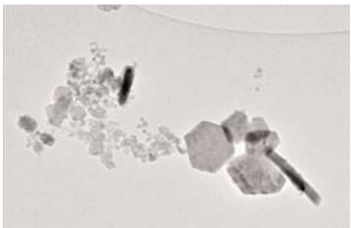
Mineralogisch-Geochemisches Institut

Albert-Ludwigs-Universität Freiburg

Annual Report 2006



Mineralogisch-Geochemisches Institut
Albert-Ludwigs-Universität Freiburg
Albertstraße 23b
D-79104 Freiburg
Germany

Telephone: +49-761-203-6396
Fax: +49-761-203-6407

E-mail: info@minpet.uni-freiburg.de
Wordwide web: http://www.minpet.uni-freiburg.de/

Director: Kurt Bucher

On the photograph (from left to right): Peter Glasnák, Kurt Bucher, Fleurice Parat, Thomas Jauß, Sigrid Hirth-Walther, Hiltrud Müller-Sigmund, Markus Daniels, Ulrike Seelig, Melanie Katt, Wibke Kowalski, Phillip Mittelstädt, Slavica Drndelic-Eich, Tobias Weisenberger, Isolde Schmidt, Sven Thor, Dagmar Flemming, Astrid Hirsch, Barbara Augenstein. Photographed by Juraj Majzlan. Missing: Reto Gieré, Sonia Ackermann, Christine Höher, Karin Eckmann, Dao Duy Anh.

Report editor: Juraj Majzlan

Cover photographs:

1. Hot springs in China. For details, see page 20.
2. Fine particles emitted into the atmosphere by burning coal. See page 23.
3. Students on a field trip before entering a coal mine. See page 43.

Director's statement

Institute Director
Professor Kurt Bucher

The daily life of the Institute in the winter semester 2005/2006 and in 2006 was dominated by the implementation of the new bachelor study program "Geowissenschaften". It appears that we have underestimated the complexity and practical problems associated with the new program. However, many partial problems and difficulties were solved by the enthusiasm and dedication of the staff of our Institute. Some of the difficulties arise because of the low numbers of the staff and cannot be solved by simple measures. In particular, we would need more qualified personnel for the field trips, field work, and laboratory exercises. We hope that the some of the funds collected from the tuition fees (from summer semester 2007 on) will be diverted to address these issues.

Approximately 90 new bachelor students enrolled in the geosciences this year. This number is even higher than that from the successful year 2005. Together with the current third-semester students, we count now 140 bachelor students. This success is a clear confirmation that the geoscience staff in Freiburg is offering an exciting and vital study program.

Dr. Rune Selbekk left our Institute in fall 2006 for a position at the Mineralogical Museum in Oslo. During his three years in Freiburg, he has supervised and led to completion several diploma works in Jotunheimen (Norway). The studies performed by him and his students brought new insights into the geology of this part of the Caledonian Europe. Dr. Selbekk, together with PD Dr. Rahn, organized and led also several field trips to the Alps, Finland, and Norway.

The free position at the Institute was taken by Dr. Fleurice Parat. She is an igneous petrologist and will take over the responsibilities of performing research and teaching igneous petrology and volcanology in Freiburg.

In 2005 Dr. Thomas Kohl was awarded a honorary professor degree, given to him from our initiative. He is a geophysicist particularly known in the field of geothermal energy. Dr. Kohl is an owner and a director of the geothermal-energy company Geowatt (www.geowatt.ch) located in Zürich in Switzerland. He strengthens the geosciences in Freiburg in our focus field of geothermal energy.

Another highlight of our work was a workshop "Geothermie" organized by the hydrogeological section of the German Geological Society in October 2006 at our Institute. The sixty participants were those who signed up early; we could not accommodate the additional demand for the workshop. This activity was conceived and organized by Prof. Dr. Ingrid Stober, our external collaborator and a geothermal-energy specialist from the Geological Survey in Freiburg. Prof. Ingrid Stober, Prof. Kurt Bucher, Prof. Andreas Henk, Prof. Thomas Kohl and three other invited speakers presented the recent advances in the geothermal science.

The employees of the Institute thoroughly enjoyed the trip to the Engstlen Alps (Berner Oberland, Switzerland). We have visited the Aareschlucht (near Meiringen, Enstlensee, Jochpass, Tannensee, and Aussichtgrat.

Kurt Bucher

Table of Contents

Teaching and student affairs

Bachelor and master program

The teaching year was dominated by the first group of B.Sc. students and the associated complete restructuring of the curricula, lectures, lab work and excursions. This task absorbed most of our total working capacity. Many questions are not answered and problems not resolved, particularly the teaching capacity of the geosciences is not sufficient for providing the students with the required courses especially field courses and excursions.

Student Recruitment

A total of 96 new B.Sc. Geosciences majors enrolled for the winter semester 2006/07. This is an impressive continuation of the success we had with the program in the year 2005/06, which we relate to our efforts to reach potential students at various public activities and also to the excellent teaching efforts for the first group of B.Sc. students. Together with the large group of students we already have from the two years before, the student recruitment is excellent. The teaching commitments of the staff of our institute include: B.Sc. Geosciences, Diploma Geology and Mineralogy, lab practical courses for chemistry majors, teaching for hydrology and geography students. Our teaching unit officially runs at more than 130 % of its formal capacity. This has the consequence that also 2005 little time is left for research during the regular working hours of the staff. We find the time for research during late night working and at the weekends. Still it is remarkable that the staff produces high caliber and internationally recognized research.

Guest Lectures Presented at MGI in 2006

Prof. Dr. **Judith McKenzie**, ETH Zürich.
Are Microbes the Solution to the Dolomite Problem? January 9, 2006.
Prof. **Torgeir B. Andersen**, Universität Oslo
Seismic faulting in deep crust and lithospheric mantle; examples from the Caledonides and Alpine Corsica. January 31, 2006.
Dr. **Wolfgang Spiegel**, CheMin GmbH, Augsburg
Müll-Mineralogie: Korrosion und Prozessoptimierung in Müllverbrennungsanlagen. February 6, 2006.
Dr. **Thorsten Weimann**, HERRENKNECHT Vertical GmbH, Schwanau
Neue Bohrtechnologie - Anpassung an Geothermie. February 14, 2006.
Dr. **Thomas Lichtensteiger**, Eawag, Schweiz
Urbane Geologie: Von der Deponie zur Lagerstätte in der Stadt. December 11, 2006.

Invited Lectures Presented by the MGI Staff

University of Applied Sciences Offenburg, Germany, November 2006, **Kurt Bucher**

Medical School, University of Freiburg, Germany, February 2006, **Kurt Bucher**

Department of Earth and Atmospheric Sciences, Purdue University, West Lafayette, USA, March 2006, **Reto Gieré**

University of Geneva, Switzerland, December 2006, **Fleurice Parat**

Third Mineral Sciences in the Carpathians Conference, Miskolc, Hungary. March 2006, **Juraj Majzlan**

University of Tübingen, Germany, May 2006, **Juraj Majzlan**

Workshop New trends in spectroscopic methods used for natural nanomaterials research, Smolenice, Slovakia, November 2006, **Juraj Majzlan**

Service to the Earth Science Community

Editorial Responsibilities

The international system of scientific journal publication of research data and results depends largely on the volunteered effort of editors and peers writing reviews and assessments. The MGI has carried a heavy burden for maintaining an international high standard publication system.

