MEDICAL GEOLOGY NEWSLETTER
INTERNATIONAL MEDICAL GEOLOGY ASSOCIATION

NORWAY: MEDICAL GEOLOGY AT 33IGC
GREECE: ANCIENT MINING CONTAMINATION
GHANA: HEALTH HAZARD PREDICTION
RUSSIA: SALIVARY CALCULI
IRAN: ELEMENTS AND DISEASES ATLAS
... and more.

SEE PAGES 4 & 30 FOR HOW TO SEND YOUR CONTRIBUTIONS

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ELEMENTS AND DISEASES ATLAS OF IRAN (See p. 36)
We hope you will find much interesting information in this latest newsletter. We rely on your contributions so please send them to the editor, Dave Elliott.

Interest in medical geology and in the IMGA continues to grow but some have not paid the modest Association dues. It is time for you to demonstrate your commitment to medical geology and to the IMGA by paying your dues through the various payment mechanisms available (PayPal, credit card, check (U.S. and Canada)). Many members have paid their dues but if you have not and not paid your dues by June 30, your name will be removed from the roster and you will no longer receive the Newsletter and other current and future benefits of membership. More importantly, you will not be part of this challenging group effort to understand and to mitigate health problems caused by geologic materials and processes. The IMGA is about to embark on an exciting period of growth and development and we hope that you will want to be part of this new phase. If you have had difficulty paying the dues or have any questions concerning the Association dues feel free to contact any of us to discuss the situation.

For IMGA to fulfill its promise to the membership, to the scientific community, and to the millions of people around the world suffering from medical geology problems it is now time for us to get down to business. The Association wants to encourage more student involvement in medical geology; foster regional, national, and international medical geology conferences; provide seed money for worthwhile research projects; provide travel support to students and young professionals from developing countries; etc. To achieve these goals we must have a steady flow of income from membership dues. When we have the resources necessary, we will fund IMGA member travels to conferences and short courses. The funding will be based on need and potential for meaningful benefits and contributions. This will be an important matter for the association. IMGA wants to support young scientists who are interested in bringing this interdisciplinary science forward. It is also important to support scientists from developing countries where many studies in medical geology are carried out.

We are also now in the process of finding solutions for the future concerning journals and regular conferences. We already have regular hemispheric conferences in South America, the next one in Uruguay next year, but we are discussing international conferences also. Some immediate plans for the future:

- In August we will be heavily involved in the 33rd International Geologic Congress in Oslo, Norway, with several days of symposia, workshops, meetings etc.. We also invite you to the annual meeting of IMGA during the second half of the congress.
- In July we will be offering a one-day medical geology short course in Ghana and in November we will have a three-day short course in Peru. Both courses are funded by outside sources. We invite all those who wish to attend either of these courses to contact us.
- We are working on a web-based medical geology education package which is almost ready. It will be tested and hopefully it will be launched this autumn so all who want can use this package for credits at your universities.
- We are working with our regional divisions and chapters. We already have some chapters and welcome all who wish to establish an IMGA chapter, a group within a region that brings together people in an area (city, country, etc.) or in an organization (university, government agency, etc.) interested in medical geology.
- Work has started with a new book on medical geology, to be published by Springer, covering regional medical geology issues all around the world. Discussions have begun on translating Essentials of Medical Geology into Spanish. The book will also soon be translated into Chinese.

So continue together with us, your councillors and all members. The future is promising and we really fill a need in the international scene.

Olle Selinus, Bob Finkelman, Jose Centeno
The Colombian medical geology group continues its work of spreading the message about medical geology and promoting the development of this fascinating field of science in Colombia at different levels. In the last months, members of the group presented a lecture at School Gimnasio Campestre with the aim of getting teachers interested. It is intended to create a consciousness about the importance of teaching Geology for our welfare and the relevance of interconnections, starting in elementary school. This will permit the perception of reality as an interweaving of phenomena instead of discrete components that are independent, and unrelated to each other. The teachers are willing to lead basic research on medical geology issues (such as easy experiments to show biogeochemical cycles). Proposals will be reviewed to find one that meets both the requirements of the school and the scope of the group.

A cycle of lectures by students and professionals of varied areas began in April 10th at the Universidad Nacional in Bogotá, with the purpose of giving an overview of the diverse aspects and applications of medical geology, and to communicate the work of the group. The lectures are aimed at the academic community in general and are given every two weeks.

This has also been accomplished by using the university media such as student’s newspapers, internal newspapers and magazines, where articles and references have been published. This has been an opportunity to get the attention of more public and as an exercise for the development of the writing skills of the group members.

Some of the articles are:


Medical geology was addressed in the article “Mother Earth cares for its children” published by NOTICyT News Agency of Science and technology of Colombia. Ana María Rojas, Carlos Valencia and Sandra Carolina Londoño, all of them members of the group, were interviewed for this article.

The group found novel ways to communicate medical geology. Since the web is a powerful, massive, medium, with worldwide coverage, we created informal and open groups where everyone can become a member and contribute to the growth of the field of medical geology. It is a good and easy way to gather people around this field and to inform them what it is about, and the purposes and relevance of medical geology. Facebook is the second world’s largest social utility (Associated Press 2008) reaching a large proportion of population which can be influenced, as happened on February 4th 2008 when millions of people took to the streets to protest against kidnapping in Bogotá and other cities and towns of Colombia as well as in other countries of the world such as Australia, Cuba, France, Germany, Japan, England, Mexico, Peru and USA (El Tiempo 2008a). The march was convened by internet, it was an initiative of a Facebook group called “Colombia is myself” (El Tiempo 2008b).

Two medical geology spaces were created in May 2008: one in Facebook (http://www.facebook.com/group.php?gid=6940895394) and the other one in google groups (http://groups.google.com.co/group/geologia_medica), since Facebook does not allow you to attach articles, as does Google. The objectives are to promote medical geology and to create work webs of cooperation and exchange of information.
Connecting people has one of the most powerful impacts: common people can get involved in medical geology and can get in touch with experts and scientists; both actors could benefit from the experience. Professionals sharing interests can also find each other and projects, research, events, alliances; etc., can arise in Facebook or google groups!

The reader is invited to visit and join the virtual groups where he can find basic information about the Colombian group, papers and published works, virtual forums, links, opinion poll, etc., it also offers the possibility to share opinions and experiences, exchange information and get in touch with other people of the world interested in the topic.

REFERENCES

Castellanos, Y. 2008. La madre Tierra cuida a sus hijos. Agen-

Periódico El Tiempo. 2008a. Colombianos en el exterior tam-
bién se manifestaron contra las Farc. Bogotá, Colombia. Available at
http://www.eltiempo.com/politica/2008-02-04/ARTICULO-
WEB-NOTA_INTERIOR-3944118.html

Periódico El Tiempo. 2008b. Millones marcharon contra las
Farc. Bogotá, Colombia. Available at
http://www.eltiempo.com/politica/2008-02-03/ARTICULO-
WEB-NOTA_INTERIOR-3943495.html

The Associated Press. 2008. Facebook acuerda con estados
mayor protección a sus usuarios. Bogotá, Colombia. Available at
http://www.univision.com/contentroot/wirefeeds/noticias/7478267.html

NOTICES

EUROGEOSURVEYS URBAN GEOCHEMISTRY

The EuroGeoSurveys Geochemistry Working Group has launched a Sub-Working Group on Urban Geochemistry lead by Dr. Rolf Tore Ottesen of the Norwegian Geological Survey.

UK NATIONAL ENVIRONMENT RESEARCH COUNCIL

Environment, Pollution and Human Health Research Theme

In the UK, Prof. Roy Harrison OBE, has been appointed leader of this new Natural Environment Research Council research theme. Prof Harrison is based at the University of Birmingham where he heads the Division of Environmental Health and Risk Management and one of Europe's leading air pollution research groups.

CALL FOR CONTRIBUTIONS TO THE NEWSLETTER

The newsletter publishes papers, notice of and reports on conferences, and items of general interest to the Medical Geology community. Regional representatives of the IMGA are particularly requested to provide periodic updates of activities in their regions.

The deadline for submissions for the next newsletter is November 10th 2008, with publication planned in the following month. Please send contributions to either:

Dr. David Elliott at davide5@telus.net
Dr. Olle Selinus at olle.selinus@sgu.se or olle.selinus@gmail.com

See page 30 for a summary of editorial policy.
For anyone interested in exploring the relationship between earth materials and earth processes on health outcomes, the annual convention of the Prospectors and Developers Association of Canada (PDAC), held in early March in Toronto, Canada, is as close to a “kid in a candy store” experience as one might ever hope to find.

**Such Stuff as Dreams Are Made On**

This is not to say that one, hopefully sidling up to the Rio Tinto, Anglo-American, or BHP Billiton booth, claiming to be a medical geologist with a research proposal won’t have to explain to some hapless staffer in Investor Relations that they do not, in fact, spend their days caring for sick pet rocks. Rather, the overwhelming impression that results from a day-long stroll at a smart clip through the aisles of the country’s premier convention centre with 20,000 of your closest friends is that there must be a goldmine of geochemical and geophysical data locked in the vaults of the planet’s mining companies.

