined by XRD supported by SEM.

The black earth soils may be classified as Yellow Latosol becoming more humid from north to south. They consist of kaolinite, quartz, goethite, hematite and some anatase. Besides these minerals, the ceramic fragments may contain aluminum phosphates, silica-bearing organic materials (cauixi and cariape) and freshwater shells. When compared to adjoining latosols (the regional background), the black earths show high concentrations of organic matter, Ca<sup>2+</sup>, Mg<sup>2+</sup>, P<sup>5+</sup>, MgO, CaO, P2O5, Ba, Sr, Mn, Zn and Cu. Enrichment of SiO<sub>2</sub>, organic matter, CaO, MgO and K<sub>2</sub>O were typically observed in A horizons. In terms of the chemical composition of B horizons of the black earths and the adjacent latosols are quite similar and suggests that the anthropogenic contribution only reached the A horizon. Geochemical maps show that P, Mg and Ca Ba, Sr, Mn, Zn and Cu discriminate the black earth site. The geochemical Ca-anomaly allow enables the locations of small concealed accumulations of shells. Arsenic. on the other hand, has been practically removed from the black earth. Concentrations of Fe, Ga, Nb, Zr, Sc, V, Hg, Pb, Cr, Cd and Co in the A<sub>1</sub> horizon decrease from north to south and is well-correlated with the actual hydromorphic transformation of these soils. Primitive anthropogenic occupation on latosols of the Amazon region may be identified by the geochemical signature:

Mg-Ca-P-Ba-Sr-Cu-Mn-Zn, with phosphate as the single best indicator.

### THE EFFECT OF URBANIZATION AND INDUSTRY ON CONTENTS OF SOME ELEMENTS IN ALLUVIAL SEDIMENTS IN POLAND

#### Józef Lis

Polish Geological Institute, Warsaw, Poland

The concentration of such elements as Ag, As, Cd, Co, Cr, Cu, Hg, Cu, Ni, Pb and Zn in alluvial deposits in Poland was studied. Data collected in the data base for the "Geochemical Atlas of Poland 1:2,500,000" (10,960 samples) was used in the study. The geochemical background at the level of P=99% median as well as the population of the towns where the samples were collected, were used for analysis. Concentration coefficients were calculated by dividing median values of element contents for samples collected from urbanised areas by median values of their content in non-urbanised area. Samples collected from village areas show concentration coefficients for the majority of elements varying from 1.2 to 1.5. In urban areas, the coefficient increases to up to 3-5 for towns with populations in the range of <10,000 - 99,900 (Cu, Cr, Hg) and from 3 to 6 for Pb and Zn. For towns with 100,000 - 1,700,000 inhabitants, the increase in the coefficient is less accentuated and shows fluctuations. The urban group of >1,700,000 inhabitants represented by the Upper Silesian area (where Pb-Zn and hard coal deposits are mined) is characterized with especially high values of Pb, Zn and Cd concentration coefficients.

The above problem is illustrated on maps showing areal differentiations of metal contents in alluvial deposits occurring in urban areas compared to the average content found in the alluvial deposits collected from non-urbanised areas. Two population groups are noted: metal contents within the geochemical background (marked on maps by small circles), and abnormally high metal contents (large circles). For most elements, sampling points with anomalous concentrations are located within areas of large cities such as Warsaw, Łodź, Gdańsk, Wrocław and Bydgoszcz, and within cities in Upper Silesia. For the smaller towns, anomalous points are observed in Central and Western Poland as well as in the Lower Silesia region. The implemented investigation has shown that studies of metal contents in alluvial sediments can be a precise tool applicable for evaluation and monitoring of the natural environment.

# TOTAL AND PARTIAL CONTENTS OF SOME ELEMENTS IN SOILS OF THE BORDERLAND OF POLAND AND LITHUANIA

# Józef Lis<sup>1</sup>, Anna Pasieczna<sup>1</sup> and Ričardas Taraškevičius<sup>2</sup> 1 Polish Geological Institute, Warsaw, Poland 2 Institute of Geology, Vilnius, Lithuania

The aim of this study was a determination of the chemistry of surficial environments (soils and water-deposited sediments) and an estimation of their pollution rate due to anthropopression. A comparison between geochemical and cartographic images based on different methods of chemical sample preparation and analytical techniques was a second aim. Sampling density was 1/25 km<sup>2</sup>, over an area of some 10,000 km<sup>2</sup> (borderland of Poland and Lithuania). Simultaneous analytical studies were made in the laboratory of the Polish Geological Institute in Warsaw (partial contents of Ag. As, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Mg, Mn, Ni, P, Pb, S, Sr, Ti, V and Zn (ICP-AES) and in the laboratory of Geological Institute in Vilnius, Lithuania (total content of Ag, Al, B, Ba, Co, Cr, Cu, Li, La, Mn, Mo, Nb, Ni, P, Pb, Sn, Ti, V, Y, Yb, Zn and Zr (DC AES), and As, Rb, Sr, Th, U (XRF). All samples were examined by both techniques. The ratio of Linear correlation coefficients between total and partially extracted contents of elements indicate distinct, largely high correlation values. In soil samples, the highest correlation coefficients (>0.70) were for Co, Cr, Cu, Mn, Ni, Sr, V, Zn. In water-deposited sediments, high coefficients (R>0.70) were found for Co, Cu, Mn, Ni, P, Pb, Sr and V. Low coefficients for elements such as barium and titanium suggest that they are hosted in primary minerals (Ba possibly in feldspar) or in heavy minerals (Ti in titanite or ilmenite).

Despite distinct differences between total and extractable contents for certain elements, the cartographic images their distribution are almost analogous. Particularly good similarity is observed for elements such as Co, Cr, Cu, Ni, P, Ti, V and Zn.

### CHEMISTRY OF INTERSTITIAL WATER FROM THE EOCENE CHALK OF AVDAT AQUIFER, NORTH-WESTERN NEGEV, ISRAEL

#### Yakov Livshitz

Blaustein Institute for Desert Research, and Department of Geology and Mineralogy, Ben-Gurion University of the Negev, Beer Sheva 84105, Israel

The groundwater of the Avdat aquifer (fractured Eocene chalks) in the northwestern Negev are brackish (TDS within the range of 600-10,000 mg/l). It was suggested that the main source of groundwater salinity of Avdat Aquifer is the ancient residual water from the chalk's porous medium. To examine this hypothesis, the interstitial waters of porous medium in the Eocene chalk were analyzed for chemical composition applying two methods of extraction:

- The centrifuge technique: centrifugation with an immiscible displacement liquid (1,2-Trichlorortifluroethane) at a speed of 15,000 rpm (pressure of  $1.5*10^8$  Pa) and at a temperature of  $4^{\circ}$ C for 2 hours.

- Soil water extraction method (1.4 dilution); the chalk was powdered (up to the grain size of 0.5-2 mm); 50 gr of powdered chalk were then added to 200 ml of distilled water; the mixture was then shaken for 4 hours and settled for 4 days; the chemical composition and the concentration of dissolved ions of the interstitial water were measured using the obtained solution and initial chalk moisture.

Results obtained from these extraction methods revealed the following:

1. Similar salinity, close to sea water, (TDS 30-34 g/l) was obtained by both extraction techniques.

2. Large differences, however, were found in the chemical composition of the interstitial water extracted by the different techniques.

3. The ratio of Br/Cl in the water obtained by both extraction techniques and also in groundwater of the Avdat aquifer were found to be similar to that of sea water  $(1.4 \ 10^{-3} - 1.6 \ 10^{-3})$ .

4. The centrifuge extracted water, Avdat aquifer groundwater and sea water have similar ratios of the major ions (Na/Cl: 0.84 - 0.85; Mg/Cl: 0.18 - 0.20).

5. Water extracted by 1:4 soil water extraction method is different from Avdat aquifer, sea water and centrifuge extracted water (except the ratio of Br/Cl:  $1.6 \times 10^{-3}$ , ratios of the major ions are different-Na/Cl: 1.36; Mg/Cl: 0.09).

6. The centrifuge technique gives better results for the extraction of interstitial water from chalk than the soil water extraction method. This technique allows the extraction of the interstitial water without a change in its chemical composition.

The comparison of chemical composition of chalk interstitial water with local groundwater and sea water confirms the hypothesis that the main source of groundwater salinity in the Avdat aquifer is residual ancient sea water in the chalk porous medium.

## HIGH DENSITY GEOCHEMICAL MAPPING OF SOILS AND STREAM SEDIMENTS IN SOUTH AFRICA

### **M. Lombard, D. De Bruin and J.H. Elsenbroek** Council for Geoscience, Pretoria, South Africa.

A high density regional geochemical mapping programme has been in progress in South Africa since 1973, formerly by the South Aftrican Geological Survey and continued by the Council for Geoscience. A total area of 280,000 square kilometres have been covered to date at a sampling density of one sample per square kilometre. This represents coverage of 23% of the surface area of South Africa. Samples from first order streams are preferentially collected but representative soil samples are taken if these are not present. A helicopter is used to collect samples and a global positioning system is used to accurately record sample positions. The minus 75 micron fraction of samples is collected by dry sieving and analysed for 24 elements (TiO<sub>2</sub>, MnO, Fe<sub>2</sub>O<sub>3</sub>, Sc, V, Cr, Co, Ni, Cu, Zn, As, Rb, Sr, Y, Zr, Nb, Mo, Sn, Sb, Ba, W, Pb, Th, U) by simultaneous XRF on pressed powder pellets. Samples from selected areas have also been analysed for additional elements using other analytical techniques. The results are processed using a Geographical Information System (GIS).

The XRF results show an excellent correlation between soil chemistry and underlying geological formations, and geological units are clearly demarcated. For example, results from the areas surrounding the western side of the Bushveld Complex, South Africa, show clear chemical distinctions between the granites (e.g., high rubidium, low nickel) and the mafic units (e.g., high chromium and nickel), while dolomites from the Malmani Subgroup (Transvaal Supergroup) and the Ghaap Plateau Formation (Griekwaland West Sequence), are characterised by high manganese values. One of the main uses of the high density geochemical mapping data set is the ability to determine background values of elements in soils over different lithological units and the identification of anomalous values relative to these. The database can be used in exploration and mining, the chemical characterisation of different geological units, as well as applications in environmental studies and agricultural fields.

Results of geochemical mapping of the Bushveld Complex, South Africa, show enhanced concentrations of platinum group elements and gold, some of which can be correlated with mining activities. A distinct anomaly of platinum and palladium has been traced over a distance of 100 kilometres and appears to be related to a stratiform platiniferous reef stratigraphically higher up in the complex than the known platinum mineralisation.

Geochemical mapping in the vicinity of the towns of Rustenburg and Springbok, South Africa, revealed large copper anomalies around areas of mining and ore processing, indicating anthropogenic contamination. Using a combination of geochemical, geological and veterinary information, soil geochemistry has also been used to explain livestock illness related to rock and soil qualities. As a result of these applications in a variety of fields, the Council for Geoscience of South Africa will continue with the present high density geochemical mapping programme in the foreseeable future.

### AN APPROACH TO THE ENVIRONMENTAL IMPACT FROM "LA SOTERRANA" MERCURY MINE (ASTURIAS, SPAIN)

# Jorge Loredo, Carlos Fernandez-Albarran and Jesus Garcia-Iglesias

Escuela de Minas, Independencia 13, 33004 Oviedo, Espana

Mercury mining was of importance in Asturias during the 60's and early 70's, representing at that time approximately 5% of the world production of mercury. In the Munon-Cimero area about 30 km southern Oviedo, the "La Soterrana" mine was intermittently exploited by underground works from the nineteen century until 1972. It is located on the southern slope of Campusas Mountain, in an sparsely populated area where land is predominantly used for grazing of cattle. A pyrometallurgic plant and tailing piles are also located in the area of the old mining works.

The presence of cinnabar with realgar and orpiment, and other heavy metal-bearing minerals in the ore deposits and those in the tailing piles pose a potential for environmental degradation of soils and superficial and underground waters in the area.

A preliminary soil geochemistry survey was carried out in an area directly affected by old mining and metallurgical works, and downward into the valley. This survey forms the basis for a semiquantitative assessment of soil contamination in the area of study. Surface soil samples (0-20 cm) were taken on a regular grid pattern over the site, and chemical analysis of samples were made for 32 elements by Flameless Atomic Absorption and Inductively Coupled Plasma Spectrometry.

Soils around the old mining and metallurgical works are strongly enriched in mercury and arsenic and occasionally in other metals such as Cu, Zn, etc. A significantly high positive correlation between mercury and arsenic is observed. Geochemical anomalies are predominantly associated with the site of tailing disposals, and mercury and arsenic again show a strong spatial association. Based on the geochemical survey carried out to date at the site of old mining and metallurgical works of "La Soterrana", it is evident that the presence of anthropogenic mercury and arsenic have a strong impact in the area, reflected by elevated concentrations of Hg and As in the soils.

### HEAVY METAL CONTAMINATION OF THE MINSK, BOBRUYSK AND MOZYR ENVIRONMENT

#### Valentine Lukashev

Institute of Geological Sciences of the Belarus Academy of Sciences, Minsk, Belarus

This report summarizes results of the first geochemical study of the urban environment of Minsk, Bobruysk and Mozyr. The investigation included geochemical analysis of the main constituents of the environment - soils, surface water, groundwater, bottom sediments of river and reservoirs, snow, vegetation cover, etc.

Due to extensive economic development, Minsk became a city with a very high concentration of industrial works, heavy traffic, and a high density of settlement zones. During the post-war years, the population of the city has increased 6 fold, and the industrial output has increased more than 100 times. Ecological problems have recently become aggravated in the city.

Metals from the surface soil cover are mostly dangerous for man, as it is source of about 50-60% of the dust in the near-earth atmospheric layer. Samples were taken from the upper 10 cm layer (sampling density 1-10 km<sup>2</sup>. The contents of 40 elements were determined by emission spectroscopy. Based on the data obtained, a series of mono- and polyelemental maps showing the distribution of metals in the city soils was compiled. Four zones with a highly polluted soil cover were distinguished within the city territory: (1) Pb, Zn, Cu; (2) W, Zn, Pb, Cu; (3) Hg, Zn, Cu, Mn, Cr, Ni; (4) Pb, Zn, Ag, Cu, Cr, V.

In industrial regions, the mineral content of snow waters usually increases (mainly due to sulphides and chlorides), together with their content of solid suspended particles, pH values, zinc, lead, copper, chromium, nickel, vanadium, manganese and other elements which are accumulated in snow. Metals are transported dozens of kilometers from the city and fall out according to the aerosol particle size. The following succession is formed in lichens: Fe>Cr(Mn, Cd, Ba, Cu) > (Ni, Zn, Al) > (Sn, Mo) > (Ag, V) > Hg > Pb.

The most highly polluted river in Belarus is the Svisloch, downstream from Minsk. Its waters and bottom sediments contain high concentrations of Cr, Ni, Zn, Cu, Ag, etc. There are several zones with high pollution soils in Bobruysk, but in general, the level of contamination is lower. The content of most heavy metals in soils of Mozyr is close to the background values, but radioactivity contamination after Chermobyl is higher.

We have estimated technogenic pollution of the soil cover in Minsk according to the scale of ecological danger based on calculations of summary indices of soil pollution by metals (Saet et al., 1982, 1986). An attempt was made to correlate heavy metal contamination with cancer and pulmonary diseases rates in Bobruysk.

### ARTIFICIAL SORBENTS FOR PROSPECTING DEEP BURIED DEPOSITS

### Valentine Lukashev

Institute of Geological Sciences of the Belarus Academy of Sciences, Minsk, Belarus

The necessity to understand more about the rules of migration of chemical elements becomes of more importance when prospecting for ore deposits buried under thick overburden. It is now established that there are very weak secondary dispersion haloes with low element contents (0.1-1.0 ppm) around many types of ore deposits even above clay-carbonate overburden of 100-600 m or more.

Although the mechanism of the formation of secondary dispersion halos in overburden are not completely known, the following may by suggested as contributing factors: (1) deep weathering which slowly, but continuously, destroys ore bodies and bedrock even in cases where they are deeply buried; (2) microbiological processes in pore solution; (3) movement of metals by capillary action through both rocks and various types of overburden, such as clays and permafrost (such processes may account for element migration at the rate of 2-4 cm/day); (4) electrochemical processes and (5) gas migration. The relative importance and contribution of these various factors are different for various types of the deposits. For example, electrochemical migration may be a key factor for some sulphide deposits.

Various highly sensitive techniques are now available to detect secondary dispersion halos which are characterized by low element concentrations.

For some years we have been developing artificial sorbents for prospecting purposes (Lukashev and Lukashev, 1978). We successfully combined hydrogeochemical and lithogeochemical methods by the use of absorbing material. The method allows the fixing of the mobile forms of many elements by resins of cation-exchangers and anionexchangers, in order to estimate their contents more confidently. It also permits the choice of sorbents with highly selective properties. Synthetic ion-exchange resins, as well as other sorbents were used (cellulose polyphosphate or cellulose ethylendiamine tetraacetate borate). These sorbents were submerged in streams, buried in the ground, or left for a period of time in soil at depth of about 1m at stations 50-200 m apart (in regions where prospecting was being carried out). Several case histories illustrate some of the different environments where the use of artificial sorbents was compared with other prospecting methods: gold prospecting in the Alpine bald zone of Sajansky Mountains; Be-RE and iron ore prospecting in Belarus; Pb-Zn-Cu prospecting in Caucasus, oil prospecting in the Baltic region, etc.

Using artificial sorbents, the distribution of Be, Ti, Cr, Mn, Ni, Cu, Zn, Y, Yb, Pb was studied in bottom sediments and waters around gas seepages on the Baltic Sea floor. Differences in the contents of Ni, Cr, Mn, Ti were detected, which may be related to deep thermal sources and presence of oil.

### RADARSAT DATA APPLICATIONS: RADAR BACKSCATTER OF GRANITIC FACIES, ZAER PLUTON, MOROCCO

# Ahmed Mahmood, Surendra Parashar and Satish Srivastava

# RADARSAT Program, Canadian Space Agency, Saint-Hubert, Quebec, Canada J3Y 8Y9

Radar backscatter in active microwave remote sensing is influenced by such physical properties of the target as its surface roughness, shape and moisture contents and varies with the wavelength and the angle of incident energy. Canada's RADARSAT-1 is the first spaceborne radar which provides flexibility of incidence angle and ground resolution. Its imaging device is a C-band synthetic aperture radar (SAR) which is particularly well suited for interpreting microroughness and soil conditions in areas of subdued macrotopography.

This articles describes a test case in which quantitative RADARSAT backscatter data is related to spatial variations in a granitic pluton to demonstrate the feasibility of the data for mapping facies of different grain size and degree of geochemical alterations. In the study area as elsewhere in the region, alteration zones are prospected for mineralizations associated with acidic intrusions. The Zaer pluton, one of several in the Central Hercynian Massif of Morocco, is formed of medium- to coarse-grained biotite granodiorites and two-mica monzogranites, which are highly weathered such that the rock surface is mostly covered with bare granitic soils of comparable mineralogical composition. The granitic soils of biotite granodiorites are richer in micaceous and clayey minerals than the soils covering the two-mica monzogranites. The radar backscatter response is attributed to grain size and volumetric moisture of these granitic facies. The results of the study are based on radar backscatter values derived from an October scene taken during an afternoon pass, using RADARSAT Standard 3 imaging beam with roughly 25 metre ground resolution and an incidence angle range of 30° to 37°. The backscatter values are plotted with textural, mineralogical and geochemical variables to underline changes within and between the facies. It is concluded that RADARSAT imagery can be used for rapid facies mapping and geochemical interpretations by highlighting grain size and moisture differences of weathered rocks.

### COMBINED EFFECT OF NATURAL GEOLOGICAL AND TECHNOGENIC RADIATION FACTORS ON THE ENVIRONMENT: EXAMPLE OF THE IZHORA PLATEAU, LENINGRAD REGION

# V.A. Maksimovskiy, M.G. Kharlamov and A.P. Karpinsky

All-Russian Geological Research Institute (VSEGEI), St. Petersburg, Russia

Different quantitative combinations of local concentrations of radioactive elements, and areas where geochemically suitable geological formations are present, can give rise to natural radioecologically unfavourable settings (i.e., areas of higher levels of radiation). In these areas, the unfavourable radioecological setting can be enhanced due to human activity during prospecting and exploitation of mineral deposits, geochemical processing of uranium ores, mass application of phosphate and potash fertilizers on farm fields, pollution of soil and air by radioactive elements from combustion of coals, peat, fuel oil, and combustible shales.

As the development of atomic industry progresses, nuclear reactors and nuclear explosions give rise to new artificial radioactive elements. Relatively long-living radioisotopes <sup>137</sup>Cs, <sup>90</sup>Sr, <sup>60</sup>Co, <sup>239</sup>Pu as well as tritium and <sup>14</sup>C are known to be radioecologically significant. These make a major contribution to the radiaoecological situation in the event of pollution of isolated territories.

The radioecological situation is particularly serious in cases of superposition of technogenic pollution on regions with unfavourable radioecological settings. This situation is observed in the Smolensk and Kaluga regions, the Russian Federation, and in the southwest of Leningrad Regions (Izhora Plateau). A real danger of the effect of synergism can appear under the combined action of natural and technogenic radionuclides as well as other adverse factors.

Abundant uranium anomalies and ore manifestations are known within the area of the Chernobyl trace. They are confined to the horizon of Lower Ordovician diktyoneme shales enriched in phosphorus and uranium. Near and within the uranium ore manifestations, radon anomalies are recorded both in water sources and in soil air.

Investigations within the limits of the Chernobyl trace on the Izhora Plateau show that <sup>137</sup>Cs begins migrating with a wider distribution than the trace recorded aerogamma spectrometric (AGS) survey. Studies on the distribution of the radon content revealed anomalies exceeding limited permissible levels not only in the soil air but in living accommodation and industrial premises as well. AGS surveys also record anomalies of radioactive potassium apparently confined to agricultural lands.

Based on these data, it is necessary to establish complex radiation monitoring in the region.

### LITHOGEOCHEMICAL MAP OF SLOVAKIA (1:500,000)

## Karol Marsina and Jaroslav Lexa

Geological Survey of Slovak Republic, Mlynska dolina 1, 817 04 Bratislava, Slovakia

A lithogeochemical map of Slovakia at a scale 1:500,000 was compiled within the framework of the "Geochemical Atlas of the Slovak Republic". A total of 64 main lithofacies were first defined together with their geochemical characteristics (3,839 samples were analyzed for major and 26 trace elements). They are placed in seven main groups reflecting the geological structure of Slovakia: 1. granitoids; 2. metamorphites; 3. Paleozoic sediments and volcanics; 4. Mesozoic sediments; 5. Paleogene sediments; 6. Neogene sediments; 7. Neogene volcanic and intrusive rocks. The raw data, a statistical summary, and additional data (author, year, regional and local geologic setting, x and y coordinates) for all samples are available in the lithogeochemical database in dbf format.

The lithogeochemical map has a close relation to the Geological Map at the same scale (Biely et al., 1992). Simple lithotypes are distinguished on the map by numeric indexes and colour. Associated lithotypes are shown by striped raster with different colours according to the proportion of the individual mineral/chemical components (main colour differentiation: carbonates - blue; mafic silicates - green; feldspars and micas - red; silica - yellow). This map provides a basic geochemical information on lithology of Slovakia for further regional geochemical and environmental mapping since it distinguishes rocks according to their suitability for the environment.

Biely, A. (ed.) and others, 1992. Geological Map of the Slovak Republic (1:500,000), Geological Survey of the Slovak Republic.

Marsina, K. and others, 1995. Geochemical Atlas of the Slovak republic - "Rocks". Geological Survey of the Slovak Republic, Sci. Rep., 115 p. (in Slovakian).

### **RADIOGEOCHEMICAL MAPPING IN LITHUANIA**

J. Mazeika and R. Petrosius Institute of Geology, Vilnius, Lithuania

Studies on radiogeochemical mapping covering several areas in Lithuania have been started in recent years by research institutions under the national state research program "Ignalina Nuclear Power Plant and the Environment" and under the International Lithuanian and Polish Regional Program of Ecogeological Research - "The Belt of Yotvings - a Fragment of Green Lungs of Europe". The first aim of the research was to evaluate the radioecological setting in the Ignalina NPP region in both hydro- and terrestrial ecosystems by means of radiogeochemical mapping. In 1995, the experiment of radiogeochemical mapping (sampling method with gamma-ray spectrometry) of bottom sediments from a cooling basin at a scale of 1:50,000, and in 1996 the experiment of soil mapping at 1:100,000, were carried out. There were four stages of investigation (lake area with 500 m grid; area near the INPP with 1 km

grid; coastal zone; monitoring areas) using different methodologies. Radionuclides concentration levels in investigated material do not exceed the control level and may be treated only as a traced admixture, with the exception of small local areas directly connected with INPP.

The second aim of research was to evaluate the cesium pollution of near-border (with Poland) districts of Lithuania after the Chernobyl NPP accident. According to the airborne gamma-ray survey of 1988 in Lithuania, the largest deposition of cesium-137 was observed in the south-eastern of the country (up to 15 kBa/m<sup>2</sup>). The selected near-border area showed the maximum deposition of cesium. The radiogeochemical mapping (1994) made use of a hand-held type gamma-ray spectrometer (Polish Geological Institute). Measurements were carried out along 1000 m N-S profiles spaced 7.5' (~ 5-7 km). Parallel soil sampling for routine gamma ray spectrometry using CsJ(Tl) scintillation and Ge(Li) semi-conductor detectors (Lithuanian part of area) was made at a scale of 1:500,000. Surfer and SPSS software were applied in preparation of the maps and for compilation and statistical calculations (uranium-238, thorium-232, potassium-40 and cesium-137+134). The Lithuanian area had low pollution levels by radioisotopes emitted during the Chernobyl NPP accident. Mean values of cesium-137 depositions from the nuclear weapons tests in this region are estimated as 0.9 kBq/m<sup>2</sup> in 1983. For comparison, a mean cesium deposition for the studied area is  $0.98 \text{ kBq/m}^2$  with a maximum value over 3.7 kBq/m<sup>2</sup>. These data indicate that from a radioecological point of view, the region is quite clear. without higher pollution of cesium.

