SGA News
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Number 15

Non-Sulfide Zinc Deposits: a new-(old) type of economic mineralization

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Introduction

It is not surprising that the Issue 98/4 (2003) of Economic Geology will be dedicated to non-sulfide zinc deposits, and that one session of the 7th Biennial SGA Meeting at Athens in August 2003 will also revolve on this subject. Indeed during the last years this type of ore deposits has been increasingly arousing the interest of mining companies and of the scientific world alike.

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7th Biennial SGA Meeting, Athens, Greece, 24-28 August 2003, extensive information

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NEWS OF THE SOCIETY

☞ News of the Council

Report of the President (D. Leach)

D. Leach reported on the period from the last Council Meeting (April 2002) to April 2003 and described his activities towards his priority goals (increased role of SGA Regional VPs, development of increased participation of industry in SGA activities and development of strategic planning of SGA Biennial Meetings).

Report of the Chairman of Nomination Committee (D. Leach)

D. Leach reported that the Nomination Committee consisting of D. Leach, R. Goldfarb and H. Papunen recommended the creation of two new positions of Regional Vice Presidents – one for Europe and one for Middle East. The Council approved this proposal.

Extension of the Presidential term for David Leach until the end of 2005

This extension is a totally exceptional situation, which resulted from the recently approved Constitutional changes. The Council approved the exceptional extension of the presidential term for D. Leach.

Report of the Chief Editors, MD (B. Lehmann, L. Meinert)

In 2002 a total of 45 papers on 808 printed pages were published in 8 issues. The number of pages will increase to 1000 pp in 2003 without a change of price for SGA members. The Council repeatedly highly appreciated the efforts of the past editors - D. Rickard and R. Goldfarb – as well as those of the present editors – B- Lehmann and L. Meinert - that resulted in the high ranking of MD among the top 8 journals in the segment of mineralogy. The citation index of Mineralium Deposita, i.e. citations in 2002 of 2000-2001 papers, is at its highest rank ever with 1.4, slightly ahead of Economic Geology with 1.3, and far ahead of other journals dealing with ore geology such as Ore Geology Reviews, Resource Geology, Mineralogy and Petrology, Canadian Mineralogist.

Status of selection procedure of SGA Award for the best paper in MD during 2001 and 2002

The Council approved that the paper by Relvas JMRS, Tassinari CCG, Munha J and Barriga FJAS (2001): "Multiple sources for ore-forming fluids in the Neves Corvo VHMS deposit of the Iberian Pyrite Belt (Portugal): strontium, neodymium and lead isotope evidence", published in MD 36: 416-427, will receive the award. The award consists of a certificate, 1500 EUR, and travel expenses for the first author associated with the receipt of the award.

SGA Young Scientist Award

After intensive discussion, the Council approved Dr. Noreen Mary Vielreicher from the Centre for Global Metallogeny, Department of Geology and Gephysics, University of Western Australia, Crawley WA 6009 as the first recepient of this prestigious award. The award consists of a citation, a certificate, 1500 EUR, and travel expenses associated with the reception of the award.

7th SGA Biennial Meeting

The 7th Biennial SGA Meeting "Mineral Exploration and Sustainable Development" will be organized by the Society for Geology Applied to Mineral Deposits in Athens (Greece) from August 24-28, 2003. To date, 310 abstracts were accepted for the proceedings volume. Several field trips had to be cancelled due to a low interest. SEG will be granted a full day to organize its own program. After discussion, the Council decided the following:

- The SGA Young Scientists Award and the Award for the Best Paper in MD will be presented during the Opening Ceremony
- Oral presentations will last 15 min. plus 5 min. for discussion
- Posters will be displayed during the whole duration of the conference and authors of poster presentations should be present two hours during two afternoons

SGA News

N.° 15 August 2003

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Date, place and programme of the General Assembly in Athens

The General assembly will be held on Monday, August 25, at 18.00 in the Great Hall, Athens Technical University (see the Third Circular). The Council approved the following programme:

1 - Report of the President

2 - Report of the Treasurer

3 - Presentation of the list of SGA officers for ballot in 2001

4 – Presentation and voting on candidates for SGA Honorary Membership

6 – Various

Status of SGA-SEG collaboration

The collaboration between both Societies is developing successfully. The SEG module within the 7th SGA Biennial Meeting and SGA module within the SEG 2004 Conference in Perth, Australia, are being prepared.

Status of SGA-IAGOD collaboration

The collaboration between both Societies is progressing successfully. The Council agreed to co-organize the 12th IAGOD Quadrennial Meeting (St. Petersburg – August 2006). SGA expects that the meeting will be both successful and profitable similarly to the joint SGA-IAGOD Meeting in London (1999) and is ready to discuss terms and conditions at a joint meeting with IAGOD representatives in Athens.

Possible role of SGA in IUGS/UN activities (IYPE)

J. Pasava informed the Council about the invitation from the IUGS President to IUGS/UN initiative on the International Year of Planet Earth (IYPE). The Council approved that SGA should take a visible role in this activity together with other Societies (SEG, IAGOD). A joint conference addressing one of "big" topics , e.g., EARTH AND RESOURCES, or joint educational courses might become an option.

Proposals for SGA Biennial Meetings in 2005, 2007

The Council approved that the 8th SGA Biennial Meeting will be held in Beijing, China, on August 26-29, 2005. The date and venue for the 9th SGA Biennial Meeting will be decided at the next Council Meeting in Athens.

Past Activities

- 11th IAGOD Symposium, July 22-27, 2002 Windhoek, Namibia.
- Uranium Deposits: From their Origin to their Environmental Impacts (September 10-12, 2002, Prague, Czech Republic).

Future Activities

- GAC-MAC-SEG joint annual meeting (Vancouver, May 25-26, 2003) – SGA exhibit – G. Beaudoin.
- World class mineral deposits and earth evolution (19-21.8.2003, Cardiff, UK) – A. Boyce – Chris Heinrich will represent SGA.
- 3rd Fennoscandian Exploration and Mining (Rovaniemi, December 3-4, 2003) - Rob Hill will represent SGA.
- 7th Biennial SGA Meeting (Athens, August 24-28, 2003)
- 32nd IGC (Florence, August 20-28, 2004) – several Symposia co-sponsored, planned SGA Council Meeting.
- SEG 2004 (Perth, Sept. 27-Oct. 10, 2004) – SGA runs its own module at this conference (R. Goldfarb et al.) and exhibit.
- The 12th IAGOD Quadrennial Symposium (August 2006, St. Petersburg, Russia) – V. Shatov – possibly co-organized with SGA.

!!! NEW !!!

SGA NEWS MAILBOX

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We expect your letters with comments, news, criticisms, ...

CHANGE OF ADDRESS FORM

If you have changed (or will change in the near future) your address please fill in this form and send it to:

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Applications to SGA for meeting sponsorship must be submitted to Jan Pasava, SGA Executive Secretary, on appropriate forms available at the SGA home page on Internet:

http://www.min.tu-clausthal.de/www/Sga/sga.html

Other requests will be not considered.

Your suggestions and ideas for any topic of interest to SGA are welcome! They can be addressed to any Council member or to

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Report of the Executive Secretary about membership

19 Regular Members and 24 Student Members applied for membership from November 1, 2002 to April 24, 2003

LIST OF NEW SGA MEMBERS
(November 1, 2002 – April 24, 2003)

Regular Members

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Reports of Regional Vice-Presidents

With this issue of SGA News a new space is dedicated to SGA Regional Vice-Presidents to introduce them to our membership and provide them with some well-deserved recognition. Their leadership and contributions to SGA Council and especially to SGA members in their regions of activity are critical to the scientific health of SGA.

ROBIN E.T. HILL
SGA Regional Vice-President for Australia

Robin E.T. Hill graduated from the University of Queensland, Australia, in 1964, with the degree of Bachelor of Applied Science. He gained the degree of PhD from Queen's University, Kingston, in 1968 (experimental geochemistry). Since then, he has completed post-doctoral research at Pennsylvania State University on the role of carbon dioxide in mantle-derived silicate melts, was senior nickel research geologist with a mineral exploration company in Canada, and from 1973 has been a research scientist with CSIRO, Perth, Western Australia.

He is leader of the Ni-Cu-PGE Research Group at the CSIRO Division of Exploration and Mining. His research interests are focussed on the genesis of komatiite-hosted sulfide deposits, komatiite volcanism and lava emplacement mechanisms (development of inflationary flow fields), exploration concepts for these deposits, and on the genesis and formulation of exploration concepts for intrusive Ni-Cu-PGE deposits.

Dr. Hill is a strong supporter of the SGA and sees this association as a forum for cutting-edge generic and applied research, which emphasises the link between research and its successful application in the minerals industry.
Dr. Hill is keen to maximise SGA involvement in economic geology activities in Australia supporting and enhancing this field of science and its associated industry.

George Beaudoin
SGA Regional Vice-President for North America

As a new vice-president North America for the SGA, I welcome your suggestions and advice for increasing the presence of the society in North America. Over the past year, the SGA had a promotion booth at the SEG-SGA Global Exploration meeting in April 2002 in Denver (supervised by D. Leach and R. Goldfarb) and at the GAC-MAC meeting in Saskatoon in May 2002 (supervised by your VP). These were new opportunities for the SGA to make a show in North America, gather its members and add new recruits to the society. In addition, exemples of our journal Mineralium Deposita were distributed and the quality of the journal made an impressive show. The SGA will continue its presence at scientific meetings by another promotion booth at the GAC-MAC-SEG meeting in Vancouver in May 2003. This will be a good opportunity to publicize our Athens meeting. Come and meet your colleagues at the SGA booth! Looking forward meeting you and bring in new members!
One of my duties is to insure that the SGA meets the needs of its members. If you have any comments and suggestion for SGA to improve its services to our membership, send me a note. Also, the society does its best to service its members, but in the event that a difficulty arise, I invite you to contact me immediately, and I will do my best to sort things out.

José Cabello
SGA Regional Vice-President for South America

I am working essentially with the idea of increasing the exchange of research, students, and senior scientist between South America and SGA members in other parts of the world. I really would like to impulse studies about the South American Metallogenesis, especially ore models, age dating and isotopic reviews. And a good way to do this is by taking advantage of the infrastructure and equipment in Europe, USA, Japan, Australia, New Zealand and others regions or countries with equivalent academic infrastructure. In my region (Andean and Shield setting) we have plenty of good examples to study. I am putting together a short proposal to be submitted to the SGA Council in late April. In this proposal I will outline a specific set of objectives and how we might start to work on these objectives. I would like to have a plan that is small in scope initially - simply to help insure that it is successful - and then build on this eventual success. I am currently working in the identification of some universities and companies that would like to participate. This idea will require support from a number of sources; therefore any help from the SGA members (especially researchers) to undertake this task will be most welcomed.