Of course, every noble endeavour encounters a few snags along the way, otherwise everyone would be doing it. Generally poor overlap of areas rich in mineral deposits with those of high population density may be one of them. Convincing for-profit organizations, who are not in the business of philanthropy, to share their wealth of proprietary information for the good of humanity may be another. In light of the mining industry’s hard-knuckled reputation, corporate espionage sounds like it might be easier. Or perhaps a remake of Mission Impossible or Ocean’s 11 should be attempted by a rag-tag collection of daring biogeoscientists in the Exploration and Development offices of the more than 800 PDAC member companies (http://www.pdac.ca) who run projects all over the world from Athabasca to Zambia?

**Can Mining Companies Be Un-Evil?**

However, before aspiring medical geologists start risking jail time, it is worth noting that something far stranger is happening, the cosmos has shifted – the mining industry is reinventing itself, or at least it’s trying to. The nuts and bolts are essentially the same. The name of the game is still finding mineral deposits that you can get out of the ground and processed for less than you can sell them. Quarterly reports are still rife with assay results and grade-tonnage estimates. But formerly foreign terms like “environmental sustainability”, “community relations” and “corporate social responsibility” are being spoken in resource company board rooms across the land. It’s almost as if *people*, and their perceptions, mattered as much as the commodity itself. Truly, we are witnessing a renaissance. And in case you had not noticed, with China and India industrializing faster than you can say “pass me the raw materials”, times are good in the mining industry right now and will be for the foreseeable future. Natural resource companies are now eager to put their money, and possibly their data, where their mouth is - which can be as hard to find as a palladium deposit, as they tend to be a secretive lot.

**Not Business as Usual**

But in the ever-changing world of mining, that may soon be a thing of the past. And while there are a variety of fascinating reasons for this corporate change of heart, it is fair to say that motives are not entirely altruistic. Although being “the mining company that cares about your health” is not a bad Public Relations niche. As it turns out, corporate social responsibility is now considered to be trendy and good business, too. This is evidenced by sold-out workshops on the topic of “obtaining and retaining the social licence to operate”, recent changes to natural resources legislation in many countries, as well as self-policed initiatives like Towards Sustainable Mining (http://www.mining.ca) with its External Outreach and Health and Safety components, and the advent of organizations like the Global Business Coalition on HIV/AIDS, TB and Malaria (http://www.gbcimpact.org).

The problem, or snag, for the mining industry is that it is as hard to teach the old dogs within the industry new business tricks as it is to do an overnight makeover on a public image that you’ve been perfecting
for centuries. The mere suggestion of increased transparency and information sharing still makes most mining company executives twitchy. Even if the mining industry is successful in performing a profound cultural transformation, which it seems intent on doing, it is going to take no small amount of consistent behaviour and grandiose expressions of good will for the general public to accept that the corporate personality change is genuine.

**Strange bedfellows**

Perhaps ironically, the “evil mining companies” are not the only ones to have been caught short by a monumental shift in priorities lately. The National Science Foundation is currently bringing all available resources to bear on the problem of steadily decreasing earth science literacy in North America (http://www.earthscienceliteracy.org) in hopes of reversing the (Malcolm) Gladwell-ian Tipping Point of social (and physical) ills caused by neglecting our relationship with the natural environment. Identifying the most important Big Ideas from the earth sciences that every citizen must know in order to make informed decisions about what to buy, where to live, and who to vote for will be the easy part. Reprogramming the consumption patterns of Abundance Era-raised Baby Boomers, and deciding who will pay for the call are most likely to be the biggest stumbling blocks in re-connecting Joe Public with Mother Earth.

Thus, the Inconvenient Truth for critics of the free market economy and supporters of big government is that the mining industry, with all of its vast financial, information and human resources, is as desperate to figure out how to start relating to their communities of interest by being model corporate citizens, as the communities of interest are to understand how to relate to their natural environment. Though it may sound utilitarian, many successful relationships have been based on far less than mutual need. And it’s not that government has no role to play in this fledgling romance – the best quality geoscientific datasets have always been produced and archived by the Geological Surveys and ministries of Natural Resources and Environment using public money – but Big Brother might make a more suitable chaperone in this case.

**Shall we dance?**

So, if public health and the mining industry are a match made in heaven, the big question then becomes, who is going to be brave enough to cross the gymnasium floor? The answer is neither – the magnetic poles will reverse before either group gets over their shyness and barriers to communication. And herein lay the opportunity for medical geology to step into the time-honoured role of intermediary and pass a note in Social Studies class. It might read something like this…

> Ashes to ashes, dust to dust and the time in between … Human health is largely determined by the interaction of Earth elements.

> Many of the diseases that are decimating your workforce may be preventable … With the skilled application of local geoscientific data.

> A healthy population of end-users spends less on medical treatment … And more buying the products that are made with your minerals.

> Societies where the adult population is healthy, educated and gainfully-employed … Are safe places to invest and operate.

> You’ve made it your business to understand earth processes and earth materials …And your Communities of Interest are eager to know what you know about their backyards.

> The key to obtaining and retaining a social licence to operate … Also opens the vault where you store your geoscientific data.

> What do mining companies and public health have common?

> Find out by joining the International Medical Geology Association.

> PS. You’ll be happy to know that community consultation expenses and baseline environmental assessments are now eligible for flow-through, so it will be a cheap date.
MEDICAL GEOLOGY PRESENTATIONS AT 33IGC IN OSLO

The 33rd International Geological Congress will be held in Oslo, August 6—14th, 2008. Sessions of Medical Geology interest are listed below. See www.33IGC.org for more information on the Congress.

Theme of the Day: Water, Human Health and the Environment, August 11
Olle Selinus Opening
Bo Olofsson Groundwater - principles and perspectives
Philip Weinstein Cultural evolution and water-borne exposure pathways
Jose Centeno Health effects of arsenic in drinking water
Mike Edmunds Fluorine: water-rock-human interactions - a global overview
Don Appleton, Jon Miles Radon and health risks of radon in groundwater
Ghislain de Marsily Climate change, demographic growth, food and bioenergy production: will there be enough water for all, including the ecosystems? PLENARY LECTURE
Philippe Schmidt-Thome Climate change adaptation and water - examples of facing multiple challenges from sea level rise to water scarcity from a planning perspective
Roger Aertgeerts Risk management of groundwater contamination in the context of water safety plans
Anders Berntell Why is groundwater neglected in water management discussions?
Andras Szollosi-Nagy Global changes, an accelerating water cycle, adaptation strategies: Can we cope?
Asfaw Dingamo Ethiopian groundwater resource management

PANEL DISCUSSION

PEE-01. Earth and Health – Planet Earth, August 12
Olle Selinus Earth and health - the impact of the geological environment on our health
Eiliv Steinnes Soils and geomedicine
Jose A. Centeno Integrating Earth Science and Public Health: Milestone and Recent Developments
Edward Derbyshire Natural mineral dust and human health: A review
Jane Plant, Rebecca Mckinlay, N Voulvoul Endocrine disrupting substances in the late anthropocene and breast and prostate cancer
Robert Finkelman Medical geology: A glance into the future

MGH-01 Medical Geology, August 12-13
GeirSverre Braut Why does knowledge remain unused in medicine? On ideological and conceptual barriers for exchange of knowledge between medicine and other sciences
Cathy Skinner Earth Sciences and Public Health
Harijoko Factors controlling Iodine Deficiency Disorder (IDD) incident in communities living within volcanic landscapes
Jacks Zinc deficiency in soils, Crops and food intake in central Mali
Soleimani Correction of soil Zn and Fe deficiency
Silva Medical geology studies in Brazil
Mantovani Geoenvironmental conditions of the Brazilian Southern Highlands and human water intake
Londono A medical geology characterization of geological materials with medical use and handling by the Uitotos indigenous society.
Valencia Geological influences on the soil contributions to infections transmitted by helminths in Colombia
Kristmansdottir Hydrothermal meddicative clays - mud fermentation cure in Iceland
Hendrickx Naturally occurring asbestos in eastern Australia: Geological occurrence, disturbance and mesothelioma risk.
Dogan Asbestos and mesothelioma in Houma, New Orleans, USA
Lepetit A geological approach to explain the unprecedented mesothelioma epidemic in Cappadocia
Engelbrecht Chemistry; and individual particle characteristics of aerosols from the Middle East
Horwell Formation of volcanic cristobalite: implications for health hazards
Derbyshire Minerogenic dust and human health: sources, pathways and health impacts
Tondel Parish classification or dwelling coordinate for exposure assessment in environmental epidemiology
Karageorgio Lignite - commodity or dangerous material?
Muller Highly time-resolved Pb exposure monitoring using laser- ablation ICPMS profiles of tooth enamel
Size Connections between earth and human body processes - uniformitarianism and homeostasis
Zhou Geochemical environmental effects of metallic sulfide deposit and its mining and origin of cancer village in Dabaoshan
from - northern Guangdong (China)

Jovanovic  The mineral waters and human health

Farakhov  Sedimentary basins: Medical and geological aspects of the studies

Navi  Contribution to the geochemical elements and diseases distribution in Iran

Hsu  Evolution, Pollution, and Cancer

Pradha  Issues in climate change and health impacts in Nepal.

Olatunji  Geochemical evaluation of the Lagos lagoon sediments.