Kurt Bucher is on the advisory board of *Journal of Petrology* and associate editor of the *Journal Geofluids*.

Reto Gieré is the Editor of the *Journal of Petrology* and the Editor of the *Swiss Bulletin of Mineralogy and Petrology*. He also co-edited (with W.R. Alexander, H. Hidaka, and H.D. Yoshida) a special issue of *Geochemistry: Exploration, Environment, Analysis* entitled Natural immobilization processes aid the understanding of long-term evolution of deep geological radioactive waste repositories.

Jörg Keller is the member of editorial boards of the *Journal of Volcanology and Geothermal Research*, *Acta Vulcanologica*, *Periodico di Mineralogia*, and *GeoActa*.

Peer Review Responsibilities

Journals

The members of the institute have invested considerable time and effort in reviewing research papers for the following international top journals: *American Journal of Science*, *American Mineralogist*, *Applied Geochemistry*, *Canadian Mineralogist*, *Chemical Geology*, *Contributions to Mineralogy and Petrology*, *Crystal Growth and Design*, *Earth and Planetary Science Letters*, *European Journal of Mineralogy*, *Geochimica et Cosmochimica Acta*, *Geofluids*, *Geology*, *Journal of Petrology*, *Journal of Metamorphic Geology*, *Journal of Volcanology and Geothermal Research*, *Lithos*, *Mineralogical Magazine*.

Grant Awarding Bodies

The experts of MGI have written assessment of grants proposals for FNSNF, NFR, DFG, Australian Research Council, INGV-DPC Italy, and the Royal Society London.

Administrative Offices

Kurt Bucher was the Vice-Dean of the Faculty of Chemistry, Pharmacy and Geosciences until October 2006. The term ended October 1.

Reto Gieré is the Society Book Advisor for the *Geological Society, London*. He is also a member of the *Deutsche Mineralogische Gesellschaft, Sektion Angewandte Mineralogie in Technik und Umwelt*; member of the *International Mineralogical Association, Subcommittee for the Epidote Group, Commission on New Minerals and Mineral Names*; and member of *Schweizerische Akademie der Wissenschaften und Bundesamt für Energie, Bern, Working Group "Sachplan Geologische Tiefenlager"*.

Jörg Keller is a member of the *Board (Präsidiumsmitglied) Stiftung Vulkaninstitut Friedlaender, ETH Zürich*; *Scientific Council for VULCANIA, Parc Européen du Volcanisme, Auvergne*; *Medal and Awards Commissions of IAVCEI and DMG*; *International Evaluation Committee for the 2006/2007 Research Programme ("Convenzione") of Italian Istituto Nazionale di Geofisica e Vulcanologia INGV and the Dipartimento della Protezione Civile DPC*. He is also the chairman for the *"Geologenarchiv" of the Geologische Vereinigung at the University Library (UB) Freiburg*.

Short Courses/Meetings

Kurt Bucher presented on lecture „Geothermal water, heat transport medium in deep geothermal systems“ at the short course: *Geothermie*, a continuous education course by FH-DGG held at MGI on October 11, 2006, organized by Prof. Dr. Ingrid Stober.

Jörg Keller is a member of the Organizing Committee of the *9th International Kimberlite Conference* which will take place in 2008.

Juraj Majzlan co-organized the *First Central European Mineralogical Conference* that took place in September 2006 in Vyšná Boca, Slovakia.

Public Outreach Activities

Our interviews with journalists of newspapers and radio and TV stations contributed to the popularisation of geoscience issues in the public.

Our public mineral museum reaches a broad and interested audience. Also in 2006 we were able to acquire some outstanding mineral specimens, particularly from the Gotthard railroad base tunnel.

A number of high-school students from the local schools visited our Institute on November 21, 2006, on the *Tag der Offenen Türen*. The staff of the Institute held several lectures for the students and offered a tour of our laboratories, explaining both the capabilities and limitations of the instruments to the interested youngsters.

Research at the Institute of Mineralogy and Geochemistry

The staff produced 25 research papers and book chapters in 2005 and 4 contributions to the media and popular science publications (see list of publications, page 11). This represents a very significant productivity increase relative to 2005. It coincides with a three fold increase in external funding.

The research of the MGI is focused on two fields: a) Geothermal Energy research and b) Environmental Geochemistry research.

Geothermal Energy: This field evolved during 2006 to the main research focus of the Geosciences in Freiburg. It involves projects developed by Prof. Bucher and Prof. Gieré (MGI), Prof. Henk (GI) and Prof. Stober (GI & LGRB). It is planned to develop Geothermal Energy research jointly to our main effort. In this context the Geosciences Freiburg plan to bundle research and teaching in this field and to establish an Institute of Geothermal Energy Research. This Institute will be closely related to the new Center of Renewable Energy Research CRER at the University of Freiburg. CRER is planned to be established in 2007 in connection with the 550 Years celebration of the University of Freiburg. The Center of Geothermal Energy is presently in its active phase of planning and development of project funding applications. Several Diploma Projects and two Ph.D. projects started this year in the field of Geothermal Energy research. Four research articles were produced in this field.

Environmental Geochemistry: This second field of research has been very successful in 2006 and produced nine research articles mostly in high caliber international journals. The focus here is on applied geochemistry of waste and on mineralogy and thermodynamics of substances of interest to environmental geochemistry.

Other published research was related to projects in the fields of igneous and metamorphic geology, volcanology and mineralogy (a total of 11 papers). Also this research appeared in international high-rank journals. We will continue to research in these fields also in the future despite the declared focus in the applied geosciences. We strongly feel that our university research institute has a commitment to support cognition oriented research also for the reason that world class teaching can only be achieved by teachers who are actively involved in high-caliber research.

In 2006 no new equipment has been aquired by the institute. The IMC-4400 is an isothermal calorimeter installed in 2005 is now in full operation and we are looking forward to the first research paper using data produced by this new instrument.