1: NON-SULFIDE ZINC DEPOSITS: A NEW-(OLD) TYPE OF ECONOMIC MINERALIZATION

Prior to the development of flotation and smelting processes for zinc sulfide ores at the beginning of the 20th century, the non-sulfide deposits (often known collectively as "Zinc Oxides") were the principal source of zinc in the world. From Roman times up to the 18th century, the non-sulfide Zn-ores, a mixture of silicates and carbonates known as "Lapis Calaminarius", "Calamine", "Galmei", or "Galman", in the Latin-, French-, German-, and Polish-speaking world respectively, were used as the source minerals for the production of brass, a zinc-copper ±tin alloy fairly widespread throughout Europe and the Mediterranean area over the centuries (Boni & Large, 2003). ⇨ Later, the non-sulfide ores were processed to produce high-grade zinc oxide in Wälz kilns, using a technology that was discovered in Belgium and then developed throughout Europe during the 19th century. Jean-Jacques-Daniel Dony, a chemist from Liège, invented the first process, patented in 1810 by Napoléon I, to transform the ores from the rich Belgian deposits (notably from "La Calamine", Moresnet) into malleable zinc. The metallurgical transformation of the "calamine" concentrates was done in horizontal crucible melting furnaces, operating for the first time in a factory at the Saint Léonard wharf in Liège (DeJonghe, 1998). ⇦

Table 1: Mineralogy commonly associated with non-sulfide Zinc deposits (modified from Large, 2001)

Mineral	Composition (approximate)	Common Associations	Comments
Smithsonite	$ZnCO_3$	Found in most deposits, both supergene and hypogene	Common component of "calamine"
Hydrozincite	$Zn_5(OH)_6(CO3)_2$	Present in many deposits; recent, might replace smithsonite	Known as zinc "bloom"
Franklinite	$ZnFe_2O_4$ or $(Fe,Zn,Mn)(Fe,Mn_2)O_4$	Rare - principal mineral at Franklin/Sterling Hill	Zn-spinel
Gahnite	$ZnAl_2O_4$	Common in Proterozoic metamorphic terranes often associated with massive sulfides	Zn-spinel
Hemimorphite	$Zn_4Si_2O_7(OH)_2.2H_2O$	Present in many deposits - common in the upper part of the calamine orebodies	Common component of "calamine"
Sauconite	Na 0.3 $(Zn,Mg)_3$ $(Si,Al)_4.OH_2.nH_2O$	Present in many deposits - typical of deposits associated with silicoclastites (es. Skorpion)	Zn-saponite - slightly different formulae reported by different AA.
Willemite	Zn_2SiO_4	Typical of hypogene deposits, but occurring also in supergene ones (es. La Calamine, Belgium)	As hexagonal prisms or concretional, cryptocrystalline structures
Zincite	ZnO	Occasional, but principal mineral at Franklin and Sterling Hill, USA	Rare
Cerussite	$PbCO_3$	Occasional in the upper oxidation zones of many carbonate-hosted deposits	Occurring at Tynagh; dominant at Broken Hill
Anglesite	$ZnSO_4$	Occasional in the oxidation zones of many complex sulfide deposits	Only in supergene deposits
Pyromorphite	$Pb_5(PO_4,AsO_4)_3Cl$	Typical of supergene deposits where the alteration is on As-minerals	Can be confused with Mimetite
Mimetite	$Pb_5(AsO_4,PO_4)_3Cl$	Typical of supergene deposits where the alteration is on As-minerals, but occurring also in hypogene ones	Occurring at Angouran
Malachite Azurrite	$Cu_2(OH)_2(CO_3)$ $Cu_3(OH)_2(CO_3)_2$	Occasional in the oxidation zones of deposits containing Cu-sulfides	Occurring at Tynagh, Skorpion and Berg Aukas (both hypogene and supergene)
Goethite Hematite	FeO(OH) Fe_2O_3	Ubiquitous in the oxididation zone of supergene deposits	Very common; can be used for paleomagnetic studies
Coronadite Hetaerolite Hollandite	$(Pb,Ba.K)_{1-2}\ Mn_8O_{16}.xH_2O$ $ZnMn_2O_4$ $(Ba,K)_{1-2}\ Mn_8O_{16}\ .xH_2O$	Mn-minerals generally occurring in hypogene, but occasionally also in supergene deposits	If containing K, suitable for absolute dating with K-Ar and ^{40}Ar-^{39}Ar methods
Ferroan dolomite	$Ca(Mg,Fe)(CO_3)_2$	Typical of hypogene fracture-controlled willemite deposits	Occurring at Vazante as a praecursor hydrothermal phase

With the development of solvent-extraction (SX) and electro-winning (EW) processes, and with the modernization of the Wälz technology for the treatment of non-sulfide zinc ores, there has been a renewed commercial interest for this style of mineralization throughout the world (Large, 2001; Boni & Large, 2003; Borg et al., 2003; Hitzman et al., 2003). The commercial exploitation of "Zinc Oxides" deposits is rapidly becoming an important source of metallic zinc and within the foreseeable future the annual production of zinc from oxide ores could vastly exceed 10% of the global zinc metal production (Table 1 in Large, 2001; Tables 1 and 3 in Hitzman et al., 2003). Today, the attraction of these deposits includes the scale economy (individual projects mostly exceed 100.000 tons zinc metal) and the projected low processing costs for the production of zinc metal or high-grade zinc oxide on site (Large, 2001). Compared to sulfide deposits, their main attraction lies in: a) their distinct scarcity or lack of Pb, S and other undesirable elements, b) their relatively low-energy recovery by SX-EW, and c) the generation of higher economic value on site.

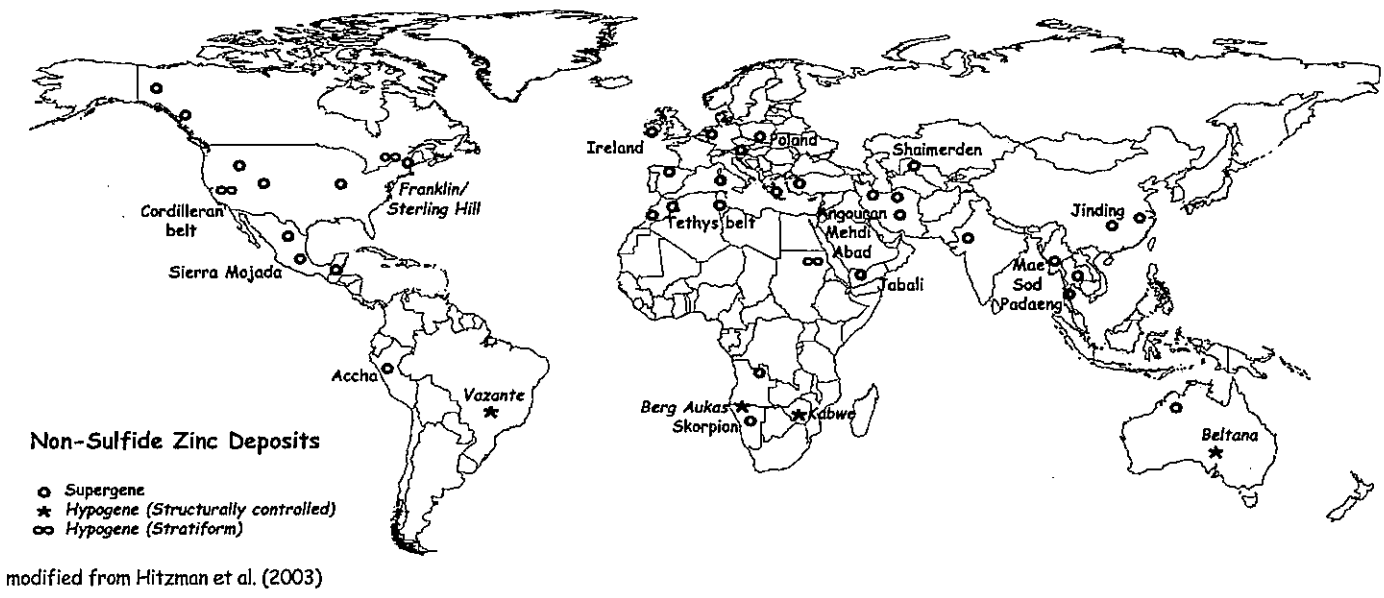


Figure 1: *Location of main non-sulfide Zn deposits in the world.*

Tonnages in the deposits range from < 1 Mt to > 200 Mt with grades of 7% to more than 30% Zn (Large, 2001; Hitzman et al., 2003; Reynolds et al., 2003). Deposits of this size include Skorpion (Namibia), Mae Sod (Thailand), Lan Ping (China), Angouran (Iran), Mehdi Abad (Iran), Shaimerden (Kazakhstan), Jabali (Yemen), Sierra Mojada (Mexico) and Franklin/Sterling Hill (USA). In addition, there are a number of other mines producing relatively small tonnages of non-sulfide zinc ores in Vietnam (Cho Dien), Turkey, China, Morocco and Egypt. For the sake of completeness, one should add to the total the high tonnages recovered in formerly exploited districts, like SW Sardinia, Belgium and Ireland, as well as in the areas where the non-sulfide zinc concentrations *are not considered a resource*, like in Upper Silesia (Poland) (Boni & Large, 2003). The location of some of the most important deposits throughout the world, is shown on Figure 1.

Scientific research, resulting from the economic interest in this class of mineralization shown recently by many mining companies, has been revived after more than fifty years of neglect of what most scientists, including this writer, have for long considered a non-economic "rubbish" which, in the most favorable case, could have been only an important indication in the exploration of a hidden sulfide primary ore.

Research is now being focused not only on several economic "Zinc-Oxide" deposits throughout the world (e.g., Skorpion, Namibia: Borg et al., 2003; Shaimerden, Kazakhstan: Boland et al., 2003; Vazante, Brasil: Monteiro et al., 1999, Hitzman et al., 2003; Beltana, Australia: Muller, 1972, Groves & Carman, 2003, Hitzman et al., 2003; Angouran, Iran: Hirayama, 1986, Gilg et al., 2003), but also on older mining districts containing smaller, historically exploited deposits (Boni et al., 2003; Boni & Large, 2003; Johnson & Skinner, 2003).

The aim of these studies is not only to understand the geological constraints on the distribution of this kind of orebodies together with their timing of formation, but to reach also a better definition of the mineralogy and geochemistry of the mineral phases (Aversa et al., 2002; Boni et al., 2003; Brugger et al., 2003). A thorough understanding of the relationships of mineralogy (Table 1) to deposit type, may significantly aid in exploration targeting. In fact, although the hydrometallurgical behavior of the non-sulfide zinc minerals is only poorly described in the modern scientific literature (there are more than abundant papers on this subject until the seventies), recent unpublished studies indicate that most non-sulfide zinc minerals, with only few exceptions, are easily leachable in sulfuric acid, allowing recoveries of >94% Zn (Hitzman et al. 2003).