### EVALUATION OF TERRA ROSSA GEOCHEMICAL BASELINES FROM CROATIAN KARST REGIONS

Slobodan Miko<sup>1</sup>, Goran Durn<sup>2</sup> and Esad Prohic<sup>3</sup>

1 Institute of Geology, Sachsova 2, Zagreb 10000, Croatia,

2 Faculty of Mining-Geology & Petroleum Engineering, University of Zagreb,

3 Faculty of Natural Sciences, Geological Department, University of Zagreb, Croatia

In karst regions of Croatia, regolith is the only favorable medium for geochemical mapping. Mediterranean climate and good drainage due to hard, fissured, permeable limestones and dolomites resulted in a frequent and spacious distribution of terra rossa (FAO-luvisols and cambisols) - a polygenetic type of soil. Samples of terra rossa from coastal and inland Croatian dinaric karst terrains were collected during the initial studies for the Geochemical Map of Croatia at a density of 1 site/25 km<sup>2</sup>. A total of 103 terra rossa samples taken from depths of 5-25 cm together with 29 samples from deeper profiles (down to 850 cm) were analyzed for total Al, Ba, Ca, Co, Cr, Cu, Fe, Ga, La, Mg, Mn, Ni, Pb, Na, Sr, Ti, V and Zn concentrations. A stoichiometric approach was applied by modeling of terra rossa baselines on the basis of linear regressions of metals on Al, and the calculation of enrichment factors on the basis of soil standards.

A noticeable enrichment of Pb was found in surface samples compared to the terra rossa deeper in the soil profile. Using these baseline relationships, an attempt is made to partition terra rossa metal concentrations into natural and anthropogenic fractions. Also the models from both polluted and less polluted (uninhabited) karst terrains improve the comparability of element contents through correction of variable background concentrations. Comparison of elemental concentrations revealed that due to contributions of bauxite debris, 'a number studied samples is enriched in Cr and Ni (also with variable amounts of boehmite). The corrections will serve to reduce data variability and to increase the detection of spatial and temporal differences presented on the geochemical maps.

# GEOCHEMISTRY AND MINERALOGY OF THE ZAOSTROVSK BAUXITE-PHOSPHORITE DEPOSIT IN THE MIDDLE TIMAN (RUSSIA)

#### Leonid E. Mordberg

All-Russia Research Geological Institute (VSEGEI), St. Petersburg, Russia

A bauxite-phosphorite deposit occurs within Timan folded area. The underlying rock is Riphean dolomite with thin rare layers of francolite and dispersed pyrite; the overlying rock is Upper Devonian quartz sandstone. The total weathering profile reaches 27 m. Samples from drill cores were analyzed for mineral (XRD) and major and trace element (XRF) compositions. The rock-forming minerals of the weathering profile are francolite, crandallite, svanbergite, diaspore and berthierine. Sericite is also present in small amounts. Goethite and kaolinite appear locally. The P2O5 content varies from 0.6 to 19% and reaches 42% at the base of the deposit. There is no distinct boundary between bauxite and phosphate zones. Crandallite and svanbergite often appear together with diaspore and the P2O5 content in the bauxite zone increases up to 10%. The Al<sub>2</sub>O<sub>3</sub> content increases upward in section from 7-13% to 39-56%. The Sr content varies from 0.02 to 5.2%.

Factor (R-mode principal components) analysis and other statistical methods have been used for determination of mineral and element associations and processes of mineral formation. The results of geochemical data processing agree with mineralogical data. The data processing shows that crandallite does not contain significant Sr concentration, and svanbergite does not contain a Ca admixture. Ba replaces Sr in the svanbergite lattice. Pb, Th, Y and Zr are closely associated with diaspore, whereas Cr. V and Ti are associated with berthierine. Ni and Co are distributed between berthierine and the remains of pyrite, and occur in higher amounts near the footwall. Unusually high Rb contents (for bauxite profiles) relate to epigenetic sericite formation; Rb strongly correlates with  $K_2O$  (r = +0.9). The distribution of uranium is not dependent on the distribution of the rock-forming minerals or elements. Francolite was inherited from the underlying rock during dissolution of dolomite and accumulated in the lowest part of the weathering profile. Diaspore, crandallite, svanbergite and berthierine were formed during dolomite leaching and weathering of phosphate and dispersed alumosilicates. Mg, Ca and Sr were derived from dolomite, and the source of S could be oxidized pyrite. Reducing conditions were responsible for berthierine formation. Kaolinization of the upper part of the weathering profile is related to late diagenesis. An epigenetic supply of alkali elements (K and Rb) was responsible for sericite formation.

# CARBONACEOUS SUBSTANCES IN SELECTED MINERAL DEPOSITS: IMPLICATIONS FOR GEOCHEMICAL EXPLORATION

### David J. Mossman

Department of Physics, Engineering & Geoscience, Mount Allison University, Sackville, New Brunswick, Canada E0A 3C0

Carbonaceous substances (CS) are intimately linked either directly and/or indirectly to the genesis of many types of mineral deposits. Examples include metal accumulations in living organisms, coals, black shales, crude oils and solid bitumens. CS interact with metals by virtue of their inherent reducing, acidic and chelating characteristics. At Elliot Lake, Canada, and South Africa's Witwatersrand, CS including kerogen and derivative bitumen (as petrographically defined) are closely related to the genesis of uranium and gold mineralization. In Paleoproterozoic sediments of the Republic of Gabon, algal accumulations generated vast volumes of petroleum following burial. Subsequently, derivative solid bitumen helped localize world class uranium deposits.

Occurrences of solid bitumen have long been important in petroleum exploration, and specific metal ratios (e.g., V/V+Ni and Mo/Mo+Cr) in viscous crudes and solid bitumen have been successfully applied in oil-source rock correlation studies. Typically, there is an increase in concentration of organometallic moities and complexes evident from crude oil to solid bitumen. A great many different metals are reported in crude oil and solid bitumen. Consequently bitumens are potentially very important in the search for, and evaluation of, diverse mineral deposits. Where linked to the hydrothermal history of organic matter in sedimentary rocks, bitumen and organic acids generated during diagenesis help prepare ground for mineral deposition and, like Pb-Zn-rich oil field brines, are genetically linked to mineral deposits. Solid bitumen may also host minerals, including clays, carbonates and sulfides, which were carried, at least in part, in a CO<sub>2</sub>-rich aqueous phase that accompanied bitumen during its emplacement. The mineral associated constituents and organically bound metals in solid bitumens provide important clues in exploration geochemistry.

### ORGANO-MINERAL SPECIES OF METALS AND THEIR MIGRATION IN HUMID LANDSCAPES

### G.V. Motuzova,

Moscow State University, Department of Soil Science, Moscow, Russia

Humid landscapes of the Moscow, Tver and Murmansk districts of Russia were investigated in the field and laboratory experiments were performed. The composition of the surface material and lysimitric waters and soil solutions was examined to reveal the patterns of metal migration. The species of Fe, Zn, Hg in the solutions were studied by the different methods of analytical fractionation. Contents of Fe in the waters and soil solutions changes from 0.04 to 0.40 ppm. The concentration of fulvic acids (FA) is 10-120 ppm and the pH ranges from 6.7 to 7.6. The Fe-content is lower at a higher pH, and is higher with an increased concentration of FA. If FA are absent in a solution with pH 6.5-7.5, the total content of Fe in solution is not dependant on the pH. A FA concentration of 10 ppm increases the Fe concentration in solution 10 times, and 100 ppm of FA increases the Fe concentration by 100 times. The strongest influence of FA on Fe mobility takes place at pH 5-6.

The relative content of the Fe(OH)<sub>2</sub>FA species is 15-60%. The concentration of Zn in the soil solution and lysimetric waters is 0.10-0.55 ppm. Colloidal species make up almost 50%. Negative charged ions of Zn predominate in the soil solutions, including organo-mineral species of Zn. The total Hg-content in the investigated solutions ranges from 0.04 ppm to 0.10 ppm. Organic species of Hg dominate in the percolated waters and soil solution, and form 75-100% of the total Hg content. The organic carbon content in percolates changes from 20 to 43 ppm at the pH = 5.5-6.5 and from 28 to 60 ppm at pH is 4.5-5.5. Most of the organic carbon in the solution is present in the FA fraction and in non-specific organic compounds. The relative content of colloidal compounds is 1-10%. The contents of Hg and organic carbon in waters and soil solutions are closely connected. The prevalence of organo-mineral species of metals in waters and soil solutions results in a high level of metal migration in the humid landscapes.

# THE GEOCHEMISTRY OF MACRO-AND MICROELEMENTS IN THE AGRICULTURAL LANDSCAPES OF SOUTH VIETNAM

G.V. Motuzova<sup>1</sup> and Ngo Thi Hong Van<sup>2</sup>

1 Moscow State University, Department of Soil Science, Moscow, Russia

2 Hanoi University, Geological Department, Hanoi, Viet Nam

The contents of macro- and microelements in rocks, their weathering products, soils and plants of South Viet Nam were determined. The samples represent the agricultural landscapes of five districts in South Viet Nam (Hills of the East Nambo, 100-300 m above sea-level, and plateau of Pleiku, 500-600 m above sea-level). The investigated area has contained the Hevea Brasilian plantation for many years. Basalt and andesite-basalt of the Q2-Q4 periods are the underlying rock units. The formation of ferralitic earth results in the eluviation of K, Mg, Si, and especially of Ca and Na from the rocks. The degree of Al and Fe eluviation from the earth crust is rather low. The present migration processes reduce the Fe content in the earth crust. The clay minerals within this crust and ferralitic soils consist of kaolinite and goethite.

The total contents of microelements in basalt is relatively high, above that of the clark values (Mn 1046-3303 ppm, Zn 77-126 ppm, Cu 162-169 ppm), especially in the landscapes of the East Nambo. There is the relative accumulation of Ni, Cr, Ti and removal of Zn, Cu, Mn, Pb in the ferralitic earth crust. The state of microelements in ferralitic soils of South Viet Nam depends on the nature of the soil-forming processes.

The highest Zn (128 ppm) and Mn (3200 ppm) values occur in the soils of the Dong Nay district (East Nambo) (Zn-Mn geochemical province). Microelement contents in the soils of plateau Pleke are reduced because of erosian, ferralitic soil processes and long periods of agricultural (Zn-84-92 ppm, Mn- 700-963 ppm). The mobility of microelements in the investigated soils depends of the pH level, the content of humus and the clay fraction. The highest mobility of Zn (0.68 ppm) and Mn (349 ppm) occurs in the ferrallitic soils with pH 4.1-4.4 and a clay content of 39-44%. Zn (0.24 ppm) and Mn (21-44 ppm) contents in the soils are reduced where the pH level is higher and the clay content is lower. The content of these microelements in the litter of the Hevea Brasilian plantation relates to their availibility in the soils.

# TRACING MARINE SEDIMENT TRANSPORT USING RADIOCESIUM IN THE EASTERN MEDITERRANEAN

# E. Ne'eman<sup>1</sup>, J. Kronfeld<sup>2</sup>, N. Lavi<sup>1</sup>, V. Butenko<sup>1</sup>, and H. Koral<sup>3</sup>

1 Radioisotope Laboratory, Ministry of the Environment, Tel-Aviv University

2 Department of Geophysics and Planetary Science, Tel-Aviv University 3 Department of Geology, Istanbul University

The final results of a radiometric and sedimentological study in two regions along the Mediterranean coast are presented. Using a high resolution gamma-ray spectrometer, radiocesium was measured in the on-shore soils of the Haifa Bay region and in the surface marine sediments off of the coast, to a depth of 200m. In Iskenderun Bay, the radiocesium was measured in the surface marine sediment throughout the bay. Most of the radiocesium is derived from the Chernobyl accident. This is determined by a 134 Cs/137 Cs ratio of approximately 0.5, when extrapolated back to 1986. The sediment grain size distribution and the clay mineralogy was measured as well.

Radiocesium can be used to trace the path of sediment erosion, transport, and dispersion in Haifa Bay. The radiocesium is found to be associated with the fine grained sediment fraction, which increases with distance from the shore. In Haifa Bay the smectite is dominant with lesser amounts of kaolinite and illite. The clay mineralogy in Iskenderun Bay. The radiocesium concentrations in the sediments are uniformly much more enriched in radiocesium. The highest values (approaching 60 Bq/kg) are found near to the Ceyhan River mouth. The sediment appears to be dispersed by a counterclockwise transport gyre across the bay.

### SYSTEMATICS OF HEAVY METALS AND HYDROCARBON MIGRATION IN THE ELECTRIC FIELD

### Marina A. Nekrasova and Vladimir A. Korolev Geological Faculty, Moscow State University, Russia

High levels of industrial production increases the probability of heavy metal and hydrocarbon contamination in upper lithospheric layers. The biosphere plays a significant role in removing these contaminants from the geochemical cycle. In addition, their concentration in solid and recent sediments can also constitute a danger within areas of industry. The development of a different restoration and clearing technique of soils and sediments is thus of importance, and the electrochemical method is described in this paper.

Clays and loams were used to study the behaviour of heavy metals (Cd, Pb, Zn, Cu) and hydrocarbons under the action of a direct electric current. The initial content of the heavy metals and hydrocarbons in these rocks materials exceeded the MAC by tens to hundreds times. The investigation demonstrates that more than 90% of the heavy metals are removed by the action of direct electric currents. The lowering of the initial concentration was observed not only in the pore solution, but also in the exchange complex of the clays. Equations were obtained of contamination lowering together with mineral composition, and physicochemical properties of the clay and the heavy metals. About 20-30% of the hydrocarbons were also removed from the emulsified clay hosts. The main component in this process is electro-osmotic transfer. The data indicate the possible use of the electrochemical cleaning of toxic pollution in soils after an understanding of the different ecological and geochemical processes.

### THE SEQUENTIAL EXTRACTION OF METAL FORMS IN THE SOIL IN SOUTH OF POLAND

#### **Barbara** Nowak

Silesian University of Medicine, Department of Toxicology, 41-200 Sosnowiec, Jagiellonska 4, Poland

The chemical forms of heavy metals in soil depend on the contamination of the soil which in turn depends on the emission sources. Sequential extraction enables the determination of the fraction of individual form of element in the soil (exchangeable Fl, carbonate F2, Mn-oxides F3, Mn-Feoxides F4, organic F5, residual F6). Soils located at Gorki Wielkie and Stozek sampled during 1993/1994 were examined. Two sites were located in "clean" regions (Stozek) and the remainder near a roadway. Gorki Wielkie is a small mountain village in Beskid Slaski in southern Poland (non-industrial region). The local emission source is the roadway where average traffic intensity is about 33 cars per 60 minutes. One way ANOVA analyses were performed to investigate the influence of sample location (roads vs "clean") and types of metal forms. Individual metal forms in soil differ essentially (p < 0.0001). The chemical forms of heavy metals in the soil depend on the contamination of the soil which in turn depends on the emission sources. Percentage Tessier fractions of particular metals in soil for two locations were applied to the data.

### URBAN ENVIRONMENTAL GEOCHEMISTRY IN A MEDIUM-SIZE INDUSTRIAL CITY IN NORTHERN SPAIN

# Almudena Ordonez, Jorge Loredo and Jesus Garcia-Iglesias

Escuela de Minas, Independencia 13, 3004 Oviedo, Espana

In most industrialized areas, the atmospheric content of heavy metals is significant and some of them are known to be harmful and constitute a health risk. Urban soils and street dust particles in areas close to industrial settlements can reach high concentration of certain heavy metals. For the purpose of the present work, a medium-sized industrial city (80,000 inhabitants) in northern Spain, where iron and steel industry and non-ferrous metal production processes are located in proximity, was studied. The aim was to characterize the heavy metal content in soils and street dust and their comparison with geochemical background values in the area. An assessment of the influence of main urban and industrial factors on the composition of soils and street dust located within the limits of the city has been considered.

Based on the analysis of total heavy metal concentrations in an area of  $\sim 10 \text{ km}^2$ , covering the urban domain and its surroundings, different sectors of the city were evaluated from a geochemical perspective to determine the composition and a comparison between urban soils and street dust particles.

For soils, 50 samples were collected in gardens and fields. The sampling methodology for street dust was based on the subdivision of the area into seven mapping units of  $1\times1$  km. Sixteen samples of ~150 gm were collected from streets and roads in each of the mapping units. The fraction below 100  $\mu$ m was acid digested and analysed for 32 elements by Flameless Atomic Absorption and Inductively Coupled Plasma Spectrometry.

Maps of total concentration and spatial distribution for heavy metals, principal statistical parameters describing their total concentrations in soils and street dust particles, and multivariate statistical methods were employed for an interpretation of the results. The heavy metal concentration in the street dust particles reaches high levels for some specific metals directly involved in the particular industrial activity, with values generally much greater than those measured in soils of the same sector.

### RELATIONSHIP OF GEOCHEMICAL LANDSCAPE OF SOILS AND GEOLOGICAL BASEMENT IN LOWER SILESIAN COAL BASIN - SW POLAND

### Anna Pasieczna

Polish Geological Institute, Warsaw, Poland

The Lower Silesian Coal Basin (Wałbrzych Coal Basin) -Sudentenland, is one of the most industrialized regions of Poland. Surficial geochemical variations in the Lower Silesian Coal Basin are governed by both natural (geological) and anthropogenic factors; a significant role is played by the chemical composition of the source rocks for soil development. The geochemical background of a group of elements (such as Cr. Mg, Al, V, Ni, Ti, Fe, Co, Sr, Ca, Zn, Cu, P, and Mn) in soils overlying metamorphic rocks of the of the Sowie Gory (Mts.) Block is highest within the study area. A slightly different set of increased element concentrations (Mg, Al, Ti, Co, Zn and Cu) characterizes the geochemical background of soils that developed on Devonian rocks (conglomerates, sandstones and siltstones) in the northern part of the area. The lithology also appears to be a factor in the increased concentrations of Cr, Mg, Al, V, Ni, Fe, Co, Zn and Cu in soils that developed on rocks of the Lower Carboniferous. Soils in the southern part of the area that developed on the Upper Carboniferous and Permian rocks are characterized by a different chemical composition. They are distinguished by a very low geochemical background of almost all elements included in this study. Mining and processing of barite, and earlier mining of ore minerals (silver and lead), have resulted in anomalies of barium, strontium, lead, zinc, cadmium, arsenic, copper, mercury and sulphur in soils. Hard coal mining, coke engineering, and the power industry have caused development of an anomaly of mixed nature (geological-anthropogenic). The influence of the Wałbrzych industrial-mining district is reflected in the soil map represented by the occurrence of extended anomalies of mercury, zinc, lead, copper and calcium. Of lesser areal extent are anomalies of strontium and arsenic. The elements cited here occur in minerals associated with coals. They enter the soils from the coal-bearing strata cropping out on the surface as well as by fallout of dust produced in the process of burning the coal.

### SORPTION OF VOLATILE METALLIC COMPOUNDS ON ACTIVATED CARBON: APPLICATION TO THE EXPLORATION FOR CONCEALED DEPOSITS IN SOUTHERN SPAIN

# H. Pauwels<sup>1</sup>, J.C. Baubron<sup>1</sup>, Ph. Freyssinet<sup>1</sup> and M. Chesneau<sup>2</sup>

1 BRGM-Research Division, B.P. 6009, 45060 Orleans cedex 2, France 2 PICA-15, Route de Foecy, 18100 Vierzon, France

Metal transfer from three buried VMS ore deposits to the soil atmosphere has been studied using soil gas collectors with specific activated carbon products. The experimental sites are located in the Southwest Iberian Pyrite Belt, where the three ore bodies (Los Frailes, Sierrecilla, Herrerias) lie beneath several tens of metres of either sandy limestone overburden or schist and volcanic country rocks. Soil gas geochemistry profiles (Rn, He, CO<sub>2</sub>, CH<sub>4</sub> and O<sub>2</sub>) were mapped at each site; detected anomalies in carbon dioxide, helium, and in some cases, radon revealed the presence of fractures cross-cutting the ore bodies at all three sites.

Gas collectors containing specific activated carbon were set up for about 100 days along 400- to 600 m-long profiles spaced 10 to 40 m apart. After collection, the metals sorbed on the activated carbon were eluted and analyzed by ICP-MS or GFAAS for Cu, Pb, Zn, As, Ag, Cd, Cr, Ni and Co. Anomalous amounts, exceeding 10 µg of adsorbed metallic components in places, were observed for all these metals over two of the ore bodies. The metal anomalies coincide with soil gas anomalies, indicating that metal transfer to the soil atmosphere also occurs through the rock fractures. However, no correlation has been demonstrated between the metal content of the soil after selective extraction and the metal content eluted from the activated carbon. This probably indicates that the geochemical background variations of trace metals adsorbed by the soil matrix are too high compared to the amount of volatile metallic compounds migrating in the soil atmosphere. Despite the lack of a soil gas anomaly, one profile over an ore body at more than 250m depth shows volatile metallic compound anomalies also related to soil Hg anomalies.

The lateral dispersion of volatile metallic compound anomalies appears to be controlled by the soil matrix characteristics. In well-developed soils overlying sandy limestone, anomalies range from 30 to 60 m in width, whereas in poorly-developed soils overlying schist and volcanic rocks, some anomalies are only 10 m wide.

No metal anomaly was observed on profiles above the Herrerias deposit. This deposit, the top of which lies at 50 m depth, contains less base and precious metals than the other two.

Observations have revealed that a flux of volatile metallic compounds is produced by sulphide mineralization. This metallic signal can be measured using specific activated carbon. Its amplitude depends on the soil matrix and the mineralization depth. Analysis using volatile metallic gas collectors appears to be a relevant tool for detecting buried or hidden mineralization.

### IMPACT OF NATURAL GEOCHEMICAL TERRAIN FIELDS ON HUMAN ACTIVITY

### V. Pevzner, G. Belyaev and YU. Ermakov VSEGEI, St. Peterburg, ASG, Moscow, Russia

The Map of Geochemical Speciation of Formational Complexes in Russia (1:5,000,000), compiled by the authors, summarizes data on the occurrence of 41 elements on a basis of weighted averages, and their associations with geological formations. Ecological constituents of the map are represented by data showing the degree of toxicity of 27 individual elements and the toxic associations. The nature of the occurrence of the toxic elements in rocks, their degree of mobility in the present-day hypergene setting, and the frequency of occurrence of the toxic elements have been taken into account when determining potential ecological hazards of geological formations. Four levels of potential ecological hazards were distinguished (highly-, moderately-, weakly-hazardous, and unhazardous = levels 1 to 4 respectively). Three vast provinces differing in the degree of ecological hazard of their geological units are present within Russia. The highest contrast occurs within the East Province (area from the meridian of the Enisei to the Sea of Okhotsk), where areas of level 1 hazard are controlled by old core of Meso-Cenozoic folded regions, young depressional structures and Cambrian platform deposits on slopes of crystalline shields. In the West Province (west Russian plate), geological units assigned to level 1 are represented by Devonian, Permian and Paleogene sedimentary strata containing sulphide mineralization. In the Central Province (Urals and West Siberian Plain), geological units with level 1 hazards are absent.

Areas of level 1 are almost ubiquitously characterized by the presence of Permian and to a lesser extent Cretaceous-Paleogene terrigenous deposits. In Russia, the surface area unrelated to that category amount to about 30%. All centres of endemic diseases resulting from an excess of biophile elements (Sr, Se, Mo, B, Be, etc.) known in the territory of Russia are confined to the areas of these geological formations.

The results obtained indicate that ecological-geochemical zonation maps can be effectively used for determining measures for environmental protection and a rational use of mineral resources.

# RESEARCH OF CLAY SOIL MICROSTUCTURAL INFLUENCE ON THE INTENSITY OF DIFFUSION-OSMOTIC TRANSPORT

### S. Polischuk, V. Korolev and V. Sokolov

Geological Faculty, Moscow State University, Russia

The amplification of anthropogenic load on the environment requires a study of the whole spectrum of geochemical processes, which previously were interpreted as insignificant when migration of elements in natural conditions were investigated. Thus, the problem of understanding pollution in subsurface part of the lithosphere by various chemical substances, including dissemination of toxic pollutants through soils, is considered. In this case, we have studied diffusion-osmotic transport in clays, as of one of the basic types of migration of pollutants in this type media. The results show the significance of clay soil microstructural characteristics for in relation to the intensity of diffusionosmotic transport in the clays.

A correlation between the parameters of diffusion-osmotic transport and certain characteristics of microstructure, in particular porosity, has been established by many researchers. However, a study of such dependencies for various types of clay soils on the complex of microstructural characteristics has not been carried out. We have measured diffusion and osmotic coefficients (diffusion transport of salt and the osmotic flow of water) together with quantitative microstructural analyses in various types of clay soils. The experiment was carried out in a two-cell device under conditions of non-stationary flow, and in a diffusional tube with a calculation of diffusion coefficients by Chernov's method.

The quantitative analyses of the microstructural characteristics of samples were examined SEM with an attached PC. The specially developed software package, STIMAN, was used. The flexible nature of the package allows to modification and expansion of a complex of investigated microstructural parameters such as porosity, porosity distribution by particle size, shape factors, interconnection and shape of pores, and orientation of struc- tural elements in space.

The result of the research was the establishment of relationships between the diffusion-osmotic parameters and the various microstructural characteristics. Significant and insignificant microstructural parameters for diffusion-osmotic transport in clays were indicated.

