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Convenors

Gregor Borg
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Carbonate-Hosted Zn-Pb Mineralization at Topla (Slovenia): Inorganic and Organic Geochemical Constraints

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The small Topla Zn-Pb deposit (250 tones ore, 4.9% Zn and 1.6% Pb, mined between 1974 and 1988) is located in the Northern Karavanke mountains, Slovenia (extension of the Drau Zug, Austria). This deposit forms part of the metallogenic province in the Triassic carbonates of the Alps with several Mississippi Valley-type (MVT) Pb-Zn deposits (e.g., Bleiberg-Kreuth, Mezica, Raibl). At Topla three stratiform orebodies (Old, Eastern, and Western orebody) with quite irregular outlines (250 m long, 20 to 50 m wide, 1.5 to 7 m thick) were formed within Anisian intra- and supratidal micritic to sparitic dolostones. The orebodies had undergone intense hydrothermal alteration recorded in nine recrystallization and remobilization stages. Topla is thought to be different from 'Alpine type' MVT deposits. The morphological, textural and sulfur isotope data suggest a syngenetic origin for this deposit. Combined inorganic and organic geochemical data from the host carbonates, including mineralized and barren samples help gain a better understanding of the genesis and alteration of the Topla deposit. To this effect we chose eighteen samples from the Western orebody, which shows particularly extensive preserved sinesedimentary and early diagenetic textures. The carbonates display a narrow isotopic covariation (1.1 to 2.8‰ $\delta^{13}\text{C}$, -9.1 to -3.4‰ PDB $\delta^{18}\text{O}$), which is consistent with prolonged and multiple temperature-dependent alteration of the host carbonates. The uniform REE patterns and negative chondrite-normalized Eu and Ce anomalies of barren and mineralized samples, combined with the increased REE content in mineralized samples (2.5 to 173.2 ppm ΣREE), evidence for host rock interaction with a local formation fluid. The organic geochemical data provide further insights into the minerogenetic processes. The hydrocarbons staining the rock samples (0.11 to 0.41 wt.% TOC) have been chemically characterized by GC/MS and were subjected to carbon isotope analysis by GC/C/IRMS. Furthermore, $\delta^{13}\text{C}$ was measured on the extractable organic matter (EOM) and the associated kerogens. The extracts from the samples are depleted (up to 5.5‰) or enriched in ^{13}C (up to 1.1‰) compared to the associated kerogens. This is evidence that the host rocks were stained by hydrocarbons produced from indigenous kerogen. The $\delta^{13}\text{C}$ values of the kerogen range between -29.4 and -26.2‰, suggesting that a variety of biomass and reducing conditions existed in the shallow-water depositional environment of Anisian age. The small variability in the $\delta^{13}\text{C}$ values of the individual *n*-alkanes (-30.8 to -26.7‰) and isoprenoids (-31.1 to -28.7‰) record fractionation during local migration/remobilization of the mobile hydrocarbons. The organic and inorganic geochemical data, combined with the morphological and textural characteristics suggest that Topla is a SEDEX deposit.

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Fluid Properties and Geochemical Patterns in the SHMS Deposits Rosh Pinah and Tsongoari, Namibia

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The Pan-African Kaoko and Gariep Belts of the Damara Orogen of Namibia, host numerous sediment- to volcanic-hosted, partly massive sulphide deposits, which have been formed during basin subsidence. Continental collision and peak metamorphism took place around 545 Ma (Frimmel and Frank, 1998). The objects of investigation, the Zn-Pb-Cu-Ag-Ba and Pb-Zn-Cu-Ba deposits Rosh Pinah and Tsongoari (TG) respectively, occur marginally to the main depositional basins. Fluid inclusion data (Gauert et al., 2000), measured in gangue quartz and sphalerite from the Rosh Pinah Mine, show overall homogenisation temperatures (T_h) between 160 to 180°C and melting temperatures at $T_m = -1$ to -3°C. A second assemblage at T_h 290-300°C

with T_m of 9-11°C for clathrate hydrate inclusions has been measured. Inclusions in dolomite, which have been trapped by ore, have T_h 's of 110°C and $T_m = -1$ to -3°C. Various generations of diagenetically formed dolomite, calcite, quartz, apatite and K-feldspar were distinguished by characteristic luminescence colours. The Tsongoari Pb-Zn-Cu-Ba deposits, are located 43 km NNW of Sesfontein in Kaokoland, northwestern Namibia (Henry & Bentley, 1994). The mineralisation is hosted by metasedimentary rocks of the Ugab Subgroup within the Upper Proterozoic Damara Sequence which have been metamorphosed to upper greenschist facies grade. More centrally situated base metal deposits grading outwards into pronounced Fe-Mn exhalites and haloes reveal a crude lateral zonation. A vertical zonation of Cu-Pb-Zn-Ba-Mn-Fe reflects cyclic exhalative activity (Henry & Bentley, 1994). FI's in gangue quartz and barite have T_h 's between 110 and 170°C with T_m 's of -5 to 8°C. FI's with positive melting temperatures imply the presence of gas clathrates. There is also a wide range in temperatures, however at low salinities. A group of inclusions in dolomite reveals distinctly elevated T_h 's between 230 to 260°C. However, both ore and alteration mineral assemblages at TG are diverse. As gangue minerals quartz, epidote, albite and Ba-bearing alkali-feldspar as well as higher amounts of barite and fluorite, have been identified mainly along cleavage planes and veins. Only subordinate amounts of carbonate occur. Whole rock geochemical data reveal a vertical and lateral zonation pattern across the gossan of the Tsongoari west to north line and in the surrounding country rocks supporting Henry & Bentley's (1994) model of cyclic exhalative activity. The fluid data so far obtained, indicate F-rich and CO_2 -poor fluids as potential mineralisers at Tsongoari compared to the more CO_2 -rich ore-forming fluids at Rosh Pinah. Characteristically, the base metal mineralising event also led to the formation of larger amounts of barite and fluorite. The temperature of the overprinting metamorphic fluids however seems to be similar in both places. Also, in each deposit, the metamorphic overprint makes the identification of ore forming fluids more complicated.

Frimmel HE & Frank W, *Precambrian Research*, **90**, 1-28, (1998).Gauert C, Wolfgramm M & Borg G, *GSA19-conference abstracts*, *J. Afr. Earth Sc. Spec. Issue*, **30(7)**, 35, (2000).Henry G & Bentley PN, *Prot. Crust. Metall. Evol. Conf.*, *WDH*, 27, (1994).

OS06 : TUpm27 : G5

Tectonic Framework and Geochronology of the Imiter Silver Deposit (Morocco): Ion Microprobe U/Pb and $^{40}\text{Ar}/^{39}\text{Ar}$ ResultsGilles Levesse (levresse@crpg.cnrs-nancy.fr)¹,Alain Cheilletz (cheillet@crpg.cnrs-nancy.fr)¹,Dominique Gasquet (gasquet@crpg.cnrs-nancy.fr)¹,

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The Imiter Ag (Hg-Pb-Zn) deposit (eastern Anti-Atlas, Morocco) is hosted by Neoproterozoic sedimentary (PII) and volcanic (PIII) series. These series and the mineralisation are unconformably overlain by a paleozoic sedimentary pile. The genetic model of this major Ag vein-type deposit (annual production ca. 400 t silver/yr) is actually highly debated (e.g. Leistel and Qadrouci, 1991; Barodi et al., 1998; Baroudi et al., 1999). The mineralized vein-system occupies the 5 km-long EW Imiter fault zone (Ouguir et al., 1994) in which the Ag (Hg-Pb-Zn) veins display mainly quartz (stage 1) and dolomite (stage 2) filling. New structural data demonstrate two tectonic patterns originating the opening of the two successive mineralised stages. The first one corresponds to a N150°E-N180°E extensional regime followed by a second slight sinistral transcurrent regime along the same EW fault zone developing a secondary N40°E-N60°E fault system. Rhyolitic volcanism controlled by the NS extensional regime and the NNE-SSW opening appears spatially associated with the Ag mineralisation. SIMS (CAMECA(r) IMS 1270, CRPG, Nancy) U/Pb ages on zircons from the rhyolitic episode yield concordant ages of eruption at 550 ± 2 Ma (Tachatert protrusion) and 545 ± 4 Ma (Tachkakacht dyke). These ages are consistent with the 557 ± 9 Ma $^{40}\text{Ar}/^{39}\text{Ar}$ plateau age obtained on phyllites from the

Ag-bearing quartz-carbonate veins allowing precise dating of the coeval tectonic, eruptive and mineralising event at the end of Neoproterozoic times. This event postdates the calc-alkaline intrusives emplacement yielding SIMS U/Pb zircon ages at 572 ± 5 Ma (Taouzzakt granodiorite). Barren hydrothermal assemblages (chlorite-phengite-quartz) from hornfels related to these earlier intrusives (B3 hill) display $^{40}\text{Ar}/^{39}\text{Ar}$ phyllite ages at 567 ± 8 Ma. In conclusion, the Ag (Hg-Pb-Zn) Imiter deposit is likely interpreted as a high-sulfur epithermal system related to normal faulting and extension

Barodi EB & al., *Chron. Rech. Min.*, **531-532**, 77-92, (1998).Baroudi Z & al., *Chron. Rech. Min.*, **536-537**, 91-111, (1999).Leistel JM & Qadrouci A, *Chron. Rech. Min.*, **502**, 5-22, (1991).Ouguir H & al., *Bull. Soc. Géol. Fr.*, **165**, 233-248, (1994).

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Geochemistry of Fossil Hydrothermal Vents of the Idrija Mercury Deposit, Slovenia: Insights from $\delta^{13}\text{C}$, $\delta^{18}\text{O}$, $\delta^{34}\text{S}$ and Organic Geochemical Data

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The Idrija mercury deposit in Western Slovenia is associated with the Middle Triassic aborted rifting and volcanism. Hydrothermal fluids following subvertical normal faults produced multiple mineralization stages. Carbonate, clastic and pyroclastic rocks of Carboniferous to Ladinian age host the mineralization. Cinnabar is the main ore mineral accompanied by pyrite, metacinnabar and native mercury. Eighty-six samples of host and gangue carbonates were taken along profiles parallel and across bedding in the Upper Permian dolomite (n=46), Lower Scythian dolomite (n=19) and other mineralized lithologies (n=21). Samples include host dolomite and fracture filling white sparry dolomite and calcite. C and O isotope analyses of these carbonates and S isotope analyses of the ore sulfides provide important insight into the relationship between the different generations of mineralization and associated carbonate alteration. Host carbonates vary between -1.0 to +5.6‰ $\delta^{13}\text{C}$ and -9.7 to +4.8‰ $\delta^{18}\text{O}$ (PDB scale), those of fracture filling carbonates between -0.3 to +4.4‰ $\delta^{13}\text{C}$ and -11.2 to -4.9‰ $\delta^{18}\text{O}$. The depletion in ^{18}O (up to 3.0‰) of mineralized samples compared to barren samples reflects the hydrothermal alteration of the carbonates during mineralization. $\delta^{34}\text{S}$ values for cinnabar (n=25) range between -0.88 and +9.10‰, for pyrite and marcasite (n=34) between -15.64 and +18.68‰. Two gypsum samples from Permian lithology (+12.31 and +16.36‰) lie in the range of Permian marine sulfates. The broad range and multiple-modal distribution of the $\delta^{34}\text{S}$ values of the ore sulfides point to at least two different sulfur sources (magmatic, marine). The Rock Eval parameters of the host rocks (0.11 to 1.42 wt.% TOC), indicate that the organic matter associated with the mineralization is post-mature ($S_1 \sim 0.03$ wt.%, $S_2 \sim 0.41$ wt.%). Results of a preliminary geochemical study of the polycyclic aromatic hydrocarbons (PAH) mineral (*idrialite*) and bitumen associated with ore samples indicate that Idrija host rocks are stained by hydrothermal petroleum of typical high temperature PAH assemblages. The uniform $\delta^{13}\text{C}$ values of the individual PAHs suggest a common source, and re-equilibration at elevated temperature. Ongoing detailed investigation of the host carbonates and associated hydrothermal petroleum from barren and mineralized samples, combining inorganic and organic geochemical analyses, will give further insights into the ore fluid sources, the fluid pathway, ore precipitation and remobilization at Idrija.

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Enargite Crystallization in the Massive Sulphide Ores: A Case Study from the Major Chelopech High-Sulphidation Cu-Au Deposit, Bulgaria

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Enargite (+ luzonite) is a principal mineral in the Cu-Au ore deposits of the high-sulphidation type. It is very important both economically, as a significant carrier of Cu, and genetically, as indicator of highly oxidation environment. However, in the massive sulphide ore bodies its specific crystallization mechanism and relationships with the other minerals are not always clear enough. Enargite is a substantial ore component also in the major Chelopech high-sulphidation Cu-Au deposit from the Srednogorie zone of the Alpine-Carpathian-Balkan metallogenic belt. The fine-grained, mineralogically complex Chelopech ores comprise pyrite, chalcopyrite, tennantite, enargite, luzonite, bornite, gold, and numerous subordinate sulphide, telluride, and sulphosalt ore minerals. Chalcedonic quartz, barite, sericite, dickite, etc. are the main gangue minerals.

Enargite, nearly stoichiometric in composition, occurs as crystal grains and also as unique radiate or parallel columnar aggregates, overgrowing clasts of early colloform pyrite, and included in dense pyrite-quartz mass. The prismatic, c-elongated enargite crystals, up to 12 cm long, have been undoubtedly formed by free crystallization in open vugs of intensively fractured zones. The high-resolution TEM study revealed some structural disorder in the layer sequences of enargite. The aperiodically distributed (001) stacking faults with variable density, are considered as growth defects. Enargite contains numerous two-phase fluid inclusions. SEM studies on cleaved surfaces, and IR microscopy in thin platelets, show that inclusions represent {110}+{001} shaped prismatic, platy or irregular negative crystals, usually 1-20 µm in size. Inclusion fluids are characterised by low Th (90-130°C, mean 118°C) and low salinity (~4 equiv.% NaCl). Since enargite, as high-temperature Cu₂AsS₄, is stable above 280-300°C, its direct crystallization is indicative for such T conditions, and the most fluid inclusions are of secondary origin. The mass spectro-metric analyses of the volatile molecular species, released by heating and decrepitation of enargite, established mostly CO₂ and H₂O. The K/Na, Ca/Na and Mg/Na ratios in the fluid, as determined through bulk crush/leach AAS technique, are 0.07, 0.016 and 0.06, respectively.

Fine-grained luzonite surrounds the large enargite crystals and often replaces them. It is suggested that this transformation is a result of increased P during the intensive later tectonic deformations.

Thus, the open space filling plays an important role during the formation of massive sulphide ore bodies, considered usually to be of metasomatic origin.

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Emerald Deposits in Madagascar: Two Different Types for one Mineralising Event

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Detailed field mapping, petrography and geochemical analyses have been used to document the two major areas of emerald deposits in Madagascar, Mananjary (eastern coast) and Ianapera (Tulear province). Two distinct models are proposed, the Mananjary mineralisation being related to pegmatites which are not observed in the Ianapera deposit. The Mananjary deposits are hosted by the archaic Ampasary group. The emerald mineralisation occurs within phlogopite developed at the contact between pegmatite and basic/ultrabasic rocks. The Mananjary district is divided into a north zone (NZ) (Ambodibakoly, Mourarano, Ambodivandrika, Ankeba, Tsaravolo pits) characterised by reaction zones at the contact with serpentinite; and a south zone (SZ) (Morafeno, Ambodibony, Ambatomameno pits) where pegmatites intrude highly folded and boudinaged amphibolites. In NZ, dextral shearing is synchronous with the injection of pegmatitic dykes and metasomatic reaction bands. These are composed in both zones of distinct mineralogical assemblages: tremolite/silicic edenite-phlogopite with Mn dendrite-emerald-spessartite-An60 to 100 plagioclase-quartz in NZ and hornblende-chlorite-phlogopite-emerald-An90 to 100 plagioclase-calcite-quartz in SZ. In this area, later magmatic events associated with molybdenite, wolframite, pyrite display secondary chloritisation of the emerald-bearing metasomatic paragenesis. δ¹⁸O on emerald yield values of 7.6±0.1 per mil (Ambodibakoly), 8.4±0.1 per mil (Mourarano) and 8.7 to 9.2±0.1 per mil (Ambodibony). The Ianapera deposit is hosted by the Vohibory Precambrian volcano-sedimentary sequence. The mineralisation is located on an isoclinal fold flank related to the D2 phase of the NS Ampanihy major shear zone. The emerald mineralisation occurs in reaction zones developed within lenses of serpentinites and amphibolites without pegmatitic bodies. The metasomatic bands are composed by balls-like talc (soapstones) included within tremolite-chlorite (talc-chlorite to pychnochlorite) lenses. Phlogopite-(rare tourmaline)-quartz-emerald veins are randomly scattered within these lenses. Secondary chlorite may be associated with a late stage of deformation as indicated by folded quartz. δ¹⁸O on Ianapera emerald yields 11.8±0.1 per mil and δ¹¹B on tourmaline give values of -8.1 per mil. ⁴⁰Ar/³⁹Ar data on phlogopite indicate ages of 490±8 Ma for Mananjary and 493±5 Ma age for Ianapera relating the Madagascar emerald deposits to the same Pan-African tectono-metamorphic event. Mananjary is clearly linked to pegmatite-basic/ultrabasic reaction zones as in a majority of emerald deposits in the world, whereas geochemical and structural characteristics of Ianapera ties it with metamorphic fluids circulations resulting from the intense granulitisation and devolatilisation of the lower crust during the D2 shearing event dated at 530-500 Ma (Martelat et al., 2000).

Martelat et al, *Precambrian Research*, **102**, 1-20, (2000).

