

## Program and abstracts

# Nordic Mineralogical Network, Annual Meeting, June 2008

Natural History Museum, University of Oslo

Only the presenters are listed in the program - full author lists are found in the abstracts.

### Monday, June 16

18.00 Reception at the Geological museum with pizza, beer, etc.

Tom V. Segalstad: Introduction to the history of the museum and mineralogical-geological research in Norway

Rune Selbekk, Reidar Trønnes: Tour of the mineral exhibit and research labs

### Tuesday, June 17

0900-0940: Tonci Balic-Zunic: Plenary meeting of the NMN, short NMN-presentation, review of recent and planned activities, budgetary situation.

0950-1015: Tom Andersen, Oslo: Composition and parageneses of Na-Ca-Nb-Ti-Zr sorosilicates in nepheline syenite pegmatites in the Larvik plutonic complex, Oslo Rift

1020-1045: Rune Selbekk, Oslo: Formation of corundum megacrysts during incongruent melting of plagioclase in SiO<sub>2</sub>-undersaturated rocks at high T

Coffee, tea, fruit

1110-1135: David Cornell, Gothenburg: Zircon dating reveals a Archaean crust beneath the Kalahari sand

1140-1215: Reidar Trønnes, Oslo: Mineralogy and dynamics of the Earth and the terrestrial planets.

Lunch

Invited lectures:

1315-1400: Svein Stølen, Dept of Chemistry and Centre for Materials Science and Nanotechnology, University of Oslo: An introduction to first principles computational mineralogy and mineral physics

1410-1455: Truls Norby, Dept of Chemistry, University of Oslo and FERMIo: Hydration and proton transport in perovskites

Coffee, tea, fruit and posters

1545-1610: Jörgen Langhof, Stockholm: Preservation status of the mineral collection at the Swedish Museum of Natural History

1615-1640: Nigel Cook, Oslo: After the mining is over: Mineral deposits and the role of museums

1645-1730: Reidar Trønnes: Field trip background: Evolution of the Oslo Rift

18.00 Dinner at Smia galleri (<http://www.smiagalleri.no/>) at Vålerenga (Opplandsgata 19, across from (west of) Vålerenga kirke)

### Wednesday, June 18

Field trip to the famous mineral occurrences associated with pegmatites in the southern larvikite massif of the Oslo Rift (Langesundsfjorden and Tvedalen areas). Main field guide: Alf Olav Larsen

0715: Departure from NHM, 0725: Departure from Haraldsheim

Drive to the Helgeroa harbour. Boat trip to pegmatite localities on islands in Langesundsfjorden

Lunch en route

Drive to the Tvedalen larvikite quarries. Inspection of pegmatite dike in the Sagåsen quarry. Sampling opportunities on the quarry waste dumps. Return to Oslo

### Thursday, June 19

0900-0950: Tonci Balic-Zunic: Plenary meeting – the future of the network ?

1000-1025: Jaanika Niitsoo, Tallinn: Phylogenetic and individual bioapatite properties variation

1030-1055: Hans Dieter Zimmermann, Aarhus: White cement: clinker phases, mineralisation and nodulisation

Coffee, tea, fruit and posters

1130-1155: Tom V. Segalstad, Oslo: Genesis of Pb-Zn-Ba vein mineralizations in Svalbard, Norwegian Arctic

Lunch

1300-1325: Tom V. Segalstad: Genesis of the Kongsberg Silver Ore Deposit, Southern Norway

1330-1355: Nigel Cook: In situ LA-ICP-MS investigation of trace elements in sphalerite

1415-1615: Possible group discussions (coordinating group). Alternative option: Geological tour of downtown Oslo (building stones, etc.). Guide: Tom Andersen

### Friday, June 20

Field trip to inspect Oslo Rift tectonics and a cross section through the Oslo Rift stratigraphy (Cambro-Silurian sediments, late Carboniferous sediments and lavas). Field guide: R.G. Trønnes

09.00: Departure from NHM

Morberg and Nærnes: Precambrian basement, fault tectonics – Oslo Rift architecture  
Slemmestad Bjørkåsholmen: Lowermost Paleozoic succession  
Vollen: Bentonite layer  
Skaugum or Kolsås areas: Carboniferous sediments and lavas

**Posters** (only presenters are listed here, see abstracts for full author list)

David Cornell, Gothenburg: Magnesian staurolite and kyanite in garnet inclusions: Further evidence of a high-pressure event in the Swedish Eastern Segment

Vija Hodireva, Riga: Museum of Geology University of Latvia as an Active Educator of Society

Hanna Hanna Junttila, Oulu: A Study of Natural Iron Precipitates as adsorbents for Cu, Ni, Zn and Co

Afsoon Moatari Kazerouni, Aarhus: Formation and dissolution of zeolite during the burial diagenesis – Examples from glauconitic sandstones in the Palaeogene Siri Canyon, Danish North Sea

Ragnar Törnroos, Helsinki: Alluvial nuggets of PG minerals and alloys from Finnish Lapland

Reidar G. Trønnes, Oslo: Mineralogy of the post-perovskite transition in CaIrO<sub>3</sub>-based analogue systems

## Invited lectures

### Hydration and proton transport in perovskites

Truls Norby, Dept of Chemistry, University of Oslo, FERMiO, Gaustadalleen 21, NO-0349 Oslo

Protons from water dissolve in perovskites and other oxides even at elevated temperatures, forming effectively positive hydroxide defects on oxide ion sites. The protons charge-compensate lower valent (acceptor) substituents or other effectively negative defects like cation vacancies or oxygen interstitials. The protons migrate by jumping between oxide ion hosts, and their mobility is favoured by large, dynamic lattices, i.e. large cations. Many Ba- and Sr-based perovskites thus constitute good solid state proton conductors. In order to predict the development of proton (or water) content as a function of temperature we are seeking to understand what influences hydration thermodynamics. The enthalpy of hydration of perovskites appears empirically to correlate with the difference in electronegativity of the A and B site cations. This predicts that some perovskites, like the high pressure polymorph of MgSiO<sub>3</sub>, exhibits endothermic hydration, i.e. in fact takes up increasing amounts of water with increasing temperature. This counterintuitive conclusion may have consequences for models of storage and transport of water in the Earth's mantle.

