Lousal, Portugal: a successful example of rehabilitation of a closed mine in the Iberian Pyrite Belt

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1. INTRODUCTION

Historically, mines in the Iberian Pyrite Belt were, and still are, important primary providers of employment, services and income. Thus, the closure of a mine always had significant impacts on the local economy and on the well being of the community. Unfortunately, in most cases in the past, both in Portugal and Spain, when mining operations ceased, mines were boarded up and abandoned. The safety, environmental and social risks arising from badly conducted mine closures resulted in severe distress for communities due to environmental, social and economic collapse. Furthermore, mining activities have often resulted in destruction of, or radical alterations to, ecosystems, implying now large clean-up costs for governments and regional authorities.

Presently, it is accepted that mine closure requires the return of land to a viable post-mining use, and that the socio-economic impacts of the closure must be assessed and managed. However, that concern did not exist in the past and thus most old mines of the Iberian Pyrite Belt, either abandoned or closed, still remain as a problem to be solved. Each case requires an individual response, as the situations identified are manifold. In favourable cases, there are ways in which closed mines can even create socio-economic development opportunities for local communities. Economic benefits from those activities provide a context favourable to investments in human resources and infrastructures that can meet local/regional development needs and create mechanisms for sustainable economic growth in a post closure situation.

The Lousal mine was an important massive sulphide deposit of the Iberian Pyrite Belt, one of the major metallogenic provinces worldwide, extending for nearly 300 km from the Southwestern coast of Portugal (near which Lousal is located) to the Guadalquivir basin, in Spain (Fig. 1). The mine was active between 1900 and 1988 and part of its surface infrastructures are rather well preserved. The Lousal mining village is currently being rehabilitated not only as a geological and mining heritage site, but also as a centre for education for science and technology and a destination for tourism of culture and patrimony. In this article we briefly describe the major components of this on-going project, which is already envisaged by many as a successful case study in Europe.
News of the Society

SGA Ordinary Council Meeting, April 17-18, 2012, Uppsala, Sweden

J. Pašava (SGA Executive Secretary), Czech Geological Survey, Prague, jan.pasava@geologie.cz


Minutes of Previous Council Meeting (September 25, 2011, Antofagasta, Chile)

The Minutes were unanimously approved.

Reports of Officers on Council (to be received prior to meeting) and Matters Arising from These Reports

Reports were submitted by the SGA Executive Secretary, Treasurer’s Office, Chief Editor of SGA website, and Regional VP for Oceania. SGA Annual Report for 2011 was highly appreciated by IUGS. In 2011 SGA reached a new membership record (1215 paying members).

After discussion, Council approved the reports and the following motions:

P. Weihed to create a Nomination Committee to start looking in collaboration with Council and general SGA membership for suitable candidates for Council positions for 2013 election.

P. Weihed to write a letter to RVP’s to encourage them to submit a concrete plan of activities for 2012-2013 in their regions.

P. Eilu to write to D. Groves to find out if he is willing with other SGA Council members to organize possibly in collaboration with Springer (Ch. Bendall from Springer needs to be contacted) SGA promotion at the 34th IGC in Brisbane.

D. Houston to prepare a call for nominations for SGA-Newmont Gold medal and SGA-Barrick Young Scientist award (for both website and upcoming SGA News).

G. Beaudoin to contact F. Robertson on Barrick future participation in the SGA-Barrick Young Scientist Award (wait for appropriate timing).

Hartwig Frimmel to organize corporate credit card for SGA Treasurer.

To reserve a part of a profit from the First African Metallogeny Course to SGA Educational Foundation.

G. Beaudoin in collaboration with D. Layton-Martens to plan improvement of SGA website.

All Council members are asked to help M. Chiaradia in identifying potential contributors for the main articles in SGA Newsletter.

E. Ferrari to provide more information on the planned field course SPG-SGA on the Central Andes Deposits.

Editorial matters (B. Lehmann, P. Williams)

The report was presented by B. Lehmann and P. Williams. The Journal continues to attract a high level of submissions and the Chief Editors agreed to increase the number of pages per volume to the maximum allowed (1000) under the current agreement with the Springer Publishing House. Council approved the report with great thanks and also highly appreciated editorial work of P. Williams who will retire from his position from 1st July 2012.

All Council members are encouraged to suggest nominations from within Council and also other nominations to B. Lehmann and P. Williams by May 8, 2012. These nominations have to be approved by the nominees. The description of duties of the Chief Editor, and also other nominations to B. Lehmann and P. Williams by May 8, 2012. These nominations have to be approved by the nominees. The description of duties of the Chief Editor, and also other nominations to B. Lehmann and P. Williams by May 8, 2012. These nominations have to be approved by the nominees.

Status of SGA Guidebook series and update on revival of SGA Special Publications

J. Slack

After a brief summary by J. Pašava, presentation of J. Slack and discussion Council approved the following motions:

J. Slack with P. Weihed to negotiate with Ch. Bendall (Springer) better conditions for publishing SGA Special Publications.

J. Slack to find out from Ch. Bendall what publications (if any) are available for a series of SGA Special Publications.

J. Pašava to send Minutes of Budapest (2010) and Madrid (2011) SGA Council meetings with relevant enclosures dealing with SGA Publications to J. Slack.