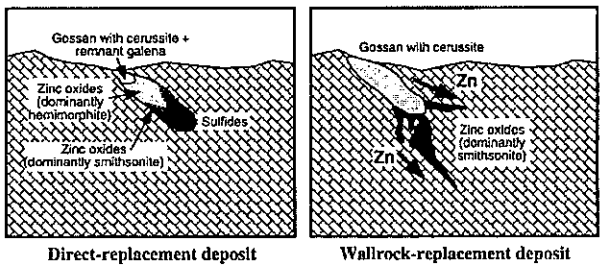
Although there are many similar features described in the past for most non-sulfide zinc deposits, the only existing classification of this kind of ores until recently was due to Heyl and Bozion (1962), and was mostly limited to the deposits in the United States.

Large (2001) describes three distinct classes of deposits, based on the style and setting of the mineralisation, as well as on the dominant mineralogy (Fig. 2). These are:

1. "Calamine"-dominated deposits in Mississippi Valley Type and other stratiform sulfide primary ores in carbonate rocks. Here the non-sulfide mineralisation is related to oxidation of primary sulfides and preservation in karst-cavity in-filling and replacement aggregations;

2. Willemite-dominated deposits in late Proterozoic to early Cambrian sedimentary rocks, where the mineralisation occurs in marked fault zones. These deposits might be hydrothermal in origin, formed under specific low S- and high O-fugacities;

3. "Gossan"-type deposits, containing hydrated zinc silicates that were formed by residual surface oxidation of primary sulfides and then preserved by a special set of circumstances (tectonic, climatic, etc.).



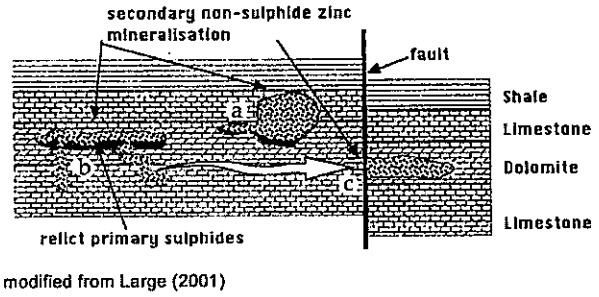


Figure 2 – Characteristics and possible sequence of events in the Supergene Deposits (Hitzman et al., 2003) and in Type 1- Calamine (Large 2001).

Hitzman et al. (2003) have produced a more articulated classification, in which a broad distinction between supergene and hypogene deposits has been contemplated for the first time.

The supergene deposits, corresponding to types 1. and 3. of Large (2001), consist mostly of the economic minerals smithsonite, hydrozincite and hemimorphite. They form primarily from the oxidation of sulfide-bearing deposits (Fig. 2) and can be subdivided into three main subtypes:

Figure 3a: Monteponi Mine one of the most important producers of non-sulfide Zinc in SW Sardinia.

i. Direct-replacement deposits (essentially the equivalent of Zn-rich gossans, where smithsonite and hydrozincite replace sphalerite). Their mineralogy (and consequent metallurgy) is quite complex, with a wide variety of minerals similar to those generally occurring in gossans;

ii. Wallrock-replacement deposits (derived by buffering reactions between acidic groundwater containing zinc and carbonate host rocks below the water table). The main ore mineral is cryptocrystalline smithsonite, as a consequence of metal refining due to different metal mobilities and separation of zinc from lead and iron. The simpler mineralogy makes this type of deposits a much more attractive economic target;

iii. Residual and karst-fill deposits (resulting from accumulation of secondary zinc minerals in a network of karst cavities). Many supergene deposits include components of more than one of these categories, leading to mixed subtypes of deposits.

Many, but not all, of the oxide deposits of supergene type, are located between latitudes 15° and 40°N (Fig. 1), and this may reflect particularly favorable climatic conditions conducive to formation of secondary zinc minerals. However, it is possible that most of the existing deposits (e.g., the European "Calamine", Boland et al., 1992; DeJonghe, 1998; Boni & Large, 2003; Boni et al., 2003) have been rather due to paleoweathering episodes post-dating important emersion phases.

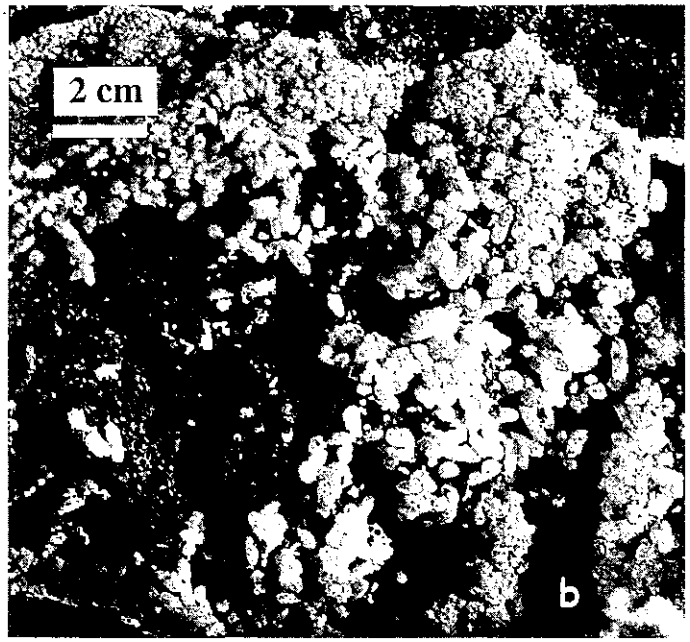


Figure 3b: "Rice grain" Smithsonite (SW Sardinia).

The critical geological features for the oxidation of primary sulfides and preservation of the secondary zinc minerals might include:

- tectonic uplift subsequent to primary sulfide mineralisation, promoting the oxidation and the development of karst systems;
- brittle fracture of the host rocks promoting the flux of oxidising fluids and mobilisation to favourable depositories;
- presence of sufficient Fe-sulfide in the primary mineralisation as an important control during oxidation, for the generation of acid required for the leaching and transport of zinc.

There is insufficient space to review the geology of numerous individual supergene non-sulfide zinc deposits, and the reader may refer to the literature cited (check mostly Hitzman et al., 2003). However, one can enumerate here the characteristics of the most important mineral occurrences among those belonging to this category.

The Shaimerden supergene deposit in Kazakhstan (Boland et al., 2003), consisting of an irregular 300 x 200 mbody extending

to a depth of over 100 m, was formed by a combination of both wallrock and direct replacement. The deposit is hosted in Lower Carboniferous carbonates occurring in a volcanic-dominated succession, and is overlain by about 40 m of Cretaceous to Quaternary cover. The ore minerals consist mainly of hemimorphite, smithsonite, and minor sauconite.

The Cho Dien district in Vietnam is a good example of supergene mineralization formed by residual karstic processes (Hitzman et al., 2003). A number of small high-grade sulfide bodies related to a Triassic granite intrusion in Devonian metasediments, was mined in the past on a high karstic plateau rising 700 m above a valley floor. Residual supergene mineralization (grading up to 10 to 30% zinc) occurs in the cavities of the same plateau and, to a lesser extent, in transported colluvial overburden. Ore minerals consist dominantly of hemimorphite, minor hydrozincite and smithsonite.

In SW Sardinia (Italy) several styles of "calamine" mineralization have been recognized throughout the district (Fig. 3a), including partial replacement of the host carbonates and stratabound primary sulfides, as well as concentrations of ferruginous, "earthy" smithsonite and hemimorphite-rich clays (Boni et al., 2003). The mineralogy of the ore is dominated by smithsonite (Fig. 3b), hemimorphite (Fig. 3c) and hydrozincite, with in-situ grades generally higher than 20% Zn. The inter-relationships between weathering, uplift and erosion in the formation and preservation of non-sulfide zinc mineralization in SW Sardinia, have been analyzed by Moore (1972) and Boni et al. (2003). Both concluded that the oxidation of primary sulfides, commonly extending to a depth of several hundred meters below the surface, show no apparent relationship to the present water table and is probably related to Tertiary and even Mesozoic geomorphologic conditions (paleoweathering).

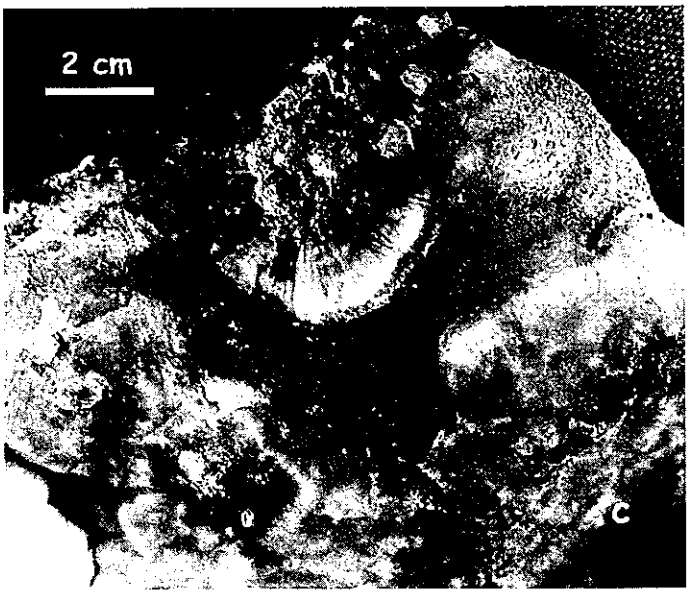


Figure 3c: Concretional cupriferous hemimorphite (SW Sardinia).

The Skorpion deposit in Namibia is a rare example of a wallrock-replacement deposit (Borg et al., 2003) derived from a pyritic volcanogenic massive sulfide orebody, hosted in a volcano-sedimentary succession of Neoproterozoic age. Uplift and erosion of the host rocks and of the massive sulfides were post-Damara orogen, thus allowing the circulation of oxidizing fluids, which then deposited zinc-silicates and -carbonates in the secondary porosity of the same volcano-sedimentary sequence. The timing of the formation of the deposit was possibly quite extended, synchronous with the discrete phases of Tertiary erosion on the pan-African continent. The mineralogy of the supergene zinc mineralization at Skorpion is dominated by hemimorphite and sauconite with lesser smithsonite. The supergene body appears to have formed primarily at the contact between carbonates with volcanic and clastic rocks. The non-sulfide ore minerals are undeformed, and have been precipitated in open spaces and small veins (Borg et al., 2003). Part of the secondary permeability was caused by the breakdown of feldspars and mica. In addition, the high feldspar content of the volcanoclastic units has contributed to the high proportion of zinciferous clays in the Skorpion deposit. The geometry and mineralogy of the deposit suggest that its main genetic process is largely due to wallrock replacement. However, the occurrence of partially oxidized sulfides in the felsic ore horizon down to depths of 800m shows that also in situ oxidation was present, and that the deposit can be partially attributed to the direct-replacement type.