### An introduction to first principles computational mineralogy and mineral physics

Svein Stølen, Dept of Chemistry and Centre for Materials Science and Nanotechnology, University of Oslo, Norway

Density functional theory has become a powerful resource for the solid state sciences. For a given chemical composition and phase the crystal structure can be optimized and the thermodynamic and elastic properties calculated. Present technology gives not only an impressive ability to predict relative stabilities at zero K, but also quantitative data that can challenge the accuracy of experimental determinations. Effects of pressure and also temperature can be taken into account and DFT is of particular value in situations where experiments are difficult, e.g. at extremely high pressures. Furthermore is DFT a valuable aid in analyses of experimental findings.

## Contributed oral and poster presentations

### Composition and parageneses of Na-Ca-Nb-Ti-Zr sorosilicates in nepheline syenite pegmatites in the Larvik plutonic complex, Oslo Rift (Oral)

Tom Andersen<sup>1</sup>, Muriel Erambert<sup>1</sup>, Alf Olav Larsen<sup>2</sup> and Rune Selbekk<sup>3</sup>

<sup>1</sup> Dept of Geosciences, University of Oslo, P.O. Box 1047 Blindern, N-0316 Oslo, Norway

<sup>2</sup> StatoilHydro ASA, Hydroveien 67, N-3908 Porsgrunn, Norway

<sup>3</sup> Natural History Museum, University of Oslo, P.O. Box 1172 Blindern, N-0562 Oslo

New electron microprobe analyses are presented for wöhlerite, låvenite, rosenbuschite, hainite and mosandrite from selected nepheline syenite pegmatites in the Larvik plutonic complex in the Oslo Rift. The minerals are part of primary magmatic parageneses of the pegmatites, which include hiortdahlite + wöhlerite ± rosenbuschite ± eudialyte (s.l.), mosandrite + fluorite ± rosenbuschite ± catapleiite, låvenite + pyrochlore + fluorite. Zircon is present as a magmatic mineral in some pegmatites, and as an alteration product after Zr-bearing silicates.

At least 14 components (Si-Al-Ti-Nb-Zr-REE-Fe+Mn-Ca-Na-K-H-O-F-Cl) are needed to account for the phase relationships in the system. The relative stability of low-variance mineral assemblages (3-4 coexisting Zr-bearing silicate minerals, pyrochlore, feldspars, nepheline, sodalite, magnetite, pyroxene, ± amphibole, ± fluorite, silicate melt, fluid) depends on the peralkalinity of the magma (expressed as  $a_{\text{Na}_2\text{Si}_2\text{O}_5}$ ) and the activities of the volatile components H<sub>2</sub>O, HF and Cl. Whereas the appearance of catapleiite at the expense of zircon is mainly controlled by increasing peralkalinity and water activity, the accompanying Zr-silicate mineral assemblages are strongly influenced by the activity of HF, with rosenbuschite-hiortdahlite bearing assemblages with or without fluorite indicating elevated  $a_{\text{HF}}$ , and wöhlerite-bearing assemblages reflecting lower  $a_{\text{HF}}$ . The stability of mosandrite extends to low  $a_{\text{Na}_2\text{Si}_2\text{O}_5}$ , whereas låvenite bearing assemblages are indicative of the highest level of  $a_{\text{Na}_2\text{Si}_2\text{O}_5}$  achieved in these pegmatites.

The pegmatites are genetically related to larvikite and associated, nepheline-bearing intrusive rocks of the Larvik plutonic complex, probably as last-stage differentiates after polybaric fractional crystallization of a mantle-derived, alkaline parent magma. The peralkalinity and volatile activities of the crystallizing pegmatite magma are most likely results of fractionation processes prior to emplacement, and the Zr-silicate assemblages are passive recorders of the physico-chemical conditions during final crystallization. Some pegmatites, however, show internal variations suggesting local control on peralkalinity and volatile activity (e.g. contrasting mosandrite- and l avenite- bearing domains in the L aven pegmatite), and / or changes of fluid composition with time (e.g. replacement of hiortdahlite + rosenbuschite by w ohlerite-bearing assemblages).

### **White cement: clinker phases, mineralisation and nodulisation (Oral)**

Anne Baarup, Tanya Villadsen, Svend Erik Rasmussen, Duncan Herfort, Hans Dieter Zimmermann  
Geologisk Institut, Aarhus Universitet,  rhus, Denmark and Aalborg Portland, RDC, Aalborg, Denmark

We report on some mineralogical aspects of white cement clinker. We have experimentally studied the effects of minor components (Mg, K, S and F) on the burning temperatures, and thus stabilities, of alite and belite, and on clinker nodulisation. The strongest mineralising effect is obtained for compositions low in sulfate and alkalis and high in magnesium and fluor. Nodulisation is favoured by low sulfate and low potassium contents. - The mineralogy of the clinker material was analysed both by routine microscopic point counting and by Rietveld refinement of standard powder XRD. In our study, the results from these two methods did not fully agree.

### **After the mining is over: Mineral deposits and the role of museums (Oral)**

Nigel John Cook, Natural History Museum, University of Oslo, Boks 1172 Blindern, N-0318 Oslo, Norway

Mineral deposits are the most ephemeral of geological objects in that they are often almost completely removed by mining. Even if some ore remains after mining ceases, either in situ or in mine dumps, access to the underground or open pit operations can be impossible or, at best, restricted. In other instances, ore piles and waste dumps are removed wholesale, for environmental or land-use reasons, such that few traces remain at the mine site.

Good descriptions, maps, cross-sections and interpretations of mineral deposits, made at the time of their exploration and exploitation are a critical lasting record that should be preserved for the benefit of future generations. National geological surveys and mining authorities are ideal repositories of geological and exploration information. In Norway, exploration and mining companies are required to deposit unpublished reports with the Directorate of Mines (Bergvesenet). This archive is an invaluable source of hard-to-find information for companies wishing to reevaluate known, abandoned deposits – such as is currently happening across Norway, and for researchers assembling syntheses of regional geology and metallogeny.

After mining has ceased, researchers involved in the study of the deposits – and geologists involved in their exploration and exploitation need to be encouraged to deposit representative ore samples, as well as polished and thin sections, in reputable museums. Such specimens are often the only way that academics and industry professionals can sample orebodies that no longer exist or are inaccessible without major investment. Synergy between academia and industry needs to be strengthened to ensure that this material is preserved in the public domain and that the material is available for study.

Curated ore specimens, especially if precisely located and collected with reference to their immediate geological setting, can be invaluable to understand paragenetic relationships, textures and fabrics and element partitioning among minerals. Advancing analytical capabilities and new technologies offer new ways of looking at old deposits. Study of ‘dead’ ore deposits, on the basis of specimens from museums, remains highly relevant for refinement of metallogenic and genetic models on which these models – and successful mineral exploration in the future - depends. Preserved ore specimens also offer an unparalleled opportunity for discovery of new minerals and improved characterization of known species.

