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Tobias Weisenberger and Hanna Junttila
Editors

Program and Abstracts of the 9th National Geological Colloquium

Oulu, 6th - 8th March 2013

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Telephone: **0294 481437, International tel: +358 294 481437**
Telefax: **08 553 1484, International fax: +358 8553 1484**
E-mail: **pekka.tuisku@oulu.fi**
www: **http://cc.oulu.fi/~resterr/**

Cover Figure:

Mineralized laminated quartz vein hosted in black shale from Bendigo Gold deposit, Victoria, Australia. Photo: Iain Pitcairn

Preface

The 9th National Geological Colloquium (Tutkijapäivät) conference/seminar is held in 2013 for the first time at the University of Oulu. Our city is located at the centre of the northern Finnish minerals boom, which has now lasted already for almost a decade. It is to be hoped that the sector will become an important pillar of the Finnish economy. It is for this reason that the motto of the 2013 Tutkijapäivät is "Mineral deposit research in Fennoscandia". We invited several prominent researchers and teachers to give keynote addresses on this theme, including Prof. Pär Weihed from Luleå University, Dr. Iain Pitcairn from Stockholm University, Dr. Jochen Kolb from the Geological Survey of Denmark and Greenland, Prof. Veli Pekka Salonen from the University of Helsinki and Marja-Liisa Räisänen from GTK.

The 2-day student conference is held on 7-8 March and is preceded by a 2-day short course on Dating Methods in Geology, presented by Andrew Murray from Århus University and Hannu Huhma from GTK on 4-5 March, and a workshop for PhD students and their supervisors on 6 March. The aim of this important meeting is to provide our future research and teaching leaders with the opportunity to meet friends and colleagues, engage in vigorous discussion about your exciting research projects, and exchange ideas, no matter how far-fetched they may seem. We thus wish all our visitors a hearty welcome and hope that you spend some entertaining, stimulating and creative days in Oulu.

Oulu, 27.2.2013

Wolfgang Maier

Program

Wednesday

Workshop for PhD-students and their supervisors

Linnanmaa, PR104

The central themes of the workshop are publishing, career planning, and students view of supervision practices. The workshop is aimed at PhD-students and their supervisors.

8.30-9.00	*Registration* (Geological museum, entrance K)
9:15–9:20	*Opening of the workshop*: Tapani Rämö, Seija Kultti
9:20–10:10	*Preparing efficiently scientific publications*, Veli-Matti Kerminen, Finnish Meteorological Institute
10:10–10:40	*Coffee and discussion*
10:40–11:10	*How to reach high and long lasting impact for publication*? Wolfgang Maier, University of Oulu
11:10–12:00	*Tools for a good research plan*, Maarit Jokela, University of Oulu
12:00–13:15	*Lunch*
13:15–13:45	*Post Post-Doc*, Anu Kaakinen, University of Helsinki
13:45–14:15	*What, from Where, and When - How to achieve finance for you research career*, Mia Kotilainen, University of Helsinki
14:15–14:45	*Coffee*
14:45–17:30	*Supervision practices – pitfalls and successes; a collective PhD student view*, Ari Brozinski, Åbo Akademi, Mimmi Oksman, University of Helsinki, and Hanna Junttila, University of Oulu
17:30–	*Icebreaker Party* (Geological museum)

Thursday

Scientific sessions

Linnanmaa, GO101

8.30-9.00	*Registration*
9.00-9.05	*Opening words:* Vesa Peuraniemi, Head of the Department of Geosciences, University of Oulu
9:05-11:00	**Session I – Palaeoecology** **Chair: N.N.**
9.05-9:20	Mira Tammelin, Tommi Kauppila: *A diatom-total phosphorus transfer function and reconstructions from the Iisalmi region, Eastern Finland*
9:20-9:35	Juha Saarinen, Aleksis Karme, Thure Cerling, Kevin Uno, Samuel Kasiki, Shadrack Ngene, Thadeus Obari, Laura Säilä-Corfe, Mikael Fortelius: *New approach to mammalian palaeoecology - occlusal wear angles of molar teeth as a measure of diet abrasiveness in elephants and their fossil relatives (Mammalia, Proboscidea)*
9:35-9:50	Samu Valpola, Asta Harju: *Peat as a resource: the future and role of geological research in the responsible use and management of peat and peatlands*
9:50-10:05	Niina Kuosmanen, Heikki Seppä, Richard Bradshaw, Jennifer Clear, Oleg Kuznetsov, Ludmila Filimonova: *The Holocene boreal forest dynamics in the modern western range limit of the Siberian larch (Larix sibirica), new insights from small hollow records*
10:05-10:20	Mimmi Oksman, Arto Miettinen, Michal Kucera: *Variability of sea surface temperatures and sea ice in Baffin Bay during the last two millennia*
10:20-10:45	*Coffee*
10:45-12:15	**Session II – Seismics and Tectonics** **Chair: Aulis Kärki, University of Oulu**
10:45-11:15	*Keynote:* Jochen Kolb: *Archaean granulite-gneiss terranes of western and eastern Greenland: tectonometamorphic evolution and nickel mineralization*
11:15-11:30	Mira Markovaara-Kovisto, Eevaliisa Laine: *Fracture density on stereogram*
11:30-11:45	Suvi Heinonen, Pekka J. Heikkinen, Ilmo T. Kukkonen, David B. Snyder: *Seismic reflection profiling in ore exploration: experiences from Pyhäsalmi VHMS deposit*
11:45-12:00	Kaisa Nikkilä, Annakaisa Korja, Hemin Koyi, Olav Eklund:Analogue *Experiments of lateral flow in the middle crust*
12.00-12:15	David M. Whipp: *3D geodynamic numerical modeling of modern and ancient orogens*
12.15-13:15	*Lunch*

13:15-14:45	**Session III – Mine Environment** **Chair: Eero Hanski, University of Oulu**
13:15-13:45	*Keynote:* Veli-Pekka Salonen: *Sedimentological investigation supporting management of the mine environment*
13:45-14:00	Sonja Sjöblom, Olav Eklund: *Geological and mineralogical aspects on mineral carbonation of rocks and mine tailings in Finland*
14:00-14:15	Peter Howett, Talvikki Savolainen, Kirsti Korkka-Niemi, Julien Moreau: *Rautuvaara: An environmental assessment for a proposed tailings facility.*
14:15-14:30	Kirsti Korkka-Niemi, Veli-Pekka Salonen, Julien Moreau, Tiina Nurminen, Anne Rautio: *Hydrogeology and groundwater - river water connections at Hannukainen mining development site in Kolari, Northern Finland*
14:30-15:00	*Coffee*
15:00-16:30	**Session IV Geokemian rengas** **Chair: Pertti Sarala, Geological Survey of Finland**
15:00-15:30	*Keynote:* Marja-Liisa Räisänen: *Geochemistry applied for supervision of metal mines*
15:30-15:45	Soile Backnäs, Antti Pasanen, Lauri Solismaa, Teemu Karlsson, Päivi Kauppila, Nina Hendriksson, Jouni Lerssi, Tommi Kauppila: *Groundwater flowpaths and contaminant geochemistry at Luikonlahti Mine*
15:45-16:00	Kaisa Turunen, Soile Backnäs, Antti Pasanen: *The effect of the anthropogenic activities on geochemical behavior of arsenic at two geologically different mine sites in Finland*
16:00-16:15	Tarja Hatakka, Timo Tarvainen, Jaana Jarva: *Geochemical baselines in the man-made fillings in Helsinki Metropolitan Area*
16:15-16:30	Pertti Sarala: *Natural geochemical characteristics of soil in northern Finland*
16:30-18:00	**Poster session**
19:00-	*Dinner at Vanha Paloasema*

Friday

9:00-10:30 **Session V - Earth Resources session**

Chair: Jochen Kolb, Geological Survey of Denmark and Greenland, Denmark

9:00-9:30 *Keynote:* Pär Weihed: Metallogeny of the Fennoscandian Shield

9:30-9:45 Toni Eerola: *The stakeholder engagement as a component of corporate social responsibility in mineral exploration in Finland – A model*

9:45-10:00 Mari Tuusjärvi, Ilmo Mäenpää, Saku Vuori, Pasi Eilu, Susanna Kihlman, Sirkka Koskela: *Scenarios of the growing metal mining in Finland – estimating the changes in economic and environmental significance*

10:00-10.15 Sofia Ziessler: *Local stakeholder engagement of mineral exploration in Finland within the Corporate Social Responsibility (CSR) framework*

10:15-10:30 Raimo Lahtinen: *Mineral potential research in the Geological Survey of Finland*

10:30-11:00 *Coffee*

11:00-12:15 **Session VI – Groundwater**

Chair: Kirsti Korkka-Niemi, University of Helsinki

11:00-11:15 Riikka Kietäväinen, Lasse Ahonen, Ilmo T. Kukkonen, Samuel Niedermann, Thomas Wiersberg: *Groundwater residence times of millions of years revealed by noble gases in Outokumpu, Finland*

11:15-11:30 Teppo Arola, Lari Eskola, Jukka Hellen, Kirsti Korkka-Niemi: *Groundwater as an energy source in Finland*

11:30-11:45 Anne Rautio, Anna-Liisa Kivimäki, Kirsti Korkka-Niemi, Veli-Pekka Salonen, Kirsti Lahti and Heli Vahtera: *Groundwater interaction with the River Vantaa and its tributaries, Southern Finland*

11:45-12:00 Samrit Luoma, Nina Hendriksson, Birgitta Backman, Arto Pullinen: *Groundwater recharge in shallow coastal aquifer in Hanko, south Finland: integration of stable isotopes and field investigation data to support groundwater flow modeling*

12:00-12:15 Pekka Rossi, Pertti Ala-aho, Bjørn Kløve: *Rokua esker aquifer: combining hydrological and geological data to reduce uncertainty in groundwater management*

12:15-13:15 *Lunch*

13:30-15:00 **Session VII –**

Chair: Tobias Weisenberger, University of Oulu

13:15-13:45 *Keynote:* Iain Pitcairn: *Metamorphic mobility of gold in the Dalradian of Scotland: insights into the formation of orogenic gold deposits*

13:45-14:00 Kirsi Luolavirta, Wolfgang Maier, Eero Hanski: *The dunite-wehrlite body within the ore bearing Kevitsa intrusion, northern Finland*

14:00-14:15 Ilona Romu, Matti Kurhila, Arto Luttinen: *Crustal evolution at the rifted Gondwana margin of East Antarctica: age and composition of xenoliths in Jurassic intrusions from Vestfjella, Dronning Maud Land*

14:15-14:30 Johanna Salminen, H.C. Halls, S. Mertanen, L.J. Pesonen, J. Vuollo, U. Söderlund: *Plate tectonics using paleomagnetism - Case example from Paleoproterozoic mafic dykes from Taivalkoski region, Eastern Finland*

14:30-14:45 Fangfang Guo, Wolfgang Maier, Jouni Vuollo, Hannu Huhma, Yann Lahaye, Hugh O'Brien, Hanna Junttila: *Geochemistry of ~2.45 Ga mafic dykes in Northern Finland: constraints on the origin of PGE mineralization in coeval layered intrusions*

14:45-15:00 O. Tapani Rämö, James P. Calzia, Virginia T. McLemore, Pasi A. Heikkilä, Niclas Blomqvist, Paavo Nikkola, Annukka Rintamäki, Otso Sattilainen: *Petrogenesis of mid-Proterozoic ultrapotassic magmatic suites along the southwestern margin of Laurentia: The Mountain Pass carbonatite-shonkinite (SE California) and the Jack Creek lamprophyres (SW New Mexico)*

15:00-15:05 *Closure of the colloquium*

Poster presentations

Hanna Autere, Juha Pekka Lunkka: *Sedimentology of the Oulujoki River basin during the Late-Weichselian and Holocene*

Toni Eerola, Irmeli Mänttäri: *Detrital zircon ages of the Neoproterozoic volcano-sedimentary sandstones at Lavras do Sul region, Southern Brazil*

Tiina Eskola, Juha Pekka Lunkka: *Updates to the paleoenvironments of central western Finland based on the pollen results*

Asta Harju, Samu Valpola: *The account of peat resources in Finland: a new approach to promote policymaking and research*

Anne Huhta: *Microstructure and its contribution to thermal properties of soapstone*

Ninna Immonen: *Glacial history of the Arctic - a study of grain surface microtextures*

Hanna Junttila, Seppo Gehör, Jaakko Rämö, Erkki Eijärvi: *Removal of Phosphorus from aqueous solutions by natural adsorbents siderite and goethite*

Ekaterina Kaparulina, Kari Strand, Juha Pekka Lunkka: *Late Pleistocene Eurasian Arctic ice sheets in transitions – consequences for climate, sea-level and ocean currents*

Robert Klein, L. Pesonen, Johanna Salminen, Satu Mertanen: *A paleomagnetic study on of Mesoproterozoic Satakunta sandstone, Western Finland.*

Jukka Konnunaho, Eero H. Hanski, A. Bekker, Tapio A.A. Halkoaho, R.S. Hiebert, B.A. Wing: *Multiple sulfur isotope evidence for assimilation of external sulfur in the Archean komatiite-hosted Ni-Cu sulfide deposit at Vaara, eastern Finland*

Anna K. Kotilainen, Irmeli Mänttäri, O. Tapani Rämö*: U-Pb zircon geochronology of granitoid-xenolith pairs in the Vaasa complex, western Finland: Preliminary results*

Kirsi Larjamo, Radoslaw Michallik, O. Tapani Rämö, Aku Heinonen*: Anatomy of a rapakivi ovoid from the Wiborg rapakivi granite batholith, southeastern Finland*

Elina Lehtonen, Asko Käpyaho: *A trial to unravel the chronostratigraphy of the Archean Tipasjärvi greenstone belt, Eastern Finland*

Elina Lehtonen, Pentti Hölttä, Hugh O'Brien, Yann Lahaye: *Age of metamorphism in the Archean Ilomantsi greenstone belt – new data on monazite*

Seppo Leinonen: *P-T-X_{CO2} pseudosection modeling of talc-magnesite soapstone*

Paula Niinikoski, Nina Hendriksson, Juha Karhu: *The residence time of river water in small and medium sized catchments: The stable isotope approach*

Anne Peltoniemi-Taivalkoski, Timo Tarvainen, Pertti Sarala: *Geochemical baselines in the Kittilä arsenic province, Northern Finland*

Abstracts

Groundwater as an energy source in Finland

Teppo Arola[1], Lari Eskola[2], Jukka Hellen[1], Kirsti Korkka-Niemi[3]

1) *Golder Associates Oy (email: teppo_arola@golder.fi)*
2) *Aalto-University Department of Energy Technology*
3) *Department of Geosciences and Geography, University of Helsinki, Finland*

The main target of this study is to investigate if groundwater can be a potential energy source in Finland. Our study focused on the utilisation of energy by groundwater heat pump (GWHP) systems, also called open systems or open loop systems. Open loop ground source heating and cooling systems extract thermal energy from and/or discharge waste heat to water bodies such as aquifers and lakes (Bonte et al., 2011; Haehlein et al., 2010). Our study mapped and categorised potential groundwater reservoirs where groundwater heat pumps could provide heating energy.

Approximately 56 500 hectares of Finnish aquifers, 801 groundwater areas, are zoned for urban or industrial land usage in Finland. According to the analyses, the groundwater of these urban and industrial areas contains 40–45 MW of heat. Assuming a value of 3.5 for the heat pump coefficient of performance (COP), heating energy power of 55 to 60 MW could be utilised with the GWHP technique from these aquifers.

Although groundwater cannot be seen as a nationwide source of renewable energy in Finland, groundwater can be a significant local source of renewable heating and cooling energy. There are several hundred sites where GWHP could be used for energy utilisation in Finland.

This study is based on natural temperatures of groundwater. For example, Allen et al. (2003), Ferguson and Woodbury (2004) and Zhu et al. (2010) reported that the urban heat island effect has increased groundwater temperatures under urban areas. Latest measurements show that urbanisation has elevated groundwater temperatures in aquifer situated under Turku, Lohja and Lahti towns. Due to warmer groundwater, approximately 50% more heat load could be utilised from urban than rural areas.

References

Allen, A., Milenic, D., and Sikora, P., 2003. Shallow gravel aquifers and the urban ‘heat island’ effect: a source of low enthalpy geothermal energy. Geothermics 32, 569–578.

Bonte, M., Stuyfzand, P., Hulsmann, A., and van Beelen, P., 2011. Underground thermal energy storage: Environmental risks and policy developments in the Netherlands and European Union. Ecology and Society 16(1), 22p.

Ferguson, G., and Woodbury, A.D., 2004. Subsurface heat flow in an urban environment. Journal of Geophysical Research 109, B002402.

Haehlein, S., Bayer, P., and Blum, P., 2010. International legal status of the use of shallow geothermal energy. Renewable and Sustainable Energy Reviews 14, 2611–2625.

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Sedimentology of the Oulujoki River basin during the Late-Weichselian and Holocene

Hanna Autere[1], Juha Pekka Lunkka[1]

1) *Department of Geosciences, University of Oulu, Finland (email: hanna.autere@oulu.fi; juha.pekka.lunkka@oulu.fi)*

There is still need to gain knowledge on the sedimentation patterns and style of glacially influenced basins and their water level fluctuations under a forced regression. The Oulujoki River Basin, in western Finland is ideally located to study a sedimentation history under a forced regression since the area has been and still is glacioisostatically uplifting.

The primary aim of the present research project is to investigate sedimentation patterns and architecture of the basin fill in the Oulujoki River valley in order to establish a conceptual sedimentation model in a forced regression setting. In addition, a reconstruction of the shoreline migration using high resolution DEM (LiDAR) and geophysical methods (GPR) and relative sea level curve obtained from shore displacement methods will be established and linked to the observed changes in the long sediment sequences obtained from the basin fill.

The core material obtained from Tupos drilling site has already been subjected to lithostratigraphical, biostratigraphical, and sedimentological investigations and the C-14 dating analyses. The total length of the sediment core drilled is 143 metres. The upper 21 metres of the core is composed of silt and clay, the next 70 metres of silt and sand, and the rest of the core composing of several diamicton units. As a whole, the basal diamicton complex and associated gravel and sand units represent glacial and glaciofluvial sediments deposited beneath and next to the ice margin whereas sand and silt units above are thought to represent glaciofluvial proximal and distal subaquatic fan deposits. The preliminary results from the upper 21 metres of the core sediments indicate that the organic content in silt and clay is relatively small ranging from 0-4 %. Clay and silt unit in the upper part of the core is mostly finely laminated. Based on lithostratigraphical and diatom analyses the top part of the core was deposited in glaciolacustrine and brackish marine environments during the Ancylus and Litorina stages of the Baltic Basin.