# ACID INSOLUBLE CONCENTRATIONS OF ELEMENTS IN SEARCH FOR VOLCANIC-HOSTED MASSIVE SULPHIDE DEPOSITS, ROSEBERY AREA, WESTERN TASMANIA, AUSTRALIA

### Aung Pwa and J.C. van Moort

Geology Department, University of Tasmania GPO Box 252-79, Hobart, Tasmania 7001, Australia

The Rosebery deposit is one of the major massive sulphide deposits in the Mount Read Volcanic belt of the western Tasmania. The 200 km by 20 km belt of the Mount Read Volcanics, which is one of the world's richest provinces of volcanic-hosted massive sulphide (VHMS) deposits, hosts more than forty mineral occurrences including such major massive sulphide deposits as: Mount Lyell, Hercules, Rosebery, Que River and Hellyer. In this study, hot HNO<sub>3</sub>-insoluble concentrations of elements are used to define the geochemical halos associated with VHMS deposits, and to identify alteration related to VHMS mineralisation. The residues after the acid treatment are mainly composed of quartz, mica and feldspar (plagioclase and K-feldspar) with traces of chlorite and kaolinite in some samples.

Mineralogical alteration characterised by quartz, sericite, chlorite, carbonate, etc., is the principle alteration related to VHMS mineralisation as well as to metamorphism and deformation in the region. There are no significant differences between the VHMS related and unrelated mineralogical alteration.

In the Rosebery area, there are two types of geochemical halos. Type 1 halo trending NE-SW is related to wall rock alteration, and is defined by enrichment in Cl, and possibly K and Rb, and depletion in Al, Ca, Na, Ti and Sr. Type 2 halo trending N-S (parallel to the stratigraphic trend) is related to massive sulphide mineralisation and is characterised by enrichment in Fe, Mn, Ba, Zn, Pb and possibly K, Rb and F. Both halos intersect at Rosebery in zones of mineralisation and associated footwall alteration. Recognition of geochemical halos has led to formulation of geochemical indices for identification of alteration related to VHMS mineralisation.

Binary relations between Mn x Ba x F and Ca x Na x Sr, and Mn x Ba and Na x Sr, and their ratios (Mn x Ba x F/Ca x Na x Sr and Mn x Ba/Na x Sr) identify the alteration related to massive sulphide mineralisation and distinguish it from alteration unrelated to the mineralisation in Rosebery area. These geochemical indices are also used for the other deposits viz. Mount Lyell, Hercules, Que River and Hellyer. All these deposits display similar geochemical alteration signatures. The alteration related to VHMS mineralisation can be distinguished from alteration unrelated to mineralisation by higher values of the geochemical indices of K x Mn x Ba x Rb, Mn x Ba x F and Mn x Ba.

# TRANSPORTED OVERBURDEN, THE TIME FACTOR

N.W. Radford<sup>1</sup> and P. Burton<sup>2</sup>

1 Normandy Mining, Perth, Australia

2 Normandy Mining, Darwin, Australia

Geoscientists traditionally see transported overburden as an impediment to geochemical sampling. Evidence now exists which suggests metal signatures, within transported overburden, can be seen which reflect mineralisation buried below. At the Fender Au deposit in Western Australia, lateritic mineralisation, in places of ore grade, is developed within transported overburden. Similarly, in North East Queensland, basal units of early Tertiary fluviatile sedimentary cover sequences sometimes carry enhanced metal values reflecting mineralisation in the basement below. In each case, recognition of the transported nature of the overburden is not sufficient to define its suitability as a geochemical sampling medium.

Where the overburden has been in place for a long time, geochemical signatures of underlying mineralisation may be present, even up to ore grades. In young transported cover materials, signatures may be weak or absent. Because dispersion patterns in the transported materials seem to be of larger dimensions than in the basement below, exploration programmes ignore this possibility their peril.

### ENVIRONMENTAL-GEOCHEMICAL MAPPING IN SLOVAKIA

Stanislav Rapant<sup>1</sup> and Maria Raposova<sup>2</sup>

1 Geological Survey of Slovak Republic, Mlynska dolina 1, 817 04 Bratislava, Slovakia 2 Ministry of Environment of Slovak Republic, Hlboha 2, 812 35

2 Ministry of Environment of Slovak Republic, Filoona 2, 812 33 Bratislava, Slovakia

The Slovak Republic ranks among the countries undertaking extensive environmental-geochemical mapping. This mapping is managed and sponsored by the Ministry of the Environment. Work carried out during 1991-1995 (excepting alluvial sediments) were a follow up of the project: Geochemical Atlas of the Slovak Republic, which presents the following environmental constituents at a scale 1:1,000,000: (a) alluvial sediments (planned for completion in 1997); (b) groundwaters; (c) soils; (d) forestry biomass; (e) natural radioactivity

Apart from these, the Geochemical Atlas project comprises a catalogue of chemical analyses of the main rock types of Slovakia. Simultaneous with this project, environmentalgeochemical mapping of the Slovak territory at a scale 1:50,000 has been initiated in selected areas, with an emphasis on areas with the highest level of environmental hazards. The mapping activity also includes hydrogeological, engineering-geological, pedological, natural radioactivity and radon hazard maps. In certain areas, snow geochemistry, seismic risk, critical load, and other maps are being prepared. The main emphasis of the environmental-geochemical mapping is on waters (underground, surface, precipitation), soils and stream sediments.

Natural waters are being assessed in the MAP OF NATURAL WATER QUALITY, which summarizes, and assesses the chemical composition and the qualitative properties of natural waters. Their qualitative properties are shown together with their environmental characteristics. The upper permissible limits of the appropriate Slovak Technical Standards for potable and surface waters for classification.

Alluvial sediments are assessed and displayed in the GEOCHEMICAL MAP OF ALLUVIAL SEDIMENTS, designed to display and assess the areal extent of anomalous occurrences, influenced by either natural, or anthropogenic agencies. The map displays two types of elemental, or compound anomalies: geochemical and environmental. Element contents within the upper permissible limits (B class) of the Slovak Technical Standards for sediments, are shown as geochemical anomalies. The toxic elements, or the elements with economic potential, are selected on the basis of statistical processing. The environmental anomalies reflect the impacts of toxic elements upon the environment.

Soils are characterized and displayed in the PEDOGEOCHEMICAL MAP, the main goal of which is to document and display the degree of contamination in soils. Anomalous natural and anthropogenic element anomalies are shown. The areas contaminated by hazardous elements are shown together with the origin of their sources using combined symbols.

For standardization and compatibility, methodical guidelines are prepared to serve as legal act of the Ministry of the Environment of Slovak Republic.

Since the environmental-geochemical mapping of Slovakia implies a broad complex of environmental factors, the methods and model sheets, comprising a synthetic and complex assessment of the geochemical factors of the abiotic constituent of the environment, have been recently designed recently. These maps display a two-way assessment of environmental-geochemical anomalies, either by means of synthesizing the individual media (Environmental Geochemistry Map, the CTB Map) or by synthesizing the elements in the individual media (Degree of Contamination Map).

# EXPLOITATION OF GOLD AND OTHER PRECIOUS METALS IN AN HISTORIC SEWAGE SLUDGE STOCKPILE, MELBOURNE, AUSTRALIA; DISTRIBUTION, EXTRACTION AND UTILISATION OF DEPLETED SLUDGE.

### Shane J. Reeves and Ian R. Plimer

University of Melbourne, School of Earth Sciences, Melbourne, Australia

Sewage sludges are dewatered, anaerobically digested or aerated end products of human sewage waste and are recognised repositories of organic pollutants and heavy metals. They may be considered targets for economic gold mineralisation because of the documented gold content of sewage sludges worldwide which are similar or higher than those of some geological ore deposits which are currently-mined for gold. They are also highly nutrient enriched (nitrogen and phosphorus) and therefore amenable to use as agricultural fertiliser. The sewage of Melbourne, Australia, a city with a current population of around 3 million, was stockpiled in large, closed, lagoonal tanks from 1895 until 1980. In 1995, an Australian gold exploration company pegged the ground surrounding the historic sludge reserves and commenced a program of resource evaluation, utilising RNAA and INAA to determine 29 elements. The current study was initiated to determine gold, silver and other metal variations in both space and time and to investigate the chemical extraction of the precious metals. 149 samples from over 50 hand-auger drillholes to a depth up to 4m have been analysed from the stockpiles, with gold assays yielding remarkably consistent results.

Average grades of 0.77 g/t gold, 18.8 g/t silver and 1.18 kg/t zinc have been documented for a measured resource of 770,000 cubic metres (of an estimated 1.6-2.5 million cubic metres contained) at a density of 1.0 g/cm<sup>3</sup>. Partitioning of dissolved metals onto solid particles in sewers takes place by a number of chemical and biochemical mechanisms including binding to extracellular polymers, intracellular metabolic uptake by bacteria and absorption by bacterial cells, clays and organic particles. Precious metal concentrations are enhanced in cities with a strong jewellery making industry and also in regions with historical (ancient and modern) gold mining. Significantly, sludges derived from domestic waste only, also contain high gold. Human and animal excreta have very low gold contents with cow manure reporting 0.2 ppb Au. Gold correlates extremely well with Cr, although no clear variations with age are found, suggesting that remobilisation within the closed system has equilibrated the metals. Laboratory-based extractive metallurgy of the Werribee sludges has demonstrated that Au, Ag and Zn can be removed with relative ease by heap leaching using modified conventional technology. The extraction of the precious metals also results in the removal of contaminant metals such as Cd, As, Sb, Hg and Cr which may render the sludges fit for sale as agricultural fertiliser. Eighty-two million tonnes (dried matter) of sewage sludge accumulate globally every year. Using this estimate of sewage outfall it can be shown that, conservatively (i.e., 1 g/t Au, 20 g/t Ag, 0.1 g/t Pt, 1 g/t Pd). 2.6 million oz. (Moz) of Au (SUS1 billion per annum), 50 Moz of Ag, 0.3 Moz of Pt and Moz of Pd are lost to the oceans globally every year. In comparison, annual geologic ore production of these metals is 50 Moz Pt and 3 Moz Pd.

### GEOCHRONOLOGY OF THE GROUNDWATER IN THE HAIFA BAY REGION, ISRAEL

### Vasily Rogojin<sup>1</sup>, Joel Kronfeld<sup>1</sup> and Israel Carmi<sup>2</sup>

1 Department of Geophysics and Planetary Sciences, Tel-Aviv University

2 Radiocarbon Laboratory, Weismann Insitute of Science, Rehovot

A variety of natural isotopes were employed to determine the interaquiferal connections and flow patterns in the Haifa Bay region. In the east, The Judea Group and Kurdani carbonate aquifers show very good aquiferal interconnection, and can be considered as single aquiferal unit. The groundwater flows westwards from the recharge region in the hills towards the coast at a rate of 1-3 m/year. The carbonate aquifer water is characterized by a lighter stable isotopic composition of hydrogen, carbon, oxygen, and strontium compared to the water in the Pleistocene Coastal aquifer. The Pleistocene aquifer is subdivided into two distinct aquifers by a thin horizon of impermeable clay. the lower subaquifer, at present, has no surface exposure. It contains much older groundwater, and receives replenishment by drainage from the juxtaposed carbonate aquifer.

It is observed that there is a direct correlation, in both the Coastal aquifer and the carbonate aquifer, between the radiocarbon activity and the U-234 excess. The U-234 excess increases over time by alpha-recoil, as a function of residence time of the groundwater within the aquifer. It is suggested that the U-234 excess can be used as a hydrologic chronometer in the Haifa Bay region for the whole of the Holocene and late Pleistocene.

# ORIGINS AND GEOCHEMICAL APPLICATIONS OF THE COMPONENTS OF SOILS OVERLYING THE BEASLEY CREEK GOLD DEPOSIT IN THE ARID NORTHEAST YILGARN OF WESTERN AUSTRALIA

### I.D.M. Robertson

Cooperative Research Centre for Landscape Evolution and Mineral Exploration, CSIRO Division of Exploration and Mining, Perth, Western Australia

The Beasley Creek Au deposit is hosted in black shales within mafic and ultramafic rocks and was S- and trace element-rich. The deposit lies within a small window of Archaean basement in the northeast Yilgarn Craton of Western Australia, and has been deeply weathered to a ferruginous saprolite and some duricrust, and slightly eroded. The residual regolith lies below 100-200 mm of neutral to alkaline, red-brown soil, strewn with a ferruginous lag of black to brown granules and minor quartz.

Colluvial wash plains surround the basement window and are mantled by a thicker (300-500 mm), acidic, red-brown soil, strewn with polymictic lag. Soil samples from a depth of 25-250 mm were collected along two traverses across the ore deposit, as were suitable background samples from some 700 m away.

The dry sieved 710-4000 µm soil fraction consists largely of black, goethite- and hematite-rich nodules (some magnetic), red to yellow ferruginous clay granules, minor quartz, calcrete and scarce gossan fragments (common close to the ore subcrop), all derived from the underlying regolith. The 75-710 µm fraction consist largely of red-brown, hematite-coated sand grains, with minor feldspar and small, ferruginous granules; this comprises a wind-blown soil dilutent. The <75 µm fraction consists of quartz, kaolinite and iron oxides, in part derived from the regolith. A clay-rich <4  $\mu$ m fraction was removed from the <75  $\mu$ m fraction by dispersion of the clays in water at pH 8.0, followed by sedimentation through 100 mm. The dispersed clays were siphoned off, flocculated at pH 4.0 and dried. The complete soil, the 710-4000 µm, 4-75 µm and <4 µm soil fractions were compared as sampling media. Due to its dominant wind-blown quartz component, the 75-710 µm fraction was not investigated.

The 710-4000 µm fraction is the most effective sampling medium; its distributions of As, Au, Cd, Cu, Sb, Se, W and Zn are related to mineralization. Gold gives a broad anomaly (>20 ppb) but locally reaches 200-300 ppb. Maxima in Ba and Mn indicate the ore host phyllites. Its effectiveness is similar to that of the fine lag, for which it provided the source. Although Cd, analysed by ICP/MS, occurs at much lesser abundances (two orders of magnitude) than Zn, its anomaly/background contrast was three times greater. The 4-75  $\mu$ m fraction was significantly less effective than the <4 µm fraction due to a much greater (wind-blown) sand content. The <4 µm fraction indicated the ore host phyllite with an increase in sericite; the phyllites and duricrusts were indicated by a kaolinite increase. Enhanced dispersions of Au. As, Cd and Cu in the <4 µm fraction show that it is a viable sampling medium and may be used in stream sediment surveys in areas of low relief.

# **ALLOY COMPOSITION OF BRONZE OBJECTS** FROM CANAAN DURING THE MIDDLE BRONZE AGE

### Amnon Rosenfeld, Shimon Ilani and Michael Dvorachek Geological Survey of Israel, Jerusalem, Isarel

The chemical composition of twenty nine figurines and jewelry, and twenty one weapons and tools of Middle Bronze age from Canaan (are of present day Israel, Lebanon and Syria) was examined. Although, tin-bronze was already alloyed in the late Early Bronze age, our results show that during the Middle Bronze age, simultaneously to tin-bronze, arsenical bronze conservatively was still in use mostly in weapons and tools. On the other hand, casting of tin-bronze figurines and jewelry flourished during the MB age, enhancing the creativity of artistic and sophisticated metal objects. The fact that some 65% of the studied weapons are made of arsenical bronze (As = 1.5 - 7.0%; 2.8% avg.), may indicate that MB metalworkers knew that arsenical bronze is as good as tin-bronze in terms of strength and hardness. Tin was not added to arsenical bronze since the latter were of sufficiently high quality for producing weapons.

The relationship between Sn and As is entirely different for MB figurines versus utilitarian artifacts. Most of the figurines (72% of the objects) are made of tin bronze (Sn =0.4 - 15.7%; 6.4% avg.), whereas only 24% of the objects contain up to 7.0% As (2.5% avg.).

Of twenty nine figurines and other domestic objects, eleven (38%) contain between 0.5 and 22% lead (5.4% avg.). On the other hand, out of twenty one weapons, only four (19%) contain lead, ranging from 0.3 to 1.8% (with one exceptional result of 9.0%). The higher Pb-content is found in the figurines and in much lesser amounts in the weapons. The metalworkers avoided mixing lead in arsenic or tin-bronzes for weapons, in order to gain adequate quality.

These results point to a trend of preferring tin-bronze for casting figurines. It is suggested therefore, that the introduction of tin-bronze in the Canaan during the MB, significantly encouraged the domestic and "artistic" production of figurines. The MB metalworkers were well acquainted with the alloying properties of tin, lead, and copper-arsenide ores, and choose the adequate alloy for functional casting.

# PALEOMORPHLOGY AS THE KEY FOR THE **UNDERSTANDING OF ANCIENT MINE WORKINGS -**IN THE TIMNA VALLEY AND IN **RIO TINTO (SW SPAIN)**

### Beno Rothenberg LAMS London

Extensive archaeological surveys and excavations in the ancient mines of Timna showed that the fragmentary relics of ancient mining could not be well understood, and properly dated, unless we are able, by paleomorphlogy, to reconstruct the ancient landscapes during the different times of the mining activities. Parallel to the archaeological detailed survey of a 4km<sup>2</sup> 'Model' area, a team of geologists, led by Aharon Horowiz, undertook its paleomorphological recording. This combined field work, used for the first time in prehistoric mining research, has shown to be the key for a new understanding of the Timna mines and led to the identification of the earliest mine workings, in the Late Neolithic period. It also created a totally new picture of the sophisticated mining technology of the Pharaonic, New Kingdom (2nd millennium BC) mining expeditions to the Arabah.

Based on our experience in Timna, the reconstruction of the ancient mining landscapes of the huge mining region of Rio Tinto (Huela), and geochemical investigations, led to the solution of a long-stading and much-discussed enigma in the techno-history of this mine, probable the oldest and largest mine of Western Europe.

### PECULIARITIES OF HEAVY METAL BEHAVIOUR IN ARID TECHNOGENIC LANDSCAPES

### L.K. Sadovnikova

Lomonosov Moscow State University, Moscow, Russia

The content and behaviour of heavy metals (Pb, Zn, Cd, Cu, Hg) in a pollution zone near a lead smelter plant have been investigated. The heavy metal content in gas-dust emissions, soils, waters, sediments, plants and migration inflows of pollutants were studied. The impact of heavy metals in the pollution zone was 200 times higher than in the natural landscape, e.g., ~ 85 kg/km/year for Pb. The migration path of metals in a polluted serozems profile was limited by the upper humic horizon as a pollutant barrier. The order of heavy metal migration decreased as follows: copper > zinc = cadmium > lead. The large amount of carbonates, high level of alkalinity, heavy particle size distribution and low rate of rainfall favoured the accumulation of heavy metals. Deep vertical migration of pollutants were absent, as indicated by low concentrations of heavy metals in soil-ground water (Zn< 50, Cu - 9, Pb - 2.5, Cd - 0.25 ppm). The area was characterised by a weak migration of metals with surface flow due to insignificant water flow, in this case, a dry subtropical landscape. River sediments contained the high amounts of heavy metals, independent of the distance from the smelter plant (Pb - 300-700, Zn - 1000-2000, Cd - 5-20, in some cases up to 90 ppm). The heavy metal content in the plants correlated significantly with soil properties such as the content of humus, carbonates and available heavy metal forms. The correlation coefficients (soil-plant) were markedly higher for Zn and Pb than for Cu.

The heavy metal inflows were extremely high in the technogenic landscape, with all forms of migration. Air migration of heavy metals was strongly expressed in elluvial and transelluvial areas as dust on soil surfaces. Air, water and deluvial-proluvial migration had a combined influence. The heavy metal inflows accumulated at the geochemical barrier and lead to enhanced pollution of the environment.

# CHEMICAL ELEMENT DIFFERENTIATION IN THE COURSE OF ALLUVIAL LITHOGENESIS IN THE POLLUTED SVISLOCH RIVER, BELARUS

#### Vladmir Savchenko

Institute for Problems of Natural Resources Utilization and Ecology, Belarussian Academy of Science, Staroborisovsky tract, 10, 220114, Minsk, Belarus

The complicated and permanent process of chemical element differentiation in the course of alluvial lithogenesis may be subdivided into 5 stages: mobilization, transportation, sedimentation, diagenetic and epigenetic transformations. The study of 40 chemical elements migrating in the lowland medium-size Svisloch River draining the large city Minsk (1.7 million people) was designed to establish the impact of urban areas on processes of alluvial lithogenesis and its products. For comparison, a similar investigation of the control area - a 110 km section of the Berezine River draining the biosphere reserve was carried out.

Effluents from Minsk cause an essential increase (factor of 62) of the sediment load per unit area. The substances involved in transportation differ from the natural ones in origin, grain-size and mineralogical composition, enrichment in organic matter (mainly artificial) and anthropogenic element associations (P, S, Pb, Cd, Cr, Ni, Ag, Cu, Zn, Sn).

Analysis of our data and that from the literature show that downstream river transport of metals from urban areas is significantly increased in both dissolved and suspended solids, and as a rule is dominated by the latter. For example, in the Svisloch River downstream of Minsk 90-98% of Cu, Cr, Pb, Ag, 72-83% Zn, Mo, and 41% of Ni are transported by suspended solids.

Differentiation of the chemical elements in the course of sedimentation is an important process. The scheme of lithofacies division of alluvial sediments was used to study geochemical products of sedimentogenesis. Concentrations of metals in 10 alluvial lithofacies differ significantly in both unpolluted and, particularly, in polluted rivers. Pollution is indicated by all lithofacies but the contrast of sediment anomalies varies from 2 to 165. As a result of extremely

severe pollution, specific alluvial sediments, so-called "technogenic silts" are stored in the river bed. Hydrotechnical constructions are another anthropogenic factor strongly affecting alluvial sedimentation. The effect of artificial geochemical barriers (dams) is characterized.

Among the several processes related to post-sedimentation changes of stream sediments, the most significant ones with respect to element differentiation are those that concern flood-plain pedogenesis and the formation of secondary minerals.

### FOUR TYPES OF ALLUVIAL SEDIMENTS: APPLICATION FOR ENVIRONMENTAL ASSESSMENT

### Vladimir Savchenko and Igor Samsoenko

Institute for Problems of Natural Resources Utilization and Ecology, Belarussian Academy of Science, Staroborisovsky Tract, 10, 220114, Minsk, Belarus

Stream sediment sampling is an universal tool for geochemical investigation. In addition, overbank sediment sampling has recently been introduced in geochemical exploration (Ottesen, 1989), and low-water sediment was suggested as a suitable and convenient medium for this purpose as well (Savchenko, 1992).

Two different studies of alluvial sediments were carried out in Belarus. The first dealt with a background area (biosphere reserve) and aimed at determining natural geochemical levels and comparing mineralogical and chemical (35 elements) compositions of (1) active sediments of a river bed; (2) "old" overbank sediments - humic horizon of floodplain soil; (3) recent overbank sediments sampled from the surface of the floodplain soil immediately after floods caused by heavy summer rains; and (4) low-water sediments. The second study explored the extent and degree of pollution of various types of rivers.

Low-water sediment is a thin layer of bottom sediment deposited on river shallows when water discharge is minimal and low-water periods occur in the river system. The decrease of the velocity and loading capacity of the flow during the low-water period causes transportation and sedimentation of much finer suspended matter and accumulation of thin layers of loose fine-grained material, i.e., low-water sediments. The investigation in the background area has shown that the low-water sediment holds a special place among recent alluvial sediments in terms of their genesis, mineralogy and chemical composition.

Geochemical maps for most of the analyzed elements were produced on the basis of the analyses and statistical data treatment. Most of known sediment anomalies and some unknown ones in the rivers of Belarus were detected with anomalous metal concentrations in low-water sediment. Moreover, the low-water sediment anomalies are characterized by better contrasts and homogeneity. The similar pattern of distribution was revealed for cesium-137 in alluvial sediments of river valleys contaminated by Chernobyl radionuclides. The use of low-water sediment allows an a significant expansion of temporal and spatial geochemical control and monitoring. It can be used for determination of background levels of elements, for distinguishing geogenic and anthropogenic anomalies, for estimation of the degree of pollution and for monitoring.

# EXPLORATION AND OCCURRENCES OF AU, PT AND PD IN THE POLISH ZECHSTEIN COPPER DEPOSITS (KUPFERSCHIEFER)

### Z. Sawlowicz<sup>1</sup> and A. Piestrzynski<sup>2</sup>

1 Institute of Geological Sciences, Jagiellonian University, Krakow, Poland

2 Department of Ore Deposits, University of Mining and Metallurgy, Krakow

Growing interest in exploration for precious elements in black shales and reports on very local but high enrichments in these elements in the mining area of the Polish Kupferschiefer, stimulated a more detailed study of this problem. Data and suggestions presented below are the results of preliminary stages of research and are based on fire assay-ICP chemical data for bulk samples and on ore and SEM-EDS microscopy.

High concentrations of Au (max. 100 ppm, avg. 1 ppm), Pt (max. 2.5 ppm, avg. 0.4 ppm) and Pd (max. 4 ppm, avg. 0.1 ppm) occur in the secondary oxidized shales and in places, in the uppermost part of the underlying sandstones. Maximum contents of Ru, Rh and Ir in a few studied samples are 22, 12 and 2 ppb respectively. These shales are characterized by lower contents of TOC (2-5%), low contents of sulphides (0.2-0.7%S), degraded organic matter, and a lower content of Re (1 ppm) in comparison with typical Cu-rich shales (Au-20) ppb, Pt <5 ppb, Pd -4 ppb, 3-15% TOC, 1-6% S and 5 ppm Re). Gold is present as native gold, electrum, isomorphic substitutions in native silver, organometallic compounds and in some Cu and Ag sulphides. Small amounts of platinum and palladium are present as Pd diarsenides or Pt-alloys but they mainly occur in unknown carriers. Samples with high contents of Pt and Pd are typically rich in Au but the reverse relationship is not so obvious. A distinction between secondary oxidized facies rich in Au, Pt and Pd and primary oxic facies without these elements, can be made on the basis of extremely low contents of TOC, S, Cu and Re in the latter.

Summarizing, the most promising areas seem to be the transition zones between sulphide-rich facies and typical oxidized Rote Faule facies, developed both laterally and vertically (5-50 cm), in the lower part of the shales and/or upper part of the sandstones. Features significant for precious metal exploration in the Kupferschiefer are as follows:

- low content of copper and lower contents of TOC, S and Re (possibly also Se) in shales (usually clay-carbonate shales).

- dark-red or brownish color of shales and/or sandstone, typically below Cu-rich black shales. Occasionally shales are macroscopically black, but numerous red reflections from finely dispersed hematite are seen under the microscope.