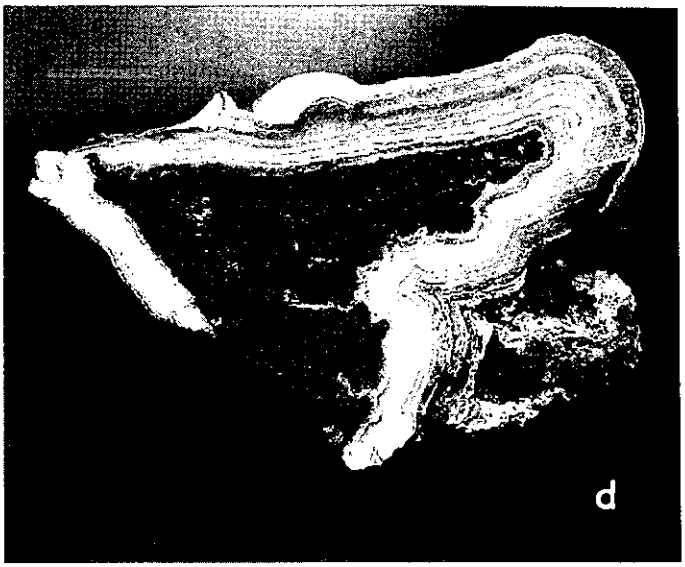


Figure 3d: Smithsonite concretions from the "oxide"-sulfide ores (Angouran).

The Angouran deposit is one of the largest of a series of carbonate-hosted mixed oxide/sulfide zinc deposits that occur within the 1600 km long Tertiary-age Zagros collisional belt of Iran (Hirayama, 1986; Gilg et al., 2003). It is hosted by a Neoproterozoic metamorphic complex consisting mostly of marbles and schists, overlain in turn by a Tertiary-Quaternary sedimentary and volcanic sequence. Estimated resources are more than 15 Mt ore at ~26% Zn and ~4% Pb. Angouran is not simply a supergene deposit, its characteristics pointing to a mixed supergene-hydrothermal origin, the latter related to fluid circulation during volcanic activity. The deposit consists of an oxide cap, underlain by a mixed sulfide-oxide body which grades downward into a sulfide body. The upper levels of the orebody are dominated by smithsonite-rich "oxide" ores (Gilg et al., 2003). Textures are variously soft and earthy, botroidal to crustiform, multiply brecciated, travertine-like, and cavernous

with abundant open spaces and voids. The carbonate-oxide ores are products of supergene weathering. Mn-poor smithsonite, Fe-Mn-oxides/hydroxides, Zn-rich clays, mimetite, calcite, hydrozincite and hemimorphite have been recorded in the weathering phases. In proximity to the footwall schist, mixed "oxide"-sulfide ores (Fig. 3d), and then sulfide-dominated ores are found. The "oxide"-sulfide ores are composed of smithsonite and accessory, co-precipitated arsenopyrite, galena, pyrite and quartz. Gilg et al. (2003) suggest that the carbonate-sulfide mineralization at Angouran was deposited by a distinct low-temperature hydrothermal system, most probably related to Tertiary-Quaternary volcanic activity.

The hypogene deposits, which have been only recently recognized as a new type of zinc ore (Hitzman et al., 2003; Large 2001, type 2.), consist dominantly of zinc silicates and oxides with minor sulfides (Fig. 1). Willemite (Table 1) with pseudo-colloidal textures instead of smithsonite or hemimorphite, seems to be the most characteristic mineral in this class of deposits. Ore deposition has been considered to occur by mixing a reduced, high temperature (>80° to <200°C) zinc-rich, sulfur poor fluid, with an oxidized sulfur-poor fluid. The latter could have been seawater, groundwater, or a basinal fluid, which has equilibrated with an oxidized rock mass, such as a red bed sequence or a weathered regolith (Hitzman et al., 2003). The hypogene deposits have been subdivided into two subtypes:

i. Structurally-controlled hypogene deposits, consisting of veins and irregular pipes of willemite-(sphalerite)-(hematite)-(manganese-rich minerals);
ii. Stratiform hypogene deposits, consisting of commonly manganiferous lenses of franklinite-willemite-zincite+gahnite. They could be an extension of the Broken-Hill type of deposits or be simply related to metamorphism of zinciferous sulfides (Franklin?).

To the first subtype belong, among others, the Vazante-Morro Agudo (Brasil), Beltana-Aroona (Australia), Kabwe (Zambia) and Berg Aukas (Namibia) deposits, which all share a number of common characteristics. They are structurally-controlled, forming veins or pipe-like bodies along normal faults and have variably developed halos of hydrothermal dolomitization, preceeding a major period of willemite precipitation. They also have a mineral assemblage which ranges from solely willemite at Beltana (Groves & Carman, 2003), to willemite-(sphalerite) at Vazante (Monteiro et al., 1999) and Berg Aukas (Chadwick, 1993) and to sphalerite-(willemite) at Kabwe (Kamona, 1993), suggesting that these deposits might represent a continuum (Hitzman et al., 2003). The most outstanding example of this class of deposits, the Vazante mine, is located in the Neo-Proterozoic succession of the state of Minas Gerais in Brasil (Fig. 1). The main resources consist of unusual willemitic ore stringers located along important structural lineations, with small sulfide bodies imbricated with the willemite (Fig. 4). Monteiro et al. (1999) show that the relationships between sphalerite and willemite at Vazante are complicated by the deformation on the Vazante shear zone, but suggest also that the willemite mineralisation should have occurred under conditions of unusual high O- and low S-fugacity during deformation (Large, 2001). In fact, the structural relationships and mineral chemistry at Vazante suggest that the mineralisation may have occurred during, or shortly after, the first deformation of the host sedimentary succession from fluids expelled from the sedimentary succession to the site of mineralisation along major cross-stratal structures. In addition to the "primary" willemite mineralisation, in the same deposit variable amounts of near-surface calamine also occur, as late replacement and cavity-fillings in host carbonates.

The hypogene stratiform non-sulfide zinc deposits appear to be a rare type of deposit (Fig. 1) and the origin of the Franklin and Sterling Hill metamorphic orebodies, which are the most characteristic of this sub-class, is still controversial. Both the above quoted mines, occurring in New Jersey (USA), are now closed but were a very important source of zinc in the past. The Franklin District, where the mineralisation was hosted by Grenvillian Upper Proterozoic marbles, produced 23 million short tons of ore (ca 20.86 Mt) from 1850 to 1954at an average grade of 19.5% zinc. Ore minerals consist of franklinite, willemite and zincite, in layers concordant with the metamorphic foliation. In the older literature, many authors proposed that prior to metamorphism, the deposit consisted already of secondary minerals, such as hemimorphite and hydrous Mn- and Fe-oxides, derived from the oxidation of preexisting sulfides. Johnson (2001), however, cautiously advances the concept that the Franklin and Sterling Hill deposits are extremely rare occurrences of exhalative zinc carbonate-silicate oxide accumulations in a sulfur-depleted basin, and in this they may have some similarities to the so-called Broken Hill-type deposits.

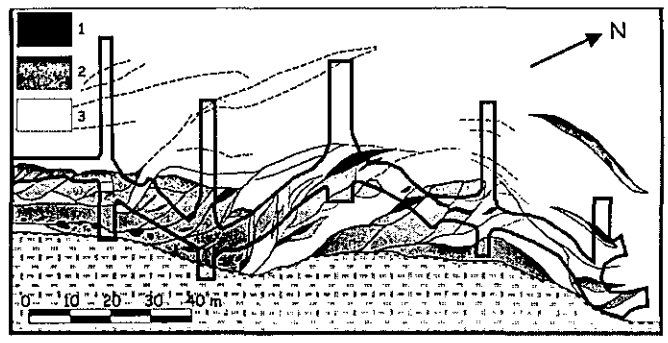


Figure 4: Geology of the 500ft level showing the morphology and distribution of the orebodies, Vazante Mine (Brazil). 1. Sulfide orebodies; 2. Willemite ores; 3. Hydrothermally altered carbonates of the Pamplona Member (modified from Monteiro et al., 1999).

In Johnson & Skinner (2003), there is a paramount view of the genetic theories on this kind of deposits, as well as an interpretation of the famous "magnetite beds" of Franklin Furnace.

However, although the newly defined hypogene deposits might be interesting, the economic focus seems to lie rather on the supergene ones, with the highest promising areas located in the Asiatic continent. A major problem for this class of deposits is that the time constraints for the deposition of many, apparently supergene, non-sulfide ores are still unclear, due to multiple oxidation events through time, controlling in turn the variable paragenesis of Zn-silicates/carbonates. Even if not considering the geologically complex deposits, like Angouran, where part of the non-sulfide assemblage seems to be rather related to primary hydrothermal segregation instead of being a weathering product (Gilg et al., 2003), there is enough evidence that also many other

100% supergene orebodies, might be recording several episodes of paleoweathering through time. Because the timing and evolution of the weathering profiles in areas with hypothesized sulfide primary ores, might be having interesting implications for the exploration (and evaluation) of this type of ore in many parts of the world, it remains a priority to try to obtain a direct age of the oxidation phenomena, either by paleomagnetic methods or by using radiogenic isotope systems, such as ^{40}Ar-^{39}Ar or U-Th-He on K-Mn-oxides.

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32ND INTERNATIONAL GEOLOGICAL CONGRESS, Florence, Italy – Contact address: Matteo Moscatelli or Erica Galli, Newtours SpA, Via San Donato 20, I-50127 Florence, Italy; phone: +39 055 33611; fax: +39 055 33611250/350; e-mail: newtours@newtours.it; web-site: http://www.newtours.it or http://www.32igc.org

September 11-19
INTERNATIONAL ASSOCIATION ON THE GENESIS OF ORE DEPOSITS, VLADIVOSTOK-2004: INTERIM IAGOD Conference on Metallogeny of the Pacific Northwest: Tectonics, Magmatism & Metallogeny of Active Continental Margins, Vladivostok, Khabarovsk, Magadan Russian Far East, Russia – Contact address: Far East Geological Institute, FEB RAS 159, Prospekt 100-letiya, Vladivostok, 690022, Russia; phone: +7-4232-31-87-50; fax: +7-4232-31-78-47; e-mail: iagodconf@fegi.ru or fegi@online.marine.ru; web-site: http://www.fegi.ru

September 27-30
MINEXPO 2004, THE NATIONAL MINING ASSOCIATION, Las Vegas, Nevada, USA – Contact address: e-mail: rmaddalena@nma.org

September 27 – October 10
SEG: PREDICTIVE MINERAL DISCOVERY UNDER COVER, Perth, Western Australia – Contact address: web-site: www.cgm.uwa.edu.au/geoconferences