Research Collaborators

The following individuals collaborated with the MGI faculty in 2006 or have active long-term collaboration:

C.T. Williams, Natural History Museum, London
T. Jeffries, Natural History Museum, London
R. Garcia-Sanchez, Natural History Museum, London
B. Williamson, Natural History Museum, London
K.L. Smith, ANSTO, Sydney
K.P.Hart, ANSTO, Sydney
M. Blackford, ANSTO, Sydney
H.J. Li, ANSTO, Sydney
G.R. Lumpkin, ANSTO, Sydney
P.J. MgGlinn, ANSTO, Sydney
D. Rumble, Carnegie Institution of Washington
S. Sorensen, Smithsonian Institution, Washington
J. Beard, Virginia Museum of Natural History, Martinsville
Peter Stille, CNRS und Université Louis Pasteur, Strasbourg
François Holtz, University of Hannover, Germany
Renat Almeev, University of Hannover, Germany
Martin Streck, University of Portland, U.S.A..
Milos Rene, University of Prague, Czech Republic
Anatoly Zaitsev, St. Petersburg University and NHM London.
Frances Wall, NHM London
Group of Gerald Ernst, Ghent University, Belgium
Ralf Halama, Maryland University
Hendrik J. Bruins, University of the Negev
Alexander MacGillavray, British Archeological Institute Athens
Andreas Klügel, University Bremen
Ralf Gertisser, Keele University, UK
Meinert Rahn, PSI, Switzerland
Michael Kraml, BGR Hannover
Natale Calanchi, Claudio Tranne, Federico Lucchi, Università di Bologna
G. Diego Gatta, Universita' degli Studi di Milano

Completed MGI Diploma Theses (undergraduate senior theses)

Haas, M., 2006: Geologische Kartierung der Zermatter Ophiolithe im Bereich des Oberen Theodulgletschers Wallis, Schweiz. (Advisor: Kurt Bucher).

MGI 2006 Publication List

Peer-reviewed Journal Articles, Books, and Book Chapters

Alexander, W.R., **Gieré, R.**, Hidaka, H., Yoshida, H.D., 2006: Natural immobilization processes aid the understanding of long-term evolution of deep geological radioactive waste repositories. *Geochemistry: Exploration, Environment, Analysis* 6, 3-4.

Armbruster, T., Bonazzi, P., Akasaka, M., Bermanec, V., Chopin, C., **Gieré, R.**, Heuss-Assbichler, S., Liebscher, A., Menchetti, S., Pan, Y., Pasero, M., 2006: Recommended nomenclature of epidote-group minerals. *European Journal of Mineralogy* 18, 551-567

Beard, J.S., Sorensen, S.S., **Gieré, R.**, 2006: REE zoning in allanite related to changing partition coefficients during crystallization: implications for REE behaviour in an epidote-bearing tonalite. *Mineralogical Magazine* 70, 419-435

Bucher, K., Frost, B.R., 2006: Fluid transfer in high-grade metamorphic terrains intruded by anorogenic granites: the Thor Range, Antarctica. *Journal of Petrology* 47, 567-593.

Gieré, R., Blackford, M., Smith, K., 2006: TEM study of PM2.5 emitted from coal and tire combustion in a thermal power station. *Environmental Science & Technology* 40, 6235-6240

Gieré, R., Smith, K.L., Blackford, M., 2006: Chemical composition of fuels and emissions from a coal+tire combustion experiment in a power station. *Fuel* 85, 2278-2285

Keller, J., Zaitsev, A.N., 2006: Calciocarbonatite Dykes at Oldoinyo Lengai: The Fate of Natrocarbonatite. *Canadian Mineralogist* 44, 857-876.

Keller, J., Zaitsev, A.N., Wiedenmann, D., 2006: Primary magmas at Oldoinyo Lengai: The Role of Olivine Melilitites. *Lithos* 91, 150-172

Klaudius, J., **Keller, J.**, 2006: Peralkaline silicate lavas at Oldoinyo Lengai (Tanzania). *Lithos* 91, 173-190.

Kraml, M., Pik, R., Rahn, M., **Selbekk, R.**, Carinnan, J., **Keller, J.**, 2006: A new multi-mineral age reference material for $^{40}Ar/^{39}Ar$, (U-Th)/He and FT dating methods: the Limberg t3 tuff. *Geostandards and Geoanalytical Research* 30, 73-86.

Majzlan, J., Kiefer, B., 2006: An X-ray and neutron diffraction and *ab-initio* study of the crystal structure of ferricopiapite, $Fe_{14/3}(SO_4)_6(OH)_2(H_2O)_{20}$. *The Canadian Mineralogist* 44, 1227-1237.

Majzlan, J., Navrotsky, A., McCleskey, B., Alpers, C.N., 2006: Thermodynamic properties and crystal structure refinement of ferricopiapite, coquimbite, rhomboclase, and $Fe_3(SO_4)_2(H_2O)_5$. *European Journal of Mineralogy* 18, 175-186.

Majzlan, J., Speziale, S., Duffy, T., Burns, P.C., 2006: Single-crystal elastic properties of alunite, $KAl_3[(OH)_6(SO_4)_2]$. *Physics and Chemistry of Minerals* 33, 567-573.

Stober, I., **Bucher, K.**, 2006: Hydraulic properties of the crystalline basement. *Hydrogeology Journal*, ISSN 1431-2174 (Print) 1435-0157 (Online).

Tichomirowa, M., Grosche, G., Götze, J., Belyatski, B.V., Savva, E.V., **Keller, J.**, Todt, W., 2006: The mineral isotope composition of two Precambrian carbonatite complexes from the Kola Alkaline Province – Alteration versus primary magmatic signatures. *Lithos* 91, 229-249.

Trommsdorff, V., Montrasio, A., Hermann, J., Müntener, O. Spillmann, P., **Gieré, R.**, 2006: The geological map of Valmalenco. *Schweizerische Mineralogische und Petrographische Mitteilungen* 85, 1-13

Vespa, M., **Keller. J.**, Gertisser, R., 2006: The Interplinian explosive activity of Santorini Volcano (Greece) during the past 150,000 years. *Journal of Volcanology and Geothermal Research* 153, 262-286.

Zaitsev, A.N., **Keller, J.**, 2006: Mineralogical and chemical transformation of Oldoinyo Lengai natrocarbonatites, Tanzania. *Lithos* 91, 191-207.

Zhang, X., Zhu, Y., Stober, I., **Bucher, K.**, 2006: The influence of impurities on the dissolution of Ca- and Sr-bearing barite at room temperature. *Chinese Journal of Geochemistry* 25, 71-84.

Proceeding Volumes and Non-reviewed Contributions

Botez, C.E., Chianelli, R.R., Zhang, J., Qian, J., **Majzlan, J.**, Pantea, C., 2006: Evidence for a structural transition to a superprotonic CsH_2PO_4 phase under high pressure. *Materials Research Society Symposia Proceedings*, paper 0929-II02-01.

Bucher, K., Stober, I., 2006: Geothermal water, heat transport medium in deep geothermal systems. In: Zahoransky, R. (ed.) Geothermal Opportunities in the Upper Rhine Valley. Proceedings of the Rhenenergy Conference. VDI, Association of German Engineers, Düsseldorf, 17-27.

Majzlan, J., 2006: Martin Chovan sixty-years old. *Mineralia Slovaca* 38, Geovestník 4-5.

Majzlan, J., 2006: Review of the university scriptum Illášová, L., Turnovec, I.: Úvod do gemológie. *Mineralia Slovaca* 38, Geovestník 8.

Stober, I., **Bucher, K**., 2006: Geothermische Verhältnisse und Nutzungsmöglichkeiten in Baden-Würtemberg - Fallbeispiele – In: Zahoransky, R. (ed.) Geothermal Opportunities in the Upper Rhine Valley. *Proceedings of the Rhenenergy Conference*. VDI, Association of German Engineers, Düsseldorf, 5-16.