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Canadian Emeralds: The Crown Showing, Southeastern Yukon

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In September, 1998, one of the authors (WW) discovered emeralds on the Goal Net property in the Finlayson Lake district of southeastern Yukon. In less than two hours he collected one kilogram of emeralds from float and outcrop. By late August of the following year numerous emerald-bearing float trains and six main source regions had been discovered in a 900 by 400 m area. Washing and hand sorting of approximately 6 m³ of material yielded more than 6 kg of emerald.

The Goal Net property is located in the Yukon Tanana Terrane, which is composed of Paleozoic metasedimentary and metavolcanic rocks. The emeralds occur where quartz veins cut mica-rich layers in a chlorite-mica schist. At least eight such veins have been found. In most cases the quartz veins are surrounded by a zone of yellow sulfate mineralization and a much more extensive, overlapping mass of fine tourmaline crystals which locally contains minor amounts of scheelite. The emeralds occur in both the sulfate and tourmaline zones and (rarely) in the quartz veins. The quartz veins seem to be genetically linked to a large granitoid pluton east of the emerald mineralization. The pluton is zoned; the outcrop closest to the emerald showing is muscovite granite that grades to a two-mica granite. A U-Pb age determination of ca. 112 Ma has been reported for this pluton.

The emeralds range in size from fractions of a mm to 4 cm in length. Some of the smaller crystals, and sections of larger crystals, are gem-quality, with excellent clarity and colour. Electron microprobe analysis of 25 crystals shows an average Cr concentration of 3208 ppm (maximum 7816 ppm). The mean and maximum V concentrations are 171 and 333 ppm, respectively. The Fe content is variable between relatively narrow limits (0.02 to 0.05 atoms per formula unit).

Investigation of polished mounts revealed an abundance of fluid and solid inclusions. Solid inclusions include calcite, chalcopyrite, molybdenite, phlogopite, pyrite, quartz, scheelite, tourmaline and zircon.

Electron microprobe analyses of tourmaline from the Crown deposit show compositions ranging from schorl to uvite. The presence of tourmaline may be a key to understanding why we do not see high Fe concentrations in the beryls (which would diminish the emerald green colour); under high B activity, tourmaline acts as a sink for Fe, Mg and Mn.

Additional work, including a fluid inclusion study and an O- and H-isotope study of the emeralds, is underway.

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The Panjshir-Afghanistan Emerald Deposits: New Field and Geochemical Evidence for Colombian Style Mineralisation

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The Panjshir emerald deposits are a source of high quality gems (Bowersox et al., 1991) that, in the future, may make this country one of the world's main producers. New field and geochemical data show that their genesis bears a close resemblance to that of the Colombian emerald deposits, formerly thought to be exceptional and unique (Cheilletz et al., 1996). Three different zones, of widespread emerald mineralised layers, are located in the Khendj and adjacent valleys (SE side of Panjshir), the Tawach area (NW side of Panjshir) and Badel in the Kunar Province. The Tawach deposit is related to the intrusion of tourmaline-bearing leucogranite into serpentinite bodies, producing weakly developed classic phlogopite reaction bands containing emerald. The temperature of formation was estimated at 550°C based on muscovite-phengite thermometry. The Khendj deposits are different, being hosted by metamorphic schists and plutonic rocks that have been subjected to an intense hydrothermal alteration. The altered zones are irregularly scattered along a fracture network and characterised by the development of albite, muscovite, biotite, tourmaline and pyrite. The estimated temperature of formation is between 220°C and 350°C (Giuliani et al. 1997). Crush-leach analysis and microthermometry of fluid inclusions in emeralds show the fluids to be highly saline (Cl = 203500 ppm, Na = 73300 ppm, K = 19300 ppm). Moreover the $\delta^{37}\text{Cl}$ (-0.32 per mil) and Br/Cl values ($4.64 \cdot 10^{-4}$) indicate that the high salinity was due to halite dissolution. $\delta^{31}\text{B}$ values, from ion-microprobe analysis of tourmaline, are between -3.3 and +5.3 per mil, similar to those from the Salton Sea, which are interpreted to arise from a non-marine evaporite source. $\delta^{34}\text{S}$ values, between +11 and +13 per mil, indicate an evaporite source of sulphate and are within the range of values reported for pyrite, $\delta^{34}\text{S}$ between +10.8 and +21.2 per mil, from the Colombian emerald deposits (Giuliani et al., 1995). Analysis of emeralds, by infrared spectroscopy and SEM, indicate the presence of natural organic compounds and graphite inclusions that are linked with thermochemical reduction of sulphate by organic matter. The SE Panjshir emerald deposits, like those in Colombia, are linked with hydrothermal fluids that derived their high salinity from leaching of evaporite sequences. In the Panjshir deposits, the introduction of hydrothermal fluids, within the medium grade wall-rocks series, was probably the result of tectonism that preceded uplift during the Himalayan orogeny.

Bowersox et al, *Gems and Gemology*, **Spring**, 26-39, (1991).
 Cheilletz et al, *Mineralium Deposita*, **31**, 359-364, (1996).

Giuliani et al, *International Geology Review*, **39**, 400-424, (1997).

Giuliani et al, *European Journal of Mineralogy*, **7**, 151-165, (1995).

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The Geology & Genesis of the 'Kandemwa' Emerald Deposit in Zimbabwe, Africa

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Introduction:

The Kandemwa emerald deposit is located about 25 km to the south-west of the village of Odzi in the eastern part of Zimbabwe. The Kandemwa area is a hill-shaped area in the southern extension of Odzi-Mutare Greenstone Belt. The general geology of the study area is composed of Shamvaian granitoids and pegmatites of the Wdeza- and Chilimanzi Suite (2.65-2.57 Ga). The fault bounded emerald bearing pegmatite is located in a greenstone lenses (size 500x200 m) which is intruded in Wdeza Suite

Gneisses. The pegmatite contains a central zone of feldspar and a quartz-feldspar paragenesis. The marginal zone of pegmatite consists of massive mica which is between 30-70 cm wide. The emerald ($\text{Be}_3\text{Al}_2(\text{SiO}_3)_6$) occurs along the contact zone between the mica zone and the feldspar zone.

Emeralds deposits

There are three types of formation of emeralds. 1. Intrusion of emerald bearing pegmatitic fluids in metasediments or metavolcanics with the growth of emeralds during a metasomatism in the contact zone (Grundmann and Morteani, 1989) (e.g. Habachtal, Austria). 2. Carbonatisation of serpentinized ultramafic protoliths in quartz-carbonate rocks (Arif, Fallick and Moon, 1996) (e.g. Pakistan). 3. Intrusion of emerald bearing pegmatitic fluids in chlorite-tremolite-magnetite schists with a biotite-phlogopite contact zone (Emerald Mine Investment Group, 1998) (e.g. Zambia).

Methods

Results from field work and from investigations by several analytical methods have led to the following results: *Cathodoluminescence*: several zoned emeralds and a fenitisation of feldspars during an alkaline metasomatism, *SEM*: diopside-olivine ultramafite with clouds of chromite, sodium dominated feldspars, *Fluid inclusion studies*: sodium-calcium dominated fluid system with temperatures of 200-300°C of quartz and emeralds, temperature increasing during emerald growing, *Thin section*: unstable pressure conditions as derived from deformation textures, temperatures of 300-550°C as derived from secondary alteration assemblages.

Discussion & Conclusions

The principles of emerald formation are similar in most types of deposits. It necessitates a chromium and beryllium source and the interaction between both. Difference between the formation type lies in the composition of the interacting rocks. The occurrence of pegmatite fluids implies that the Kandemwa emerald deposit is of the third type of known deposits. On basis of the data gained so far, the following genetic model is suggested: Granitoid magma intruded in local country rocks including an ultramafic xenolith. Pegmatitic fluids migrated along faults through the ultramafic body. Temperature and pressure increased through serpentinization of ultramafics. Contact metamorphism and alkaline metasomatism of immediate wallrocks followed. Source of beryllium are pegmatitic fluids, source of chromium are olivine in ultramafic rocks. Subsequently Be-bearing fluids entered the system and crystallized in the contact zone between the ultramafic rocks and the pegmatite. For further works, it would be interesting to check the surrounding ultramafic lenses for emerald occurrences.

OS06 : TUpm36 : G5

The Role of Biotite Dehydration Melting in the Formation of the Uranium Deposit Rozná, Moldanubian Zone, Bohemian Massif

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Several of the world's uranium deposits are granite-related, e.g. Rössing in Namibia; Aue-Oberschlema in Germany; Huangou in China. The common features of all deposits are relations to the S-type granites, and long interval elapsed between granite intrusion and final forming of the ore. The source of uranium is traced in the metasedimentary protoliths of the fertile granite.

The source of U in the Rozna uranium deposit is traced in the neighboring Moldanubian biotite-bearing paragneisses as well. Uranium and Th contents in these gneisses vary between 3 - 12 ppm, and 7 and 12 ppm respectively. Nevertheless, granites are rare in the close vicinity of the mined area, and the mineralization occurs in veins, tectonic zones or metasomatic bodies located mainly in the gneisses. The granites found in the Rozná deposit are garnet bearing, and very felsic. The internal fabrics of the feldspars indicate their crystallization from a melt. The granites were located in two different structural positions. They form (1) concordant layers in the paragneisses and amphibolites (several-meter-thick). The zones of

migmatites are often developed at the contact between gneiss and granite. The breakdown of the primary biotite accompanied by formation of the granitic melt and restitic garnet was observed in the vicinity of the granite layer. Some granite (2) have a true intrusion character. They exhibit discordant, sharp contacts to the host paragneisses, the zone with migmatites is not developed. The intrusive granites indicate that the granitic melt generating during the dehydration melting of biotite-bearing gneisses was separated from garnet-rich restite. The uranium content in the both types is highly variable (3 - 37 ppm), Th is moderate (3 - 17 ppm). The granites are strongly depleted in Al, Fe, Mg, Ca, Ti, P, Sc, Co, Cs, Hf, Nb, Sr, Ta, V, Zr, H₂O and light REE, but enriched in Si, K, Rb and heavy REE, chiefly Er, Tm, Yb, and Lu if compared with parental gneisses. The amphibolites intercalations were not affected by the melting processes. The observed melting in the biotite-bearing lithologies with restitic garnet but unaffected associated amphibolites allow us to estimate the p,t conditions of the granite generation such as p > 4 kba and T < 850°C. The geochemical data indicate the high mobility of U in the partial melting processes of the biotite bearing rocks and corroborate therelation of these processes in the formation of the Rozná deposit.

OS06 : TUpm37 : G5

The Vredefort Impact Event and Distribution of Gold in the Central Rand Group of the Witwatersrand Basin, South Africa

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The Witwatersrand gold deposit of South Africa is the largest known accumulation of gold ever to have formed on Earth. The gold is confined to certain conglomerate units in a series of Archaean alluvial fans and braid-plain deposits which formed within the Witwatersrand Basin between 2910 and 2700 Ma. This siliclastic-dominated sequence, the Central Rand Group (CRG), has experienced repeated episodes of regional metamorphism through burial by overlying extrusive and sedimentary sequences, the intrusion of the Bushveld Igneous Complex and finally, a bolide impact now preserved as the deeply-eroded Vredefort Impact Structure (VIS). Geochronological studies have established dates and causes of these metamorphic events, but the affect that each event had on gold distribution is not known. Despite over a century of exploitation and study, the origin of the gold remains controversial.

The new data presented here represents initial results from a basin-wide study which aims to establish which of the regional metamorphic events may have contributed to the current distribution of gold. Optical and cathodoluminescence (CL) petrography and mineral chemical analysis by electron probe microanalysis (EPMA) have been applied to samples from auriferous units of the Evander, West Wits, Welkom goldfields and a new prospect in the Vredefort Collar.

Local events, and others whose effects are visible throughout the CRG are identifiable in the goldfields. Most striking of the regional events is brittle deformation of sulphides, chromite (sometimes also zircon and chloritoid) which occurs throughout the preserved geographic and stratigraphic extent of the CRG. Pyrite (both detrital and hydrothermal), arsenopyrite and chromite are shattered into irregular fragments. Close to the VIS, detrital zircons are shattered or pulverised. The only known event capable of causing this shock deformation throughout the CRG is the Vredefort Impact of 2025 Ma.

Many associations of gold have been reported from the Witwatersrand Basin. Evidence for polyphase mobilisation of gold within the basin argues strongly against late introduction of gold into the basin by hydrothermal fluids. In all goldfields sampled, gold is present between the shattered fragments of sulphide and, less frequently, silicate grains. This indicates that a major episode of gold remobilisation and redeposition occurred during metamorphism and fluid movement which followed the Vredefort impact. CL has demonstrated the presence of widespread fracturing in quartz clasts in conglomerates and quartzite units. The relative timing of this deformation is currently being investigated, and is of importance since much of the fracturing is at high angle to bedding and may have facilitated significant fluid transport across stratigraphic boundaries.

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- Barnicoat AC, Henserson IHC, Knipe RJ, Yardley BWD, Napier RW, Fox NPC, Kenyon AK, Muntingh DJ, Strydom D, Winkler KS, Lawrence SR & Cornford C, *Nature*, **386**, 820-824, (1997).
- Frimmel HE, *Terra Nova*, **9**, 192-197, (1997).
- Gibson RL, Armstrong RA & Reimold WU, *Geochimica et Cosmochimica Acta*, **61**, 1531-1540, (1997).
- Phillips GN, Law JDM & Meyers RE, *South African Journal of Geology*, **93**, 54-69, (1990).
- Phillips NG & Law JDM, *Ore Geology Reviews*, **9**, 1-31, (1994).
- Robb LJ, Charlesworth EG, Drennan GR, Gibson RL & Tongu EL, *Australian Journal of Earth Sciences*, **44**, 353-371, (1997).

OS06 : TUpm38 : G5
Phosphate Minerals of Some Granitic Rocks and Central Quartz Veins from Northern and Central Portugal

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Phosphate minerals are common in northern and central Portuguese granitic rocks. They occur in granites, aplites, granitic pegmatites and associated quartz veins from five selected Portuguese localities (Neiva et al., 2000). The granitic rocks are of S-type and Hercynian in age.

Triphylite is the only primary phosphate known from only two localities with quite different values of Fe/Mn (1.90 ± 0.09 and 13.16 ± 0.82). At Paredes da Beira, it occurs in a muscovite granite, while at Vidago it was found in aplite veins. Inferences concerning temperatures of formation are not feasible, as the different degrees of Fe-Mn fractionation could be rooted in the bulk chemistry of the parent rocks. Triphylite is altered to strengite in the muscovite granite at Paredes da Beira, and to manganian vivianite, blue ludlamite, phosphoferrite and mitridatite in aplite veins at Vidago.

Triphylite is rimmed by manganian vivianite, which is pleochroic from blue to brownish. The structural identity with vivianite was confirmed by X-ray diffraction study. It must have lost a part of its water content during the electron microprobe analyses.

Other triphylite crystals are rimmed by blue ludlamite. Phosphoferrite occurs in irregular crystals and has a similar value of the Fe/(Fe+Mn+Mg) ratio to that of blue ludlamite. Green ludlamite lacking direct relationship to triphylite has lower Mg, Mg+Mn and higher Fe/Mn, Fe/Mg and Fe/(Fe+Mn+Mg) than blue ludlamite.

Childrenite, eosphorite and intermediate compositions in this solid-solution series occur in muscovite granites at Paredes da Beira and Penamacor-Monsanto, muscovite-biotite granites at Penamacor-Monsanto and in aplite veins at Vidago. The compositions of childrenite and eosphorite are similar in each of these localities. At Vidago, eosphorite is locally rimmed by brushite. Perloffite was also found at Vidago. Gormanite occurs in a muscovite granite at Segura. The absence of any potential primary phase at Penamacor-Monsanto and Segura avoids to find out the conditions of formation of these secondary phosphates.

Oxidation of arsenopyrite and galena were essential for the formation of mimetite with As/P ratio of 1.04 and a kintoreite-like phase which occur in quartz veins at Segura, but the source of phosphorus is unknown.

Montebrasite and natromontebrasite were found in Li-aplite-pegmatite veins from Gonçalo and Segura. The range of composition at Gonçalo is larger than at Segura. There is a complete solid solution between these primary montebrasite and natromontebrasite.

Neiva AMR, Silva MMVG, Antunes IMHR & Ramos JMF, *J. Czech Geol. Soc.*, **4**, 1-9, (2000).

OS06 : WEam01 : G5
Diagenesis and Subsequent Regional Metamorphism and Deformation at Bamsar Skarn Tungsten-Tin Occurrence in Central Iran

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Bamsar tungsten-tin occurrence is located 45 km southwest of Shazand, central Iran in Sanandaj-Sirjan Zone. Paleozoic and Triassic volcano-sedimentary rocks and Upper Triassic-Jurassic detrital-chemical and volcanic units outcrop in the region. Upper Triassic-Jurassic rocks consist of phyllites, micascists, quartzites, metamorphosed cherty limestones and metamorphic acidic and basic tuffs. The intrusives in the region have granitic and granodioritic compositions which have caused metamorphic haloes in the Upper Triassic-Jurassic units.

Six ore-bearing skarn horizons have been identified in the area. Country rocks at Bamsar are mainly calcareous actinolite-tremolite-diopside-quartz schists (meta volcano-sedimentary) in which ore minerals occur in fine-grained laminae (metamorphosed acidic tuffs) and coarse-grained garnet-bearing diagenetic veins and layers.