Groundwater flowpaths and contaminant geochemistry at Luikonlahti mine

Soile Backnäs[1], Antti Pasanen[1], Lauri Solismaa[1], Teemu Karlsson[1], Päivi Kauppila[1], Nina Hendriksson[2], Jouni Lerssi[1], Tommi Kauppila[1]

1) *Geological Survey of Finland, Kuopio, Finland (email: soile.backnas@gtk.fi)*
2) *Geological Survey of Finland, Espoo, Finland*

The Luikonlahti mine in Eastern Finland (Fig. 1a) has been a target in several geochemical and modeling studies carried out in the Minera project focusing on the development of a procedure for metal mine environmental risk assessment. The geological structure of the site was studied and a geological 3D-model and groundwater flow model was constructed using GSI3D and FeFlow®. In addition, several water samples were collected and analyzed for metal and metalloid concentrations, anions, DOC, TOC, pH, redox, alkalinity and oxygen and hydrogen isotopes. Metal speciation and mineral precipitation and dissolution behavior in waters was modeled by PHREEQC. Soil samples were analyzed by *aqua regia* extraction for total elements, ammonium acetate extraction for easily mobilized, bioavailable elements and soil-water partition coefficients (Kd) for the estimation of contaminant leaching potential.

Geochemical analyses showed that As, Co, Cr, Cu, Ni, Zn and S are the most important contaminants affecting the environment. Metals occurred mainly as sulfide and iron precipitates and only a small fraction of them occurred in a bioavailable form. Based on Kd-values and PHREEQC modeling, Ni and Co are the most important metals for the estimation of groundwater pollution risk. Their concentrations are elevated in water and soil samples and they occur as free ions in water. The soil and groundwater geochemical data correspond well to the modeled groundwater flowpaths (Figs. 1b-d). The highest concentrations were detected close to the processing plant, tailings and settling ponds and at the modeled flowpaths. In addition, the geophysical studies and groundwater modeling show the importance of bedrock fractures as contaminant flowpaths. It is also seen in the bedrock groundwater geochemistry and isotopes showing a young age of the groundwater and ground and surface water interaction. Groundwater modeling proved its strength in estimation of contaminant transport pathways for preventing the risks of contaminant migration to ground and surface waters and for planning of an environmental monitoring program.

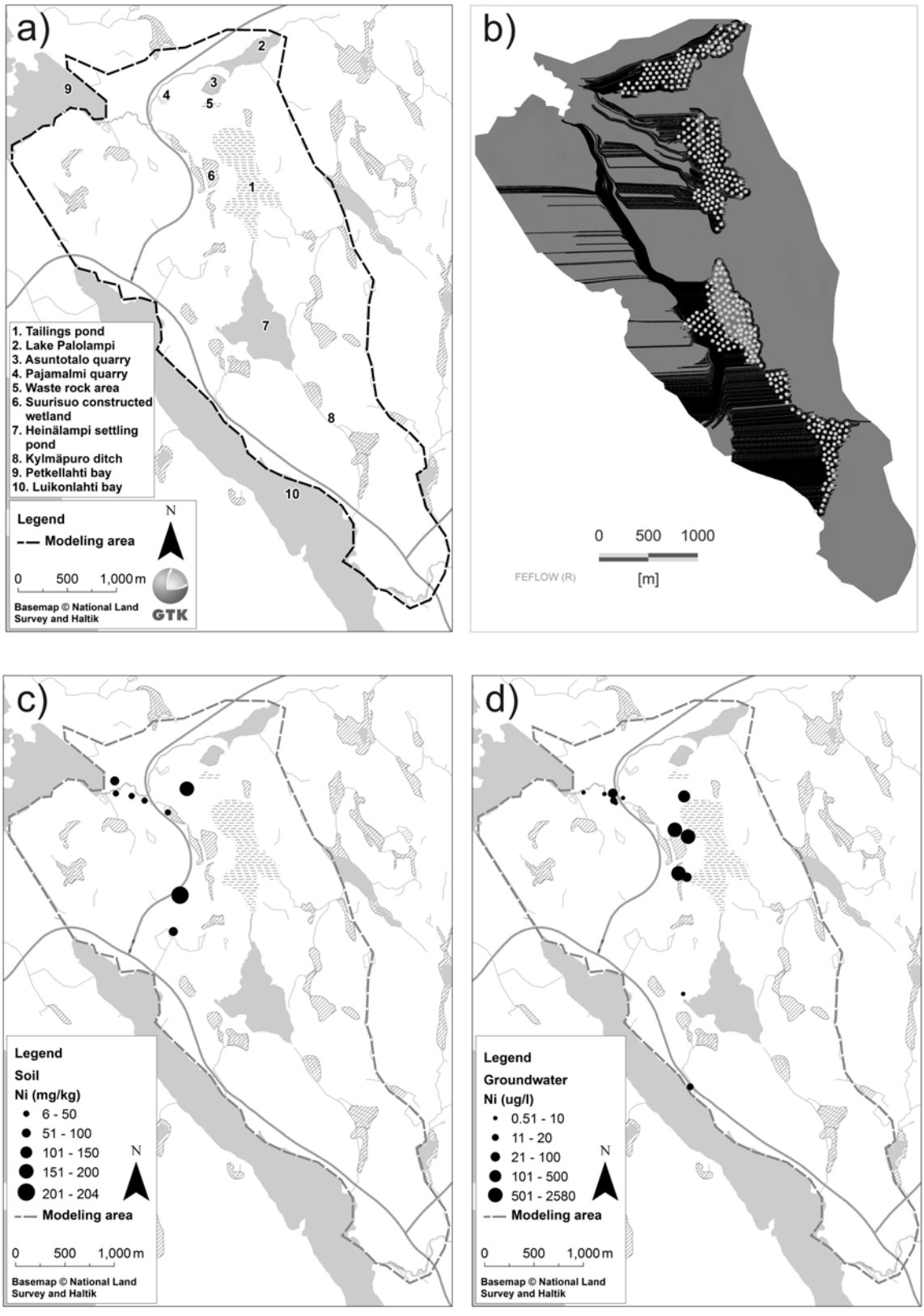

Figure 1. a) Luikonlahti study area and outline of the modeling area, b) modeled groundwater flowpaths from contamination sources, c) Ni concentrations in soil samples (soil contamination threshold value 50 mg/kg, lower guideline value 100 mg/kg and upper guideline value 150 mg/kg), d) soluble Ni concentrations in groundwater samples (environmental quality standard 10 µg/l, drinking water standard 20 µg/l).

The stakeholder engagement as a component of corporate social responsibility in mineral exploration in Finland – A model

Toni Eerola[1]

1) *Geological Survey of Finland, Espoo, Finland (e-mail: toni.eerola@gtk.fi)*

The growing interest in the Fennoscandian mineral potential has resulted in a mining boom in Finland. A number of foreign companies are operating in Northern and Eastern Finland. This has caused public opposition, firstly regarding the uranium exploration, but now concerning also other commodities, and even geological mapping and research.

The stakeholder engagement is one of the main components of the corporate social responsibility. Engaging with the local communities at the very beginning of mineral exploration has helped companies to establish a good relationship with local people, earning the social license to operate. This paper describes a model of stakeholder engagement that has been used by the author in mineral exploration in Finland. It is suggested to be applied in the country by the Mining Academy.

The main components of the local communities to be considered in Finland are the residents, landowners, reindeer herders, municipalities, the media, NGOs, and entrepreneurs. All of these should be contacted at an early stage of exploration, preferentially already at the reconnaissance stage, but at least at the moment of a claim application, which is the most critical moment. Communication should be in two-ways: locals should be allowed to express their worries and expectations to the company. However, if the local community is not previously aware about the company's intentions and activity, and the claim application is announced by the authorities or newspaper, it can cause fear and anxiety. This can culminate in opposition against the mineral exploration activities.

The different approaches that are applied when engaging with the community are described in the paper. Those are suggested to be performed by the geologists working in the field. The method can also be used in geological research and mapping, respecting the local people and taking them in account when moving on private lands, avoiding possible conflicts.

Detrital zircon ages of the Neoproterozoic volcano-sedimentary sandstones at Lavras do Sul region, Southern Brazil

Toni Eerola[1], Irmeli Mänttäri[1]

1) *Geological Survey of Finland, Espoo, Finland (e-mail: toni.eerola@gtk.fi)*

The Neoproterozoic Santa Bárbara Basin in southernmost Brazil was filled by volcano-sedimentary rocks of the Camaquã Supergroup, deposited on the Vila Nova Belt (900-700 Ma) during the São Gabriel event at ~600 Ma. At Lavras do Sul, the succession is composed by the Ediacaran Maricá, and Bom Jardim Groups (BJG). The BJG begins with the volcanic Hilário Formation (HF, 590-580 Ma). It is overlain by the volcano-sedimentary Picada das Graças Formation (PGF), composed by conglomerates, sandstones, diamictites, and shales with lonestones, covered by andesites. The formation has been thought to be glacially influenced during the Gaskiers glaciation (~583 Ma).

Detrital zircon grains were dated by SIMS from Neoproterozoic volcanic sandstones and conglomerates collected from the basal unit of the PGF at Passo da Areia, Lavras do Sul, for studying its provenience and maximum sedimentation age. Because of small samples and limited SIMS dating schedule, six samples were combined.

The zircon population is fairly homogeneous, consisting mainly of medium to fine-grained, transparent, euhedral (l:w~2-3) zircon with oscillatory zoning visible in CL images. Traces of abrasion cannot be detected. On the concordia diagram, the U-Pb data plot in a tight cluster between 560 Ma and 610 Ma. The 51/55 concordant U-Pb data points determine an age of 583 ± 2 Ma for the zircon grains.

The invariable ages, the only slightly varying Th/U ratios, as well as the rather homogeneous zircon morphology and internal texture indicate a common source for all the sandstone and conglomerate zircons. Sediments were probably deposited in a proximal area of a volcanic alluvial fan setting. As the sandstones lay directly over the volcanic HF, it can be suggested as the source area. Although coeval with the Gaskiers glaciation, the zircons do not show evidence of long distance transport, nor glacial influence.

Updates to the paleoenvironments of central western Finland based on pollen studies

Tiina Eskola[1], Juha Pekka Lunkka[1]

1) *Department of Geosciences, University of Oulu, Finland (email: tiina.eskola@oulu.fi)*

Pollen analysis of fine-grained sediment layers was made from a 54.5-m-thick Quaternary sediment sequence in order to obtain more detailed information on the glaciation history of northern Fennoscandia. The coring site, Muhos 1, is situated in the Oulujoki river valley, approximately 30 km south-east of Oulu and 27 m above sea level. The sediment core on top of the Neoproterozoic Muhos Formation is composed of Holocene fluvial, marine and glaciolacustrine sediments and several till units intervening with fluvial sand and fine-grained sediments. The age of the sandy layers was determined by the OSL method. Pollen analysis was carried out from two different, sorted layers located at depths of 29.55-29.85 m and 38.74-38.81 m. Based on the OLS results, the sediments are older than 110 ka. In this preliminary study, a total of 7 pollen samples were utilized. Samples were treated with heavy liquids (LST) and a minimum of 200 arboreal pollen per sample was counted. All samples were dominated by trees, both deciduous (*Betula, Alnus*) and coniferous (*Pinus, Picea*) trees. The amount of crumbled pollen and spores was relatively high in every sample suggesting reworking and re-deposition. Nevertheless, pollen analysis suggests forested environment for the studied sediments. On the basis of the preliminary pollen results, these inter-till sediments indicate two different ice-free periods, either representing an interstadial cycle or the beginning of an interglacial cycle.

Geochemistry of ~2.45 Ga mafic dykes in Northern Finland: constraints on the origin of PGE mineralization in coeval layered intrusions

Fangfang Guo[1], Wolfgang Maier[1], Jouni Vuollo[2], Yann Lahaye[3], Hannu Huhma[3], Hugh O'Brien[3], Hanna Junttila[1]

1) *Department of Geology, University of Oulu, Finland (email: fangfang.guo@oulu.fi)*
2) *Geological Survey of Finland, Romaniemi, Finland*
3) *Geological Survey of Finland, Espoo, Finland*

The Karelian craton contains abundant ~2.45 Ga mafic dykes, spatially and temporally related to PGE mineralized ultramafic-mafic layered intrusions. The mafic dykes include siliceous high magnesium basalt (SHMB), gabbronorite (GBNO), Ti-poor tholeiite (TTH) and Fe-tholeiite (FTH). We carried out Nd isotope whole rock analyses and in-situ Sr isotope analyses on plagioclase. The SHMB and GBNO have $^{87}Sr/^{86}Sr_{(i)}$ ratios ranging from 0.7028-0.7036, and initial eNd ranging from −2.4 to −1.8. These data indicate moderate degrees of contamination with Archean basement or magma derivation from an enriched mantle source. The TTH show a lower radiogenic Sr isotope composition with an average $^{87}Sr/^{86}Sr_{(i)}$ ratio 0.7022, and a higher eNd ranging from +0.3 to +1.7. These data is consistent with magma derivation from a depleted asthenospheric mantle plume. Most dyke types are undepleted in PGE, with 10-20 ppb Pt and Pd, and mantle-like Cu/Pd ratios in the more primitive members, suggesting sulphide undersaturation both at the source and en route to the surface. Sulfide saturation was achieved in the more evolved magmas, and in many cases the sulfides were entrained by the magma, resulting in high Cu and PGE contents (up to 37 ppb Pd), creating some of the world's most PGE rich basalts. The data indicate that all 4 dyke types are prospective for PGE mineralization.

The account of peat resources in Finland: a new approach to promote policymaking and research

Asta Harju[1], Samu Valpola[2]

1) *Geological Survey of Finland, Western Finland Office, Finland (email: asta.harju@gtk.fi)*
2) *Geological Survey of Finland, Western Finland Office, Finland (email: samu.valpola@gtk.fi)*

In order to responsibly use and manage a certain natural resource, such as peat, there has to be knowledge of the volume, quality, distribution and location of resources. Policymaking, permission procedures and community planning require that the knowledge of the needs and stresses of possible conflicting purposes of use or management are also considered carefully. To ensure a fluent and correct evaluation of these questions the information related to a certain resource has to be impartial and easily available for the public.

Peat reserves in Finland are rather well investigated and documented. The Geological Survey of Finland (GTK) has investigated over third of Finnish peatlands. Since 1940's over 1.9 million hectares of mires and peatlands have been investigated. GTK' databases contain over 1.5 million coring points on ca. 16 000 separate mires or peatlands. The estimated total volume of peat resource is ca. 70 billion m^3, of which ca. 24 billion m^3 is suitable for energy production and 6 billion m3 for horticultural and environmental purposes.

In October 2012 Geological Survey of Finland published a web service, which offers information about investigated peatlands and peat reserves and land use of peatlands in general (http://geodata.gtk.fi/Turvevarojen_tilinpito/index.html). The aim is to support coordination and planning of sustainable use of peatlands in a new, effective way. Specific information on single mire as well as areal compilations is offered in the web service. The data includes e.g. the area and amount of investigated peat reserves, natural state of investigated peatlands, peat production areas and peatlands under conservation. The geographical extent of the web service is extending (from municipality of Southern Ostrobothnia) during year 2013. Another aim of the service is create new research ideas and promote co-operation in the field of geological peat and peatland research.

Geochemical baselines in the man-made fillings in the Helsinki Metropolitan Area

Tarja Hatakka[1], Timo Tarvainen[1], Jaana Jarva[1]

1) *Geological Survey of Finland, Espoo, Finland (email: tarja.hatakka@gtk.fi)*

The Geological Survey of Finland (GTK) has taken 48 topsoil samples of man-made land filling areas in Helsinki, Espoo and Vantaa in 2009 and 2011. The sampling sites were chosen in cooperation with the environmental authorities of the cities. The sites were located in different parts of the cities and there are variations in the age of the land fillings as well as in the grain size of the sampling material. The grain size of the samples was variable but the sand and silt fractions were predominant.

Concentrations of some elements were dependent on the amount of organic matter or on the amount of clay fractions. For example, the sulphur and molybdenum concentrations were the higher the more organic matter the sample contained and the highest arsenic concentrations were found in fine grained fillings. Over a half of the arsenic concentrations in the studied fillings exceeded the threshold value 5 mg/kg, given in the Decree on the Assessment of Soil Contamination and Remediation Needs (214/2007) (Fig. 1). In 15% of the samples the lead values exceeded the threshold value 60 mg/kg, and the mercury concentrations were higher than the threshold value 0.5 mg/kg in some cases.

The concentrations of organic compounds were usually very small in the man-made fillings. The median concentration for PAH compounds and the median sum concentrations for PCB compounds were lower than the analysis' detection limits (0.25 mg/kg for PAH compounds and 0.01 mg/kg for PCB compounds). In the sample taken from a park in downtown Helsinki, the total concentration of PAH compounds exceeded the lower guideline value 30 mg/kg (Decree 214/2007). The sum concentration of PCB compounds was higher than the threshold value of 0.1 mg/kg (Decree 214/2007) in four cases, all of them in Helsinki.

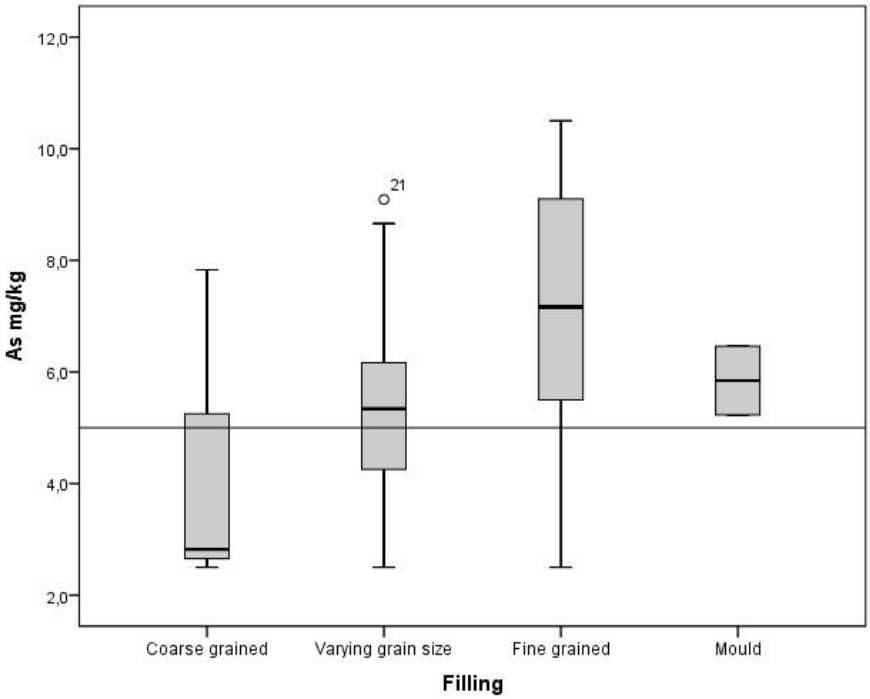

Figure 1. Distribution of arsenic in the man-made fillings of Helsinki Region in 2009 and 2011 (topsoil, <2 mm size fraction, aqua regia extraction). Number of samples: Coarse grained filling 7, varying grain size filling 31, fine grained filling 8 and mould 2. Solid line: threshold value 5 mg/kg (Decree 214/2007). Commas are used instead of decimal points.