Abstracts

Ackermann S., **Gieré R.**, **Majzlan J.**, 2006: Antimony speciation in highly contaminated soils. *Berichte der Deutschen Mineralogischen Gesellschaft, Beihefte zum European Journal of Mineralogy*, Vol. 18/1, 4.

Botez, C.E., Chianelli, R.R., Zhang, J., Qian, J., **Majzlan, J.**, Pantea, C., 2006: Evidence for a structural transition to the superprotonic phase of CsH_2PO_4 under high pressure. *Materials Research Society meeting*, San Francisco, CA, USA.

Bucher, K., **Weisenberger, T.**, 2006: Zeolites on fissures of crystalline basement rocks in the Swiss Alps. *GSA Abstracts with Programs*, 37, A228-3, ISSN 0016-7592.

Gertisser, R., Chadwick , J. P., Condomines, M., Handley, H.K., **Keller, J.**, Kelley, S. P., Troll, V. R., 2006: Volcanic hazards at Merapi, Central Java, Indonesia: inferences from the volcano’s past history. *Abstract Cities on Volcanoes* 4, Quito, Ecuador.

Gertisser, R., Condomines, M., **Keller, J.**, Kelley, S.P., Thomas, L., 2006: Chronology of Merapi Volcano, Central Java, Indonesia. *Abstract Volcanic and Magmatic Study Group Meeting*, Leeds.

Gieré, R., Jeffries T., Garcia-Sanchez R., Williams, C.T., 2006: Light element distribution in an amphibolite-facies metapelite. Abstracts of the *16th Annual V.M. Goldschmidt Conference*, CD-ROM, 0608025abstract00164.pdf.

Gieré R., **Majzlan J.**, 2006: Thermodynamic aspects of the formation of sulfate minerals from hot gaseous phase. *AGU Fall Meeting*, San Francisco, Abstract # MR43B-1085.

Gieré R., Smith, K.L., Blackford, M., 2006: Mineralogy of PM2.5 emissions from a coal-fired power plant. *Berichte der Deutschen Mineralogischen Gesellschaft, Beihefte zum European Journal of Mineralogy*, Vol. 18/1, 45.

Jankulár, M., Hiller, E., Jurkovic, L., Kordík, J., Slaninka, I., **Majzlan, J.**, 2006: Mobilisation of arsenic and zinc in contaminated stream sediments and impoundment material from chemical manufacturing and environmental implications. *7th European Meeting on Environmental Chemistry*, Brno, Czech Republic.

Keller, J., 2006: The Ionian Sea as tephrochronological archive for major paroxysms in Italian explosive volcanism of the upper Quaternary. *Workshop CNR-AIQUA Tefrostratigrafia del Quaternario recente italiano tra vulcanologia e scienze del Quaternario*, Roma. Invited Paper.

Keller, J., **Klaudius, J.**, 2006: Historical Activity and Volcanic Hazard at Oldoinyo Lengai, Tanzania. *Abstract Cities on Volcanoes* 4, Quito, Ecuador.

Klaudius, J., **Keller, J.**, 2006: Petrogentic evolution of Oldoinyo Lengai silicate lavas. *Berichte der DMG Beih. z. Eur. J. Mineral.* Vol. 14, 81.

Kordík, J., Jurkovic, L., Slaninka, I., Durža, O., Pastierová, J., Fargašová, A., **Majzlan, J.**, 2006: Contamination of Kyjov catchment by arsenic and its possible negative impact on biota. *Geoenvironment contamination and Quality of Life*, Bratislava, Slovakia.

Lalinská, B., **Majzlan, J.**, Chovan, J., Šottník, P., Milovská, S., 2006: Mineralogical and Geochemical study of mine tailings material from the antimony deposit Pezinok – Kolársky vrch (Slovakia), volume of contamination and remediation project. *1st Central European Mineralogical conference*, Vyšná Boca, Slovakia.

Majzlan, J., Chovan, M., Lalinská, B., Milovská, S., Jurkovic, L., 2006: The structure and ageing of AS-rich ferrihydrite from Pezinok, Slovakia. *3rd Mineral Sciences in the Carpathians meeting*, Miskolc, Hungary.

Majzlan, J., Chovan, M., Lalinská, B., Jurkovic, L., Milovská, S., Göttlicher, J., 2006: Formation, composition, structure, and ageing of As-ferrihydrite from Pezinok, Slovakia. *16th Goldschmidt conference*, Melbourne, Australia.

Majzlan, J., Grapes, R.H., 2006: Minerals of the exocontact of a pegmatite and ultrabasic rocks in Hermanov, Czech Republic. *1st Central European Mineralogical conference*, Vyšná Boca, Slovakia.

Majzlan, J., Nielsen, U., Phillips, B., Ziliox, M., Grey, C.P., 2006: A multi-nuclear solid state NMR investigation of alunite, $(K,Na,H_3O)Al_3(SO_4)_2(OH)_6$. *Deutsche Mineralogische Gesellschaft Tagung*, Hannover, Germany, September 2006.

Mazeina, L., **Majzlan, J.**, Navrotsky, A., 2006: Polymorphic transformations of iron oxides: a thermodynamic view. *16th Goldschmidt conference*, Melbourne, Australia.

Parat, F., Streck, M., Holtz, F., Almeev R., 2006: Crystallization of An-rich plagioclase in ‘dacitic’ melt at Arenal volcano: Natural occurrence and experiments. *American Geophysical Union*, San Francisco, USA.

Payne, T.E., **Gieré, R.**, Lumpkin, G.R., Hart, K.P., McGlinn, P.J., 2006: Partitioning and leaching behaviour of actinides and rare earth elements in a zirconolite-bearing hydrothermal vein system. International Symposium on the Scientific Basis for Nuclear Waste Management XXX, *MRS2006 Fall Meeting*, Boston. Program with Abstracts, p. 1007.

Selbekk, R.S., **Weisenberger, T.**, 2006: Zeolite facies metamorphism in the Hvalfjördur area, Iceland. In Bowmann R.S. and Delap S.E. (eds). Zeolite `06 - *7th International Conference on the Occurrence, Properties, and Utilization of Natural Zeolites*, Socorro, New Mexico USA, 16-21 July 2006, p. 220

Stober, I., **Bucher, K.**, 2006: Hydrochemische und hydraulische Eigenschaften von Tiefenwässern. *DGG Jahrestagung Berlin, Schriftenreihe der Deutschen Geologischen Gesellschaften*, 50, 113. ISBN 3-932537-45-9.

Weisenberger, T., **Bucher, K.**, 2006: Zeolites on fissures of alpine crystalline basement rocks in the Swiss Alps. *Berichte der Deutschen Mineralogischen Gesellschaft, Beih. z. Eur. J. Mineral.* Vol. 18, p.153.

Weisenberger T., **Bucher, K.**, 2006: Zeolites on fissures of crystalline basemnet rocks in the Swiss Alps. In Bowmann R.S. and Delap S.E. (eds). Zeolite `06 - *7th International Conference on the Occurrence, Properties, and Utilization of Natural Zeolites*, Socorro, New Mexico, USA, p. 253.