Status of planning for the 12th SGA Biennial Meeting to be held in 2013 in Uppsala (P. Weihed)

This item was discussed separately with members of the LOC on April 18, 2012 from 11.00 to 16.00 (including a visit to SGA 2013 Meeting venue). The meeting “Mineral Deposit Research for a High-Tech World” (August 12-15, 2013, Uppsala, Sweden) will be organized by the Swedish Geological Survey in collaboration with Nordic countries. More info is available at www.akademikonferenser.uu.se/sga2013. After a brief introduction of all present members of SGA Council and LOC and discussion of the following motions we approved:

J. Pašava to prepare and send to P. Weihed a draft of MOU between SGA and LOC which will be signed by both sides.

P. Weihed to serve as Technical liaison between SGA Council and LOC.

P. Eilu and H. Frimmel to become members of the Sponsorship Committee.

A Conference profit/loss will be shared 50/50 between SGA and LOC.

P. Weihed to write an official letter to SEG and IAGOD to suggest their activities (a subject of approval by SGA Council).

J. Pašava to work jointly with SGA 2013 Field trip coordinator to identify as many field trips as possible for publishing Field trip Guidebook.

LOC to submit a written report summarizing the progress of the meeting’s organization to J. Pašava (by May 15, 2012).

LOC to revise originally proposed budget including registration fee (below 500 EUR).

LOC to adapt technical program including proposals for session chairs.

LOC to revise important deadlines.

LOC to specify field trips including fees.

LOC to submit a draft of the Second Circular to J. Pašava for Council approval by September 15, 2012.

Status of call for SGA 2015 Biennial Meeting (J. Pašava)

J. Pašava briefly informed about a status of received bids. SGA Council received two bids – one preprop by a group from Brazil and the second one prepared by a French-German-Belgian consortium. At this moment, both groups are working on replies to additional questions, which were raised by Council members. After the receipt of both materials the complete bids will be emailed to SGA Council members for an electronic vote.


Progress report on the creation of SGA Educational Foundation (J. Pašava et al.)

After presentation of a summary report by J. Pašava and discussion Council approved the following motions:

G. Beaudoin (coordinator) with P. Weihed, J. Pašava and H. Frimmel to set up the SGA EF either in Switzerland or in any other country.

J. Pašava to inform D. Groves about the importance of the preparation of the 8-days training course in Mokrsko, Czech Republic as suggested in his letter to mining companies.

Council greatly appreciated recent voluntary effort of D. Groves and his wife Sue which resulted in confirmed commitments from several mining companies over a period of 5 years.

Progress report on membership drive from the last SGA Council meeting (P. Eilu, J. Pašava, A. Vymazalova)

The report was presented by P. Eilu. In 2011 SGA had 1163 paying members and to date our membership grew to a new record of 1215 paying members. Unfortunately, the loss of members remains a serious problem. Sabine Lange recently distributed an excel file listing members who haven’t paid their fees (since 2010 we have 403 members who haven’t paid their fees). Council approved the report with great thanks and recommended the following actions. All RVP’s in collaboration with Council members should contact the members who haven’t paid with their fees. S. Lange to prepare a next list of people who didn’t renew SGA membership and send to all Council members by July 5, 2012 so that individual Council members and Regional Vice-Presidents could contact individual people.

S. Lange to email reminders to all who didn’t renew SGA membership at least 3 times a year (every 4 months).

Status of development of SGA Student and Young Scientist network – Reports from Prague, Baltic and Novosibirsk Chapters (A. Vymazalova and J. Relvas)

The report was presented by A. Vymazalova. After discussion Council approved all reports with great thanks and the following budgets for 2012 activities (Baltic Chapter – EUR 2500, Novosibirsk Chapter – EUR 1000, Prague Chapter – EUR 2500).

Past activities

• Geological Society of Bolivia Anniversary Meeting (October 3-4, 2011 La Paz, Bolivia) – B. Lehmann – one of keynote speakers – received a letter thanks from President of the Bolivian Geological Society with a request for continuing SGA support

• Baltic Student Chapter Meeting (December 6-9, 2011 Cracow, Poland) – requested EUR 660 to cover part of expenses for 15 participants – M. Sosnicka et al.

• African Metallogeny Course (March 12-18, 2012 Ouagadougou, Burkina Faso) – H. Frimmel et al.

Council greatly appreciated efforts of all organizing teams who contributed to successful SGA promotion. Baltic Metallogeny Course was highly appreciated by the President of IUGS.

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Future activities

• The 6th International Siberian Early Career Geoscientists Conference – (June 9-23, 2012 Novosibirsk, Russia) – organized by a network of SGA Novosibirsk Chapter – J. Relvas (SGA keynote speaker)

• Ophiolites and related ores and industrial minerals (16-22 May 2012, Trabzon, Turkey) – SGA sponsored workshop – organized by I. Yilmaz

• Session “Trace elements in oxides minerals from ore deposits...” (within Theme 9-Earth’s Resources: Origin, Evolution, Sustainable Exploitation and Remediation of the 22nd Goldschmidt Conference – June 24-29, 2012 Montreal, Canada – Brenan et al. – approved EUR 1000 for 4 students (SGA members).
• Session “Black shale-hosted mineral resources: deposit characteristics, geochemical controls, and exploration potential” (Theme 9) of the 22nd Goldschmidt Conference – June 24-29, 2012 Montreal, Canada – Slack et al. – approved EUR 1000 for 4 students (SGA members)
• Freiberg Short Courses in Economic Geology (organised annually by G. Gutzmer) – SGA sponsorship (student’s participation) – at the moment no funding requested
• 48th IGC (Aug 5-10, 2012 Brisbane, Australia) – 2 SGA sessions and 1 SGA co-sponsored session and SGA Council Meeting – D. Houston et al. – reservation for SGA Council meeting had to be cancelled due to insufficient presence of SGA Council members, possible SGA promotion in discussion
• 2nd Short Course on African Metallogeny (the Central African Copperbelt, 2013, locality and dates still to be decided) – S. Roberts et al.