- presence of sulphide relics, mainly chalcopyrite and covellite.

- red spots and poor copper mineralization in the upper part of sandstones. Additionally very local (mm-cm scale) and very rich concentrations of precious metals can be found in samples with high radioactivity, high Hg, Ag, Bi and As contents, higher phosphorus and organic matter contents and low Cu contents.

# METALLURGICAL REMAINS FROM EIN ZIQ AND BE'ER RESISIM, CENTRAL NEGEV, ISRAEL

### I. Segal<sup>1</sup> and R. Cohen<sup>2</sup>

1 Geological Survey of Israel, Jerusalem, Isarel

2 Israel Antiquities Authority, P.O. Box 586, 91004 Jerusalem, Israel

Metallurgical remains investigated in this work were recovered at two sites in the Central Negev: Ein Ziq and Be'er Resisim. These sites are dated as Middle Bronze Age I. The remains include copper ingots, slags and prills. Bar-shaped ingots, triangular in section, of unalloyed copper, are distinctive for the above mentioned period. This study presents chemical and metallographical characteristics of thirty-five bar-ingots from Ein Ziq and Be'er Resisim as well as of slags and prills recovered along with the ingots.

In order to ascertain the provenance of the ingots in the present study, their chemical, isotopic and mineralogical compositions were compared to those of the copper ores from Timna (southern Israel) and Feinan (Jordan).Based on the chemical composition of the ingots, they did not originate in Timna ores occurring in the Amir-Avrona Formation, but are similar to the ore from the Timna Formation (Timna) and to the ore within the Dolomite Limestone Shales from Feinan. Lead-isotope ratios yielded similar results.

Four ingot types were ascertained on the basis of the composition of microinclusions. All ingots contain copper sulfides and lead. The first type has no additional inclusions. The second contains iron oxide inclusions within copper sulfide, suggesting the presence of iron ores in the charge during smelting. The third type contains iron phosphides. The fourth reveals a  $Cu_2O$ -Cu eutectic. Ingots formed in the presence of copper oxide spots can be related to the fourth type.

A metallurgical study of the ingots reveals an equiaxial grain structure which together shrinkage on the upper part of the ingots, suggest secondary casting in one-sided molds with a triangular groove. In both chemical composition and structure, the ingots from Ein Ziq and Be'er Resisim are similar to those from Atar Har Yeruham, the Hebron Hills, Atar Har Sayyad.

The presence of slags and prills suggests that metallurgical activity took place at the site. As no ore fragments were found at the site, the raw copper for the ingots was probably manufactured in areas close to the sources of the ore. The ingots themselves were cast at the site. The presence of manganese-rich slag attached to the ingot, found at Be'er Resisim, point to Feinan as a source of the ores for the raw copper. Analysis of slags from Ein Ziq revealed their magnetite-type affinity, with a surprisingly high cobalt content (in spite of the very low Mn-content). The presence of the high cobalt values in these slags still remains an enigma.

# GIS ANALYSIS OF THE EFFECTIVENESS OF THE COMBINATION OF QUANTITATIVE PETROGRAPHIC AND ROCK GEOCHEMICAL DATA: A CASE STUDY FROM THE YUBILEINYOE CU-AU DEPOSIT, WESTERN KAZAKHSTAN

### V.V. Shatov<sup>1</sup> and C.J. Moon<sup>2</sup>

1 All Russian Geological Research Institute (VSEGEI), St. Petersburg, Russia

2 Geology Dept., Leicester University, Leicester, University, Leicester, U.K.

Rock geochemical data has conventionally been interpreted with limited petrographic information. Staff at VSEGEI have conducted a number of orientation rock geochemical surveys that have also examined the thin section petrography of each sample and quantified mineral abundance and hydrothermal alteration in the sections in an attempt to assess the utility of the extra information.

These orientation areas included the Yubileinyoe Cu-Au deposit in the southern Urals. This deposit is hosted in a 250 m diameter plagiogranite porphyry stock that intrudes mafic volcanics and terrigenous sediments of Silurian and Devonian age.

Surface and core samples were collected on an approximate 500m grid over a 10x10 km area surrounding the deposit, the sample mass ranging from 200 to 500 g. In areas of intense hydrothermal alteration, the grid size was reduced to  $250 \times 250$  m or even 100 x 100 m. All 1083 samples were analysed by DC arc spectrometry and for Au. Analyses were normalized by Clarke values and by lithology using petrographic and lithologic data from the PC database.

GIS based analysis of the data set utilised Arc/Info to extract lithological information and the size of haloes around the granitic stock. Simple plots show that major hydrothermal minerals (hydrosericite, chlorite, quartz, epidote, pyrite) and Cu, Mo, As, Au, Ag and W form haloes of up to 1000 m diameter surrounding the stock, with mineral haloes superimposed on regional patterns.

The main advantage of quantitative petrography is that it enables estimates to be made of elemental loss and gain relative to unaltered lithologies. Such an approach made it possible to reconstruct the sequence of hydrothermal events within the Yubileinoe deposit area and determine the geochemistry of alteration zones related both to the mineralized granitic stock and to pre-granitic volcanic and sedimentary units. Based on this information mass balances for Au, Cu, Mo, Cr and other elements in the alteration zones associated with ore-bearing granitic rocks were calculated.

## PETROCHEMISTRY OF BALLAST STONES: A KEY TO THE HOME PORT AND ROUTE OF A SUNKEN PHOENICIAN-PERIOD VESSEL

### Aryeh E. Shimron<sup>1</sup> and Dov Avigad<sup>2</sup>

1 Geological Survey of Israel, Jerusalem, Israel 2 Hebrew University, Jerusalem, Israel.

An entire Phoenician-period vessel with its hoard of artifacts, including 10 tons of ballast stones, was recovered by divers off the coast of Israel. The vessel, which sank during the 5th century BCE had a load capacity of about 15 tons, it is 15 m long and about 4 m wide and in an excellent state of preservation. We carried out a detailed petrographic and petrochemical study on representative specimens from the ballast in an attempt to reconstruct the vessel's site of manufacture and, what may have been, its only journey. The ballast assemblage contains a metamorphic (50%), magmatic (12%) and sedimentary (38%) rock suite, the slabs are generally large (av. 1/2-1 m). Some lead ingots and galena were also found. The metamorphic suite is mostly composed of phyllonites with glaucophane and phengite, higher temperature minerals are absent. The well rounded magmatic boulders consist of dominantly fresh (non-tectonized and non-metamorphic) dolerite-gabbro with lesser amounts of plagiogranite and serpentinized peridotite. The sedimentary suite consist of pelagic limestones with accessory breccia, and radiolarian chert. Beach rock is abundant and is almost entirely comprised of clasts identical to the metamorphic suite. The metamorphic suite (and beach rock) were derived from a single location, comprising a high pressure/low temperature (HP/LT) blueschist facies terrain. The protolith was a felsic volcanic archipelago. The magmatic rocks, collectively with the pelagic limestones and cherts, were very likely derived from an ophiolite complex.

Both suites are unique, albeit fairly typical associations, in the Mediterranean basin which decorate the suture-collision zone between the colliding continents of Africa and Eurasia. HP/LT blueschists are virtually confined to Corsica, Calabria and the northernmost Cyclades islands. We identified an identical metarhyolite(with beach rock) association in the Bay of Karystos (Island of Evia). Non-tectonized ophiolites occur only in the eastern Mediterranean region. On the Pearce and Becalluva discrimination diagrams the ballast gabbroids reveal trends typical of the Upper Cretaceous ophiolites, with values identical to those of the Troodos Complex. We succeeded in narrowing down the collection site of this suite to a small delta of the Kouris River, near the ancient port of Curium in southern Cyprus. Our suggested scenario: the vessel was constructed in Karvstos Bay, partially loaded with blueschist ballast it sailed for Lavrion, where a cargo of galena and/or lead ingots, was added. The vessel continued to the Cypriot port of Curium, where the lead cargo was unloaded and replaced by the ophiolitic portion of the ballast. The heavily-laden vessel continued on the ill-fated, final leg of its journey to Palestine. It mysteriously sank, or was sunk, just off the coast near the present Kibbutz Ma'agan Mikhael, only 7 km south from the important Phoenician-Sidonian port-capital of Dor.

# A TALE OF TWO CITIES - URBAN GEOCHEMISTRY OF JERUSALEM AND HAIFA

### M. Shirav, N. Wolfson, S. Ilani and L. Halicz Geological Survey of Israel, Jerusalem, Isarel

Environmental geochemistry is concerned with the sources. dispersion and distribution of elements in the surface environment. High precision geochemical maps can be used to identify area with increased levels of potentially toxic elements and have, therefore, application in the fields of human health, agriculture, anthropogenic pollution and land-use planning. Within the course of the National Geochemical Mapping Project, detailed stream sediment sampling (1-2 samples/km<sup>2</sup>) was carried out between Bet Shemesh and the eastern border of the Judean Desert (including the Jeruslem area) and the Mount Carmel area. including the city of Haifa. The <100 mesh fraction of the samples was analzed for 30 trace and major elements using ICP-AES and atomic absorption techniques. Date analysis (R-mode factor analysis - varimax rotated) and the main retained factors can be largely explained on the basis of the chemical composition of the underlying rocks as reflected by the mineralogy of the stream sediments: AL, Si, Fe, REE, V, Mn - elements associated with the clay fraction and heavy minerals; Ni, Co, Cr, P, Mg, Zn, Pb - ferro-magnesian minerals (Carmel volcanics); S, Sr - gypsum crust on Mount Scopum Group rocks (Judean Desert); P. Cr. Ni, V. Y. Zn. Sb - associated with phosphatic rocks (Judean Desert); Ba barium enriched stream sediments derived from Senonian-Eocene formations (Mount Carmel area); Pb, Zn, Sb, Cu samples enriched with these elements are located within the metropolitan areas of Jerusalem and Haifa. These elements are known to have a high rates of dispersion into the environment by combustion of leaded fuels, sewage sludge, refining, use of paint pigments, pesticides, additives in plastics and alloys, etc. Thus, although some of the potentially harmful elements are naturally associated with common lithologies (i.e., phosphates in the Judean Desert, volcanics in the Mt. Carmel area), this factor determines a geochemical signature of an urban area, where high levels of Pb, Zn, Sb and Cu reflect contamination by industrial activities, domestic wastes and motor vehicle emisssions.

According to current European standards, both Jerusalem and Haifa are considered to be "highly polluted" on the basis of trace metals concentrations.

The distinct contrast between background and anomalous concentrations of gold makes it a sensitive indicator of contamination orginating from sewage sldge and waste disposal sites. Anomalies of up to 3000 ppb gold were detected within the environs of the twocities, usually in streams draining waste disposal sites.

Some firmly-established links between geochemistry and human health have been made in recent years, and similar regional geochmical maps play a significant role in detection and investigation of associations between the levels of certian elements in stream sediments, soils and waters and the distribution of various diseases. High levels of blood-lead reported in children from the Haifa area is only one example of such possible assiciations.

# A NEW TECHNIQUE FOR EVALUATING MERCURY ANOMALIES

### S.L. Shvartsev

United Institute of Geology, Geophysics and Mineralogy SB RAS, Tomsk, Russia

A new geochemical method for evaluating ecological and ore mercury anomalies will be presented. The basic principles of the method are based on the development of the chemical composition of water from its equilibriumnonequilibrium state due to water-rock reactions. Analyses were made of some 150 samples of underground waters occurring in carbonates and in zone of jointing within the weathering crust of volcanogenic sedimentary rocks in the basin of middle stream Katun (Gorny Altaj). An intensive water-rock exchange leads to the formation of weakly alkaline hydrocarbonate calcium waters with a total mineralization up to 0.6 g/l. Hg-analyses were carried out using an AYP-01 atomic-absorption unit with a sensitivity of  $0.1 \times 10^{-2}$  mkg/l. The dissolved mercury content in waters varies from concentrations below 0.01 mkg/l up to 0.27 mkg/l, with an average of 0.03 mkg/l. Taking into account the fact that by dissolution of rocks mercury is distributed between solid and liquid phases depending on the contents of secondary products, characteristics of the geochemical environment, the nature of migration, and the composition the phases formed, were calculated by thermodynamic methods.

The primary secondary minerals formed are kaolinite, hydromica and calcite. In the studied area, aluminosilicate rocks form from 2/3 up 3/4 of the fine-grained fraction and from 1/3 up to 1/4 enter solution. The data obtained data are the basis for the calculation of the mercury balance in the bedrock-water-secondary mineral phase system and for the utilization of a volumetric - genetic method of determining hydrogeochemical anomalies. The results indicated that base (background) contents reflect the degree of water-rock interaction in the specific hydrogeological and landscapeclimatic conditions. Where mercury contents are higher than background, additional sources are postulated which in majority of cases are represented by various ore minerals. Consequently, such above-background mercury concentrations are direct indications in ore body exploration.

# ENVIRONMENTAL GEOCHEMISTRY -GEOCHEMICAL EXPLORATION: LINKED PRINCIPLES AND PROCESSES; CONTRASTING PROBLEMS AND SOLUTIONS

**Frederic R. Siegel<sup>1</sup> and Joseph H. Kravitz<sup>2</sup>** 1 George Washington Univ., Washington, D.C. USA 2 Office of Naval Research, Arlington, Virginia USA

"Anomalous" concentrations of one or more chemical elements or compounds in an ecosystem can be natural and/or the result of human actions. Elements most studied are heavy metals (Cd, Co, Cr, Cu, Fe, Ni, Pb, V and Zn), As and Hg, and process determinants (Al, Ca, Fe, Mn and S). They may signal rock type(s), mineral or energy resource(s), agricultural areas, or geographically proximate mining and/or industrial operations that emit gaseous, particulate and fluid effluents into the ecosystem. High (or low) element concentrations from natural and/or human activities establish environments with toxicity potential from their excess (or deficiency) element contents. These pose health risks to plant, animal and human populations via ingestion (or lack thereof) through the atmosphere, the food web and water.

Chemical element or compound concentrations in ecosystem materials and their bioavailability can be enhanced or decreased by site conditions that affect mobility (dispersion), precipitation and complexation. These can be changing pH and/or Eh, organic matter content and state, chemical concentrations and forms of metals, adsorption onto or desorption from active particle surfaces, flow regimes and other factors that affect samples. Biomagnification can be an important factor. It is influenced by species, age, moisture and the accumulator or discriminator response to pollutants in the growth environment.

Recognition of such processes allows a better assessment of how to proceed in a mineral exploration project to find the source area(s) of chemical anomalies and further define a prospect. It also directs design solutions for identified environmental problem sites and at contaminant source(s). Process recognition is basic for project pre-planning to prevent environmental intrusion by potentially toxic elements and compounds. Some examples are given from ongoing research in terrestrial, wetlands, and marine systems in the Arctic, Africa and the Middle East.

# APPLICATION OF PLATINUM GROUP ELEMENT AND LEAD ISOTOPE GEOCHEMISTRY TO THE STUDY OF THE CORROSION PRODUCTS OF ARCHAEOLOGICAL ARTIFACTS TO CONSTRAIN PROVENANCE.

### Willem Snoek<sup>1</sup>, Tony Sogona<sup>2</sup> and Ian R. Plimer<sup>1</sup>

1 University of Melbourne, School of Earth Sciences

2 University of Melbourne, Department of Classics and Archaeology

Corrosion rinds on copper and copper-alloy archaeological artifacts were studied to determine whether this rind could be used instead of the valuable metal core to provide information relating to the provenance of the ore and the development of metallurgy in the early Bronze Age. Metal core and corrosion rind from four corroded copper artifacts from Tell Ahmar in Syria were analysed for platinum group elements (Pd, Pt, Ir and Ru) and gold via NiS fire assay, preconcentration radiochemical neutron activation analysis (RNAA), and for Pb isotopes via thermal ionisation mass spectrometry (TIMS). The Pb isotopic signature was indistinguishable for all four samples, suggesting that the copper used came from a single ore deposit in Cyprus. The Pb isotopic signature for the Tell Ahmar artifacts and their associated corrosion products range between 2.075 to 2.085  $^{208}$ Pb/ $^{206}$ Pb and 0.833 to 846  $^{207}$ Pb/ $^{206}$ Pb, while the Cypriot Pb isotope field ranges between 2.067 to 2.085 <sup>208</sup>Pb/<sup>206</sup>Pb and 0.833 to 0.847  $^{207}$ Pb/ $^{206}$ Pb. The data suggests that the corrosion products of an artifact can be used to identify the

source ore deposit as both the metal and associated corrosion have the same or similar Pb isotopic signature.

Additionally, synthetic artefacts were produced by smelting examples of Australian ore bodies and artificially corroded in order to determine whether selected geochemical elements, ratios and isotopes could be used as tracers in provenance studies. In particular, the platinum group metals, gold, silver, cobalt and nickel in the ore, smelted copper produced from the ore, and the associated corrosion, were determined. The PGEs were selected for trace element studies because, although in copper ores they are only present in the parts per trillion to parts per billion range, they are chalcophile and spatially and petrologically associated with copper minerals in most ore deposits. During smelting to produce the copper, the PGEs do not fractionate and so follow the copper into the melt. Gold, silver, cobalt ant nickel, like the PGEs, also partition strongly into the melt, regardless of smelting method. The PGEs are the preferred elemental indicators to study the provenance of copper rather than base metals because base metals are less strongly, and variably, partitioned into the blistered copper melt and may also be volatilised. Preliminary investigations suggest that chondrite normalised PGE patterns, coupled with Pb isotopic ratios and base metal data, may be useful in determining the provenance of archaeological artifacts.

### **RADON DETECTION IN CAVES OF RUSSIA**

# E.A. Solomatina and A.P. Karpinsky

All-Russian Geological Research Institute (VSEGEI), St. Petersburg, Russia

Measurements of radon in natural and man-made caves and of radon concentrations in underground workings in non-radioactive mineral deposits, show that the process of radioactive gas accumulation is very intensive.

In the man-made Sablino Caves (Leningrad Region) with general radioactivity of rocks ranging from 12 to 45 mkr/hr, radon concentrations in quartz sandstones, shales and limestones may be as high as 16,000 - 21,000 Bq/m<sup>3</sup> in halls situated in internal parts of the cave. In halls near entrances, seasonal variations of radon concentrations range from 30 to 2000 Bq/m<sup>3</sup>. In the latter, radon contents at night are three times higher than those in the day time.

In the natural Kapa Caves (Bashkortostan) with gamma activity of 4-15 mkr/hr, the radon content ranges from 16 to 2740 Bq/m<sup>3</sup> depending on the distance of the hall from the entrance, the extent of jointing of rocks, and the presence of large regional faults. High radon concentrations 100-300 times higher than the permissible levels adopted for enclosed spaces were also recorded during the construction of tunnels for the Baikal-Amur Railway, particularly those situated in seismic regions. Tests in coal mines show that in many instances, values of equivalent three D activity of radon exceed those adopted in Russia (310 Bq/m<sup>3</sup>).

Thus, tests carried out in underground cavities of different geological settings indicate that radioactive gases (radon, thoron) accumulated in all cases. Of particular importance in the accumulation of gas are the morphology of cavities, including near-entrance parts of underground workings, microclimate (direction of air flows in different seasons at different times of the day), the extent of jointing of rocks, and fault tectonics.

### MONITORING OF THE TECTONICALLY RELATED RADON FLUX IN ISRAEL

G. Steinitz<sup>1</sup>, U. Vulkan<sup>2</sup> and B. Lang<sup>1</sup>

1 Geological Survey of Israel, Jerusalem, Isarel

2 Soreq Nuclear Research Center, Yavne, Israel

Monitoring (since 1992) the radon (Rn) flux, at radon anomalies in gravel, rock and water, along major tectonic lineaments of the Dead Sea Rift (DSR) was performed, using 3-4 day integration (SSNTD), at the northwestern corner of the Dead Sea over a>15km long sector. Results from 5 to 7 sites covering the sector exhibit: a) a multi-year increase of ~2~fold recorded over three years (1992-94) of monitoring; b) a yearly or annual variations (~360 day cycle, >x10-20), especially evident along faults; c) short-term (7-20 days) Rn flux fluctuations - termed Rn events (RnE) - which are superimposed on the long-term and annual variation at all sites. RnE temporal variations may attain up to 40,000 pCi/l at 1.2 m depth, compared with a "background" of 250 pCi/l. A high correlation (>50%) of RnE occurs over the whole monitored sector implying that the fluctuating radon anomaly system extends at least 15 km along the western boundary of the DSR. Testing for a relation between RnE and earthquakes (EQ) shows a significantly higher temporal correlation between populations of RnE and EQ in the nearby sector (200 km long) of the DSR, compared with other areas. This correlation improves for EQ with magnitudes>2, with confidence levels>87%. This implies a causal relationship between the RnE and EQ in the adjoining sector of the DSR. Mechanical processes, i.e., strain and stress in this sector are presumably involved.

The temporal resolution of the radon flux measurements, was increased (in 1995) by placing three automatic electronic stations, integrating every 10-15 minutes (Nal sensor), next to the main fualt, and a fourth one in a Rn-rich water source. The measurements show small systematic daily fluctuations, possible related to local atmospheric factors, as well as large non-systematic variations lasting one to ten days showing variable patterns (i.e., RnE). Some of the Rn-events were simultaneously recorded at all 4 electronic stations (along fault and in water). Some of the high temporal resolution Rn measurements show close time relations with EQ. This corroborates the finding using the SSNTD method and indicates the complexity of the processes controlling both the release of Rn at the source and its transport to the surface.

### AN INTEGRATED G.I.S. APPROACH TO UNDERSTANDING GEOCHEMICAL DISPERSION WITHIN THE LATERISED TERRAIN OF SOUTHEAST MALL

### A.D. Stewart, C.J. Moon, M. Langford and P.F. Fisher University of Leicester, University Road, Leicester, LE1 7RH, England

This study uses an integrated Geographical Information System (GIS) for interpretation of initial regional geochemical soil samples within an undulating and laterised environment. This approach provides an advance in mapping and understanding geochemical dispersions.

The study region extends over an area of 65 x 120 km in SE Mali, West Africa, including the Syama Mine, and is underlain predominantly by lower Proterozoic, Birrimienaged lithologies. In the west, lithologies are a volcanosedimentary melange, plus argillite, greywacke, and conglomeratic units, forming the N-S orientated Bagoe basin, whereas the east is characterised by a granite-gneiss massif. Intruded into these are a number of smaller granitic stocks of variable composition. All lithologies are blanketed by residual laterite, presumed Tertiary in age, which subdue, enhance and distort the geochemical signatures.

By adopting a G.I.S. approach to the study of element dispersion in a lateritic environment, interpretations are no-longer restricted to the traditional two dimensional bivariant data sources of geochemical point data and geology, but can now utilise and integrate additional important and inter-related information to help in the interpretation. These data include topography and slope properties (derived from a DEM), proximity measures, the location of lateritic caps, profile information, lithology, structure and information obtained from the analysis of LANDSAT TM and SPOT imagery. The remote sensed techniques include image classification, band ratioing, P.C.A. and band combination P.C.A. for the identification of hydroxyl-bearing minerals and iron oxides-hydroxides. The advantage of adopting a G.I.S. is that all these themes can be cross-analyzed and algorithmically combined within a single system. This allows a multidisciplinary approach to develop between the study of topography, lithology and laterite whilst establishing the nature and underlying significance of the geochemical patterns.

The work reported here has utilised the Arc/Info and ERDAS Imagine GIS.

### DETERMINATION OF SOIL GEOCHEMICAL ANOMALIES BASED ON PHOTOMETRIC MEASUREMENTS OF VEGETATION

### V.G. Surin<sup>1</sup>, G.A. Ladner<sup>1</sup> and E.V. Kuvaldin<sup>2</sup>

1 Institute of Remote Sensing Methods for Geology, Birzhevoy Proezd, 6, St. Peterburg, Russia

2 Vavilov State Optical Institute, Birzhevaya Linija, 14, St. Peterburg, Russia

The detection of geochemical anomalies is important both for environmental monitoring and exploration, and generally involve expensive chemical methods. A proposed alternative method is based on distinguishing vegetation properties as indicators of soil geochemical anomalies. A new type of field tool was developed, consisting of a five band precise pulse photometer with a built--in light source. The instrument yields a accuracy of reflectance measurements (more then 1%). This technique was tested at the North Ladoga Lake region on the Colchedan ore deposit which is characterized by low contrast geochemical anomalies. We chose a number of sensitive types of arboreal vegetation: birch, alder, willow, old and yound firs.

Measurements of reflectance in various bands (R - number of bands) were made on fresh leaves stacked in ten layers in four spectral bands: 1 - 0.3-0.63 mm, 2 - 0.63-0.8 mm, 3 -0.8-1 mm, 4 - 1-1.175 mm. A photometric scale of vitality V1.3=R1/R3 (index of vitality) was developed for primary classification plots according to the intensity of geochemical pollution. Then we have made data classification (V1.3) for four bands in more details.

A combined analyses of soil geochemical pollution and vegetation state were made. and yielded a plot showing two groups: higher concentration of ore elements, and lower concentration of biophile elements. We obtained objective indicators of biological stability of chlorophyl destruction by a study of the R1 band reflectance as a derivative function  $(\lambda R1/\partial V1,3)$  of the vitality index for various types of plants. The stability number was as follows: fir (more stable), birch, alder and willow (less stable). Qualitative and quantitative features of stress phenomena for various types of plants caused by geochemical pollution were indicated.

### ECOGEOCHEMICAL INVESTIGATIONS OF URBANIZED AREAS IN LITHUANIA

### **Ričardas Taraskevičius and Rimanté Zinkuté** Institute of Geology, Vilnius, Lithuania

Ecogeochemical investigations in urbanized areas of Lithuania began in 1985 in Vilnius, over an area of some 260 km<sup>2</sup>. Samples were taken (at a scale of 1:100,000) of approximately 670 topsoils, as well as 350 snow-cover samples, and 100 stream sediments. These were analysed by DC Arc Emission Spectrometry and XRF for the determination of 29 trace metals.