Popular Science

Gieré, R., 2006: The waste tire problem: solution through combustion? *Geochemical News* 127, 12-17.

Weisenberger, T., Selbekk, R.S., 2006: Die Zeolith-Fundstelle Hvalfjordur, Island. *Mineralien Welt* 17, 50-56.

Research Abstracts

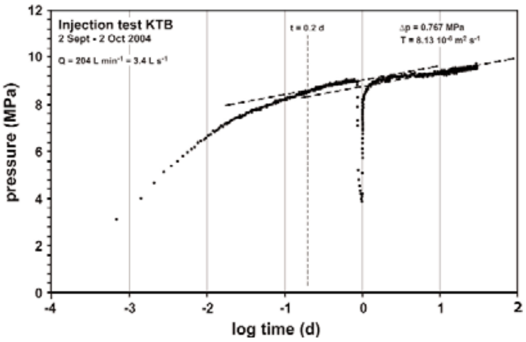
Geothermal energy research

Hydraulic properties of the crystalline basement

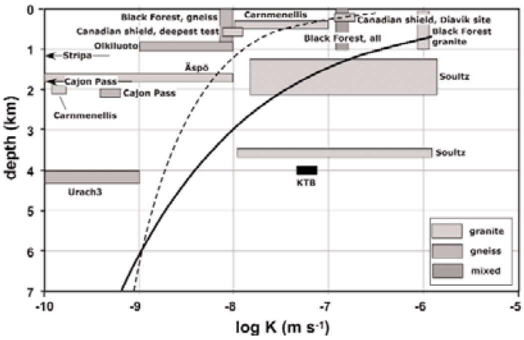
Ingrid Stober and Kurt Bucher

This is the most important research paper of the year 2006 in the field of geothermal research. It has been published online in Hydrogeology Journal in October 2006, the print version will follow in early 2007.

Hydraulic tests in boreholes, up to 4.5 km deep, drilled into continental crystalline basement revealed hydraulic conductivity (K) values that range over nine log-units from 10^{-13} - 10^{-4} m s^{-1}. However, K-values for fractured basement to about 1 km depth are typically restricted to the range from 10^{-8} to 10^{-6} m s^{-1}. New data from an extended injection test at the KTB research site (part of the Continental Deep Drilling Programm in Germany) at 4 km depth provide K = 5 10^{-8} m s^{-1}. The summarized K-data show a very strong dependence on lithology and on the local deformation history of a particular area. In highly fractured regions, granite tends to be more pervious than gneiss. The fracture porosity is generally saturated with Na-Cl or Ca-Na-Cl type waters with salinities ranging from < 1 to > 100 g L^{-1}. The basement permeability is well within the conditions for advective fluid and heat transport. Consequently, fluid pressure is hydrostatic and a Darcy flow mechanism is possible to great depth. Topography-related hydraulic gradients in moderately conductive basement may result in characteristic advective flow rates of up to 100 L a^{-1} m^{-2} and lead to significant advective heat and solute transfer in the upper brittle crust.



Pressure (Mega Pascals) versus log time (days), from an injection test of 30 days duration in the 4000 m deep research borehole at the KTB site. The pressure excursion after 1 day (time 10^0)was caused by a short pump failure. Δp = slope of stipled line in MPa. The properties of the homogeneous isotropic aquifer (stipled lines) dominate after 0.2 days (marker). The stipled lines are displaced by the effects of the interuption in pumping.



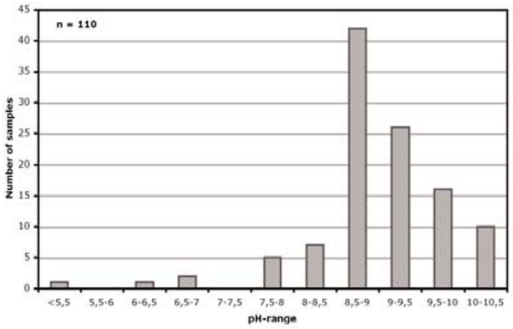
Hydraulic conductivity (K) of crystalline basement. Data from well tests summarized and cited in the text. Solid curve: log K depth dependence derived by Ingebritsen and Manning (1999). Dashed curve: extrapolation of log κ = f(log z) dependence derived from Black Forest hydraulic data.

Hydrochemical evolution of deep groundwater in fractured basement aquifers

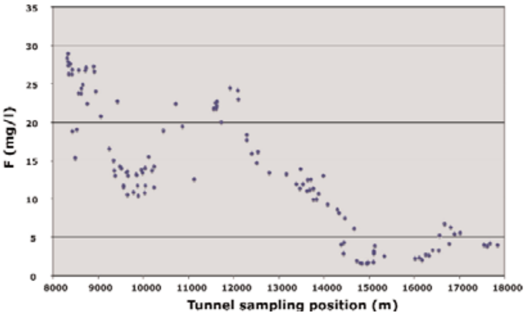
Kurt Bucher and Ingrid Stober

Co-worker of the project is Ulrike Seelig, who started a PhD program in October 2005.

The project has access to an absolutely remarkable set of water samples from the world longest railroad tunnel currently under construction between Erstfeld and Bodio in Switzerland (NEAT Alptransit, Gotthard). The drilling of the Amsteg section has been completed in 2006 and the last water samples arrived at the MGI in October. The sampling of the complete Amsteg section (Aar Massif) is finished. In 2006 we visited the Sedrun section several times and collected unique water samples from the Gotthard massiv and the Urseren zone.



pH of water samples from the Amsteg section of the Gotthard base tunnel (NEAT).



Fluoride concentration of water samples from the Amsteg section of the Gotthard tunnel.

The chemical data of the analyzed set of more than 120 water samples from the Amsteg section collected from water producing fissures reveal some extraordinary features. The chemical composition strongly depends on the lithology of the rock metrix. The type of water includes Na-Cl, Na-HCO_3, Ca-SO_4 and their mixtures. A common feature of all waters is a very high pH value as shown on the diagram below. Such high pH values are very uncommon for groundwater in granitic rocks and have only been described from a few localities worldwide. This and other features such as an extraordinary high fluorine content underline the very special chemical character of these thermal waters in the crystalline basement.

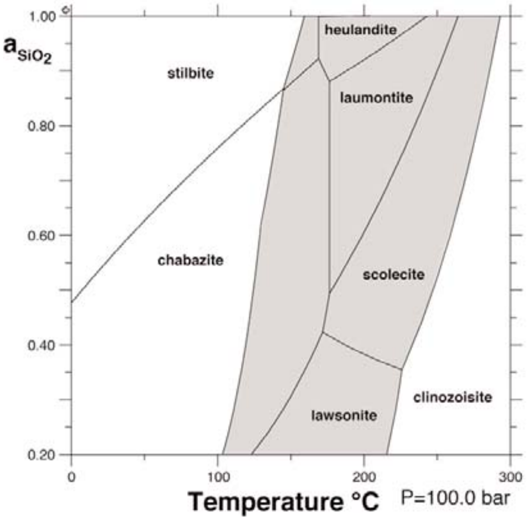
The NEAT Gotthard tunnel project will be our central research effort in the field of water and geothermal energy research.