Seismic reflection profiling in ore exploration: experiences from the Pyhäsalmi VHMS deposit

Suvi Heinonen[1], Pekka J. Heikkinen[1], Ilmo T. Kukkonen[2], David B. Snyder[3]

1) *Department of Geosciences and Geography, University of Helsinki, Finland (email: suvi.heinonen@helsinki.fi)*
2) *Department of Physics, University of Helsinki, Finland*
3) *Geological Survey of Canada, Ottawa, Canada*

In the HIRE project (HIgh-REsolution reflection seismics for ore exploration 2008–2010, Geological Survey of Finland), 2D seismic reflection profiles were acquired at 15 mining camps in Finland including the Pyhäsalmi mining area. Pyhäsalmi is a volcanic hosted massive sulphide (VHMS) deposit located in a Proterozoic volcanic belt in central Finland. At Pyhäsalmi, six seismic profiles were acquired with 45 total line kilometers. The network of seismic profiles image sub-surface structures down to 5 km depth enabling geological modeling well beyond the mined depths.

Seismic velocities and densities derived from drill hole logging provide crucial information about physical rock properties forming the basis for seismic interpretation. Besides the acoustic impedance, the scale and orientation of the geological structures also influence reflectivity. At Pyhäsalmi, it was shown that sub-vertical structures are not imaged directly with seismic reflection data and only the sub-horizontal fold hinges are visible in seismic section while steep flanks need to be interpreted indirectly. Reflection seismic profiles at Pyhäsalmi show the continuation of the volcanic lithologies underneath intrusive granites, thus expanding the area of interest for exploration.

Heterogeneous geological surroundings and an unfavorable shape of the Pyhäsalmi ore deposit mask the seismic signal originating from the ore-host rock contact. The latter is thus not clearly imaged with reflection seismic data. Based on these experiences, hardrock seismic exploration is most efficiently done through geological 3D-modeling instead of only hunting bright spots.

Rautuvaara: An environmental assessment for a proposed tailings facility

Peter Howett[1], Talvikki Savolainen[1], Kirsti Korkka-Niemi[1], Julien Moreau[2]

1) *Department of Geography and Geology, University of Helsinki, Finland*
2) *Department of Geography and Geology, University of Copenhagen, Denmark*

The purpose of this research is to establish the suitability of reopening a former mining and tailings site at Rautuvaara, Lapland, from an environmental prospective, through a number of methods. These include the correlation of data from over 400 boreholes, 53 km of ground-penetrating radar (GPR) lines, 34 piezometers, 21 trial pits and various geochemistry samples and groundwater-surfacewater interaction methods. This data provides a 3D subsurface evaluation of sedimentology, bedrock depth and glacial history as well as a good overview of groundwater/surfacewater flow quantity and quality, with aid of aerial infrared photography, especially in those waters influenced by previous mining and tailings activity.

Results from the field excursions and from looking at old borehole records show that the bedrock within the area is relatively shallow (deepest 30 m) and dips gently towards the SSW, with the shallowest areas being situated on the hills either side of the valley and the deepest on the east side of the valley. The groundwater was found to be topographically bound, flowing into the Niesajoki river valley basin and towards the SW. A watershed was located in the middle of the present northern settling pond, with some flow therefore to the NE. As expected, the areas most influenced by sulphate-rich mine waters are located in and around the existing tailings area, indicating AMD (Acid Mine Drainage). The river valley consisted of various till layers with mostly poor hydraulic conductivity; problematic areas include the E-SE side of the valley where sediments are thickest and include differing till units with differing hydraulic conductivities. The most suitable location therefore, is to the SW of the valley where bedrock is shallowest and sedimentary layers do not differ as much.

Further research will look at incorporating the data into a 3D hydrogeological model to assess groundwater/surfacewater interactions and potential impacts to the local fragile rivers and ecosystems.

Microstructure and its contribution to thermal properties of soapstone

Anne Huhta[1]

1) *Department of Geosciences, University of Oulu, Finland*

Soapstones are low- to medium-grade metamorphic rocks which often have been formed due the alteration of ultramafic igneous rocks. They contain 30 % to 70 % talc, and the quantity of other constituents such as oxides, chlorites and carbonates is the basis for the further classification. The percentage of hard silicates is also an important factor of proposed classification scheme of soapstones (Kärki et al., 2008).

The priority of this study was to create a reliable method to determinate the value of thermal shock resistance for various soapstone types. The goal was achieved by heating thousands of samples of several soapstone types in different temperatures and cooling these in different mediums as quick as possible.

The major contribution to thermal shock resistance of soapstones is derived from microstructure and mineral composition. The grain size and the texture of soapstone samples are highly essential variables concerning the thermal shock resistance. Concentrating only on carbonate soapstones we can conclude that high thermal shock resistance values are mainly deserved from fine-grained and homogeneous rock types in which the structure is sustainable.

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Kärki, A., Leinonen, S., and Uusitalo, J., 2008. Soapstones- how should they be defined. International Geological Congress, Oslo, Abstract.

Glacial history of the Arctic - a study of grain surface microtextures

Ninna Immonen[1, 2]

1) *Thule Institute, University of Oulu, Finland (email: ninna.immonen@oulu.fi)*
2) *Department of Geosciences, University of Oulu, Finland*

This research aims to reveal the palaeoenvironmental conditions in the Arctic, especially related to ice sheet development in the Eurasian continent over the past glacial stages. Integrated Ocean Drilling Program Expedition 302 (Arctic Coring Expedition) and the Arctic Ocean 1996 expedition (AO96) deep marine sediments, obtained from the central Arctic Ocean Lomonosov Ridge, were used as the materials for this study. The methods are based on scanning electron microscope (SEM) and energy dispersive spectrometer (EDS) analysis, grain feature and surface microtexture observations and statistical cluster and principal components analysis (PCA). The results show that deep marine ice rafted detrital quartz grains can be differentiated by surface microtextural characteristics to glacial (including subglacial, englacial and glacifluvial) or non-glacial (e.g. fluvial/alluvial) origin (Fig. 1). Hence, the appliance of total ice rafted debris (IRD) as a glacial proxy is more complicated than generally thought. IRD deposits of older glacial stages are often interpreted as glacial origin while they may also result from deposition of sea-ice rafted non-glacial grains. This interpretation would require a hypothesis of thick shelf-based glacier and may result to overestimation of glacier extent and underestimation of coeval non-glacial processes. To conclude, differentiation between glacial and non-glacial grains is necessary when the environmental conditions are interpreted. For further research, microtextural composition of the Rautuvaara (northern Finland) pit section till deposits will be studied in order to compare the deep marine data with the data from terrestrial late Pleistocene sediments.

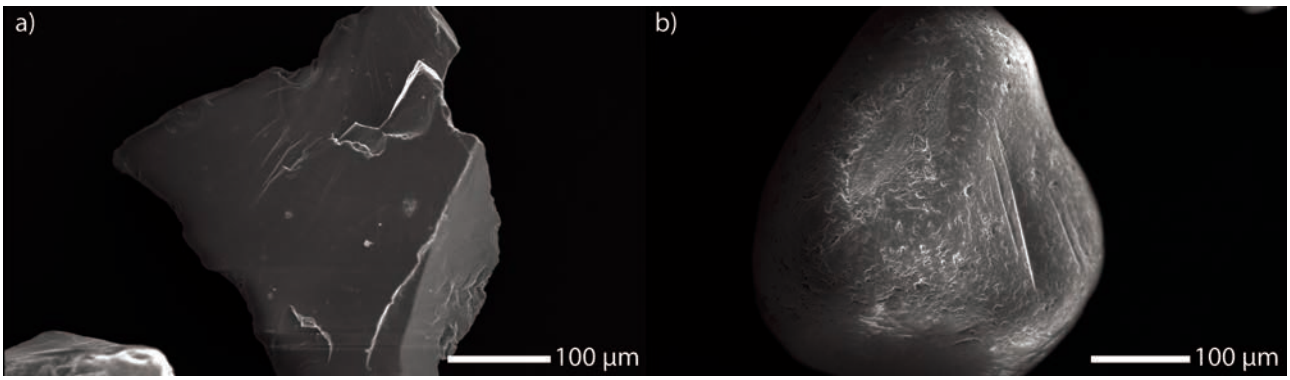

Figure 1. Ice rafted grain of glacial and non-glacial origin. a) Very angular glacial grain showing subparallel linear fractures (96/12-1pc sample 45, 0.811 mbsf). b) Well rounded non-glacial grain with grooves and impact v-pits on the surface (96/12-1pc sample 11b, 1.507 mbsf).

Removal of phosphorus from aqueous solutions by natural adsorbents siderite and goethite

Hanna Junttila[1], Seppo Gehör[2], Jaakko Rämö[3], Erkki Eijärvi[1]

1) *Department of Geosciences, University of Oulu, Finland (email: hannajunttila@oulu.fi)*
2) *Department of Environmental and Process Engineering, University of Oulu, Finland*
3) *Thule Institute, Oulu, Finland*

Natural iron bog ores in the Vihanti area, central Finland, have been studied as adsorbents for phosphorus, and their adsorption properties have been evaluated by batch tests. The bog ores are mainly composed of siderite (SID) and goethite (GOT). The factors controlling phosphorus removal from synthetic wastewater are the dosage of the sorbent, the initial concentration of P in solution, the pH of the solution, as well as the zeta potential and total surface charge of the adsorbents. The main results of our investigations indicate that the studied materials adsorb 99% of phosphorus at pH 3. When the dosage of the adsorbents is increased up to 5 g/l, the effect of the solution's pH decreases, and the adsorption efficiency is 95% for SID and 58% for GOT at mildly alkaline conditions (pH 8). A contact time of 24 h is adequate to remove phosphorus from solutions at dosages of more than 2.5 g/l, whereas 14 days are required in the case of minor dosages. Siderite has a better adsorption efficiency than goethite, but goethite is a more stable mineral, releasing less Fe in the solution.

Late Pleistocene Eurasian Arctic ice sheets in transitions – consequences for climate, sea-level and ocean currents

Ekaterina Kaparulina[1], Kari Strand[2], Juha Pekka Lunkka[3]

1) *Thule Institute, University of Oulu, Finland (email: ekaterina.kaparulina@oulu.fi)*
2) *Thule Institute, University of Oulu, Finland*
3) *Institute of Geosciences, University of Oulu, Finland*

The relevance of this study is connected with a global modern problem of the Earth's climate warming. The understanding the changes of climate, sea-level and global ocean circulation that occurred in the past is the key to the interpretation of present global climate change and development the possible future scenario. Major past environmental changes are registered in marine and terrestrial sediments. The detailed study of sediments via proxies provides information for paleoenvironmental reconstruction.

The present research is carried out in the project "Rapid environmental changes in the Eurasian Arctic - lessons from the past to the future" (REAL). The understanding the ice sheet transitions within past 130 ka is one of the aims of this study. The main objective is to product information on the rate of environmental changes and extreme events in the Eurasian Arctic.

This poster represents the framework of our research concerning the study of ice sheet transitions in the Eurasian Arctic. The lithological, mineralogical and geochemical data previously generated from cores drilled in different parts of the Eurasian Arctic (e.g. Lomonosov Ridge (IODP ACEX 302, AO–96), Yermak Plateau (ODP), Barents Sea) make it possible to reconstruct the ice sheet development. The data will be correlated to the land sections. The terrestrial sediment records will provide the data especially for the last interglacial transition. These information and models should clarified the time and duration of relatively fast climatic and environmental transitions that caused hydrological changes including changes in sea level, glacial ice extent and volume, drainage basins and ocean currents.

Groundwater residence times of millions of years revealed by noble gases in the Outokumpu Deep Drill Hole, eastern Finland

Riikka Kietäväinen[1], Lasse Ahonen[1], Ilmo T. Kukkonen[1,2], Samuel Niedermann[3], Thomas Wiersberg[3]

1) *Geological Survey of Finland, Espoo, Finland (e-mail: riikka.kietavainen@gtk.fi)*
2) *Department of Physics, University of Helsinki, Finland*
3) *Deutsches GeoForschungsZentrum (GFZ), Potsdam, Germany*

Methane-, nitrogen- and hydrogen-rich, saline groundwaters with a water stable isotope composition distinct from meteoric and sea water have been found to host isolated ecosystems within the Precambrian crystalline bedrock of Outokumpu (Kietäväinen et al., 2012). In order to investigate the geochemical and microbial evolution of the deep subsurface of the area, time scales are of great importance. To address the question, accumulation of radiogenic (^{4}He, ^{40}Ar), nucleogenic (^{21}Ne) and fissiogenic (^{134}Xe, ^{136}Xe) noble gases in the crust was used to determine residence times of saline groundwaters sampled from different depths of the 2.5 km deep Outokumpu Deep Drill Hole. Both water and gas samples were analysed for their noble gas isotopic composition using a VG 5400 noble gas mass spectrometer at GFZ Potsdam, Germany. More than 99 % of the air-corrected He is crustal in origin with virtually no contribution of mantle gases. The observed vertical variation of geochemistry and microbiology together with hydrogeological and geophysical measurements indicate negligible fluid flow in the bedrock. Therefore we consider *in situ* accumulation applicable. Using average values for porosity, density and concentration of radioactive elements (U, Th and K) in the Outokumpu deep drill core, residence times between 5 and 50 Ma are indicated by the ^{4}He, ^{21}Ne and ^{40}Ar accumulation. ^{134}Xe and ^{136}Xe indicate longer residence times of up to 500 Ma, but the very low concentrations of these isotopes together with the poorly constrained release factor make the calculation more prone to errors.

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A paleomagnetic study of Mesoproterozoic Satakunta sandstone, Western Finland

R. Klein[1], L. Pesonen[1], Johanna Salminen[1], S. Mertanen [2]

1) *Division of Geophysics and Astronomy, Department of Physics, University of Helsinki, Finland*
2) *Geological Survey of Finland, Espoo, Finland*

A paleomagnetic study of the Mesoproterozoic Satakunta sandstone formation was carried out to obtain a new paleomagnetic pole for Baltica, to obtain a better age estimate of deposition, and to verify the union of Baltica and Laurentia between 1.83-1.26 Ga (Pesonen et al., 2003). Two components of natural remanent magnetization (NRM) were isolated in the sandstone with alternating field (AF) and thermal demagnetization treatments. The first is a high coercivity/unblocking temperature component which, after tilt and inclination shallowing corrections, yields a remanent magnetization of D = 25.2°, I = 3.9°, α_{95} = 9.1°, 10 sites, corresponding to a paleomagnetic pole of Plat = 27.8° N, Plon = 173.2° E, A_{95} = 6.5°. Positive reversal and tilt tests as well as a stratigraphic order of the site mean poles, strongly indicate a primary remanence. At least one reversal has taken place during the deposition of the sandstone, and it occurs at the upper part of the sampled section. The second component is a lower coercivity/unblocking temperature component with a remanent magnetization direction (D = 34.0°; I = -40.7°; α_{95} = 8.1°; 13 sites) similar to the post-Jotnian Satakunta diabase intrusions (D = 44.0°; I = -52.3°; α_{95} = 8.3°; k = 45.8; 8 sites), which are widespread in the area. This proximity of the sandstone to the diabase sheets, and identification of baked and partially baked specimens lead us to believe that the secondary component is caused by diabase intrusion. Therefore, the paleomagnetic component obtained by earlier paleomagnetic study on Satakunta sandstone (Neuvonen, 1973) is most likely a secondary component. The relative age of the sandstone, based on the present study, is estimated at ca. 1600 based on the proximity to other well define poles of 1540-1770 Ma. Comparing APWPs of Baltica and Laurentia during 1.77-1.27 Ga gives strong support to the NENA configuration at 1.6 Ga.

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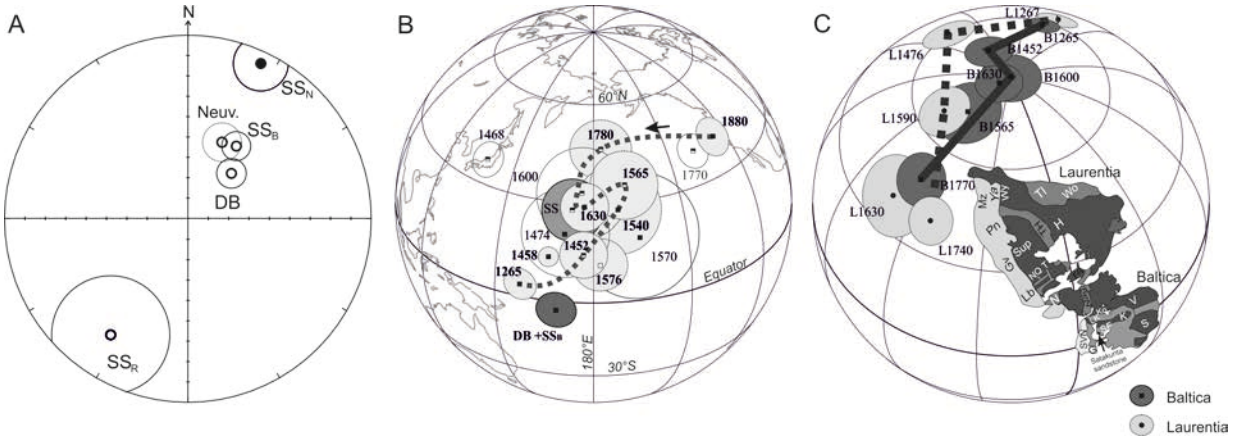

Figure 1. (A) Mean paleomagnetic directions for sandstone normal polarity (SS_N), sandstone reversed polarity (SS_R), sandstone secondary (diabase) component (SS_B) and diabase (DB) component. Neuv. represents the paleomagnetic direction for sandstone by Neuvonen (1973). (B) Paleomagnetic poles of this study plotted with selected paleomagnetic poles all with 95% confidence circle. (C) Reconstruction of Baltica and Laurentia at 1.6 Ga based on mean poles for Baltica and Laurentia. Poles for Baltica and Laurentia shown with age (Ma).

Archaean granulite-gneiss terranes of western and eastern Greenland: tectonometamorphic evolution and nickel mineralization

Jochen Kolb[1], Annika Dziggel[2], Leon Bagas[3], John Owen[3], Marco Fiorentini[3]

1) *Department of Petrology and Economic Geology, Geological Survey of Denmark and Greenland, Denmark (email: jkol@geus.dk)*
2) *Institute of Mineralogy and Economic Geology, RWTH Aachen University, Germany*
3) *Centre for Exploration Targeting, The University of Western Australia, Australia*

Eoarchaean to Neoarchaean terranes exposed in the North Atlantic Craton, Greenland provide a unique opportunity to study Archaean tectonics and mineral systems in the lower crust. The Tasiusarsuaq Terrane of southern West Greenland and the Thrym Complex of South-East Greenland have been chosen with the aim to compare and contrast their geological histories.

The Tasiusarsuq Terrane is characterized by narrow mafic to ultramafic enclaves in tonalite-trondhjemite-granodiorite gneiss, which have been metamorphosed at medium-pressure, fluid-saturated granulite facies conditions (850°C, 7.5 kbar) followed by near-isobaric cooling (700°C, 6.5-7 kbar) at fluid-undersaturated conditions. The retrogression is related to thrust tectonics that lasted ca. 100 m.y. at amphibolite facies conditions. The terrane represents the deep part of the orogenic foreland, where deep-crustal rocks are thrust along shallow detachment horizons. The tectonically imbricated ultramafic and mafic rocks that locally have preserved pillow structures host nickel mineralization that was probably formed at the surface.