At present, we have at our disposal ecogeochemical data (including Cd and Hg in some samples) of more than 6,000 topsoil samples of Vilnius. These were collected in areas containing over 60 industrial sites (scale of 1:2,500), in areas

of municipal solid waste landfill, certain areas of housing which include industries (scale of 1:10,000), and in the remainder of the area, including recreation sites (scale of 1:25,000). In addition to Vilnius, the following towns were also investigated in sufficient detail: Kedainiai - 425 topsoil samples; Siauliai - 1,900 samples, including six industrial sites; Panevezys - 2,444 samples, including fifty-two industrial sites; Alytus - 800 topsoil samples. Stream sediments, snow cover, plants (and their fruit) were also analysed in some towns.

Statistical methods were applied to the resulting data, and mono-element and multi-element ecogeochemical maps were drawn in comparison with (1) the local pedogeochemical background and (2) sanitary and phytoxical limits.

# METAL OCCURRENCE IN SOILS DEVELOPED ON BASALTIC BEDROCK: THE INFLUENCE OF RAINFALL

Nadya Teutsch<sup>1</sup>, Yigal Erel<sup>1</sup>, Ludwik Halicz<sup>2</sup>, and Oliver A. Chadwick<sup>3</sup>

1 Institute of Earth Sciences, The Hebrew University of Jerusalem, Jerusalem , Israel

2 Geological Survey of Israel, Jerusalem, Israel

3 Department of Geography, University of California Santa Barbara, Santa Barbara 93106 CA, USA

The effect of differences in rainfall patterns on Mn, Fe, Cu, Zn, Pb, and Ti behavior in soil profiles developed on basaltic bedrock of the same age was studied in a detailed transect on the southwest slope of Kohala mountain, Kohala peninsula, Hawaii island. Total and acid-leached concentrations of soil and bedrock samples were analyzed. Mass transport calculations yielded the amounts accumulated or depleted in the soil relative to the bedrock. In addition, element mobility and the distribution between the labile and the residual fraction were examined.

Based on mass transport calculations, there is no significant effect of rainfall amount in the dry sites (3 sites, 160 - 570 mm/yr) on the accumulation or depletion of all elements (with the exception of Cu) within the soil. In the intermediate (4 sites, 930 - 1380 mm/yr) and in the wet (1 site, 2500 mm/yr) sites, most metals show a strong rainfall effect. The extent of rainfall effect varies from one element to the other, but there is a general trend of less accumulation and more leaching from the soil with increasing amounts of rainfall. Iron is enriched slightly in all sites and the enrichment decreases in the intermediate rainfall sites. Except for the rainy site, titanohematite is the main host mineral of Fe in the soil. Manganese behavior in the soil is strongly affected by rainfall. Mn is accumulated in the soil probably as Mn-rich oxides which undergo reductive dissolution with increasing rainfall amounts. The rainfall effect on Zn in the intermediate and wet sites is similar to that of Mn. Unlike all other elements, there is less accumulation of Cu with increasing rainfall in the dry sites, but there is no effect in the intermediate and wet sites. Lead is remarkably enriched in all the sites and in general the enrichment increases with increasing rainfall. The ratio
$([M_{leach}] / [M_{total}])$  was found to be a good measure for the lability and the mobilization of an element in the soil profile (except Zn). The lability of the studied metals in the Kohala soils decreases in the order Mn (23%) > Pb (18%) > Cu (14%) > Fe (7%) = Zn (7(% <Ti (0.6%). In the most rainy site (M), the order of lability is entirely different. Nevertheless, the relative mobility of the oxide forming metals, Mn > Fe > Ti, is consistent in all the profiles. The behavior of Pb, Zn, and Cu in the soil are affected by the different phases they are associated with. Lead is adsorbed and coprecipitate mostly with am-Fe(OH)<sub>3</sub>, Zn is mostly associated with organic matter, Mn oxides, and am-Al(OH)<sub>3</sub>, while Cu is primarily bound to organic matter.

# STREAM SEDIMENT EXPLORATION FOR GOLD AND SILVER IN NEVADA - APPLICATION OF AN OLD PROSPECTING METHOD USING MODERN ANALYTICAL TECHNIQUES

#### J. V. Tingley and S.B. Castor

Nevada Bureau of Mines and Geology; University of Nevada; Reno, Nevada, USA

The Nevada Bureau of Mines and Geology has completed a mineral resource assessment of the Nellis Air Force Ranges (NAFR), an area of 12,500 km<sup>2</sup> in southern Nevada that has essentially been withdrawn from mineral entry since the 1940s. The NAFR is mainly underlain by Proterozoic and Paleozoic miogeoclinal rocks, Tertiary volcanic rocks, and Quaternary continental deposits. It contains more than twenty historic mining districts with known, but minor, gold and silver production. Most of the mineralization is hosted by Tertiary volcanic rocks and includes both low sulfidation and high sulfidation types. Assessment of potential for metallic mineral deposits in the NAFR was carried out using background rock sampling, and remote sensing, followed by examination and sampling of historic mining districts and altered areas. Geochemical analyses were performed by INAA, ICP-ES (with organic extraction), and AA methods. Silt and float chip sampling were selected as the most efficient methods following a pilot stream sediment sampling study in regional mining districts that also included analyses of panned concentrates. Threshold values for anomalous samples were determined from background rock samples. Float chip samples, which consist of small fragments of visibly mineralized and altered rock (generally limonitized and silicified rock) collected from stream sediment sampling sites, were determined to be the most effective in the differentiation of favorable areas for gold and silver deposits. Ag, As, and Au were present in anomalous amounts in dry stream beds that drain most of the areas in the NAFR that were determined to have high precious metal potential on the basis of subsequent rock sampling. Hg, Mo, and Te were also found to be effective precious metal pathfinders in many cases. Silt sampling was clearly less effective, but was found to be useful in combination with float chip sampling. Ag, As, and Au appear to the best indicators of potential in silt samples. On the basis of this work, combined silt and float chip sampling is recommended for gold and silver exploration in Tertiary volcanic rocks.

# ADSORPTION OF ZINC ONTO PEAT FROM PEATLANDS OF POLAND AND ISRAEL

Irena Twardowska<sup>1</sup>, Yoram Avnimelech<sup>2</sup>, Joanna Kyziol<sup>1</sup> and Tal Goldrath<sup>2</sup>

1 Polish Academy of Sciences, Institute of Environmental Engineering, 41-819 Zabrze, Poland

2 TECHNION - Israel Institute of Technology, Haifa 32000, Israel

Peat, defined as a young Quaternary, mainly Holocene, organogenic sedimentary rock in the first stage of coalification, has received increasing attention due to the potential to act as an ubiquitous effective agent either for the removal of metal ions from dumping site leachate and wastewater or for retrospective monitoring of their migration and accumulation in the environment. For these purposes, adsorption capacity and binding strength of peat with respect to different metal ions under different conditions, as well as the mechanism of binding, should be thoroughly known. To date, this knowledge is still limited. Both Poland and Israel have peat deposits of various types. In Poland, in over 49 thousand peatbogs predominantly of the lowmoor type (89%) over a total area of 13x10<sup>6</sup> hectares, peat resources have been estimated at ~18x10<sup>9</sup> m<sup>3</sup>. In terms of their genesis, Rush Reed-Sedge and Alder peat of different fiber contents prevail.

We present results of studies on adsorption/desorption properties of representative peat samples for zinc, which is one of the most mobile trace metals in the environment. Three representative lowmoor Polish peat samples from the Wizna peatbog, two peat samples from the Hula Valley, Israel, as well as fresh humic sewage sludge and compost, were tested. The experiments were performed by applying a zinc solution (pH 5.5 and 4.0) on the either untreated or pretreated material by adjusting pH values to those of the input solution (pH 5.5). The batch studies were performed for  $Zn^{2+}$  in single cation and binary systems (Zn-Cd). Column experiments under saturated flow conditions at pH 4.0 and  $Zn^{2+}$  concentrations of 250 and 500 mg/dm<sup>3</sup> in input solution (single component system) were also conducted. Finally, batch and column zinc adsorption experiments on the selected peat samples were carried out using real multi-component wastes from the electroplating process. The zinc desorption rate at different pH values adjusted by HCl was also evaluated.

To assess the binding strength of peat with respect to zinc, sequential extraction was applied in order to identify the bonding of the metal to the adsorbents. The adsorption capacity for zinc of lowmoor Polish peat which is typical of the northern hemisphere with pH 6.21-6.45 was 29,510 to 32,700 mg Zn/kg. Lower values were found for the Hula peat and fresh humic compounds. The presence of equivalent amounts of Cd showed moderate influence on the uptake of Zn by different peat, suggesting weak competition of metal ions for adsorption sites available, despite the binding of these metals in similar ratios in the same most labile fractions. There was, however, a difference in the binding of

Zn and Cd in the more stable fractions where no competition between Zn and Cd occurred. Desorption experiments proved that zinc can be released with acid treatment.

The data presented are part of a larger joint Israeli-Polish project, supported by US AID-CDR Grant No. TA-MOU-C12-050.

# POLLUTION OF CZECH FRESHWATERS BY TRACE ELEMENTS

#### Josef Vesely and Vladimir Majer

Czech Geological Survey, 118 21 Prague 1, Czech Republic

Pollution freshwater and river sediments by trace elements were investigated in the Czech Republic. Samples of river sediments (n=298) were analyzed for up to 65 elements using AAS, XRA and NAA; samples of surface waters (n~14,000) were analyzed by GAAS, FAAS and HPLC.

A majority of Czech rivers are polluted by Ag, As, Au, Bi, Cd, Cu, Hg, P, Pb, Sb, Se and Zn whose median concentrations are more then twice average concentrations of these elements in shales. Maximum concentrations found were often very high: Ag (37 mg/kg), Cd (69 mg/kg), Hg (28 mg/kg), Pb (2200 mg/kg), Sb (203 mg/kg). Some rivers were also strongly polluted by U (146 mg/kg), Sn (185 mg/kg), Be (51 mg/kg) and Cr (1030 mg/kg). Pollution of rivers results from discharge of industrial waste waters and historic mining activity (e.g., As, Pb, U and Sb). The later type of pollution is important in the western part of the country (Bohemia) where uncontaminated lake and overbank sediments are older than 500 years.

Concentrations of Be, Cd, Zn and Mn are higher in freshwater of streams acidified by long-range transport of S and N compounds. High concentrations of As were observed in freshwaters in the vicinity brown coal burning power stations and in regions were oxidation of arsenopyrite occurs. Variability of trace elements contents was investigated by principal factor analysis. Variability of Sr and F in waters depends on bedrock and groundwater influence; pH values affects concentrations of Be, Cd, Zn and Mn; the content of organic matter affects concentrations of Pb, Cu, Zn, Fe and Cd; and sorption of Fe-oxyhydroxides explains to a large extent the variability in the contents of As. In river sediments, heavy metals (Zn, Pb, Cd, Hg, Cu, Sb, Bi) are mostly bound as sulfides, while variability of REE, Th. Y. Zr. Hf, Nb and Ta depends on the presence of heavy minerals (monazite, zircon and titanite).

The results of principal factor analysis, maps of concentrations of selected trace elements both in freshwater and river sediments will be presented. The history of pollution will be demonstrated on changes of metal concentrations in lake and overbank sediments with time.

# GEOCHEMICAL MERCURY SURVEY IN THE AZOGUE VALLEY (BETIC AREA, MIRCIA, SE SPAIN)

#### M. Viladevall<sup>1</sup>, X. Font<sup>1</sup> and A. Navarro<sup>2</sup>

1 Dep. Geoquimica Petrologia I Prospeccio Geologica, University of Barcelona, Spain.

2 Dep. Mecanica de Fluidos, Polytechnic University of Catalonia, Spain

Mercury vapor haloes were detected in a geochemical survey in an old mine exploited for mercury at a 19th century site in Azogue Valley (Betic zone) near Aguilas (Murcia, SE Spain) using a Jerome 431-X mercury vapor analyzer. Anomalous Hg was also identified in the soil using INAA.

The strong mercury-anomalous area is related to a lode hosted in low-grade metamorphic Permo-Triassic schist and dolomite, with no spatial relationship to the Tertiary regional volcanism of the Betic orogenic belt.

Recent studies reveal high contents of Hg, Ag, Au, Sb, As and Ba, suggesting the existence of a deposit extending for up to 1 km in length, similar to "hot spring" type epithermal deposits with very high mercury and gold values. The mercury anomalies outline and mark an enrichment zone at the fault - lode intersection.

From a geochemical point of view, this survey clearly proves the effectiveness of the mercury vapor method, revealing the existence of an epithermal deposit and suggesting its usefulness in similar deposits of the area and also in the search for other types of deposits.

# BIOGEOCHEMICAL EXPLORATION USING THOLAS IN THE ANDEAN HIGHLAND (BOLIVIA AND ARGENTINA)

M. Viladevall<sup>1</sup>, J. Ponce<sup>2</sup>, R. Santivanez<sup>2</sup>, J. Saavedra<sup>3</sup>,

I. Queralt<sup>4</sup>, S. Lopez<sup>5</sup> and R. Arganaraz<sup>5</sup>

1 University of Barcelona, Spain

2 University Mayor de San Andres, La Paz, Bolivia

3 CSIC, Salamanca, Spain

4 CSIC, Barcelona, Spain

5 University of Salta, Argentina

Pilot biogeochemical prospecting was carried out using a type of vegetation known as *tholas* (*Bacharis incarum* Weddell, *Parastrephia leptophyla*, *Baccharis leptophyla* and *Fabiana densa*), within siliciclastic materials of the saddle reef-type Sb-Au ores (Antofagasta mine), in placer gold deposits near the La Joya gold district (Caracollo), in the Khollpana formation of the Bolivian highland. The same type of vegetation (*Bacharis incarum* Weddell) was used in the tuffaceous volcanic rocks hosting the epithermal and mesothermal ore deposits near the Poma and Concordia mines (San Antonio de los Cobres) in the Argentina Highlands.

Gold and antimony in *Thola* leaf occurs within the saddle reef type Sb-Au ores mainly on the western flank of the anticline. Factorial analysis show a "gold" factor, which as far as we could observe, is only present when the stratum is enriched with this element.

In the Khollpana Formation of Bolivia, most gold-bearing *thola* leafs are located around the old Spanish works. In the

Argentinean epithermal and mesothermal deposits, the *thola* leafs show Cs-Sb anomalies in argillitic and silicified zones, and Pb-Zn anomalies in the chlorite zone.

In all three sites, *thola* leafs were an excellent tool for geochemical prospecting for gold, antimony, arsenic, lead and zinc in the Andean highland because they reflected the substratum composition and, therefore, its mineralization. Furthermore, this method can replace geochemical prospecting of soils.

We are indebted to the Commission of the European Community for the Cl1-CT90-0784 and the CE93-0021 contracts.

# RESULTS FROM THE MULTIDATASET ANALYSIS FOR THE DEVELOPEMENT OF METALLOGENETIC/ECONOMIC MODELS AND EXPLORATION CRITERIA FOR GOLD DEPOSITS IN WESTERN EUROPE (MIDAS PROJECT): THE CATALONIAN COASTAL RANGES (NE SPAIN) APPLICATION

M. Viladevall, J.M. Carmona, X. Font and D. Perez Dep. Geoquimica Petrologia I Prospeccio Geologica (University of Barcelona), Spain

The main objective of the "Midas" project in the Catalonian Coastal Ranges (C.C.R. - NE Spain) was to determine the potential for gold deposits. Our starting point is the presence of major anomalies of Pb-Zn-Cu-As of exhalative-sedimentary origin in Caradocian and Silurian rocks of the Montseny massif and the presence of free gold in the alluvium of the Tordera River (NE of Barcelona), located in this same massif. Likewise, the presence of Zn-Pb-Cu ores in Cambro-Ordovician units of the Montseny-Guilleries massif (similar origin) and the strong geochemical anomalies of bismuth in the late-Hercynian granites of these massifs, pass to a series of anomalous lineations trending NW-SE, N80°E and N110°E.

The research aimed at locating possible gold mineralization of two models: (A) the "classical" model of saddle-reef structures within turbidite-hosted gold deposits (THGD); and (B) Gold deposits developed on the margins of Late-Hercynian granitic intrusions (granite-related gold deposits, or GRGD) like those of Moskro in the Bohemia massif in the Republic of Czechoslovakia.

On the basis of these models, it was possible to define areas of THGD and granite-related (GRGD) mineralisation in the Catalonian Coastal Ranges. Successful geochemical follow-up surveys demonstrated the validity of these models and allowed for further investigations in unknown potential gold-bearing areas.

We wish to thank the Commission of the European Community for the MA2M-CT90-0009 (SMA) contract.

# THE RATE OF MIGRATION OF A URANIUM DEPOSITION FRONT: AN EXAMPLE FROM THE UITENHAGE AQUIFER

J.C. Vogel<sup>1</sup>, A.S. Talma<sup>1</sup>, T.H.E. Heaton<sup>2</sup> and J. Kronfeld<sup>3</sup> 1 Environmentek, CSIR, P.O.Box 395, Pretoria, South Africa 2 NERC Isotope Geosciences Laboratory, Keyworth, Nottingham, UK 3 Department of Geophysics and Planetary Sciences, Tel Aviv University

238U-series isotopes were measured in the water of the fractured Ordovician quartzite aquifer of the Table Mountain Group near the town of Uitenhage. The age of the groundwater in this artesian aquifer increases systematically down flow from recent to 28,000 years. Uranium isotopes in the water are used to determine the present position of the reducing barrier within the Uitenhage aquifer. The solubility of uranium is very sensitive to redox changes. As the concentration of dissolved oxygen decreased within the confined the parts of the aquifer the uranium concentration in the water decreased and the 234U/238U activity ratio rose by alpha- recoil inputs. Radium and radon in the water can be used to indicate the migration path that the zone of oxygen depletion has followed over the past 105 years.

During this time, it noted that the reducing barrier must have moved. As it did so it left behind a trail of precipitated uranium on the aquifer walls in various stages of equilibrium with its daughter 230Th. The 226Ra daughter of 230Th is not very mobile. It mostly has been generated within the aquifer, for, its half-life(1620 years) is short compared to the age of the groundwater. Its growth upon the aquifer wall is reflected in the radon content of the water. This in turn indicates the degree to which 230Th in-growth was established, as a function of time, before the redox barrier migrated.

# DISTRIBUTION AND ABUNDANCE OF MOBILE FORMS OF METALS IN DIFFERENT SETTINGS AND THEIR IMPLICATIONS FOR MINERAL EXPLORATION IN CONCEALED TERRAINS

Xueqiu Wang, Zhizhong Cheng and Dawen Liu Institute of Geophysical and Geochemical Exploration, Langfang, Hebei 065000, China

Leaching of mobile forms of metals in overburden have been widely used for the search for concealed deposits in China's diverse overburden terrains in recent years and a large number of data have been accumulated. In this presentation, the distribution and abundance of mobile forms of metals in different geographic and geologic settings have been statistically investigated. Case history studies from different climate and geographic settings show that:

(1) Mobile forms of metals in overburden occur not only as ionic or complex metals chemically or physically absorbed on exchangeable, or bound with, iron and manganese oxides, clay minerals, colloidal particles, soluble salts, carbonates and suspended matter, but also as ultrafine particles (submicron to nanometer) physically absorbed onto them. (2) In temperate alluvium terrains, water-extractable and absorbed or exchangeable forms of metals make up a large proportion and can show the most prominent expression of concealed mineralization.

(3) In arid desert sand terrains, water-extractable metals and absorbed onto oxides make up a large proportion of total content and can demonstrate the most remarkable indications of mineralization.

(4) In cold grasslands, organically bound and waterextractable metals make up a large proportion and can give a significant response to mineralization at depth.

(5) In subtropical and tropical laterite terrains, waterextractable metals (Au, Hg) absorbed or exchangeable metals (Cu, Pb) make up a large proportion and can give significant indications of mineralization at depth.

Our case history studies surprisingly showed that water-extractable gold makes up a large proportion of total mobile forms of gold and usually give the most significant indication to gold mineralization at depth in any geographic settings. The contrast between anomalous and background concentration of metals can be maximized through the use of selective leaching of different mobile forms of metals from the host minerals in different settings and the leached product of mobile forms of metals can be successfully used for the search for deeply buried mineralization.

#### **REGIONAL GEOCHEMICAL EXPLORATION IN DEEPLY WEATHERED AND DESERT TERRAINS**

# Xueqiu Wang, Dawen Liu, Zhizhong Cheng and Xuejing Xie

Institute of Geophysical and Geochemical Exploration, Langfang, Hebei 102849 China

There are large desert overburden terrains in China that still remain to be surveyed by cost-effective surface geochemical methods. However, conventional geochemical methods are ineffective for concealed deposits in this kind of overburden terrains. New geochemical methods - the nanoscale metals in earthgas (NAMEG) and mobile forms of metals in overburden (MOMEO) have been widely tested in known deposits and used both in regional and detailed surveys. In this presentation the case history studies from the world-class Olympic Cu-U-Au-Ag deposit, Australia, in deeply weathered terrain, and the giant Muruntau gold deposit, and Southern Xinjiang, China, in desert terrains, are given.

1. Muruntau

Regional orientation surveys were carried out across the giant Muruntau gold deposits and extending into background areas at 5-10 km intervals along accessible roads. The results show NAMEG and MOMEO Au, As and Sb coexist around the Muruntau and Kokpatas gold deposits. High values of Au coincide above the two giant deposits.

2. Olympic Dam

A regional survey was carried out in the Olympic Dam Cu-U-Au-Ag deposit. This study was specifically designed to investigate the possibility of this method for giving a response to the deep-seated deposit covered by post-mineral sedimentary rocks and a deeply weathered terrain where conventional surface geochemical methods are not likely to be used. The results show that large-scale anomalies of MOMEO Cu, Au and Hg, and NAMEG Au, Hg, Ta and Ir around the giant Olympic Dam Cu-U-Au-Ag deposit have been delineated. The highest values of Hg are directly over the deposit.

3. Xinjiang

A regional survey at sample spacing of 10 km has been carried out around the edge of Tarim desert basin, Southern Xinjiang. Significant anomalies of Au and associated elements have been delineated both in the known gold deposits and in un-explored areas.

The case history studies allow us to draw the following conclusions: Large regional anomalies obtained by NAMEG and MOMEO exist around large or giant ore deposits or metallogenic belts. Methods focusing on them can be used to detect stronger geochemical patterns for the discovery of giant ore deposits beneath deeply weathered and desert overburden terrains. NAMEG and MOMEO surveys give significant response to deep-seated mineralization. The cover does not mask the mineralization indicators at surface. Use of both NAMEG and MOMEO can yield more reliable information generating from the deeply buried mineralization.

# A STUDY OF THE MEASURING OF IONIC CONDUCTIVITY OF SOIL IN SEARCH FOR CONCEALED ORE DEPOSITS

#### Luo Xianrong

Guilin Institute Technology, 12 Jiangan Road Guilin Guangxi, China

The ionic conductivity of soil (ICS) was systematically measured to determine involving halo-forming mechanisms, working methods, application conditions, quantitative discriminant analyses for true or false anomalies, possibilities for locating concealed ore deposits, and proficiency for prospecting.

It was found that the formation of ICS anomalies is not a simple transitional process of soil geochemical anomalies but four complicated physicochemical processes dominated by geoelectric chemistry. After analyzing ionic components of the ionic conductivity anomalies, we found that ICS substantially reflects several chemical components controlled by a fixed group of ions,

and that ionic components remained unchanged under various geological or geochemical conditions while ionic contents of ICS changed.

An idealized model formation of ICS anomalies was established. ICS measurements were applied in Au, Ag, Cu, Pb, Zn, W, Sn, Fe, etc. ore-bearing regions and was found to be effective not only in ore zones but also in some regions where several anomaly targets were discovered. Some concealed ore deposits have been found successfully by the method.

# REGIONAL ORIENTATION OF NEW GEOCHEMICAL METHODS FOR DELINEATING LARGE GEOCHEMICAL PATTERNS AROUND THE GIANT DEPOSITS IN THE CENTRAL KYZYLKUM DESERT TERRAIN, UZBEKISTAN

# Xuejing Xie<sup>1</sup>, Xueqiu Wang<sup>2</sup>, Li Xu<sup>1</sup>, A.A. Kremenetsky<sup>2</sup> and V.K. Kheifets<sup>3</sup>

1 Institute of Geophysical and Geochemical Exploration, Langfang, Hebei, 102849 China

2 Institute of Mineralogy, Geochemistry and Crystal Chemistry of Rare Elements, Moscow, Russia

3 Geological and Geophysical Research Center, Tashkent, Uzbekistan

The use of Nanoscale Metals in EarthGas (NAMEG) and Mobile forms of Metals in Overburden (MOMEO) methods developed at the IGGE, China, have been tested in regional scale geochemical exploration for giant gold deposits in the Kylzylkum desert terrain, Uzbekistan. This study was designed to investigate the usefulness for the delineation of large geochemical patterns around the clan of the known giant deposits of Muruntau in desert terrain. If successful, the methods will be used to carry out surveys for large or giant gold deposits in the Southern Xinjiang desert terrain of China located in the same geological and geographical belt of Tianshan Mountains as Muruntau.

The study area is located in the central Kyzlkum desert of Uzbekistan, one of the world's largest gold ore provinces. The province geologically and tectonically belongs to the South Tiang Sheng (Tianshan Mountains) Hercynean belt. The ore-hosting rocks are Proterozoic black shales. Over 80 % of the area is covered by Palaeozoic and Mesozoic sedimentary rocks including carbonates, dolomites, sandstones and shales overlain by desert sand with a thickness of several meters to tens of meters. The thick sequence of overlying sedimentary rocks and desert sand masks both the ore-hosting black shales and mineralization from conventional geochemical exploration methods. Overburden drilling can be used to collect geochemical samples from bedrock and to accomplish rudimentary geological mapping and geophysical methods can be used to delineate the ore-hosting rocks. However, drilling and geophysical operations are very expensive, and produce a relatively small amount of information. Thus low-cost and efficient geochemical methods which can rapidly cover a large area are needed in this kind of difficult terrain.