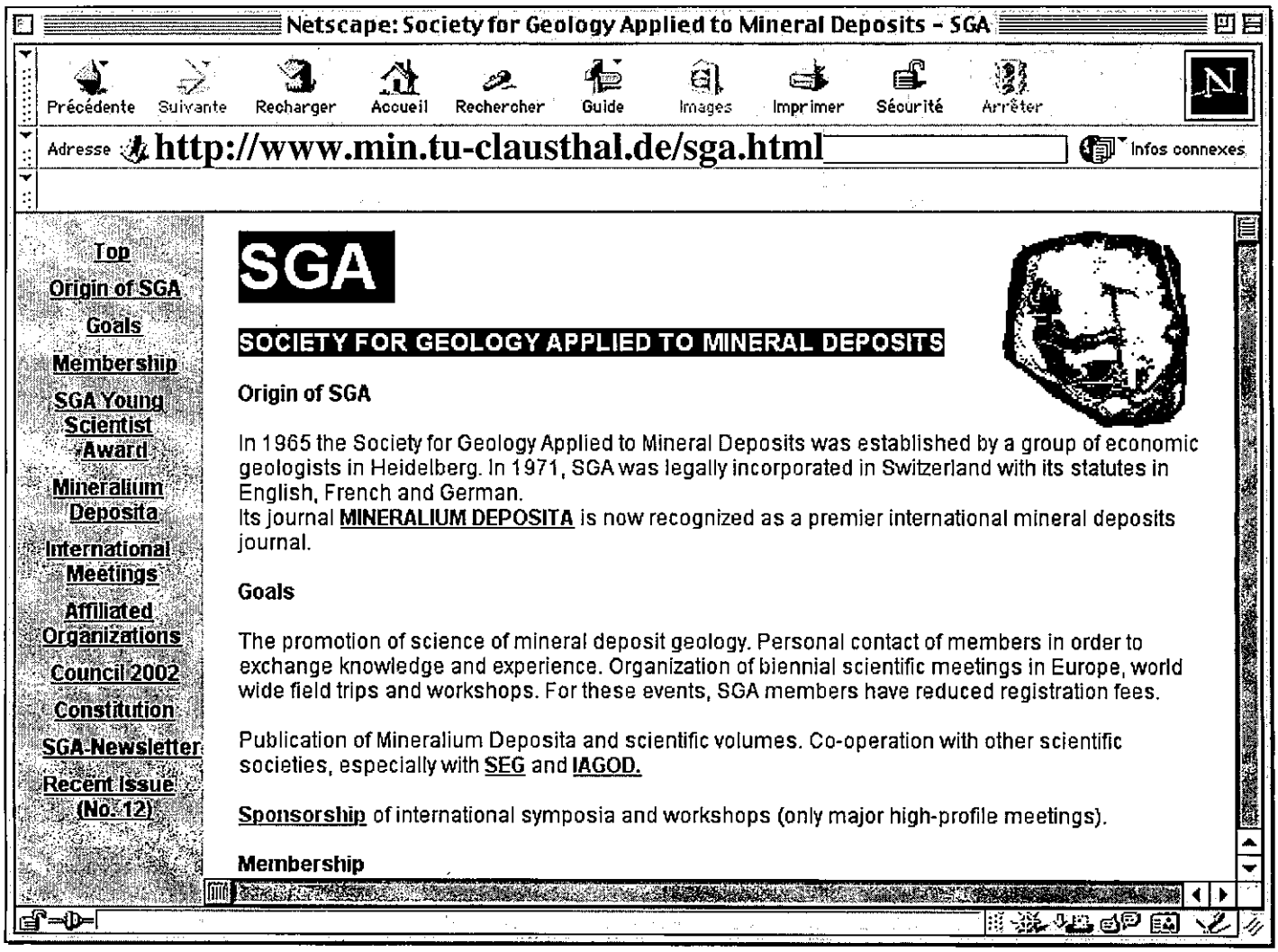
October 10-15
SOCIETY OF EXPLORATION GEOPHYSICISTS (SEG), 74TH ANNUAL MEETING AND INTERNATIONAL EXPOSITION, Denver, CO, USA – Contact address: Debbi Hyer, 8801 S. Yale, Tulsa, OK 74137, USA; phone: +1 918 497 5500; e-mail: dhyer@seg.org; web-site: meeting.seg.org

2005

★ **May 20-24**
Goldschmidt Conference 2005. University of Idaho, Moscow, Idaho, USA. www.gold2005.uidaho.edu. Contact: gold2005@uidaho.edu

THE SGA HOMEPAGE ON INTERNET

The SGA homepage has a new address on INTERNET. From this homepage you can get information about biennial scientific meetings in Europe, worldwide field trips and workshops, membership application form for the SGA and authors and titles of this year contributions to Mineralium Deposita as well as the electronic edition of SGA News.



SOCIETY FOR GEOLOGY APPLIED TO MINERAL DEPOSITS

SGA Membership Application Form

I would like to become a member of the **Society for Geology Applied to Mineral Deposits (SGA)** and to receive my personal copy of *Mineralium Deposita*.

Surname/Corporation .....
First name .....
Title .....
Mailing address .....
.....
.....
Phone ..... Fax .....
E-mail .....
Date of birth..... Nationality.....
Degrees obtained from Universities or Colleges .....
.....
Present position .....
.....
Membership in other scientific societies .....
.....
Are you a member of the Society of Economic Geologists? (If yes, no sponsors are necessary) ❑ Yes ❑ No

❑ 65 EUR (~65 US$)	Regular
❑ 10 EUR (~10 US$)	Student (up to Ph. D., max. 4 years)*
❑ 45 EUR (~45 US$)	Senior (after retirement)*
❑ 200 EUR (~200 US$)	Corporate (includes 3 copies of *Mineralium Deposita*)

*Certificate required

If the application is approved by the SGA Council, I authorize the "Society for Geology Applied to Mineral Deposits" to charge the above amount (please tick)

to my ❑ Visa ❑ Mastercard/Eurocard ❑ American Express

Card No. ☐☐☐☐ ☐☐☐☐ ☐☐☐☐ ☐☐☐☐

Expiry date ☐☐ ☐☐

Signature .....
Place and date .....
(If you do not intend to pay by credit card, an invoice will be issued after acceptance of your application)

Two SGA Sponsors (If you have difficulty in finding sponsors, please send this form to the Executive Secretary who will recommend sponsors)

Name, place, date, signature

SPONSOR 1 _____
_____

SPONSOR 2 _____
_____

Send the Membership Application Form to:

Dr. Jan Pasava
SGA Executive Secretary
Czech Geological Survey
Klárov
CZ-11800 Prague 1
CZECH REPUBLIC

Tel.: +420 2 58 17 390
Fax: +420 2 58 18 748
e-mail: pasava@cgu.cz

Join the SGA now...

The Society of Geology Applied to Mineral Deposits was established in 1965 by an international group of economic geologists. Its Journal *Mineralium Deposita* is now recognized as a premier international mineral deposits journal.

GOALS

-The promotion of science of mineral deposit geology
-Personal contact of its members in order to exchange knowledge and experience
-Organization of scientific meetings, field trips, workshops. For these events, SGA members have reduced registration fees and in certain cases may apply for travel grants
-Cooperation with other scientific societies, especially with SEG and IAGOD
-Publication of *Mineralium Deposita* and scientific volumes

MEMBERSHIP

Membership in SGA is open to all persons interested in economic geology, mineral resources, industrial minerals and environmental aspects related to mineral deposits. SGA is an international society with global membership in over 50 countries. Members have reduced registration fees in SGA-sponsored events and in certain cases are eligible for travel grants. Subsides for publication of color plates in *Mineralium Deposita* also may be applied. Current membership fees are listed on the left-side column of this page.

MINERALIUM DEPOSITA

Editors: Bernd Lehmann (Clausthal, Germany) and Larry Meinert (Pullman, WA, USA).
Mineralium Deposita publishes papers on all aspects of the geology of mineral deposits. It includes new observations on metallic and non metallic minerals and mineral deposits, mineral deposit descriptions, experimental and applied inorganic, organic and isotope geochemistry as well as genetic and environmental aspects of mineral deposits. *Mineralium Deposita* is published bimonthly. Fast publication: *Mineralium Deposita* publishes *Mineral Deposita Letters* within 3 months and regular papers normally within 4 months after manuscript acceptance and usually 6-9 months after manuscript submission.

..and receive
***MINERALIUM DEPOSITA* & SGA *NEWS*!!!**

Additional information in the SGA homepage on Internet: http://www.min.tu-clausthal.de/www/sga/sga.html

SOCIETY FOR GEOLOGY APPLIED TO MINERAL DEPOSITS (SGA)

Seventh Biennial *SGA* Meeting

Mineral Exploration and Sustainable Development

August 24-28, 2003
Athens (Greece)

Co-organizers

INSTITUTE OF GEOLOGY AND MINERAL EXPLORATION (IGME)
ATHENS TECHNICAL UNIVERSITY (NTUA)
ATHENS UNIVERSITY
UNIVERSITY OF THESSALONIKI
SOCIETY OF ECONOMIC GEOLOGISTS (SEG)
GEOLOGICAL SOCIETY OF GREECE - SECTION OF ECONOMIC GEOLOGY AND GEOCHEMISTRY

Organizing Committee

Demetrios **Eliopoulos** (I.G.M.E, Chairman)
Costas **Panagopoulos** (N.T.U.A, Vice-Chairman)
Demetrios **Bitzios** (I.G.M.E, Secretary)
Demetrios **Galanos** (I.G.M.E., Treasurer)
Alexander **Demetriades** (I.G.M.E, Excursions)

Nickolas **Arvanitidis** (I.G.M.E), Gregor **Borg** (Promotion Manager, SGA), George **Christidis** (U.C), George **Christofidis** (U. Th- GSG), Maria **Economou-Eliopoulos** (U.A), Purification **Fenoll-Hach Ali** (President, SGA), Richard Goldfarb (SEG), Martha **Grossou-Valta** (I.G.M.E), Peter **Herzig** (Treasurer, SGA), Brian **Hoal** (SEG, Executive Director), Jeffrey **Hedenquist** (SEG), Dimitris **Kaliampakos** (N.T.U.A), Stefanos **Kilias** (U.A), David **Leach** (SGA), Ferenc **Molnar** (SEG), Euripidis **Mposkos** (N.T.U.A)), Costas **Papavassiliou** (U.A), Jan **Pasava** (Executive Secretary, SGA), Adam **Piestrzynski** (U.M.M Poland), Michael **Vavelidis** (U.Th).

Invitation by the Organizing Committee

Under the general theme "*Mineral Exploration and Sustainable Development*" the Organizing Committee invites economic geologists from academia, government, and industry to discuss current issues regarding exploration for mineral deposits and their sustainable development by the minerals industry. Sustainable development is a matter of great concern to our discipline, as during the previous two decades the focus on environmental, social and economic issues of sustainability has been dramatic. We kindly invite those of you interested in the publication of your current research related to these topics to submit extended abstracts by the end of January 2003 for either oral or poster presentation at the 7th Biennial SGA Meeting. We anticipate that the growing interest in global mineral exploration, and associated issues of sustainability, will result in a large and provocative international forum that will interest economic geologists from both the academic and private sectors.