The Thrym Complex, characterized by similar mafic to ultramafic enclaves in predominantly granodiorite gneiss, has been metamorphosed at granulite facies conditions (800°C, 7.5 kbar) and was followed by a ca. 50 Ma retrogression at amphibolite to greenschist facies conditions (300°C, 1.5 kbar). The complex represents the central part of an orogen characterized by crustal thickening and relatively fast exhumation. Nickel mineralization present in ultramafic and mafic rocks probably formed in the deep crust. Volatile-bearing phases associated with the mineralization indicate Ni-enrichment by fluids in the mantle to an ultramafic melt or in the deep crust.

Multiple sulfur isotope evidence for assimilation of external sulfur in the Archean komatiite-hosted Ni-Cu sulfide deposit at Vaara, eastern Finland

Jukka Konnunaho[1], Eero Hanski[2], A. Bekker[3], Tapio A.A. Halkoaho[4], R.S. Hiebert[3], B.A. Wing[5]

1) *Geological Survey of Finland, Rovaniemi, Finland (email: jukka.konnunaho@gtk.fi)*
2) *Department of Geosciences, University of Oulu, Finland*
3) *Department of Geological Sciences, University of Manitoba, Winnipeg, Canada*
4) *Geological Survey of Finland, Kuopio, Finland*
5) *Department of Earth and Planetary Sciences and GEOTOP, McGill University, Montreal, Canada*

The range of $d^{34}S$ values in Archean supracrustal rocks is much smaller than that in Phanerozoic examples, with $d^{34}S$ values being often close to mantle $\delta^{34}S$ values and therefore distinction between mantle and country rock sulfur in magmatic Ni-Cu deposits is not easy to make. However, photochemical reactions in the Archean anoxic atmosphere (Farquhar et al., 2000) generated mass-independent fractionation of sulfur isotopes, expressed as non-zero $D^{33}S$ values, which can be preserved in Archean sedimentary rocks, thus providing a unique tool to investigate the potential role of external sulfur in Ni-Cu sulfide ore formation.

We have studied the ca. 2.8 Ga Vaara Ni deposit in the Archean Suomussalmi greenstone belt. It occurs in the central part of the serpentinized olivine cumulate zone of a komatiitic extrusive body and is formed by disseminated interstitial sulfides, mostly pyrite and millerite, accompanied by abundant magnetite, indicative of post-magmatic, low-temperature hydrothermal oxidation of the primary magmatic sulfide assemblage. Multiple sulfur isotope data reveal a considerable mass-independent sulfur isotope range both in country rock sedimentary sulfides ($D^{33}S$ values from -0.50 to +2.37‰) and in the Vaara mineralization ($D^{33}S$ values from +0.53 to +0.66‰) (Fig. 1), which provides strong evidence for assimilation of crustal sulfur, and points to a possible mechanism to trigger sulfide melt immiscibility. This is compatible with the observation that, in contrast to the common komatiite types in the eastern Finland greenstone belts, the Vaara rocks are moderately enriched in LREE compared to MREE, suggesting that assimilation of felsic crustal rocks played an important role in the genesis of the Vaara deposit.

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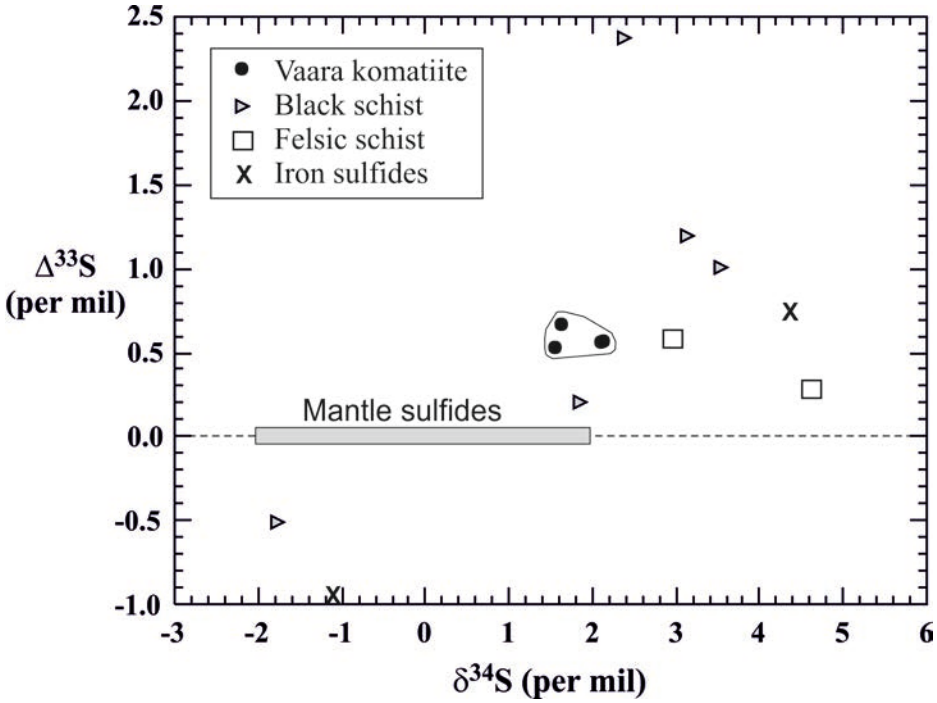

Figure 1. $D^{33}S$ versus $d^{34}S$ data for sulfides from the Vaara komatiitic body and its country rocks (normalized to VCDT, Vienna–Canyon Diablo Troilite). The mantle $d^{34}S$ value is taken from Ripley and Li (2003), whereas the mantle $D^{33}S$ value is based on Ueno et al. (2008).

Hydrogeology and groundwater - river water connections at the Hannukainen mining development site, Kolari, northern Finland

Kirsti Korkka-Niemi[1], Veli-Pekka Salonen[1], Julien Moreau[2], Tiina Nurminen[1], Anne Rautio[1]

1) *Department of Geosciences and Geography, University of Helsinki, Finland (e-mail: Kirsti.Korkka-Niemi@helsinki.fi)*
2) *Department of Geography and Geology, University of Copenhagen, Denmark*

Environmental issues play an increasingly important role in planning large-scale mining activities. Potential impacts are often related to groundwater systems, which may be inadequately understood and assessed. This is true especially in Lapland, where subsurface and surface water reserves and their hydraulic connections have rarely been studied. The main purpose of this study was to collect background information about the hydrostratigraphy of a mining development area. This means to describe the aquifers and aquitards; to measure or calculate hydraulic conductivity (K) of different units and; to observe hydraulic heads and groundwater flow directions. The specific target was also to characterize chemical and stable isotopic composition of waters and to evaluate the groundwater - river water interactions. Based on the sedimentological studies and ground penetrating radar survey, the Hannukainen mine development site hosts a complicated aquifer system with notable connections to natural river systems. The Quaternary sediments are exceptionally thick (>50 m in places) and genetically complex. There are aquifers related to fluvial and glaciofluvial sands and gravels (K: 10^{-3}…10^{-5} m/s) and aquitards related to tills and/or fines (K: 10^{-6}…10^{-8} m/s) causing intricate perched water bodies. According to water and river bed sediment temperature measurements, water chemistry, stable isotopic composition (δD and $\delta^{18}O$) of waters, the hydraulic head measurements and low altitude aerial infrared (AIR) survey, Rivers Kuerjoki and Valkeajoki are strongly fed by groundwater. Groundwater is discharging into the River Äkäsjoki from the open pit area, as well. This hydrogeological background information is crucial in planning and positioning essential mining operations such as tailings areas in order to prevent any undesirable environmental impact. At Hannukainen, it is vital to identify the aquifers and aquitards; to estimate the water volumes and; to understand the groundwater flow patterns and the influence of groundwater discharge into the rivers both now and in the future.

U-Pb zircon geochronology of granitoid-xenolith pairs in the Vaasa complex, western Finland: Preliminary results

Anna K. Kotilainen[1], Irmeli Mänttäri[2], O. Tapani Rämö[1]

1) *Department of Geosciences and Geography, Unversity of Helsinki (anna.kotilainen@helsinki.fi)*
2) *Geological Survey of Finland, Espoo*

The Vaasa complex in western Finland, formed during the ~1.9 Ga Svecofennian orogeny, consists of a ~8000-km^2 granitoid batholith (the Vaasa Batholith; Mäkitie et al., 2012), surrounding diatexitic and metatexitic migmatites, and metasedimentary rocks of the Bothnia Belt. The contact between the batholith and the migmatites is gradual and the metamorphic grade of the Bothnia Belt metasediments decreases outward from the batholith. The bulk of the Vaasa Batholith consists of garnet-bearing K-feldspar-megacrystic and even-grained granodiorites, smaller occurrences of pyroxene granitoids (tonalite, granodiorite) and biotite granites are also found. The granitic rocks frequently contain xenoliths of metasedimentary rocks as well as calcareous concretions.

Zircons from six granitoid-xenolith pairs from the Vaasa Batholith were dated using the U-Pb LA-MC-ICPMS method. The granitoid samples indicate crystallization ages of 1.88–1.87 Ga, whereas inherited zircon cores and grains are typically 2.05–1.9 Ga; Archaean ages from 2.9 to 2.5 Ga were also detected. Three of the xenoliths examined yield maximum sedimentation ages of ~1.93 Ga and have the main detrital zircon age population in the 2.02−1.92 Ga range. In addition, Archaean and ~2.1 Ga zircon ages are present. The granitoid hosts of the three xenoliths show similar inheritance patterns and thus imply derivation of the granitoids from metasedimentary sources akin to the xenoliths.

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The Holocene boreal forest dynamics in the modern western range limit of the Siberian larch (*Larix sibirica*), new insights from small hollow records

Niina Kuosmanen[1], Heikki Seppä[1], Richard Bradshaw[2], Jennifer Clear[2], Oleg Kuznetsov[3], Ludmila Filimonova[3]

1) *Department of Geosciences and Geography, University of Helsinki, Finland, (email: niina.kuosmanen@helsinki.fi)*
2) *School of Environmental Sciences, Department of Geography, University of Liverpool, United Kingdom*
3) *Institute of Biology, Karelian Research Centre of RAS, Russia*

Investigation of the past vegetation-climate relationship can provide valuable information regarding the potential effects of future changes in climate on the boreal vegetation. To understand the processes affecting boreal forest composition, both local and regional factors, needs to be considered. The Siberian larch (*Larix sibirica*) has a significant role in boreal forests across the taiga zone in Russia. Still, the western distribution of the species during the Holocene is practically unknown. To investigate the boreal forest dynamics and the Holocene history of Siberian larch, we analyzed pollen, conifer stomata and charcoal from small forest hollow sites located in the modern western range limit of Siberian larch in Eastern Russian Karelia, east from Lake Onega. Stomata records can give more reliable evidence of the in situ presence of species. Particularly the larch stomata are more abundant and identifiable than larch pollen, and when analyzed from small forest hollows within the modern larch stands, can produce reliable evidence of past occurrence of the Siberian larch.

Results from the small hollow records indicate that the boreal trees have been present near the sites already from the early Holocene. The cores cover the last 10 000 years of Holocene. Larch stomata are abundant and show that larch has been present since ca. 9100 cal yr BP, suggesting that western range limit of Siberian larch in Europe has remained constant since the early Holocene. Spruce (*Picea abies*) stomata were also found throughout the cores and the pollen records show expansion of the spruce population ca. 7000 cal yr BP. The charcoal records from the study sites are markedly different, but show decreasing fire frequency during largest spruce population.

Mineral potential research in the Geological Survey of Finland

Raimo Lahtinen[1]

1) *Geological Survey of Finland, Finland (email: raimo.lahtinen@gtk.fi)*

The Geological Survey of Finland (GTK) is an internationally oriented geoscience research center. The main research focus is in mineral resources and their sustainable utilization. The mineral potential research programme is tasked with identifying commercially significant mineral deposits and prospective terrains in order to secure raw material supplies for mining and mineral extraction industries. Mineral potential assessment considers mineralization formation, host rock and rock succession. Seismic reflection and other geophysical techniques are helping improve our knowledge of deep structures and their ore potential. Thus, we can model in more detail the evolution of Precambrian bedrock and the geological processes involved. Particular interest involves high-tech metals vital to 21st century technologies (e.g. lithium batteries, rare earth element magnets and gallium-arsenide microprocessors). The geological resource accounting involves inventory of commercially significant geological resources (e.g. minerals, metallic ores and industrial minerals) along with the byproducts and waste generated by mining. Programme goals: 1) Assess reserves and discovery potential of metal ores and industrial minerals, and evaluate their life cycle and total environment impact; 2) Study ores and ore-forming processes, and develop exploration innovations for their delineation; 3) Study ore-potential formations and structures, and create improved tectonic and metallogenic models of the Fennoscandian shield. GTK is also active in Europe and we are strongly involved in EU's raw materials related initiatives and projects. GTK has also a large project portfolio in the Tekes Green Mining-programme. In the future we would like to enhance the number of multidisciplinary collaborative research projects with universities and research institutes in Finland, Europe and Internationally.

Anatomy of a rapakivi ovoid from the Wiborg rapakivi granite batholith, southeastern Finland

Kirsi Larjamo[1], Radoslaw Michallik[1], O. Tapani Rämö[1], Aku Heinonen[1]

1) *Department of Geosciences and Geography, University of Helsinki, Finland (email: kirsi.larjamo@helsinki.fi)*

In preparation for assessment of the 4D evolution of the Wiborg rapakivi granite magma system, we present structural, mineralogical, and mineral chemical data on a plagioclase-mantled alkali feldspar ovoid from the east-central part of the Wiborg batholith in Husu, Ylämaa. The ovoid (2 cm by 2.5 cm) is composed of three separate alkali feldspar grains. In the section examined, two of the grains are about 0.7 cm in diameter and one of these shows some hypidiomorphism. The third grain is larger, 1 cm by 1.5 cm, and is either fractured or twinned into two optically slightly different parts. The boundaries of the three grains are sutured, sometimes myrmekitic and marked by small grains of quartz, hornblende, and biotite. Within the three alkali feldspar grains, inclusions of sodic plagioclase, biotite, quartz, apatite, zircon, and some opaque minerals are found. Hornblende seems to be restricted to the grain boundaries only. The three alkali feldspar grains are perthitic and register varying overall compositions (~$Or_{85}Ab_{15}$; ~$Or_{90}Ab_{10}$; ~$Or_{80}Ab_{20}$). The composite alkali feldspar core of the ovoid is mantled by a continuous, 0.2–0.5-cm-thick plagioclase rim composed of several small and a couple of larger grains. The composition of the plagioclase rim is independent of grain size and ranges from ~$Ab_{77}An_{21}Or_2$ adjacent to the alkali feldspar core to ~$Ab_{68}An_{31}Or_2$ in mantle interior. The examined ovoid testifies to a complex magmatic history characterized by stabilization of mafic silicates and co-precipitation of plagioclase and alkali feldspar during ovoid growth, as well as a final phase of oligoclase crystallization at the expense of alkali feldspar.

Age of metamorphism in the Archean Ilomantsi greenstone belt – new data on monazite

Elina Lehtonen[1], Pentti Hölttä[2], Hugh O'Brien[2], Yann Lahaye[2]

1) *Geological Museum, University of Helsinki, Finland (email: elina.lehtonen@helsinki.fi)*
2) *Geological Survey of Finland, Espoo, Finland*

The Ilomantsi greenstone belt is one of the Archean greenstone belts in Finland which were formed ca 3.0-2.7 Ga ago. The age and tectonic evolution of the volcanic and sedimentary rocks in the greenstone belts have been discussed in many papers, but the age of metamorphism in the greenstone belts has not been studied in details. Metamorphism in the Archean Western Karelia Province mostly represents PT conditions of upper amphibolite to granulite facies. In the Ilomantsi belt metamorphism was mid or low amphibolite facies. Mineral assemblage of the peraluminous metasediments is usually bt-pl-qtz±ms. These rocks occasionally contain also garnet and staurolite and andalusite or their muscovite-filled pseudomorphs. Sillimanite is found in the NE part of the belt. Age determinations on monazite were done from one sillimanite-bearing sample grains using the multiple-collector inductively coupled plasma mass spectrometer (LA-MC-ICPMS). In total 27 analyses were made and the result was 2 different age population: 1 837 ±13Ma and 2 664 ±33 Ma. These preliminary results show that the greenstone belt has clearly gone through two different metamorphic events. The older one is of the same order than the granulite facies metamorphism in the Iisalmi complex (Hölttä et al., 2000, Mänttäri and Hölttä, 2002). The younger monazite is of the same age as zircon and monazite in the late orogenic microcline granites in the Southern Finland migmatite belt (Kurhila, 2005). The Proterozoic heating of the Archean bedrock was already noticed in the K-Ar work by Kontinen et al. (1992), and our results show that this heating was related with late Svecofennian events.

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A trial to unravel the chronostratigraphy of the Archean Tipasjärvi greenstone belt, Eastern Finland

Elina Lehtonen[1], Asko Käpyaho[2]

1) *Geological Museum, University of Helsinki, Finland (email: elina.lehtonen@helsinki.fi)*
2) *Geological Survey of Finland, Espoo, Finland*

The Tipasjärvi greenstone belt is the southernmost part of the ~N-S trending 10 km narrow and 220 km long Suomussalmi-Kuhmo-Tipasjärvi (SKT) greenstone belt. The volcanic rocks in the SKT greenstone belt ranges from felsic to ultramafic, but in the Tipasjärvi area there are fewer rocks with intermediate composition than in the Suomussalmi and Kuhmo areas. The U-Pb zircon ages from the volcanic rocks of the SKT greenstone belt ranges from 2.80-2.92 Ga (Huhma et al., 2012), locally intercalacted with quartz-kyanite rock (Taipale, 1982). The volcanic rocks are postdated by sedimentary rocks (eg. tuffites and BIFs). The SKT greenstone belt is surrounded by granitoid rocks rocks with ages of c. 2.83-2.70 Ga and paragneisses that have protolith age of c. 2.70 Ga. The host rock of the Taivaljärvi Ag-Zn-Pb mineralization belonging to Tipasjärvi greenstone belt (TGB) is c. 2.79 Ga. It is proposed that the mineralization is syngenetic with the felsic volcanism (Vaasjoki et al., 1999). According to the new age data (Huhma et al., 2012), and structural studies (Parkkinen, 2012) the previous stratigraphy (Taipale, 1982; Papunen et al., 2009) has come more detailed and raised also new questions related to chronostratigraphy of the belt. In this study we concentrate to study following questions: 1) What is the age and importance of the kyanite-quarzite unit; 2) Is there two separate events of felsic volcanism (2.83 and 2.79 Ga) or continous period of volcanic activity from 2.83 to 2.79 Ga; and 3) What is the relationship of the metagreywacke unit within the TGB to surrounding metasedimentary rocks (Nurmes paragneisses)?