NAMEG and MOMEO orientation surveys were carried out in the central Kyzykum desert by the IGGE (China) in cooperation with the GGRC (Uzbekistan) and IMGRE (Russia), along two long profiles across the known gold deposits and other short profiles, totaling over 1000 km in length. Gas and soil samples were collected at 5-10 km intervals along accessible roads across the Muruntau, Kokpatas and Amantau gold deposits and extending into background areas. Soil samples were collected from a depth of 20-30 cm where the soil is more cemented and harder than the overlying loose materials. The upper loose sand was scraped away to reveal the cemented and hard horizon so that contamination would be avoided as much as possible. Gas samples were collected from a depth of approximately 60 cm just beneath the hard layer. Determinations of metals in earthgas are made by INAA for Au, Ag, As, Sb, Hg, Br, Cr, Fe and Co. determinations of soil samples after the leach of mobile forms of metals were made by AAS for Au, Ag, Cu, Pb, Mn, and by Atomic Fluprescence Specytrometer for As, Sb and Hg. The distribution of Au in earthgas, in water-extractable forms along the N-S profile across the Muruntau and Kokpatas gold deposits shows that high values of Au in gas, water-extractable and absorbed forms coincide above the two giant deposits. High values are also present in the southern area of the Muruntau deposit, which has potential for new gold deposits. Distinct anomalies of As also coincide above the two deposits, but in other areas, the anomalies are not consistant.

# GAMMA-RAY ANALYSIS OF THE SEDIMENTS OVERLYING THE HELEZ AND KOCHAV OIL FIELDS

N.E. Yanaki<sup>1</sup>, D. Ashery<sup>1</sup> and J. Kronfeld<sup>2</sup>

1 School of Geophysics and Astronomy, Tel-Aviv University 2 Department of Geophysics and Planetary Sciences, Tel-Aviv University

A very precise analysis of <sup>40</sup>K, <sup>232</sup>Th, and <sup>238</sup>U in the sediments overlying the Helez and the Kochav oil fields was carried out using a sensitive, low-background gamma-ray spectrometer and a large Ge-Li-detector. Samples were collected at a 5 m depth across Helez and from 4 and 5 m depths across Kochav. Grain-size analysis was carried out and the individual sand, silt, and clay fractions were each radiometrically

measured in addition to the bulk sediment. All of the radionuclides exhibit very similar geochemical behaviour in the soils. They are strongly correlated to the clay fraction and negatively correlated to the sand fraction. A clear negative anomaly is found to exist over the Helez field which verifies a previously reported total intensity gamma-ray halo-type anomaly. A similar negative anomaly is found over the Kochav oil field. The gamma-ray anomaly is due to a depletion in all three radionuclides, and is not due to changes in pedology or lithology. The gamma-ray anomaly coincides with the position a hydrocarbon ( both methane and ethane) halo-type anomaly that had been

noted in the soils in the early 1960s. The interpretation of the hydrocarbon study at the time engendered controversy; for, it predicted additional oil to the north of Helez, in the area that was later to be the Kochav field. Despite the absence of an adequate theory at present to account for a genetic connection between these anomalies and oil reservoirs at depth, the present study suggests that unconventional prospecting techniques may warrant consideration.

# THE CHEMISTRY OF THE DEAD SEA AND THE SURROUNDING THERMAL BRINES

#### Y. Yechieli and I. Gavrieli

Geological Survey of Israel, Jerusalem, Isarel

The Dead Sea is the lowest surface on earth, presently at a level of 410 meters below mean sea level. This terminal lake is one of the most saline lakes in the world with a density of 1.236 g/cc and a salinity of 340 g/l, which is about 10 times the salinity of seawater. The Dead Sea brine is characterized by its Ca-chloride composition  $(Ca/(HCO_3+SO_4) > 1)$ , i.e., enriched in chloride (220 g/l) and depleted in sulfate and bicarbonate. Presently the Dead Sea is saturated to oversaturated with respect to halite (NaCl), gypsum  $(CaSO_4 \cdot 2H_2O)$  and aragonite  $(CaCO_3)$  and is precipitating these minerals.

Two types of brines are found along the western shores of the Dead Sea. Both are characterized by anoxic conditions and contain  $H_2S$  which gives the water their typical odor. These brines are exploited for health spas in several locations. Studies of the isotopic composition of the sulfur show that the sulfide is derived from bacterial sulfate reduction. The two brine types are:

(1) Hydrothermal springs with salinities of about half that of the Dead Sea which emerge close to the shoreline at a temperature of 42-44°C. The ionic ratios of these springs are generally comparable to that of the Dead Sea, though there are several distinctive differences.

(2) Brines found mostly in shallow boreholes with salinities ranging between the hydrothermal springs and the Dead Sea. The temperature of these brines is lower than 34°C. The ionic ratios in these brines are closer to those of the Dead Sea as compared to the hydrothermal springs.

The Dead Sea brines system evolved in the Neogene from seawater by a series of processes which include evaporation, mineral precipitation and water rock interactions (Starinsky, 1974). Throughout their history, additional salt contributions arrived from inflowing surface water and groundwater. Evaporation of the water lead to increased salinity and resulted in the precipitation of gypsum and halite, thereby changing the ionic ratios in the water (e.g., decrease in the Na/Cl and increase in the Br/Cl ratios). During periods of high stands, the concentrated brine infiltrated into the mostly carbonatic country rock, inducing dolomitization of the limestone. This resulted in additional gypsum precipitation and to an increase in the Mg/Ca ratio. At low stands the brines drained back to the Dead Sea and its precursors saline lakes (e.g., the Lisan lake) in a process similar to the present drainage of the hydrothermal springs. The brines in the shallow boreholes are remnants of brines that infiltrated the nearshore sediments during relatively recent high stand (Dead Sea or Lisan) and are currently being washed back to the Dead Sea.

# SULFIDE AND SILICATE GEOCHEMISTRY IN THE BLEIDA ORE DEPOSIT: A GUIDE TO GEOCHEMICAL EXPLORATION

#### Y. Zinbi, B. Maamar, L. Maacha and R. Ziyadi Ona-Polemines-52 Avenue Hassan II Casablanca, Maroc

The Bleida deposit is located in the Bouazer-El Grara inlier of the Anti-Atlas, southern Morocco, about one hundred km south of Ouarzazate. The predominant copper mineralization consists of bornite, chalcopyrite and pyrite. This mineralization is spatially associated with faults and is zoned, with the bornite crystallizing close to the fault, with a central zone of chalcopyrite, followed in the outer zone by pyrite. This zonation has been explained by differences in solubility between the minerals.

Two types of mineralization have been distinguished at Bleida. The first, "North" type, is stratiform and reticulated (8% Cu), and the second, "South" type, forms a stockwork (2 - 3% Cu). Stable isotope studies of the pyrite show two sources for that mineral: regional, biogenic (low  $\delta^{34}$  S) and hydrothermal (high  $\delta^{34}$  S) which relates to the mineralization (Leblanc et al., 1994).

The aim of our study is to distinguish between the biogenic and hydrothermal pyrites using trace element geochemistry. The hydrothermal pyrite is a good indicator for favourable zones of copper-bearing mineralization. A study of the chlorite using the Fe/Fe+Mg vs Mg diagram is used to distinguish between hydrothermal and metamorphic chlorites.

The pyrite was sampled at the Bleida deposit, a separated to obtain a pure phase. Chemical analysis were made by ICP-AES in the REMINEX laboratory (ONA-Mining Pole). Only the Co and Ni contents were found to differ in the "North" and "South" type pyrites. The latter are characterized by a Co:Ni ratio of >1, and the have Co:Ni <1. The higher ratios therefore indicate hydrothermal-type pyrite.

Chlorite associated with the sulfides was analysed by electron microprobe. There is a clear evolution of this ratio from chlorite associated with primary synsedimentary pyrite to that associated with the bornite. This evolution is marked by a decrease in Mg and an enrichment in Fe. The hydrothermal chlorites are thus richer in iron than the metamorphic chlorites.

# LIST OF PARTICIPANTS

(AS OF MAY 15, 1997)

AJAYI R. Taiwo Dept of Geology, Obafemi Awolowo University, Department of Geology, Ile-Ife, Osun NIGERIA Phone: +234 36 230 290 **ANDOR Ladislav** Jerusalem Renaissance Hotel Ministry of Environmental of the Slovak Rebublic, 1 Nam.L.Stura, Bratislava, 81235 SLOVAKIA Phone: +42 1 07 5162133 Fax: +42 107 5162123 Jerusalem Renaissance Hotel BARAKSO John J. 912-510 W. Hastings St., Vancouver, BC, V6B1L8 CANADA Phone: +1 604 684 5133 Fax: +1 604 684 8564 BARR M. John Senior Geochemist, Avmin, 56 Main Street, Marshalltown 2107, Johannesburg, 2001 SOUTH AFRICA Phone: 11 634 9111 Fax: 11 634 0500 **BAVINTON A. Owen** Jerusalem Renaissance Hotel **Bavinton Beverly** Minorco, 43-45 Margit Krt., Budapest, 1024 HUNGARY Phone: +36 1 301 2644 Fax: +36 1 212 5461 **BETTENAY** Leigh F. Jerusalem Renaissance Hotel Principal Geochemist, MIM Exploration Pty. Ltd., PO Box 1121, West Perth, WA, 6872 AUSTRALIA Phone: +61 9 321 4888 Fax: +61 9 321 2866 **BEYTH Michael** Geological Survey of Israel, 30 Malkhe Israel St, Jerusalem, 95501 ISRAEL **BLOOMSTEIN Edward** Jerusalem Renaissance Hotel Bloomstein Elena Director, Central Asia Exploration, Santa Fe Pacific Gold Corp., 153 Abai Ave, Ste 17, Almaty, 480009 KAZAKHSTAN Phone: +7 3272 414 620 Fax: +7 3272 405 813 **BODIS Dusan** Jerusalem Renaissance Hotel Environmental Geochemistry, Geological Survey of the Slovak Republic, Mlynska Dolina 1, Bratislava 8170 SLOVAKIA Phone: +421 73 705 342 Fax: +421 73 371 940 **BOGOCH Ron** The Geological Survey of Israel, 30 Malkhe Israel Street, Jerusalem, 95501 ISRAEL Fax: +972 2 380688 **BONOTTO Marcos Daniel** Jerusalem Renaissance Hotel IGCE/UNESP, Dept. de Petrologia e Metalogenia, Av. 24-A, No 1515, Rio Claro, Sao Paulo, 13506-900 BRAZIL Phone: +55 0195 340 522 Fax: +55 0195 249 644 Email Address: dpm@geo001.uesp.ansp.br **BRENNER B Joe** Dishon Street 9/9, Jerusalem ISRAEL

BRISTOW P.J. Andrew	Jerusalem Renaissance Hotel
Technical Specialists Unit, JCI Ltd, PO Box C566 Cantonments, Accra	
GHANA	
Fax: +233 21 779 051	
Email Address: apjb@ncs.com.gh	
BURTON Paul E.	Jerusalem Renaissance Hotel
Normandy Exploration Ltd, 66 Coonawarra Road, PO Box 38970, Winnellie, NT, 0821 AUSTRALIA	
Phone: +61 8 8984 4554 Fax: +61 8 8984 4565	
CAMERON Eion M.	
Department of Geology, University of Ottawa, Ottawa, ONT, KIN 6N5 CANADA	
Phone: +1 613 996 9129 Fax: +1 613 996 3726	
Email Address: cameron@qsc.nrcan.qc.ca	
CAMPBELL Jain D.	Jerusalem Benaissance Hotel
3/223 Harborne Street. Glendalough WA 6016	
AUSTRALIA	
	lerusalem Benaissance Hotel
Exploration Department, Samax Resources Ltd, PO Box 9098 K.I.A., Accra	oerusalem henaissance hotei
GHANA	
Phone: +233 21 778 707 Fax: +233 21 772 384	
CANTLE John	
Cantle Hannah	
Cantle Susan	
VG Elemental, Road 3, Winsford, Cheshire, CW7 3BX	
UK	
Fax: +44 1606 552 588	
CARVER Richard N.	Jerusalem Renaissance Hotel
Chief Geochemist, Exploration Division (Aust), Western Mining Corp Ltd, 6 Lawley Place, Mt Lawley, WA, 6050 AUSTRALIA	
Phone: +61 619 479 8440 Fax: +61 619 419 8358	
Email Address: geochem@ozemail.com.au	
CASTELO BRANCO A. Maria	Jerusalem Renaissance Hotel
Estacao Agr Nac. Dep. Pedol., Quinta do Marques, 2780 Oeiras PORTUGAL	
Phone: +351 1 441 6855 Fax: +351 1 441 6011	
CASTOR B. Stephen	
Research Geologist, Nevada Bureau of Mines & Geology 178, University of Nevada, Reno, NV, 89557-0088 USA	
Phone: +1 702 784 1768 Fax: +1 702 784 1709	
Earth Crust Institute. St Patershura State University. Universitetekeye Neb. 7/0. St Patershura, 100024	
RUSSIA	
rnone: +/ 812 218 9651 Fax: +/ 812 218 4418	
CHENG Zhizhong	
Inst. of Geoph & Geochem Exploration, 84 Jinguang Hoad, Langfang, Hebei, 065000	
rax. +00 3 10 20400//	
בווומו הטעובשי גובגטפשיטטונט.טומ.וופרטו	

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**CISZEWSKI** Dariusz Park Plaza Hotel, Jerusalem Polish Academy of Sciences, Institute of Nature Conservation, 46 Lubicz Street, Krakow, 31-512 POLAND Phone: +48 12 215144 x 275 or 259 Fax: +48 12 210348 **COHEN Yuval** Israel Oceanographic and Limnological Research, National Institute of Oceanography, PO Box 8030, Haifa, 31080 ISRAEL **DANGIC** Adam Faculty of Mining & Geology, University of Belgrade, Djusina 7, Belgrade, 11000 YUGOSLAVIA Fax: +381 11 4885296 or 182363 **DAVY Richard** Park Plaza Hotel, Jerusalem Davy Frances Geological Survey of WA, 13-B Todd Avenue, Como, WA, 6152 AUSTRALIA Phone: +61 9 367 3248 Fax: +61 9 367 3248 Email Address: r,davy@dme.wa.gov.au or a.sanders@dme.wa.gov.au **DE BRUIN Deon** Council for Geoscience, Private Bag X112, Pretoria, 0001 SOUTH AFRICA Phone: +27 12 841 1273/5 Fax: +27 12 841 1278 Email Address: ddbruin@geoscience.org.za **DEJONGHE** Leon Service Geologique de Belgique, Rue Jenner 13, Brussels, 1000 BELGIUM Phone: +32 2 627 03 50 Fax: +32 2 647 73 59 **DOBUSH M. Tim** Jerusalem Renaissance Hotel Geosoft Inc, 85 Richmond St W, Apt. 8, Toronto, ONT, M5H 2C9 CANADA Phone: +1 416 369 0111 Fax: +1 416 369 9599 **DUNN Colin E.** Head, Geochemical Research, Geological Survey Of Canada, 601 Booth St, Ottawa, ONT, K1A 0E8 CANADA Phone: +1 613 996 2373 Fax: +1 613 996 3726 Email Address: dunn@gsc.emr.ca **DURIS Miroslav** Czech Geological Survey, Klarov 3, Prague, 11821 **CZECH REPUBLIC** Phone: +42 2 590740 Fax: +42 2 581 8748 +42 2 590478 **EL GORESY Ahmed** Jerusalem Renaissance Hotel Max-Planck-Institut for Kernphysik, PO Box 103980, Heidelberg, 69029 GERMANY Fax: +49 6221 516 324 · Email Address: goresy@selket.mpi-hd.mpg.de **EREL** Yigal Department of Geology, Hebrew University, Jerusalem, 91904 ISRAEL Phone: +972 2 658 6515

**FEINSTEIN** Shimon

Geological and Environmental Sciences, Ben Gurion University, Beer Sheva, 84105 ISRAEL

Phone: +972 7 647 2622 Fax: +972 7 647 2997

3

	loruppion Densionance Hotel
University Of British Columbia, Dept Of Geological Sciences, EOS, 6339 Stores Bd, Vancouver, BC, V6T 174	Jerusalem Renaissance Hotel
CANADA	
Fax: +1 604 822 6088	
Email Address: fletcher@unixg.ubc.ca	
FREIRE AVILA Paula	
Instituto Geologico e Mineiro, Rua da Amieira, Apt. 89, S. Mamede de Infesta, 4465 PORTUGAL	
Phone: +351 2 9511915 Fax: +351 2 951 4040	
FREYSSINET Philippe	Park Plaza Hotel, Jerusalem
Chief Projects, Research Division, BRGM, BP 6009, 45060 Orleans FRANCE	
Phone: +33 2 3864 3005 Fax: +33 2 3864 3652 Email Address: p.freyssinet@brgm.fr	
GARCIA PEREIRA J.F. Henrique	
C V R M , Seccao de Mineralurgia e Planeamento Min, I.S.T Av. Rovisco Pais, Lisbon, 1096	
PORTUGAL	
Phone: +351 1 841 7274 Fax: +351 1 841 7442	
Email Address: ncmrp@alfa.ist.utl.pt	
GARNETT L. David	Jerusalem Renaissance Hotel
Becquerel Laboratories, PMB 1, Menai, NSW, 2234	
AUSTRALIA Phone: 161 2 05/12 26/14 Eav: 161 2 05/13 2655	
Finall Address: naa@hg.com.au	
GILAT Arie	
Geological Survey of Israel, Minerals & Energy Res Division, 30 Malkhe Israel Street, Jerusalem, 95501	
ISRAEL	
Phone: +972 2 531 4248	
GINN Robert M.	Jerusalem Renaissance Hotel
Ginn Dorothy	
Consulting Geologist, 84 Glencairn Avenue, Toronto ONT M4R 1M8	
CANADA	
Phone: +1 4164889219	
GOLDBERG ISSAI	
Ionex Pty LTD, Suite 4-1 Ridge St, North Sydney, NSW, 2060	
Phone: +61 61 2 9233 5153 Fax: +61 61 2 9231 2174	
GOLOVIN A. Arkadii	Jerusalem Renaissance Hotel
Head, Dept of Geochem Mapping, Inst of Mineralogy, Geochemistry & Crystal Chemistry, 12-169 Aviatorov St, Moscow, 1	19620
RUSSIA	
Phone: +7 095 443 9041 Fax: +7 095 443 9043	
GOODARZI Fariborz	Jerusalem Renaissance Hotel
Energy and Environment Subdivision, Geological Survey of Canada (Calgary), 3303 - 33rd Street N.W., Calgary, Alberta, CANADA	T2L 2A7
Fax: +1 403 292 7159	
GUO Yonghai	
Environmental Center, Beijing Research Inst. of Uranium Geology, PO Box 9818, Beijing, 100029 CHINA	
Phone: +86 10 6491 2211 Fax: +86 10 6491 7143	

`

**GURVICH I. Vladimir Tsukernik Alexey** Geopolis Consulting Eng., 64 Shipilovskaya Apt 290, Moscow, 11568 RUSSIA Phone: +7 095 396 0222 Fax: +7 095 396 0222 **GUTTMAN** Joseph Tahal Consulting Engineering Ltd, Tel Aviv ISRAEL GZYL E. Jadwiga Institute for Ecology of Industrial Areas, 6 Kossutha St., Katowice, 40-831 POLAND Phone: +48 32 154 6031 Fax: +48 32 154 1717 HALICZ L. Geological Survey of Israel, 30 Malkhe Israel St, Jerusalem, 95501 ISRAEL Phone: +972 02 531 4205 Fax: +972 02 538 0688 Email Address: halicz@mail.gsi.gov.il HALL E.M. Gwendy Head, Analytical Method Development, Geological Survey of Canada, 601 Booth St, Room 702, Ottawa, ONT, K1A 0E8 CANADA Phone: 613 992 6425 Fax: 613 996 3726 Email Address: hall@gsc.emr.ca **HAWLEY L. David** Bechtel Nevada Inc., Remote Sensing Laboratory, PO Box 98521 MS/RSL-19, Las Vegas, NV 89193-8521 USA **HOFFMAN Eric L.** Activation Laboratories Ltd, 1336 Sandhill Drive, Ancaster, ONT, L9G 4V5 CANADA Phone: +1 905 648 9611 Fax: +1 905 648 9613 Email Address: actlaba@ibm.net **IKRAMUDDIN Mohammed** Jerusalem Renaissance Hotel Dept of Geology, MS 70, Eastern Washington University, 526 - 5th Street, Cheney, WA, 99004-2499 USA Phone: +1 509 359 7866 / 2855 Fax: +1 509 359 4386 Email Address: mikramuddin@eagle.ewu.edu ILANI S. Geological Survey of Israel, 30 Malkhe Israel St, Jerusalem, 95501 ISRAEL **JACKSON G. Robert** Jerusalem Renaissance Hotel 150 E. Flora Lane, Elko, NV, 89801 USA Phone: +1 702 778 4026 Fax: +1 778 4030 JAFFE F. 1 Barak Street, Jerusalem ISRAEL **KERN Dirse** Park Plaza Hotel, Jerusalem Trav. Castelo Branco, Belem Para BRAZIL **KLAVINS Maris** Faculty of Geographical and Earth Sciences, University of Latvia, 19 Rainis Blvd, Riga, LV 1586 LATVIA Phone: +371 733 2704 Fax: +371 782 0113

#### **KLUKANOVA** Alena

Geological Survey of the Slovak Republic, Mlynska dolina 1, 817 04 Bratislava SLOVAKIA

Phone: +42 7 370 5162 Fax: +42 7 371 940

#### KOLODNY Y.

Dept of Geology, Hebrew University, Jerusalem ISRAEL

# **KOVAL Pavel V.**

Applied Geochemistry, Vinogradov Institute of Geochemistry, PO Box 4019, Irkutsk 664033 RUSSIA Phone: 395 2 465978 Fax: 395 2 464050

Email Address: koval@igc.irkutsk.su

#### **KOVALEVSKII L. Alexander**

Buryat Geological Institute, Siberian Division of the Russian Academy of Sciences, 6a Sakhyanova Street, Ulan-Ude, 670047 RUSSIA

Phone: +7 30122 36013 Fax: +7 30122 63244

Email Address: burgin.ulanrex@rex.iasnet.ru

#### **KRECHETOVA V. Elena**

V.I. Vernadsky Institute of Biochem & Analytical Chemistry of Russian Academy of Sciences, Kosigina Str. 19, 117975 RUSSIA

Phone: +7 095 137 4773 Fax: +7 095 938 2054

Email Address: elkor@geokhi.msk.su

#### **KREMENETSKY A. Alexander**

Institute of Mineralogy, Geochemistry & Crystal Chemistry of Rare Elements (IMGRE), 15 Veresaeva Str, Moscow, 121357 RUSSIA

Phone: +7 095 444 2215 Fax: +7 095 443 9043

Email Address: krem@sovam.com

# **KRONFELD** Joel

Dept of Geophysics and Planetary Sciences, Tel Aviv University, Kiryat Hauniversita, PO Box 39070, Tel Aviv, 69978 ISRAEL

Email Address: yoelk@post.tau.ac.il

# **KUBANTSEV A. Ilia**

IMGRE, 15 Veresaeva Str, Moscow, 121357 RUSSIA

Phone: +7 095 444 2215 Fax: +7 095 443 9043 Email Address: krem@sovam.com

Linaii Address, Riem@sovam.co

#### **KURILENKO** Vitaly

Dept of Geology Earth Crust Instit., St Petersburg State University, 7/9 Universitetskaya emb., St Petersburg, 199034 RUSSIA

Phone: +7 812 2189466 Fax: +7 812 2180792

#### **KWOLEK Kenneth Julian**

Burt Brill and Cardens, 14 Sussex Square, Kemp Town, Brighton, E. Sussex, BN2 5AA

#### UK

Phone: +44 1273 608037 Fax: +44 1273 570837

## LADNER A. George

Laboratory of Geoindicational Researches, Institute of Remote Sensing Methods for Geology, Birzhevoy proezd, 6, St Petersburg, 199034 RUSSIA

Phone: +7 812 218 2801 Fax: +7 812 218 3916

#### **LADONIN V. Dmitry**

M.V. Lomonosov Moscow State Univ, Soil Science Dept., Lenin Hills, Moscow, 119899

RUSSIA

Phone: +7 095 976 9320 Fax: +7 095 976 9320

.

Park Plaza Hotel, Jerusalem

# Jerusalem Renaissance Hotel

Jerusalem Renaissance Hotel

LAICHTER S.

PAMA (Energy Resources Development) Ltd, Mishor Rotem, 86800 ISRAEL

Phone: +972 7 655 4711

#### LEVI Y.

Rotem Negev Amfert Ltd, PO Box 187, Yeruham, 80500 ISRAEL

Phone: +972 7 658 9346

# LIMA DA COSTA Marcondes

Geochemistry and Petrology, 2350 Trav. Timbo Apt 1203, Belem, Para, 66093-340 BRAZIL Phone: +55 91 249 5028 Fax: +55 91 211 1609 / 1428

Email Address: mlc@marajo.ufpa.br

#### LIS Franciszek Jozef

#### Lis Barbara

Polish Geological Institute, Rakowiecka 4, Warsaw, 00-975 POLAND Phone: +48 +48 22 495351 Fax: +48 22 49 5342

#### **LIVSHITZ Yakov**

Water Resources Research Center, Institute for Desert Research, University of the Negev, Beer Sheva, 84105

ISRAEL

Phone: +972 7 653 2807 Fax: +972 7 655 7042

Email Address: livshits@bgumail.bgu.ac.il

#### **LOMBARD** Michelle

Geochemistry Section, Council for Geoscience, Private Bag X112, Pretoria, 0001 SOUTH AFRICA

Phone: +27 12 841 1405 / 1275 Fax: +27 12 841 1278

Email Address: mlombard@geoscience.org.za

#### LOREDO Jorge

Universidad de Oviedo, Escuela de Minas, Independicia 13, 33004 Oviedo SPAIN

Phone: +34 8 510 4295 Fax: +34 8 510 4245

#### LUKASHEV Valentine

Inst. of Geochemistry and Geophysics, Belarus Academy of Sciences, Zhodinskaya 7, Minsk, 220072

#### BELARUS

Phone: +375 17 263 9057 Fax: +375 17 263 6398

Email Address: lukashev@ns.igs.ac.by

#### **MAACHA** Lhou

Ingenieur Geologue, C.T.T. O.N.A., 52 Avenue Hassan II, Casablanca

MOROCCO

Phone: +212 20 06 70 Fax: +212 26 99 23 .