Requests for sponsorship

• Black shale and ore deposits (SGA sponsored session at the 29th IAS Meeting, September 10-13, 2012 Schladming, Austria) – B. Lehmann and J. Pašava (requested EUR 1000 for sponsoring SGA student participation – Chair: J. Pašava) for another MD session
• J. Raith asked if SGA would consider sponsoring also SGA student participation in his session – Sediment hosted base metal deposits – approved
• EMC 2012 (September 1–7, 2012 Frankfurt am Main, Germany) – MD sessions:
  1. Ore – belts in Europe, 40 EUR per day for 8 people
  2. PGM and related accessory minerals in mafic-ultramafic rocks and unconventional deposits, 8 people participating
• Electronic “Talk list” (J. Slack) – Presentation by J. Slack (item 15-1). Council approved the document with great thanks. Action: G. Beaudoin to initiate a new on-line SGA Talk Listserv through SGA website.

Insurance for SGA (update by H. Frimmel)

A contract on corporate third party insurance for SGA has been finalised with Zurich and is in effect since beginning of September 2011.

SGA award for recognition of special services to the society – update (H. Frimmel)

H. Frimmel informed Council that the proposal is under preparation by D. Houston (Chair of Award Committee).

Report of the Technical Liaison on the SGA Biennial Meeting held in Antofagasta in September 2011 (F. Torres)

The SGA keynote speakers (SGA would cover economy air fare) and to inform O. Arce.

Requests from SGA Chapters (Prague – 2500 EUR, Baltic – 4030 EUR, Novosibirsk – 1000 EUR) – approved by SGA and session chairs will be informed of a decision by July 15, 2012. The recipients of the grants will be selected and announced at a later date.

Date and Place of the Next Council Meeting

To be decided and announced at a later date.
2. GEOLOGICAL SETTING

The Iberian Pyrite Belt embraces a large amount of volcanic-hosted massive sulphide deposits, with a pre-mining total tonnage that exceeds 1750 Mt of sulphides, enclosing 22 Mt of copper, 34 Mt of zinc and 12 Mt of lead metals (Tornos, 2006). The province has been mined continuously since the Chalcolithic era. The Rio Tinto deposit in Spain is acknowledged as being the largest deposit of its class ever to form, with over 500 Mt of sulphide ores (Leistel et al., 1998). The Aljustrel and Neves Corvo deposits in Portugal, and the Lousal deposit in Spain, are acknowledged as being the world’s richest deposits of their class (Matos and Oliveira, in prep). The ores have long been known to contain significant amounts of gold, which was sporadically exploited as a by-product. Recently, Reiser et al. (2010) and the Oliveira et al. (2011) addressed the fact that some ores contain significant amounts of Ge and In, respectively.

3. THE LIFE-TIME OF THE MINE

The chronology of the lifetime of the Lousal mine is relatively simple (Rodrigues, 2005; Vida da Minha – Memórias, Percursos e Identidades). Although the area shows several signs of mining activity since the Bronze age (ca. 3300 BC), with particular emphasis on constructions probably built for defence as well as for ore storage, the ‘modern’ discovery of the deposit only took place in 1882 by a local farmer – António Manuel – who required from the Portuguese “Ministry of Public Works and Mines” an official document dated from that year recording the discovery of the Lousal gossan. He was granted a temporary lease in 1885, but lost it in 1889 for not having submitted an exploitation plan to the authorities. Between 1900 and 1934, the exploitation rights were property of several individuals and companies, including the company Henry Burnay & Cia, which exploited the mine for about one decade. In 1934, the mining lease became property of the Société Anonyme Belge des Mines d’Aljustrel, which ran both mines (Lousal and Aljustrel) for two years. Finally, in 1936, the Belgian corporation Société Anonyme Mines et Industries S.A., which preceded SAPEC, became the owner of the Lousal mine. SAPEC still owns the mine despite the shut down of the operation in 1988.

In 1931, the Lousal village had just 167 inhabitants. However, the boom of mining activity, which followed the purchase of the mine by the Société Anonyme Mines et Industries, SA, in 1936, caused a rapid population expansion: in 1940 there were 1273 inhabitants, and in 1960 this number had increased to 1906. With the onset of mechanized production, less people were employed in the mine, with consequent fall in local population numbers: 1252 inhabitants in 1970; 957 in 1981; and as few as 734 in 2001, when the mine was already shut down. According to the last demographic survey, in 2011, the population amounted to just 401 inhabitants. The urban structure of the Lousal village is centred on the build-ings related to the mining activity – head-frames, workshops, stores and laboratories – and presents a uniform volumetry, with buildings spread out over all the mine perimeter. Besides the mining buildings, there are two other groups of structures in the area: the social support buildings – medical ward, school, church and market – and the housing buildings, including accommodation for the miners and for the technical personnel, and the administration building.

The exploitation methods and equipment available changed considerably along the lifetime of the mine; the same was true for the ore-processing procedures. Mechanized production progressively replaced manual work (Fig. 3). Working condi-tions and safety inside the mine were also much improved, namely by the use of safety gear (helmets, steel-tipped boots, face-masks with filters, personal battery-powered lamps) and by the onset of stricter regulations concerning fresh-air circulation inside the mine. The underground mining works reached about 500 m depth. After the early 1950’s, pyrite ore went out through the mineshaft and was processed in a crushing plant on surface. The treat-ment of pyrite ore began with a preliminary granulometric selection (sizing), followed by successive crushing and grinding op-erations, and finally handpicked by women (Silva, 1968). The ores were sold on the national market and exported to Belgium. Pyrite was used to produce sulphuric acid to which phosphorite from Morroco was added to make super-phosphate fertilizers used for agriculture.