POSTERS

Sahakyan  Mercury in urban ecosystem as a risk factor

Denisova  Ecoregional factors and diseases of a thyroid gland of the population in Tomsk region

Rajchel  Medicinal waters in Carpathian spas

Volfson  Medical and mineralogical aspects of the study of flints

Quintela  Diatoms from volcanic mud samples: Preliminary studies for Pelotherapy application

Gianfagna  Characterization of fibrous tremolites of environmental and health interest

MGH-02 Groundwater - Geopollution, Contamination and Health Aspects, August 13

Invited lecture: Komai, Takeshi; Kawabe, Yoshishige; Takeuchi, Mio; Haru, Junko  Risk Assessment of heavy metals due to exposure from soil and groundwater in Asian countries

Nirei, Hisashi; Hiyakma, Tomoyo; Takashi, Kusuda; Furuno, Kunio  An illustrative example of the geo-pollution and the diagnostic standard for cleanup on the geo-pollution sites - In the case of VOCs such as PCE, TCE, etc.

Backman, Birgitta; Luoma, Samrit; Ruskeenimi, Timo; Karttunen, Virpi  Arsenic in bedrock groundwater in the Pirkanmaa region of Finland

Satkunas, Jonas; Arustiene, Jurga; Kanopiene, Roma  System of inventory, databasing and monitoring of contaminated land and groundwater, case of Lithuania

Fujita, Hiroshi; Kinjo, Yugo; Hiyama, Tomoyo; Nirei, Hisashi  The basic study on the behavior of ground air flows with polluted ground air from the view point of geo-pollution science

Stojiljkovic, Dragica  Electromagnetic detection of groundwater pollution sources

Kusuda, Takashi; Kasahara, Yutaka; Yoshida, Takeshi; Nishikawa, Jyunji; Kamura, Kazuo; Kinjo, Yugo; Nirei, Hisashi  River water contamination of TBP caused by LNAPL in disposal site and domestic groundwater monitoring system

Furuno, Kunio; Takanaka, Fumio; Satoh, Kenzi; Nirei, Hisashi; Kazaoka, Osimu; KUSUDA, Takashi  Simulation of groundwater pollution at geo-pollution site by trichloroethylene, Mobar, Chiba Prefecture, Japan

Kochergina, Nataliya  Mathematical models of contaminant transport with groundwater in the system of groundwater monitoring

Atal, Surendra; Pauwels, Hèdène; Ahmed, Shakeel  Geogenic fluoride contamination in granitic hard rock aquifer, India

Pogadala, Sreedevi; Ahmed, Shakeel  Alarming Fluoride contents in groundwater in semi-arid region in India: Analyzing for its vulnerability

Mehrparo, Layla  An investigation on sources and amounts of heavy metal pollutant in drinking water in Kurdistan province (west Iran)

Das, Madhumita; Goswami, Shreerup  Groundwater contamination due to manganese mining and its impact on health of mine-workers- a case study from India

Thanabalasingam, Jeyaruba; Thushyanthy, Mikunthan  Health hazards by nitrate pollution of groundwater in intensified agricultural areas

Rylander, Ragnar  Ground water composition and mineral homeostasis

Kousa, Anne; Havulinna, Aki S.; Moltchanova, Elena; Taskinen, Olli; Nikkarinen, Maria; Salomaa, Veikko; Karvonen, Marjatta  The spatial variation of acute myocardial infarction incidence and magnesium in well water in rural Finland

POSTERS

Takashima, Hiroshi  Most vulnerable aquifer and geo-environmental management by local government

Xu, Younging  Content characteristics of heavy metal in the Villager's hair in Xiaoqinling gold mine area

Matic, Ivan; Vujasinovic, Slobodan; Minic, Goran  Ecogeological conditions of contaminated river deposits cleanup process near the water supply source of Belgrade

Zhang, Ming; Ono, Akira; Sawada, Akira; Komai, Takeshi; Marumo, Katsumi; Sugita, Hajime  Electrokinetic remediation of
heavy metal polluted low-permeability geoformations by using clean energy
Pinto, Paulo; Pereira, Alcides; Vicente, Ana; Neves, Luis Assessment of natural radioactivity in groundwater in Central Portugal - a preliminary study
Nirei, Hisashi; Maker, Brian; Satkunas, Jonas; Furno, Kunio Two types of mechanism of geo-pollution and stratigraphical classification of man-made strata
Paramonova, Nina; Ognianik, Nikolay; Shpak, Olena Experimental research on accumulation of a light petroleum product layer above a groundwater table
Kagawa, Atsushi; Furuno, Kunio; Nirei, Hisashi; Kusuda, Takashi Important role of continuous and precise groundwater monitoring in polluted groundwater pumping tests on geo-pollution sites
Kazaoka, Osamu; Murakoshi, Mitihito; Kusuda, Takashi; Nirei, Hisashi; Tanaka, Takeshi; Aoki, Katsuhiko; Yamaki, Akiko; Takeuchi, Mio Natural attenuation, groundwater flow and groundwater quality of shallow aquifer on VOCs Geo-pollution site in Urabe district, northern part of Shimousa upland, northern Boso Peninsula, central Japan
Hiyama, Tomoyo; Ikeda, Hidefumi; Takahata, Hideyuki; Nirei, Hisashi How to use the groundwater resources at geo-pollution area on organoarsenic compounds
Fujsaki, Katsuhiko Groundwater modeling in assessments of geo-pollution research and remediation
Yoshida, Takeshi; Nirei, Hisashi Distribution of arsenic concentrations in Holocene deposits of Tokyo lowland, Japan
Soma, Kunika; Nirei, Hisashi; Hirata, Noriko A study on depositional process of man-made strata in an overland depression for the basic study of geo-pollution
Nishikiori, Tatsuhiko; Obara, Takatsugu; Takeshima, Toshiyuki; Kameyama, Shun; Fuse, Taro; Nirei, Hisashi; Takamatsu, Takejiro Nitrogen contamination of groundwater and hydro-stratigraphic unit from the view point of geo-pollution science
Glinskiy, Mark Arrangement of ecological monitoring of surface storages and subsurface disposal sites
Chaves de Oliveira, Igor José; Brenha Ribeiro, Fernando; de Oliveira Lucas, Fabio Ground water radioactivity levels in some granitic and metamorphic rocks from Southeastern Brazil
Rajchel, Lucyna; Czop, Mariusz; Motyka, Jacek Mineral and therapeutic groundwater beneath the highly urbanised area of the Cracow City (South Poland)
Rajchel, Lucyna; Chau, Nguyen Dinh; Chruoecl, Edward; Rajchel, Jacek; Motyka, Jacek Investigations of natural radioactivity of carbonated waters from the Poprad River valley in the Polish Carpathians
Rajchel, Lucyna; Rajchel, Jacek Landscape and scientific valours of springs in the Polish Carpathians
Yudakhin, Felix; Malov, Alexander Natural strontium in drinking water of the Arkhangelsk region

MGH-05 Medical Mineralogy, August 14
Pogacnik, Zelko; Andrejasic, Miha; Murko, Simona Salnoit Anhovo Coral calcium elemental fingerprints from the food additives
Dogan, A. Umran; Dogan, Meral Quantitative medical mineralogy as applied to erionite series minerals
Dogan, Meral; Dogan, A. Umran Quantitative aspects of regulatory and nonregulatory asbestos group minerals
Gunter, Mickey Detection and characterization of amphibole and asbestiform amphibole in natural materials: The importance to society and why geologists must take the lead
Kuleci, Hakan; Dogan, Meral; Schleicher, Helmut; Ballirano, Paolo; Dogan, A. Umran Characterization of fossil bone minerals using high resolution powder x-ray diffraction
Skinner, H. Catherine W Problems in biogenesis/diagenesis: methods of evaluation of bioapatites
Smoliga, John Mineralogy in the pharmaceutical industry
Ballirano, Paolo; Andreozzi, Giovanni; Dogan, Meral; Dogan, A. Umran Crystal chemical characterization of fibrous erionite from Rome, Oregon, USA
Alaygut, Dogan; Yesilyurt, F. Irem; Canga, Bora; Tuzuner, Tugrul Characterization of fibrous tremolite type asbestos minerals using scanning electron microscopy-energy dispersive spectroscopy-powder X-Ray diffraction
McGlothlin, James; Albrecht, William; Carbone, Michael; Dogan, Umran; Dogan, Mera; Miller, Aubrey; Brass, Brian; Nutt, Connie; Akkus, Murat A pilot study of activity-based real-time airborne particle sampling for eronite and particle size at six villages in Cappadocia, Turkey
REPORTS ON CONFERENCES


The conference was co-organised by the Hellenic Institute of Geology and Mineral Exploration (IGME) and the Faculty of Geology and Geoenvironment, National & Kapodistrian University of Athens (UOA) with the following themes:

- Health implications of mineral pollutants with emphasis on asbestos
- Air-Soil-Water pollution and health
- Endocrine disrupting substances and health
- Health impact of waste management
- Environmental geochemistry in the decision making process for health protection
- Site specific versus generic guideline values
- Geochemical baselines
- Marine pollution

Keynote Speakers included the following:
David Gee (European Environment Agency, Denmark). Late onset environmental stressors: the implications for early prevention.
Luc Hens (Vrije Universiteit Brussel, Belgium). Health impact assessment of motorised mobility.
Klea Katsouyanni (National & Kapodistrian University of Athens, Hellas). Effects of ambient particles on health.
Anthony J Newman Taylor (National Heart and Lung Institute, Imperial College London, UK). Mineral dusts and disease.
Olle Selinus (Geological Survey of Sweden). Medical Geology.