# MAHMOOD Ahmed

Canadian Space Agency, 6767 Route De L'Aeroport, Saint-Hubert, PC, J3Y 8Y9 CANADA Phone: +1 514 926 4432 Fax: +1 514 926 4433

Email Address: ahmed.mahmood@space.gc.ca

# MARK-ANTHONY Leo

Mark-Anthony Beverly 2020 Lake Otis Pkwy, Anchorage, Alaska, 99508-3283 USA Phone: +1 907 279 4702 Jerusalem Renaissance Hotel

Park Plaza Hotel, Jerusalem

Jerusalem Renaissance Hotel

## Jerusalem Renaissance Hotel

MARSINA Karol	Jerusalem Renaissance Hotel
Geological Survey of the Slovak Republic, Apt. 233 Mlynska Dolina 1, 817 04 Bratislava SLOVAKIA	
Phone: +42 7 3705 240 Fax: +42 7 371 940	
MARTINS Luis	Park Plaza Hotel, Jerusalem
Instituto Geologico e Mineiro, Estra Portela 3I, Bairro do Zambujal, Apart 7586, Alfragide, 2720 PORTUGAL	
Phone: +351 1 471 8922 Fax: +351 1 471 8940	
MATTHEWS M.	
Geological Survey of Israel, 30 Malkhe Israel St, Jerusalem, 95501 ISRAEL	
Phone: +972 2 531 4201 Fax: +972 2 538 0688	
Email Address: matthews@mail.gsi.gov.il	
MAZEIKA Jonas	
Inst. of Geology, Shevchenkos Str. 13., Vilnius, 2600 LITHUANIA	
Fax: +370 2 236 710	
MAZZUCCHELLI Richard H.	Jerusalem Renaissance Hotel
Mazzucchelli Brenda	
Searchtech Pty. Ltd, PO Box 189, Kalamunda, WA 6076 AUSTRALIA	
Phone: 9 257 2332 Fax: 9 257 2334	
MIKO Slobodan	Park Plaza Hotel, Jerusalem
Institute of Geology, Sachsova ul. 2, Zagreb, 10000 CROATIA	
Phone: +38 1 61 52 300 Fax: +38 1 615 0567	
MONDOE Comoron Soott	
Chief Geologist, Exploration Geology, Cominco Madencilik San. As., Farabi Sok. 3/5 Cankaya, Ankara, 06680	
Phone: +90 312 468 4841 Fax: +90 312 468 4843	
MOON J. Charles	
Leicester University, Dept Of Geology, University Road, Leicester, LE1 7RH UK	
Phone: +44 116 252 3804 Fax: +44 116 252 3918 Email Address: cim@le.ac.uk	
MORDBERG Leonid	
Fachgebiet Lagerstattenforschung, TU Berlin - Sekr. BH-4, Ernst-Reuter-Platz 1, Berlin, D-10587 GERMANY	
Phone: +49 30 314 26165 Fax: +49 30 314 26591	
MOSSMAN J. David Mesemen Merie Susen	Jerusalem Renaissance Hotel
Mossman Marie Susan Den ef Physics Engineering & Goelegy Mount Alligen University Sockville NP E04 200	
CANADA	
	· .
i an. Ti Juu Jut 2003 Fmail Address: dmossman@mta ca	
Dept of Soil Chemistry, Moscow State University, Faculty of Soil Science, Vorobiovy Hills, Moscow, 119899 RUSSIA	
Phone: +7 095 939 4589 Fax: +7 095 939 0989 Fmail Address: Ik@soil.msu.ru	

NACHMIAS Yoseph PAMA (Energy Resources Development) Ltd, D.N. Arava, Mishor Rotem, 86800 ISRAEL Phone: +972 7 655 4711 Fax: +972 7 655 3990 or 7 655 3990 NATHAN Y. Geological Survey of Israel, 30 Malkhe Israel Street, Jerusalem, 95501 ISRAEL NE'EMAN E. Radioisotope Laboratory, Ministry of the Environment, Tel Aviv University, Ramat Aviv, 69978 ISRAEL **NEKRASOVA A. Mazina** Geological Faculty, Dept Engineering Geology, Moscow State University, Vorobievy Gory, Moscow, 117234 RUSSIA Phone: +7 095 939 3587 **NHUAN Mai Trong** Dept of Geochemistry, Hanoi National University, 208 D3 Thanh Cong, Ba Dinh, Hanoi VIETNAM **NISSENBAUM Aryeh** Weizmann Institute of Science, Rehovot, 76100 ISRAEL Phone: +972 8 934 3859 Fax: +972 8 947 1667 Email Address: rsnis1enb@wis.weizmann.ac.il **NOWAK Barbara** SECOTEX, Silesian Univ of Medicine, Dept of Toxicology, Jagiellonska 4, Sosnowiec, 41-200 POLAND Fax: +48 32 668 968 Email Address: tokswi@infomed.slam.katowice.pl **OATES J. Christopher** Jerusalem Renaissance Hotel Munoz Donoso Vivianne WMC Resources LTDA - Chile, 130 El Bosque Sur Las Condes, Piso 7, Santiago CHILE Phone: +56 2 203 1290 Fax: +56 2 203 1294 +56 2 203 1059 **PALLANDT** Charles c/o Elsevier Science B.V., Sara Burgerhartstraat 25, Amsterdam, 1055 KV THE NETHERLANDS Fax: 20 4852696 **PASIECZNA Anna** Jerusalem Renaissance Hotel Polish Geological Inst, Rakowiecka 4, Warsaw, PL 00-975 POLAND Phone: +48 22 495351 Fax: +48 22 495 342 **PAUWELS Helene** BRGM - Research Division - MGG, Avenue Claude Guillemin, B.P. 6009, Orleans, 45060 FRANCE Phone: +33 2 3864 3406 Fax: +33 2 3864 3652 Email Address: h.pauwels@brgm.fr **PETROVSKY Eduard** Jerusalem Renaissance Hotel Petrovska Marianna

Geophysical Institute, Bocni II/1401, Prague 4, 14131 CZECH REPUBLIC Phone: +42 2 6710 3333 Fax: +42 2 761549 Email Address: edp@ig.cas.cz

Park Plaza Hotel, Jerusalem

#### Park Plaza Hotel, Jerusalem

PFAU Mark. I.	Jerusalem Renaissance Hotel
Pfau Ljean	
Managing Geologist, Tellurian Exploration, 3275 Terrace Drive, Missoula, MT, 59803 USA	
Phone: +1 406 251 4235 Fax: +1 406 2514235	
PLUEGER Walter L.	Jerusalem Renaissance Hotel
Plueger Barbara Aachen University of Technology, IML/Labor fuer Geochemie and Umweltanalytik, Suesterfeld Str. 22, Aachen, D-52056	
GERMANY Phone: +49 241 805 775 Fax: +49 241 888 8341	
Email Address: plueger@rwth-aachen.de	
POLISCHUK L. Svetlana	
Geological Faculty, Dept Engineering Geology, Moscow State University, Vorobievy Gory, Moscow, 117234 RUSSIA	
Phone: +7 095 939 587	
PORAT Naomi	
Geological Survey of Israel, 30 Malkhe Israel St, Jerusalem, 95501 ISRAEL	
Phone: +972 02 531 4209 Fax: +972 02 538 0688	
Email Address: naomi@mail.gsi.gov.il	
PUIG G. Alvaro	Park Plaza Hotel, Jerusalem
Puig Maria Eugenia	
Gerencia De Exploraciones, Corporacion Del Cobre(USA) Inc., Departmento Exploracion, Huerfanos 1270 Apt 7, Santiago CHILE	· .
Phone: +56 2 690 3741 Fax: +56 2 690 3739	
Email Address: apuig@reuna.cl	
RAPANT Stanislav	Jerusalem Renaissance Hotel
Environmental Geochemistry, Geological Survey of the Slovak Republic, Mlynska Dolina 1, 817 04 Bratislava SLOVAKIA	
Phone: +42 7 370 5213 Fax: +42 7 371 940	
RAPOSOVA Maria	Jerusalem Renaissance Hotel
Ministry of Environmental of the Slovak Republic, 1 Nam.L.Stura, Bratislava, 81235 SLOVAKIA	
Phone: +42 7 5162208 Fax: +42 107 5162123	
REEVES J. Shane	Jerusalem Renaissance Hotel
University of Melbourne, School of Earth Sciences, cnr Elgin and Swanston Sts., Parkville, Melbourne, VIC AUSTRALIA	
Phone: +61 3 9344 6514 Fax: +61 3 9344 7761	
Email Address: shane_reeves@muwayf.unimelb.edu.au	
ROBERTSON Ian D.M.	Jerusalem Renaissance Hotel
Cooperative Research Centre for Landscape Evolution & Mineral Exploration, CSIRO, Div of Exploration & Mining, Private AUSTRALIA	Bag, PO Wembley, WA, 6014
Phone: +61 9 387 0748 Fax: +61 9 387 8642	
ROGOJIN Vasily	
Department of Geophysics & Planetary Sciences, Tel Aviv University, Ramat Aviv, 69978 ISRAEL	
ROSENFELD Amnon	
Geological Survey of Israel, 30 Malkhe Israel St., Jerusalem, 95501 ISRAEL	
ROTHENBERG Beno	
LAMS, London	
UK	

•

**RYFTIN Vladimir** Ministry of Natural Resources, Institute of Mineralogy, Geochemistry and Crystal Chemistry of Rare Elements, 15 Varesaeva, Moscow, 121357 RUSSIA Phone: +7 095 444 22 14 Fax: +7 095 443 90 43 SADOVNIKOVA K. Ludmila Sadovnikov Jouri Moscow State University, Dept. Soil Science, B-234, Leninskye Gori, 119 899 Moscow RUSSIA Phone: +7 095 939 3197 Fax: +7 095 939 0989 Email Address: sadov@soil.msu.su SALMINEN Reijo K. Head of Department, Geochemistry Department, Geological Survey of Finland, Espoo, FIN-02151 FINLAND Phone: +358 2055011 Fax: +358 2055012 **SANTOS OLIVEIRA Manuel Jose** Instituto Geologico e Mineiro, Rua da Amieira, S.Mamede Infesta, 4465 PORTUGAL Phone: +351 2 951 1915 Fax: +351 2 951 4040 Jerusalem Renaissance Hotel **SAVCHENKO** Vladimir Inst, for Problems of Natural Resources Utilization & Ecology, Belarussian Academy of Sciences, Staroborisousky tract, 10, Minsk, 220114 BELARUS Phone: +375 172 644321 Fax: +375 172 642413 Email Address: ipipre@bas18.basnet.minsk.by SAWLOWICZ Zbigniew Institute Geological Sciences, Jagiellonian Univ., Oleandry 2A, Krakow, 30-063 POLAND Fax: +48 12 332 270 Email Address: zbyszek@ing.uj.edu.pl SEGAL Irena Geological Survey of Israel, 30 Rehov Malchai Israel, Jerusalem, 95501 ISRAEL SHIMRON A.E. The Geological Survey of Israel, 30 Malkhe Israel Street, Jerusalem, 95501 ISRAEL SHIRAV Moshe The Geological Survey of Israel, 30 Malkhe Israel Street, Jerusalem, 95501 ISRAEL Phone: +972 2 314256 Fax: +972 2 380688 SHVARTSEV L Stepan P.O. Box 2282, Tomsk, 634055 RUSSIA **SIEGEL R. Frederic** Jerusalem Renaissance Hotel Professor of Geochemistry, George Washington University, Dept Of Geology, Washington, DC, 20052 USA Phone: +1 202 994 6194 Fax: +1 202 994 0450 SIMONOV Alexei Jerusalem Renaissance Hotel Exploration Central Asia, Santa Fe Pacific Gold Corporation, PO Box 27019, Albuquerque, NM, 87125 USA Fax: +1 602 504 8950 SIMPSON Peter R. Jerusalem Renaissance Hotel Minerals Environmental. & Geochemical Surveys Division, British Geological Survey, Keyworth, Nottingham, NG12 5GG UK Phone: 1159 363 532 Fax: 1159 363 200

SINGER Shosh	Jerusalem Renaissance Hotel
9 Malal Str., Haifa, 32714	
ISRAEL	
SNOEK Willem	Jerusalem Renaissance Hotel
University of Melbourne, School of Earth Sciences, 82 Temple Rd., Selby, Victoria AUSTRALIA	
Phone: +61 3 9344 7761 Fax: +61 3 9344 6514	
Email Address: shane_reeves@muwayf.unimelb.edu.au	
STEINITZ Gideon	
Geological Survey of Israel, Minerals & Energy Res Division, 30 Malkhe Israel Street, Jerusalem, 95501 ISRAEL	
STEWART D. Alison	
University of Leicester, Dept of Geography, Leicester, LE1 7RH UK	
Fax: +44 116 252 3854	
Email Address: ad52@leicester.ac.uk	
TANDY Steve	
Dead Sea Works Ltd, PO Box 75, Beer Sheva, 84100 ISRAEL	
Phone: +972 7 646 5604	
TARASKEVICIUS Ricardas	Jerusalem Renaissance Hotel
Inst. of Geology, T. Sevcenkos str.13, Vilnius, 2600	
LITHUANIA	
Phone: +370 2 235 819 Fax: +370 2 236 710	
Email Address: geologin@ktl.mii.lt	
TAUFEN Paul M.	Jerusalem Renaissance Hotel
Chief Geochemist, Geoscience Technology Group, Western Mining Corporation, 191 Great Eastern Highway, Belmont, P	erth, WA, 6104
AUSTRALIA Bhanna - 61 610 470 0694 Fave - 61 610 470 9259	
Filolie. +01019 4/9 0004 Fax. +01019 4/9 0000	
	Januarian Danaisaanaa Hatal
Exity Diman	Jerusalem Rehalssance Holer
TURKEY	
Phone: +90 312 468 4841 Fax: +90 312 468 4843	
TEUTSCH N.	
Institute of Earth Sciences, The Hebrew University of Jerusalem, Jerusalem, 91904 ISRAEL	
TWARDOWSKA Irena	Park Plaza Hotel, Jerusalem
Inst. of Environmental Engineering, Polish Academy of Sciences, ul. M. Sklodowskiej-Curie 34, 41-819 Zabrze POLAND	,
Phone: +48 32 171 6481 Fax: +48 32 171 7470	
UNERSOY Levent	
Exploration Geology, Cominco Madencilik San. As., 3/5 Farabi Sok Cankaya, Ankara, 06680 TURKEY	·
Phone: +90 312 648 4841 Fax: +90 312 468 4843	
VAN MOORT Jan C.	
University of Tasmania, Dept of Geology, GPO Box 252-79, Hobart, Tasmania, 7001 AUSTRALIA	
Phone: +61 3 662 2476 Fax: +61 3 6223 2547	
VESELY Josef	Jerusalem Renaissance Hotel
Czech Geological Survey, Klarov 3/131, Prague 1, 11821 CZECH REPUBLIC	
Fax: +420 2 581 8748	

÷

**VILADEVALL** Manuel Geochemistry, Petrology and Geol. Prosp., University of Barcelona, Zona Universitaria De Pedralbes, 08071 SPAIN Phone: +34 3 402 1397 Fax: +34 3 402 1340 VOGEL J.C. c/o J. Kronfeld, Dept of Planetary Sciences, Tel Aviv University, Kiryat Hauniversita, PO Box 39070, Tel Aviv, 69978 ISRAEL **VRANA Kamil** Jerusalem Renaissance Hotel Hydeko-KV, Muchovo Namestie 1, Bratislava, 85101 SLOVAKIA Phone: +421 7 846 745 Fax: +421 7 846 745 Jerusalem Renaissance Hotel WANG Xueqiu Inst. of Geophys & Geochem Exploration, 84 Jinguang Road, Langfang, Hebei, 102849 CHINA Phone: +86 316 201 5872 Fax: +86 316 204 0677 Email Address: xiexue@public3.bta.net.cn WINTERBURN A. Peter Park Plaza Hotel, Jerusalem Winterburn Michelle New Mining Business Division, Anglo American Corporation of South Africa, PO Box 61587, Marshalltown, 2107 SOUTH AFRICA Email Address: pwinterburn@mhs1.tns.co.za **XIE Xuejing** Jerusalem Renaissance Hotel Inst of Geophys & Geochem Exploration, 84 Jinguang Road, Langfang, Heibei, 065000 CHINA Phone: +86 10 6833 0276 Fax: +86 10 6831 0894 Email Address: xiexue@public3.bta.net.cn YANAKI N.E. Dept of Geophysics and Planetary Sciences, Tel Aviv University, Ramat Aviv, 69978 ISRAEL YECHIELI Y. Geological Survery of Israel, 30 Malkhe Israel Street, Jerusalem, 95501 ISRAEL Fax: +972 02 538 0688 Email Address: yechieli@mail.gsi.gov.il **YOUNG Bailey Brian** Jerusalem Renaissance Hotel Exploration Geology, Cominco Madencilik San. A.S., 3/5 Farabi Cankaya Str, Ankara, 06680 TURKEY

Phone: +90 312 468 4841 Fax: +90 312 468 4843

...