The geometry of ore body is layered (stratiform) and vein-type (cross-cutting). The veins formed within the lenses congruent with layering (stratabound). In the fine-grained laminae and coarse-grained garnet-bearing layers, ore is laminar and disseminated, respectively. Ore paragenesis is similar in both coarse-grained garnet-bearing layers and veins. It includes scheelite, chalcopyrite, arsenopyrite, sphalerite, pyrite, cassiterite, chalcocite and covellite. The gangue minerals are quartz, calcite, garnet, diopside, actinolite and clinzoisite. The ore paragenesis in laminae includes arsenopyrite, pyrite, cassiterite, chalcopyrite and sphalerite. The gangue minerals are quartz, tremolite, sphene and chlorite. Ore minerals in garnet-bearing veins are coarser than those in garnet-bearing layers and laminae.

Bamsar ore-bearing samples have identical chondrite-normalized REE patterns when compared with those of the metamorphic rocks in the region. Following the findings of (Ghaderi et al., 1999) on scheelites from Western Australian gold deposits, Bamsar scheelites exhibit derivation from a reduced fluid with moderate Na activity. Fluid inclusion studies reveal that only one fluid was responsible for the mineralization, with a temperature of homogenization at 350-400°C and salinity of 12-20 wt.% NaCl equivalent.

On the basis of geological, textural, mineralogical, geochemical and fluid inclusion studies, it is suggested that Bamsar tungsten-tin occurrence is sedimentary-diagenetic in origin, subsequent concentration happening through Late Kimmerian regional metamorphism and deformation.

Ghaderi M, Palin JM, Campbell IH & Sylvester PJ, *Econ. Geol.*, **94**, 423-437, (1999).

OS06 : WEam02 : G5
Cr, Ni, PGE and Au Geochemistry of Kizildag Ophiolites (Middle Anatolia)

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The Kizildag Ophiolites belonging to the Refahiye Ophiolitic Melange are generally consist of wherlite of transition zone, gabbros of mafic cumulate sequence and pyroxene gabbros, hornblende gabbros, microgabbro intrusions, meta basalts and spilitic basalts. The ophiolitic complex is cut by Neogene magmatics, represented by aplite veins, granite, quartz monzonite and diorite as well as volcanic products such as andezite and basalt. Ni enrichment, up to 4630 ppm took place within the ophiolite bodies. Ore microscopy studies have revealed that the source of Ni is limonite, bravogite, gersdorffite, millerite, heazlewoodite and pentlandite minerals. This study reveals that Ni occurring at 0.2 to 0.3% in primary ultramafic rocks show enrichments up to 0.46%. It is believed here that, by investigating more detailed and direct methods, economical nickel deposits may be found. The ultramafic rocks in the investigation area shows differences about Pt group elements. Os and Ru shows enrichment, Ir, Rh and Pt

shows depletion, Pd shows both effects but with few changes. Au, which treat geochemically with Pt group elements, shows generally enrichment with few amounts.

KEYWORDS: Sivas - Kizildag Ophiolites, Ni - PGE - Au Geochemistry

- Brugmann GE, Arndt NT, Hoffmann AW & Tobschall HJ, 1987, *Geochim. Cosmochim. Acta*, **51**, 2159-2169
- Clark AMS, 1978, *Mineralum Deposita*, **13/2**, 221-234
- Clark AL, Greenwood WR, 1972, *U. S. Geological Survey, Pr.P.800*, C21-C27
- Coleman RG, 1977, *Minerals and Rocks*, **12**
- Coleman RG, Keith TE, 1971, *Journal of Petrology*, **12**, 331-328
- Moores EM, 1973, *Earth Science Rev*, 241-258

OS06 : WEam03 : G5
Deep Exhumation and Tectonic Emplacement of the Nishni Tagil Ultramafic Complex and its Platinum Ores, Urals, Russia

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The emplacement of the zoned ultramafic complexes of the Palaeozoic Uralide Orogen has been the subject of scientific debate for a long time. The lensoid complexes occur as an intermittent N-S chain within the Middle and Northern Urals. Economically significant platinum ore bodies and sub-economic mineralisation are associated with this ultramafic 'Pt-bearing belt' of the Urals. The belt is hosted by the Tagil-Magnitogorsk zone, comprising predominantly mafic and intermediate igneous rocks, formed in an island arc setting. Virtually all ultramafic complexes are situated immediately east of the Main Uralian Fault zone and thus structurally above the suture zone between the East-European and West-Siberian plates. Os-isotope studies of both ultramafic (dunitic) rocks and isoferrroplatinum-rutheniridosmine aggregates, occurring interstitial to cumulate dunites and chromitites revealed clear mantle signatures. Enrichment of LILE in some of the associated mafic and ultramafic rocks document, that wet partial melting has probably occurred above a dehydrating subducted plate. Thus the (zoned) ultramafic cumulates (fractionated crystallisation of rutheniridosmine, chromite, isoferrroplatinum, olivine, and clinopyroxene) have formed relatively deep within a mantle wedge. The isoferrroplatinum aggregates contain inclusions of chromite and several hydrosilicates, predominantly amphiboles, that have probably replaced primary non-hydrous silicates. Both microprobe and microdiffraction (GADDS) analyses have identified the amphiboles in one Pt-nugget as cumingtonite and gedrite (high- to medium T), glaucophane (high-p, low-T), and winchite and actinolite (low-p, low-T). These minerals probably document the p-T path of deep exhumation of the cumulate body. The rocks of the ultramafic body generally show intensive serpentinisation, both on surface and in deep bore holes. This is likely to have resulted from fluids ascending from the dehydrating underlying subducted slab. Initial uplift was probably diapiric, due to buoyancy, and subsequently tectonic from the transpressional stress of the colliding plates. The ultramafic body lacks any significant contact metamorphic aureole and the contact to the surrounding country rocks is a markedly sheared to mylonitic, and thus relative 'cold', tectonic one. Wrap-around textures, foliations and lineations of the western and eastern contacts document pronounced oblique-slip (45°) reverse shearing with a sinistral sense of movement. This sense of movement is in agreement with the clock-wise rotational collision of the Siberian with the European plate. The ascent of the Nishni Tagil ultramafic body and its Pt-ores contained therein, comprised an early, diapiric, fractional crystallisation stage, a buoyant, hydrated (serpentinised) cumulate stage, a deep collisional stage - up-thrusted through a blue schist (subduction) regime - and finally a low-(retro)grade metamorphic, sinistral transpressional stage. The latter resulted in the tectonic emplacement within the present country rocks, prior to regional isostatic uplift and erosion to the present level.

OS06 : WEam04 : G5

Chemistry and Morphology of Chromite Grains in an Early Archaean Ultrabasic Intrusion, West Greenland

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Numerous enclaves of dunites and peridotites are found in the ~3.7 Ga Amitsoq gneisses of West Greenland together with supracrustal enclaves such as the Isua Greenstone Belt. The ultrabasic enclaves range in size from a few tens of square metres to a few kilometres long and a few hundred metres wide (Chadwick and Crew, 1986). The ultrabasic rocks consist mainly of olivine with lesser amounts of pyroxene. Chromite has only been found at one location

The investigated chromite is from an ultrabasic intrusion some 45 m thick. Dunites are seen at the base and dunite-amphibole harzburgite units at the top. Narrow anorthositic bands ca 30 cm wide are present in the harzburgite units. In the lower dunites chromite occurs in two forms. Firstly, as massive pod like bodies a few metres thick and a few tens of metres long. Secondly, as thin bands grading into disseminated chromites traceable for tens of metres. Chromites further up in the intrusion, in the dunite-harzburgite units, occur as disseminated grains.

The massive chromites show in some cases enrichment in FeO and Fe₂O₃ and depletion in Al₂O₃ and MgO from core to rim (Chadwick and Crew, 1986) but mostly they are homogenous in composition but with inclusions of sulphides, silicates and rare earth element phosphates. The chromites from the thin bands in the dunite are homogenous although some local variations in the Cr/Fe ratio may occur. The Fe-content is higher than in the massive chromites. The same type of inclusions as in the massive ones have been observed.

Most of the disseminated chromites from the dunite-harzburgite units show a complex structure with various types of exsolution and replacements. The primary chromite was an Fe-rich phase with low Al and Mg contents. This chromite has a fine network of exsolved Cr-rich chromite and larger exsolution lamellae of a Ti-rich phase, possibly ilmenite. Both types of exsolution are related to the crystal planes of the chromite. The Fe-rich chromite was subsequently replaced by a Cr-Al-rich chromite.

The compositional variations in the chromites have been investigated and compared with earlier investigations of the relation between chromite chemistry and the tectonic setting of Archaean ultrabasic rocks (Rollinson, 1995). From this it is suggested that the massive chromites and the chromites in the dunite are related through an evolution of a komatiitic magma. The Cr-Al-rich chromites, which replace the Fe-rich chromites, have compositions typical of those found in association with anorthositic magmas.

Chadwick B & Crew MA, *Economic Geology*, **81**, 184-191, (1986).

Rollinson HR, *Sub-Saharan Economic Geology, Balkema Press*, 7-23, (1995).

OS06 : WEam05 : G5

Complex Metasomatic Process between Serpentinized Ultrabasic Rocks and Alkaline Intrusive Bodies in Divrigi

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The study area is located to the north of the Divrigi region of the Sivas province (Central Anatolia Turkey). There are several iron ore deposits of different type. Some of them are still working. Main geological units of the area consist of the following units, 1-the Lower Jurassic recrystallized limestones, 2-an ophiolitic sequence composed of serpentine, pyroxenite, diabase, and listwanite that obducted in Upper Cretaceous time, and 3- magmatic rocks that intruded the limestones and the ophiolite in Campanian-Maestrichtian time. The scope of this study is to understand better process of formation of contact metamorphism/meta-

somatism at the contact of ultrabasic rocks with alkaline intrusions. In the Divrigi area contact metasomatic iron ore deposit was formed within the serpentinized ultrabasic rocks as a result of complex contact metamorphic/metamorphic reactions at the contact of a monzonitic-syenitic alkaline intrusion. The serpentinized ultrabasic rocks played an important role as a country rock during contact metamorphism/metamorphism related to intrusion emplacement. Some authors called such deposits as 'skarn deposits' sensu lato. Trommsdorf and Evans (1974), Sanford (1982), Barton (1991), Tracy and Frost (1991) were studied contact metamorphism and aureole systematics of ultrabasic rocks. Contact metamorphic/metamorphic reactions in Divrigi were rather complex, including alkaline metasomatism and late hydrothermal alterations of serpentinized ultrabasic rocks. Contact metamorphic/metamorphic transformations were developed both in the intrusives and the country rocks. The contact metamorphic zones were well developed in the serpentinized ultrabasic rocks, nearby the monzonitic intrusives. The ilmenite exsolution lamels within magnetite evidence of mineralization developed by high temperature hydrothermal fluids. Metasomatic reactions that are responsible from formation of mineralization, also caused redistribution of alkaline and trace elements within the contact metamorphic zone. The redistribution of trace elements through contact zone also identified by correlation matrix diagrams. Effect of potassic metasomatism was observed in serpentinized rocks while endoskarn zones of monzonitic intrusive undergone sodic metasomatism. Isochemical mineralogical transformations formed during contact metamorphism can be observed at broad zones especially at the contact zone between the serpentine and monzonitic intrusive. Contact metamorphism was a continuous process, gradually changing with time. The contact metamorphic mineral assemblages show close evidence of retrograde reactions. Influence of magmatic fluids that was responsible from contact metasomatic ore, continued till the lower temperature limit of hydrothermal period. Maghemite and martite developed as a result of this alteration. Martitization of primary ore implies chemical character of hydrothermal fluids by time. Therefore variable mineral assemblages occurred in different phases of contact metamorphic/metamorphic processes.

Barton MD, Ilchik RP & Marikos MA, *Reviews in Mineralogy Contact Metamorphism (American Mineralogist)*, **26**, 321-345, (1991).

Tracy RJ & Frost BR, *Reviews in Mineralogy Contact Metamorphism (American Mineralogist)*, **26**, 207-280, (1991).

Boztug D, Yilmaz-Sahin S, Oltu N, Tatar S, *Theological Considerations and a Field Excursion in Central Anatolia Turkey TUBITAK-BAYG NATO-D Programme (Sivas Cumhuriyet University)*, **13/1**, 105-146, (1997).

Trommsdorf & Evans BW, *Antigorite Ophicarbonates Contact Metamorphism in Val Malenco (Italy)*, **vol 62 No 2**, 301-302, (1977).

Ozturk H, *Origin Interpretation of Divrigi Ore Province (PhD Thesis Istanbul University Unpublished)*, (1991).

Isik MA, *Metamorphism Magmatism and Mineralizations in Divrigi Region (PhD Thesis Istanbul University unpublished)*, (1998).

OS06 : WEam06 : G5

The Modes of Occurrence of PGE in Low-Sulphide Platinum Ores of Norilsk Region (Russia)

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Extra-large Pt-Cu-Ni sulphide deposits located in the Noril'sk district are well-known. However recently a new type of ores - low-sulphide Pt mineralization in the upper zone of the massifs was discovered. This is an important resource of PGE in Russia. We present new data concerning mineralogy and distribution of PGE in these horizons. There are two modes of platinum metals' occurrences in the ores: they form their own phases (29 minerals) and were found as solid solution in sulphides (Pt - 1% , Pd - 5% of PGE total concentration). The most common Pt minerals are Fe-Pt alloys, Pt and Pd sulphides and intermetallic compounds. Fe-Pt alloys are represented by isoferroplatinum, tetraferroplatinum, tulameenite and Pt₂Fe. Pt and Pd sulphides are cooperite, braggite, vysotskite, sulphide of Pt,Pb,Cu,Ni. They are often intergrow with Fe-Pt alloys. Sperrylite is widespread mineral in Talnakh low-sulphide horizon, but Pt₂Sn - PdSn and Fe-Pt alloys dominate in Noril'sk 1 intrusion, especially Pt-atokite is common.

Isomorphism is very typical in minerals of composition A₃B, A₃B₂ and A₃B₃ (A = Pt and Pd, B = Sn, As, Sb, Pb). Pd minerals - paolovite (Pd₂Sn), palladorsenite (Pd₂As) and phases Pd₂(Sn,As), Pd₂(As,Sb) have variable relations between Sn, As and Sb. Among bismuth-tellurium minerals were determined kotulskite, Bi-kotulskite, moncheite and Bi-merenskyte. Only one mineral of Rh - hollingworthite - was found in this ores. About 90% of all PGM are located inside Cl-, F-, H₂O - bearing silicate minerals. Solid solutions of PGE are found in main sulphide minerals. Maximum concentration Pd in pentlandite reaches up 300 ppm (average - 30-100 ppm). Rh is concentrated in pentlandite and pyrrhotite, his content is 1 ppm. The same value has Ir concentration in pentlandite - near 1 ppm. The highest level of PGE contents is typical for arsenides and sulphoarsenides Ni, Co and Fe - niccolite, maucherite, gersdorffite cobaltite. The following concentrations were distinguished (mas.%): Pt - 0.89; Rh - 0.44; Pt - 0.41. The finest grains of PGM (5 mk) are discovered in these minerals permanently. PGE are concentrated in sulphide melt at the magmatic stage of massif's formation. They are distributed into a fluid at the postmagmatic stage. Temperature of noble metals' crystallization varies from 250 up to 450°C. This study was supported by RFFI (grant 00-05064507).

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P-T Conditions of Formation of Lherzolitic Diamonds

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To date, accurate thermobarometry of syngenetic inclusions in diamonds has only been possible on rare polyminerale inclusions containing appropriate mineral assemblages. The results are however ambiguous, because of potential reequilibration of touching minerals after diamond growth and possible disequilibrium between non-touching minerals. I have calculated T and P for over one-hundred, mostly isolated, chromian-diopside inclusions in peridotitic diamonds and for associated peridotitic xenoliths from worldwide occurrences, using the newly developed single-pyroxene thermobarometers of Nimis and Taylor (2000). Although Cr-diopside inclusions constitute only a partial record of the mantle environment in which diamonds may form, Cr-diopside thermobarometry extends the applicability of thermobarometric methods enabling simultaneous retrieval of P and T for a large number of poly- and monomineralic inclusions. Pressure-temperature estimates obtained from chromian-diopside inclusions can thus yield useful constraints on the thermal evolution of the cratonic lithospheres as well as on the mechanisms of diamond genesis. Several lherzolitic diamonds formed during major thermal events, which are ascribed to advection of hot C-rich fluids or melts. In some cases, diamonds have recorded heating events, which probably took place several 100 Ma before the eruption of the host kimberlites. In some cases (e.g., Premier, South Africa), these events were localized near the base of the lithosphere, whereas in others (e.g., Siberia) they involved the whole diamond window. Although certain diamonds undoubtedly formed during heating/cooling episodes, many others grew under normal conductive regimes. These regimes are often comparable to those recorded by the associated xenoliths, but in some instances they reflect ancient thermal conditions characterized by higher thermal gradients and mantle temperatures up to 200°C above those extant at the time of eruption.

Nimis P & Taylor WR, *Contrib. Mineral. Petrol.*, **139**, 541-554, (2000).

OS06 : WEam10 : G5

Loss of Copper during Mining and Processing and its Effect on Sustainability

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Sustainable yields of renewable resources have long been recognised as valuable concepts. Applying the concept of sustainability to non-renewable mineral resources such as copper, leads to concern about both depletion of resources and degradation of the environment, and also raises questions about the adequacy of supply to meet future demands.

Analysis of resource scarcity is generally focused on non-renewable commodities such as energy and mineral resources and warnings about shortages of material stocks of natural resources have been recurrent through history. Before that background, major concerns have been expressed about the availability of mineral supplies necessary for the maintenance of economic stability and growth.

Research into applicability of the concept of sustainability to nonrenewable resources is currently being pursued by the Collaborative Research Center 525 established in 1997 by the Deutsche Forschungsgemeinschaft (DFG) at the Aachen University of Technology (RWTH). The long-term goal of this research project is to develop an integrated resources management system that analyses and quantifies the flow of materials and energy through the entire production cycle of metallic raw material and thus provides a scientific base for improving production and resource-use efficiency and identifying areas where adverse impacts on the environment can be minimised.