### **In situ LA-ICP-MS investigation of trace elements in sphalerite (Oral)**

Nigel John Cook<sup>1</sup>, William Skinner<sup>2</sup>, Cristiana L. Ciobanu<sup>3</sup>, Allan Pring<sup>3</sup>, Masaaki Shimizu<sup>4</sup> and Leonid Danushevskiy<sup>5</sup>

<sup>1</sup> Natural History Museum, University of Oslo, Boks 1172 Blindern, N-0318 Oslo, Norway

<sup>2</sup> Ian Wark Research Institute, University of South Australia, Adelaide, S.A., Australia,

<sup>3</sup> South Australian Museum, Adelaide, S.A., Australia      <sup>4</sup> Department of Geology, University of Toyama, Japan

<sup>5</sup> CODES, University of Tasmania, Hobart, Tasmania, Australia

Sphalerite is an important host mineral for a range of minor and trace elements. The distribution of trace elements in sphalerite has implications for economic exploitation and processing of Zn-ores, as well as in environmental remediation. In situ LA-ICP-MS techniques were used to understand the distribution of Ag, As, Bi, Cd, Co, Cu, Fe, Ga, Ge, Hg, In, Mn, Mo, Ni, Pb, Sb, Se, Sn and Tl in samples from >20 ore deposits, including specimens with wt.% levels of Mn, Cd and In. The aim was to constrain ranges of solid solution in natural samples, compare these data with published phase equilibria, distinguish between solid solution and microscale inclusions, and to identify potential geological or genetic controls on sphalerite geochemistry.

Cadmium, Co, Ga, Ge, Hg, In, Fe, Mn, Se and Tl (and sometimes Ag and Sn) are present in solid solution. The concentrations of most elements vary significantly between deposits, over several orders of magnitude, and in some cases between samples from a specific deposit. Sphalerite tends, however, to be characterized by a characteristic range of Cd (ca. 0.2-1.0 wt.%) in each deposit. Higher concentrations are rare; spot analyses show up to 13.2 wt.% ( $\text{Cd}^{2+} \leftrightarrow \text{Zn}^{2+}$ ). In

contrast, Pb, Sb and Bi are most commonly encountered as microinclusions, rather than solid solution. Silver and tin may be both as solid solution and as microinclusions. Inverse correlation between Mn and Fe is observed; Mn-enrichment (up to ~4 wt.%) does not appear to enhance incorporation of other elements.

Sphalerite from Toyoha, Japan contains complex zoning. In-bearing sphalerite (up to 6.7 wt.% In) coexists with Sn-rich sphalerite (up to 2.3 wt.%). Indium concentration correlates with Cu, corroborating coupled  $(\text{Cu}^+\text{In}^{+++}) \leftrightarrow 2\text{Zn}^{++}$  substitution. Sn, however, correlates with Ag, suggesting coupled substitution involving Ag and Sn. The dataset reveals no evidence of coupled substitution involving Ge. We accordingly postulate that Ge may be present as  $\text{Ge}^{2+}$  rather than  $\text{Ge}^{4+}$ .

Concentrations and fractionation of a given element into sphalerite are influenced by type of deposit, crystallization temperature, metal source, cooling history and proportion of sphalerite in the ore. In a broad sense, epithermal and some skarn deposits have higher concentrations of most elements in solid solution. local metal source, crystallization temperature and cooling history contribute to the coexistence/absence of associated trace minerals where In, Ga, Ge etc. are major components

### **Zircon dating reveals a Archaean crust beneath the Kalahari sand (Oral)**

David Cornell<sup>1</sup>, Joanna Wojtyla<sup>1</sup>, Linn Karlsson<sup>1</sup>, Åsa Pettersson<sup>1</sup>, Olof Ingolfsson<sup>2</sup>, Anders Scherstén<sup>3</sup>

<sup>1</sup> Institute for Earth Sciences, University of Gothenburg, Box 460 Göteborg SE40530

<sup>2</sup> University of Iceland, Reykjavik, Iceland    <sup>3</sup> GEUS, Copenhagen, Denmark.

Continents are subdivided into structural provinces based on the age of the last orogeny or major magmatic event which imprinted the structural fabric on the bedrock. These first-order subdivisions are important in understanding how the continents were assembled. The continuity and boundaries of provinces such as the Namaqua-Natal Province in Southern Africa have been established, however adjoining Kheis province which lies almost entirely under the Tertiary to Recent Kalahari sands, has thus far defied attempts to understand its age and geological history. A foreland thrust complex developed in 1.92 Ga redbeds at Olifantshoek (Fig. 1a) was postulated by Cornell et al. 1998. However the much younger 1.2 Ga to 1.1 Ga Sinclair Sequence volcanic and plutonic rocks exposed in the same area suggest that the Kheis Province could have experienced an Andean-type orogeny at ~1.2 Ga. Thus Moen (1999) suggested that much of the Kheis Province was coeval with and belonged to the ~1.2 Ga Namaqua-Natal Province. At Rietfontein on the eastern margin of the Kheis, tillites of the Permian Dwyka Group, were found to contain abundant cobble-sized clasts of crystalline bedrock. Bearing in mind the generally westward transport directions for the Dwyka Ice sheet (Fig. 1a), these exposures were investigated to see if they contained information about what lies under the Kalahari. These granotoid cobbles are badly weathered, but we succeeded in dating them using an ion probe and laser ablation ICPMS, by the U-Pb method. The data is largely discordant, reflecting ancient lead loss at the time of glaciation. Nevertheless we find compelling evidence that Archaean and 2.0 Ga (Bushveld Complex age) granitic crust exists beneath the Kalahari. We also failed to find any evidence for the existence of younger granitic crust or high-grade metamorphic terranes.

The published concepts of the Kheis Province as either a 1900 - 1750 Ma collisional orogen, or an extension of the 1200 Ma Namaqua Province find no support in our data.

The possibility of Archean and Bushveld-aged rocks occurring as basement beneath the Kalahari has important implications for diamond, base and precious metal prospecting in the western Kalahari in South Africa, Botswana and Namibia. These possibilities should be tested by drilling with geophysical control, the last such campaign having been completed in Botswana in 1984.