The venue of the meeting is the city of Athens, specifically at the modern facilities of the National Technical University on the eastern side of the city. Athens, the historical capital city of Greece, has been a scientific and cultural center for many centuries, and is the host city of the 2004 Olympic Games.

Programme

Sunday, August 24	09:00-18:00	Registration at the National Technical University, Main Building
	14:00	SGA Council Meeting
	19:00	Ice-breaking party
Monday, August 25	09:00	Opening Ceremony, NTUA Great Hall, Main Building
	09:30-11:00	Plenary Session, Great Hall
	11:00-11:30	Coffee break
	11:30-13:00	Plenary Session, Great Hall
	13:00-14:30	Lunch
	14:30-16:00	Thematic Sessions
	16:00-16:30	Coffee break
	16:30-18:00	Thematic Sessions
	18:00	SGA Plenary Meeting, Great Hall
Tuesday, August 26	09:00-11:00	SEG Symposium, Great Hall
	11:00-11:30	Coffee break
	11:30-13:00	SEG Symposium, Great Hall
	13:00-14:30	Lunch
	14:30-16:00	SEG Symposium, Great Hall
	16:00-16:30	Coffee break
	16:30-18:00	SEG Symposium, Great Hall
	09:00-11:00	Thematic Session
	11:00-11:30	Coffee break
Tuesday, August 26	11:30-13:00	Thematic Session
	13:00-14:30	Lunch
	14:30-16:00	Thematic Session
	16:00-16:30	Coffee break
	16:30-18:00	Thematic Session
	20:30	Greek night at "Gazi"
Wednesday, August 27	09;00-11:00	Thematic Sessions
	11:00-11:30	Coffee break
	11:30-13:00	Thematic Sessions
	13:00-14:30	Lunch
	14:30-16:00	Thematic Sessions
	16:00-16:30	Coffee break
	16:30-18:00	Thematic Sessions
Thursday, August 28	09:00-11:00	Thematic Sessions
	11:00-11:30	Coffee break
	11:30-13:00	Thematic Sessions
	13:00-14:30	Lunch
	14:30-16:00	Thematic Sessions
	16:00-16:30	Coffee break
	16:30	Closing Ceremony

Thematic Sessions

S1 Sustainable development and geoenvironmental impact models
Session leaders: Kate Johnson, Cam Allan, Demetrios Kaliambakos

S2 Supergene metallogenic processes
Session Leaders: Gregor Borg, Maria Boni, Euripidis Mposkos

S3 Seafloor hydrothermal systems
Session Leaders: Fernando Barriga, Costas Papavassiliou

S4 Porphyries/granites and the magmatic-hydrothermal transition
Session Leaders: Chris Heinrich, John Thompson, Tim Baker

S5 Epithermal systems
Session Leaders: Jeff Hedenquist, John Naden, Stefanos Kilias

S6 Ore forming processes associated with mafic and ultramafic rocks
Session Leaders: Giorgio Garutti, Maria Economou-Eliopoulos

S7 Basin evolution and ore forming processes
Session Leaders: Karen Kelly, Philippe Muchez, Alex Brown

S8 Orogenic hydrothermal systems
Session Leaders: David Groves, Richard Goldfarb, Vincent Bouchot

S9 Organic matter and mineral deposits
Session Leaders: Jan Passava, Andy Gize, Patric Landais

S10 Industrial minerals
Session Leaders: George Christidis, Peter Scott, Michael Stamatakis

S11 Laurium, 3000 years of silver mining
Session Leaders: Costas Panagopoulos, Alexander Demetriades

S12 Open session
Session Leaders: Paul Spry, Holly Stein, George Beaudoin

Special Session on
"FeOx-Cu-Au, VMS, and orogenic gold deposits in light of the tectonic evolution of the Fennoscandian Shield".
Session Leaders: Pär Weihed, Pasi Eilu
Co-sponsored by GEORANGE

SYMPOSIUM
EXPLORING FOR TETHYAN ORES DEVELOPMENT FROM HISTORIC ROOTS
ORGANIZED BY THE SOCIETY OF ECONOMIC GEOLOGISTS

The Tethyan metallogenetic belt has been intensively explored since the dawn of civilization. Despite thousands of years of mining in various parts of this belt, new discoveries of important ore bodies are continuing, even in old mining districts. Reconstruction of the complex geodynamic evolution of this belt is a key factor in the exploration for ores. The tremendous amount of knowledge accumulated during the long history of mining, combined with new results from academic and industry research are leading to new syntheses.

This symposium aims to review the present state of our understanding about Tethyan metallogeny, highlight new achievements related to mineral exploration in the belt, and trigger an exchange of ideas between academic and industry experts. Keynote lectures will focus on the geodynamic evolution and economic geology of the western half of the Tethyan orogenetic belt that stretches from Iran to Central Europe. This region has experienced renewed exploration interest during the past decade, with several important discoveries.

Oral and poster presentations are welcome on:

- The plate tectonic aspects of ore formation,
- Case studies describing new deposits within their tectonic setting,
- Exploration in old mining districts as well as new target areas.

In conjunction with the theme of this symposium a post-conference field trip is being considered to the Cretaceous deposits of the Srednogorie zone in Bulgaria. This trip will visit working porphyry and epithermal mines as well as other deposits.

For further information and to receive a preliminary registration form, please contact:
Ferenc Molnár at the Department of Mineralogy, Eötvös Loránd University.
Mailing address: Budapest, Pázmány Péter s. 1/C, 1117 Hungary.
Fax: 36 1 381 2110 e-mail: molnar@abyss.elte.hu
Or visit the SEG website: www.segweb.org

Abstract submission date: January 31, 2003. Final registration date: April 30, 2003. Please also visit the homepage of the 7th SGA Biennial Meeting: www.igme.gr/sgaconference.htm

Keynote lectures

Keynote lectures will be held both during the Plenary Session for all participants and in the Thematic Sessions. We have invited several distinguished keynote speakers and discussions with others are in progress.

Abstracts and the Proceedings Volume

The Organizing Committee kindly invites participants to prepare and submit papers for oral and poster sessions. Extended abstracts of the papers accepted for presentation will be published as a Proceedings volume, which will be distributed to all participants at the meeting. The price of the volume is included in the registration fee. The language for the abstracts is English, and non-English speaking authors are kindly requested to have their papers edited by a native English speaker. The Scientific Committee will determine the acceptability of all abstracts after a peer-review process; those abstracts determined to be acceptable will be returned to the lead authors for revision following comments from the reviewers and committee members. The maximum length of printed abstracts will be four pages, including references; black-and-white diagrams and gray-tone photographs will be accepted, but they must be included in the length of four pages.

Copyright of the paper will be transferred to the publisher, A.A. Balkema, and all contributions will be provided to the participants in electronic form on CD-rom, fixed in a CD envelope to the inside back cover of the hardbound volume, with adequate search facilities. Instructions for camera-ready abstracts will be available on our website and on the Balkema site (www.millpress.com). To view these, the author must select the Instructions button and then downloading instructions are explained on the screen. Click on the name of the conference.

Deadlines for Abstracts

January 31st, 2003: submission of extended abstract to the Organizing Committee. ***Please indicate the session and your choice of oral/poster presentation.***

February 28th, 2003: authors will be notified of the acceptance of abstracts.

April 30th, 2003: return the final camera-ready abstracts and payment of registration fees.

The abstracts will be printed only if the registration fee is paid at the time the camera-ready abstracts are submitted to the Organizing Committee. For late payments (after April 30th, 2003) publication of abstracts cannot be guaranteed.

Posters

Poster sessions will be held from August 25 to 29, concurrently with the thematic sessions. The space offered is: Vertical length 120 cm, horizontal length 100 cm. Poster authors will be required to be present with their posters at a predetermined time.

Field trips

There will be a large variety of pre- and post-meeting field trips to different geological settings and ore types in Greece and the neighbouring countries. Field trip guidebooks will be prepared and distributed to the participants. As we can accept only a limited number of participants, reservations will be made on a first come-first serve-basis. You can register for a field trip with the registration form included in this circular.

Pre-meeting field trips

A1 Xinjiang, China (August 9-21, 2003)

In coordination with the IGCP-473 Field Symposium in Urumqi and Xinjiang entitled: "Paleozoic Geodynamic Processes and Metallogeny of the Chinese Altay and Tianshan".

Field trip leaders: Mao Jingwen (jingwenmao@263.net), Reimar Seltmann, Rich Goldfarb and local geologists

The field excursion in northern Xinjiang will allow the participants to develop a better understanding of the Paleozoic geology of this part of central Asia, and to study the relationship of its geology to the distribution of some of the most important recently discovered mineral deposits. The excursion will include visits to a series of different syngenetic and epigenetic deposit types and related geological features. These include the Kalatongke Cu-Ni-PGE deposit (associated with mafic-ultramafic intrusive complexes emplaced along deep faults), the world famous Keketuohai No. 3 pegmatite (Li-Be-Nb-Ta-Cs-Zr-rich bodies with gem quality tourmaline and aquamarine), Keketale Pb-Zn deposit, Mengku Fe skarn, Altay granite-hosted metal deposits, Ashele VHMS Cu-Zn deposit, and Dulanasayi and Saidu orogenic gold deposits. These deposits are mainly located along the southern margin of the Altay Mountains and are relatively easily accessible by motorized vehicles. The Arxi and Yilmend epithermal gold deposits represent the site of the largest gold mining activity in western China. It is located in the western Tianshan Mountains, to the south of the Altaids and across an extensional basin between the two ranges. The field trip will focus on these Hercynian metallic deposits and their geological setting, observing their field features and relating their genesis to the Hercynian orogenic processes, which is typical of much of central Asia. Additionally, Precambrian metamorphic assemblages, post-Hercynian rocks and other ore deposits will also be examined along the trip route.

Cost: From/to Urumqui 1000 USD (for further details see trip website below).
Deadlines: 31 March 2003 for registration (max. 50 participants, first-come-first-served) and 31 May 2003 for payment (directly to the organizers).
Further information: http://www.nhm.ac.uk/mineralogy/cercams/index.htm
Contact e-mails: Mao Jingwen (jingwenmao@263.net)
Wang Denghong (wangdenghong@hotmail.com.cn)

A2 Base Metal Mineralization in a classic mining district, the Harz Mountains, Germany (21 – 24 August 2003)

Field Trip Leaders: Duncan Large, Hans-Joachim Franzke and Bernd Lehmann

Mining in the Harz Mountains, central Germany, has a 1000 year mining history that was based on massive sulphide (SEDEX and VHMS), sediment-hosted Cu (classical Kupferschiefer mineralization) and vein-type Zn-Pb-Ba and fluorite deposits.

In addition to the metallogenic variety within a small area that is supported by excellent outcrops and preserved mines, there are numerous museums that demonstrate the history of the mining technologies that were developed in the Harz Mountains.