During the last decade, copper production has increased from 8,7 Mio t in 1988 to 12,2 Mio t in 1998, and a further increase of copper demand is expected for the future. Proven and probable copper reserves are estimated at 650 Mio t which implies a static lifetime of copper for about 54 years.

Current methods used for mining and processing of copper ores result in significant losses of the metal and, thus, in a reduction of geology-based reserve estimates and a decrease of copper availability in the future.

The aim of this study is to provide an assessment of the amount of copper that is sterilized during the extraction and beneficiation process. In the light of the concept of sustainability, resource-efficiency is an important aspect for the adequacy of resource supply since copper that remains unextracted in a given mine, means additional adverse environmental impacts due to new mining activities in the future.

From the production figures of nearly 250 copper mines, the evaluation of mining methods employed, and the recovery grade yielded in ore processing, it was estimated that the amount of sterilized copper in 1998 was in the range of 3 Mio t (this amounts about 25% of the world copper production in 1998). Approximately a third of this value are attributable to insufficient mining methods, whereas two thirds are related to ore beneficiation. The figures indicate that the effective amount of metal mined from presently known reserves is by far lower than implied by the reserve figures. In the approach of this study, values for the loss of copper will be presented for various different mining methods, ore deposit types and mining sites.

OS06 : WEam11 : G5

Resource Oriented Characteristics of Copper Deposits in the Context of Sustainable Development

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Nonrenewable mineral resources deteriorate when used as an input into industrial production and the concomitant enormous flows of materials through modern economies have a significant impact on the environment. Warnings about shortages and limits of material stocks of mineral resources have been recurrent through history. Although this issue remains central, the scope of discussion has broadened to incorporate concerns about limits to the sink and purification capacity of the environment. Materials flow analysis helps to track the life cycle of a material from its origin through to ultimate disposition. The method aims at assessing the cumulative effect that a particular material use has on the environment. A generic concept commonly considers all stages of materials flow such as the raw material source (i.e. the ore deposit), ore extraction, processing, fabrication, consumption, recycling, and waste disposal. In the approach of this paper, materials flow analysis is used to assess the first stages of materials flow associated with the copper cycle. It represents a mine-to-gate approach and includes an assessment of geologic and mineralogic characteristics of copper deposits that critically effect subsequent extraction and beneficiation of copper ore. The work involves key multidisciplinary research within the Collaborative Research Center 525 'Resource Orientated Analysis of Metallic Raw Material Flows' Copper has been

in use since the dawn of civilisation largely due to a good combination of several mechanical and electrical characteristics such as electrical and thermal conductivity. In 1975, world copper production was 6,7 million tons, and in 1995 it had risen to 10,5 million tons. Considering projected population growth in developing countries, concomitant rate of consumption, and development aspirations, the expected additional demand for copper in 2015 may be in the order of 15.8 million tons. This figure implies doubling the world's copper production over the course of less than two decades. A fundamental goal of the project is to understand the key links between ore deposit characteristics or signatures and their influence on the environmental response to mining and beneficiation. The research involves inventory of all significant currently operating world Cu deposits, as well as prospects that are in an exploration state, or where feasibility studies have been completed. A number of critical ore deposit signatures are being assessed on a global-scale, that include ore deposit type, ore and gangue mineralogy, trace element distribution in different mineral assemblages, hostrock lithology and mineralogy, orebody geometry, mining and beneficiation methods, ore reserves, ore production, and climatic conditions. This data provide the basis for an information system with the help of which a global environmental assessment model for Cu deposits is being established. Results from the project present essential attributes to the scarcity concern with mineral resources in that they provide scientific information for assessing global Cu availability. They further help to assess the adequacy of copper supply in the future, and to examine the magnitude of the resource stock if in addition to technologic and economic factors environmental considerations are included in ore reserve calculations.

OS06 : WEam12 : G5

The High Temperature Behaviour of Defect Hydrous Species in Quartz: Implications for Hydrogen Isotope Studies

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Infrared (IR) spectroscopy of hydrothermal vein quartz, known to have anomalous δD signatures, identified two hydrogen reservoirs; molecular water aggregates and defect hydrous species incorporated into the crystal lattice. Defect hydrogen is the dominant hydrous phase in samples yielding anomalously light δD signatures (Grant, Gleeson and Roberts, 2000). Room temperature IR spectra exhibit strong bands of similar intensity at 3380 and 3481 cm^{-1} attributed to absorption by AIOH species and Li dependent OH centres respectively. These are accompanied by a weaker band at 3321 cm^{-1} attributed to HOH species. AIOH centres correspond to defects formed by an interstitial H⁺ ion bonded to an oxygen adjacent to the substitutional Al³⁺. The detailed defect structure corresponding to the bands generated by Li and H dependent centres remains unclear. In an attempt to quantify the extraction of the individual defect hydrous species upon heating, an in situ micro-FTIR investigation of hydrous defects in natural, hydrothermal quartz crystals was performed between -150°C and 600°C. Major spectral changes during heating of the quartz samples are characterised by a systematic increase in the vibrational frequencies of both the AIOH and LiOH centres. This is accompanied by a marked increase in the intensity of the LiOH absorption with increased temperature. The observed spectral changes are attributed to variations in hydrogen bond length with temperature. A peak in the vibrational frequency at ~300°C suggests that the H-bond effect appears to be less significant above these temperatures. Temperature reversible spectra up to 300°C suggests that, up to these temperatures, there is no permanent loss of hydrogen associated with AIOH, LiOH or HOH defects. A significant shift in vibrational frequency, observed at ~550°C, is thought to be closely associated with structural changes in the crystal lattice involved in the α - β transition. At 600°C the dominant absorbance is produced by LiOH species. Both AIOH and LiOH species demonstrate decreased integral IR absorbance with increased temperature attributed to increased O-H-O distance. No reduction of defect concentration upon cooling suggests a decrease in the molar absorptivity, associated with a decrease in the net dipole moment of both AIOH and LiOH species with increased temperature. Heating of quartz crystals at 600°C for one hour permanently removes HOH defects but not AIOH or LiOH species suggesting that the α - β transition does not provide

a mechanism for permanently removing all impurity species. Although LiOH species are permanently removed following heating at 1000°C for 1 hour, AIOH species remain evident.

OS06 : WEam13 : G5

Ganterite: A New Barium Dominant White Mica

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A barium analogue of muscovite has been discovered in the crystalline basement rocks of the Berisal Complex, Simplon, Switzerland. Examples of the mica are found in a band of white mica schist, and lenses of similar material in a leucocratic zoisite-celsian gneiss. Some examples of the schist and gneiss are characterized by whole-rock BaO contents of up to 15% by wt. The mineral paragenesis consists of zoisite, quartz, plagioclase, apatite, zircon and amphibole in the schist, and zoisite, celsian, quartz, margarite \pm armenite in the gneiss. The micas are light grey to silver in colour, have a glassy lustre, a perfect mica (001) cleavage, a laminated fracture and a flexible tenacity. A Moh's hardness of 4-4.5 was determined from micro-hardness indentations. The refractive indices are $n_x = 1.619$ and $n_z = 1.622$, and the measured 2V, value is $42.5^\circ \pm 2^\circ$. The calculated theoretical density of the most Ba-rich micas is 3.11 g/cm^3 . Single crystal X-ray diffraction patterns for the mica were obtained using Weissenberg and Precession cameras, and powder patterns were obtained with both Gandolfi and Guinier-Haegg cameras. The Ba-mica is a 2 M₁ polytype and crystallized in the space group C2/c. The unit cell dimensions were refined at: $a = 5.2068(7)\text{\AA}$, $b = 9.027(1)\text{\AA}$, $c = 19.963(4)\text{\AA}$ and $\beta = 95^\circ 42'(1)$. The calculated unit cell volume is 930.4(3) \AA^3 .

Concentrations of BaO between 14 and 17% by wt. are consistently found in some crystals. This corresponds to an average formula of $(\text{Ba}_{0.87}\text{Na}_{0.56}\text{K}_{0.52})_{\Sigma=1.95}(\text{Al}_{1.71}\text{Mg}_{0.14}\text{Fe}_{0.08}\text{Ti}_{0.06})_{\Sigma=4.01}\text{Si}_{3.31}\text{Al}_{2.69}\text{O}_{20}(\text{OH})_4$ or, ideally $(\text{Ba},\text{Na},\text{K})\text{Al}_2(\text{Si},\text{Al})_4\text{O}_{10}(\text{OH})_2$.

This is the first recorded occurrence of a Ba-dominant muscovite type mica, and a proposal for a new mineral has been accepted by the International Commission for New Minerals and Mineral Names. The mica has been given the name ganterite, after the Ganter Valley, in Canton Wallis, Switzerland close to where the mineral was found.

OS06 : WEam14 : G5

Compositional, EPR and SQUID Magnetometry Data on the Tetrahedrite Group Minerals

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The tetrahedrite group minerals can be described by the general formula $(\text{Cu},\text{Ag})_{10}(\text{Fe},\text{Zn},\text{Hg},\text{Cu},\dots)_2(\text{Sb},\text{As})_3\text{S}_{13}$. Due to their mineralogical complexity some problems are still open in particular as far as concerns the possibility of different valence states and site occupancies of some elements. An accurate mineralogical and compositional characterization therefore, has been performed on a large number of natural samples. As to the specific characteristics of the bond type of this mineral group, some representative and significant samples of the different 'varieties' have been selected for EPR and magnetic investigations. In particular, the 'controversial' presence of Cu(II) in the M1 tetrahedrite site (Wuensch, 1964) could be ascertained by EPR investigations which avoids the Fe(II) (d^6 ; $S=1$) interference. Concentrated Fe(II), on the other hand, is one of the main goal of SQUID measurements in sulphides (Vaughan and Burns, 1972). Perfect linear corre-

OS06

Mineralogy, Ore Geology and Mineral Resources

Wednesday PO Session

OS06 : WEpo01 : PO Geochemistry of Minerals from Granitic Rocks and Associated Quartz Veins from Segura, Central Portugal

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At Segura, Hercynian two-mica granite, muscovite granite, granodiorite porphyry veins and Li-bearing granitic aplite-pegmatite veins containing cassiterite and lepidolite intrude the Cambrian schist-metagraywacke complex. Aplite veins intrude this complex and granites, whereas quartz veins with cassiterite and wolframite intersect the schist-metagraywacke complex. Quartz veins with barite, galena and sphalerite intersect this complex and the muscovite granite. The two-mica granite contains Fe²⁺-biotite, while the granodiorite porphyry veins have Mg-biotite, but they are not related. All granitic rocks contain primary muscovite, but muscovite granite and aplite veins also have some hydrothermal muscovite. Primary muscovites show trends of fractionation for major elements from two-mica granite to granitic pegmatite. There are also increases in P₂O₅ contents of K-feldspar and albite and decrease in anorthite content of albite from this sequence. Primary muscovites from muscovite granite and aplite have similar compositions. Aplite is probably related to muscovite granite, which is formed by partial fusion of metasedimentary materials. Generally K-feldspar has higher P₂O₅ content than coexisting plagioclase, but there is no significant fractionation of phosphorus between them. In pegmatite, lepidolite is richer in Si, F, Rb and poorer in Al than muscovite that partially replaces. Primary topaz, montebrasite and natromontebrasite also occur in the pegmatite.

Hydrothermal muscovite from quartz veins has more Mg and Mg/(Mg+Fe) and less Al_{VI}, Al_{VI}+Al_{VI} and paragonite content than primary muscovites from the granitic rocks. Cassiterites from pegmatite and quartz veins show sequences of alternating parallel darker and lighter zones. In pegmatite, the darker zones of cassiterite have Mn >> Fe and more Nb and Ta than the lighter zones, while in quartz veins the darker zones show Fe >> Mn and more Ti than the lighter zones, which are mainly pure SnO₂. The darker zones of cassiterite from quartz veins are richer in Ti and poorer in Nb, Ta, W, Mn and (Ta+Nb)/(Fe+Mn) than those of cassiterite from pegmatite, which show exsolved manganocolumbite and manganoferrucolumbite. Wolframite has Fe >> Mn, and in single zoned crystals Mn, Mn/Fe increase and Fe decreases from rim to core.

The quartz veins with cassiterite and wolframite have monoclinic pyrrhotite, arsenopyrite (locally altered to pharmacosiderite), pyrite, sphalerite, chalcocopyrite, stannite, matildite and schapbachite. The quartz veins with barite, galena and sphalerite correspond to a later generation and also contain cobaltite, pyrite and chalcocopyrite, but galena is altered to anglesite, mimetite and kintoreite.

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OS06 : WEpo02 : PO Whole-Rock and Clay Fraction Mineralogy of the Bottom Sediments of Köycegiz Lake, SW Anatolia, Turkey

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Köycegiz lake is a meromictic lake located in the south-western Anatolia, Turkey. It covers a surface area of 55 km² and accommodates 850 million m³ water. The area is a part of Taurus mountain belt and comprise of Mesozoic carbonate and ophiolitic rocks as well as recent alluvium. The lake is fed from rainfall, streamflow and thermal ground water and discharges into Mediterranean Sea via 14 km long, meandering channel. A total of fifty-nine sediment samples (31 surface samples and 28 borehole samples

of 2 cm thickness) from the bottom sediments of Köycegiz Lake was subject to mineralogical analysis to determine the origin and lateral and vertical variations in the whole-rock and clay fraction minerals of mainly clay-silt fraction by X-Ray Diffraction Method. Whole-rock analysis show that existence of clay, serpentine, calcite, dolomite, aragonite, quartz, feldspar, amphibole, mica, kaolinite, halite, gypsum and natron (?). Clay mineral assemblages consist of kaolinite, chlorite, serpentine, smectite and illite. It has been concluded that carbonate (calcite, dolomite and aragonite), sulfate (gypsum), chloride (halite?) and bicarbonate (natron?) minerals are the products of chemical precipitation. Feldspar, quartz, amphibole, Serpentine and mica are related to detritic origin. Smectite and kaolinite can be related to the alteration products of volcanic materials. Aragonite which, can be related to increasing of the hydrothermal input or bacterial activities were found only in two samples at the deeper sections of borehole (49-52 cm). Both conditions are met in the lake water. Aragonite is also major carbonate mineral in one of the surface samples. Although mineralogy of lake sediments shows a homogeneous spatial distribution, their abundance change both in lateral and vertical extent. This indicates the change in lake water's salinity which is certainly related to temporal variations in fresh water and thermal water recharge rates. Interestingly, mica observed almost in all surface samples was not found in the borehole samples which represent the 1 m depth from bottom surface. This is attributed to alteration of mica by time. Hornblende is seen only in the northern basin of the lake where there is recharge from a stream which is fed from ophiolitic terrain.

OS06 : WEpo03 : PO New Date of the Jadeite Colour of Lion-Kechpelsk Deposit

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Jadeite is a well-known as jewelry material for, many years but jadeite deposits are very rare and great gem are single. A Lion-Kechpelsk deposit of jadeite is one of the known Russian deposits, which is situated on the west mountain-side of Payersk blok of Voikaro-Synyensk massive. Massive has been packed mainly from different degree serpentinized rocks of harzburgin-dunit complex. Jadeite bodies in the manner of veins or lenses by extent 15-60 m and power 4-11 m streten in antigorit serpentins. Jadeite bodies have a zonal construction with determined lokation areas. The following types of rocks follow each other from jadeite nuclear to serpentin harzburgits: aktinolith-phlogopit clay, chlorit-aktinolith-phlogopit rocks, semiore serpentins and further antigorit serpentins. For the estimation of jadeite fitness as jewelry material is taken one of the gemmological features: a colour and shade of stone. Finerystallogical jadeite rock is distinguished by the pale green colouring with different shades (from the colour of green to the colour of emerald). A number of mineral methods were used to stades jadeite colouring. Petrological research revealed a dependency of jadeite colouring on its separation forms and on the geological within veins. It is known that the shade of jadeite rock greatly depends on secondary minerals. Roentigeno-structural analysis has allowed to elaborate a mineral composition of rock. Results of roentigeno-structural analysis revealed the chemical particularities of pyroxene and have marked a place in the nomenclature Natraproxene. Results of optical-spectroscopy analysis have pointed out the reason of different jadeite colouring appearance. We analyse the spectrum of adsorbing bright-green streak of jadeite in plates and grey-green main mass of jadeite in section.

OS06 : WEpo04 : PO
South-East Asian Marble-Hosted Ruby Deposits

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Marble-hosted ruby deposits represent the first largest source of coloured precious gemstones in South-East Asia. They occur in Turakuloma (Tajikistan), Jegdalek (Afghanistan), Hunza Valley (Pakistan), Nangimali (Azad Kashmir), Chumar, Ruyil (Nepal), Mogok, Mong Hsu (Myanmar), Luc Yen, Yen Bai (North Vietnam) and Yunnan Province (South China).

These primary deposits show specific and similar geological features:

Geological setting : they are hosted by metamorphosed sedimentary platform series composed of a succession of sandstone, shale and limestone, with intercalation of mafic rocks and intrusion of dykes of granite and/or desiccated pegmatites. Rubies occur within marble and cipolin horizons ranging from 0.1 up to 300 m thick and with up to 50 km in extension. The mineralization is disseminated or concentrated within fractures concordant with the main regional tectonic structures.

Mineralogical assemblages: The composition of the marbles varies between calcite and dolomite. The paragenesis is composed of diopside ± spinel ± phlogopite ± garnet ± chlorite ± margarite with sometimes graphite. The associated schists and gneisses show kyanite ± amphibole ± clinopyroxene ± garnet ± biotite.