### **Magnesian staurolite and kyanite in garnet inclusions: Further evidence of a high-pressure event in the Swedish Eastern Segment (Poster)**

David Cornell, Eva Danielsson, Eric Austin Hegardt

Institute for Earth Sciences, University of Gothenburg, Box 460 Göteborg SE40530

The Borås Mafic Intrusion is a large zoned magmatic body which melted an envelope of its country rocks to form dacitic magma during intrusion at 1674 Ma. It was affected by Sveconorwegian metamorphism around 970 Ma, dated on zircon by ion probe and on garnet by Sm-Nd and Lu-Hf. Samples of garnet amphibolite with a basaltic composition are found to contain peraluminous assemblages such as Mg-rich staurolite (mg# 31-33), kyanite and sometimes clinozoizite or white mica, included in garnet. These minerals have been analysed by X-ray microanalysis using our scanning electron microscope and confirmed by electron backscatter diffraction. The thermodynamic packages TWEEQU, THERIAK and DOMINO were used to investigate the conditions under which these parageneses formed, and the bulk compositions from which they could form. We conclude that they formed in rocks which experienced plagioclase-out reactions producing kyanite and clinozoizite, due to high-pressure, low-temperature conditions analogous to the blueschist facies. Furthermore the analysed bulk rock composition does not have a stability field for staurolite-bearing parageneses according to our calculations, although some experiments have produced staurolite in mafic rocks at >24kb. This suggests a two-stage process in which an aluminous and hydrous assemblage such as chloritoid, kyanite and clinozoizite first became isolated from the whole rock by inclusion in garnet, followed by the development of the parageneses we observed by reaction of chloritoid with kyanite and garnet to produce staurolite. THERIAK and DOMINO petrogenetic grids show that possible precursor parageneses are stable in the bulk rock at 480 to 580°C and 17 to 24 kilobars, corresponding to depths of 50-70 km. This work has implications for the tectonic evolution of the Eastern Segment. A model has been suggested in which slices of eclogite were tectonically emplaced into the Eastern Segment from depth, implying that the Eastern Segment as a whole did not experience a high-pressure event. This cannot explain our findings in the Borås Intrusion, which is clearly an integral part of the Eastern Segment and shows no evidence of such a tectonic process.

## **Museum of Geology University of Latvia as an Active Educator of Society (Poster)**

Vija Hodireva (vhodirev@lanet.lv), Museum of Geology, University of Latvia

National programmes today have accentuated the multifunctional character of museum work. In order to make more active museums' contribution for society, co-operation of museum and education systems – on school, higher level and life long learning is regarded as priority. The Museum of Geology has favourable conditions to realise progressive teaching methods particularly within natural and environmental science programmes. Minerals, rocks and fossils collected in Latvia make the main part of exhibition.

- The Museum serves and supports both the education process and research work
- The subjects of exposition are compiled corresponding the taught courses in study programs with an emphasis on the geology of Latvia
- Part of exposition is flexible and periodically changed – in order to show the collections for current studies and training
- Highly qualified museum guides propose various services: professional information and consultations; excursions in museum or in Riga; lectures accompanied with specific demonstration material e.g. mineral samples

Exhibition shows a lot of thematic collections – “Geological section of Latvia”, “Minerals in Latvia” and others. Our exhibition is based on systematic of minerals and rocks to teach students in their study courses (mineralogy, petrology, sedimentology).

We have widely co-operation, consulting and daily information exchange between Museum and University scientific staff. Museum staff participates in research work, too. It gives possibility for students to use the result of close co-operation. We have separate easy-accessible training collections for students' practice work – samples of minerals and rocks. We have organised geology excursions – to see mineral materials in buildings or monuments, on the streets of Old Riga - the capital of Latvia and have discussed corrosion of mineral materials, growing of new minerals, decaying and weathering of rock forming minerals by aggressive city environment.

It must be mentioned as important aspect – museum takes part in teachers' lifelong learning programmes. It gives for everyone actual, easy understandable information on scientific achievements and gives information about museum collections, which at the same time is advertisement for museum. Museum of Geology, University of Latvia has to think how to become more reachable and known in more opened society.

## **A Study of Natural Iron Precipitates as adsorbents for Cu, Ni, Zn and Co**

Seppo Gehör, Erkki Eijärvi and Hanna Junttila

Department of Geosciences, University of Oulu, Finland

The study of natural iron precipitates as adsorbents concerns the siderite, goethite and hematite occurrences, at Vihanti, Central Finland. The precipitates were formed from redeposited interglacial and weathered glacial sediments derived from the bedrock (Virtanen, 1994) and are found to form incohesive layers at the interface between sand and peat, having the thickness from a few centimeters to at least 140cm (Virtanen, 1994). According to the resource estimation (Virtanen 1994) the density of the occurrences at Vihanti area is exceptionally high in comparison with the other areas in Finland.

The adsorption efficiency of the iron minerals on Ni, Cu, Zn and Co was studied by using the batch technique. A known amount of adsorbent and 200ml of solution was added to 250 ml plastic bottle. The bottles were shaken 24h in a shaker at 40-50 rpm at room temperature. After equilibration the content of the bottle was filtered and the residual concentration of metal ion was determined by the methods of atomic adsorption spectrometry (AAS). Reference tests were made by using commercial synthetic goethite as a reference material. The tests were performed in conditions of selected pH, dosage of adsorbent, concentration of solution and time.

Initial pH and the dosage of adsorbent were found to have the major effect in adsorption reactions. All the precipitates from Vihanti appeared to have an excellent capacity to adsorb the tested ions from the solution. When initial pH of the solution were increased, the adsorption capacity of the material increased. Also dosage of the material increased the amount of metal cation adsorbed.

The effect of reaction time was relatively small. Results indicate that with small concentration (10 mg/L) and small geomaterial dosage the maximum adsorption is achieved after four hours of shaking. The effect of initial concentration of the solution was studied by creating simple adsorption isotherms. These isotherms indicate that the adsorption capacity of the chosen precipitates increases when the concentration of metal cation in solution increases. These studies were made in pH 5.

### References

Virtanen, K. 1994: Geological control of iron and phosphorous precipitates in mires of the Ruukki-Vihanti area, Central Finland, Bulletin 175, Geological Survey of Finland

## **Formation and dissolution of zeolite during the burial diagenesis – Examples from glauconitic sandstones in the Palaeogene Siri Canyon, Danish North Sea (Poster)**

Afsoon Moatari Kazerouni<sup>1</sup>, Henrik Friis<sup>1</sup>, Johan B. Svendsen<sup>2</sup>, Rikke Weibel<sup>3</sup>

<sup>1</sup> Geologisk Institut -Aarhus University, Århus, Denmark    <sup>2</sup> Dong Energy, Copenhagen, Denmark

<sup>3</sup> Geological Survey of Denmark and Greenland, Copenhagen, Denmark

The Palaeogene Siri Canyon fill consists of hemipelagic and turbidite marl and claystones interbedded with massive and blocky glauconitic sandstones deposited from sandy mass-flows and sandy turbidites. The Palaeogene sediments in the Danish area are rich in siliceous microfossils as well as late Paleocene–early Eocene volcanic ash layers.