Zeolites in fissures of crystalline basement rocks

Kurt Bucher

Co-worker on the project is Tobias Weisenberger. He started a PhD program in January 2006.

A number of zeolite species have been described from Alpine fissures in crystalline basement rocks of the Swiss Alps. The zeolites typically overgrow



Stability of Ca-zeolites as function of quartz activity and temperature (100 bar). shaded area represents the stability area of prehnite.

earlier minerals of the fissure assemblages, but zeolites also occur as single stage fissure deposits in granite and gneiss. A systematic study of zeolite samples in the collections of Swiss Natural History Museums showed that the majority of finds originate from three main areas. Two of them are located in gneiss and granite of the southern Aar-Massif and one in granite-gneiss of the Pennine nappes of the Ticino area. In addition to these known localities from the surface, tunnel construction in the Alps provided excellent zeolite material from fissures in basement rocks. At present, a new 53 km long Gotthard railroad base tunnel is excavated and offers the unique opportunity to study the in-situ formation of low-temperature minerals.

Reported zeolite species from Alpine fissures in granite and gneiss include: chabazite, heulandite, laumontite, scolezite, stellerite, stilbite. The zeolites often occur with other species in the fissures including: quartz, apophyllite and chlorite. Earlier minerals in zeolithe-bearing fissures may include: prehnite, adularia, fluorite, hematite and others.

Particularly spectacular are the extensive occurrence of laumontite vein fillings in the new Gotthard rail tunnel (NEAT). Laumontite covers fissure walls as dense mats. Up to 1cm long white needles of laumontite are the last minerals that precipitated from hot water in the fissures and cavities. It overgrows “primary” fissure quartz and chlorite coatings of the fissure walls. Locally, apophyllite overgrows laumontite as euhedral crystals thus it is the last mineral formed in the fissures. Laumontite is the absolutely dominant zeolite of the tunnel fissures, but the mineral is rarely preserved in surface outcrops where chabazite and stilbite dominate. Laumontite in the tunnel forms by precipitation from alkaline hot water that acquired its chemical composition by reaction with primary plagioclase at temperatures of about 160°C. The present day rock temperature in the tunnel is < 44°C. Alpine cooling and exhumation rates for the Aar Massif suggest that fissure laumontite formed about 2-5 Ma ago.

Scolecite, image width 5 mm.

A project focusing on groundwater quality has been launched in 2005 by the "Hessisches Landesamt für Umwelt und Geologie" (HLUG) in Wiesbaden. The English short version of the project title is:

Regional variation of groundwater composition in Hessen and its relation to the aquifer geology

Kurt Bucher

The responsible investigator at HLUG is Dr. Leßmann. Florian Ludwig is co-worker on the project and will use the results of the investigation for a PhD project under the guidance of Kurt Bucher and Ingrid Stober.

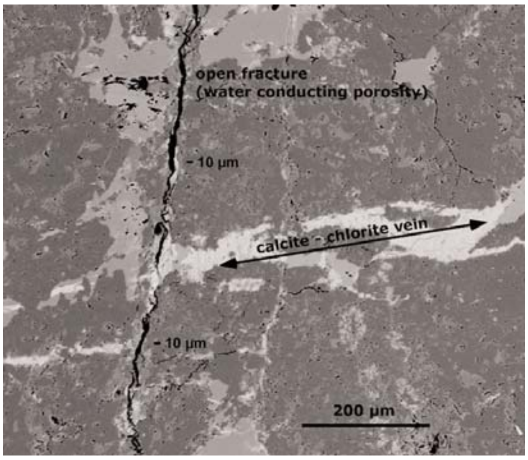
The project will produce more than 1000 new full analyses of groundwater including data for a large number of trace elements. The first series of data have been produced for wells in basement rocks and Buntsandstein in the south of Hessen.

Hot Spring in crystalline rocks, Western Tian Shan, China

Kurt Bucher, Lifei Zhang, Xuping Li, Ingrid Stober

A cooperative project with scientists from CUG and BU, Beijing, PR China

Research cooperation with chinese scientists continued also in 2006. A new cooperative project has been initiated by Prof. Dr. Xuping Li from the Chinese University of Geosciences in Beijing. It also involves Prof. Dr. Lifei Zhang from the Beijing University. The thermal water of the hot springs collected in 2005 at Muzhaerte in the Tian Shan range has been analyzed and a paper manuscript has been submitted to "Geofluids" in August 2006. The paper is still in the review process. The abstract is given below:



BSE texture image of Muza granite showing fracture apertures of about 10 μm ± 5μm. Dissolution features at the intersection of shear II calcite vein with late brittle water conducting fracture are absent.

The western Tianshan range is a major Cenozoic orogenic belt in central Asia exposing predominantly Paleozoic rocks including granite. Ongoing deformation is reflected in very rugged topography and an E-W trending fracture and fault system. In the Muzhaerte valley upwelling hot deep water uses such a fault system in the Muza granite as a flow conduit. About 20 l min^{-1} Na-SO$_4$-Cl water at about 55°C and a total mineralization of 1 g L^{-1} flow from hot spring. The Cl/Br ratio of 1500 ppm/ppm suggests that the mineralization has an evaporitic source originally. The oxygen and hydrogen isotopic composition supports a meteoric source with little impact of reaction with granite. Leached salts from powders of Muza granite show the same Cl/Br signature as the hot spring water. The salty fluid in the granite is stored in fluid inclusions, which have been introduced by a ductile shearing event related to ongoing orogenesis. The stored fluid, however, is of evaporitic and meteoric origin. The hot water remobilizes the salty fluid, a process that is related to the alteration of Muza granite to a low-temperature epigranite.

Hot springs and salt lakes in the Qaidam Basin, China

Kurt Bucher, Ingrid Stober

A new cooperative project with Prof. Dr. Zhong Jianhua from the College of Geo-Resources and Information at the University of Petroleum in Dong Yiag City of the Shan Dong Province has been established in 2005. In the summer 2006, we visited the Qaidam baisin and the Qaidam oilfields by invitation from Prof. Zhong and SINOPEC, the second largest Chinese oil company.

During field work in the oil fields, the salt deserts, the Altun and Qilian mountains we collected water samples from hot springs, salt lakes and tributaries to the lakes. In addition salt and rock samples were collected. The water samples have been analyzed during the fall. Currently the data are analyzed and interpreted.

Our Chinese friends (Prof. Zhong second from left), the drilling rig in the background is located on 3750 m a.s.l. in the Qilian mountains and drills a 4500m deep exploration drill hole.

Hot spring - hot river, the temperature of the water in this brook has nearly 70°C.