External and internal features of rubies: Crystals are generally composed of reddish and colour-zoned hexagonal prisms with bipyramids ; rhomboedral and pinacoidal faces may be developed. Apatite, calcite, dolomite, rutile, mica, pyrite and spinel are the main solid inclusions. Carbonic monophase or biphasic cavities characterise the primary fluid inclusions. These rubies show low iron contents (normally less than 0.2%wt FeO). Vanadium contents are highly variable and can reach high values (up to 0.35%wt V₂O₅ in Mogok rubies). **Genetic models** : The model generally proposed for such primary deposits is the regional metamorphism of limestones under high temperature and pressure conditions (600-620°C, 7 kbar in Hunza ; T>650°C, 4 to 8 kbar in Luc Yen). The close association, in some areas, with granitic pegmatite led to consider a model of mixing of fluids from metamorphic and magmatic origin. In Luc Yen, (O, C) isotopic studies suggest exchange and equilibration between marine carbonate and organic material from black shales during metamorphism, through devolatilization and fluid circulations.

To understand the genesis of marble-hosted ruby deposits, the source of elements such as aluminium, chromium, iron or titanium and their mechanisms of extraction, transport and deposition must be studied in details.

OS06 : WEpo05 : PO
Anisotropy of Magnetic Susceptibility (AMS)
and Traces Chemistry: A New Approach to
Discriminate between Hydrothermal and
Supergene Processes in Goethite-Rich Ore
Deposits. Application to the Ba-Fe-F
Deposit of Chaillac (Indre, France)

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Located at the southern part of the Bassin de Paris, where Triassic formations lay unconformably on the basement of northern Massif Central, the Chaillac deposit is composed of a stratiform Ba-Fe ore body connected to a F-Ba vein.

The stratiform part is hosted by Hettangian fluviatile sandstones. The so-called 'Iron-barite complex' is a typical major facies with barite and goethite banded veinlets cross-cutting a mineralised sandstone (barite and goethite rich cement) [6]. Today barite is mined in two open pits: La Raillerie and Les Redoutières. Respective parts of hydrothermalism and lateritization in the genesis and evolution of 'Iron-barite complex' was formerly largely discussed at Les Redoutières [1][2][3][5][6].

In La Raillerie open pit, field evidences clearly demonstrate a lower ferruginous sandstone related to hydrothermalism and an upper ferruginous sandstone which have been lateritized. The cements of these sandstones are composed of goethite with different textures: a colloform one for the lower level and a massive one in the upper level. These cements have been analysed in order to define their chemical signature as a marker of their origin. As₂O₃ low content in goethite of the lower ferruginous sandstone confirm its hydrothermal origin. TiO₂ low content, without As₂O₃, in goethite of the upper ferruginous sandstone confirm a lateritic origin of the cement.

AMS measures have been performed on the previous described levels in La Raillerie open pit, and on two levels in Les Redoutières open pit, respectively at the basis and at the top of the 'Iron-barite complex'. In these four sampled sites goethite carries the magnetic susceptibility. In La Raillerie open pit the hydrothermalised lower sandstone has a prolate AMS shape; the vein plane carries the direction of K1. The lateritized sandstone has an oblate AMS shape, K3 directions are well vertically grouped and K1, K2 are scattered horizontally comparable to which has been described in weathered samples [4]. These results are used to interpret AMS measures in the Redoutières open pit. At the basis of the 'iron-barite complex' AMS shapes are prolate, K1 directions are well grouped and carried by the associated vein plane. At the top of the complex AMS shape is oblate, K3 directions are well vertically grouped and K1, K2 are scattered horizontally as in the lateritized sandstone of La Raillerie sandstones. AMS results on the 'iron-barite complex' at Les Redoutières only show a superficial lateritization (about 2 metres) of a hydrothermal deposit, with an uncommon inherited morphology. In addition, on this deposit different goethite textures are clearly related to different AMS fabrics, these results could favour further investigations using AMS data to track flow directions of fossil hydrothermal systems.

Deurbergue A, *Thèse de troisième cycle, Orléans*, 152, (1984).

Parron C, Nahon D, Tardy Y, *Mém. B. R. G. M.*, **104**, 385-396, (1980).

Tardy Y, Norbert C, Fontes JC, Nahon D, *C. R. Acad. Sci. Paris, Série II*, **295**, 219-224, (1982).

Tarling DH, Hrouda F, *The magnetic anisotropy of rocks, Chapman & Hall, London*, 29-64, (1993).

Touray JC, Ziserman A, *Mém. B. R. G. M.*, **104**, 377-380, (1980).

Ziserman A, *Mém. B. R. G. M.*, **104**, 344-374, (1980).

OS06 : WEpo06 : PO
Computer Modeling of the Equipondant
Crystal Form in the Context of Study of
Zircons from Metamorphic Rocks

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Empirical data have been accumulated recently, suggesting that morphology of zircon crystals from metamorphic rocks is controlled by varying conditions of metamorphism. Different zircon generations are recognised, which morphological distinctions require theoretical explanations. A need has arisen to establish patterns of zircon crystal morphology variations in relation to varying conditions of crystallisation. A computer simulation has been proposed based on calculation of surface energies for each crystal face. Surface energies, in their turn, are found with the help of interatomic pair potentials for a 'cold' and uncompressed crystal. External factors are taken into account by introducing adequate new variables into conditions of the lattice equilibrium. The proposed model can reveal how the crystal form of accessory minerals from endogenic rocks depend on P-T conditions of the rock-forming medium. Thus, it is possible to make theoretical determinations of morphological types of zircon corresponding to particular thermodynamic rock-forming conditions and compare them with empirical data.

OS06 : WEpo07 : PO
Report of Two New Rock Forming Minerals

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We report two new rock forming minerals from metamorphic rocks. Both were recognized by electron microprobe and analysed by WDS. The first is calcium-titanium-(oxi)silicate from basaltic eclogites in the ~1.9 Ga Ubendian belt, Tanzania (Muhongo and Tuisku, submitted). On the basis of the formula CaTi₂SiO₆, the mineral has an orthosilicate structure like sphene and is an intermediate phase in the sphene-rutile system. One oxygen may be partly substituted by hydroxyl group because the WDS analysis sum is 99%. Optical properties closely resemble those of sphene. The mineral is possibly stabilized by the relatively high pressure of 13 kbar and temperature of 830°C calculated by garnet-clinopyroxene-plagioclase-quartz thermobarometry for these rocks.

The other mineral may be considered an potassium-iron rich analogue of trioctahedral sodium-magnesium mica wonesite with one vacant A-site and has a formula of (Ca_{0.01}Na_{0.06}K_{0.74})_{0.81}(Fe_{2.08}Mg_{2.67}Fe³⁺_{0.15}Cr_{0.02}Ti_{0.21}Al_{1.86})₆(Al_{2.28}Si_{3.72})₆O₂₆(OH)₄. The mineral occurs in the alkali-deficient amphibolite facies psammopelites of the ~1.9 Ga Kainuu mobile belt (Tuisku, 1991). Optical properties are similar to biotite and wonesite. The mineral was formed in mid-amphibolite facies at 540°C and 4.5 kbar and was maybe stabilized due to the Al-rich and relatively alkali-poor composition of the host rock.

Muhongo S & Tuisku P, *J. African Earth Sci.* (submitted).
Tuisku, *Res Terrae Ser A*, **4**, 1-47, (1991).

OS06 : WEpo08 : PO
Dynamics of Silver Ore Formation in the
Beregovo Ore Field (Intercarpathian
Volcanic Belt, Ukraine)

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The ore bodies are presented by veins and stockworks. Sulfide (sphalerite+galena+pyrite), quartz-sulfide and quartz parts of the ore bodies are divided. Ag content of sulfide parts varies from 300 to 400 ppm, quartz-sulfide - 100-150 ppm, and quartz parts not contain economic silver ore. The depletion of silver contents is accompanied with lowering thermoelectric effect of both n- and p-type galena along the ore bodies. 5 galena and 3 sphalerite nucleations control internal structure of the sulfide aggregates. Galena contains singenetic boulangerite and native antimony blebs. Often galena individuals are zoned, that is a result of rhythmic fluctuation of Sb content in galena composition and is often underlined boulangerite 'chains'. Thermoelectric power of primary galena is negative and indirectly depends on the Sb impurity content. It is established, that quartz-sulfide aggregates are depleted with later nucleations of sphalerite and galena as a result of their selective destruction during quartz development and transformation of sulfide into quartz-sulfide aggregates. Chiefly silver resources are connected with Ag-Sb sulfosalt (pyrrargyrite and polybasite) blebs, which were formed in the way of diffusive replacement of earlier antimony-boulangerite mineralisation in galena. The intensity of Ag-Sb-sulfosalts formation depended on primary permeability of sphalerite-galena aggregates. At the beginning the blebs of Ag-Sb sulfosalts formed thin bands in Sb-enriched galena along sphalerite-galena borders. Here n-type galena transforms into p-type. The minerals were formed and replaced in the sequence of Sb ejection and Ag saturation of the mineral-forming system: burnonite-pyrrargyrite-polybasite-acanthite. The sequential development of the minerals redounded to arising of circumferential zonation in galena aggregates. The size of individuals of every later sulfosalts grew larger, but with rarefaction. This behaviour is an evidence of their growth due to dissolution of all earlier sulfosalts. Exploration of sulfosalt distribution in the ore bodies shows that Ag-enriched ores of sulfide veins are presented both polybasite and pyrrargyrite, which are accompanied by native antimony, boulangerite, burnonite, acanthite and tetrahedrite in galena and sometimes in sphalerite. But Ag-depleted ores of quartz-sulfide parts contain only rare polybasite and tetrahedrite grains only in galena. Therefore, the destruction and silification of the sphalerite-galena bodies led to transformation of Ag-rich ores into

Ag-poor ones with dissolution of Sb-enriched sulfosalts. The galena destruction was accompanied with partly delay of silver that led to the formations acanthite with angleite, native silver-acanthite-polybasite assemblages. Numerical modeling of forming conditions of the established parageneses performed with 'CHILLER' software package showed that the sequential formation: native antimony-bourmonite-pyrrargyrite-polybasite-acanthite is an indicator of oxidation of the mineral-forming environment. Sulfosalts are formed as a result of reaction between argentic chlorides and thioantimonite derivatives. Their contents increase and decrease accordingly because of oxidation and sulfosalts are forming from Sb-enriched to Sb-depleted, but with increasing of Ag content.

OS06 : WEpo09 : PO
Gold-Bearing Quartz-Sulfide Aggregates and
Quartz Evolution in the Muzievo
Gold-Silver-Base Metal Epithermal Deposit
(Intercarpathian Volcanic Belt, Ukraine)

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Base-metal veins in the deposit were developed along contraction faults of the rhyolitic tuffs of the Beregovo Sarmathian explosive caldera. Quartz is widespread both in the veins and in wall rocks, altered into quartz-adularia, quartz-sericite and quartz-kaolinite metasomatites. Majority of quartz aggregates of the veins were formed during decaying of the mineral-forming system with destruction of the earlier sulfide (sphalerite+galena+pyrite) aggregates and gradual silification of the system. Native gold was precipitated in front of the silification, on account of sulfides served a geochemical barrier for oxidized solutions. Homogenisation temperature of fluid inclusions in gold-bearing quartz aggregates shows temperatures from 80 up to 270°C. The work is performed for features revelation of the gold-bearing quartz aggregates. To perform the work we used detailed textural-structural analyses. Terminations of the sulfide crystallisation are mainly fixed by formation of thin rhythmic quartz-sphalerite banded aggregates. Quartz of these rhythms is fine-grained or plumose. Sphalerite presents spheroidal microaggregates. On the other hand the change of sulfide-quartz formation is observed as partial crossing of the plumose quartz by sphalerite crystals. Textures of quartz-sulfide aggregates, where quartz replaces sulfide aggregates, chiefly depend on textures of primary sulfide aggregates. Mainly they are banded as a result of selective dissolution of radial sphalerite rhythms or dappled because of cementing of the grained sulfides by fine-grained quartz. Usually in the veins four types sequentially formed quartz aggregates are observed: 1) fine-grained quartz, formed; 2) druse quartz; 3) plumose quartz; 4) chalcedony. 1-st and 3-nd types were priority formed by metasomatic replacement of sulfides. Druse quartz is widespread, but its formation always is connected with growth in hollows, which were created with fast dissolution of sulfides or occurred along cracks. Optical axes of the crystals of fine-grained and druse quartz often is similar, reflecting geometrical selection from micro- to macro-level. Both fine-grained and druse quartz develop in plumose quartz, arising as a result of multiple iteration of splitting and following geometrical selection of quartz crystals. Splitting is often underlined by lengthened inclusions of a dark material. Chalcedony presents long (to 5 mm) quartz fibres, which are rhythmic split. The borders between rhythms are fixed with occurrence thin (~0.1 mm) zones of flamboyant chalcedony, which were formed with temporary disorientation of the quartz fibres after each of splitting.

OS06 : WEpo10 : PO
Characteristics of Volcanic- and Sediment-
Hosted Base Metal Anomalies in the Vicinity of
Rosh Pinah Mine, Namibia

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Rosh Pinah Mine is located in southwestern Namibia. This base metal deposit lies within Late Proterozoic to early Palaeozoic volcano-sedimentary formations of the Gariep Belt. The Rosh Pinah Formation, which hosts the Rosh Pinah ore bodies, is part of the Port Nolloth Zone, a para-autochthonous passive continental margin on the western

rim of the Kalahari Craton. The Gariepian succession represents an early phase of continental rifting, accompanied by bimodal volcanism. The Pb-Zn-Cu ore bodies are hosted by siliciclastic rocks but are at least spatially related to both felsic and mafic volcanic rocks. The ores are generally thought to be of SEDEX origin. Nevertheless, many indications suggest that it might rather represent a distal VMS deposit or even a transitional type. The area north of the mine lease hosts several base metal anomalies in distinctly different settings: The first type occurs immediately to the north of Rosh Pinah Mine. Here the base metal anomalies are related to metamorphosed and partly altered mafic, locally vesicular volcanic rocks. Metamorphism, alteration and deformation have modified the primary composition and textures of these mafic igneous rocks. However, the inner parts of the mafic units seem to have been of basaltic composition. Lateral variations of these rocks are biotite schists, chlorite-amphibole schists, and chlorite schists. Two main mafic igneous units can be distinguished and both are hosted by feldspathic, partly carbonatic quartzite and argillite. The second type of base metal anomalies, further northwest on Farm Spitskop, is related to several prominent gossans within felsic volcanic (predominantly pyroclastic) rocks. The gossans show a typically sharp contact to the surrounding felsic volcanic rocks and metasediments, the latter comprising both siliciclastic and carbonate rocks. Although most of the gossans consists predominantly of magnetite and hematite, a distinctly magnetic and a non-magnetic type can be distinguished. The gossans of this area occur spatially related to carbonate units. Several types of carbonates have been distinguished to date, based on macroscopic characteristics alone. Several of the carbonate units display typical features of clastic (bedded) and biogene (stromatolitic) origin. Laminated calcitic carbonates, in some low-strain domains, still maintain the typical shapes of laterally linked hemispheroidal stromatolites. Other carbonates are dark brown, massive chaotic masses with irregular aggregates of hematite and specks of quartz, possibly pseudomorphing pre-existing barite (?), dispersed throughout the rock. These different carbonates might represent carbonates of biogene origin and exhalative carbonates, the latter having possibly formed as part of a mineralising process. These altered mafic and felsic volcanic rocks, gossans, and different types of carbonates, and their potential genetic relationship to base metal mineralisation will be the focus of our current metallogenetic investigation.

OS06 : WEpo11 : PO
Preliminary Mineralogical Investigations of the
Skorpion Non-Sulphide Zinc Deposit,
Southern Namibia

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The Skorpion non-sulphide zinc deposit is situated in the southern part of the Namib Desert, Namibia, and approximately 40 kilometres north of the Orange River. It occurs within a Late Proterozoic series of the Port Nolloth zone as part the Gariep Orogenic Belt, which belongs to the Pan-African belts in southwest Africa (Corrans et al. 1993). The Port Nolloth zone consists of a wide variety of sediments, mainly arkoses, marls, shales, and limestones but also bimodal volcanics. The host rocks have been strongly folded, faulted and overprinted by lower amphibolite facies metamorphism (Fimmel 1995). The deposit is not exposed on surface; a sandy plane with calcrete covers the non-sulphide orebody.

The deposit has a resource of 24,6 Mt, at an average grade of about 11% Zn (Mining Journal 2000) in the form of Zn-silicates, -carbonates and minor -oxides. The Skorpion deposit belongs to a group of so-called non-sulphide deposits which - quite recently - have become of particular economic interest since a tailor-made solvent extraction and electro-winning process allows the production of high-purity zinc on site at low cost.

The ores have been studied by reflected and transmissive light microscopy of samples from drill cores. SEM-EDX, XRD and GADDS analysis have been carried out for detailed mineral identification. ICP/MS and XRF were used for major and trace element geochemistry of whole rock samples.

The non-sulphide zinc mineralisation is mainly hosted within siliciclastic rocks (arkose, quartzite and shale) and minor limestone. The predominant ore minerals comprise hemimorphite (Zn₄[(OH)₂/Si₂O₇]²⁺H₂O), a zinc-rich clay mineral, saconite (ZnAl[(OH)₂/AlSi₃O₁₀](0,5Ca,Na)_{0,5}(H₂O)_n, and zinc-carbonate, smithsonite (ZnCO₃). The Zn-concentrations within these ore minerals can be as high as 23,8% for hemimorphite, 46,5% for saconite, and 78,0% for smithsonite. The ore minerals are predominantly fine-grained and generally not noticeable macroscopically in drill core. Hemimorphite, seen under the microscope, is intimately associated with quartz and muscovite, partly forming spherical aggregates, i.e. 'concretions'. To date, saconite and smithsonite have been detected by XRD only and seem to occur throughout the mineralised host sediment. No sulphides have been detected within the non-sulphide mineralisation so far.