In 1958, Frédéric Velge, son of Antoine Velge, the main holder of Société Anonyme Mines et Industries, SA, became director of the Lousal Mine and opened an epoch of great expansion for the mine. With the help of the on-site geologist Günter Strauss,
he modernized the management and introduced new methods of mechanized mining production. During the 60’s and the 70’s, the Lousal mine was an example of innovation and modernity in the Iberian Pyrite Belt. By that time, the annual production of the mine reached 250,000 tons of mined ore. Simultaneously, living conditions in the Lousal village also knew progressive improvement: water and electricity-equipped housing for miners and other mine employees, a hospital, church, bakery, recreation hall and other amenities. Besides his investment in mechanized production, it can be said that the social awareness of Frédéric Velge was part of the reason for the enormous success of the mine and the extraordinary increase in its productivity. The closure of the Lousal Mine, in 1988, was not an isolated case in the Iberian Pyrite Belt. The low copper and zinc contents of the mined ores compromised their economic viability following the present-day unsustainability of sulphur extraction from pyrite.

4. THE "RELOUSAL" REHABILITATION PROGRAM

The name RELOUSAL stands for REvitalization, Reewing, Recovery and REhabilitation of community life in the Lousal village. The RELOUSAL Program required a solid institutional framework, which catalysed the joint efforts of the mine owner—the SAPEC Corporation—with the local authorities—the Municipality of Grândola—leading to the creation of the Frédéric Velge Foundation. Thus, less than ten years after the closure of the mine, it was decided to promote an integrated development program in Lousal, encompassing several complementary features. In 1995, Fundação Frédéric Velge appointed “Oficina de Arquitectura” a private company of architects to co-ordinate the program. The aim of the program is to rehabilitate the village, both in environmental, economic and social terms. Emphasis has been given to the cultural and scientific aspects, but the touristic potential of the whole project was strongly valued as well.

The number of technical professionals and scientists involved in the RELOUSAL program is really exceptional. More than fifty researchers coming from different institutions—Universities, Research Institutes, Museums and the Portuguese Association for Industrial Archaeology—and covering many different fields in Science and Technology (e.g., Geology, Biology, Chemistry, Physics, Mathematics, Engineering) have already been involved somehow. As of the components of the Program. In particular, the strong commitment of the University of Lisbon, through its Faculty of Science, and the National Museum of Natural History and Science has raised very high the scientific standards of the whole initiative.

Several facilities have been created in the framework of RELOUSAL, aimed at adding value to the Lousal mining heritage, via reuse of the industrial complex, equipment and objects of the old mine (Fig. 4). The positive impacts of the program in terms of socioeconomic regeneration of the local community have been notable. Since 1996, the RELOUSAL program has supported a number of different activities and projects of different nature, including partial re-accommodation of the resident population, professional training for the ex-miners and their families, promotion of handicraft activities and family-scale manufacturing, public-ware equipment, a handicraft centre (1999; Fig. 5A), a restaurant in the main storehouse of the mine (“Armazém Central”, 2000), patrimonial valorisation, soil decontamination, reforestation and a visitor welcoming centre (2001). In 2003, a local technical office of the Grândola Municipality was installed in Lousal, and, in 2005, a charming hotel located in the ancient house of the mine administration was inaugurated (Sta. Bárbara Lodge; Fig. 5B). The Urban Plan for the village was formally ratified in 2007, fuelling the requalification of the urban space, the marketing of touristic projects and the internationalization of the whole initiative.

It should be said that, despite all these advances, probably the major achievement of the RELOUSAL Program is that, in the course of these years, the local new generation, sponsors, administrators, professionals, scientists and mine owners collectively became “contaminated” by this place and by its community, which remains determined to keep alive their mining traditions, patrimonial legacy, culture and way of living.

5. ENVIRONMENTAL RESTORATION

Besides some copper-rich gossans exploited on surface during the early years of the mine, the Lousal mining operation was mostly underground and oriented for the deeper pyritic lenses (Matos & Oliveira, 2003). Notwithstanding this, one main open-pit, now partially flooded, was developed in association with the underground works in order to assure the supply of barren rocks needed to refill the exploited underground galleries (Fig. 6). In addition, large volumes of waste were generated by the mining activities, ranging from barren overburden and barren rock, to various types of tailings (the amount of waste stored on-site is estimated to be greater than 1 Mt; Silva et al., 2005). Rainwater...
able remediation measures. This study was focused in aspects such as ore geology and mineralogy, ore extraction and processing, mineralogical and chemical compositions and physical characteristics of the tailings, safety, industrial relevance, etc. This approach led to the sorting of more than 100 mine sites according to hazardousness (Oliveira et al., 2002). Expectedly, after this study, the Lousal mine area was among the sites targeted as requiring an intervention with high priority. Later on, several other studies were made in the Lousal mine in order to characterize in detail the environmental situation and to propose a remediation strategy for this particular area (e.g., Silva et al., 2006, 2009; Matos & Martins 2008). A rehabilitation plan directed to reclaim the Lousal contaminated area was defined by EDM (Empresa de Desenvolvimento Mineiro), the public company responsible for the implementation of remediation projects in old prospects and abandoned mines in Portugal. Presently, in the Iberian Pyrite Belt, EDM develops projects in the Aljustrel, Lousal, Chãna, São Domingos and Cavelina mines, all of them affected by AMD (Matos & Martins 2006, Silva et al. 2009, Abreu et al. 2010). Due to the RELOUSAL program, which was already running, the strategy adopted by EDM to the Lousal area aimed to preserve as much as possible the memory of the mining activities, with significant protection of the mining landscape, essential to the development of mining heritage projects (Matos et al. 2008). Their intervention was delineated to confine within the impacted perimeter the environmental aggressions identified, and sort them out without obliterating from the landscape the visual impressions left by almost a century of mining. The contamination sources at this area were assessed and a variety of combined interventions were implemented.