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P-T-X_{CO2} pseudosection modeling of talc-magnesite soapstone

Seppo Leinonen[1]

1) *Geological Survey of Finland, Eastern Finland Office, Finland (email: seppo.leinonen@gtk.fi)*

Soapstones are metamorphic ultramafic rocks containing 30-70 vol% talc. They are massive and dense, and soft enough to be engraved with a knife. Rocks consisting mainly of talc and magnesite are the mostly utilized soapstone varieties in a furnace use, because they have well-known heat resistance properties. The talc-magnesite assemblage appears to have been generated at the expense of serpentine, when an ultramafic rock reacts with a carbon dioxide-bearing metamorphic fluids under greenschist-lower amphibolite facies conditions. The object of this study was to define metamorphic carbonate-fluid phase equilibria of different ultramafic whole-rock compositions and how to use it for exploration of potential soapstone formations. Thermodynamic modeling using the Theriak-Domino software (de Capitani and Petrakakis, 2010) indicates that a soapstone mineral assemblage is preferred in ultramafic rocks with high $SiO_2/(SiO_2+MgO)$ of >0.55 (0.4-0.7). Among 44 modeled whole-rock compositions, silica varies from 20.3 to 64.3 wt% (avg. 47.8 wt%) and MgO from 20.9 to 49.8 wt% (avg. 34.8 wt%). The CaO content is low (0.0-18.6 wt%; avg. 3.9 wt%) as well as Al_2O_3 (0.2 to7.9 wt%, avg. 3.0 wt%). Total iron oxide, calculated as Fe_2O_{3tot}, averages 10.2 wt% and shows a wide range from 2.6 to 23.5 wt%. According to modal analyses, the talc content is ca. 40 vol%, magnesite and dolomite carbonates total 25 wt%, and the content of chlorite is 15 vol% and that of serpentine, when present, up 82.1 vol% (avg. 22 vol%). Magnesite is not a pure Mg endmember but comprises ca. 5-20 wt% FeO. Dolomite is usually present to some extent. Fe- and Mn-rich Ca-Mg-compositions are classified as ankerite. Dolomite dominates as the only carbonate in relatively calcium-rich rock compositions (CaO >3 wt% and >10 wt% MgO). Magnesite and dolomite are in equilibrium with serpentine and talc in very low carbon dioxide concentrations (X_{CO2} >0.01) and, as shown in Fig. 1, over a wide P-T range (P up to 10 kbar, T=410-580 ^oC). The position of the magnesite-in reaction line depends only on the CO_2 content or temperature, but with the high MgO-low SiO_2 compositions (30 to 47 wt% MgO and 20 to 49 wt% SiO_2), the reaction boundaries are curves extending from high (T=580 ^oC) to low temperatures (T=225-475 ^oC) with rising X_{CO2} values (Fig. 1).

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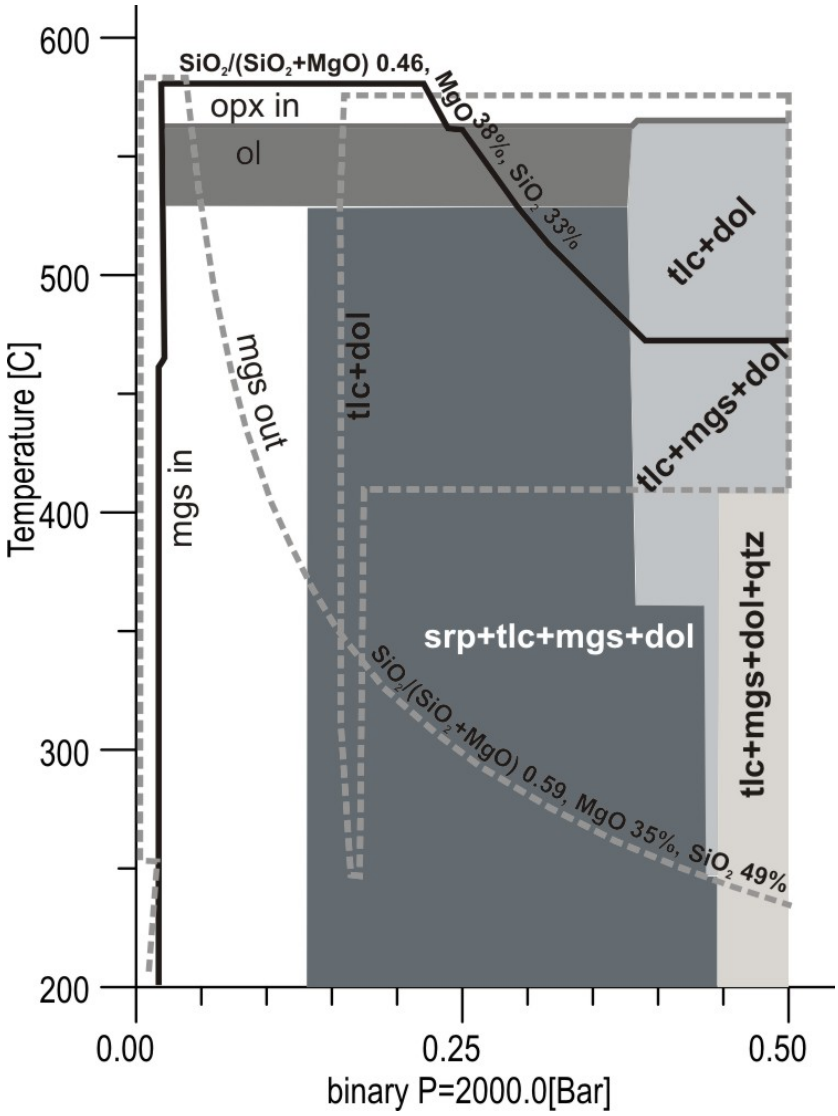

Figure 1. A simplified T-X_{CO2} pseudosection calculated at 2 kbar for X_{CO2} = 0–0.5, showing stable phases for two high-MgO talc-carbonate soapstone compositions. Grey-shaded stability fields and a solid magnesite-out reaction line are for a low-silica, ultramafic composition, sample 4313-348-48.90 with the following bulk rock composition (wt%): SiO_2 (32.5), Al_2O_3 (0.2), Fe_2O_{3tot} (13.5), MnO (0.2), MgO (37.6) and CaO (0.3). Dashed lines constrain a talc-dolomite-(magnesite) stability field and magnesite in-out reaction lines of a high-silica composition, sample 3.1.7 with (wt%) SiO_2(45.7), Al_2O_3(0.3), $Fe_2O_3^{tot}$ (13.8), MnO (0.1), MgO (34.2) and CaO (0.1). Abbreviations: Srp = serpentine; tlc = talc; mgs = magnesite; dol = dolomite; Qtz = quartz; Opx = orthopyroxene; Ol = olivine; mgs in = magnesite-in; mgs out = magnesite-out.

The dunite-wehrlite body within the ore- bearing Kevitsa intrusion, northern Finland

Kirsi Luolavirta[1], Wolfgang Maier[1], Eero Hanski[1], Frank Santaguida[2], Markku Lappalainen[2], Teemu Voipio[2]

1) *Department of Geology, University of Oulu, Finland (email: kirsi.luolavirta@oulu.fi)*
2) *First Quantum Minerals Ltd, Finnex, Sodankylä, Finland*

The 2.05 Ga mafic-ultramafic Kevitsa intrusion is located in Central Lapland, ca. 40 km north from Sodankylä. The ~1 km thick ultramafic lower part of the intrusion consists of pyroxene-olivine cumulates (olivine pyroxenites) hosting a large disseminated Ni-Cu-(PGE) ore deposit.

Ultramafic inclusions are abundant within the mineralized olivine pyroxenites, interpreted as komatiitic country rock xenoliths by Mutanen (1997). In addition, a large mass of Mg-rich rocks, namely dunites and wehrlites, occurs as a discrete north-plunging intrusive body within the core of the deposit that is discordant to the broad SW-dipping magmatic layering at Kevitsa (Fig. 1). Within individual drill holes, sections of dunite and wehrlite are up to 100 meters thick and contacts to hosting olivine pyroxene are usually irregular, diffuse, brecciated or characterized by complex zones of mixed and mingled dunite and olivine pyroxenite. Blebs of dunite and wehrlite may show a ductile behavior, or, the fabric of the host olivine pyroxenites can be seen to persist into the dunites and wehrlites. The structural evidence suggests that the dunite-wehrlite rocks were incompletely solidified when emplaced within the Kevitsa intrusion. Olivine pyroxenites in the footwall of the dunite-wehrlite body are well mineralized whereas, in general, the dunites and wehrlites are barren or poorly mineralized.

Both olivine and clinopyroxene compositions of the dunites and wehrlites are similar to their immediate olivine pyroxenite host rocks. Forsterite content of olivines ranges from 82 to 86 mole % and suggests a basaltic rather than komatiitic parental magma for the dunites and wehrlites. Whole-rock compositions and mineral geochemistry of the dunites and wehrlites suggests that these rocks are related to the Kevitsa olivine pyroxenites by differentiation or by mixing.

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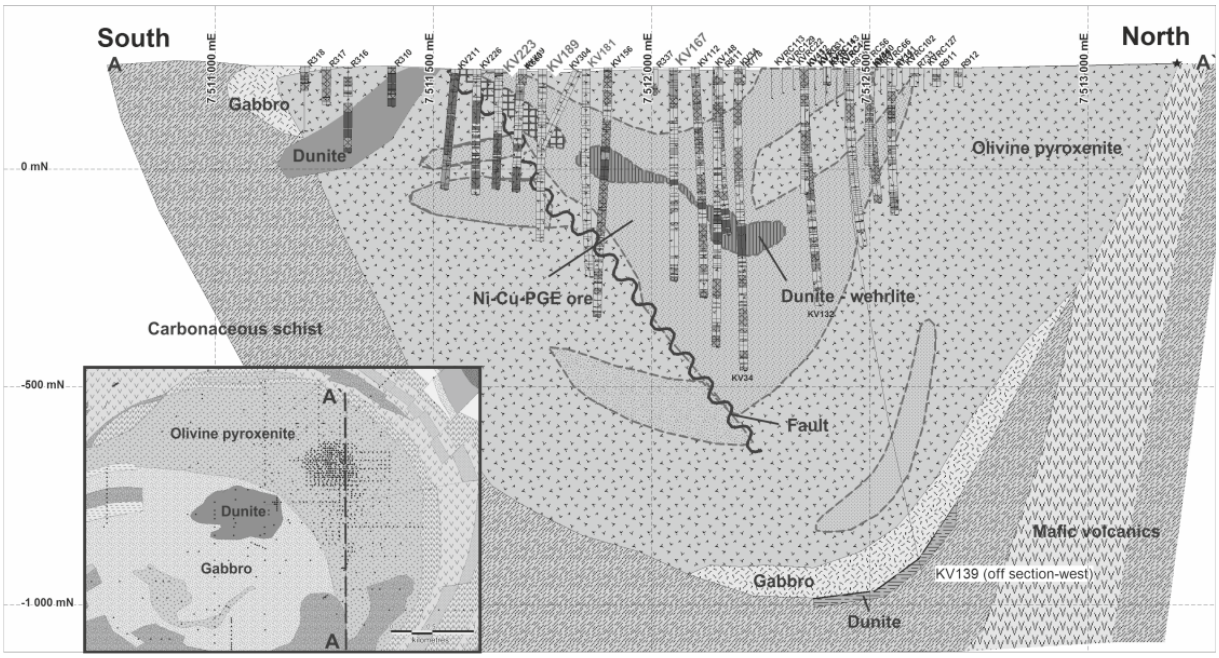

Figure 1. North-south section through the Kevitsa Intrusion and Ni-Cu-PGE orebody. A portion of the dunite-werhlite body occurs within the orebody dipping to the north.

Groundwater recharge in shallow coastal aquifer in Hanko, south Finland: integration of stable isotopes and field investigation data to support groundwater flow modeling

Samrit Luoma[1], Nina Hendriksson[1], Birgitta Backman[1], Arto Pullinen[1]

1) *Geological Survey of Finland, Espoo, Finland (email: samrit.luoma@gtk.fi)*

An accurate estimate of groundwater recharge is one of the important tasks for groundwater flow modeling for shallow aquifer in Hanko (Luoma et al., 2013). Integration of stable isotope ratios of oxygen and hydrogen, and data from field investigation and monitoring (electrical conductivity, pH, dissolved oxygen, Eh, temperature, CO_2, groundwater level and geochemistry) are used to identify water source, timing and magnitude of recharge and to support groundwater flow direction in shallow coastal aquifer in Santala area in Hanko (average thickness 25 m, surface area 17 km^2). Mean values of δD and $\delta^{18}O$ of groundwater (n=53) is -80.39 ± 2.52‰ VSMOW and -11.37 ± 0.36‰, VSMOW respectively. These values consistent with the local meteoric water line of precipitation in south Finland (Kortelainen, 2007) and are significant different from surface water (mean value of δD and $\delta^{18}O$ for lake water (n=3) -55.57 ± 9.65‰ VSMOW and -6.85 ± 2.08‰ VSMOW, and for sea water (n=4) -57.65 ± 2.35‰ VSMOW and -7.55 ± 0.38‰ VSMOW, respectively). The stable isotopes suggest that recharge in this area percolates directly from precipitation with insignificant contributions from surface water. Variations of aquifer materials and amount of precipitation affect directly to groundwater recharge. In wells that contains sand and gravel with high hydraulic conductivity, groundwater level shows a rapid response to the heavy rain event. With an increasing of annual precipitation 377 mm in 2012 higher than 2009, groundwater levels in 2012 increase 0.1-0.9 m higher than in 2009. It is unable to determine the age of groundwater by base only on the stable isotope data, but geochemical and field data imply a younger groundwater occupies large part of the upstream area in Sanata than in the downstream area.

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Fracture density on stereogram

Mira Markovaara-Kovisto[1], Eevaliisa Laine[1]

1) *Geological Survey of Finland, Finland (email: mira.markovaara-koivisto@gtk.fi)*

Fracture density is an important factor of rock quality in engineering geology because it can affect the span of the planned underground space, the required reinforcement, possible water leakage into the excavated space et cetera. Density of rock fractures is commonly defined from a linear sampling along a road cut, quarry wall, drill core, tunnel wall or on an outcrop. Terzaghi (1974) pointed out the orientation dependency of the fracture density, and came up with a correction factor. The correction factor depends on the angle between the sampling line and the normal of the sampled fracture or fracture set. Fracture density can also be used to describe the brokenness of the rock with the Rock Quality Designation value (RQD, Deere, 1974). The orientation dependent fluctuation of fracture density and RQD value can be visualized on an area stereographic projection. In this study we developed a MATLAB script for lower hemisphere equal-area stereographic projection of the data. Knowledge of the sparsest and densest orientations of the fracturing may be needed for example in orienting the planned underground space in a favorable way.

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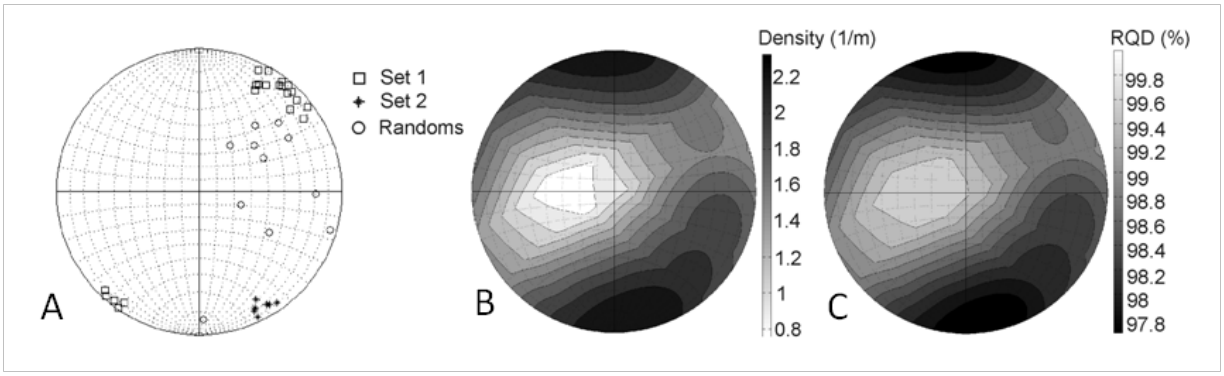

Figure 1. A) Fractures and fracture sets, B) fracture density and C) RQD on lower hemisphere equal-area stereographic projection.

The residence time of river water in small and medium sized catchments: The stable isotope approach

Paula Niinikoski[1], Nina Hendriksson[2], Juha Karhu[1]

1) *Department of Geosciences and Geography, University of Helsinki, Finland (email: paula.niinikoski@helsinki.fi)*
2) *Geological Survey of Finland, Espoo, Finland*

The isotopic composition of oxygen and hydrogen in rainfall depends on air temperature. They form a sinusoidal curve with minimum values in winter and maximum values during summer. The variation can be seen in river water, but storage in lakes reduces the amplitude of the curve, as does mixing with groundwater. The maximum and minimum values are delayed compared to rainfall, and according to Burgman et al. (1987) both the damping of the curve and the phase shift can be used to calculate the residence time of water.

In this study we examined two rivers, Kokemäenjoki and Vantaanjoki, located in southern and western Finland. They differ by three important factors: 1) The catchment of Vantaanjoki has fewer and smaller lakes. 2) The River Vantaanjoki is characterized by abundant interaction with groundwater (Korkka-Niemi et al., 2012). 3) Kokemäenjoki has a mean annual discharge of over ten times that of Vantaanjoki.

The aim of this study was to determine how the differences in the two rivers and their catchments affect the residence time of water. The residence times were calculated after measuring the annual variation in the isotopic composition of oxygen in rainfall and comparing it to the seasonal trends of river water by fitting a sinusoidal curve on both. For Kokemäenjoki the phase shift method gave a residence time of 79 days, and for Vantaanjoki the result was 78 days. In the case of Vantaanjoki this largely reflects the residence time of snow cover, as spring flooding is the most important factor influencing the fluctuation of the isotope curve.

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Analogue experiments of lateral flow in the middle crust

Kaisa Nikkilä[1], Annakaisa Korja[1], Hemin Koyi[2], Olav Eklund[3]

1) *Department of Geosciences and Geography, University of Helsinki, Finland (email: kaisa.nikkila@helsinki.fi)*
2) *Department of Earth Sciences, Uppsala University, Sweden*
3) *Department of Natural Sciences, Åbo Akademi University, Finland*

In this study, we have used scaled analogue centrifuge modeling to simulate extensional lateral flow at the boundary zone between two rheologically different tectonic blocks (block P and A). The analogue models simulate both the evolution of a mechanical boundary, and the role of pre-existing weaknesses at moderate angles (representing the old stacking structures). In three-layer models, the upper layer is brittle, the middle layer is ductile, and the lower layer is semi-ductile. The layers represent upper, middle and lower crust, respectively. The layers in the P block have lower viscosity values than the layers in A block at similar depths. The three layered models are extended unilaterally.