Environmental Geochemistry

Sb speciation in shooting range soils

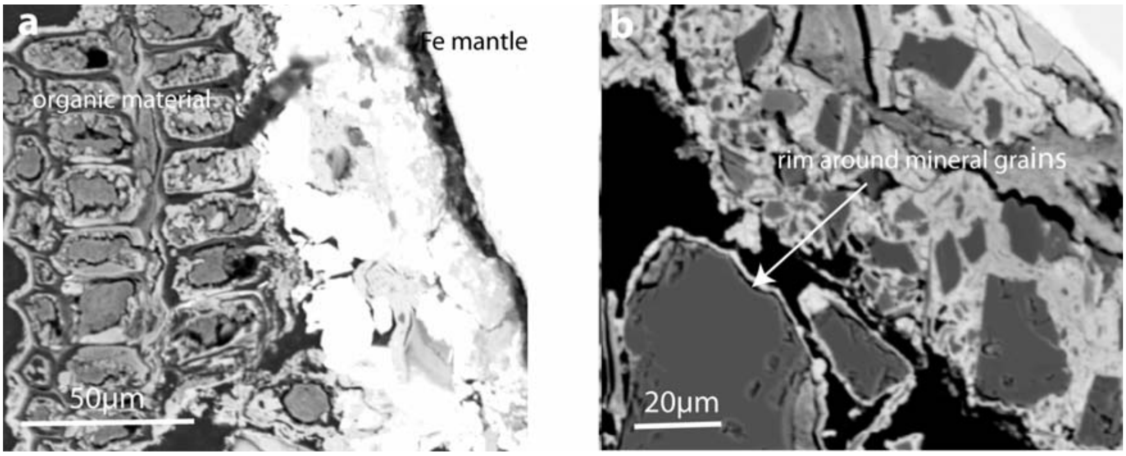
Sonia Ackermann, Reto Gieré

Shooting activities lead to an enormous contamination of the environment with heavy metals. The major polluters in this case are the national armies, which fire many tons of ammunition into the ground every year. The bullets used by the Swiss and EU armies are typically composed of alloys containing Pb and Sb. In Switzerland alone, the estimated annual input of these elements into the environment by such activities is 400 to 500 tons of Pb and approximately 6 tons of Sb. The weathering of bullets releases various amounts of heavy metals whose toxicity and bioavailability depends on their speciation. Some of these metals are incorporated into secondary products which form Fe-rich weathering crusts surrounding each bullet. Depending on the weathering conditions and soil parameters, different secondary phases and speciation can be expected. In this study we focus on the speciation of Sb because this element has been found to affect human health significantly and has been neglected in previous works.

To study the effect of climate and soil parameters on the retention of Sb within the weathering crust around corroded bullets, the two sampling sites Losone and Lucerne (Switzerland) were chosen. The stop butt materials of the two sites differ in pH and the content of organic material. Stop butt material from Losone has a very low total carbon content (0.84±0.03 wt%), whereas at Lucerne contents are approximately 20 times higher (18.21±0.06 wt%). More than 85% of the total carbon content is attributed to organic material, like saw dust particles which are added to the stop butt material.

After a total digestion of the weathering crust the Sb, Pb, and Fe content was determined by atomic absorption spectroscopy. The total Sb contents in the weathering crust ranged from 0.3 to 1.3 wt%. Lead and Fe concentrations of up to 26 wt% were measured.

The chemical components measured by AAS are distributed among phases identified by XRD. The phases found



BSE images of major Sb-bearing weathering products within weathering crust from corroding bullets.. (a) organic material with Fe and Sb trapped within the cellular structure (sampling site Lucerne). (b) Sb-rich rim around mineral grains (sampling site Losone).

were cerussite ($PbCO_3$), litharge (PbO), goethite, and quartz. Feldspars were only observed in samples from Losone, whereas litharge (PbO) was only identified in the sample from Lucerne. To quantify the phase fractions of these minerals and the amount of amorphous material, Rietfeld refinement with an internal standard method will be performed.

Electron microprobe analyses showed that rims around mineral grains and secondary Pb products represent the major Sb-bearing phases for weathering crust from Losone. The rim around mineral grains are only 2 to 3 micrometers thin and are composed of Fe, Pb and Sb. Secondary Pb phases are composed of Pb and Sb. In individual spots Sb concentrations of up to 5 wt% were measured. In weathering crust from Lucerne fragments of organic material and secondary Fe phases play the most significant role in the retention of Sb. (Fig. 1).

Preliminary results from Raman spectroscopy indicate that the rims around mineral grains are likely to be goethite whereas Fe phases towards the bullets core are more likely to be lepidocrocite. Whether Sb and Pb are adsorbed to or coprecipitated with these phases is unknown.

It is planned to perform X-ray absorption experiments on these samples and in particular these weathering products to investigate the bonding of Sb.

Chemical composition of fuels and emissions from a coal+tire combustion experiment in a power station

Reto Gieré, Katherine Smith, and Mark Blackford

This study is a collaboration between our Institute and the Australian Nuclear Science and Technology Organisation in Sydney. It has been published by the journal *Fuel*.

Medium-sulfur bituminous coal and a mixture of 95 wt% coal plus 5 wt% tire-derived fuel (TDF) in the form of shredded automotive tires were combusted in a stoker boiler under the same conditions. This paper presents quantitative chemical compositions of the fuels and of the gaseous and particulate emissions. The coal+TDF mixture is considerably richer in Zn than the pure coal as a result of the high Zn content of the shredded tires (~ 1 wt% Zn). Atmospheric emissions of Zn increased from 15 g/h to nearly 2.4 kg/h when coal+TDF was combusted. Similarly, emissions of most other metals and metalloids, as well as those of HCl increased when TDF (~ 3000 ppm Cl) was added. The enhanced metal emissions might be due to formation of gaseous metal chloride species in the stack gases. On the other hand, emissions of CO decreased slightly, whereas those of NO_x, SO_2, and total particulate material remained virtually unchanged. These results help in assessing the environmental impact of energy recovery from scrap tires in stoker boilers.

Short overview of recent studies of natural immobilisation processes as an aid to understanding the likely long-term evolution of deep geological radioactive waste repositories

W.Russell Alexander[1], Reto Gieré, Hiroshi Hidaka[2] and H. Dora Yoshida[3]

This project is dedicated to the understanding of natural analogue processes and materials for the long-term immobilisation of radioactive waste. It focuses on the geology and geochemistry of the Tono uranium deposit and the surrounding environments in Japan. It is a collaboration between our institute, the Swiss National Co-operative for the Disposal of Radioactive Waste (NAGRA), Hiroshima University, and Nagoya University. All research on this topic was collected as a series of papers, which were published as a special issue of the Journal *Geochemistry: Exploration, Environment, Analysis* (6, p. 3-67.) This special issue is the result of a symposium we convened in 2003 at the Goldschmidt Meeting in Kurashiki, Japan.