(i) In order to avoid that the deep slopes of the tailing deposits would promote the down slope movement of eroded material that easily would reach the Corona stream, large volumes of contaminated soils, sediments and mine processing waters have been stabilized and consolidated on site. This provided more stable surfaces, preventing the erosion by reducing water runoff. In addition, plants vegetation was also grown in order to reinforce the topsoil and reduce the soil erosion and water loss by evaporation.

In order to minimize contaminant runoff leaving the site, several measures were undertaken, including diversification of trenches and culverts, and evaporation ponds. Some localized soil-covered impermeable capping was applied to avoid the direct exposure of metal-rich or acid-producing solid wastes to rainwater and superficial weathering.

(ii) A wetland system, composed by seventeen “pools”, was built between the groundwater spring and the Corona stream in order to minimize the complex problem of AMD related with two main sources: the milldred ore deposited in the railway area and the old mine open pit (Fig. 7). This phytoremediation system envisages the reduction of the input of contaminated loads on the Corona stream ecosystem, and consists of two different groups of pools, one group with an aerobic environment used for iron precipitation, and a second one designed to favour the precipitation of heavy metals in an anaerobic environment.

The main stages of implementation of the EDM’s remediation project for Lousal are almost completed; nevertheless, some improvements in the functioning of the constructed wetlands are still missing, being planned for the near future.

6. MINING MUSEUM

One of the first big projects that have been completed under the scope of the RELOUSAL program was the Mining Museum. The project was promoted by the Frédéric Velge Foundation, and developed between 1998 and 2001 with the technical support of APM, the Portuguese Association for Industrial Archaeology. This museum was installed in a large building formerly hosting the electrical plant of the mine (“Central Eléctrica”). The installation accommodates several rehabilitated equipment that possess valuable significance from an industrial archaeologi- cal standpoint. Among the pieces contained therein stand out a number of huge electrical alternators and air compressors that closely follow the major steps of the evolution of the mining exploitation methods through time (Tinoco et al., 2002; Fig. 8A). The museum has multiple focal points, including an exhibition, inaugurated in 2006, of over fiftyscale models made of wood and metal that perfectly represent machines and devices used for mining exploitation during the 19th century (Fig. 8B). The collection was originally produced in Germany and was used for several decades to teach mining engineering, firstly at the Fribourg University in Germany, and afterwards at the Technical University of Lisbon, in Portugal. The models went to Lousal in a very bad shape and were fully reconstructed by a local craftsman (ex-miner). Upon request, groups of visitors to the Mining Museum can be guided by a local ex-miner, who was one of the electricity technicians of the mine and thus is able to share with the public his own memories of the electrical plant and of the mine while they were still operating.

7. SCIENCE CENTRE

In Portugal, there is a national network of science centres called “Ciência Viva” that depend directly of the government, through the “Ciência Viva” Agency, and are run jointly with the Pavilion of Knowledge in Lisbon, in collaboration with local authorities and Portuguese scientific institutions and research community. There are nineteen “Ciência Viva” Centres distributed all over Portugal, which invite people of all ages to join in the activities and interactive exhibitions in order to spread scientific and technological culture among the wider Portuguese public. The “Ciência Viva” Centres use examples of modern scientific museology. The main goals of the network are promoting knowledge and education on science and technology, mostly through attractive, hands-on, thought-provoking experiments.
The “Ciência Viva” Centre of Lousal - Mine of Science was inaugurated in 2010 (Fig. 9A; http://www.lousal.cienciaviva.pt/home/). It was conceived for a large-spectrum audience in terms of age, education and social or geographic origin. The general idea consists of taking advantage of the old mine environment to use the concept of “georesource” as a window opened through a wide range of fields of knowledge that include the natural and exact sciences, applied technologies and several fields of engineering. In the Mine of Science, one exploits science and extracts knowledge, always with interactivity at the fingertips. There, the visitors may discover some of the most fascinating phenomena of the world of science and technology, through tens of interactive experiences and “hands-on” exhibits (Fig. 9B). One can also try a virtual descent into a mine, by means of immersive 3D visualization technology. The development of immersive environments based on virtual reality (“CAVE-Hollowspace”) is a must of this centre, creating imaginary environments where the past realities, or future possibilities can be recreated. The potential uses of this powerful technological tool extend from scientific purposes to virtual prototypes or industrial applications.

The Centre was set up in a building that was associated with the past activity of the mine (geology office, lanterns room, miners’ locker room and bathhouse). The building has been adapted in order to function as a space for the dissemination of scientific and technological culture and today it offers a variety of functions: exhibition areas, interactive exhibits, the virtual mine, a chemistry laboratory, a cybercafé and a modern auditorium with 60 seats, for presentation of documentaries and organization of meetings, conferences, seminars and lectures. The Centre is extremely dynamic and promotes also many educational activities that go far beyond the walls of the building: guided visits to the open-pit, geo- and bio-field trips, astronomy observations, scientific camping, among many others (Fig. 9C).