A post-conference workshop, FROM RISK ASSESSMENT TO RISK RESPONSE: Communicating Complex Risks To Concerned Stakeholders brought together researchers and practitioners, to explore ways of improving risk communication about environmental threats to health, in order to enhance risk management and risk response.


A session on “Iodine and Selenium Anomalies in Soils and Health” was held at the EGU in Vienna in April 2008. The session focussed on the geochemistry of these elements in soil and uptake and implications for plant, animal and human health.

Fuge, R. Iodine in soil, relationship with human and animal health
Korobova, E. Soil and landscape geochemical factor of iodine distribution in the main environmental components and agricultural food chain within the central Russian plain
Johnson, C. C., Fordyce, F. M. Iodine and Selenium in soils: British Geological Survey case studies into trace element deficiencies and human health from around the world.
EUROGEOSURVEYS AGRICULTURAL SOIL GEOCHEMICAL MAPPING PROJECT. Berlin 5-7 March 2008

The EuroGeoSurveys Geochemistry Working Group had a meeting in Berlin from March 5-7, 2008. At this meeting the GEMAS-Project (Geochemical Mapping of Agricultural Land and Grazing Land Soils of Europe) was launched. 34 European Geological Survey Organisations have agreed to collect samples of arable land (ploughing layer, 0-20 cm) and of land under permanent grass cover (0-10 cm) at a density of 1 site per 2500 km$^2$ in their territory. The total area covered will be about 5.8 million km$^2$. The project is a continuation and extension of the Baltic Soil Survey (Reimann et al., 2003). The project is led by Dr. Clemens Reimann, of the Norwegian Geological Survey, who is Chair of the EuroGeoSurveys Geochemistry Working Group and Vice President of the International Association of Geochemistry (IAGC). The European metals industry, represented by EuroMetaux in Brussels, will contribute to this project over a period of four years.


GEOLOGICAL SOCIETY OF AMERICA. GEOHEALTH I: BUILDING BRIDGES ACROSS THE GEOLOGICAL AND HEALTH SCIENCES. Reston, Virginia, 4—6 March, 2008

This conference was held at the U.S. Geological Survey headquarters in Reston, Virginia, March 4-6, 2008 and attracted nearly 100 participants representing about 50 different government, academic, and private organizations. The format of the conference generated considerable discussion and interaction between the participants. Following an hour-long presentation of a case study an additional hour was allocated for questions, answers and open discussion. The case studies included:

Human Exposure to Drinking Water Contaminants - Arsenic, led by Joseph Graziano and Lex van Geen of Columbia University
Human Exposure to Drinking Water Contaminants – TCE and PCE at Camp Lejeune, NC led by Morris Maslia and Daphne Moffett of the Centers for Disease Control
Perspectives on Airborne and Soilborne Contaminants – Lead and other contaminants Before and After Hurricane Katrina, led by Howard Mielke and Felicia Rabito of Tulane University

In addition there were presentations by:

Bruce Fowler (Agency for Toxic Substances and Disease Registry) - Building Bridges Across the Earth and Health Science Disciplines
Bob Finkelman (University of Texas at Dallas) Geology and Health: A Brief Look at the Past and a Glance Into the Future
Mark Stenzel (American Industrial Hygiene Association) An Overview of Exposure Assessment Techniques;
Donna Myers (USGS) Geology and Human Health: The Earth Scientist’s Perspective
Ed Ohanian (US EPA) Human Health and Geology : The Health Scientist’s Perspective
Jose Centeno (AFIP) Earth Materials and Health Research Priorities for Earth Science and Public Health
Tee Guidotti (George Washington University) Emerging Needs/ Research Agenda
Bernard Goldstein (University of Pittsburgh) Building Bridges Across the Geologic and Health Sciences, and to Our Target Audiences (public, policy makers, decision makers).

The Geological Society of America will soon issue a report on the conference.
PROBLEMS OF ENVIRONMENTAL GEOCHEMISTRY IN THE XXI CENTURY
REPUBLIC OF BELARUS, MINSK, June 25-26, 2008

An International Scientific Conference devoted to the Seventieth anniversary birthday of Member-Correspondent of the National Academy of Sciences of the Republic of Belarus, Dr. Valentine Lukashov (1938-1998). Shortly after giving a paper at the first meeting of what ultimately became the International Medical Geology Association in Uppsala in 1998, Dr. Valentin Lukashov collapsed, and died shortly afterwards in hospital.

The conference will focus on five key areas:
- Geochemistry of natural landscapes
- Urban geochemistry
- Geochemistry of river and limnological systems
- Methods of environmental geochemistry
- Medical geochemistry

For full details of the conference contact the conference organizing committee:
Chair of Dynamic Geology, Organizing Committee of the International Conference "Problems of Environmental Geochemistry in XXI Century", 220050, Belarus, Minsk, pr. Nezavisimosti, 4, State University of Republic of Belarus, Geography Department,

Conference Science Secretary Dr. Oleg V. Lukashov, Minsk, Belarus, Tel.: +375-17-209-50-86, E-mail: v_k_lukashev70@tut.by

SOUTH AMERICA INTERNATIONAL WORKSHOP AND SHORT COURSE ON MEDICAL GEOLOGY. LA MOLINA, PERU, November 26-29, 2008

The International Medical Geology Association in collaboration with the Peru Institute for Mining Engineers is pleased to announce the organization of the South America International Workshop and Short Course on Medical Geology, in the week of November 26-29, 2008, in La Molina, Peru. This conference is aimed at strengthening the role of medical geology research programs in South America with particular emphasis on the Peruvian context. The scientific program will have presentations from national and international scientists working on environmental and medical geology issues. The third day of the workshop will be dedicated to a field trip to explore regional medical geology issues. For additional information, please contact the organizers of the workshop at:

Venancio Astucuri, Jefe de Educación Continua, Instituto de Ingenieros de Minas del Perú Los Canarios 155 - 157, La Molina.
Tel: (511) 313-4160 Anexo: 292; email: vastucuri@iimp.org

To obtain information about this workshop please visit the following website at: (http://www.iimpvirtual.com/cursos/p_geologia.htm)
The Lavreotiki peninsula is situated in the southeastern tip of Attiki Prefecture, Hellas.

According to archaeological evidence, it is certain that mining of the valuable mineral, silver bearing galena, which provided the financial means for the civilisations that flourished in the ancient Aegean, began about 3500 B.C. The mines closed down at the end of the 1st century B.C. Andreas Cordellas in 1860 A.D., was the first to foresee the potential of exploitation of ancient slag and mine tailings, which were estimated to be a few million tonnes. The recent history of ore exploitation began in 1864 A.D., when the Italian J.B. Serpieri founded at “Ergastiri”, the present port of Lavrion, the metallurgical company Roux Serpieri Fressynet C.A. Hence, the first metallurgical company was formed with Castillian type kilns, small washing plants, an engineering section, and a train. In 1865 A.D. the production of silver bearing lead began once again from the treatment of ancient slag and mine tailings, and after the second year of operation new ore exploitation began.

In 1873 A.D. the company Roux Serpieri Fressynet C.A. was purchased by the representative of the Bank of Constantinople, Anreas Syngros, and was renamed Société des Usines du Laurium. In 1876 A.D. Serpieri founded at “Kiprianos”, a larger company, the Compagnie Française des Mines du Laurium, at which sulphide and other ores were treated, such as sphalerite, pyrite, galena, cerussite and smithsonite. The main centres of ore exploitation were Kamariza, Souriza and Plaka. Lavrion, with all these activities was revived, and became one of the most significant mining and metallurgical centres in Europe.

Kamariza (the present village of Aghios Constantinios) was the centre of mining operations, not only in ancient times, but in recent years. Here in 1869 A.D. the first tunnel was excavated for the first railway line in Hellas, which transported ore to the port of Lavrion.
The working and living conditions of the miners were particularly harsh. For this reason there were repeated strikes demanding better working conditions. The “Lavreotiki events” were very significant for the recent workers movement in Hellas, thus giving a special value to the town of Lavrion.

In 1977 the mines closed down completely and, in 1989, the metallurgical plant. In 1992 the installations of Compagnie Française des Mines du Laurium were purchased by the Hellenic State with the aim to develop a Technological-Cultural Park, a project undertaken by the National Technical University of Athens.

Environmental Impact
Exploitation of the mineral wealth of Lavreotiki peninsula, from ancient to recent times, resulted in the accumulation of enormous quantities of waste materials, such as
- waste rock,
- mine tailings,
- slag and
- other coarse- to fine-grained metallurgical processing residues,
found in many parts of the peninsula, and especially the Lavrion urban area.