The model results show that during extension the rheologically different layers deform and spread at different rates during the tectonic collapse. This results in 1) vertical rotation of the A and P boundary; 2) the pre-existed faults become listric and discontinuous; and 3) the upward flow of the low viscosity middle layer to fill the newly-formed gaps between the upper layer blocks. The rising of the middle layer indicates that large scale fold structures may form even extensional process. The middle crustal antiforms filling the gap of the upper crust may be observed in core complexes, where the upper parts of the middle crust may be exposed the field.

The exposed Svecofennian crust (50-65 km) has been suggested to have thickened in continental accretion between Archean and Paleoproterozoic terranes, probably at a high convergence rate. It is likely that this thickened orogen experienced lateral spreading during its final stages. The experiments show geometrically similar crustal-scale structures to those observed in the deep seismic reflection profiles (FIRE) in the Svecofennian crust.

Variability of sea surface temperatures and sea ice in Baffin Bay during the last two millennia

Mimmi Oksman[1], Arto Miettinen[1], Michal Kucera[2]

1) *Department of Geosciences and Geography, University of Helsinki, Finland (email: mimmi.oksman@helsinki.fi)*
2) *MARUM and Department of Geosciences, Bremen University, Germany*

The Arctic region has undergone very rapid changes in the past 50 years. Climate models predict accelerating rates of change in the Arctic and long-term perspectives on natural climate variability are therefore needed to understand these changes and their further effects. We used marine fossil diatom assemblages from Baffin Bay to investigate August sea surface temperatures (aSSTs) and sea ice variability during the last two millennia. The Baffin Bay area is sensitive to changes in the climate system due to its location, where it is influenced by Atlantic and Arctic water masses.

The top most 77 cm of a 600 cm long marine sediment core (GeoTü SL-170) was used for a high resolution study of quantitative aSST and sea ice reconstructions based on fossil marine diatoms. A calibration dataset consisting of 155 surface samples from the North Atlantic and a new set of 24 surface samples from Baffin Bay (Miettinen et al., in prep.) with 52 diatom species was utilized to convert diatom counts to aSSTs using the weighted averaging partial least squares (WA-PLS) transfer function method (Ter-Braak and Juggins 1993). The sea ice reconstruction was based on a qualitative method for specific diatom assemblages (Andersen et al. 2004). The age model for the core is based on the ^{14}C method.

Our data shows a slight warming trend of the surface waters in Baffin Bay for the last ca. 2 kyr. The highest aSSTs occurred during the Medieval Warm Period (MWP), presumably due to the increased advection of warm Atlantic water from the West Greenland Current into Baffin Bay. After the MWP, the sediment was poor in diatoms during the Little Ice Age (LIA) suggesting that the study area was covered by sea ice also in the summertime. The sea ice has decreased to its minimum during the last 100 years.

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Geochemical baselines in the Kittilä arsenic province, northern Finland

Anne Peltoniemi-Taivalkoski[1], Timo Tarvainen[2], Pertti Sarala[1]

1) *Geological Survey of Finland, Rovaniemi, Finland (email: anne.peltoniemi-taivalkoski@gtk.fi)*
2) *Geological Survey of Finland, Espoo, Finland*

Soil geochemical baselines refer both to the natural geological background concentrations and the diffuse anthropogenic input of substances. In Finland, geochemical baselines must be taken into account in the assessment of soil contamination and remediation needs (Government Decree 214/2007). Information of soil geochemical baselines is available from the national geochemical baseline database, Tapir (www.geo.fi/tapir). The database is hosted by the Geological Survey of Finland (GTK).

The public user interface of the Tapir system holds the statistical summary information from the pre-defined geochemical provinces. Statistics are calculated separately for each soil type and for each geochemical province. Geochemical provinces are regions with elevated concentrations of arsenic or other potentially harmful elements. Provinces are delineated using old regional geochemical maps.

One of the arsenic provinces is located in the Kittilä area, northern Finland. In 2012, samples were collected from 31 test sites (Fig. 1) to assess the natural geochemical geological background concentrations of the area. The test pits were located outside densely populated areas to avoid possibly contaminated areas and they were also placed evenly around the province. From each test pit excavated by shovel, two till samples were taken. The upper sample was taken from leached and enrichment horizons while the lower sample was taken from unaltered C-horizon, on average from a depth of 50 cm. The elemental determinations were done from the samples that were sieved to size fraction of <2 mm, and then pulverised and dissolved in aqua regia before analyzing by ICP-OES.

According to the new results and earlier till geochemical data from Kittilä, the upper limit of the baseline variation for arsenic is 17 mg/kg, which is higher than the threshold value of 5 mg/kg given in the Decree (214/2007). Several other metals also show elevated contents exceeding the threshold values (Table 1). Thus the geochemical baseline should be taken into account in the assessment of soil contamination.

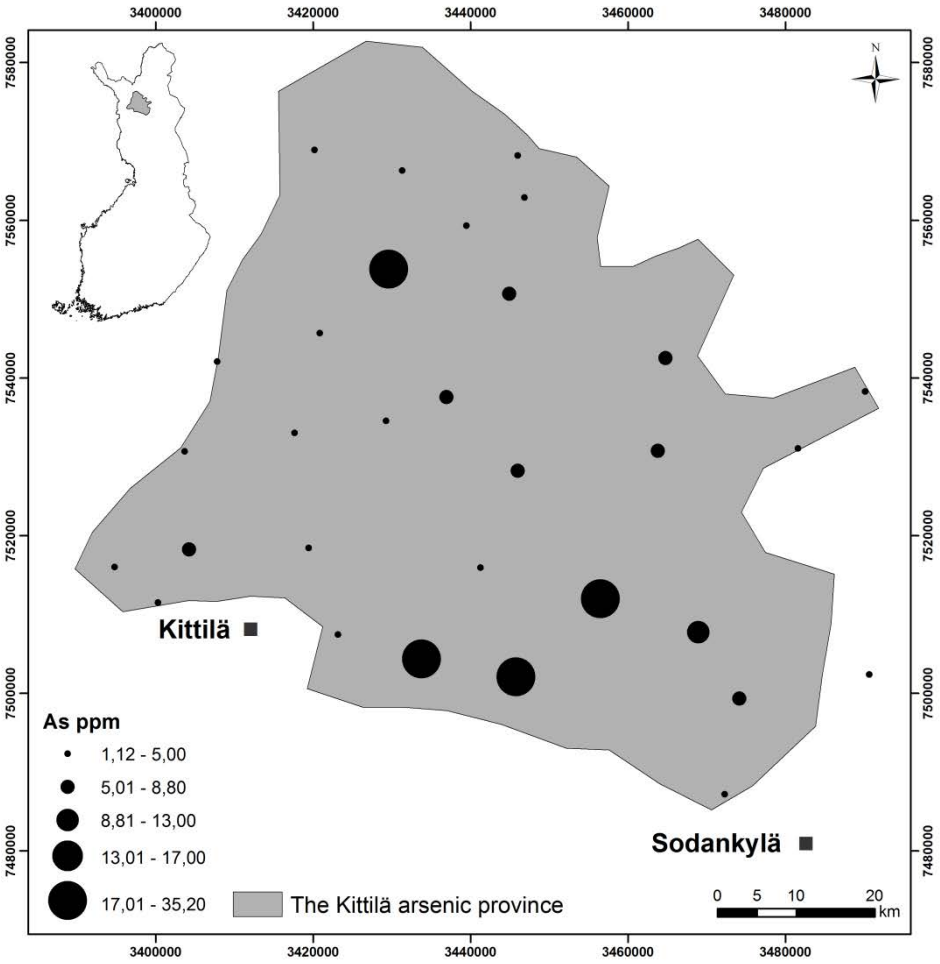

Figure 1. Location of the Kittilä arsenic province in northern Finland and As content at the sampling sites. Basemaps © Maanmittauslaitos and Hallinnon tietotekniikkakeskus.

Table 1. Statistical parameters of some metals in soil in the Kittilä arsenic province. Source: www.geo.fi/tapir.

		As mg/kg	Sb mg/kg	Co mg/kg	Cr mg/kg	Ni mg/kg	V mg/kg	Cu mg/kg
N	Qualified	43	49	1325	1325	1325	1319	1325
	Missing	1282	1276	0	0	0	6	0
Average		7,92	0,16	15,19	69,90	44,36	68,47	40,39
Median		4,33	0,06	14,53	52,21	35,51	67,79	36,90
Maximum		35,18	1,42	64,01	571,96	266,39	254,49	228,62
Percentile	25	3,37	0,03	10,46	38,43	24,55	52,60	26,59
	75	8,70	0,19	18,88	79,24	51,63	82,41	49,15
SSTP		**17**	**0,44**	**32**	**140**	**92**	**127**	**83**
Threshold value		**5**	**2**	**20**	**100**	**50**	**100**	**100**

Glacial dispersal of base metals in the Honkanen hummocky moraine, northern Ostrobothnia

Vesa Peuraniemi[1], Tiina Eskola[1]

1) *Department of Geosciences, University of Oulu, Finland (email: vesa.peuraniemi@oulu.fi)*

The study area is a part of the Paleoproterozoic Northern Ostrobothnian schist area composing of metasedimentary and metavolcanic rocks. Area is located in the central part of the Pleistocene Fennoscandian ice sheet. The Quaternary deposits are composed of glacigene till deposits, glaciofluvial esker chains and thin postglacial silt, clay and peat deposits. Honkanen hummocky moraine field is a 30 km long and 4-5 km broad train oriented from WNW to ESE. The thickness of till in moraine hummocks is usually 8-10 m and in depressions between hummocks 2-3 m. One big moraine hummock was studied by geophysical measurements and by two drill holes. Till samples were taken from the drill holes down to the bedrock surface. The fine fraction of the till samples was dry-sieved and analyzed chemically by AAS. The heavy sand fraction of the till samples was separated by wet-sieving and by Goldhound spiral concentrator. The non-magnetic heavy fraction was analyzed chemically by AAS and mineralogically by SEM. Sulphide minerals were found in both oxidized and unoxidized till samples. Separate pyrite, chalcopyrite, sphalerite and galena grains were found in the heavy fractions, but mainly they occur as tiny inclusions inside coarse pyrite grains (Fig. 1). Sulphide minerals were found in the heavy sand fraction both of those till samples with anomalous base metal contents in their fine fraction and of those samples with background base metal contents in their fine fraction. As pointed out, the conventionally used fine fraction till geochemistry in ore prospecting is not always the best indicator for sulphide mineralizations.

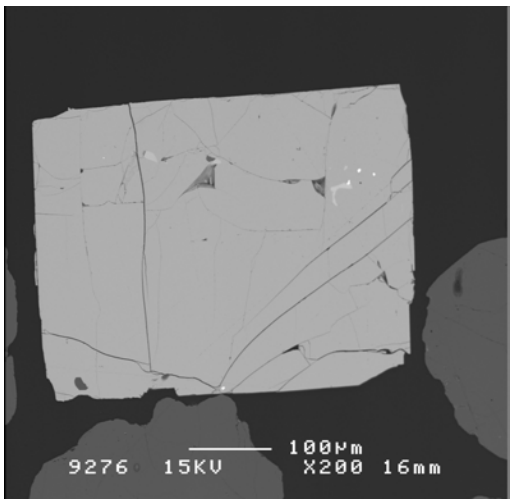

Figure. 1 Pyrite grain with small inclusions of galena (bright) and chalcopyrite (light grey). Heavy mineral concentrate of till sample from drillhole 430, depth 2-3 m. Polished thin section, SEM, backscattered electron image.

The environmental impact assessment of sulfur compounds

Raija Pietilä[1], Taina Eloranta[1], Marja-Liisa Räisänen[2], Tuomo Törmänen[1], Ulpu Väisänen[1], Hannu Hirvasniemi[1], Pentti Kouri[1]

1) *Geological Survey of Finland, Northern Finland Office, Finland (email: raija.pietila@gtk.fi)*
2) *Geological Survey of Finland, Eastern Finland Office, Finland*

The Geological Survey of Finland (GTK) is a partner in the research project: Sulphur containing emissions in the mining industry (SULKA). The SULKA project is realized under the umbrella of the Oulu Mining School and the SkyPro Oulu Clean Air Cluster and is financed by the European Regional Development Fund. The aim of GTK is to investigate the impact of sulfur compounds, possibly originating from sulphide ore sources, surrounding soils, moss, surface and ground waters and lake sediments. The purpose is to explore and develop geochemical measuring methods by way of a case study at Kevitsa mine.

The Kevitsa study area is located some 140 km northeast of Rovaniemi, Finland. The Kevitsa Ni-Cu-PGE deposit is a low grade, disseminated sulphide mineralization, which occurs in the ultramafic zone of the Kevitsa intrusion. The intrusion is surrounded by mica schists with graphite- and sulphide bearing interlayers, acid volcanic rocks and magnesian pelites. Most of the ore is composed of the so-called regular type (Mutanen, 1997), which typically contains 0.3-0.6% Cu, 0.2-0.4% Ni and about 0.5ppm of combined Pt+Pd+Au. Other ore types include the Ni-PGE type and the so-called false ore type which locally forms massive pyrrhotite-rich sulphide bodies.

The first GTK studies at Kevitsa were carried out in the 1980's and in the mid-1990's. The latter project included investigations by means of geological mapping, drilling and geophysical measurements. Bedrock, quaternary deposits, geochemical properties of surficial deposits, mineral resources, groundwater and surface water quality and hydrological situations were studied as well. The project produced plenty of information about the natural state of the Kevitsa region. Several baseline studies have also been carried out in the Kevitsa area during environmental impact assessments (Lapin Vesitutkimus Oy, 2006; Pöyry, 2011) in the 2000's.

In the ongoing Sulka project, 13 water, 14 stream sediment and 11 moss samples have been taken in 2012. Samples of lake sediments and soil will be taken during the spring and the summer 2013. The focus is on analysis of different sulfur forms, but more than 40 other elements have also been analyzed.

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Metamorphic mobility of gold in the Dalradian of Scotland: insights into the formation of orogenic gold deposits

Iain Pitcairn[1]

1) *Department of Geological Sciences, Stockholm University, (email: iain.pitcairn@geo.su.se)*

Better understanding of ore forming processes is required for future discovery of ore deposits and although poorly mineralized orogenic belts may be of limited interest for exploration companies, they can provide significant insights into ore forming processes. It is not well known why some metamorphic belts are heavily endowed with orogenic gold deposits whereas others are not. This study investigates the mobility of gold during prograde metamorphism in the Dalradian of Scotland, a classic metasedimentary terrane that is relatively poorly endowed with orogenic gold deposits. A suite of around 100 metasedimentary samples from chlorite zone greenschist facies to sillimanite zone amphibolite facies were collected from Glen Esk, Stonehaven and the SW Scottish highlands. Whole-rock concentrations of Au, As, Sb, and Hg, analyzed using ultra-low detection limit methods at Stockholm University (Pitcairn et al., 2006a), all show systematic decreases with increasing metamorphic grade. Sillimanite zone amphibolite facies rocks contain on average >50% less gold than chlorite zone greenschist facies rocks. Mobility of Au, As, Sb and Hg is controlled by the behaviour of sulfide minerals during prograde metamorphism. Pyrite, cobaltite, gersdorffite and sphalerite host Au, As and Sb in the lower metamorphic grade rocks but these minerals become less abundant with increasing metamorphic grade, with the conversion of pyrite to pyrrhotite being key. Whole-rock and mineral chemistry from the Dalradian metasedimentary Belt shows very similar characteristics to other more heavily mineralized orogenic belts such as the Otago and Alpine Schists, New Zealand (Pitcairn et al., 2006b, 2010). There is potential for undiscovered orogenic gold deposits in the Scottish Dalradian but their low abundance may be due to a lack of appropriate conditions for efficient precipitation of gold from gold-rich metamorphic fluids. Efficient fluid focusing and abundant reactive host rocks may control on the regional distribution of orogenic gold deposits.

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Groundwater interaction with the River Vantaa and its tributaries, Southern Finland

Anne Rautio[1], Anna-Liisa Kivimäki[2], Kirsti Korkka-Niemi[1], Veli-Pekka Salonen[1], Kirsti Lahti[2], Heli Vahtera[2]

1) *Department of Geosciences and Geography, University of Helsinki, Finland (e-mail: anne.rautio@helsinki.fi)*
2) *Water Protection Association of the River Vantaa and Helsinki Region, Helsinki, Finland*

The River Vantaa is one of the raw water reserves for Finland's capital area (ca. 1 million people) and 21 important aquifers (associated with glaciofluvial eskers) in close vicinity to river beds are used by municipal water companies. The main aim of this study is to gain a better understanding of aquifer–river channel interaction throughout the catchment of the River Vantaa.

The results of a low altitude aerial infrared (AIR) survey in the River Vantaa and its tributaries during 2010 and 2011 is presented. We also observed the stable isotopic composition ($\delta^{18}O$, δD) and dissolved silica (DSi) concentration of river water (RW) (N = 32) and groundwater (GW) (N = 29) under baseflow or low-flow conditions in 2011 at locations identified with AIR.

Based on the AIR survey, nearly 380 groundwater–surface water interaction sites were located along the catchment of the River Vantaa (a 270-km-long river system). These sites could be confirmed also with lower RW and sediment temperatures. There was a statistically significant difference between measured stable isotopic composition and DSi values on RW samples from "GW effect" sites and "no GW effect" sites. The river flow rate measurements with the RiverSurveyor® M9 Acoustic Doppler Current Profiler (SonTek) demonstrated that in the low-flow period the river flow within its major GW discharge location increased by approximately 10 % (0.1 m^3/s, i.e. 8 640 m^3/d.)

GW discharge zones may have a more significant impact on water quality, quantity and characteristics of the aquatic environments in the River Vantaa and its tributaries than has thus far been acknowledged (Korkka-Niemi et al., 2012). The predicted climate change will significantly increase flooding risk on the catchment due to the flat topography and poor infiltration rate of the soils. Site-specific water supply as well as river water basin management activities targeted to control bank infiltration are needed at several sites.