The “Ciência Viva” Centre is administrated by five associated institutions: the local Municipality (Grândola), the Frédéric Velge Foundation and the “Ciência Viva Agency”, which are the three funding entities, and the Faculty of Science of the University of Lisbon and the ISCTE (another Portuguese University), which are responsible for the renewing and credibility of the scientific and technological contents and activities of the Centre. The Centre is operated by a team composed by thirteen skilled young professionals, most of them graduated with a MSc. degree (geology, biology, physics, chemistry, engineering, computer graphics, sociology; Fig. 9D).

In two years, about twenty two thousand people – mostly scholar groups, families and tourists – have visited this science centre, and many other persons visited or benefited from the remaining components of the RELOUSAL program. These circumstances completely changed the daily life scenario in Lousal. The dynamic activity of the “Ciência Viva” Centre and its team brought a new reality to the village, pushed forward new economic activities, justified new job opportunities for the local population, and for the youth in particular, and opened a new cycle in the revitalization of the RELOUSAL program. These circumstances completely changed the daily life scenario in Lousal. The dynamic activity of the “Ciência Viva” Centre and its team brought a new reality to the village, pushed forward new economic activities, justified new job opportunities for the local population, and for the youth in particular, and opened a new cycle in the revitalization program initiated almost two decades ago.

8. WHERE TO NEXT?

The rehabilitation of Lousal is an on-going process that has already reached a point that allows one to look at the future with justified expectations. The steps forward that have been pursued so far have put together, in a consolidated way, a number of partners with different, but complementary and compatible motivations. The implemented component of the program brought with them the critical experience needed to envisage the future challenges with renewed confidence. Despite all the difficulties, one crucial aspect that is thought to be part of the Lousal success lies on the permanent concern in keeping a strong dependence between the interests of the local community, high quality standards, and encouragement of local entrepreneurship and creativity. The forward-looking policy of the institutions involved – local and municipal authorities, “Ciência Viva” agency, universities and mine owners – provided the motivation and the capacity to polarize significant funding from national and European sources over time. The key words for the future are now consolidation, step-by-step development and economic sustainability. Sooner or later, Lousal should pass from a mining village under a rehabilitation program, to a territory able to attract investments and where good economic opportunities may emerge.
for temporary exhibitions. In addition, the project will include the creation of a document archive, properly organized and opened to the public. This important component of the project will provide an opportunity to recover and properly classify and manage the abundant documentation left by decades of mining activity at the Lousal mine (maps, mine plants, reports on the ore geology and engineering, files, etc.). There is a continuing demand for this type of visits, given their ample educational return, at all levels from high school to postgraduate and professional.

Lousal receive frequent visits from under- and postgraduate students, professors and researchers, both from Portuguese and foreign universities, mostly interested in ore geology, mining engineering, environmental sciences and sociology. However, the potential to translate this kind of collaboration is far from being exhausted. Lousal belongs already to a number of international networks related with mining industry and mining heritage sites. The European authorities encouraged the intensification of those contacts in order to provide more and better visiting and learning opportunities to European students and citizens in general. This aim intersects with a medium-term project directed to build a research centre in Lousal, devoted to metallogeny and environmental geochemistry, which would attract researchers and PhD students, a favorable condition to assure the scientific sustainability of the whole project in a long run. There is also a strong bet in adding value to this territory by promoting the geo- and biotourism in the area (Martins and Matos, 2010). Tourism is a fundamental piece for regional development in this part of the country, and the authorities are committed in supporting initiatives that may potentiate a link between the tourism of nature, patrimony and mining legacy, with the classic coastal destinations. Obviously, this opens a window of opportunity for Lousal in terms of sustainable development and, simultaneously, an opportunity for Science in terms of public outreach. Accordingly, the long-term project is one that will include an underground visit to the Lousal mine (Relvas et al., 2004). This is a realistic objective once there is an underground gallery that is still well preserved and can be recovered and kept at a reasonable cost (located above the water table, in the flank of a hill; Figure 11).

ACKNOWLEDGEMENTS

This article is dedicated to the people of Lousal and to the extraordinary Lousal “Ciência Viva” team. Acknowledgements are due to those who have dedicated part of their lives to this project.

REFERENCES


Figure 9B. Photo-mosaic showing a variety of “hands on” exhibits at the “Ciência Viva” Centre

Figure 9C. Guided geologic trip to the Lousal open pit

Figure 9D. The “Ciência Viva” team at the Lousal Centre


The SGA website

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http://www.e-sga.org
After many months of planning and rising excitement, the 1st Short Course on African Metallogeny was held from 12th to 18th March 2012 in Ouagadougou, Burkina Faso.

Having been the first event of this kind and of what is planned to become an annual series of courses, it was naturally an experiment with initially uncertain outcome. With hindsight it can safely be said that it was a huge success and not only from the perspective of the extra-university training of mine and exploration geologists in Africa.

The principle idea behind the Short Course followed the model of the highly successful UNESCO-SEG-SGA Latin American Metallogeny Courses that have run annually in different locations in South America for the past three decades. The African continent is well endowed with mineral resources and yet much of Africa’s mineral riches remain to be discovered.

Mining has played a pivotal role in the economy of many African countries with contributions to foreign exchange exceeding 50 % in many cases. There is no doubt that the exploitation of mineral deposits could form a substantial, if not the mainstay of the economy of many African countries with examples from South America for the past three decades.