Conophagos (1980) estimated that the ancient Hellenes excavated at least 13,000,000 tonnes of rock; he stressed that this is a very conservative figure. The volume of excavated material during the 19th and 20th century operations is not easy to estimate. Since, modern underground and open pit mining uses explosives and mechanical equipment, the dimensions of adits and pits are much larger, and the quantity of excavated rock should at least be double of what Conophagos (1980) estimated for ancient exploitation. A cautious estimate of excavated material is two to three times the quantity of the ancients, i.e., approximately 30,000,000 tonnes. As it may be appreciated, a considerable amount of waste rock is present in the Lavreotiki peninsula, and is exposed to the processes of weathering, erosion and deposition.

The Lavrion urban and suburban area is covered by a large volume of slag, flotation tailings, and pyritiferous sand. These metallurgical wastes cover approximately 25% of the 7.235 km² of the area studied. The effects, of mining and smelting activities, were the burdening of residual soil and alluvial sediments with additional amounts of toxic elements. It is stressed that natural soil and alluvial sediments, because of the mineralisation, had ‘naturally’ high concentrations of toxic elements.

Ancient exploiters built ore crushing and washing plants in valleys, for they required water for separation of ore-grade material from the waste rock. This practice facilitated transportation of waste rock and mineral processing wastes by erosion processes.
Geochemical maps of lead (Pb) showing its distribution in parent rocks (primary) and in surface soil (secondary), Lavreotiki peninsula (From Demetriades et al., 1994).

(fluvial and aeolian), and their subsequent deposition in the floodplains and gulfs of Lavreotiki peninsula. These processes have been going on for at least the past 5,000 years. From 1865 mine and flotation tailings (ekvolades and plynites) left by the ancients gradually disappeared, due to their exploitation, and new waste products generated by modern exploiters from ancient waste materials, such as beneficiation/flotation residues (flotation tailings) and slag, and from mining new ore they produced large quantities of waste rock, mine tailings, and metallurgical wastes. It is stressed, that ancient pits and adits directed modern exploiters, who enlarged the adits, excavated open pits near valleys, and tipped waste rock again on hill slopes and valley bottoms.

In the Lavrion urban and suburban area, a number of streams have their outlets. Within their drainage basins, there is a very large number of ancient and recent mining and smelting sites. Hence, the alluvial plains in Lavrion have been contaminated.

Late 19th and 20th century metallurgical processing wastes have been dumped, mainly in the Lavrion urban area and the nearby gulfs, thus upsetting the natural balance of the local terrestrial and marine ecosystems. Their transportation, by erosion (fluvial and aeolian) processes and human activities, resulted in the toxic element contamination of soil in the greater part of the Lavrion urban environment. In fact, houses, schools, parks, playgrounds, sport fields and roads are either situated on or are very close to these wastes. The consequences are the health related problems of the local population, documented
This was one of the most serious and challenging issues that the team of researchers from the Hellenic Institute of Geology & Mineral Exploration (I.G.M.E.), the National Technical University of Athens (N.T.U.A.), and PRISMA, faced at the end of the project “Soil Rehabilitation in the Municipality of Lavrion” (see below the risk communication information leaflet). The I.G.M.E. geoscientists had a lot more experience, because they worked in the LAVRION, GREECE, Cont.

by different medical studies.

**RISK PERCEPTION AND COMMUNICATION IN LAVRION**

*How does one communicate risk to people that live and work in one of the most extremely contaminated areas in Europe, and where the health related consequences are not so evident?*

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**Photographs showing the exploitation of ore in the Lavreotiki peninsula**

- Twin entrance to an ancient adit at Aghia Triadha. (Photo by E. Dimou & V. Perdikatsis)
- Large quantities of mining wastes are still found in front of one of the largest ancient adits. (Photo by E. Dimou & V. Perdikatsis)
- Interior of an ancient adit widened by recent exploitation. (Photo by E. Dimou & V. Perdikatsis)
- Today the only inhabitant and “keeper” of the ancient adit, the bat, comes out frightened by the camera flash. (Photo by E. Dimou & V. Perdikatsis)
area since 1989 and had personal contact with many local people, teachers, medical officers, local and central politicians, and also were acquainted with the results of three cross-sectional epidemiological studies.

Perception of environmental risk in an area where the people worked in mines and smelters, for almost their whole life, and their homes are built on hazardous wastes, is indeed difficult to communicate. Whole families are known to suffer from signs of mental retardation, because of high blood-lead concentrations. As one medical officer said: “these people are at a disadvantage, because they are born in area where environmental contamination causes a reduction in their I.Q., which depends on the physiology of each person”.

It is worth mentioning the reaction of a person with noticeable mental retardation, when told that the Lavrion urban area is highly contaminated and may cause health problems: “we have been raised here, and we are not stupid!” Evidently, this particular person is not in a position to perceive the health risk. During our work in the Lavrion urban area and Lavreotiki peninsula, we have met families with quite evident mental retardation, but seemingly happy with their lives. Therefore, the first problem of communicating risk lies on the capability of people to understand the hazardous environmental conditions.

The other problem comes from politicians of both the local and central government that do not want to know anything about the health related hazard in the Lavrion urban area and Lavreotiki peninsula, although they are aware of the conditions. The I.G.M. E., as a State research institute, is obliged to submit its environmental impact assessment reports to all interested parties, i.e., Municipalities and Ministries. Up to now three reports have been submitted, i.e., the first in 1992 was concerned with the urban geochemistry of Lavrion and Aghios Constantinos; the second in 1994, covered the whole Lavreotiki peninsula (170 km²) with soil geochemistry, and the third in 1999 was a very detailed multidisciplinary environmental impact and management study that covered the Lavrion urban and suburban environment (7 km²). Therefore, the politicians are well aware of the health related hazards, but are not interested to find a viable solution.

To understand the attitude of local politicians the following statement from one of them is mentioned: “we cannot publicise the results of your study, because if we do, people will be scared and most likely leave. New buyers will not be interested to invest in...
the area, and, therefore, property prices will be affected”. Although, environmental quality is an issue of concern on paper, and included in the political agenda of all parties, when a real health related environmental issue is raised the first variables examined are property prices and political cost. Therefore, scientists communicating environmental risk, should take into account how this is perceived, not only by the inhabitants, but also by the local and central politicians.

Since, we knew that it will be difficult to communicate environmental risk in the Lavrion urban area, during the compilation of the LIFE project, a number of communication actions were included:
(a) compilation of an information leaflet (see below),
(b) a video tape showing project results and recommendations, and;
(c) public presentation of results.

The information leaflet with recommendations to the local inhabitants was never distributed; it remained in the storerooms of the Municipality. Not many people came to the public presentation of project results; again the invitations were the responsibility of Municipality officers. The Mayor, during the presentation, intervened by stating that the situation is not so serious, since he and his family lived all their lives in Lavrion and there is nothing wrong with their health. The scenario of the videotape was carefully written to communicate project results in an understandable manner, and not to cause unrest to the local population. The videotape was never shown to the public and schools. The irony of the situation is that the Municipality of Lavrion was the co-ordinator of the project.

How does one communicate risk, therefore, to people that are not interested to hear the truth about the state of their living environment, and to politicians that are mainly concerned about the political cost

Photographs from Demetriades and Stavrakis (1995) and Demetriades (1999).
and property prices, and not the improvement of the quality of the urban environment and the health of people?

**EPIDEMIOLOGICAL STUDIES**

The problems and effects of contamination in the Lavrion urban area were detected to begin with, by cross-sectional epidemiological studies in the 1980s. Their conclusion was that children of nursery and primary school age had a severe problem of lead-poisoning (plumbosis). In addition, their system had high concentrations of arsenic. The last cross-sectional epidemiological study, which was carried out in 1988 on 235 children from Lavrion, showed the seriousness of environmental contamination on the health of children.

The cross-sectional epidemiological studies have also shown that there is a strong correlation between high blood-lead levels in children and;

(1) their composite mental functions, i.e., intelligent quotient (IQ), verbal intelligence quotient (VIQ);

(1) a comparative reduction in their development, especially with respect to the circumference of their head and chest.

**METALLURGICAL WASTES AND SOIL CONTAMINANTS**

The geographical distribution of contamination, in relation to metallurgical processing wastes, has been mapped in detail by the I.G.M.E. geoscientists. The metallurgical wastes, constitute the major source of contamination, and can be grouped into three broad categories: flotation residues, pyriticous tailings and slag.

The great area covered by the metallurgical processing wastes, their continuous shifting from one place to another, and their use by the inhabitants, as well as the transportation of their fine-grained component by strong winds, blowing in the area, has resulted in the multi-element contamination of soil.
CONCENTRATIONS OF LEAD IN CHILD BLOOD

- 90% of the children (n=235) that participated in the cross-sectional epidemiological study had more than 100 micrograms of lead per litre of blood,
- 50% had more than 180 micrograms of lead per litre of blood,
- 10% had more than 310 micrograms of lead per litre of blood, and
- 5% had more than 380 micrograms of lead per litre of blood.

Number of children: 235

It is noted that 100 µg Pb/litre of blood is the maximum admissible level for children (i.e., 10 µg Pb/100 ml or 10 µg Pb/decilitre).