Sphalerite mineralisation occurs at a distance from the non-sulphide ore body but the stratigraphic, structural and metallogenetic relationship of the sulphide and non-sulphide mineralisation are not fully understood yet. Forthcoming investigations will include the study of stable isotopes to investigate any potential genetic relationships between sulphide and non-sulphide bodies. Metal zonation patterns are currently interpreted to show the spatial relationship between sulphide and non-sulphide bodies. Properties of inclusions of mineralising fluids will be determined by microthermometry. This combination of methods will hopefully lead to a more detailed understanding of the metallogenetic processes at the Skorpion non-sulphide zinc deposit.

Corrans RD, Gwald H, Whyte RM & Land BN, Abstracts:
Conference on Mining Investment in Namibia, 17 - 19
March 1993, Windhoek, 46-57, (1993).
 Fimmel HE, S. Afr. Tydskr. Geol. 98, 176-190, (1995).

OS06 : WEpo12 : PO
Ore-Forming Fluids in Idrinja Mercury Mine,
Slovenia

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The Idrinja mercury mine is situated 50 km west of Ljubljana, in the region which belongs to the Alpine promontory, transitional zone between Alps, Dinarides and Adriatic microplate. The ore deposit was formed by hydrothermal and exhalative processes within a Middle Triassic trough, deepened by extensional tectonics during the Tethyan rifting stage. Middle Triassic tectonics gave way to the upwelling hydrothermal solutions, which expelled their load onto the sea bottom through a thick pile of the Upper Paleozoic, Permian, Scythian, and Anisian clastics and carbonates, forming stratiform, syndimentary mercury, pyrite rich ore in the black Sconca shales (Mlakar & Drovenik, 1971; Placer, 1976). On their way to the sea bottom, they mineralized fissures, pores, faults, breccia zones, and metasomatically replaced carbonates, and cement in clastics, assigning to the mineralization a clear epigenetic character. Mineral paragenesis of the deposit is almost monomineralic and consists of cinnabar, metacinnabar, native mercury, sporadic iron sulphides and gangue minerals, calcite and quartz. The objects of FIs study were colourless, transparent single quartz crystals, prepared as 0.2 mm thick wafers, and red, irregular cinnabar grains, prepared as 0.05-0.1 mm thick wafers. The most widespread FIs in Idrinja ore deposit are low saline (1.75-11.50 wt.% equ. NaCl), L+V, CaCl₂-NaCl-H₂O with NaCl/CaCl₂ ratio between 25 and 40%. Total homogenization into liquid phase was observed in the temperature interval between 175 and 215°C. Homogenization temperature could not be recorded into cinnabar samples due to decrepitation in temperature interval between 120 and 160°C. High saline CaCl₂-NaCl-H₂O FIs, with presence of isotropic daughter minerals, were observed only within one quartz crystal. NaCl/CaCl₂ ratio and homogenization temperature are into the same range as in the low saline FIs. In the same sample the low saline (6,75-8,00 wt.% equ. NaCl), L+V, NaCl FIs were observed.

Mlakar I & Drovenik M, *Geologija, Ljubljana*, 14, 67-126, (1971).
 Placer L., *Rudarsko-metalurški zbornik, Ljubljana*, 1, 3-30, (1976).

OS06 : WEpo13 : PO
A Concept for the Investigation of the Economic Potential of Undiscovered Copper Deposits in Mauritania

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The long-term goal of the Collaborative Research Center 525 (CRC 525) 'Resource-Oriented Analysis of Metallic Raw Material Flows' is the identification of key options for resource-sensitive supply and processing of metallic raw materials, considering restrictions imposed by geology, technology, as well as societal, economic and environmental factors. In this context, traditional estimates of resource quantity are no longer meaningful as they do not account for many ecological and social concerns placed on mineral extraction and beneficiation.

General goal of this project is the evaluation of the potential of undiscovered copper deposits in Mauritania. This will include the development of new efficient methods, that place a strong emphasis on the concept of sustainable development of nonrenewable mineral resources. The methodology focuses on specific geographic areas and involves assessment of essential parameters such as original resources estimate, ore mined and lost in mining, as well as environmental, geological, and technological constraints and land use. The integration of regional data sets for mapping mineral potential is being carried out on a Geographic Information System (GIS). With this, regional geological, geophysical, geochemical, and environmental data are brought together into a single data base accommodating spatial and non-spatial information. Mauritania has been chosen as a country of focus because it is underexplored by international standards and its mineral potential is recognized by the international mining industry. Therefore, the country provides considerable opportunity for explorers and developers of mineral resources. The investigation of the economic potential of undiscovered copper deposits in Mauritania is a pilot project which supports a government initiative to stimulate foreign investment into the mining sector with the aim to promote economic growth and the well-being of the people. The work involves key collaborative research with international mining companies currently operating in area, the Ministry of Mines and Industry of Mauritania, as well as the World Bank.

The study, firstly, focuses on the Guelb Moghrein area, located approximately 260 km northeast of the capital city of Nouakchott. The area is known for significant copper production during ancient times and has been subject to numerous copper-gold mining and exploration campaigns. The copper-gold mineralization at Guelb Moghrein is hosted by a massive magnetite and sulfide bearing iron-magnesium-carbonate within a sequence of Lower Proterozoic greenstones, made up of both amphibolites and chloritic schists belonging to the Lambeth Formation of the Akjoujt Series. The Guelb Moghrein Occidental orebody contains a measured and indicated copper and gold resource estimated at 23.7 million tons to a depth of 220 meters, grading 1.88% copper and 1.41 g/t gold and 144 ppm cobalt, using a 1% copper cut-off grade. The carbonate rich formations, which host the Guelb Moghrein copper-gold deposit, are prime exploration targets in the surrounding areas.

The scope of this paper is to introduce the methodology employed and to present first results with respect to the potential of undiscovered copper deposits in the Guelb Moghrein area of Mauritania.

OS06 : WEpo14 : PO
Petrological And Geochemical Evidence of Fluid-Rock-Interaction In The Strike Reef of The Hutti Gold Mine, North Karnataka, India

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Gold mineralisation at Hutti gold mine is controlled by a NNW-SSE trending shear zone in the Hutti-Maski schist belt. The hooked shape belt consists of a heterogeneous assemblage of volcano-sedimentary units, surrounded by a granite-gneiss assemblage within the eastern area of the Dharwar Craton, south India. The Strike Reef is one of nine gold-quartz-sulphide lodes in the Hutti gold mine, which is currently producing 1.3 t Au/a at a grade of 6.42 g/t.

For the purpose of this study, the whole spectrum of lithologies from metabasalts (host rocks) through various alteration and ore zones were sampled from a drill core driven perpendicular to the reef.

The metabasalts are massive to weakly foliated with a greenish appearance, dominated by fine-grained amphiboles. The amphibole crystals are elongate (20m) with irregular platy ends. Matrix minerals include albite, zoisite and opaques. This paragenesis represents metamorphism to greenschist facies. The amphibole is later replaced by biotite and chlorite; biotite is then further replaced by chlorite representing two retrograde phases in the greenschist facies.

The first distinguishable alteration zone is a foliated, brownish coloured rock, dominated by fine-grained, irregular crystals of biotite. Amphibole and albite decrease in number whereas both titanite and zoisite increase. The biotite zone progresses into a paler, chlorite rich rock, which has an increase of both quartz and calcite in the matrix. An increase in frequency of calcite and quartz veins can also be observed. The sulphide assemblage of arsenopyrite, pyrite, pyrrhotite, chalcopyrite, sphalerite, and gold increase in proportion towards the central area of the reef, where pyrite is the dominant sulphide. The sulphide crystals become larger in size with arsenopyrite and occasionally pyrite being idiomorphic. Gold is present as inclusions in arsenopyrite and pyrite as well as free gold. The sulphides have been subjected to both brittle and ductile deformations. Oxides are also present but with less abundance, they include ilmenite and rutile.

The transformation from the metabasalt to the alteration zone can be defined as an increase in gold, sulphides, quartz, calcite, biotite and chlorite as well as a decrease in amphibole and albite. This correlates well with the geochemical data which shows an increase in Au, S, SiO₂, K₂O, CO₂ as well as a decrease in MnO, CaO, Na₂O and Al₂O₃.

The increase in foliation, veining, and geochemical/mineralogical variation towards the central area of the Strike Reef can be directly attributed to an increase in fluid-rock-interaction.

OS06 : WEpo15 : PO
The Genesis of Metamorphogenic Hg-Gold of the SE Block of Kochkar Gold Deposit, Southern Ural

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Kochkar Ore Field is the largest on the Southern Ural by amount of extracted gold. The deposit is connected with the Early Carboniferous Plastovsky dike-like intrusion of adamellites, which is 35x10x6-8 kms in size. The intrusion is broken by the powerful network of fractures and has blocked structure. Three large tectonic blocks with various types of the gold mineralization could be distinguished: Northern Block (NB): ore is poor in sulphides (2 percent), productive association of minerals: gold + galenit + tellurides Bi, Pb, Au. South-Western Block (SWB): ore is poor or moderate in sulphides (3-10 percent), productive association: gold + galenit + bismuthin + sulphosalts Bi. South-Eastern Block (SEB): gold ores are enriched by sulphides (5-10 percent) (galenit, chalcopyrit, pyrit, tetradrit, Sb-sulphosalts Pb) and silver. Large Borisovsky Granite Massive (Late Permian) is situated to the west of the ore field. All rock and ores of the deposit were metamorphized by the thermal influence of the massive. The parameters of metamorphism correspond the amphibole - amphibole-horn facies (NB: P 8.5 to 3 kb, T 600-530°C; SWB 8.7 to 2.9 kb, 590-520°C; SEB 6.3 to 2.4 kb, 530-490°C). The south-eastern block is hypabyssal in the type of mineralization, and less metamorphized. Typical minerals: Fe-tetradrit, boulangierit, Bi-jamesonit, rarely meneghinat, bournonit occur. The native gold is represented by two types and tightly associated with tetradrit (fill intervals between the grains and occurs as visible inclusions in them). Unmetamorphogenic gold is composed of isometric microscopic inclusions up to several mm in diameters in tetradrit and chalcopyrit; rarely in galenit and Pb-Sb sulphosalts. Standard of gold is low, less than 800 units. Composition varies within the single sample or even within the single grain. Large grains of gold are zoned. Their neucleuses are rich of Au (Au_{74.87}Ag_{24.86}Cu_{0.06}), margins - Ag (Au_{71.65}Ag_{27.09}Cu_{0.26}). Low-standard (700 units) metamorphogenic gold fills the cracks and intervals between the grains of tetradrit, arsenopyrit and chalcopyrit associated with Bi-jamesonit. Its composition varies from Hg-gold to

Hg-electrum. The Hg amount in gold reaches 15%. The established changes of mercury and silver amounts along a small crack (Au_{79.65}Ag_{16.28}Hg_{4.10}Cu_{0.09} to Au_{71.68}Ag_{16.23}Hg_{11.40}Cu_{0.03} to Au_{62.08}Ag_{22.74}Hg_{14.95}) testified that mercury was driven off to colder parts of the block. The powder depositions of cinnabarit associated with Mg-calcite and other metamorphogenic minerals were observed on cracks walls of the south-eastern block. Thus, mercury sublimated from more metamorphized ores of the deposit was fixed inside the cracks of less metamorphized south-eastern block. It has resulted in origin of the new type of gold ore with metamorphogenic Hg-gold as a basic component.

OS06 : WEpo16 : PO
The Gondwana Metal- Potential GIS

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The Gondwana Metal-Potential GIS is the product of a collaborative French - South African project between BRGM and CIGCES. It has been developed using ArcView(r) GIS (ESRI(tm)) and SynArc(r) (a BRGM ArcView extension for combining data (Braux, 1997)), and is available as a stand-alone CD-ROM (Gondwana Georama).

The GIS is a global geological and metallogenic synthesis at 1:10,000,000 scale of the Gondwana supercontinent reconstructed at 150 Ma. As such it includes Africa, in its present-day position, Madagascar, India, South America, Antarctica, Australia and the Arabian Peninsula, and represents one third of the world's continents, and contains about 60% of the world's mineral resources.

The Gondwana Metal-Potential GIS is based on two main data layers, that were developed by CIGCES (Wilsher, 1995), and that have been modified and completed by the joint BRGM-CIGCES project: i) the geology layer, which contains more than 18,000 informed polygons (age, lithology, overprint); and ii) the mineral resources layer, which contains more than 15,000 mineral deposits and occurrences, each linked to attributes reflecting their metallogenic and geologic environments (substances, type, age...). These main data layers can be broken down into basic and thematic layers.

The basic layers are represented by four different maps: i) a small-scale summary geological map highlight the Precambrian cratons of Gondwana for large-scale analysis; ii) a medium-scale geological map; iii) a detailed geological map showing faults; and iv) a mineral-resources map. The thematic layers are represented by several types of map at the scale of Gondwana: i) a geographical analysis by element and by associations like Au-Fe-Mn, Cu-Pb-Zn or Ni-Cr-Sn-W; ii) these maps are accompanied by chronological analysis diagrams; and iii) gold-potential maps calculated on the geological polygons or on lithological contacts.

The Gondwana Metal-Potential GIS has, in particular, been conceived for academic or industrial research as an aid to understanding the Gondwana metallogenic provinces. However, the addition of specialized realisations, such as an animation showing the reconstruction of the Gondwana, also makes it useful as new-technology tool for education.

Braux C. *Actes de la première conférence française des utilisateurs ESRI - Paris. Collection Hermes*, 11 p. (1997).
 Wilsher WA, 1995. *The Distribution of Selected Elements within Mineral Deposits throughout Gondwana with Geodynamic Implications*. Ph.D. dissertation, 240 p. University of Cape Town, South Africa. (1995).

OS06 : WEpo17 : PO
GIS Andes: Mining Districts

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Mining Districts is one of the 13 layers of GIS ANDES. The 162 metal mining districts correspond to polygons of very varied size (from several tens to 1000 km²) contained within the borders of the seven countries concerned: Venezuela (5 districts), Colombia (12 districts), Ecuador (8 districts), Peru (54 districts), Bolivia (19 districts), Chile (34 districts) and Argentina (30 districts).

Seventeen Belts, divided into 32 Sub-Belts independent of political frontiers and take into account the timewise and spacewise metallogenic evolutions along the entire Andes Cordillera, are denoted either by commonly used geographic or structural names (e.g., Eastern Cordillera, Intra-Andean Graben), or by major geological families (e.g. Andean Neogene-Quaternary volcanics, porphyry-epithermal belt), or by a combination of the two (e.g. S-Peru/N-Chile Cretaceous-Paleocene porphyry/epithermal belt).

The mining districts cover one or more mining centres, mineral showings and/or prospects and, more rarely, zones with no known major deposit or showing but with a true potential for a certain type of mineralization (e.g. Machu-Picchu District with a Sn-W-Au potential). The district name is that of its major deposit qualified by the geological type or subtype (e.g. Río Blanco-Los Bronces: porphyry-epithermal Cu-[Mo]).

The geological lexicon used in the deposit database includes:

10 main families characterizing the most common geological environments so as to enable syntheses at small scales (>1,500,000): e.g. C: *Ore deposits in an acid and alkaline plutonic context.*

54 major classic deposit types to enable a rapid classification and the construction of small-scale (<1,500,000) predictive maps: e.g. C5: *Porphyry and porphyry-related ore deposits: Cu, Au, Mo, Sn, Ag, (W, Pb, Zn...).*

143 sub-types defined over the past 20 years and taking into account the latest metallogenic models for the correct orientation of modern exploration. e.g. C55: *Porphyry wolfram deposit: W.*

The district identification sheet includes:

An index comprising the country code and a sequence number.
 The name of the Belt and possibly the Sub-Belt (cf. lexicon) and that of the District.
 A list of the deposits, showings and/or prospects (cf. lexicon) contained in the district.
 The main (max. 3) and secondary (max. 4) economic substances (cf. lexicon) with the geological reserves (in tonnes) calculated automatically from the deposit data of the district.
 The geological family, geological type(s) and possibly subtype(s).
 The name of the country rock units with lithological description
 Structural control of the mineralization.
 The age of the mineralization and country rock.
 The description of the District.
 The major references.

Cassard, D., 1999. GIS Andes on the WEB: <http://www.brgm.fr/sigand>

OS06 : WEpo18 : PO
GIS Central Europe: The Metallogenic GIS of Central and South-Eastern Europe

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GIS Central Europe was designed and initiated by BRGM in 2000 to be a homogeneous geographic information system for Central and South-Eastern Europe based on original syntheses and compilations. It covers an area of 1.7 million km² and extends for some 1750 km from the West Carpathian Mountains in the west to the Gulf of Antalya (southwestern Turkey) in the east. Some 15 countries are concerned by this synthesis, which includes the Carpathian - Balkan Arc, the Dinarides - Hellenides Belt, the Rhodopean Massif and Western Anatolia.

GIS Central Europe has been conceived as a tool aimed primarily at the mining and academic sectors. For the former it will be an invaluable aid to mineral exploration and mine development, taking into consideration the environmental problems induced by the extractive industry and its downstream activities. For the latter it will aid in developing new metallogenic models, and should contribute to resolving certain R&D problems such as the relationship(s) between the mineralized belts and collision zones, subduction zones, thermal anomalies, etc., or the structural controls of the mineralization, or yet again the spatial and temporal distribution of the paleohydrothermal systems.

GIS Central Europe is thus a tool designed both for creating maps of metallogenic potential - or favorability maps - and for a more global approach to metallogeny.