**AUTHOR INDEX** 

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Kovalevskii, A.L.       15, 22, 25       18, 19, 20       Morozov, A.F.       19       4         Kravitz, J.H.       17       40       Morris, P.       24       6         Krechetova, E.V.       15       20       Mossman, D.J.       14       29         Krenetetova, E.V.       15       20       Mostam, D.J.       14       29         Krenetetsky, A.A.       19       21, 48       Motuzova, G.V.       16, 21       29, 30         Krenetetsky, A.A.       19       21       Nathan, Y.       17, 21       22         Kurlenko, V.V.       15       5, 21       Nathan, Y.       15       10         Kuvaldin, E.V.       15       43       Navarro, A.       23       45         Kwolek, J.K.       26       22       Ne'eman, E.       16       30         Kyzio, J.       25       44       Nekrasova, M.A.       22       31         L       Nissenbaum, A.       19       Ladonin, D.V.       15       22       22       31         Ladonin, D.V.       15       22       O       24       26       42       Ordonez, A.       17       31         Ladonin, D.V.       26       42       Ordonez, A.	Kovalevskava, O.M.	22	20	Moreira, O.	17	
Kravitz, J.H.       17       40       Morris, P.       24       6         Krechetova, E.V.       15       20       Mossman, D.J.       14       29         Krenchetova, E.V.       15       20       Mossman, D.J.       14       29         Krendeld, J.       15, 16, 22,       13, 30, 35,       23, 26       46, 48       N         Kubantsev, I.A.       19       21       Nachmias, Y.       17, 21       22         Kurilenko, V.V.       15       5, 21       Nathan, Y.       15       10         Kuvaldin, E.V.       15       43       Navarro, A.       23       45         Kuvaldin, E.V.       15       43       Navarro, A.       23       45         Kuvaldin, E.V.       15       43       Navarro, A.       23       45         Kuvaldin, E.V.       25       44       Nefed'ev, M.A.       15       18         Ladner, G.A.       15       43       Nowak, B.       22       31         Ladner, G.A.       16       30       Ordonez, A.       17       31         Ladner, G.A.       26       42       Odegov, A.S.       15       18         Langford, M.       26       42       Or	Kovalevskii, A.L.	15, 22, 25	18, 19, 20	Morozov, A.F.	19	4
Krechetova, E.V.       15       20       Mossman, D.J.       14       29         Kremenetsky, A.A.       19       21, 48       Motuzova, G.V.       16, 21       29, 30         Kronfeld, J.       15, 16, 22, 13, 30, 35, 23, 26       46, 48       N       Kubantsev, I.A.       19       21       Nachmias, Y.       17, 21       22         Kubantsev, I.A.       19       21       Nachmias, Y.       17, 21       22         Kuvaldin, E.V.       15       5, 21       Nathan, Y.       15       10         Kuvaldin, E.V.       15       43       Navarro, A.       23       45         Kwolek, J.K.       26       22       Nefed'ev, M.A.       15       18         Ladonin, D.V.       15       22       1       14       29         Ladonin, D.V.       15       22       0       14       15       18         Lang, B.       26       42       Omotade, G.O.       26       26       22       24       31         Leonerko, LV.       24       4       Pasieczna, A.       22       24, 31       31         Leonerko, LV.       24       4       Pasieczna, A.       22       24, 31       31 <td< td=""><td>Kravitz, J.H.</td><td>17</td><td>40</td><td>Morris. P.</td><td>24</td><td>6</td></td<>	Kravitz, J.H.	17	40	Morris. P.	24	6
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Kronfeld, J.       15, 16, 22,       13, 30, 35,       Nachmisor, U.       17, 21       22         Kubantsev, I.A.       19       21       Nachmisor, Y.       17, 21       22         Kurilenko, V.V.       15       5, 21       Nathan, Y.       15       10         Kuvaldin, E.V.       15       43       Navarro, A.       23       45         Kwolek, J.K.       26       22       Nefed'ev, M.A.       15       18         Kyzio, J.       25       44       Nefed'ev, M.A.       15       18         Ladonin, D.V.       15       22       Nowak, B.       22       31         Ladonin, D.V.       15       22       O       Lang, B.       26       42       Odegov, A.S.       15       18         Lagford, M.       26       42       Odegov, A.S.       15       18       Lagford, M.       26       22       24       26       24       27         Leonenko, L.V.       25       19       P       Leonenko, L.V.       24       Parashar, S.       24       27         Leonova, G.A.       17       17       17       31       Leonova, G.A.       17       13         Leonova, G.A.       17 <td< td=""><td>Kremenetsky, A.A.</td><td>19</td><td>21, 48</td><td>Motuzova, G.V.</td><td>16 21</td><td>29 30</td></td<>	Kremenetsky, A.A.	19	21, 48	Motuzova, G.V.	16 21	29 30
23, 26         46, 48         N           Kubantsev, I.A.         19         21         Nachmias, Y.         17, 21         22           Kurilenko, V.V.         15         5, 21         Nathan, Y.         15         10           Kuvaldin, E.V.         15         43         Navaro, A.         23         45           Kwolek, J.K.         26         22         Ne'eman, E.         16         30           Kyzio, J.         25         44         Nefed'ev, M.A.         15         18           L         Nissenbaum, A.         19         14donin, D.V.         15         22         31           Ladner, G.A.         15         43         Nowak, B.         22         31           Ladner, G.A.         15         22         0         15         18           Lang, B.         26         42         Odegov, A.S.         15         18           Langford, M.         26         42         Omotade, G.O.         26         22         24, 31           Leoner, M.         25         8         P         12         22         24         31           Leov, A.V.         25         19         P         14         24         <	Kronfeld, J.	15, 16, 22,	13, 30, 35,		10, 21	20,00
Kubantsev, I.A.       19       21       Nachmias, Y.       17, 21       22         Kurlenko, V.V.       15       5, 21       Nathan, Y.       15       10         Kuvaldin, E.V.       15       43       Navarro, A.       23       45         Kwolek, J.K.       26       22       Nefed'ev, M.A.       15       18         Kyzio, J.       25       44       Nefed'ev, M.A.       15       18         Ladner, G.A.       15       43       Nowak, B.       22       31         Ladner, G.A.       15       43       Nowak, B.       22       31         Ladner, G.A.       15       43       Nowak, B.       22       31         Ladonin, D.V.       15       22       0       23       46         Lang, B.       26       42       Omotade, G.O.       26       26       22       24       31         Levi, N.       16       30       Ordonez, A.       17       31       31       20       32         Leonenko, L.V.       24       4       Parashar, S.       24       27       24, 31       32       46       32       46       32       46       32       46       32		23, 26	46, 48	Ν		
Kurilenko, V.V.       15       5, 21       Nathan, Y.       15       10         Kuralcin, E.V.       15       43       Navaro, A.       23       45         Kwolek, J.K.       26       22       Ne'eman, E.       16       30         Kyzio, J.       25       44       Nefed'ev, M.A.       15       18         L       Nissenbaum, A.       19       14       15       18         Ladonin, D.V.       15       22       O       23       15       18         Ladonin, D.V.       15       22       O       24       24       27         Ladonin, D.V.       16       30       Ordonez, A.       17       31         Ladonin, D.V.       15       22       0       26       22       Mowak, B.       22       31         Ladonin, D.V.       16       30       Ordonez, A.       17       31       31         Ledister, S.       21       22       O       24       27       24       27         Leoney, A.V.       25       19       P       22       24, 31       24       27         Leoney, G.A.       17       17       7       Pasieczna, A.       22	Kubantsev, I.A.	19	21	Nachmias, Y.	17, 21	22
Kuvaldin, E.V.       15       43       Navarro, A.       23       45         Kwolek, J.K.       26       22       Ne'eman, E.       16       30         Kyzio, J.       25       44       Nefed'ev, M.A.       15       18         L       Nekrasova, M.A.       22       31         L       Nissenbaum, A.       19         Ladner, G.A.       15       43       Nowak, B.       22       31         Ladonin, D.V.       15       22       O       2       31         Ladonin, D.V.       15       22       O       2       31         Laichter, S.       21       22       O       2       31         Lang, B.       26       42       Odegov, A.S.       15       18         Lang, M.       26       42       Ordonez, A.       17       31         Lebox, A.V.       25       19       P       2       2       43         Leonenko, L.V.       24       4       Parashar, S.       24       27         Leonova, G.A.       17       17       Pauwels, H.       20       32         Leva, J.       24       28       Perez, D.       23       46<	Kurilenko, V.V.	15	5. 21	Nathan, Y.	15	10
Kwolek, J.K.       26       22       Ne'eman, E.       16       30         Kyzio, J.       25       44       Nefed'ev, M.A.       15       18         Ladner, G.A.       15       43       Nowak, B.       22       31         Ladner, G.A.       15       43       Nowak, B.       22       31         Ladonin, D.V.       15       22       0       15       18         Laidonin, D.V.       15       22       0       15       18         Lang, B.       26       42       Odegov, A.S.       15       18         Langford, M.       26       42       Omotade, G.O.       26       26         Lavi, N.       16       30       Ordonez, A.       17       31         Lbov, A.V.       25       19       P       1       16       20       32         Leonenko, L.V.       24       4       Parashar, S.       24       27       24       31         Leonova, G.A.       17       17       Pawels, H.       20       32       32         Levi, Y.       13       24       28       Perez, D.       23       46         Lis, J.       16, 22       23, 24<	Kuvaldin, E.V.	15	43	Navarro, A.	23	45
Kyzio, J.       25       44       Nefed'ev, M.A.       15       18         L       Niserasova, M.A.       22       31         Ladner, G.A.       15       43       Nowak, B.       22       31         Ladonin, D.V.       15       22       0       15       18         Ladonin, D.V.       15       22       0       15       18         Lang, B.       26       42       Odegov, A.S.       15       18         Langford, M.       26       42       Odegov, A.S.       15       18         Layi, N.       16       30       Ordonez, A.       17       31         Lbov, A.V.       25       19       P       12       12       14       14       15       13         Leonenko, L.V.       24       4       Pasieczna, A.       22       24, 31       13       13         Levi, Y.       13       Pauwels, H.       20       32       14       14       14       14       15       13         Levi, Y.       13       14       23       Perez, D.       23       46         Livi, J.       16       22       23, 24       Petrosius, R.       16       2	Kwolek, J.K.	26	22	Ne'eman, E.	16	30
L         Nekrasova, M.A.         22         31           L         Nissenbaum, A.         19           Ladner, G.A.         15         43         Nowak, B.         22         31           Ladonin, D.V.         15         22         0         15         16         17         15         18           Laichter, S.         21         22         O         26         42         Odegov, A.S.         15         18           Lang, B.         26         42         Oddegov, A.S.         15         18         11         31           Lov, A.V.         25         19         P         22         24, 31         24         27           Leonenko, L.V.         24         4         Pasieczna, A.         22         24, 31           Leonova, G.A.         17         17         Pauwels, H.         20         32           Lis, J.         24         28         Percz, D.         23         46           Lima da Costa, M.         15         14, 23         Percy, D.         23         46           Liu, D.         13, 24         46, 47         Petrosity, R.         22, 24         15           Liw, D.         13, 24 <t< td=""><td>Kvzio. J.</td><td>25</td><td>44</td><td>Nefed'ev, M.A.</td><td>15</td><td>18</td></t<>	Kvzio. J.	25	44	Nefed'ev, M.A.	15	18
L Nissenbaum, A. 19 Ladner, G.A. 15 43 Nowak, B. 22 31 Ladonin, D.V. 15 22 Laichter, S. 21 22 O Lang, B. 26 42 Odegov, A.S. 15 18 Langford, M. 26 42 Omotade, G.O. 26 Lavi, N. 16 30 Ordonez, A. 17 31 Lbov, A.V. 25 19 P Leblanc, M. 25 8 Prashar, S. 24 27 Leonenko, L.V. 24 4 Pasieczna, A. 22 24, 31 Levi, Y. 13 Pelchat, J.C. 15 13 Lexa, J. 24 28 Perez, D. 23 46 Lifshits, A.B. 18 23 Perricka, E. 21 9 Lis, J. 16, 22 23, 24 Petrosius, R. 16 28 Liu, D. 13, 24 46, 47 Petrosius, R. 16 28 Liu, D. 13, 24 46, 47 Petrosius, R. 16 28 Liu, D. 13, 24 46, 47 Petrosius, R. 13 38 Lopez, S. 25 45 Pirajno, F. 24 6 Loredo, J. 17, 18 25, 31 Pliner, I.R. 13, 21 34, 41 Lukashev, V. 20, 21 26 Plugen, W.L. 18, 22 7 Luo, X. 20 47 Plugen, W.L. 18, 22 33 Lustenberg, E.E. 26 17 Polischuk, S.L. 22 33 Lustenberg, E.E. 26 17 Polischuk, S.L. 22 33	· · · · · · · · · · · · · · · · · · ·			Nekrasova, M.A.	22	31
Ladner, G.A.       15       43       Nowak, B.       22       31         Ladonin, D.V.       15       22       O       Ladonin, D.V.       15       15       18         Lang, B.       26       42       Odegov, A.S.       15       18         Langford, M.       26       42       Omotade, G.O.       26         Lavi, N.       16       30       Ordonez, A.       17       31         Lbov, A.V.       25       19       P       Leonenko, L.V.       24       4       Parashar, S.       24       27         Leonova, G.A.       17       17       17       Pasieczna, A.       22       24, 31         Levi, Y.       13       Pauwels, H.       20       32       32         Lexa, J.       24       28       Perez, D.       23       46         Lifshits, A.B.       18       23       Perez, D.       23       46         Lima da Costa, M.       15       14, 23       Pertrosky, E.       22, 24       15         Liv, D.       13, 24       46, 47       Petrovsky, E.       22, 24       15         Liv, J.       16, 22       23, 24       Petrovsky, E.       22, 24       15	L			Nissenbaum, A.	19	
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Rogojin, V.       22       35       van Moort, J.C.       20       33         Rosenfeld, A.       21       36       Vesely, J.       17, 22       45         Rothenberg, B.       21       36       Vieira e Silva, J.M.       17       3         S       Viladevall, M.       23, 25       45, 46       Vogel, J.C.       23       46         Saavedra, J.       25       45       Volokh, A.A.       19       21       36         Saanders, A.       24       6       Wang, X.       13, 19, 24       46, 47, 48         Santivanez, R.       25       45       Wolfson, N.       17       40         Santos Oliveira, J.M.       18       1       3       46, 47, 48         Savchenko, V.       14, 22       37       Xie, X.       13, 19, 24       46, 47, 48         Sauviouz, Z.       13, 14       38       Xu, L.       19       48         Schlick-Nolte, B.       21       9       Xuejin, Z.       20       47         Segal, I.       22       38       Y       33       48         Shirav, N.       17, 19       2, 40       Yeager, J.R.       20       13         Shirav, M.       17, 19	Rogers, P.	20	13	V		
Rosenfield, A.       21       36       Vesely, J.       17, 22       45         Rothenberg, B.       21       36       Vieira e Silva, J.M.       17       3         Savedra, J.       25       45       Voladevall, M.       23, 25       45, 46         Savedra, J.       25       45       Volokh, A.A.       19       21         Sadovnikova, L.K.       22       36       Vulkan, U.       26       42         Samsonenko, I.       22       37       W       Santos Oliveira, J.M.       17       40         Santos, J.       25       45       Wolfson, N.       17       40         Santos, J.       17       3       X       3       3       3         Savtoeneko, V.       14, 22       37       Xie, X.       13, 19       47, 48         Schlick-Nolte, B.       21       9       Xuejin, Z.       20       47         Segal, I.       22       38       Y       3       48       3         Schlick-Nolte, B.       21       9       Yaaki, N.E.       23       48         Shirav, M.       17, 19       2, 40       Yeager, J.R.       20       13         Shirav, M.       17, 19<	Rogoiin. V.	22	35	van Moort, J.C.	20	33
Rothenberg, B.       21       36       Vieira e Silva, J.M.       17       3         S       Vieira e Silva, J.M.       17       3         Saavedra, J.       25       45       Volokh, A.A.       19       21         Sadovnikova, L.K.       22       36       Vulkan, U.       26       42         Saminen, R.K.       27       W       Sanders, A.       24       6       Wang, X.       13, 19, 24       46, 47, 48         Santivanez, R.       25       45       Wolfson, N.       17       40         Santos Oliveira, J.M.       18       1       1       36       Xue, X.       13, 19, 24       46, 47, 48         Santos Oliveira, J.M.       18       1       3       X       38       Xue, L.       19       48         Satoschenko, V.       14, 22       37       Xie, X.       13, 19       47, 48         Sawlowicz, Z.       13, 14       38       Xu, L.       19       48         Schick-Nolte, B.       21       9       Yuegin, Z.       20       47         Segal, I.       22       38       Y       Shatov, V.V.       26       39       Yanaki, N.E.       23       48         Shirav,	Rosenfeld A	21	36	Vesely J	17 22	45
Noninstructure       21       20       Vilade value, value       11       10       10         Saavedra, J.       25       45       Volokh, A.A.       19       21         Sadovnikova, L.K.       22       36       Vulkan, U.       26       42         Salminen, R.K.       27       Vulkan, U.       26       42         Samsonenko, I.       22       37       W       30       31       19, 24       46, 47, 48         Sanders, A.       24       6       Wang, X.       13, 19, 24       46, 47, 48       31	Rothenhera B	21	36	Vieira e Silva J M	17	
S       Vogel, J.C.       23       46         Saavedra, J.       25       45       Volokh, A.A.       19       21         Sadovnikova, L.K.       22       36       Vulkan, U.       26       42         Samsonenko, I.       22       37       W       3anders, A.       24       6       Wang, X.       13, 19, 24       46, 47, 48         Santos Oliveira, J.M.       18       1       Yuejin, Z.       13       19       47         Santos Oliveira, J.M.       18       1       Santos Oliveira, J.M.       18       1       Yuejin, Z.       20       47         Savchenko, V.       14, 22       37       Xie, X.       13, 19       47, 48         Sawowicz, Z.       13, 14       38       Xu, L.       19       48         Schlick-Nolte, B.       21       9       Xuejin, Z.       20       47         Segal, I.       22       38       Y       Shatov, V.V.       26       39       Yanaki, N.E.       23       48         Shirav, M.       17, 19       2, 40       Yeager, J.R.       20       13       49         Shegel, F.R.       17, 21       40       Z       Zangieva, T.D.       21       3	nothenberg, b.	21	00	Viladevall M	23 25	45 46
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Saltminen, R.K.       27         Samsonenko, I.       22       37       W         Sanders, A.       24       6       Wang, X.       13, 19, 24       46, 47, 48         Santivanez, R.       25       45       Wolfson, N.       17       40         Santos Oliveira, J.M.       18       1       3       X       3       3         Savchenko, V.       14, 22       37       Xie, X.       13, 19       47, 48         Sawlowicz, Z.       13, 14       38       Xu, L.       19       48         Schlick-Nolte, B.       21       9       Xuejin, Z.       20       47         Segal, I.       22       38       Y       Shatov, V.V.       26       39       Yanaki, N.E.       23       48         Shirav, M.       17, 19       2, 40       Yeager, J.R.       20       13         Shirav, M.       17, 19       2, 40       Yehieli, Y.       14       49         Siegel, F.R.       17, 21       40       Z       Zangieva, T.D.       21       3         Simpson, P.R.       27       Zangieva, T.D.       21       3       49         Sokolov, V.       22       33       33       49 </td <td>Sadovnikova I K</td> <td>22</td> <td>36</td> <td>VOIOKII, A.A.</td> <td>19</td> <td>21</td>	Sadovnikova I K	22	36	VOIOKII, A.A.	19	21
Samsoneko, I.       22       37       W         Sanders, A.       24       6       Wang, X.       13, 19, 24       46, 47, 48         Santivanez, R.       25       45       Wolfson, N.       17       40         Santos Oliveira, J.M.       18       1       X       3       3       X         Savchenko, V.       14, 22       37       Xie, X.       13, 19       47, 48         Sawlowicz, Z.       13, 14       38       Xu, L.       19       48         Schlick-Nolte, B.       21       9       Xuejin, Z.       20       47         Segal, I.       22       38       Y       Shatov, V.V.       26       39       Yanaki, N.E.       23       48         Shiron, A.E.       21       39       Yanaki, N.E.       23       48         Shiron, A.E.       21       39       Yeager, J.R.       20       13         Shirav, M.       17, 19       2, 40       Yehieli, Y.       14       49         Siegel, F.R.       17, 21       40       Z       Zangieva, T.D.       21       3         Simpson, P.R.       27       Zangieva, T.D.       21       3       49         Sogona, T. </td <td>Salminen RK</td> <td>27</td> <td>00</td> <td>vulkan, U.</td> <td>20</td> <td>42</td>	Salminen RK	27	00	vulkan, U.	20	42
Sanders, A.       24       6       Wang, X.       13, 19, 24       46, 47, 48         Santors, J.       17       3       X       3       3       40         Santos Oliveira, J.M.       18       1       X       3       40         Santos Oliveira, J.M.       18       1       X       3       3       40         Santos Oliveira, J.M.       14       22       37       Xie, X.       13, 19       47, 48         Sawlowicz, Z.       13, 14       38       Xu, L.       19       48         Schlick-Nolte, B.       21       9       Xuejin, Z.       20       47         Segal, I.       22       38       Y       3       48       3       3       3         Shatov, V.V.       26       39       Yanaki, N.E.       23       48       48         Shirron, A.E.       21       39       Yeager, J.R.       20       13         Shvartsev, S.L.       22       40       Yehieli, Y.       14       49         Siegel, F.R.       17, 21       40       Z       Zangieva, T.D.       21       3         Slaninka, I.       14       2       Zinbi, Y.       13       49     <	Samsonenko I	22	37	W		
Santivanez, R.       25       45       Wolfson, N.       17       40         Santos Oliveira, J.M.       18       1       X       Santos, J.       17       3       X         Savchenko, V.       14, 22       37       Xie, X.       13, 19       47, 48         Sawlowicz, Z.       13, 14       38       Xu, L.       19       48         Schlick-Nolte, B.       21       9       Xuejin, Z.       20       47         Segal, I.       22       38       Y       Shatov, V.V.       26       39       Yanaki, N.E.       23       48         Shirron, A.E.       21       39       Yanaki, N.E.       23       48         Shirron, A.E.       21       39       Yeager, J.R.       20       13         Shirron, A.E.       21       39       Yeager, J.R.       20       13         Shirron, M. 17, 19       2, 40       Yehieli, Y.       14       49         Siegel, F.R.       17, 21       40       Z       Zinbi, Y.       13       49         Sogona, T.       21       41       Zinkute, R.       22       43       Sogona, T.       21       41       49         Solowatina, E.A.       41 </td <td>Sanders A</td> <td>24</td> <td>6</td> <td>Wang X</td> <td>13 10 24</td> <td>16 17 18</td>	Sanders A	24	6	Wang X	13 10 24	16 17 18
Santos Oliveira, J.M.       18       1       X         Santos Oliveira, J.M.       18       1       X         Santos Oliveira, J.M.       14, 22       37       Xie, X.       13, 19       47, 48         Savchenko, V.       14, 22       37       Xie, X.       19       48         Sawlowicz, Z.       13, 14       38       Xu, L.       19       48         Schlick-Nolte, B.       21       9       Xuejin, Z.       20       47         Segal, I.       22       38       Y       Shatov, V.V.       26       39       Yanaki, N.E.       23       48         Shiron, A.E.       21       39       Yeager, J.R.       20       13         Shirav, M.       17, 19       2, 40       Yehieli, Y.       14       49         Siegel, F.R.       17, 21       40       Z       Zinbi, Y.       13       49         Siegel, F.R.       17, 21       40       Z       Zinbi, Y.       13       49         Sogona, T.       21       41       Zinkute, R.       22       43         Sogona, T.       21       41       Ziyadi, R.       13       49         Solonov, V.       22       33	Santivanoz R	25	45	Walfson N	10, 10, 24	40, 47, 40
Santos Onvena, J. M.       16       1         Santos, J.       17       3       X         Savchenko, V.       14, 22       37       Xie, X.       13, 19       47, 48         Savchenko, V.       14, 22       37       Xie, X.       19       48         Schlick-Nolte, B.       21       9       Xuejin, Z.       20       47         Segal, I.       22       38       Y       39       Yanaki, N.E.       23       48         Shimron, A.E.       21       39       Yeager, J.R.       20       13         Shirav, M.       17, 19       2, 40       Yehieli, Y.       14       49         Siegel, F.R.       17, 21       40       Z       Zangieva, T.D.       21       3         Simpson, P.R.       27       Zangieva, T.D.       21       3       3       49         Sogona, T.       21       41       Zinkute, R.       22       43         Sogona, T.       21       41       Ziyadi, R.       13       49         Sokolov, V.       22       33       Solomatina, E.A.       41       Sousa, A.J.       26       9         Strivastava, S.       24       27       54 <t< td=""><td>Santos Olivoiro IM</td><td>10</td><td>+0</td><td>Wollson, N.</td><td>17</td><td>40</td></t<>	Santos Olivoiro IM	10	+0	Wollson, N.	17	40
Sartos, J.       17       3       A         Savchenko, V.       14, 22       37       Xie, X.       13, 19       47, 48         Sawlowicz, Z.       13, 14       38       Xu, L.       19       48         Schlick-Nolte, B.       21       9       Xuejin, Z.       20       47         Segal, I.       22       38       Y       20       47         Shatov, V.V.       26       39       Yanaki, N.E.       23       48         Shirron, A.E.       21       39       Yeager, J.R.       20       13         Shirrav, M.       17, 19       2, 40       Yehieli, Y.       14       49         Siegel, F.R.       17, 21       40       Z       Zangieva, T.D.       21       3         Sharinson, P.R.       27       Zangieva, T.D.       21       3       49         Sogona, T.       21       41       Zinkute, R.       22       43         Sogona, T.       21       41       Ziyadi, R.       13       49         Sokolov, V.       22       33       33       Solomatina, E.A.       41         Sousa, A.J.       26       9       9       Steinitz, G.       26       42 <td>Santos Unveira, J.IVI.</td> <td>10</td> <td>1</td> <td>×</td> <td></td> <td></td>	Santos Unveira, J.IVI.	10	1	×		
Savorieriko, V.       14, 22       37       No, X.       10, N.       13, N.       13, N.       13, N.       13, N.       13, N.       13, N.       10, N. </td <td>Santos, J.</td> <td>14 00</td> <td>د ٦٦</td> <td>Xie X</td> <td>13 19</td> <td>47 48</td>	Santos, J.	14 00	د ٦٦	Xie X	13 19	47 48
Sawiowicz, Z.       13, 14       38       Xu, L.       13       40         Schlick-Nolte, B.       21       9       Xuejin, Z.       20       47         Segal, I.       22       38       Y       39       Yanaki, N.E.       23       48         Shiraov, V.V.       26       39       Yanaki, N.E.       23       48         Shirav, M.       17, 19       2, 40       Yeager, J.R.       20       13         Shvartsev, S.L.       22       40       Yehieli, Y.       14       49         Siegel, F.R.       17, 21       40       Z       Zangieva, T.D.       21       3         Slaninka, I.       14       2       Zinbi, Y.       13       49         Sogona, T.       21       41       Zinkute, R.       22       43         Sogona, T.       21       41       Ziyadi, R.       13       49         Sokolov, V.       22       33       Solomatina, E.A.       41       Sousa, A.J.       26       9         Srivastava, S.       24       27       Steinitz, G.       26       42       2         Stewart, A.D.       26       42       43       43       43 <td>Savchenko, v.</td> <td>14, 22</td> <td>37</td> <td>Yu I</td> <td>10, 10</td> <td>47,40 78</td>	Savchenko, v.	14, 22	37	Yu I	10, 10	47,40 78
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Segal, I.       22       38       Y         Shatov, V.V.       26       39       Yanaki, N.E.       23       48         Shimron, A.E.       21       39       Yeager, J.R.       20       13         Shirav, M.       17, 19       2, 40       Yehieli, Y.       14       49         Siegel, F.R.       17, 21       40       Z       Zangieva, T.D.       21       3         Simpson, P.R.       27       Zangieva, T.D.       21       3       49         Slaninka, I.       14       2       Zinbi, Y.       13       49         Sogona, T.       21       41       Zinkute, R.       22       43         Sogona, T.       21       41       Ziyadi, R.       13       49         Sokolov, V.       22       33       Solomatina, E.A.       41       50       50       50       50         Steinitz, G.       26       9       51       50       42       51       50         Stewart, A.D.       26       42       43       50       50       50       50         Stewart, A.D.       26       42       43       50       50       50       50       50       5	Schlick-Nolte, B.	21	9	Adejin, Z.	20	47
Shatov, V.V.       26       39       Yanaki, N.E.       23       48         Shimron, A.E.       21       39       Yeager, J.R.       20       13         Shirav, M.       17, 19       2, 40       Yehieli, Y.       14       49         Shvartsev, S.L.       22       40       Yehieli, Y.       14       49         Siegel, F.R.       17, 21       40       Z       Zangieva, T.D.       21       3         Slaninka, I.       14       2       Zinbi, Y.       13       49         Sogona, T.       21       41       Zinkute, R.       22       43         Sogona, T.       21       41       Zinkute, R.       22       43         Solomatina, E.A.       41       Ziyadi, R.       13       49         Solomatina, E.A.       41       Susa, A.J.       26       9       5         Stewart, A.D.       26       42       27       5       5       43	Segal, I.	22	38	Y		
Shimron, A.E.       21       39       Yeager, J.R.       20       13         Shirav, M.       17, 19       2, 40       Yeager, J.R.       20       13         Shvartsev, S.L.       22       40       Yehieli, Y.       14       49         Siegel, F.R.       17, 21       40       Z       Zangieva, T.D.       21       3         Simpson, P.R.       27       Zangieva, T.D.       21       3         Slaninka, I.       14       2       Zinbi, Y.       13       49         Sogona, T.       21       41       Zinkute, R.       22       43         Sogona, T.       21       41       Ziyadi, R.       13       49         Sokolov, V.       22       33       33       49         Solomatina, E.A.       41       Ziyadi, R.       13       49         Steinitz, G.       26       9       5       5       43         Stewart, A.D.       26       42       43       43	Shatov, V.V.	26	39	Yanaki N F	23	48
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Shvartsev, S.L.       22       40       Termen, T.       14       49         Siegel, F.R.       17, 21       40       Z         Simpson, P.R.       27       Zangieva, T.D.       21       3         Slaninka, I.       14       2       Zinbi, Y.       13       49         Snoek, W.       21       41       Zinkute, R.       22       43         Sogona, T.       21       41       Ziyadi, R.       13       49         Sokolov, V.       22       33       33       33       349         Solomatina, E.A.       41       Ziyadi, R.       13       49         Sousa, A.J.       26       9       9       5rivastava, S.       24       27         Steinitz, G.       26       42       27       5       5       43	Shirav, M.	17, 19	2, 40	Vehieli V	14	10
Siegel, F.R.       17, 21       40       Z         Simpson, P.R.       27       Zangieva, T.D.       21       3         Slaninka, I.       14       2       Zinbi, Y.       13       49         Snoek, W.       21       41       Zinkute, R.       22       43         Sogona, T.       21       41       Zinkute, R.       22       43         Sokolov, V.       22       33       13       49         Sokolov, V.       22       33       3       3       49         Solomatina, E.A.       41       Ziyadi, R.       13       49         Sousa, A.J.       26       9       5       5       41         Stewart, A.D.       26       42       27       5       5       42         Stewart, A.D.       26       42       43       43       43       43	Shvartsev, S.L.	22	40	remen, r.	14	45
Simpson, P.R.       27       Zangieva, T.D.       21       3         Slaninka, I.       14       2       Zinbi, Y.       13       49         Snoek, W.       21       41       Zinkute, R.       22       43         Sogona, T.       21       41       Zinkute, R.       22       43         Sogona, T.       21       41       Ziyadi, R.       13       49         Sokolov, V.       22       33       33       33       49         Solomatina, E.A.       41       Ziyadi, R.       13       49         Sousa, A.J.       26       9       5       5       41         Steinitz, G.       26       42       27       5       5       42         Stewart, A.D.       26       42       27       5       43	Siegel, F.R.	17, 21	40	Z		
Slaninka, I.       14       2       Zinbi, Y.       13       49         Snoek, W.       21       41       Zinbi, Y.       13       49         Sogona, T.       21       41       Zinkute, R.       22       43         Sokolov, V.       22       33       33       30       33       49         Solomatina, E.A.       41       Ziyadi, R.       13       49         Sousa, A.J.       26       9       5       5       5         Steinitz, G.       26       42       27       5       5         Stewart, A.D.       26       42       27       5       5         Sterinitz, G.       26       42       27       5       5       43	Simpson, P.R.	27		– Zangieva T.D	21	3
Snoek, W.       21       41       Zinkute, R.       22       43         Sogona, T.       21       41       Zinkute, R.       22       43         Sokolov, V.       22       33       13       49         Solomatina, E.A.       41       Ziyadi, R.       13       49         Sousa, A.J.       26       9       Srivastava, S.       24       27         Steinitz, G.       26       42       27       5       5       43         Surin, V.G.       15       43       43       43       43	Slaninka, I.	14	2	Zinhi Y	13	10
Sogona, T.       21       41       Zivadi, R.       13       49         Sokolov, V.       22       33       34       34       34       34       34       34       34       34       34       34       34       34       34       34       34       35       35       35       35       36	Snoek, W.	21	41	Zinbi, T. Zinkute R	22	43
Sokolov, V.       22       33         Solomatina, E.A.       41         Sousa, A.J.       26       9         Srivastava, S.       24       27         Steinitz, G.       26       42         Stewart, A.D.       26       42         Surin V.G.       15       43	Sogona, T.	21	41	Zinkule, N. Zivodi P	12	40
Solomatina, E.A.       41         Sousa, A.J.       26       9         Srivastava, S.       24       27         Steinitz, G.       26       42         Stewart, A.D.       26       42         Surin V.G.       15       43	Sokolov, V.	22	33		15	49
Sousa, A.J.     26     9       Srivastava, S.     24     27       Steinitz, G.     26     42       Stewart, A.D.     26     42       Surin V.G.     15     43	Solomatina, E.A.		41			
Srivastava, S.     24     27       Steinitz, G.     26     42       Stewart, A.D.     26     42       Surin V.G.     15     43	Sousa, A.J	26	<u>``</u>			
Steinitz, G.         26         42           Stewart, A.D.         26         42           Surin V.G.         15         43	Srivastava S	24	07			
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