CONCENTRATIONS OF ARSENIC IN CHILD URINE

- 8.4% of the children (n=235) that participated in the cross-sectional epidemiological study had more than 20 micrograms of arsenic in 24-hour urine, and
- 5.0% had more than 65.9 micrograms of arsenic in 24-hour urine.

Number of children: 235

It is noted that 20 µg of Arsenic (As) in 24 hour urine is the upper acceptable limit for children (20 µg As/24 hr).

INTEGRATED ENVIRONMENTAL MANAGEMENT SCHEME

Development of an integrated environmental management for the greater Lavrion urban area constitutes the ultimate aim of the whole study. For its realisation, relevant data, generated during the project, were used, i.e., geochemical distribution maps of toxic elements, metallurgical processing wastes map, land use map, hazard and child exposure assessment maps, pilot project rehabilitation techniques, etc.

Human exposure assessment to environmental contamination is defined by the concentration of a contaminant (e.g., in air, soil, water) and the available quantity for inhalation and ingestion or dermal absorption.
The flotation residues or tailings from the beneficiation of ore, which are called “savoura” by the inhabitants of Lavrion, cover a significant part of the residential area. They extend from the Alakó factory, cover the larger part of “Prasini Alepou”, the area with the sport installations, the Mineralogical Museum, the Secondary School, and almost reach the smelter of the French Company. They contain high concentrations of toxic elements, such as lead, cadmium, arsenic, antimony, etc. The flotation residues are considered to be the most hazardous metallurgical processing wastes, because a large part of the town of Lavrion is built over them, and the local population, and children especially, come in contact with the contaminated material.

Pyritiferous tailings are wastes from the beneficiation of ore. Pyrite, apart from having high toxic element contents, is oxidised by the action of air and rain, and produces acid drainage, i.e., the water coming into contact with pyrite becomes acid and highly contaminated. Pyritiferous tailings are found mainly along the coastal part of Thorikon and at Kavodokanos.

Slag is the waste from the melting of ore for the production of silver bearing lead. It is found round natural hills in the southern and northern part of Lavrion and on beaches. Slag has been used as hardcore for road construction, school yards, port facilities, etc.

Due to the above mentioned reasons the soil of the Lavrion urban area is at the present time, as a whole, heavily contaminated by toxic elements, such as lead, arsenic, antimony, cadmium, mercury, etc.

Note: Norway for residential areas, and especially kindergartens, has lowered the Pb level in soil to 100 mg/kg. The variation of Pb in the Lavrion surface soil is from 810 to 151,579 mg/kg, with a median of 7,305 mg/kg.
The map below shows the degree of child exposure to different contaminant sources in the Lavrion urban and suburban area. Exposure ratings are on an arbitrary scale varying from 0 to 255. The estimations were made on blocks of 50 x 50 m. The map indicates that the greater exposure to environmental contaminants is in the area with the beneficiation wastes. As it has been shown by the rehabilitation tests, vegetation cannot be developed on these wastes. Therefore, dust is easily generated by wind and human activities.

Utilisation of conclusions, resulting from the work carried out, and after considering the effectiveness and cost of alternative technologies for rehabilitation, the planning and gradual application of remediation actions could start.

The cost/benefit index map (below, right) shows the distribution of the ratio of the cost index in relation to the benefit index of the recommended rehabilitation methods for the Lavrion urban environment. For its compilation the degree of child exposure to environmental contaminants, and other parameters were used, taking into account that the required objective is the rehabilitation of the surface environment, in an appropriate manner, to reduce child exposure to toxic elements derived from the metallurgical processing wastes and contaminated soil.

It is noted that the lower the cost/benefit index of a block of land, the higher is the priority for its rehabilitation.

Note: The recommendation to the Lavrion Municipality was, after informing the people about the state of the urban and suburban environment, to subsidise each owner to rehabilitate his/her property with supervision by the technical services of the Municipality.
The problem of pathogenic biomineralization in living organisms is one of the oldest medical afflictions known to mankind. Sialolithiasis is a common disease of salivary glands. It is caused by the formation of salivary calculi (sialoliths), which are calcified masses that grow in the intra- or extra-glandular duct system. Salivary calculi may occur in any major salivary gland or ducts but are most common in the submandibular gland (83-94%) [1]. Statistic tell us that this disease affects about 1.2% of the population and corresponds to about 30% of the salivary pathologies [1]. Epidemiologic investigations have shown that the disease is more common for males than for females [2]. Additionally, it was demonstrated that genetic and environmental factors are also strong influences in the occurrence of the disease [1-3].

Several theories have been proposed to explain the development of sialoliths [1-3]. However the mechanism of salivary calculus formation has not been clearly understood until now.

Detailed analysis of the composition and structure of salivary calculi is necessary for a deeper understanding of the causes and mechanism of the disease.

Fourteen samples of salivary calculi were collected from nine adult patient of different sexes and ages (28 – 56 years) admitted to hospitals from the Saint Petersburg region (Russia). The collected sialoliths were characterized by X-Ray diffraction analyses (XRD), FT-IR-spectroscopy, light microscopy, scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDX), transmission electron microscopy (TEM) and X-ray computed microtomography. The most investigated calculi have round, oval, or elongated habit, and are from 0.3 to 1.5 cm in size (Fig.1). Using light and scanning electron microscopy it was demonstrated that the surface of the aggregate is irregular and knobby (Fig. 2). The cross-section reveals one or two structural cores (Fig. 3) and in most samples, laminations, wherein organic mineral layers alternate (in a few cases a central core was lacking). The thickness of the mineral layers varies from 0.4 to 0.7 mm, while the organic layers are thinner and vary from 0.1 to 0.4 mm. By means of X-ray microtomography it was shown, that within one sample the density of material changes discontinuously. Thus the inner structure of calculi indicates the varying formation conditions.

The content of the organic component in mature calculi is less than 10-20 wt. %. The inorganic component consist mainly of calcium phosphates (apatite, whitlockite, brushite) [4-8]. Apatite was present in different amounts in all investigated samples. This basic calcium phosphate usually crystallized in the form of small spherulites or globular aggregates which are about 0.5-0.7 µm in size (Fig. 4 A). By means of TEM and electron diffraction it was demonstrated that apatite aggregates are composed of elongated or rounded nanoparticles which are usually less than 50 nm in size (Fig. 5 A, B). Whitlockite (Ca,Mg)3(PO4)2 occurred in 79% samples and had a small granular structure. Brushite CaHPO4·2H2O was identified only in 21% of samples. Brushite crystals are needle-like or elongated
rods which frequently form intergrown rosette-like aggregates (Fig.4 B, C). Besides calcium phosphates the calcium oxalate dihydrate, weddellite, occurs rarely [9]. This mineral was found only in one sample. It forms tetragonal bipyramidal crystals with sharp edges (Fig.4 C, D) which are usually twinned. Thus we found an unusual calculus, composed by brushite, weddellite and apatite.

Furthermore, it was demonstrated that the composition of calculi also can significantly vary within a sample. Different ratios of apatite and whitlockite are found in the core, as well as in the outer layers of aggregates, while brushite is usually identified in the outer layer or on the surface. This observation corroborated with previous investigations, which demonstrated, that brushite is formed in the initial stage of mineral phase crystallization, and its content changes depending on the stage of formation [6,8].

The unit cell parameters of salivary calculi apatites vary within a wide range (Fig. 6). The parameter a is higher than that of stoichiometric hydroxyapatite (JCPDS N 9-432), while c is usually smaller. In accordance with literature data [10-12] the observed lattice constants belong to calcium-deficient hydroxyapatite containing small amount of carbonate ions and a great deal of water molecules in crystal structure.

Using EDX it was shown that apatite of salivary calculi is really calcium-deficient with the Ca/P molar ratio of salivary apatite varying from 1.50 to 1.65, that is smaller than that of stoichiometric apatite (1.67) Additionally in the composition of salivary apatite, small amounts of Na (0.4 – 1.0 wt.-%), Mg (0.5 – 3.7 wt.-%), K (0.02 – 0.3 wt.-%); S (0.4 – 1.0), Cl (0.02 – 0.2 wt.-%) and Rb, Sr, Ba, Zn, Cd, Zr, Sb (less then 10^3 wt.-%), were detected.

The presence of [PO_4]^{3-}, [HPO_4]^{2-}, [OH]^{-}, [CO_3]^{2-}, H_2O and organic molecules in the apatite calculi was confirmed by FT-IR-spectroscopy. Figure 7 shows a representative spectrum of such salivary calculus. This spectrum is similar to that some biological hard tissues previously reported by several authors [10, 11, 13]. The four modes (v_1, v_2, v_3, v_4) of the internal vibration of the phosphate group are presented. The v_1 band appears at 960 cm^{-1}, v_2 at 468 cm^{-1}, v_3 in the region from 1040 cm^{-1} to 1090 cm^{-1} and v_4 at 550 – 606 cm^{-1}[10-12]. The bands corresponding to the [HPO_4]^{2-} group are detected at 550 cm^{-1} and 864 cm^{-1} (as broad shoulders) [12]. The infrared adsorption bands of carbonate were found at 865 cm^{-1} with a shoulder at 873 (v_2) (Fig. 6 C), 1416 cm^{-1} (v_3) and 1456 cm^{-1} that indicate the B-type carbonate substitution (phosphate replacement) [10-13]. The FT-IR spectra of all the samples under investigation show a broad band in the high energy region from 3700 cm^{-1} to 2700 cm^{-1} and a band at about 1650 cm^{-1} (overlap with the Amide I band, see below) that can be assigned to the water molecule stretching and bending modes, respectively [10, 11]. The bands located at 1655 cm^{-1} and 1550 cm^{-1} were assigned to the absorption of Amide I and Amide II respectively, which indicate the present of proteins in the aggregates [14]. Additionally the vibration modes of CH_2 groups of organic molecules were identified at 2853 cm^{-1}, 2873 cm^{-1}, 2925 cm^{-1} and 2960 cm^{-1}. Small amounts of [OH]^{-} groups in the apatite component of the calculi are indicated by the existence of a broad weak band at 640 cm^{-1} which can be assigned to OH librational modes [10]. The [OH] stretching band (at 3540 cm^{-1}) was not observed. Thus the FT-IR spectra prove that the salivary calculi are organic-inorganic composites.