Zeolites have a hydrated aluminosilicate framework with varying amounts of alkali and alkaline earth metals. Authigenic zeolites may be common in deep marine sediments, and in volcanoclastic deposits. They are generally related to dissolution of siliceous fossils or diagenetic alteration of volcanic glass. Authigenic zeolites are uncommon constituents in most sandstones. However, authigenic zeolites are common in some of the glauconitic sandstones from the Siri Canyon, where it is generally associated with thick coatings of opal/microquartz on the detrital framework grains. The remaining open pore space may be filled with berthierine, chlorite, calcite or quartz, together with minor amount of other minerals such as alkalifeldspar, siderite or pyrite, but in general, a high porosity (25-32%) is seen.

Most occurring zeolites have a void in their central part, most likely reflecting dissolution of an early phase with different chemical composition. In many samples, zeolites have been totally dissolved, leaving impression marks in the opal/microquartz coating. The textural relation demonstrates that zeolite was dissolved after microquartz precipitation. In most cases, the dissolution of zeolite has exposed the surface of detrital grains, allowing large syntaxial quartz overgrowths to form in the impression.

This paper presents the occurrence and compositional variance of the authigenic zeolites in the Siri Canyon sandstones, and discuss the physico-chemical conditions which prevailed during formation of zeolites, pore water chemistry, composition of mineralogical precursors and the host sediments. The zeolite formation is only occasionally related to volcanic ash; it seems that a rapid supply of dissolved silica from dissolution of siliceous fossils were the main reason for the early co-precipitation of opal and zeolite. The formation of zeolites has been restricted because of the chemical complexity of naturally occurring systems containing zeolites. Stability is also limited because of low temperatures with slow reaction rates at which most zeolites form.

### **Preservation status of the mineral collection at the Swedish Museum of Natural History (Oral)**

Jörgen Langhof, Dept of Mineralogy, Swedish Museum of Natural History, P.O. Box 50007, SE-104 05 Stockholm

The Department of Mineralogy houses approximately 200 000 specimens in nearly 150 000 catalogue entries, all digitalized since 10 years back and accessible via internet (<http://www.nrm.se>). The oldest specimens date back to the early 18th century, but accession has for many reasons varied over the years and nowadays 200-500 samples enter the collection. This is maintained by field collecting, purchase, exchange and gifts. One of the main tasks for the Department of Mineralogy is to preserve and enrich the mineral collection, which is used mainly for exhibitions and research.

The buildings of the Swedish Museum of Natural History (SMNH) will celebrate their 100-year anniversary in 2016 and the storage facilities for the collections are to a large extent from the time of the opening of the museum in 1917. The collections have grown immensely since then and methods of collection management have changed like-wise. Today's demands for an accurate collection management are completely different. The then new museum was planned for an accession for the next 30 years! As a result most of the different collections at the museum suffer from overflowing and many collections are spread in the museum buildings and are also located in external repositories.

As part of a large governmental project called ACCESS the SMNH got the opportunity to document the conservation status of all collections at the museum and the methods and routines used in the collection management work. This documentation was done in September 2006 to March 2008 and has resulted in several department reports and two final conclusive reports. This enables the collections management staff of the different departments at the SMNH to start a more progressive work, with new methods and a written document to proceed from, for the first time in the long history of the museum. This has been one of the main goals for the newly established Preventive conservation group at the museum, a central organ for the whole SMNH and the entire Swedish museum community.

### **Phylogenetic and individual bioapatite properties variation (Oral)**

Jaanika Niitsoo, Jüri Nemliher

Institute of Geology at Tallinn University of Technology, Ehitajate tee 5, 19086 Tallinn, Estonia

Together with calcite, aragonite and silica, apatite is a common biomineral. Compared with others, apatite is characterized by extremely flexible lattice, ranging as much as about 10% of lattice volume value. The empirical study of bioapatite properties revealed taxa-specific properties of those, well correlating with an age of group under study. The unit cell volume of bioapatite of the oldest known apatite secreting animals – lingulates – shows the lowest value, around  $520\text{Å}^3$ , for shark scales the value have found intermediate, being around  $522\text{Å}^3$ , and for mammals (therian and methatherian, both) the value is the highest, about  $589\text{Å}^3$ . Apatite of scales and bones of fishes, bony fishes sensu stricto and older groups, lays into this range, being, however, in clear correlation with phyletic age of taxa under study.

On the other hand, dimensions of (elementary) crystallite reveal a diminishing in dimensions in concordance with youth of taxa. So, the shells of lingulates are built up of biocrystals, about  $185*600\text{Å}$ , shark teeth and scales  $60*500\text{Å}$  and endoskeletons of mammals are constructed of crystals of the tiniest dimensions:  $100*300\text{Å}$ .

An individual variation of bioapatite properties has shown that practically there are no differences between mineralized tissues of the same origin. So, the apatite of scales of whitefish coincides with a difference about  $0.001\text{Å}$ . On the contrary, mineralized tissues of different origin, such as exo- and endodermis-generated, differ significantly. A lattice constant of the apatite of tooth enamel of wild boar exceeds the same of other tissues of the same specimen, such as different bones and dentine, as much as  $0.3\text{Å}$ .

### **Genesis of Pb-Zn-Ba vein mineralizations in Svalbard, Norwegian Arctic (Oral)**

Tom V. Segalstad<sup>1</sup>, Krister Sundblad<sup>2</sup>, Torfinn Kjernet<sup>3</sup>

<sup>1</sup> Geological Museum, Natural History Museum, University of Oslo, Norway

<sup>2</sup> Dept. of Geology, University of Turku, Finland

<sup>3</sup> Directorate of Mining with Commissioner of Mines at Svalbard, Norway

Numerous hydrothermal vein fillings of calcite [magnesian], dolomite, barite, sphalerite, galena; fluorite; chalcopyrite; witherite, strontianite; and occasional late quartz with barite and dolomite occur at Bjørnøya [B] and along the western part of Spitsbergen [SB] in the Svalbard archipelago of the Arctic.