Potential participants should be aware that there is no mining active today and, although there will be an opportunity of examining mineralization at historical mine sites, the emphasis of the trip will be on demonstrating the geological, stratigraphic and structural setting of the deposit types within the relatively small geographic area of the famous Harz Mountains mining district.

The field trip will provide participants with an overview of the geological setting of two economically important styles of mineralization that supported mining operations until the early 1990's.

- Rammelsberg polymetallic SEDEX mineralization hosted by Devonian shales, and the Einheit volcanic-hosted massive sulphide (VHMS) mineralization associated with Devonian volcanics, and discussion of the regional tectonic setting
- Mansfeld-Sangershausen district of "Kupferschiefer" stratabound copper mineralization hosted by the Permian Zechstein sequence.
- In addition participants will have the opportunity of examining several occurrences of younger (Mesozoic/Tertiary) polymetallic vein-type mineralization.

August 21st: assemble at Hannover airport during the afternoon, transport to hotel in Clausthal. Introduction to the trip and opportunity to view the mineral collection in the GeoMuseum, Technical University, Clausthal.

August 22nd: field stops to demonstrate the geological setting of the Rammelsberg SEDEX deposit. Visit to the Rammelsberg museum to view the outstanding collection of Rammelsberg ore-types. Visit the Elbingerode VHMS deposit. Overnight Clausthal.

August 23rd: visit classic vein-type mineralization at Strassberg, and field-stops to demonstrate the stratigraphic and structural setting of the Kupferschiefer stratabound copper mineralization in the south Harz

foreland, as well as the mineralization preserved underground. Overnight in Goslar - a historically famous mining town.

August 24th: transfer to Hannover airport in time to catch flights to Athens for the SGA Meeting.

A comprehensive guide-book with maps will be prepared.

Provisional Cost: Euro 500.00 per person (NB: Participants to make their own travel arrangements to Hannover airport, and from Hannover to Athens). Minimum No. of Participants: 10 registered by 30 April 2003

Post-meeting field trips

B1 Cretaceous porphyry-epithermal systems of the Panagyurishte ore district (August 29-31, 2003)
Organized by the Society of Economic Geologists

Field trip leader: Prof. Kamen Bogdanov, Sofia University (Sofia Student Chapter sponsor)
Field trip departs from Sofia, Bulgaria, after the SGA meeting (fly from Athens early August 29, 2003).

1st day: Sofia-Vlaikov Vruh porphyry copper deposit; Elshitsa LS epithermal deposit-Pangyurishte; Assarel porphyry copper deposit (operating mine, open pit); Medet porphyry copper deposit. night in Panagyurishte.
2nd day: Drive to Chelopech HS epithermal deposit (with possible underground visit depending on the number of the participants and the situation in the operating mine). Drive to Elatsite porphyry-copper deposit. Night in the guesthouse of the Elatsite mine.
3rd day: Elatsite porphyry Cu-Au-PGE deposit (operating mine, open pit). Discussion on the geology and ore genesis of the Elatsite porphyry system. Return to Sofia.

For further information, please contact:
Ferenc Molnár at the Department of Mineralogy, Eötvös Loránd University.
Mailing address: Budapest, Pázmány Péter s. 1/C, 1117 Hungary.
Fax: 36 1 381 2110 e-mail: molnar@abyss.elte.hu. Or visit the SEG website: www.seqweb.org

B2 Troodos Ophiolite Complex and related mineralization, Cyprus (August 28-September 1, 2003)
Co-organized by the Geological Survey of Cyprus

The Troodos Zone or the Troodos Ophiolite Complex dominates the central part of the island and constitutes the geological core of Cyprus. It outcrops in two regions (main mass of the Troodos mountain range and in the Limassol and Akapnou Forests to the south of the range) and has a characteristic elongated dome structure.

It was formed in the Upper Cretaceous (90 Ma) on the Tethys sea floor, which extended from the Pyrenees through the Alps to the Himalayas. It is regarded as the most complete and well-studied ophiolite in the world. It is a fragment of a fully developed oceanic crust, consisting of intrusive and volcanic rocks and chemical sediments. Stratigraphic completeness of the ophiolite makes it unique. It was created during oceanic spreading and formation of oceanic crust and was emplaced in its present position during complex tectonic events relating to the collision of the Eurasian plate to the north and the African plate to the south. The stratigraphy of the ophiolite shows a topographic inversion, with the lower suites of rocks outcropping in the highest points of the complex, while the upper suite rocks appear on the flanks of the ophiolite. This apparent inversion is related to the way the ophiolite was uplifted (diapirically) and to its differential erosion. The diapiric rising of its core took place mainly with episodes of abrupt uplifting through time until the Pleistocene (2 Ma).

1st day: Late afternoon flight from Athens to Cyprus, hotel arrangements in Nicosia.
2nd day: Troodos ophiolite complex, visit exposures of the plutonic rocks (mantle and cumulates), intrusives, volcanics and chemical sediments. Introduction to the geological evolution of the ophiolite complex.
3rd day: Mineralization related to plutonic rocks. Chromite and asbestos mines.
4th day: Cyprus type sulphide deposits. Skouriotissa-Phoinix mining district.
5th day: Sedimentary formations and industrial minerals. Visit the archaeological sites of Choirokition and Kourion.
Cost: 650 (Including Air fare Athens-Cyprus-Athens, accommodation in single rooms, transportation in Cyprus)
Maximum No of participants: 25

B3 Ovacik and Küçükdere Epithermal Gold Deposits, Turkey (August 29-31, 2003)

Field trip leader: Assoc. Prof. Huseyin Yilmaz, Dokuz Eylul University

The Ovacık gold deposit is located 100 km north of Izmir in western Turkey. It occurs adjacent to the ENE-trending Bergama graben, and consists of a series of high-grade gold-bearing epithermal quartz veins hosted by sub-aerial andesitic-dacitic lava dome facies of Lower Miocene age. Middle to Late Miocene extensional tectonism was responsible for the formation of NNE-SSW- to NE-SW-trending grabens. The extensional activity was accompanied by normal faulting with a later, variable sinistral strike-slip component oriented E-W and NW-SE. It is probable that these faults were critical in controlling the development of epithermal quartz veins, both mineralized and unmineralized.

Two of four nearly EW-trending epithermal veins at Ovacik contain significant Au mineralization and display typical low-temperature epithermal textures, including crustiform banding, quartz pseudomorphs after bladed calcite, and multiphase hydrothermal breccias. Veins outcrop over a maximum strike length of 400 m, with widths at the surface up to 35 m. Mineralization extends down dip for at least 200 m. To date, a resource of 2,980,000 tonnes at 9.0 g/t Au containing 947,000 ounces Au has been delineated.
The Küçükdere gold deposit is located 140 km north of Izmir in western Turkey. It occurs adjacent to the ENE-trending Edremit graben, and consists of a series of gold-bearing, vertical to flat-lying quartz and carbonate epithermal veins hosted by the subaerial andesitic porphyry lava dome facies of Lower Miocene age. Middle to Late Miocene extensional tectonism was responsible for the formation of NNE-SSW-trending Edremit graben. Four NE-trending veins outcrop irregularly over a distance of 2 km, with widths at the surface up to 30 m, although only two of these veins contain economic gold grades. Ore grade veins consist of siliceous breccia and carbonate, which is in turn composed predominantly of chalcedonic quartz with coarse banding, shattered fragments of andesite/quartz and comb quartz. To date, a resource of 1,413,000 tonnes at 6.4 g/t Au containing 219,000 ounces Au has been delineated.

1st day: Arrival at Izmir Airport. From Izmir to Bergama. Overnight in Bergama (Bergama is 7 km from the Ovacik Mine).
2nd day: Visiting Ovacik Gold Mine and Küçükdere Gold Deposit. Overnight in Izmir.
3rd day: Departure from Izmir.
Cost: 480 (including single room with breakfast, transportation within Turkey, return air fare Athens - Izmir - Athens).
Maximum No of participants: 25.

B5 Milos Island-Workshop on Industrial Minerals (August 29-September 1, 2003)

Field trip leader: Prof. Ian Plimer
There has been a 10,000-year-long history of mining on the island of Milos (Cyclades). Commodities such as obsidian, mill stones, salt, sulphur, pozzolan, pumice, alunite, kaolinite, bentonite, copper, silver and lead were mined in antiquity from the Pliocene-Pleistocene volcanic rocks. Hot springs reflect the current extremely high geothermal gradient of up to 8°C/10 m and vents release 2.5 Mt CO_2 per annum. Milos is currently the world's second bigger producer of bentonite and perlite. The bentonite, kaolinite and perlite mines of Silver & Baryte Mining Ores SA will be visited, as well the defunct submarine hydrothermal Mn-Fe-Ba deposit at Cape Vani where white smokers occur in outcrop. The trip will include visits to the recent discoveries of epithermal precious metal deposit at Profitis Ilias (crack-seal quartz-adularia), breccia pipes (Triades) and ore deposits formed during advanced argillic alteration and in steaming grounds (Milos Sulphur Mine; silica barite, alunite and kaolinite mines; sinter terraces). Participants will also visit the oldest and best-preserved Christian catacombs, sites of archaeological interest, hot springs, beaches and quaint fishing villages.

1st day: Arrival to Milos from Pireaus by high-speed boat. In the afternoon, introduction to the geology of the island.
2nd day: Visit the bentonite, kaolinite, perlite mines and the processing plant. In the afternoon visit the epithermal precious metal deposit at Profitas Ilias and the submarine hydrothermal Mn-Fe-Ba deposit at Cape Vani.
3rd day: Workshop on the industrial minerals of Greece at the "George Eliopoulos" Conference Centre, Milos.
4th day: Return to Pireaus
Cost: 450 (Transportation from Piraeaus to Milos by high-speed boat, accommodation, transportation within the island)
Maximum No of participants: 45

B5 Santorini (August 29-30, 2003)

Field trip leader: Dr. George Vougioukalakis
The Santorini volcanic field is the most active volcano of the South Aegean volcanic arc. It comprises two of the three active volcanic Aegean centers, Kameni and Kolumbo. Santorini is one of the world's most violent caldera volcanoes. During the last 400,000 years, more than 100 explosive eruptions were manifested. Twelve of these discharged volumes of magma exceeding a few cubic kilometers, and triggered at least four caldera collapses. The latest of these was the so-called Minoan eruption (3.6 ka) that shaped the present Santorini Island group (Thira, Thirasia and Aspronisi Islands) and buried the late Bronze Age settlements of Santorini. After the Minoan eruption, volcanic activity continued, mainly localized in the intra-caldera area. Extrusive, effusive and slightly explosive activity produced the dacitic lava domes, flows and pyroclasts that built up Palea and the Nea Kameni islets between 197 BC and 1950 AD. Outside the caldera depression, historic volcanic activity was manifested only once, during 1649-1650 AD and built up the Kolumbo submarine volcano.