Layer description (see Cassard, 1999)

GEOGRAPHIC: A DCW(r): geographic base DEM: Two digital elevation models: one oceanic (2' arc) and one continental (30" arc) with a structural analysis of the topography
IMAGERY: SPOT 4 VEGETATION(r) images at 1x1 km
GEOLOGIC MAP COVERAGE: Present state of geological coverage

GEOLOGIC SYNTHESIS: Synthetic geological map at 1:1,500,000 scale and simplified map with morpho-structural domains and main tectonic elements

VOLCANIC: Data on Holocene volcanism
GEOTHERMAL RESOURCES: Based on inventories at present being compiled for the EU
GEOCHEMISTRY: Composition and age of magmatic and volcanic rocks - isotope data

ORE DEPOSITS: Linked to a database under Access(r), using a new metallogenic lexicon and including mineralogical, fluid-inclusion and isotopic data of the main deposits
GEOCHRONOLOGY: Synthesis of existing data, methods used, reliability, references, etc. (collaboration with Utrecht University)

MINING DISTRICTS: Delimitation, magmatic and structural controls, potential, etc.

HEAT FLOW GRAVIMETRIC: Bouguer anomaly calculation; isostatic correction and corresponding residual anomalies; vertical gradient ...

SEISMIC: Distribution of earthquakes in order to better constrain crustal structures

MOHO: Depth contour map
TOMOGRAPHY: 3D model of the lithospheric structure (collaboration with Utrecht University)

SOCIAL AND ENVIRONMENTAL FACTORS

Cassard, D., 1999. GIS Andes on the WEB: <http://www.brgm.fr/sigand>

OS06 : WEpo19 : PO
GIS Africa: A 1 : 2,000, 000-Scale Tool for Sustainable Development

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A Geoscience GIS of the African continent was launched as a scientific project by BRGM in 1998. Its purpose is to exploit, at a synthesis scale of 1:2,000,000 suitable for sustainable development, the large amount of excellent-quality, but commonly scattered, data concerning the Earth sciences (geology, mineral and water resources, etc.) in Africa. GIS Africa began with the construction of (i) a meta-data GIS, known as GEOCARTE, containing information on the availability of public sector map coverages, and (ii) a GIS dedicated to the geology and mineral resources of central

Africa. Both these GISs will be demonstrated. GIS Africa will fill a gap between the very general global syntheses put out by the International Agencies and the very detailed (1:50,000- to 1:1,000,000-scale) geological and mining documents produced by the different countries. The 1:2,000,000 scale of the GIS is suitable for an objective comparative analysis of regional potential. The project aims to produce digital 'sans frontières' syntheses at regional scales that will provide an intermediate step to accessing the detailed documents of the different countries by highlighting the specificities of each State's potential. The GIS emphasizes (i) certain 'metalliferous peaks' that represent 'flash' marker levels within the geological time scale, and (ii) the Precambrian collision belts, accentuating the role of the forelands, which host world-class metal deposits (Au, Mn), and the emplacement of different types of mineralization at precise periods in the geodynamic evolution of these belts. The GIS's updated and homogenized data are stored in relational databases under Access97(r) and include more than 60 specifically adapted lexicons and glossaries. Data extraction is through MapInfo(r), ArcInfo(r), ArcView(r), etc., and processing is by SynArc(r). The GIS GEOCARTE provides information (metadata) -type, author(s), date of publication, scale, format, publisher, owner, etc.- concerning 5000 public-sector maps; these represent about 90% of the geological maps and 50% of the mineral-resource and hydro-geological maps of Africa. The GEORAMA version of GIS Africa, which uses Geokiosk(r) (ESRI France), enables both thematic (geology, hydrogeology, mineral resources) and geographic (by country or town) searches. The progress of the digital regional syntheses at 1:2,000,000 scale will be presented along with a demonstration of the GEORAMA version of the GIS relative to central Africa, and showing (i) a harmonized and georeferenced geology layer integrating data from the geology polygons and fault vectors and designed to display the stratigraphic structure of the formations combined with their depositional environments, (ii) the boundary 'matches' that enable geological marker formations to be followed across different countries, and (iii) the major mineral deposits (classes A, B and C).

OS06 : WEpo20 : PO

SignateX:
A Deposit-Model Base for Mineral Exploration

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SignateX is a deposit-model base developed under Oracle by BRGM, the French Geological Survey. It contains models of metalliferous and other (gold, PGE, base metal, kaolin, etc.) deposits that are considered as classic or emergent. The models are grouped into major deposit families (Table 1) for which the classification is based on a reasoning that takes into account the substance, the geodynamic context of the mineralization (epigenetic versus syngenetic) and specific regional characteristics.

Family: Epithermal gold deposits Model type: low-sulfidation type gold Model subtype: Tertiary low-sulfidation type gold of the Andes Cordillera.

Family: Base-metal deposits associated with volcanogenic massive sulfides (VMS) Model type: VMS hosted by a Phanerozoic bimodal series Model subtype: Devonian-Dinartian VMS of the South Iberian Province.

Table 1: Classification of deposit models in the SignateX base

Each deposit model is composed of a set of metallogenetic suited to the different major exploration stages, i.e. geological objects (veins, faults, granite cut by veins, etc.) that can be used as pathfinders in the search for mineral deposits or favourable prospects. Each metallogenetic is characterized by a range of specific signatures obtained through adapted exploration tools in the fields of geology, geophysics, geochemistry and remote sensing.

The SignateX base is thus i) a decision-aid tool for mineral resource exploration because it contains pertinent information concerning the model deposits and the suitable approaches for their exploration, and ii) a deposit prediction-aid tool in that the SignateX deposit model can be exported to a GIS dataset for predictive mapping.

OS06 : WEpo21 : PO**Mineral Resources in the Central Part of the Serbo-Macedonian Metallogenic Province**

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In the Serbo-Macedonian metallogenic province have been enclosed mineral deposits formed in the area of confrontation of Dinarides and Karpatho-Balkanides during the period of closure of Vardar-anatolian ocean (one part of Tethys) at the end of Jurassic. Spatially, metallic mineral deposits in this province, were deposited in the eastern and northeastern margins of Dinarides, Vardar zone and Serbo-Macedonian province. These deposits take place between Dinaride metallogenic province on the west and Karpatho-Balkanian metallogenic province on the east. To the south, Serbo-Macedonian metallogenic province continues in Macedonia, Greece, Turkey, partly in Bulgarian Rhodopes, while to the north this province dive under Panonian sediments and in the northwest direction can be followed up to the Alps. In the group of the endogene mineral deposits, dominate Pb-Zn and Sb deposits, also important are Cu, Au, Ag, Bi, Cd, Mo, partly Fe and Mn, very specific are Tl and As while U, W, Sn and Hg deposits are very rare. In the crust of weathering on the serpentine, important are: Ni, Fe, Fe-Ni and Mg. In the shale rocks very important are boxites (Al) while in the unconsolidated sediments important are Au, Sn and locally Nb-Ta deposits. With tertiary subvolcanic-hypobasalt intrusions of calc-alkaline magmas are connected numerous deposits and occurrences of metallic minerals (Pb, Zn, Sb, Cu, Mn etc.). Economically important are: (a) Zone of magmatic complexes localized through unstable northern, north-eastern and eastern margin of Dinarides and ophiolites of the Vardar zone. (b) Zone of magmatic complexes, located in deep dislocations in the middle part of Vardar zone near by ophiolites (serpentinites). This zone is starting from Fruska Gora on the north and goes through Slavonia-Sumadija (metallogenic zone), Kopaonik (metallogenic zone) up to the Macedonia on the south. In this zone are present economically very important Pb-Zn deposits. (c) Zone through the regional dislocations on the western margin of the SMM with occurrences of magmatic complexes that can be followed from Crni Vrv on the north, through Lece and Novo Brdo up to the Bucim in Macedonia on the south. Metallic mineral deposits are located in some settings in Serbo-Macedonian massif, mesozoic terranes western from SMM and in magmatic complexes. There are known two more subparallel zones: Tupal dislocation, localized through the western margin of SMM and Vardar zone, characterized by serpentinites and more eastern Merdar dislocation. Through Tupal dislocation were formed smaller magmatic complexes connected with formation of the ore field Sijerinska Banja and ore field Bujanovac. To this structural and magmatic zone belongs Zletovo magmatic complex. (d) Metallogenic zone of Besna Kobila-Osogovo is also very important regarding metallic mineral deposits. In this metallogenic zone are located numerous magmatic complexes (Surdulica granitoid massif and numerous, small intrusions of dacitoid andesites and quartzlatites) and (para) genetic mineralizations of Cu, Pb-Zn, W, Au, U etc., connected to them.

OS06 : WEpo22 : PO**Structural Classification of Microscopic Gold in Orogenic Au Deposits from Sudetes – The European Variscan Belt**

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Studies in reflected light and microprobe investigation of gold-bearing polymetallic ores and quartz veins from Phanerozoic orogenic gold deposits located in Sudetes allowed to elaborate the classification of microscopic gold ('visible gold'). Microscopic gold is divided into 7 main groups (1- Au inclusions in sulphides; 2- Au inclusions in sulphides in association with other sulphides; 3- Au in microfissures; 4- Au on sulphides surface; 5- Au in caverns; 6- Au as a free gold; 7- Au within pseudomorphoses) and 19 subgroups (1a- monomineral Au inclusions in sulphides; 1b- polymineral inclusions of Au with Ag, Te or Bi minerals in sulphides; 1c- mono- and polymineral Au inclusions within sulphides; 1d- pole inclusions of Au and Bi minerals in sulphides; 2a- Au inclusions between B sulphide hosted by A sulphide; 2b- Au inclusion in B sulphide formed inclusion in A sulphide; 2c- Au between B

and C sulphide inclusions hosted by A sulphide; 3a- Au within microfissures in sulphides; 3b- Au in sulphides veinlet cuts sulphides; 3c- Au microveinlets in cataclased sulphides; 3d- Au in quartz ±carbonates veinlet cuts sulphides; 4a- Au between sulphides; 4b- Au intergrowth with sulphides; 5a- Au within cavern in quartz; 5b- Au in voids within sulphide; 5c- Au in caverns within mining slugs; 6a & 6b- individual Au grains ('free gold') in rock with/not electrum; 7a- Au in pseudomorphoses after primary sulphide.

The microscopic gold indicate also for Au redistribution from its primary concentration within arsenic minerals ('invisible gold'). In the most studied cases at least two generations of microscopic gold occurs: the oldest one as inclusions in sulphides (first generation) and younger within microfissures of ores minerals, in veinlets or as a free gold distributed in voids (second generation). The successions of microscopic Au generations are correlated with regional tectonic events. In weathered zones of Au-bearing sulphide deposits, the youngest generation of microscopic gold within Fe-oxides pseudomorphoses appear.

Native gold, electrum, and less common malodonite are representing Au minerals. They are in close association with Bi minerals (native bismuth, bismuthinite) and/or with Te minerals (hessite, tellurobismutite, hedleyite, pilsenite). Native gold beside Ag and Bi admixtures may contains Te, Cu and Se traces.

Mikulski SZ, *Przegląd Geologiczny*, **48**, 911-916, (2000).

OS06 : WEpo23 : PO**A 3-D Model for a Banded Iron Formation Hosted, Epigenetic Gold Mineralisation at Ajjanahalli, South India**

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The Ajjanahalli gold mine is located 80 km to the south of Chitradurga at the eastern margin of the Chitradurga greenstone belt. It is part of the south Indian Dharwar Craton. The belt mainly consists of volcanics, both clastic and chemical sediments of the Chitradurga Group and is rimmed by the Peninsular gneiss.

Six benches of the open cast were mapped and structural data were collected to clarify the genesis of the deposit.

The following lithological sequence was recognised during field work. Metabasalt (MORB) was found at the base of the succession. It is overlain by phyllites and oxidic BIF. Quartz-sericite schists are at the top.

Metabasalts consist of actinolite, albite, calcite, and chlorite; phyllites mainly of sericite and chlorite; quartz-sericite schists of quartz, sericite, chlorite and detrital plagioclase and ilmenite. Therefore, lower greenschist facies metamorphism is evident. BIF is showing mesobands of magnetite and quartz.

Careful structural mapping has shown, that the whole succession is folded into an anticline. Fold axes of second order isoclinal and chevron folds are dipping moderately to the north. To the east of the deposit, sheath folds are developed in an oxidic BIF horizon. The direction of long axes of this folds indicate a strike slip shear zone. In the anticlinal structure ferrous carbonates and sulphides are associated with gold and are replacing primary magnetite. Only where both suitable structures and lithology are present, economic gold mineralisation can be expected. This indicates an epigenetic nature of gold mineralisation.

However, a syngenetic model for the gold mineralisation at Ajjanahalli, including the development of sulphide and carbonate facies BIF, was proposed by some authors (Hussain et al., 1996, Khan et al., 1996). Exploration for gold on this background has caused problems in order to define possible targets.

The change in the genetic model made it necessary to develop a 3-D model of the orebody. The relationships between structure and mineralisation were visualised giving a better understanding for mining and planing further exploration activities.

Hussain, S.M.; Naqvi S.M.; Ramachandra K.T.; Sawkar R.H. & G.R. Group, *Proc. Symp. Gold Resources of India*, 258-265, (1996).

Khan, R.M.K.; Das Sharma, S., *Proc. Symp. Gold Resources of India*, 271-273, (1996).

OS06 : WEpo24 : PO**Mineralogy, Fluid Inclusion Study, and Re-Os Dating of Mo-Bearing Mineralization from the Vlaikov Vrah Porphyry Copper Deposit, Panagyurishte District, Bulgaria: Preliminary Results**

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The Vlaikov Vrah porphyry copper deposit is located in the southern part of the Panagyurishte district, Srednogie metallogenic zone, Bulgaria. The deposit is associated with granodiorite to quartz diorite porphyry which is intruded along the contact of rocks from the Elshitsa volcanic field (andesites, dacites, breccias and tuffs) and the Precambrian (?) metamorphic and Palaeozoic granitic basement. The intrusion extends in a subequatorial direction and is intersected by later dacitic dykes. The vein-like and disseminated copper ore mineralization is hosted by all rock types. The mineralization is accompanied by both - K-silicate and phyllic alteration. Molybdenum was deposited at a very early stage in the evolution of the hydrothermal system, followed by copper. The studied mineralization occurs in 5 to 10 cm wide veinlets, crosscutting late-magmatic apatite-pegmatitic veins and the granodiorite. It consists of quartz, molybdenite, titanite, rutile, muscovite, pyrite, chalcopyrite, and isolated inclusions of pyrrhotite. The early hydrothermal fluids are represented by quartz-hosted high-temperature (325-370°C) and high-salinity (up to 48 wt% NaCl equiv.) liquid-rich, and medium- to high-temperature (260-310°C) and low-salinity (4.7-5.9 wt% NaCl equiv.) fluid inclusions with variable liquid / vapour ratios. High-salinity fluid inclusions usually contain numerous solid phases, including NaCl, anhydrite, chalcopyrite, hematite and two unidentified solids. The studied fluid inclusions are interpreted to represent an orthomagmatic fluid which boiled, causing the sulphide precipitation. Re content of molybdenite is low (0.02-0.96 wt%). Preliminary results from Re-Os dating on molybdenite show that the mineralizing process took place about 80 Ma ago.

OS06 : WEpo25 : PO**Efficient Technology of Ore Minerals Investigation of PGE-Bearing Deposits – Case Study**

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Few examples of ore minerals study from PGE-bearing deposits of various genesis are represented. The use of hydroseparator of original construction allowed to receive thin (<60 μm) products (with the weight 5-7 mg), which concentrating (a 10 000 times and more from initial sample of 50-500 g) opened grains of heavy accessories, in the first order, platinum group minerals (PGM). Grains of PGM were described in polished sections of mentioned products: diagnostics of mineral species, determination of chemical composition and sizes of individual species, photos of PGM, registration of mineral assemblages and interrelations with other minerals, reconstruction of mineral parageneses. This key information about PGM of heavy concentrates is compared with that of typical ores of the same samples.

1. For the first time, properly Pt-mineral (sperryllite), 8 Pd minerals (cabrite, taimyrite, atokite, majakite, arsenopalladinite, mertieite II, froodite, unnamed Pd₁₁As₂(Pb,Hg)₂), 4 minerals of Au (tetra-aurocupride, electrum, Au₂Ag, kustelite) and 5 minerals of Ag (silver, stromeyerite, jalpaite, hessite, argentopentandite) - 98 grains in total - were determined in carbonatitic ores of the Loolecop deposit (Phalaborwa Complex, RSA) in sulfide flotation

concentrate (0.23 Pt, 0.40 Pd, 2 Au in ppm). These minerals belong to two parageneses of sulfides in carbonatites: 1) cobalt pentlandite-chalcocopyrite-bornite, 2) millerite-chalcocosine group minerals. They crystallized in temperature interval of 480-80°C.

2. PGE-mineralization of two types of sulfide ores from Yoko-Dovyrensky dunitite-troctolite-gabbro Layered Massif (Northern Pribalkaise, Russia) was studied: 1) low-sulfide type ore from anorthositic horizon (wt.%: 0.20 Ni, 0.40 Cu, 0.91 S; ppm: 1.56 Pt, 3.20 Pd, 0.04 Rh, 0.01 Ru, 0.099 Ir, 0.01 Os); 2) Cu-Ni sulfide ore (wt.%: 1.81 Ni, 0.40 Cu, 17.0 S; ppm: 0.12 Pt, 0.73 Pd, 0.007 Ru). It was determined that PGE-mineralization are contrasting different. Moncheite, tetraferroplatinum and potarite are predominant in the first type; moreover, kotulskite, paolovite, sobolevskite, sperrylite, isoferroplatinum, atokite, majakite, zvyagintsevite, mertieite I, telargpalite (?), unnamed (Pd,Cu,Fe,Hg)₂S(Te,Pb) were found (in total 66 grains); trace concentration of Pd in the pentlandite of ore is 360 ppm. In second type (in total 59 grains were found), sperrylite and sudburyite are dominant; in addition geversite, mertieite I and unnamed Pd₂Sb were discovered; trace concentration of Pd in maucherite in ores is 0.12 wt.%. Probably, these two ore types from Yoko-Dovyrensky Massif have different origin.