The theoretical part of the course covered the required funds will continue to rest with the mining and exploration industry. The demand for this course was however, so overwhelming that, although several (late) applicants had to be turned down, a total of 61 delegates ended up for the course, most of whom came along for the field trip as well. Altogether 14 different exploration companies were present. The consequences for exploration companies of the successful work done by his wife and all the TTG staff he organized all the logistics on his own account, he managed the opening ceremony on Monday, 12th March, attended by Mr Jean Baptiste Camara, the Chamber of Mines of Burkina Faso. On the next day, Mr Salif Kaboré, Burkina Faso’s Minister of Mines, Carriers and Energy himself, honoured our meeting with his presence and opened the course for this initiative but also his hope for a continuation of the training of West African geoscientists in the years to come.

The theoretical part of the course covered a wide range of lectures. Following an introduction to the principal requirements for the formation of an ore deposit and an introduction to the regional geology, specific topics that were addressed in greater detail included hydrothermal ore-forming processes, structural control on mineralization, exploration methods and styles of pronunciation.

For logistics reasons the number of participants was initially set to no more than 50 for the theoretical part of the short course and not more than 20 for the post-workshop field trip.

The entire short course was presented in English. A dominance of delegates from English-speaking countries led to initial concerns that language could be a stumbling block. Our French-speaking colleagues were quickly proven wrong, however, that their presentation style had been underestimated and that they could follow the English-speaking presenters perfectly well, in spite of having to deal with a variety of dialects and that they could follow the English-speaking presents perfectly well, in spite of having to deal with a variety of dialects.

A principal goal of this and hopefully all following Short Courses on African Metallogeny has been and will remain the provision of a platform for further training of young geologists who have difficulties in obtaining such training in the fields of ore deposit research and exploration due to financial or logistic constraints.

Thanks to our local sponsors in Burkina Faso, Teng Tsuama Geoservices and Volta Resources!
Dr. Morou Francois Ouedraogo (left) is opening the short course in the presence of the Mr. Koala, Executive Secretary of the Chamber of Mines (background left) and Mr Nombre, representative of the Minister of Mines (middle) and Prof. Frimmel, course coordinator (right).

Mr. Salif Kaboré, the Minister of Mines, Carriers and Energy of Burkina Faso in the middle with Dr. Morou Francois Ouedraogo (to his left), surrounded by the lecturers and TTG staff in front of the TTG training centre.

Lenka Baratoux explains the intricacies of geological structures and their role in mineralization.

An enthusiastic Roberto Xavier explains the principles of hydrothermal ore formation.

Some of the delegates gathering for a “family” photo around Mr. Koala, Executive Secretary of the Chamber of Mines and Mr. Nombre, representative of the Minister of Mines (middle left).

Peter Williams sharing his vast experience in geophysical exploration in West Africa.

Location of the short course: the Teng Tuuma Geoservices Training Centre in Ouaga 2000.

Morou Francois Ouedraogo provides insights into the regional geology of Burkina Faso.

Delegates trying to solve an orogenic gold exploration exercise.

A happy round of lecturers during coffee break (from left: Nic Beukes, Roberto Xavier, Lenka Baratoux, Marieke van Lichtervelde, Hartwig Frimmel, Pasi Eilu)

Delegates following the old-timers’ tracks in the search for copper near Gaoua.
News from the Baltic Student SGA Chapter

Karolina Kielczyk, Andrzej Lis, Marta So nicka, Friederike Minz, Lisa Andersson

AGH University of Science and Technology, Cracow, Poland
Luleå University of Technology, Sweden

The Faculty of Geology, Geophysics and Environmental Protection of the AGH University of Science and Technology in Cracow, Poland, hosted the SGA Student Conference “Ore deposits” in December 6-9, 2011. The Meeting was organized by the Polish members of the Baltic Students Chapter SGA.

In the meeting participated 17 members: 6 students from Luleå University of Technology in Sweden (Anders Zettergren, Lisa Andersson, Evelina Eriksson, Sanna Naasilavaara, Andreas Karlsson, Friederike Minz), one student from University of Turku in Finland (Mira Valkama) and 9 students of the AGH University of Science and Technology in Poland (Marta Soń nicka, Władysław Żygo, Ireneusz Król, Karolina Kielczyk, Andrzej Lis, Gabriela Kowal, Tomasz Cwir tniarnia, Arkadiusz Piotrowski, Małgorzata Zawadzka, Agnieszka Bagnicka).

The Baltic Student Chapter Meeting included field trips to underground mines (pre-session field trip to Polish Kupferschiefer Cu-Ag mine and post-session field trip to MVT Zn-Pb mine), presentations of the SGA Scientific Session, celebration of the Miner’s Day at the AGH University of Science and Technology and Cracow city sightseeing.

On the first day, all participants visited the underground copper mine in Polkowice-Sieroszowice, exploiting copper ores from Polish Cu-Ag (copper shale) deposit. It is one of the largest deposits of copper in Europe. The ore deposit is located in south-western Poland, and covers an area of around 467.6 km². Mining operations are currently carried out at a depth between 0.6 and 1.38 km. The ore body is related to a formation of Permian rocks inclined towards the north-east. The ore contains around 2% of Cu and significant amounts of silver. In addition, salt rocks are extracted from the Zechstein beds located above the Kupferschiefer horizon. The room-and-pillar mining system is the applied mining method. During a four-hour tour, students saw the copper exploitation front and also the chamber in overlaying huge salt beds.