The veins occur in Late Precambrian to Ordovician calcareous sedimentary successions, and in Devonian to Permian Red Bed deposits. Barite veins also occur in Devonian strata on northern SB: Sigurdfjellet [SF] with a Cu-Pb-sulfides; Zeipeldalen [Z] and Ridderborgen [R] with minor sulfides. All veins are spatially (and genetically?) related to large-scale post-Devonian faults.

Age and genesis of these veins are unknown. Flood (1969) assumed a pre-Devonian, Caledonian, age. We found veins cutting sedimentary strata from Late Precambrian through Permian; hence field evidence shows a Triassic or younger age. The heat source may have been the adjacent Tertiary Vestbakken volcanism associated with Atlantic continental rifting.

Fluid inclusions were too small for microthermometry.  $\delta^{18}\text{O}$  of coexisting calcite – dolomite gave eq. temp. 180°C for a vein at B.  $\delta^{34}\text{S}$  in all sulfides range -0.6 to 12.7‰; in all barites 13.4 to 27.0‰. Coexisting sulfides – barite show  $\Delta^{34}\text{S}$  of -0.2 to 26‰; no eq. values, as expected from the low hydroth. temp., hence the  $\delta^{34}\text{S}$  can be used as a tracer to the source of S: local Hecla Hoek wallrocks, Perm. evaporites, and wallrock Devonian sulfate.  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$  point out wallrock source of O and C; later indicating mixing with a fluid carrying oxidized coal C.

Deep crustal fluids with metals, Ba, and Cl, were mixed with a descending fluid carrying dissolved evaporite sulfate, partly reduced to H<sub>2</sub>S by local coal beds; depositing the vein barite and metal sulfides.

Pb isotopes in galenas from B and SF show two <sup>206</sup>Pb/<sup>204</sup>Pb populations; 18.180 and 18.346 (Sundblad et al. 2006). The Pb source was eroded Caledonian crust, homogenized during transport to Devonian sedimentary basins. Fluids leached Pb while circulating lower stratigraphic levels, where galena precipitated in fractures together with sphalerite and barite.

### **Genesis of the Kongsberg Silver Ore Deposit, Southern Norway (Oral)**

Tom V. Segalstad, Geological Museum, Natural History Museum, University of Oslo, Norway

Native silver (Ag) in Permian hydrothermal calcite veins in the Kongsberg District occurs where the veins cross S-rich fahlbands. Ag formed both from transform. of argentite (Ag<sub>2</sub>S) and precipitated directly from the fluid. Earlier vein systems are quartz + sulfides; and barite in a separate vein system. Wall rock alteration to K-feldspar and chlorite occurs with some of the veins. Coalblende (carboniferous substance) is characteristic with Ag.

The main ore forming stages carry in mineralizing order quartz, pyrite, calcite (5 generations), coalblende, fluorite, galena, sphalerite, chalcopyrite, sulphosalts of silver, argentite, silver, and pyrrhotite (Neumann, 1944).

Fluid inclusion data by Johansen (1985) showed that Ag formed by heating the hydroth. system from ~250 to ~300°C with salinity decrease from ~25 to <20 wt.% NaCl-eq. The Ag veins saw at least 3 stages of heating and cooling from ~200 to 300 and back to ~200°C.

$\delta^{18}\text{O}$  values in the quartz-sulfide veins are constant in the Fiskum Area E of Kongsberg, indicating an open system, with flu. incl. t of form. ~250°C. Computed  $\delta^{18}\text{O}_{\text{SMOW}}$  for H<sub>2</sub>O is ~-1; crustal water in equilibrium with wall rocks. Calculated metal solubilities show that metal transport may have occurred at ~300°C, pH ~4, log O<sub>2</sub> activity ~-34.  $\delta^{13}\text{C}$  in coalblende and calcite show C originating from the black Alum Shale.  $\delta^{18}\text{O}$  in calcite shows closed mineralizing systems, when fractionated crystallization occurred in the fluids at pH from ~4 to ~5.

Thermochemical modelling confirm that barite, Ag<sub>2</sub>S, Ag and pyrrhotite could not form in an open system at pH 4 to 5. The veins must have been filled several times by hot fluids separated from their sources, and reacted with host rocks in closed sub-systems. Reacting with pyrrhotite in fahlbands, protons were consumed, pH increased. After precip. of sulfides, fluid S decreased, and Ag<sub>2</sub>S and later Ag reached their stabilities and precip. At incr. pH and/or decr. fluid S, pyrrhotite reached stability. Fluids now reached eq. with wall rocks, and the Ag precip. stopped.

Fluids, heated 200-250°C, can dissolve 1000 times more Ag (~0,005 to 5 ppm). Further heating 250-300°C the soly. decreases, up to 90% Ag can precipitate; up to 9.9% more by cooling to 200°C. The process concentrates available Ag in the area, with a potential Ag-precipitating efficiency of 99.9%.

### **Formation of corundum megacrysts, related to K-rich fluids infiltration during incongruent melting of plagioclase in SiO<sub>2</sub>-undersaturated rocks at high T (Oral)**

Rune S. Selbekk<sup>1</sup>, Kåre Kullerud<sup>2</sup>, Erling Ravna<sup>2</sup>

<sup>1</sup> Natural History Museum, University of Oslo, P.O. Box 1172 Blindern, N-0318 Oslo, Norway

<sup>2</sup> Department of Geology, University of Tromsø, N-9037 Tromsø, Norway

The 200 km<sup>2</sup> Skattøra Migmatite Complex (SMC) of the Nakkedal Nappe belongs to the Uppermost Allochthon of the North-Norwegian Caledonides. SMC is composed mainly of migmatites that vary from metatexites, stromatic to schlieric of mafic rocks with anorthositic to leucodioritic leucosomes and mesosomes of amphibolite. Originally a SiO<sub>2</sub>-undersaturated layered mafic intrusion, the SMC is now characterized by extreme net-veining of anorthositic dykes up to several meters in thickness. The dykes commonly constitute 50 %, and locally up to 90%, of the rock massif. In addition to plagioclase, the anorthositic dykes contain 0-10 modal % amphibole (ferropargasite).