The work was done under the financial support of International Science Foundation INTAS, Project 97-0722.

OS06 : WEpo26 : PO Geology, Mineralogy and Au-PGE Geochemistry of Kizildag Listwaenites (Middle Anatolia)

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Listwaenites, which are generated by the silicification - carbonatization alterations of the ultramafic rocks which lies on the west part of Refahiye Ophiolitic Melange (Kizildag Ophiolites) have been investigated in Kizildag, which lies between Imranli (Sivas) and Refahiye (Erzincan) area. These rocks mainly lies in the fault and shear zone of the serpentinized ultramafic rocks. Additionally, they form like laterites at the top of the ultramafic rocks or crushed and disordered blocks. The mineral paragenesis of the Kizildag Listwaenites were investigated by X-Ray Diffractometer and they mainly consist of ? - quartz + dolomite; ? - quartz + galenite + chalcocopyrite; ? - quartz + ilmenite; ilmenite + ? - quartz + gersdorffite; dolomite + quartz; dolomite + calcite + quartz. They were analyzed for Au and PGE and didn't get any enrichment. But in some areas they include different shaped sulphurized zones and some of them include some Ag enrichments. The listwaenites are mainly as a 2. Type of listwaenites and they can't be enriched by the Au.

KEYWORDS: Kizildag, Listwaenite, Au - PGE.

Buisson G, Leblanc M, *London Inst. Mining Metallurgy*, 121-132 (1986).

Buisson G, Leblanc M, *Economic Geology*, **82**, 2091-2097 (1987).

Clark AMS, *Mineralum Deposita*, **13**, 221-234 (1978)

Coleman RG, *J. Geophys. Resources*, **86**, 2497-2508 (1981).

Evans BW, Frost BR, *Geochim. Acta*, **39**, 959-972 (1975)

Jagoutz E, Palme H, Baddenhausen H, Blum K, Cendales M,

Dreibus G, Spottel B, Lorenz V, Wanke H, *Geochim.*

Cosmochim. Acta, **Supplement 11**, 2031-2050 (1979).

OS06 : WEpo27 : PO Metamorphism of the Pansky Tundra PGE-Bearing Layered Intrusion (Kola Peninsula)

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Rocks of the Pansky Tundra Intrusion have been metamorphosed to a variable degree. Most part of the intrusion is almost unmetamorphosed, or metamorphosed at the green-schist facies (plagioclase-actinolite-hornblende-clinozoisite-biotite) and bears relics of earlier autometamorphism (plagioclase-pyroxene-cummingtonite+actinolite) and the actinolite-pumpellyite facies metamorphism (plagioclase-pyroxene-pumpellyite-actinolite-clinozoisite). The highest metamorphic grades, down to the epidote-amphibolite facies (plagioclase-actinolite-

actinolite hornblende-hornblende-clinozoisite-epidote-titanomagnetite-sulfides) and the initial stages of the amphibolite facies, are found (1) at the contact with the host volcanic-sedimentary Tundra-Varzuga structure (in the south) and the White Tundra granitoids (in the north); (2) in rocks of the Lower Layered Horizon, which contain PGE and sulfide mineralization; and (3) along tectonic fault zones. The origin of the sulfide ore material and its association with early metamorphic silicate minerals (cummingtonite, clinozoisite, biotite, hornblende), as well as the mode of occurrence of sulfides (as tight intergrowths in silicate metamorphic minerals and as inclusions in them) suggest that the initial accumulation of the ore material could take place during the autometamorphic (late-magmatic) stage of the Intrusion development. The ore component was not diluted during the superimposed regional and dislocation metamorphism, but was only recrystallized and partially redistributed. The currently observed mineral silicate parageneses are originally metamorphic and they are related to the superimposed processes that resulted in the formation of postmagmatic mineral associations.

OS06 : WEpo28 : PO Geological Structure and Genesis of the Urals Diamond Deposits

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One of the main kind of the Urals diamond deposits are the erosive depressions, which are filled by removal products from surrounding territory. The depressions are disposed on the elevated part of the relief and confined to the quartzitic sandstone. They have sizes to 1000 m long to 500 m width and to 40 m depth. The upper layer of the sediment in the depressions, thickness to 30 m is represented by brown clay loam. The clay loam layer is underlain by unsized gravelly, pebbled and fragmental material. The main number of diamonds is concentrated in the basal section of the depressions. The source of the diamonds in the erosive depression deposits is quartzitic sandstone impregnated by iron oxide and clay material. There are two finds of diamonds in the Silurian quartzitic sandstone enriched by iron oxide and clay material and no one finds in the primary sandstone. The zones of impregnation of the primary quartzitic sandstone by iron oxide and clay material is controlled by the faults. The iron oxide and clay material were transported by alkaline clay suspension, which contains Fe₂O₃ in ferrate form: (Na,K)FeO₄. The ferrate iron complexes interact with quartzitic sandstone and quartz cement is replaced by hematitic one: [(Na, K) FeO₃] + SiO₂ (r) Fe₂O₃ + [(Na, K) SiO₃] solution solution. The erosive depressions are formed as a result of weathering of quartzitic sandstone enriched by iron oxide. The weathering leads to transformation of hematitic cement to goethitic ones. The volume of the cement is enlarged and sandstone is transformed to quartz sand. The weathered quartzitic sandstone is eroded by water and depression is formed. The carst cavities formed in the carbonate rocks on the contact with quartzitic sandstone are combine with erosive depressions in the sandstone and form common depressions. The diamonds outwashed from the quartzitic sandstone do not lose and accumulate in the basal section of the depression. There is process of sizing of diamonds when they accumulate. The big crystals go down through the clay loam layer, but the little crystals (less than 1.0 mm) remain in the clay loam. The primary source of the Urals diamond is unknown. Their morphological features and the presence of the associated minerals typical for kimberlites allows us to suppose they are kimberlite ones.

OS06 : WEpo29 : PO Relationships between the Segmentation of Urals Paleozoic Structure and the Geological Setting and Productivity of Urals Massive Sulphide Ore Fields

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The ore regions in the Urals fold belt are situated in three submeridional metallogenic zones (Taghilo-Sakmarskaya, Magnitogorsko-Mugodjarskaya and Eastern-Uralian) extended up to 1000 - 1500 kms with width of tens kms.

The productive volcanic sections include the following complexes: tholeiitic basalts (element of ophiolitic association), bimodal rhyolite-basalt and andesite-basalt of calc-alkaline series. The forming of the complexes takes place at Ordovician - Devonian in the marginal seas, island arcs, inter-arcs and back-arcs basins flanking the Urals paleocean [Ivanov, 1997]. There is observed a segmentation of island-arc structures expressed by sublatitudinal dislocation [Zaykov et al. 1996, Frolova and Burikova, 1977]. On the map of a deep Earth crust structure for the Urals [Berlyand, 1983], some oval uplifts of a basalt layer with a long axis of 150-200 kms are revealed. They are divided by sublatitudinal faults expressed by sinvolcanic depressions, packages of dikes, and intrusive massifs [Zaykov et al. 1996]. By similarity with analogous structures of modern island arcs there are reasons to believe, that the formation of segments has taken place under island-arc stage of development of a folded belt. The apical parts of uplifts correspond to the central raised parts of segments. In the investigated part of the Urals folded belt, on the basis of the analysis of large-scale geological maps and lateral zonation of volcanogenic sedimentary formations the authors have established 8 segments of length 200-250 kms. The southern segments are complicated by cross dislocations approximately in their apical parts. Within the limits of zones, massive sulphide deposits ore fields are restricted to fragments of paleoceanic ridges or groups of central type paleoceanos in central parts of paleo-island-arc segments and near cross dislocations. Ore fields have width of 5-25 kms and length of 20-60 kms and controlled by local structures similar grabens and rift valleys. By prevailing type of Urals massive sulphide deposits ore fields are divided into four groups (Urals, Kuroko, Cyprus, Besshi). The quantitative characteristics of the Urals massive sulphide deposits are given by Popov [1997], Kontar' & Libarova [1997]. The total resources of copper and zinc (extracted + reserves) are estimated in 65 m. ts. The distinct decrease of reserves on a direction from southern to northern segments is evident. Two massive sulphide-bearing zones are unique: Sibay-Gay in the III segment and Uchaly-Alexandrinka in the IV segment. On resources they a little below the Iberian Pyrite belt.

OS06 : WEpo30 : PO Promising for Pt Mineralization, Precambrian Basic-Ultrabasic Massives of Transbaikal Region, Siberia, Russia

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Southern Siberia is the Russia's third platinum province. Deposits are located in the basic-ultrabasic layered massives of the great Baikal-Okhotsk plutonic belt (3,000 km). This paper concerns some intrusions with sulphide and titanomagnetite mineralizations. The Chiney pluton (3 km thickness) provides the most considerable interest in respect of economic copper (with Co, Ni, Au, Ag, PGE) and unique vanadium (with Ti, Fe) mineralizations: nowadays this is a greatest V deposit in Russia. The major pluton's features are basic composition of rocks and beautiful layering. Sulphur ores is enriched in Pd (Pt/Pd = 0.6, Pt+Pd=300 ppm). A very copper rich composition is typical for Chiney ores, Cu/Ni ratio varies from 3 to 100. PGE occur as own mineral species (sperrylite, froodite, michenereite, merenskyite et ctr.) and as isomorphous admixture in some minerals (niccolite, maucherite and cobaltite). Luktur massif is similia the Chiney pluton. It is located in the Chara depression and has thickness 1.7 km. Coarse-grained leucogabbro dominate in its bulk, so there are melagabbro and pyroxenite. All rocks contain titanomagnetite (up to 15 vol.%). Sulphide mineralization is characterized by very low Cu/Ni ratio (0.1). Ore mineral assemblage comprises pyrite, chalcocopyrite, pyrrhotite and Co-poor pentlandite. PGE content in disseminated sulphide mineralization ranges up to 500 ppb, including Rh of 20 ppb and Ir of 30 ppb. The Sludinsky massif is located in the north-western Baikal area. It is mainly composed of gabbro-norites with disseminated and massive Fe-Ti ores. The ore mineralization is formed by ilmenite (90 - 95%) and pure magnetite (5 - 10%), without Ti and V in terms of those the Chiney pluton. Sulfides are very rarely found, being represented by hexagonal pyrrhotite, pentlandite (2 - 3 wt% Co), and chalcocopyrite. Their total content does not exceed 3 vol.%. In spite of such low sulphide concentration, the ores are enriched by Pt+Pd = 410 ppb. The Tonky Mys massif is situated near the Sludinsky massif and comprises anorthositic, gabbro and peridotites interlayered. Fe-Ti oxides, especially ilmenite, are hosted by pegmatoid gabbro and in fine-grained pyroxenite dykes. Chalcocopyrite, pentlandite and troilite were recognized in these rocks. Pt and Pd are graded at 50 and

410 ppb, respectively. The Angashan intrusion is represented by a little block 2 x 3 km. It consists of layered pyroxenite and gabbro containing ilmenite-titanomagnetite ores (with apatite). Titanomagnetite is very similar to that observed in the Chiney massif-this mineral contains up to 1.65 wt% of V₂O₅. PGE concentrations fluctuate: Pt = 40 - 80 ppb and Pd = 50 - 250 ppb. These investigations performed allowed us to reveal enhanced and commercial platinum-bearing capacity of some basic-ultrabasic intrusions in Transbaikalia.

OS06 : WEpo31 : PO PGE-Cu-Ni Ore Deposits of Volcano-Intrusive Ore-Bearing Complexes

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1. Genetic type of sulfide PGE-Cu-Ni ore deposits consists on two ore assemblages, manifested during different metallogenic epochs in geological history of the Earth: deposits of large layered intrusion (Bushveld, Stillwater, Monchegorsk, etc.) and volcano-intrusive assemblages, linked with areas of continental rifting or trap provinces. Both of them have evolved in the within-plate situations.

2. PGE-Cu-Ni deposits of volcano-intrusive assemblages were formed during 4 epochs of ore formation: (i) Neoproterozoic (greenstone belts: Norseman-Wiluna, Australia; Abitibi, Canada; Belligwe, S.Africa, etc.); (ii) Paleoproterozoic (Pechenga Structure, Baltic Shield); Neoproterozoic (Midcontinental Rift, complex Duluth, Canadian Shield); Mesozoic (Noril'sk region, Siberian Traps; Insizwa, Africa). The most widespread type of ores of volcano-intrusive assemblages, especially in the unique Noril'sk region, is sulfide mineralization in layered sills and lenticular bodies. Disseminated ores gravitate towards near-bottom parts of intrusions. The most high concentration of sulfides are fixed in picritic and taxitic gabbro-dolerites, and increased volume of ores coincide with maximum of intrusion thickness. Massive ores are located in rocks of the lower endocontacts and underlying wall-rocks, or rarely occur in the rocks of upper endocontact also. The most variability of morphological types of ore bodies (plate-like veins and blocks, lenses, stockwork-vein mineralisation) is characteristic for deposits of unique Talnakh ore field (Noril'sk). These bodies are surrounded by streaky-disseminated ores. Inner structure and zonation of the massive PGE-Cu-Ni ores associated with evolution and crystallizing differentiation of sulfide melt, which took place after crystallization of the intrusions. Low-sulfur PGE ores were found in the upper marginal zone of Noril'sk intrusions, where they located between anorthitic gabbro-dolerites and underlying gabbro-diorites (Dyuzhikov et al., 1988; Sluzhenikin et al., 1994). These ore-bearing horizons could be analogs of reefs in the large layered intrusions.

3. Thus, the PGE-Cu-Ni ore deposits of volcano-intrusive assemblages are linked with relatively small sill- or lenticular coarse layered intrusions which are characterised by disseminated and massive sulfide mineralization and low-sulfur PGE mineralization. Features of the large layered plutons are attractive rhythmic layering, presence of mainly disseminated mineralization and extended persisted PGE- and Cr-bearing horizons

Dyuzhikov OA, Distler VV, Strunin BM et al, *Geology and metallogeny of the Noril'sk region. Nauka, Moscow, 280, (1988).*

Sluzhenikin SF, Distler VV, Duzhikov OA et al, *Geology of Ore Deposits, 36, 195-217, (1994).*

OS06 : WEpo32 : PO The Bruvann Cu-Ni Ore Deposit, Rana Intrusion, Norway Isotopic Evidences of Crustal Contamination

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Bruvann is the most important nickel ore deposit of Norway with 43 Mt of ore. It is a Ni-sulphide-bearing magmatic deposit associated with an ultramafic-mafic complex emplaced into graphite-bearing schist. Graphite content in ore is up to 30%. The first sulphur isotopic results of Boyd and Mathiesen (1979) showed an obvious sulfur crustal contamination in the sulphide-poor and graphite-rich samples, and a sulphur magmatic signature in sub-massive to massive ore samples. Complementary oxygen, carbon and sulphur isotopic data realised on recent sampling from drill-holes confirm the important role of graphite-bearing schist in the ore deposition. The $\delta^{18}\text{O}$ of mineralised and barren ultramafic-mafic rocks are quite homogeneous and around +8‰ (SMOW); That indicates an important contamination of magma by schist, probably favoured by a long activity of the magmatic chamber. The $\delta^{34}\text{S}$ of sulphides from disseminated ore and massive ore are quite close to 0‰ (CDT) and different from the $\delta^{34}\text{S}$ of sulphides from schist (around -10‰); that strongly suggests a magmatic origin of sulphur. The $\delta^{13}\text{C}$ of graphite ranges between -14 and -21‰ (PDB). The highest values, near -14‰, are measured in sulphide-poor mafic rocks; they are similar to mantle carbon values given by literature. The lowest values, near -21‰, are measured in graphite-rich mineralised samples; They are quite similar to $\delta^{13}\text{C}$ of graphite in schist. The combined isotopic data show the complexity of the assimilation/contamination mechanisms, for a large part related to the disconnection between the magma and the volatile phase during the magmatic cooling. The isotopic contamination of the magma by schist is realised by assimilation processes and also by isotopic exchanges between schist and magma via a volatile phase. In the case of a graphite-rich and sulphide rich host-schist, the emplacement of magma at 1200°C induces an important thermal metamorphism, that induces dehydration and desulphuration of schist and the formation of a H₂O-CO₂-CH₄ fluid. The large size of the magmatic system and the associated heat flow can largely favour fluid circulation and isotopic exchanges.

OS06 : WEpo33 : PO Statistical Characteristics of Oscillatory Zoning of Cave Calcite- Popcorn from Hungary

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Grey level optical variations in cave calcite and PIXE trace element data were investigated using statistical methods. Spectral analysis of grey level shows a pronounced periodicity. Fractal geometry applied to the grey level variation gives Hurst exponent of 0.65 by measured width and spectrum-power methods, indicating persistent behavior. The grey level is strongly correlated with Sr concentration. The Sr content is anti-correlated with Fe content. This means that Sr-rich zones are light and Fe-rich zones are dark. Spectral analysis of PIXE data has found that Fe distribution and Sr distribution are periodic. Other trace elements (As, Cu, Ni, Zn) do not show a periodicity. This suggests that 1) the experimental noise level for these elements is too great, or 2) their substitutions is decoupled from Fe and Sr. The zoning profiles of As, Cu, Ni and Zn can be described in term of self-affine fractals only at length scales smaller than 1 mm, where they have Hurst exponents in range 0.15 - 0.36. Profiles of Fe and Sr can be described in term of self-affine fractals at any length scales and they have persistent behavior (H>0.5) at length scales smaller than 0.1 mm.