The Student Scientific Session took place at the AGH University of Science and Technology in Cracow on the 8th of December 2011. The official language of the SGA Session was English. Different aspects of ore deposits from Finland, Ukraine, Mongolia, Laos, Kosovo, Botswana and Poland were covered in the presentations given by the students. All presentations were evaluated by scientific committee of: Prof. Adam Pięt zryński, Dr Eng. Jadwiga Pierszanka and Dr Hab. Jarosława Piek; the committee awarded the best presentations among PhD students: Tomasz Cwirt niarnia and Mira Valkama and among Master students: Małgorzata Zawadzka, Anders Zettergren and Arkadiusz Piotrowski. After SGA Scientific Session the Meeting participants listened to the planar lecture given by Prof. Adam Pięt zryński about the genesis of Polish Kupferschiefer Cu-Ag deposit. After the presentation, the SGA BSC’s future was discussed and the new council was elected.

The 2012 Council of the Baltic Student Chapter SGA consists of: the President of the Chapter: Marta Soń nicka (Poland), the Secretary: Evelina Eriksson (Sweden), the Treasurer: Mira Valkama (Finland) and the Webmaster: Tomasz Cwirt niarnia (Poland). In the evening Polish and international participants enjoyed student night-life in Cracow during the ice-breaker party.

On the 9th of December participants visited the MVT Zn-Pb deposit in Olkusz-Pomorzany underground mine. The tour was guided in English by the main geologist Włodzimierz Cieśl. The initial mining reserves were estimated at about 70 Mt grading 4.6% Zn and 1.9% Pb. Current annual production of the Pomorzany mine reaches 2.17 Mt of ore grading 4.99% Zn and 1.73% Pb. The milling and concentrat ing facilities at the Olkusz-Pomorzany mine have a capacity of about 10,400 t/day. Economic Zn-Pb ores in Upper Silesia district are hosted by dolomites of the Muschelkalk (middle Triassic). It is estimated that 95% of the ore produced in the Silesia district is hosted by the 35-70 m thick ore-bearing dolomite. The lens-shaped ore bodies reach locally up to 25 m of thickness. The ore is composed mainly of fine grained, banded or colloform sphalerite, galena, marcasite and pyrite. Zn-Pb ores are also rich in the following elements: Ag, Cd, Ge, Ga and TI.

Back to Cracow, the participants attended the Miner’s Day, called “Barbara”. The event has been celebrated by Polish miners since the end of the 19th century. The program of the celebrations at the AGH University of Science and Technology usually includes a holy mass, an official meeting, the “jumping over an apron” – a tradition that symbolizes that mining “apprentices” or “foxes” are admitted to the Miners’ community. The celebrations were accompanied by the miners orchestra.

Interesting and informative days in Poland where achieved during this meeting, and a special thanks are directed to all the people who helped arranging this successful event.
The first “Ophiolites and Related Ore and Industrial Minerals” workshop was held in Trabzon, Turkey during May 16th to 22nd. It was honored by 6 invited speakers and about 70 scientists from fourteen different countries that presented new data and updated knowledge on ophiolites mainly from Turkey but also from other important ultramafic complexes in the world such as Iran, Canada, Scotland, Portugal, Russia, Italy, Austria, Japan and Dominican Republic.

After opening ceremony the meeting was started by introducing the Society for Geology Applied to Mineral Deposits (SGA) in a 30 min. presentation given by J. Pasava (SGA Executive Secretary). SGA was co-organizer of this important international geoevent.

The meeting was a fruitful environment for the discussion of ideas and future cooperation projects, and also enabled friends and colleagues that share a passion for ophiolitic rocks to enjoy generous hospitality of the Karadeniz Technical University and to meet its fantastic facilities. The workshop has been sponsored by 10 different companies: Koza Gold, TPAO, Pozitif Sondaj, Matel, Akmetal, Eti Bakır A.Ş., TürkMag, Vommak, Kürfez Restaurant and Doğuş Çay. They all deserve great thanks of the local organizing committee.

The organization from the Karadeniz Technical University, the Society for Geology Applied to Mineral Deposits and International Mineralogical Association was highly appreciated by all participants. In addition to a social trip to Batumi (Georgia), two field trips were organized after the 2 days of scientific sessions which was also an opportunity to view the astonishing Turkish geology:

1. Chromite and magnesite deposits at Aşkale, Erzurum (NE Turkey): Different types of mostly Cr-rich chromitites, with more than 12 million tons of reserve, including massive, disseminated and banded textures are present in the Kop ophiolites which extend from Erzincan to Erzurum in NE Turkey and consist mainly of highly serpentinitized harzburgite and limited dunite and lherzolite. The chromitites have low total platinum group element (PGE) concentrations (up to 600 ppb). In the same region, magnesites, with an estimated reserve of 8 million tons, is also widely exposed within the ultramafic rocks consisting predominantly of serpentinitized harzburgite. Magnesites are exposed along NE-SW trending normal faults in the ultramafic rocks and occur either as sediment or infill of vein-type fractures.

2. Volcanogenic Massive Sulphide deposit at Küre, Kastamonu (North Turkey): Production of copper and pyrite concentrate at Eti Copper Kastamonu Küre facilities are realized with an annual capacity of 1,000,000 tons of ore, resulting in 90,000 tons copper concentrate and 400,000 tons pyrite concentrate from the 3 open and 1 underground mines.
Participants of the workshop having tea, sponsored by Dogusway

Participants of the workshop in front of the Congress centre in the University campus

Participants of the workshop in front of the Congress centre in the University campus
The audience during the workshop

Magnesite outcrops at Askale, Erzurum (north-east Turkey)

R. Taylor, James Cook University, Townsville, QLD, Australia

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