Pink corundum megacrysts (up to 5 x 2.5 cm) in migmatites of anorthositic to gabbroanorthositic compositions constitute 1 - 8 modal % of the rock within a c. 1.5 m wide and 50 m long band, oriented parallel to the main schistosity of the migmatite. The megacrysts are partly pseudomorphosed, mainly by margarite. In the least altered samples, corundum shows well developed crystal faces with a 0.2 mm thick reaction corona composed of needles of margarite along the contact to the surrounding plagioclase. Alteration products of margarite and diaspore are also found along internal

fractures. The matrix is dominated by plagioclase, but hornblende and biotite are abundant. The two corundum-bearing samples show about 50.5 wt % SiO<sub>2</sub>, comparable to the average composition of the anorthositic rocks. However, the corundum-bearing rocks have higher contents of Al, K, Rb and Ba, and lower contents of Ca.

Experimental work shows that the SMC underwent anatexis under H<sub>2</sub>O-rich conditions at 1.0 GPa and 900-925 °C. The intimate association between the corundum megacrysts and the leucosomes of the SMC suggests that the formation of corundum was related to migmatitization. The large grain-size of corundum compared to the other minerals suggests crystallization from a H<sub>2</sub>O-rich melt, rather than via sub-solidus reactions.

Corundum formation was triggered by the introduction of a K-rich hydrous fluid during partial melting of the protolith. K-rich fluid stabilized biotite during anatexis, while plagioclase was destabilized. We suggest that the biotite of the corundum-bearing rock formed in a similar way; i.e. in response to K-metasomatism. The intimate association between biotite and corundum suggests that plagioclase under these conditions underwent incongruent melting, resulting in corundum formation.

#### *References:*

Selbekk, R.S.; Skjerlie, K.P., Pedersen, R.B., 2000, *Geol. Mag.* 137, 609-621.

Selbekk, R.S. & Skjerlie, K.P. 2002, *J. Petrol.* 43, 943-962

### **Alluvial nuggets of PG minerals and alloys from Finnish Lapland (Poster)**

Ragnar Törnroos<sup>1</sup>, Kari Kojonen<sup>2</sup>, Bo Johanson<sup>2</sup>

<sup>1</sup> Dept of geology, P.O. Box 64, FIN-00014 University of Helsinki, Finland

<sup>2</sup> Geological Survey of Finland, P.O. Box 96, FIN-02151 Espoo, Finland

Placer platinum-group element (PGE) mineral nuggets were studied from Ivalojoiki and Lemmenjoiki tributaries of the Paleoproterozoic ca. 2 Ga granulite belt in Finnish Lapland. The nuggets are found in glaciofluvial river gravels, sands and terraces, poorly sorted sandy till and weathered bedrock.

A total of 40 platinum group minerals (PGM) were recognized occurring together with Au and Au-Ag alloy grains, garnet, monazite, zircon, pyrite, Cr-Fe-spinel, magnetite, ilmenite, rutile, hematite, columbite-tantalite, tapiolite, uraninite-thorianite, galena, Pb-Sn alloy, wolframite, amphiboles and pyroxenes. The PGE minerals exist as individual grains or as inclusions in larger PGM grains (Törnroos and Vuorelainen, 1987, Törnroos et al., 1996, Kojonen et al., 2005)

The main Pt minerals consist of sperrylite, Pt-oxide, native Pt, isoferroplatinum, moncheite, platarsite, rustenburgite, Pt-Pd alloys, braggite, cooperite, luberoite Pt<sub>5</sub>Se<sub>4</sub>, undefined Pt<sub>9</sub>TeSe<sub>6</sub>, and hongshiite. Pd minerals consist of kotulskite, keithconnite, stillwaterite, isomertieite, mertieite I Pd<sub>11</sub>(Sb,As)<sub>4</sub>, mertieite II, a new PGE mineral **miessiite** Pd<sub>11</sub>Te<sub>2</sub>Se<sub>2</sub> (Kojonen et al., 2007), palladseite Pd<sub>17</sub>Se<sub>15</sub>, vincentite (Pd,Pt)<sub>3</sub>(As,Sb,Te), and the unknown phase Pd<sub>3</sub>(Sb,As,Sn), undefined (Au,Ag)<sub>6</sub>PdCu and (Au,Ag)<sub>4</sub>(Pd,Cu). Os-Ir-Ru-Rh minerals include: Os,Ir,Ru alloy, laurite, irarsite, erlichmanite, cuproiridsite, and cuprorhodsite.

The great variety of PGM suggests a complex and multi-stage mineralization in the source rocks and a close origin. PGM were concentrated during weathering, erosion, glaciofluvial and fluvial processes from layered mafic-ultramafic intrusions.

#### *References:*

Kojonen, K. Tarkian, M., Knauf, V.V. and Törnroos, R. 10th Int. Platinum Symp. Oulu, Finland, Abstract Vol., 145-149 (2005)

Kojonen, K., Tarkian, M., Roberts, A.C., Törnroos, R., Heidrich, S. *Can. Min.* 45, pp. 1221-1227, (2007).

Lawrance, L.M. *Geochem. Exp. Env. Anal.* 1. 323-339 (2001).

Törnroos, R. and Vuorelainen, Y. *Lithos* 20, 491-500 (1987).

Törnroos, R., Johanson, B and Kojonen, K. IGCP Project 336, Symposium, Rovaniemi Finland, Progr. and Abstr. p.86-86 (1996)

### **Mineralogy and dynamics of the Earth and the terrestrial planets (Oral)**

Reidar G. Trønnes, Natural History Museum (Geology), University of Oslo, Norway

The oxygen fugacity during planetary accretion governed the metal-silicate proportion of the terrestrial planets and planetary size controls the internal pressure variation. The radial structure of the Earth's mantle is dominated by density and seismic wave discontinuities at 410 and 660 km depth, delineating the upper mantle, transition zone and lower mantle (UM, TZ, LM). A discontinuity 100-300 km above the core-mantle boundary outlines the D''-zone. The discontinuities correspond to phase transitions of the main minerals in peridotite and basalt. The UM to LM densification involves olivine to wadsleyite (410 km), wadsleyite to ringwoodite (520) and ringwoodite to perovskite + ferropericlaase (660) transitions combined with gradual dissolution of pyroxenes into coexisting majoritic garnet. Majoritic garnet breaks down and dissolves in MgSiO<sub>3</sub>-rich perovskite (Mg-pv) at 23-24 GPa. Small amounts of CaSiO<sub>3</sub>-perovskite (Ca-pv) coexist with Mg-pv in the LM. A peridotite crystallizes about 80% Mg-pv, 15% ferropericlaase and 5% Ca-pv. The versatile pv crystal structure can accommodate a wide range of cations, as well as oxygen defects, resulting in a wealth of physical properties, many of which are interesting also from a technological point of view. The high entropy of pv gives a negative dp/dT-slope for the pv-forming reactions, resulting in intermittent storage of cold subducted lithosphere near the 660 km discontinuity.