By means of XRD, FT-IR spectroscopy and EDX analyses it was shown that the composition of apatite of salivary calculi strongly differs from stoichiometric hydroxyapatite. This biological apatite can generally be characterized as calcium-deficient hydroxyapatite with some amounts of carbonate ions on the phosphate site and water molecules within the channel of crystal structure. Furthermore it was established that phosphate ions can be partially substituted by SO_4^{2-} as well as Ca-ions by Na^+, Mg^{2+}, K^+, Rb^+, Sr^{2+}, Ba^{2+}, Zn^{2+}, Cd^{2+}.

In conclusion, this study shows the results of a detailed analysis of the composition, morphology, and structure of salivary calculi of residents from Saint-Petersburg region (Russia). It was demonstrated that...
the composition of salivary calculi varies strongly from sample to sample as well as within a calculus. This finding suggests that the growth conditions during calculi formation vary significantly.

The results of complex diagnosis of patients with sialolithiasis, together with detail analysis of salivary calculi are necessary for a deeper understanding of the cause and mechanism of this disease. These data permit a more effective development of the methods for treatment of this pathology and prevention of the disease or its relapses. Further investigations are needed in order to clarify the mechanism of sialolith formation in detail.

REFERENCES

Figure 1. Overview of salivary calculi.
Figure 2. SEM image of the globular surface of calcium phosphate salivary calculus.

Figure 3. Light microscopic images of the cross-section of salivary calculi with one (A) and two (B) central cores; (C) SEM image of cross-section of salivary calculus, illustrating layers of mineralization.

Figures 4 A and 4 B (left) Caption on next page
Figure 4. SEM images of the minerals found in salivary calculi: (A on previous page) globular aggregates of apatite; (B on previous page) rosette-like aggregate of brushite; (C) tetragonal bipyramidal crystal of weddellite.

Figure 5. (A) TEM image of apatite nanoparticles from salivary calculi; (B) electron diffraction pattern of apatite nanoparticles aggregates in (A). Rings of 3.4 Å and 2.7 Å correspond to the 002 and 300 reflections of apatite, respectively.
than 50 µg L\(^{-1}\); in Mexico, the population affected is about 500,000, and in Chile - where the problem has been partially solved - Bolivia and Peru, the number of people affected reaches more than 200,000. While in these countries the problem has been known for several decades, in Uruguay, Brazil, Ecuador, Nicaragua, Honduras and El Salvador, the problem has been detected or investigated only in the last years. In other countries with similar geological features, information is still absent. It is estimated that, in total, about 4 million people in Latin America are affected, but new legislation introduced in the last years, allowing only 10 µg L\(^{-1}\) in human drinking water, indicates that the number of people in those conditions would be much higher.

IBEROARSEN-BD is an online database created in the framework of the IBEROARSEN network that joins 23 research groups from 10 countries of Latin America, Spain, and Portugal. The aim of the network is to promote joint actions and assistance to collect and to exchange the available information about the occurrence of As in natural systems of the region, the analytical methods for arsenic determination in natural samples, and the methods of arsenic removal from water.

The consumption of water with high arsenic concentrations affects an important proportion of the Latinamerican population. About 1.5-2 million inhabitants living in small rural settlements in Argentina drink groundwater with arsenic concentrations higher than 50 µg L\(^{-1}\); in Mexico, the population affected is about 500,000, and in Chile - where the problem has been partially solved - Bolivia and Peru, the number of people affected reaches more than 200,000. While in these countries the problem has been known for several decades, in Uruguay, Brazil, Ecuador, Nicaragua, Honduras and El Salvador, the problem has been detected or investigated only in the last years. In other countries with similar geological features, information is still absent. It is estimated that, in total, about 4 million people in Latin America are affected, but new legislation introduced in the last years, allowing only 10 µg L\(^{-1}\) in human drinking water, indicates that the number of people in those conditions would be much higher.

IBEROARSEN-BD: AN ONLINE DATABASE ON IBEROAMERICAN WATER QUALITY WITH EMPHASIS ON ARSENIC

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Most arsenic in drinking waters originates from natural sources. One of the main sources in South and Central America, as well as in Mexico is the weathering of volcanic sediments deposited during the Andean orogeny. In the mining area of Mexico, arsenic originates from the leaching of As-bearing sulphide minerals. In the Chacopampean plain of Central and North Argentina, arsenic is released to water from the weathering of volcanic shards and volcanic glass spread within the loessic sediments that cover the entire plain. Anthropogenic sources also liberate arsenic to the environment, mainly associated with mining activities in Mexico, Bolivia, Brazil, Portugal, and Chile. In spite of the widespread presence of As-bearing sediments in the region, there is not yet enough information about the occurrence of this toxic substance in drinking water, which makes the area of interest for future research.

Data compiled in IBEROARSEN-BD are:
- Location of sampling stations and characteristics of the sampled water bodies (geographical coordinates, altitude, country, type of reservoir, lithology, aquifer depth, potentiometric head)
- Water physico-chemical data (pH, conductivity, Eh, total dissolved solids, dissolved oxygen, temperature, major ions, trace elements of environmental concern, such as As species, F, V, Mo, Fe, Mn, Zn, Pb, Cd, etc.)
- Publications

The website of IBEROARSEN-BD is: www.iberoarsen.com.ar. Due to the amount of data and the extension of the involved territory, IBEROARSEN-BD is a unique and valuable tool. The database can be searched by country, by type of reservoir (groundwater, river, lake, etc), and by range of arsenic concentration.

We are convinced that IBEROARSEN-BD is a way to contribute to a better management of the water resources in our countries, as it compiles reliable information of water quality that is actually dispersed and unknown. Potential users are governmental institutions and non-governmental organizations devoted to the protection of the environment and public health, hospitals, educative centers, and the international research community that deals with arsenic issues.

We encourage researchers and public and private institutions of the region to submit new information in order to promote the knowledge on water quality in our countries and the development of adequate policies of protection and remediation of this vital resource.

**SUMMARY OF EDITORIAL POLICY** (see website for further details)
- The language of publication will be English.
- Articles should typically be about two pages long, of single spaced Times Roman 12 point text. Longer articles may be included subject to space availability.
- Submissions may be edited to fit into the space available in the Newsletter or for clarity.
- The current newsletter is not refereed. It is the editor’s responsibility whether or not to publish an item in the newsletter. In case of doubt, this will be referred to the members of the Journal Committee and/or the Chairman.
- Submission of an item implies the assignment of a non-exclusive copyright to the IMGA.
- Articles should not have been published previously. It is the author’s responsibility to ensure that there are no copyright violations.

**SUBMISSIONS**
- Submissions should be in digital form, preferably in MS Word 2000 format.
- Lists of references and data should be kept short, and full information should be obtainable from the author.
- Graphic material and tables may be submitted in colour and but should also be fully legible in black and white.
- Figure captions should be separate from the graphics.
- Since graphic material may be reduced in size for publication, authors should ensure that it is designed to remain readable when reduced. Preferred file types are .jpg, .bmp, .gif, .wmf (Windows Metafile). All articles should contain the author’s contact information.
ABSTRACT
Groundwater from boreholes sunk in the Bole and West Gonja districts in Northern Ghana has been analysed. Using World Health Organisation (WHO) Standard as a basis, the results reveal that the concentration of fluoride ranges from deficient in some places to an excess amount in others. Some prevalent health problems occurring in the locality consequent upon these extreme (high and low) concentrations further confirm our results. Potential areas for dental caries and skeletal fluorosis were delineated. As a guide, a geochemical atlas map for fluoride has been constructed for groundwater in the two districts. KEYWORDS: dental caries, and fluorosis

INTRODUCTION
In the last two decades, considerable interest has been developed in assessing the risks posed by metals and trace elements for environmental quality and human health. Many of these health-related problems are known to be associated with geological materials. For example, the occurrences of endemic goitre and cretinism have both been associated with iodine deficiency and, in Ghana, are commonly found in the savannah regions several kilometres from the sea. A deficiency of selenium has resulted in some parts of China, in health cases relating to muscular dystrophy as well as the introduction of endemic cardiomyopathy. Excess fluorine in drinking water has also been associated with endemic dental and skeletal fluorosis in several geographical areas, and Ghana is no exception. For instance in the Bongo district in the Upper East region of Ghana the concentration of fluoride in groundwater ranges from 0.11 to 4.5 mg/l (Apambrie et al., 1990). Also, there have been well-documented cases of chronic arsenic poisoning from the consumption of contaminated drinking water in southern Taiwan, Chile, Argentina, Mexico, China, and in West Bengal and Bangladesh (Centeno et al., 2007). It is apparent that climate change may impact indirectly and directly on environmental and geological related health issues.