1st day: Departure from Athens. Arrival at Thira. Bus transport to the hotel and then to Fyra cable car. Boat transport to Nea Kameni island. Visit to the historic volcanic features of the island, the central craters and the active fumarole field. Intracaldera sailing near the caldera cliffs. Observation of the composite Santorini volcano edifices, structure and features. Lunch on boat and swimming stop. Transport back to the hotel. Transport for sunset in Ia village. Dinner in a traditional tavern.
2nd day: Visit to the Prehistoric Archaeological Museum in Fyra town. Visit to a pumice quarry, observation of the Minoan deposits facies sequence and older products. Visit to the Akrotiri Late Bronze Age Settlement excavation. Visit and observation of the Kolumbo tuff ring edifice (NE Thira). Swim at the spot. Lunch in a traditional tavern. Transport back to the hotel. Free afternoon to spend in Fyra town. Transport to the airport. Departure from Thira to Athens.
Cost: 450 (Air fare Athens-Santorini-Athens, accommodation in Santorini, cable car ticket, boat rental, bus rental, lunch and soft drinks for the first day, entrance to the archaeological sites.)
Maximum No of participants: 45

B6 Fe-Ni laterite ores, Lokris (August 29, 2003)

Field trip leader: Dr. Demetrios Eliopoulos
The Fe-Ni laterites of Greece are mainly found in the sub-Pelagonian and Pelagonian geotectonic zones and are related to Upper Jurassic to Lower Cretaceous ophiolites. These deposits have been affected by intense tectonism, which has included overthrusting, folding and other faulting. This has resulted in the transportation of the laterite bodies, disrupting their continuity and, in some cases, mixing them with underlying rocks. The multistage deposition of the Fe-Ni ores, the redistribution of ore metals, the intense tectonism and metamorphism (which have affected all the Ni-laterite deposits of Greece), have almost totally changed the initial mineralogical composition and textures of the ores. Interpretations of the mechanism(s) and conditions of their genesis are complicated.

During the field trip three sites will be visited:

- Tsouka

The Tsouka Ni-laterite deposit is developed on highlyaltered peridotite and it is characterized by a saprolite zone, 1-m-thick, followed by a pelitic-pisolitic horizon, 4-m-thick, the upper part of which is comprised of variably transported material. Lower Cretaceous limestone layers, alternating with Ni-laterite ore, conformably overlie the mineralized horizon.

- Kopais deposit

The Kopais deposit is developed on karstified limestone of Jurassic age below the Quaternary lacustrine sediments of the Kopais basin. These Cretaceous sediments are comprised of marls and clays. The ore extends along a zone 600-m-long l, 500-m -wide and has an average thickness of 20 m.

- Nissi (Bauxitic Ni-laterite deposit)

The Nissi deposits lie on karstified Jurassic limestone and are conformably overlain by Lower Cretaceous limestone. A peculiarity of the Nissi deposits is that they may occur either as isolated typical Ni-laterite or bauxitic laterite ores or as an association of Fe-Ni ore at the lowest part of the deposit, followed by bauxitic laterite in its upper part.

The Fe-Ni-laterite ore is mainly composed of goethite, hematite, Ni-bearing chlorite, illite, quartz, calcite and chromite. Boehmite, gibbsite and kaolinite are common minerals in the bauxitic laterite. Goethite, hematite, chromite (usually as very small fragments), rutile and sulfides (pyrite, Ni-pyrite) are also present, whereas smectite and takovite are more abundant towards the lowest part of the deposit.
Cost: 50 (Including transportation and lunch)
Maximum No of participants: 30

B7 Parnassus bauxite deposits (August 29, 2003)

Field trip leader: Ass. Prof. M. Laskou
Greece is the largest bauxite producing country in the E.U. The major Greek bauxite deposits are located and hosted in the Parnassos-Ghiona geotectonic zone.
In the Parnassos-Ghiona zone five bauxitic horizons are developed covering stratigraphically the period from Upper Triassic to Lower Cretaceous. Today only two bauxitic horizons are mined economically: (i) the middle horizon of Upper Jurassic to Lower Cretaceous period mainly of boehmitic composition and (ii) the upper bauxitic horizon of Middle to Upper Cretaceous period, being characterized by the increased presence of diaspore, resulting in increased hardness and abrasiveness.

Cost: 60 (Including transportation, entrance to the archaeological site of Delphi, lunch)
Maximum No of participants: 30

B8 Lavrion (August 29, 2003)

Field trip leader: Alexander Demetriades
The Lavreotiki (Lavrion) area is renowned for two reasons:

1. The exploitation of argentiferous galena during ancient and recent times,
2. The abundance of tens of common and unique primary and secondary (*lavrionite, kamarizite, ktenasite, thorikosite, serpierite*, etc.) minerals occurring in its subsurface.

Exploitation of argentiferous galena dates back to approximately 3500 BC, with a production peak during the 5th century BC, the "Golden Age of Athens or Pericles". Ancient Greeks developed a unique technology of crushing, gravity separation and smelting of ore. Because the operations were in an area with a dry climate, the ingenious system of cisterns and washing plants, designed for water conservation, amaze even present day visitors. Mining and smelting activities produced an enormous amount of toxic wastes, which have seriously contaminated the surface and subsurface environments.
The Lavreotiki (Lavrion) excursion is unique because it combines geology, history, culture and sight-seeing. The visitor will be informed about the geological setup of the ore, the ancient and recent mining and beneficiation activities (ancient adits, washing plants, etc., the 19th-20th smelter complex, which is now converted into a Technological-Cultural Park), and the environmental problems caused by the contamination in the Lavrion urban area. The excursion will end up at Sounion promontory, with a visit to the Temple of Poseidon to see the beautiful sunset, "garnished" with coffee.
Cost: 30
Maximum No of participants: 50

General Information

Meeting venue
The meeting will be held at the National Technical University of Athens, Technical University Campus, Zografou, Athens.

Language
The official language of the meeting is English. All publications and information will be issued in English. Simultaneous translation of oral presentations will not be available.

Registration
The registration form can be found on the Meeting website (http://www.igme.gr/sgaconference.htm) and contains registration for the Meeting, field trips and social events. Please, indicate the session code for which you intend to submit your presentation(s) or poster(s) and the code of any field trip you wish to attend. Registration will be confirmed in writing.

The registration fee includes the scientific program, Proceedings Volume and CD-rom, coffee and refreshments during breaks, as well as the ice-breaking party. Please, return your registration form to the following address:

Dr. Demetrios G. Eliopoulos
I.G.M.E, 70 Messoghion Str., GR 115 27 Athens, GREECE
Ph.: +30 210 77 07 830, FAX: +30 210 77 73 421, E-mail: eliopoulos@igme.gr

Registration fees:

	By April 30	After April 30
SGA/SEG Members	**250 EUR**	**350 EUR**
Non-Members	**350 EUR**	**45 EUR**
SGA/SEG Student Members	**10 EUR**	**15 EUR**
Student Non-Members	**15 EUR**	**20 EUR**

Payments
Registration fee should be paid in EURO, by bank transfer or internationally accepted credit card (VISA, MasterCard, American Express), free of bank charges to the recipient, at the Organizing Committee bank Account:

ALPHABANK 365-002101-045631
Swift Code: CRBAGRAAXXX
With the note SGA 2003

In agreement with the SGA Board the Organizing Committee has allocated limited funds to cover travel and accommodation expenses for a number of students and junior staff.

Accommodation
PAM TOURS Ltd. has been appointed to provide the accommodation for Meeting participants and accompanying persons. Rooms will be booked on a first-come-first served basis, so please, indicate your 1st and 2nd choice of hotel. **PAM TOURS Ltd.** reserves the right to book another hotel of the same category in case the hotel indicated is fully booked.
Accommodation has been reserved in the following hotels, breakfast included:

Hotel Divani Caravel* ****
2 Vas. Alexandrou Str.
GR 161 21 Athens
Tel. +30 210 720 7000
www.divanicaravel.gr
- Single room 140
- Double room 76 /night/person

Hotel Alexandros* * *Superior***
8 Tim. Vassou Str
GR 115 21 Athens
Tel. +30 210 643 0464
www.airhotel-hotels.com
- Single room 123
- Double room 66 /night/person

Hotel Parthenon* * *Standard***
6 Makri Str.
GR 117 42 Athens
Tel. +30 210 923 5797
www.airhotel-hotels.com
- Single room 96
- Double room 55 /night/person

Hotel Titania* * *Standard***
52 Panepistimiou Str.
GR 106 78 Athens
Tel. +30 210 330 0111
www.titania.gr
- Single room 90
- Double room 53 /night/person

Hotel President* * *Standard***
43 Kifissias Str.
GR 115 23 Athens
Tel. +30 210 698 9000
www.president.gr
- Single room 85
- Double room 55 /night/person

Hotel Stanley* * *Standard***
1-5 Odysseos Str.
GR 104 37 Athens
Tel. +30 210 524 1611
www.aqn.gr/hotel/stanley
- Single room 66
- Double room 43 night/person

Please, find the hotel reservation form as a separate part of the registration form. Pl turn the completed form before April 30, 2003 with a 50% deposit to:

PAM TOURS Ltd.
3 Spirou Donta Str.
GR 117 42 Athens, Greece
FAX: +30 210 92 41 803
E-mail: root@pamtours.ath.forthnet
Payment can be made by:
a. By Bank transfer to :
EFG Eurobank Ergasias –Athens/Greece – Account no 026 207 020016897265 0 Favour PAM TOURS ltd
b. By Credit card:
Visa, American Express, MasterCard and JCB card
Unfortunately, personal checks are not accepted.
Participants are **strongly** advised to book their hotels as early as possible, because Athens is a popular tourist destination. Please, make sure that your name is properly indicated on the bank transfer.
***All hotel fees are payable directly to* PAM TOURS Ltd.**
For further questions about your accommodation please, contact:
Mrs. Despina Gyra, PAM TOURS Ltd., 3 Spirou Donta Str., GR 117 42 Athens, Greece
FAX: +30 210 92 41 803
E-mail: root@pamtours.ath.forthnet

Cancellation
Cancellation must be made in writing to the Organizing Committee. A refund of 80% of the total amount paid will made upon cancellation before July 1st, 2003. No refunds will be made after this date.

Accompanying persons program
The accompanying persons program will be organized by PAM TOURS Ltd. The following activities will be available:

- Athens cultural tours
- Daily excursions to archaeological sites (Delphi, Epidavros, Mycenae etc)
- Daily cruises to the Saronic gulf
- Cruises in the Aegean Sea
- Ticket reservations for the Athens Festival

Correspondence
Dr. Demetrios G. Eliopoulos
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70 Messoghion Str.,
GR 115 27 Athens
GREECE
Ph.: +30 210 77 07 830, FAX: +30 210 77 73 421, E-mail: eliopoulos@igme.gr

REGISTRATION AND ACCOMMODATION FORMS CAN BE DOWNLOADED FROM THE MEETING WEBSITES

www.igme.gr/sgaconference.htm

www.minetech.metal.ntua.gr/sgaconference.htm