Complex material properties and seismic structures of the D''-zone above the core mantle boundary (CMB) are associated with the newly discovered post-perovskite transition. The phase relations and mineral physics of this transition govern core-mantle heat flow and Earth evolution. Preliminary indications of excess densification of basaltic material may cause efficient compositional segregation in spite of huge thermal gradients near CMB. Seismologists and geochemists have suspected such segregations and recent paleomagnetic studies indicate long-term stability of seismically defined warm and dense piles under Africa and the Pacific.



Venus is also pv-dominated, but too small (and too hot ?) for post-pv stabilization. Mars has probably only a very thin pv-rich veneer above the core mantle boundary. The large difference in evolution and dynamics between the sister planets Earth and Venus may be explained by the presence (Ea) and absence (Ve) of minor amounts of H in the mantles as well as the lack of post-pv in Venus.

### **Mineralogy of the post-perovskite transition in CaIrO<sub>3</sub>-based analogue systems (Poster)**

R.G. Trønnes<sup>1</sup>, S. Stølen<sup>2</sup>, T. Boffa-Ballaran<sup>3</sup>, D.J. Frost<sup>3</sup>, T. Balic-Zunic<sup>4</sup>, L.A. Olsen<sup>4</sup>

<sup>1</sup> Natural History Museum, University of Oslo, Norway <sup>2</sup> Dept of Chemistry, University of Oslo, Norway

<sup>3</sup> Bayerisches Geoinstitut, Universität Bayreuth, Germany

<sup>4</sup> Dept of Geography and Geology, University of Copenhagen, Denmark

The perovskite (pv) to post-perovskite (ppv) transition in MgSiO<sub>3</sub>-based systems explains the complex material properties and seismic structures of the D''-zone above the core mantle boundary (CMB). Separation of compositionally dense material in the D''-zone is most likely related to a density contrast between peridotitic and basaltic-komatiitic compositions. Mineral physics data indicate that the latter is densest for both pv and ppv. Basaltic or komatiitic material may either originate from residual high-density melts of magma ocean crystallization or be gravitationally separated from subducted slabs.

Of fundamental importance to the structure and dynamics of the lowermost mantle is the partitioning of FeSiO<sub>3</sub>, Al<sub>2</sub>O<sub>3</sub>, Fe<sub>2</sub>O<sub>3</sub>, FeAlO<sub>3</sub> and MgAlO<sub>2.5</sub> between pv and ppv. The determination of these partitioning relations by LH-DAC with in-situ synchrotron-XRD is very challenging. Most studies of the divalent Fe-Mg-partitioning indicate that Fe is preferentially partitioned into ppv, apparently in good agreement with seismology and geodynamics. The miniscule sample volumes and unquenchable nature of Mg-ppv preclude single crystal XRD-refinement and single crystal compressibility and thermal expansion studies. However, in CaIrO<sub>3</sub>-based compositions, the pv-ppv-transition can be studied in the piston cylinder p-T-range, and synthesized crystals of both polymorphs are structurally quenchable to ambient conditions. Our recent results from experimental studies and DFT-computations demonstrate that CaIrO<sub>3</sub>-pv and -ppv are good analogues for the corresponding MgSiO<sub>3</sub>-polymorphs. Furthermore, the entropy, volume and elastic changes across the phase transition are generally consistent in the two systems (experimentally and computationally) and in agreement with the seismological indication of increasing shear-wave speed and decreasing bulk sound speed from pv to ppv. Further studies of CaIrO<sub>3</sub>-based pv-ppv-assemblages will be aimed at determining the partitioning relations and the resulting crystallographic and elastic changes for compositions with divalent A-site substitution (e.g. Ba) and trivalent A- and/or B-site substitutions (e.g. Sc, Y, In). Complementary DFT-computations on selected compositions in the MgSiO<sub>3</sub>- and CaIrO<sub>3</sub>-based systems may be useful in examining the strengths and limitations of CaIrO<sub>3</sub>-rich analogues.

### **An ore petrological study of the polymetallic skarn ores at Pitkäranta (Presentation by abstract, only)**

Mira Valkama<sup>1</sup>, Nigel Cook<sup>2</sup> & Krister Sundblad<sup>1</sup>

<sup>1</sup> University of Turku, Finland <sup>2</sup> University of Oslo, Norway

The polymetallic skarn ores of Pitkäranta are located along the northeastern shore of lake Ladoga, 40 km southwest of the exposed margin of the Archaean craton in the Fennoscandian Shield. The Pitkäranta region is dominated by a Palaeoproterozoic sequence of amphibole schists, marbles and turbidites, which, together with a slab of gneissic Archaean crust, constitute an allochthonous terrane complex that amalgamated to the Archaean continent during the Svecokarelian orogeny. This complex is cut by the 1.54 Ga anorogenic Salmi batholith, one of the rapakivi granite plutons that have intruded into Palaeoproterozoic crust in southern Finland and westernmost Russia. The ores are hosted by skarn-altered marbles extending over a distance of 30 km along the western margin of the Salmi batholith.

The first ore discoveries in Pitkäranta were reported in 1810 after which more than 50 mines and prospects have been found. Mining for a number of metals, including Fe, Cu, Zn, Pb, Sn and Ag, took place during the 19th to 20th centuries. Numerous mineralogical and genetic studies have been carried out on the Pitkäranta ores, including contributions by Törnebohm (1890; 1891), Brøgger (1891), Trüstedt (1907), Palmunen (1939) and Sundblad (1991). Most authors have favored a classical skarn model for the ore genesis suggesting that hydrothermal solutions emanated from the intruding Salmi batholith and reacted with the marble horizons. This model is supported by the identical isotopic compositions of lead in the rapakivi feldspar and the Pitkäranta ores. In contrast to the many mineralogical studies that were carried out during the earliest years of mining, very few, if any, microprobe-based petrological studies have been carried out on these mineral-rich deposits.

In spite of the fact that the mine field now is abandoned, a great potential for advanced petrological studies of Pitkäranta material still exists by using the extensive collections in geological museums in e.g. Turku, Helsinki and Petrozavodsk. A study of the Hopeavuori part of the Pitkäranta system was therefore initiated during the spring 2008 in order to shed light on some of the metallogenetic features in this important ore system. The study has started with some In- and Ag-rich sphalerite-cubanite-bearing samples.