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Petrogenesis of mid-Proterozoic ultrapotassic magmatic suites along the southwestern margin of Laurentia: The Mountain Pass carbonatite-shonkinite (SE California) and the Jack Creek lamprophyres (SW New Mexico)

O. Tapani Rämö[1], James P. Calzia[2], Virginia T. McLemore[3], Pasi A. Heikkilä[1], Niclas Blomqvist[1], Paavo Nikkola[1], Annukka Rintamäki[1], Otso Sattilainen[1]

1) *Department of Geosciences and Geography, Unversity of Helsinki, Finland (email: tapani.ramo@helsinki.fi)*
2) *U.S. Geological Survey, Menlo Park, California, U.S.A.*
3) *New Mexico Tech, Socorro, New Mexico, U.S.A.*

Ultrapotassic ~1.4 Ga plutonic rocks are a rare yet conspicuous petrologic feature along the southern margin of Laurentia in present southwestern United States. At Mountain Pass (San Bernardino County, California) a ~1410-Ma shonkinite and associated ~1375-Ma carbonatite (Sulphide Queen; a premier source of rare earths) were intruded into the cratonic rocks of the 1.78–1.68-Ga Mojave province. In the northwestern Burro Mountains (Grant County, New Mexico), ~1460-Ma lamprophyres (Jack Creek) were emplaced into the ~1.70–1.60-Ga Mazatzal crustal province. The shonkinites (undersaturated melasyenites) have high K_2O (7–10 wt.%), MgO (8–15 wt.%), and K_2O/Na_2O (5–6); this is also true with the lamprophyres (slightly oversaturated minettes) with 3–7 wt.% K_2O, 7–9 wt.% MgO, and K_2O/Na_2O of 3–17. Both suites thus conform to the lamproite class of ultrapotassic rocks. The two suites also show high Mg numbers (Mountain Pass 68–81; Jack Creek 66–74), Ni (100–450 ppm; 150–320 ppm), and Cr (370–1300 ppm; 440–1050 ppm). These are the characteristics of mafic melts in transient equilibrium with mantle peridotite, and hence both suites most probably include primary melt compositions. Initial e_{Nd} values of the Mountain Pass suite are -4.1, -4.0 (shonkinite), and -3.1 (calciocarbonatite), those of the Jack Creek lamprophyres +2.2 to +2.7 and +4.0. This shows that the suites were derived from quite different mantle sources – that beneath Mountain Pass was metasomatized much earlier. Our data are also compatible with liquid immiscibility as a viable petrogenetic process for the Mountain Pass carbonatite-shonkinite. Overall, the two suites are located along a major, ~1.1-Ga transcurrent fault system that runs along the southern margin of Laurentia north of the Mojave-Sonora megashear. This zone might have been active already at ~1.4 Ga, allowing the ultrapotassic magmas a swift transit from the subcontinental mantle into the overlying cratonic crust.

Crustal evolution at the rifted Gondwana margin of East Antarctica: age and composition of xenoliths in Jurassic intrusions from Vestfjella, Dronning Maud Land

Ilona Romu[1], Matti Kurhila[2], Arto Luttinen[3]

1) *Geological Survey of Finland, Eastern Finland Unit, Kuopio, Finland (email: ilona.romu@gtk.fi)*
2) *Department of Geoscience and Geography, University of Helsinki, Finland*
3) *Museum of Natural History, Helsinki, Finland*

The geological record of the poorly exposed Dronning Maud Land is scattered due to natural limitations. The main tectonic units, covered mainly by Antarctic ice sheet and partially by Jurassic flood basalt formations include parts of the Archean nucleus of Kaapvaal Craton and Mesoproterozoic volcanic arc-assemblage known as Maud-Natal-Belt. The Maud-Natal Belt was later metamorphosed and partially molten during the Neoproterozoic ~500-600 Ma.

Lamproite- and basalt-hosted xenoliths from Kjakebeinet (73º47’ S, 14º53’ W) and Muren (73º43’ S, 15º02’ W), south Vestfjella, Western Dronning Maud Land, Antarctica, show a diverse suite of crustal rock types. The suite is dominated by partially molten felsic and mylonitic gneisses together with metagabbroic and minor metasedimentary rock types. Our recent zircon U-Pb SIMS data, together with earlier SHRIMP analyses (provided by Joachim Jacobs), record periodical crystallization of crustal rock types from Jurassic to Mesoproterozoic in Vestfjella. On the basis of the zircon morphology, zircon U-Pb-Th contents, xenolith whole-rock geochemistry and mineralogy, the studied felsic xenoliths include detrital, re-crystallized and igneous zircon populations. The obtained zircon ages of the felsic xenoliths together with Sm-Nd two-mineral diagrams of the metagabbroic xenoliths record isotopic equilibrium in Mesoproterozoic (~1050 - 1300 Ma single zircon; Sm-Nd closure) and Jurassic (e.g. concordant igneous 165 Ma age; Sm-Nd closure). In addition, controversial Neoproterozoic zircon ages were obtained. The common, prolonged geological history of Dronning Maud Land and SE Africa is reflected by diverse zircon crystallization ages, which are also indicative of the complex evolution of the basement of Vestfjella.

Rokua esker aquifer: combining hydrological and geological data to reduce uncertainty in groundwater management

Pekka Rossi[1], Pertti Ala-aho[1], Bjørn Kløve[1]

1) *Water Resources and Environmental Engineering Laboratory, University of Oulu, Finland (email: pekka.rossi@oulu.fi)*

Rokua esker aquifer, a part of a chain esker ridge in Northern Ostrobothnia, has been studied to understand the reasons of declining water levels of the areas groundwater dependent lakes. Esker has an area of 92 km^2 and the pre-existing geological data from the area was scarce. During 2008-2010 a campaign of geophysical measurements (GPR, seismic refraction and reflection measurements) and boreholes was conducted. Geological surveys were used to estimate the bedrock elevation and soil type. Based on the data, soil type was mainly fine and medium sand with a single observation of coarse gravel deposit. No continuous large scale stratigraphical layers were found, and due to the size of the area uncertainty in the hydrogeological structure prevailed. Three geological conceptual models were interpreted to be used in the groundwater flow modeling; 1) homogenous sand with uniform hydraulic conductivity, 2) spatial variation of sand hydraulic conductivity based on theoretical esker deposition processes and 3) model 2 with a continuous gravel core. Groundwater flow models of the area were calibrated using PEST pilot point procedure to solve the hydrology of the area (water levels and discharges) by producing a refined map of soil hydraulic conductivity for each groundwater flow model. The used model calibration approach was able to produce a consistent estimate for the esker hydraulic conductivity by combining information from hydrological and geological data. This kind of method, in which the inevitable uncertainty in geological interpretation can be reduced, should be more frequently utilized in sustainable groundwater management.

New approach to mammalian palaeoecology - occlusal wear angles of molar teeth as a measure of diet abrasiveness in elephants and their fossil relatives (Mammalia, Proboscidea)

Juha Saarinen[1], Aleksis Karme[1], Thure Cerling[2], Kevin Uno[2], Samuel Kasiki[3], Shadrack Ngene[3], Thadeus Obari[4], Laura Säilä-Corfe[1], Mikael Fortelius[1]

1) *Department of Geosciences and Geography, University of Helsinki, Finland (email: juha.saarinen@helsinki.fi)*
2) *Department of Geology and Geophysics, University of Utah, Salt Lake City, UT, U.S.A.*
3) *Tsavo Research Centre, Tsavo East National Park, Voi, Kenya*
4) *Kenya Wildlife Service, Nairobi National Park, Nairobi, Kenya*

The analysis of the secondary, wear-induced shape of the occlusal surface of herbivorous mammal teeth, known as the mesowear analysis, has proven out to be a rapid and robust method for assessing the proportion of abrasive plant material (mainly grass) in the diet of herbivorous mammals. This method has important applications for palaeoecological reconstruction, because it reflects the actual diet in populations of herbivorous mammals and it gives valuable information about feeding ecology in fossil mammal communities, and ultimately it reflects environmental conditions.

The traditional mesowear method can only be applied for herbivorous mammals which have clearly observable outer edge in their molar teeth, because it requires observing the relative height of the outer tooth cusps and the shape of the cusp tips. However, the principle can be extended to other kinds of tooth morphology. Elephants have specialised lamellar tooth morphology, and their peculiar chewing causes a wear pattern that cannot be analysed with the traditional mesowear method. Here we introduce a new approach similar in principle to the mesowear method based on angle measurements taken from dentine valleys between the enamel lamellae on the occlusal surface of an elephant molar. We show that these tooth wear angles correlate almost perfectly with stable carbon isotope values measured from tooth enamel of fossil and recent populations of elephants in tropical Eastern Africa and Asia. Because the carbon isotope values reflect the proportion of C4-photosynthetising grasses in the diet of tropical elephant populations, we conclude that the wear angle measurements reflect the proportion of abrasive material, mainly C4 grass, in elephant diet. We applied the wear angle method for assessing the diet of the Late Pleistocene Columbian mammoth population from Rancho la Brea, California, and found it to be highly abrasion-dominated, as expected.

Hydrogeochemical evolution at the Olkiluoto site based on fracture mineral studies

Elina Sahlstedt[1], Juha Karhu[1], Petteri Pitkänen[2]

1) *Department of Geosciences and Geography, University of Helsinki, Finland (email: elina.sahlstedt@helsinki.fi)*
2) *Posiva Oy, Olkiluoto, Finland*

Several episodes of fracture mineral formation can be observed at Olkiluoto. Paleofluid evolution can therefore be partly reconstructed using the chemical and isotopic composition of the fracture minerals. The study benefits the safety assessment of the repository for spent nuclear fuel considered for the site. Fracture mineral phases provide evidence of three to four major fracture mineral formation episodes. Earliest events to induce fracture mineral formation are rapakivi granite magmatism at ~1.6 Ga and mafic magmatism at ~1.3 Ga. Hydrothermal fracture mineral phases include calcite, quartz, pyrite, pyrrhotite and fluorite. Based on isotopic and fluid inclusion evidence from calcite the fluids were high temperature (110-245 °C), dilute, possibly meteoric waters that interacted with the host rock. Sulfur isotopes from fracture pyrite, $\delta^{34}S_{py}$ = -8.6…+3.9 ‰ (Sahlstedt et al., in press), suggest input of magmatic sulfur into the bedrock. Following the hydrothermal episode/episodes, fracture mineral formation occurred at moderate temperatures (50-80 °C) from high salinity fluids. Isotopic evidence from fracture pyrite indicates that bacterial sulfate reduction occurred under closed system conditions resulting in highly variable $\delta^{34}S$ values, from -40 to +82 ‰ for the pyrite (Sahlstedt et al., in press). The episode is tentatively linked to deep burial during the Caledonian foreland basin stage (~350 Ma). Precipitation of calcite and pyrite continued at low temperatures and was affected by microbial activity and changing redox conditions, as evidenced by highly variable $\delta^{13}C$ values of calcite and $\delta^{34}S$ values of pyrite (Sahlstedt et al., 2010; in press). Low temperature geochemical evolution and, specifically, the effects of microbial activity to the geochemistry of the groundwaters are the most relevant paleohydrological factors to be considered for the long term safety of the repository.

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Plate tectonics using paleomagnetism - Case example from Paleoproterozoic mafic dykes from Taivalkoski region, Eastern Finland

Johanna Salminen[1,2], H.C. Halls[3], Satu Mertanen[4], L.J. Pesonen[1], Jouni Vuollo[4], U. Söderlund[5]

1) *Department Physics, University of Helsinki, Finland (email: johanna.m.salminen@helsinki.fi)*
2) *Department of Geosciences and Geography, University of Helsinki, Finland*
3) *Department of Geology, University of Toronto, Canada*
4) *Geological Survey of Finland*
5) *Department of Geology, Lund University, Sweden*

Paleomagnetism combined with geochronology remains the only quantitative method to reconstruct Precambrian continents to an absolute paleogeographic reference frame. Apart from paleogeography paleomagnetism is useful tool when studying the geological history of the area. Magnetic minerals record the changes in environment (pressure, temperature, or presence of fluids) and these changes are traceable by paleomagnetic method.

We present here paleomagnetic results for Paleoproterozoic mafic dykes in the Taivalkoski area in northern Karelia Province of the Fennoscandian shield where, based on K-Ar data, the crust has seen minimal effects of the otherwise pervasive 1.8-1.9 Ga Svecofennian orogeny. Within this study a new U-Pb baddeleyite age of 2339±18 Ma has been determined for one of the E-W trending dykes (site AD13).

The paleomagnetic results show that a strong Svecofennian remanence is still pervasive. Upon thermal or AF demagnetization four remanence directions were obtained. Most typical are the secondary Svecofennian remanence direction A (intermediate down to the NNW) and remanence direction B (intermediate down to the NNE). Component D (intermediate down WSW) is obtained from baked rocks for dyke WD, and based on a positive baked contact test is interpreted to represent the primary magnetization dating from about 2.4 Ga. Dyke AD13 itself carries secondary A and B components, its unbaked host migmatites carry reversed A (A_R) component, and the baked host rock carries a component D' (shallow upward SSE).

The paleomagnetic data from Karelia compared to similar-aged paleomagnetic data from the Superior Province yield a looser fit of the Karelian and Superior cratons compared to a recently proposed Superia configuration, based upon dyke swarm trajectories.

Natural geochemical characteristics of soil in northern Finland

Pertti Sarala[1]

1) *Geological Survey of Finland, Rovaniemi, Finland (email: pertti.sarala@gtk.fi)*

Chemical and physical characteristics of the soil are determined by the geology and geological processes that form the foundation to the natural ground. Chemical characteristics are seen as natural mineralogical composition and the element concentrations of the soil in the region. However, the element contents can vary widely in different scales. This is also the case in northern Finland (Sarala, 2012), where the bedrock is mainly composed of Archaean and Palaeoproterotzoic rocks ranging in type from granitoids and granite gneisses to volcanic, calciferous and sedimentary rocks. After pre-glacial chemical weathering followed by several glacial periods with glacial erosion, transportation and deposition, the bedrock is almost totally covered by till and other glaciogenic sediments.

Based on soil geochemistry, a general level of the content of most elements in Lapland can be considered as the lowest in Europe and Scandinavia. However, a closer look reveals shows high regional differences, particularly in ore potential areas, where contents are much higher than in general levels. However, the levels of harmful elements like heavy metals and radioactive elements are seldom too high for nature and people. Although the ground can be considered naturally clean in Lapland, human acts can disturb the natural element balance and cause the raise of contents over the recommended levels. Soil treatment, metal and mineral mining, and other raw material quarrying, for example, can cause harmful effects. Generally, an influence of these acts to the nature and, for example, to animals and fish or berries and mushrooms is only local and temporal in Lapland.

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Geochemical gradients in the chronosequence of lake basins (Hailuoto, Finland)

Olli-Pekka Siira[1]

1) *Department of Geology, University of Oulu, Finland (email: olli-pekka.siira@oulu.fi)*

This research work is related to a PhD study on the development of the lakes on the coast of the Bothnian Bay. New lakes are forming continuously from the Baltic Sea, due to postglacial land uplift process (e.g. Eronen, 1974; Tikkanen, 2002). Upheaval ground is an ideal research area for geochemical chronosequence studies (Petäjä-Ronkainen et al., 1993; Starr and Lindroos, 2006). Geochemical gradient in chronosequense of four lake basins from the sea shore to the middle of the island, related to the age of soil from 0 to 1220 years, were examined. The concentrations of essential nutrients: NH_4, PO_4, K, Ca, Mg, Fe, and Na; in water, soil and sediment, were analyzed. For water samples standard methods of SFS, and for soil and sediment samples 0.1 M HCl extract, were used. Marks of the podzolization were detected in the soil of 10 m a.sl. (age of 1220 years). Accumulation of nutrients was encountered in the soil of 2.0 – 3.0 m a.s.l. (age 260 – 380 years). Under that stage the soil was poor in nutrients. In the lake basins above that stage most of the nutrient concentrations decreased. Marine influence was the dominant factor for the geochemical evolution in the area of Hailuoto formation sand and gravel terrain.

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Geological and mineralogical aspects of mineral carbonation of rocks and mine tailings in Finland

Sonja Sjöblom[1], Olav Eklund[1]

1) *Department of Natural Sciences, Geology and Mineralogy, Åbo Akademi University, Turku, Finland (email: sonsjobl@abo.fi)*

Finland lacks geological formations for carbon capture and storage (CCS). Therefore, carbon capture and mineralization (CCM) is considered to be the only possible storage option. The aim of this research is to study waste rocks and mine tailings from active mines in Finland and their suitability for binding anthropogenic carbon dioxide in an economical way. Suitability and developing an economically useful system are the main questions. A considerable part of the costs for CCM comes from grinding and transporting the raw material. It will be an advantage if the suitable material is available on site as the carbonation can be done at the mines. Using material from active mines would be a benefitting factor if the mine tailings show potential for the carbonation process. Mine tailings are good reservoirs as energy costs for grinding and transportation will be saved. The carbonation process has been outlined in a study on carbonation of $Mg(OH)_2$ in a pressurized fluidized bed (Fagerlund et al., 2010). The process begins by extraction of $Mg(OH)_2$ from the ground ultramafic material followed by an exothermic reaction with CO_2 forming stable magnesite, $MgCO_3$. Hydrated Mg-rich silicates in mafic and ultramafic rocks have been identified as the most promising for carbonation process (Zevenhoven et al., 2006). Therefore, the study materials are collected from five mines in Finland; Talvivaara, Kevitsa, Hitura, Pampalo and Horsmanaho. Kevitsa and Hitura have serpentinite ($(Mg, Fe)_3Si_2O_5(OH)_4$) as host rock and therefore their suitability for CO_2 sequestration is promising. The collected waste rock materials from the mines consist mostly of different varieties of serpentinites but also of talc. The samples containing quartzite and schists are most probably not suitable for mineral carbonation.

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A diatom-total phosphorus transfer function and reconstructions from the Iisalmi region, Eastern Finland

Mira Tammelin[1], Tommi Kauppila[2]

1) *Department of Geography and Geology, University of Turku, Finland (email: mhtamm@utu.fi)*
2) *Geological Survey of Finland, Kuopio, Finland*

Eutrophication is a major water quality issue for freshwater lakes. Past lake water total phosphorus (TP) concentrations can be inferred with a well-established method by using diatom-TP transfer functions. However, their predictive ability may be unsatisfactory in the case of shallow lakes (e.g. Bennion, 1995; Sayer, 2001). Training sets are often regional in scale, which might further reduce model performance in areas with atypical environmental conditions.

We used 48 lakes in the exceptional Iisalmi region in Eastern Finland (with a steep local TP gradient ranging 4-122 μgl^{-1}) to test whether a statistically reliable local transfer function could be constructed for the shallow and humus-rich lakes in the area. None of the currently published Finnish diatom-TP models were designed for this lake type (Turkia et al., 1998; Kauppila et al., 2002; Miettinen, 2003). The new transfer function, based on weighted averaging partial least squares (WA-PLS) regression, showed good performance statistics (r^2_{jack}=0.82, $RMSEP_{jack}$=0.150 log $\mu gTPl^{-1}$; Fig. 1). Model testing was based on diatom identification results by Viitasalo (2007) from one of the training set lakes.

The new model predicted relatively high TP values for various fossil samples cored from our training set lakes. The fossil samples were presumed to represent time before intensive human impact, and they were selected based on magnetic susceptibility and ^{137}Cs analyses. Further studies are needed to clarify the reason behind the high TP values. They might be indicative of a notable change in the diatom assemblages between recent and fossil samples leading to a model lack-of-fit. Another explanation could be prolonged human impact in the Iisalmi area, where slash-and-burn cultivation preceded modern agriculture.