GEOLOGICAL SETTING AND MINERALISATION
The Bole district is underlain by metavolcanics and metasedimentary rocks intruded by both belt and basin granitoids (Doubin and Roudakov, 1964; Hirdes...
and Davis, 1993 and Griffis et al., 2002). The foliations in these rocks are generally north-easterly, and dips range between 55° and 65° SE. The foliated granitoids, consisting of hornblende- and biotite-bearing granitoids, diorites and granodiorites, with associated quartz veins and dolerite dykes, occur within the metasedimentary package and cover most parts of the district. The nonfoliated belt granitoids consisting of tonalities, tromdhjemites, and quartz diorites, also intrudes the meta-volcanic rocks in some places. The meta-volcanic rocks consist of basalts, andesites, dolerites, dacites, rhyolites, and some gabbros, whereas the metasedimentary rocks are comprised of phyllites, schists, greywacke and some epiclastic units. These lithological units are isoclinally folded and are characterised by numerous quartz-feldspar porphyry dykes which have a mean thickness of 4m and are commonly silicified. Randomly oriented and occasional concordant quartz veins up to 1m wide and 300m in length occur, and are extensively developed in the phyllite and in the schist.

The West Gonja district area is within the Voltain basin and consists generally of great varieties of sandstones and shales with some conglomerate interbeds, a few carbonate sequences and clastic units. The area is flat lying or seems to be characterised by very gently dipping sediments sitting on a major Precambrian unconformity. This unconformity marks an erosional surface that apparently covered the entire Man Shield.

Fluorine is naturally occurring mineral that occurs in sedimentary rocks such as limestone and sandstones that are commonly found in the West Gonja district and igneous rocks such as the granites intruding the Birimian volcanic belt of the Bole area. Usually the surface water does not contain high fluorine but the groundwaters often are associated with high fluorine because the common source is fluorine rich rocks (Sahelian, 2007). When water percolates through fluorine–rich rock it leaches out the fluorine from the rocks, after which the solution drains into the stream and the groundwater system. The residues remain in the regolith where farming activities are going on. The major sources of fluorine for human ingestion and exposure are; water, food, air, medication, and cosmetics. Also residential combustion of coal with high fluorine contents has been shown to cause dental and skeletal fluorosis in China (Finkelman et al., 1999). But research has shown that an estimated 60 % of the total intake of fluorine is through drinking water (Sahelian, 2007). Fluorine present in water is in a form that is readily absorbed from the stomach. Other sources are from foods that are rich in fluorine, for example some teas, fluoridated toothpaste, plants and vegetables cultivated in soil and water rich in fluoride.

**DATA ACQUISITION AND ANALYSIS**

Hydrogeochemical data from 90 and 31 boreholes from the Bole and the West Gonja districts of northern Ghana, respectively, were obtained from the Ghana Community Water and Sanitation Company. The data were obtained from water samples collected from boreholes that were analysed at a commercial laboratory for fluorine (F), lead (Pb) Manganese (Mn), Total iron (Fe), and Quartz (SiO2) that may impact on human health. The hydro-geochemical data obtained from the analysis of the water samples in the two districts are presented in Tables 1 and 2. As seen from Tables 1 and 2, all the other trace elements analysed fall within the permissible levels except for fluorine. Because of that the results of the concentration of fluorine obtained from the borehole waters have been developed into a geochemical atlas to show good dental health, dental caries, skeletal and dental fluorosis areas, in the two districts. This was done by creating a scatter plot; indicating the tolerance limits of fluorine concentrations for humans in drinking water that may not pose any health hazards. Boreholes that recorded fluoride concentrations > 1.5 mg/l were grouped and classified as dental and skeletal fluorosis zone whereas boreholes with < 0.5 mg/l fluoride areas were classed as dental caries zones. These data were then processed to create a geochemical atlas map using GIS software.

**DISCUSSION AND CONCLUSIONS**

The concentration of fluorine in groundwater, which is the main source of drinking water in the two dis-
HEALTH HAZARDS IN BOLE AND WEST GONJA DISTRICTS OF GHANA Cont.

Figure 1. Concentration of fluorine in groundwater in the Bole district showing dental health situations.

Figure 2. Concentration of fluorine in groundwater in the West Gonja district showing dental health situations.

Footnote.
Table 1 Hydro-geochemical data from groundwater analysis in Bole District (mg/l)
Table 2 Hydro-geochemical data from groundwater analysis in West Gonja District (mg/l)

These tables are too large to be included in the Newsletter. Please contact the author directly to request them.
sis using WHO acceptable levels as a guideline. Again, the dental and skeletal fluorosis risk would be expected between UTM-coordinates 540500E to 560000E and 1000500N and 1010500N. The patterns shown in Figure 3 suggest that the high fluorosis areas are underlain by basin-type granites whereas the dental caries areas are underlain by the belt-type granitoid. These observations need further investigation to establish the genesis and linkages of dental caries and fluorosis to the two types of granites in the district. But the situation at West Gonja district is similar to those at Bole; the only exception is that low and high concentration fluorine tends to follow the stratigraphy of the underlying rocks. The distribution and trends of fluorine as shown in Figure 4 could be due to the different types of sandstones that underlie the district. The eastern block of the district has good dental health, followed by high fluorosis area, which may be characterised by dental and skeletal fluorosis. This area then grades into a good dental health area based on the concentrations of fluorine in the environment after which it then grades into a dental caries zone.

The distribution of fluorine in groundwater is not uniform, but appears to be randomly distributed in the groundwaters in the two districts perhaps because of the different lithological units that underlie the various communities. Higher and lower concentrations of fluorine than WHO acceptable values were obtained at different geographic locations with time. Whilst having varying concentrations based on geological materials the study concludes that the genesis of the fluorosis in these districts should be thoroughly investigated and that the communities should be advised on the use of food, drinks or chemicals to which fluorides have been added.

REFERENCES

Figure 3. Geochemical map showing fluorine concentrations in groundwater in the Bole District in Ghana
Figure 4 Geochemical map showing fluorine concentrations in groundwater in the West Gonja District in Ghana

IMGA WEBSITE
Check the IMGA website: http://www.medicalgeology.org/

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- Information on and reviews of the book, Essentials of Medical Geology
- Courses and seminars
- Glossary of terms
- Links to other sites
- Short papers and reference list

... And more
Medical geology is a modern response to the interpretation of disease distribution that can be affected by geologic materials and processes.

In recent years Iran has experienced increases in population, mineral exploitation, and disease incidence of unknown causes. Therefore, medical geology studies have become absolutely essential. As a first step we made a schema for representing the total distribution of elements and diseases in Iran - Elements and Diseases Atlas of IRAN.

Preparation of Elements and Diseases Atlas was based on the distribution of chemical elements extracted from geochemical data, plotted on a scale of 100K to 1 from the Geological Survey of Iran and mortality raw data from the Health Ministry of Iran. The Mortality rate is from the period March 2003-March 2004 and it defined as mortality rate per 100,000 populations in cities. We mapped the raw data of mortality (see example on page 38) by Arc GIS 9.X software on a windows operating system. Mortality rate is shown by color, red color indicating a very high mortality, orange a high morality, yellow for moderate mortality, green for low mortality, blue for very low mortality, and white representing the areas where no data exist.

For the geochemical data, the value is in ppm for elements and percent of major oxides in rock units. The fading colors reflect decreasing concentrations of elements and major oxides. The geochemical maps do not cover all of Iran and only consider the parts where geochemical sampling has been done. Therefore, some regions have a high density of mortality but are without geochemical data.

Information on various geogenic diseases was derived from the book "Essentials of Medical Geology" edited by Olle Selinus et al. (2005). Mortality and geochemical maps have been integrated, and possible relationship between them has been shown. Therefore, the distribution of elements might be an effective parameter in understanding the incidence of diseases.

In this atlas 18 mortality maps and their related elements maps were prepared (Table 1). The most important outcomes of the Atlas are mortality maps and integrated maps, consequently effective geological parameters can be recognized and suggested solutions for the promotion of the inhabitant’s environmental conditions.

REFERENCES:

CENTERS
1-Health Department, Ministry of Health and Medical Education
2-Geological Survey of Iran
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<thead>
<tr>
<th>Geochemical Map’s name</th>
<th>Mortality Map’s name</th>
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<td>Fe2O3, Al2O3, Se, Carbonate Rocks</td>
<td>Cardiovascular Diseases Mortality Map</td>
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<td>CaO</td>
<td>Stroke Mortality Map</td>
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<td>Fe2O3, Cu, Co</td>
<td>Anemia Mortality Map</td>
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<td>Hg, Pb, Sn</td>
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<td>Alzheimer Mortality Map</td>
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<td>Se</td>
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Table 1. Geological and Mortality Maps