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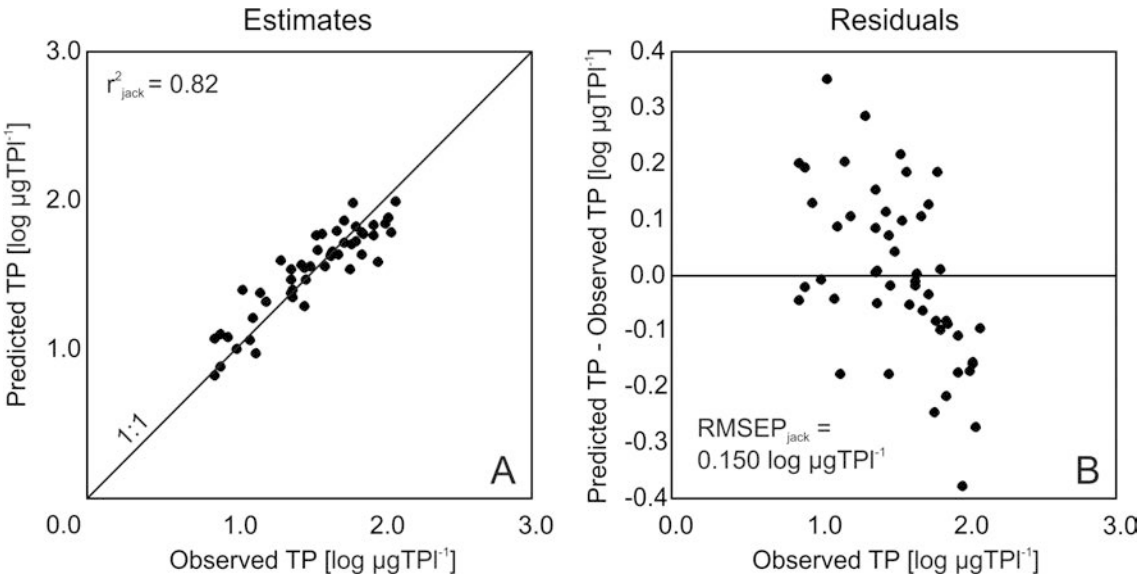

Figure 1. The performance statistics of the diatom-total phosphorus transfer function constructed for the shallow and humus-rich lakes under a steep local phosphorus gradient in the Iisalmi region in Eastern Finland. A) The predicted (log-transformed) phosphorus values plotted against the observed (log-transformed) values for the 48 lakes (50 sampling points) used in the final model with a jackknifed coefficient of determination (r^2_{jack}) of 0.82. B) The residuals (log predicted – log observed) plotted against the observed (log-transformed) values with the jackknifed root mean squared error of prediction (RMSEP$_{jack}$) of 0.150 log µgTPl^{-1}.

Modelling of the groundwater level variation and deformations in clay deposits characteristic to Helsinki metropolitan area

Tiina-Liisa Toivanen[1], Riku Raitala[2], Jouni Rautiainen[3], Jussi Leveinen[4]

1) *Department of Civil and Environmental Engineering, Aalto University, Finland (email: tiina-liisa.toivanen@aalto.fi)*
2) *Technical Department, City of Espoo, Finland (email: riku.raitala@espoo.fi)*
3) *Technical Department, City of Espoo, Finland (email: jouni.rautiainen@aalto.fi)*
4) *Department of Civil and Environmental Engineering, Aalto University, Finland (email: jussi.leveinen@aalto.fi)*

One of the factors influencing the scale of deformation in clay deposits is the variation on the groundwater table. In addition to natural variation, the groundwater levels are influenced by changes in land usage, underground construction, changes in climate, and in the long run by glacial rebound. The aim of this study is to use various modelling approaches to examine the groundwater level variation and other factors influencing deformations in clay deposits characteristic to the Helsinki metropolitan area. The purpose of the modelling is to find correlations between the local area geology, hydro-geological properties, and geotechnical deformation characteristics. The ultimate goal of the study is to develop cis- and cad-tools to support planning of land use and geotechnical decision making.

The chosen research area is Perkkaa in Espoo, where the groundwater level is currently being monitored, and soil investigations have been made by the Geotechnical Unit of Espoo. The construction history of the area is well known as well. In addition to the Espoo municipality monitored subsidence of infrastructure, the Finnish Geodetic Institute will provide geodetic SAR images that have been used to track ground level deformations.

The soil investigation data will be processed using a database software suite. A model of the bedrock contours and 3D soil layers can be created to describe the geotechnical properties of the soil and its layers. The soil layer model created will be used in further modelling of the actual flow of groundwater and local deformations. Multi-physical modelling programs will be used to model the deformations. Simplified deformation calculation methods will be used to keep the amount of parameters and variables manageable in relation to the wide scale of the study.

The effect of the anthropogenic activities on geochemical behavior of arsenic at two geologically different mine sites in Finland

Kaisa Turunen[1], Soile Backnäs[1], Antti Pasanen[1]

1) *Geological Survey of Finland, Kuopio, Finland (e-mail: kaisa.turunen@gtk.fi)*

Arsenic is a common element in a number of ores in Finland and cannot be avoided in mining activities. Mining may also affect the geochemical behavior and form of arsenic by changing the chemistry and oxidizing conditions of water and soil. In this study the geochemistry of natural and anthropogenic arsenic was characterized by analyzing soil, sediment, peat and humus samples as well as ground and surface water samples at two geologically different mine sites in Finland. The bedrock of the study sites was either naturally rich in arsenic (Suurikuusikko gold mine in Kittilä), or poor in arsenic, but having arsenic-rich calcinate tailings (YARA industrial site in Siilinjärvi).

The soil and sediment samples were analyzed by using different extraction methods that represent total, chemically adsorbed and bioavailable fractions of arsenic. Water samples were analyzed for total and soluble metal and metalloid concentrations, anions, DOC, TOC, pH, redox and alkalinity. Metal speciation in waters was modeled by PHREEQC. According to the results, total concentrations, the proportion of chemically adsorbed oxalate extractable fractions and easily mobilized, bioavailable acetate extractable fractions were elevated at both sites. The difference in natural and mining affected water quality was seen in dissolved and total arsenic and as well as in alkali and alkali earth metal concentrations in water samples of the Suurikuusikko mine site. At the Yara industrial site, the same effect was detected in ground and surface waters near the calcinate tailings.

The elevated proportion of chemically adsorbed and bioavailable arsenic in the soil at both mine sites indicate an increase in anthropogenic arsenic pollution. Despite the geological background concentrations, mining activities have increased the ecological risks either by changing arsenic into more soluble and mobile form, or by elevating arsenic concentrations in the surrounding environment.

Scenarios of the growing metal mining in Finland – estimating the changes in economic and environmental significance

Mari Tuusjärvi[1], Ilmo Mäenpää[2], Saku Vuori[1], Pasi Eilu[1], Susanna Kihlman[1], Sirkka Koskela[3]

1) *Geological Survey of Finland, Espoo, Finland (email: mari.tuusjarvi@gtk.fi)*
2) *Thule Institute, University of Oulu, Finland*
3) *Finnish Environment Institute, Helsinki, Finland*

The metal mining industry is currently experiencing a significant boom in Finland. The new mining activity is based especially on base metals and gold, but also deposits for platinum-group-metals and iron are actively developed. Before the current boom the economic and environmental significance of the metal mining industry has been relatively minor in Finland, but evidently the situation will change.

In this research we model the expected development of metal mining in Finland from 2010 to 2020 and 2030 to see the relationship between the value of production and the pressure on the environment (as mineral flows and CO_{2eq}). The modeling was based on an individual performance data of each mine, collected from different public data sources. The results give the best estimate on future development of extraction, as well as minimum and maximum ranges, with steady stage operational environment assumption. Based on the change in extracted ore, there will be marked changes in the value of production, waste mineral flows and CO_{2eq} emissions. The development is mainly driven by the utilization of large open-pit deposits with low metal content, and the more valuable products in terms of metal type and metal content. This increases the value of production, but also the waste mineral flows and CO_{2eq} emissions associated to energy use and the mineral processing technology.

The mining industry in Finland will continue to gain more significance in economic terms. The estimated increase in mineral waste and CO_{2eq} emissions gives ground for increased research efforts associated to product design, mineral waste production and increased energy efficiency. An interesting research question is also raised: will the increased metal content in many mining products decrease the down-stream CO_{2eq} emissions in the life cycle of metals production?

Peat as a resource: the future and role of geological research in the responsible use and management of peat and peatlands

Samu Valpola[1], Asta Harju[2]

1) *Geological Survey of Finland, Western Finland Office, Finland (email: samu.valpola@gtk.fi)*
2) *Geological Survey of Finland, Western Finland Office, Finland (email: asta.harju@gtk.fi)*

Peat is a significant natural resource not only in Finland but worldwide. There are over 400 million hectares of peatlands on Earth, of which approximately 60% still accumulates peat (Clarke and Rieley, 2010). In Finland there are ca. 9,4 million hectares of peatlands and the evaluated amount of the peat is approximately 70 billion m^3.

The use of peat and peatlands is also global: there are ca. 300 000 km^2 peatlands in agricultural use, 150 000 km^2 are drained for forestry and 4000 km^2 for growing media and energy purposes, locating mostly in northern hemisphere (Clarke and Rieley, 2010). It is estimated that in tropical regions ca. 150 000 km^2 of peatlands have been drained especially for oil palm and paper pulp plantation, but also for many other purposes. (Clarke and Rieley, 2010; Hooijer et al., 2010). In Finland, the use and management of peatlands is well documented: ca. 3 million hectares are in pristine state, 1,1 million hectares are pristine and protected by law, over 4,5 million hectares are drained for forestry, 0,3-0,5 million hectares for agriculture and ca. 0,06-0,08 million hectares for peat production. Finnish Government's decision in principle on sustainable and responsible use and protection of the mires and peatlands (30.8.2012) and especially its background report (Working group on a national strategy for mires and peatlands, 2011) are an internationally unique plan for reasonable and wise use and management of peat and peatlands.

Still, in practice there is a need for research and answers concerning the wise use of the peatlands in Finland. What is the role of geological research in the peat and peatland management? What will be the key topics of the research during the next decade? What are the questions that must be solved by using geological knowledge?

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Soiden ja turvemaiden kansallista strategiaa valmistellut työryhmä, 2011. Valtioneuvoston soiden ja turvemaiden kestävää ja vastuullista käyttöä ja suojelua koskevan periaatepäätöksen (30.8.2012) taustaraportti: Ehdotus soiden ja turvemaiden kestävän ja vastuullisen käytön ja suojelun kansalliseksi strategiaksi 2011. 161 p.

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Presentation of the laboratories of the Department of Geosciences and Geography, University of Helsinki

Juhani Virkanen[1], Pasi A. Heikkilä[1], Hanna Reijola[1], Tuija Vaahtojärvi[1]

1) *Department of Geosciences and Geography, University of Helsinki, Finland (email: juhani.virkanen@felsinki.fi)*

Our laboratories offer a wide range of modern instruments and practices. We do inorganic, structural and isotopic analyses of different kinds of samples like water, rock, sediment and soil. ICP-MS and recently delivered MS-AES are used for trace element analysis from liquid or solid samples. We can measure 68 elements, and the limits of quantification are at level of some tens of ppt. IC chromatography is used to determine anions and cations from liquid samples. Total nitrogen and total phosphorus are measured with spectrophotometer. We have a CNS- analyser for determinations of carbon, nitrogen and sulphur from solid samples. Quality assurance and quality control of analyses are controlled with appropriate number of replicates and blank samples and the use of certified reference materials. Our laboratory takes part of NIVA intercalibration study yearly, with excellent results. Structural analyses from solid samples are made with X-ray diffractometer and FT-IR spectrometer. We can measure particle sizes from 2 μm to 2000 μm based on laser diffraction from liquid or solid samples. For chemical analysis of rocks X-ray fluorescence is used and for chemical analysis of minerals electron probe micro analyser. Oxygen and hydrogen isotopes of water are analysed with cavity ring-down spectrometer. Stabile isotopes from solid material are analysed with isotope ratio mass spectrometer. Every year we teach up to twenty undergraduate students to good laboratory practices. After participating and passing this course the students are qualified to perform their own analyses regarding to their Master´s thesis.

All these above mentioned analysis are sold also outside the University community. More information is available in our website http://www.helsinki.fi/geo/tutkimus/laboratoriot.html. In case you want us to analyse your samples at our laboratory, ask for a special offer from Juhani.Virkanen@Helsinki.fi

ENVIMINE – developing environmental and geodynamical safety related to mine closure in the Barents region

Ulpu Väisänen[1], Peter Johansson[1], Janne Kivilompolo[1], Juho Kupila[1], Jouni Pihlaja[1], Vladimir Konukhin[2], Anatoly Kozyrev[2], Lena Alakangas[3]

1) *Geological Survey of Finland, Northern Finland Office, Rovaniemi, Finland (email: ulpu.vaisanen@gtk.fi)*
2) *Mining Institute – Russian Academy of Sciences – Kola Science Centre, Apatity, Russia*
3) *Luleå University of Technology, Luleå, Sweden*

A project of mining environmental research in the Barents region is carried out in 2012-2014, in cooperation between the Geological Survey of Finland, the Mining Institute of the Kola Science Centre, Russia, and Luleå University of Technology, Sweden. The study area in Finland is the Kemi chrome mine, in production since 1968, the closed mines of Laver in Norbotten and Umbozero in the Murmansk region. The Laver mine with iron sulphide ore was in operation 1936-1946 and the Umbozero mine with loparite ore and rare metals in 1984-2004.

The objectives are to develop a methodology for environmentally safe mine closure, under specific conditions in the Barents region, by cross border cooperation, and also to produce information for target groups with interest of the mining environment. The aim is to create a new, updated database of the mine sites and develop multilateral relations between Finnish, Russian and Swedish organizations, responsible for environmental management. The aim is also to develop and carry out environmental research with best available techniques (BAT), to exchange experiences and scientific knowledge.

Field studies started in 2012, and will continue during 2013. Research of construction and composition of surficial deposits in tailings and their surroundings are made, and the quality of groundwater, surface water and bottom sediments of streams in the mine sites and reference areas of surroundings will be analyzed. Field work is carried out by means of geophysical measurements (GPR, ground penetrating radar), XRF measurements, drillings, hydrological studies, installing groundwater observation wells, sampling and analyses of surficial deposits, sediments, groundwater and surface water. Conclusions and recommendations for after care planning and monitoring of water quality will be made on the basis of previous and new research data. This project is funded by the European Union.

Metallogeny of the Fennoscandian Shield

Pär Weihed[1]

1) *Luleå University of Technology, Sweden*

In the Fennoscandian Shield the Palaeoproterozoic hosts most known economic mineral deposits contrary to most other Shield areas. Compared to the present-day global plate-tectonics, Archaean and Proterozoic plate tectonics probably involved faster moving, hotter plates that accumulated less sediment and contained a thinner section of lithosphere mantle. This geodynamic evolution of the Fennoscandian Shield from 2.06 to 1.78 Ga is described in the context of metallogeny. With a few exceptions, all major ore deposits were also formed during this evolutionary stage and thus a strong geodynamic control on ore deposit formation is suggested.

All orogenic gold deposits formed syn- to post-peak metamorphism and their timing reflects an orogenic younging of the shield towards the southwest and west. Most orogenic gold deposits formed during periods of crustal shortening and peaked at 2.72–2.67 Ga, 1.90–1.86 Ga, and 1.85–1.79 Ga.

The *c.* 2.5–2.4 Ga Ni-Cu±PGE deposits formed both as part of layered igneous complexes and associated with mafic volcanism, in basins formed during rifting of the Archaean craton at *c.* 2.5–2.4 Ga. Svecokarelian *c.* 1.89–1.88 Ga mafic-ultramafic hosted Ni-Cu deposits are confined to linear belts possibly related to slab break-off and interaction of hot asthenospheric mantle with a cooler and more hydrous lithospheric mantle wedge.

All major VMS deposits in the Fennoscandian Shield formed during 1.97–1.88 Ga, related to extensional settings, basin inversion and accretion. The oldest "Outokumpu-type" deposits were obducted onto the Archaean continent during the onset of convergence. The Pyhäsalmi VMS deposits formed in 1.93–1.91 Ga accreted primitive, bimodal arc complexes formed during extension of the arc. The Skellefte VMS deposits are 20–30 m.y. younger and formed in a strongly extensional intra-arc region that developed on continental or mature arc crust. Deposits in the Bergslagen–Uusimaa region are of similar age as the Skellefte deposits and formed tentatively in a microcraton that collided with the Karelian craton at *c.* 1.88–1.87 Ga.

Iron oxide-copper-gold deposits are diverse in style. At least the oldest mineralising stages, at *c.* 1.88 Ga, are coeval with calc-alkaline to monzonitic magmatism and coeval subaerial volcanism related to continental arcs or to magmatic arcs inboard of the active subduction zone. Younger mineralization of similar style took place when S-type magmatism occurred at *c.* 1.80–1.77 Ga during cratonisation distal to the active N–S trending subduction zone in the west.

3D geodynamic numerical modeling of modern and ancient orogens

David M. Whipp[1]

1) *Institute of Seismology, Department of Geosciences and Geography, University of Helsinki, Finland (email: david.whipp@helsinki.fi)*

Reconstructing the tectonic and exhumation history of modern and ancient orogens requires an understanding of the interactions between thermal, mechanical and erosional processes active in mountainous regions. Geodynamic numerical models are one proven tool for studying these processes, capable of simultaneously solving basic heat transport and fluid dynamics equations in models with flexible geometries. Advances in computing power and newly developed software tools have recently made possible fully 3D thermal and mechanical numerical experiments that include the influence of surface processes, variable rock rheology and large deformation magnitudes. The aim of this presentation is to provide an introduction to modern geodynamic modeling via two case studies in the Himalaya. The first study uses 3D thermokinematic numerical experiments to quantify Pliocene-to-recent rates of tectonic and erosional processes in the central Nepalese Himalaya. The second study investigates mass transport and strain partitioning in 3D mechanical models of oblique convergence in a Himalaya-like model orogen. Finally, I outline how 3D geodynamic numerical models might be utilized to study the Paleoproterozoic Svecofennian orogen. A deeper understanding of the first-order thermal and mechanical processes controlling the evolution of the Svecofennian orogen is important in assessing the potential for new natural mineral resources and the stability of the continental crust in Finland.

Local stakeholder engagement of mineral exploration in Finland within the Corporate Social Responsibility (CSR) framework

Sofia Ziessler[1]

1) *Geological Survey of Finland, Finland (email: sofia.ziessler@gtk.fi)*

In the last years, dozens of companies have rushed to do mineral exploration in Finland in the hope of finding ore deposits. However, they might encounter problems with local stakeholders such as landlords, environmental NGO's, reindeer herders, tourism entrepreneurs, local governance and citizens.

From the corporate perspective, local but internationally intertwined stakeholder engagement is part of the Corporate Social Responsibility framework. Within this framework, deficient stakeholder engagement in mineral exploration might endanger the company's Social License to Operate, whereas for society it might cause an atmosphere of fear.

Finnish stakeholder engagement in mineral exploration has been studied only in terms of communication in uranium exploration conflicts but hardly regarding other minerals, which until recent years have not seemed to intrigue major company-community conflicts. Hence, this study serves for broadening and updating the perspective to concern stakeholder interaction in exploration in general in Finland.

The cross-disciplinary Master's thesis study looks into the anatomy of stakeholder dynamics in three case studies of multinational companies performing mineral exploration in Northern Finland. The objective is to look into the companies' organization of stakeholder engagement processes and their underlying drivers, objectives, and challenges.

The findings will contribute to the comprehension of successful and responsible stakeholder engagement, and provide frameworks for achieving good outcomes and facing challenges.

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