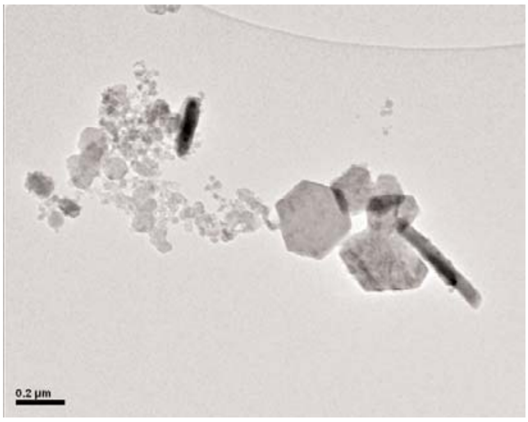
[1]Nagra, [2]Hiroshima University, Japan, [3] Nagoya University, Japan

TEM Study of Fine Particulate Material Emitted from Coal and Tire Combustion in a Thermal Power Station

Reto Gieré, Katherine Smith, and Mark Blackford

This study is a collaboration between our Institute and the Australian Nuclear Science and Technology Organisation in Sydney. It has been published in the Journal *Environmental Science and Technology* and presented at the Jahrestagung der Deutschen Mineralogischen Gesellschaft in Hannover.

The research presented here was conducted within the scope of an experiment investigating technical feasibility and environmental impacts of tire combustion in a coal-fired power station. Previous work has shown that combustion of a coal+tire blend rather than pure coal increased bulk emissions of various elements (e.g., Zn, As, Sb, Pb). The aim of this study is to characterize the chemical and structural properties of emitted single particles with dimensions <2.5 µm (PM2.5). This transmission electron microscope (TEM)-based study revealed that, in addition to phases typical of coal fly ash (e.g., aluminum-silicate glass, mullite), the emitted PM2.5 contains amorphous selenium particles and three types of crystalline metal sulfates never reported before from stack emissions. Anglesite, $PbSO_4$, is ubiquitous in the PM2.5 derived from both fuels and contains nearly all Pb present in the PM. Gunningite, $ZnSO_4{\cdot}H_2O$, is the main host for Zn and only occurs in the PM



TEM bright-field image of fine particulates emitted from the coal-fired power plant of Purdue University, USA. Photo: M. Blackford, ANSTO derived from the coal+tire blend, whereas yavapaiite, $KFe^{3+}(SO_4)_2$, is present only when pure coal was combusted. We conclude that these metal sulfates precipitated from the flue gas, that they may be globally abundant aerosols, and have, through hydration or dissolution, a major environmental and health impact.

Thermodynamics of the minerals of the jarosite group

Peter Glasnák, Juraj Majzlan

This study is the PhD project of Peter Glasnák. Funding is provided by *Deutsche Forschungsgemeinschaft*.

Jarosite and related minerals are invariably found in natural environments acidified either through the action of acid rain or by acidic mine drainage. In spite of their importance and common occurrence, the data which could describe the solubility, precipitation and distribution of elements between jarosite and aqueous solutions are fragmented or questionable. The overall goal of this PhD work is determine the thermodynamic properties (formation enthalpy, entropy and Gibbs free energy of formation) of the jarosite group of minerals by calorimetric techniques. The measured thermodynamic quantities will be confronted with high P-T experiments on jarosite minerals via mathematical programming analysis. The result will be an internally consistent thermodynamic data set for jarosite group minerals. The systematics obtained will provide an excellent basis for models of dissolution, precipitation, pollutant transport and element fractionation in environments affected by acidic input.

In order to achieve the overall goal, we will:

- Synthesize jarosite compounds (Na, K, H_3O, Rb)
- Characterize samples, using X-ray techniques, AAS, electron microprobe, nuclear magnetic resonance
- Carry out the thermodynamic measurements on the jarosite samples, using acid-solution and adiabatic calorimetry
- Perform HT/HP reversal experiments on the jarosite
- Compile high-quality thermodynamic data (enthalpy, entropy, heat capacity) and published literature (Gibbs free energy) for use in thermodynamic databases

The jarosite group comprises a large number of minerals. Some of them, for example jarosite, are found in numerous geological environments and exhibit a range of unusual physical properties. These minerals draw significant interest of geologist, chemist, physicists and material scientists (Dutrizac and Jambor 2000). Jarosite and related phases are found invariably in precipitates from acid-mine drainage (Bigham and Nordstrom 2000), mostly due to oxidation of pyrite and formation of sulfuric


Detail of jarosite mineral (Jaroso ravine, Sierra Almagrera, Spain).

acid.

These minerals are also common in weathering zones of sulfide deposits and acid sulfate soils. Acid-mine drainage has been documented in abandoned mines and waste tailings sulfide ore exploitation or abandoned and active coal mines.

Bigham, J.M., Nordstrom, D.K., 2000: Iron and aluminium hydroxysulfates from acid sulfate waters. In Alpers, C.N., Jambor, J.L., Nordstrom, D.K. (eds) Sulfate Minerals – Crystallography, Geochemistry and Enviromental Significance. *Rev Mineral Geochem* 40, 351-403.

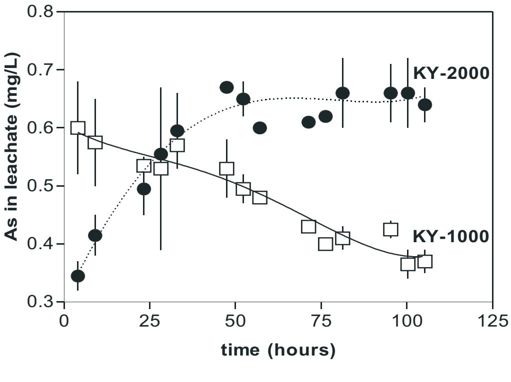
Dutrizac, J.E., Jambor, J.L., 2000:Jarosite and their application in hydrometallurgy. *Rev Mineral Geochem* 40, 405-452.

Leaching behaviour of arsenic and zinc in contaminated stream sediments and impoundment material from chemical manufacturing

Juraj Majzlan, Edgar Hiller, Ľubomír Jurkovič, Jozef Kordík, Igor Slaninka

The results of this project are submitted to *Environmental Science Letters*. Funding is provided by the *Deutsche Forschungsgemeinschaft*.

Leaching and mobility patterns of As and Zn were studied in contaminated samples of impoundment material and stream sediments located near the village of Poša (eastern Slovakia). The stream sediments contain 20- to 401-times more As than the natural background level for this element (8 mg/kg). Only one stream sediment sample close to the impoundment was contaminated with Zn as compared with the natural background value (90 mg/kg). The solution used in the column leaching experiments contained 2×10^{-5} M phosphate, 2.8×10^{-3} M chloride, and 3.2×10^{-3} M sulphate which are the major anions present in surface water at the studied site. The results of the column leaching experiment indicated that As was more mobile than Zn. The percentages of As and Zn leached were generally less than 10% of the total element content. Nevertheless, the small percentages represented high amounts of As leached from the impoundment material and stream sediments with a mean value of 83 mg/kg of total As released. The mobility of As and Zn appeared to be controlled primarily by the sediment Fe and Mn content and by pH. We conclude that over the four decades of its existence, the studied impoundment generated secondary reservoirs of the toxic elements in the stream sediments and the remediation of this environmental problem cannot be restricted to the treatment of the impoundment material alone.



Leachability of arsenic in column-leaching experiments as a function of time. The composition of the leaching medium was described in the text.

Igneous petrology and volcanology

Crystallization of An-rich plagioclase in ‘dacitic’ melt at Arenal volcano: Natural occurrence and experiments

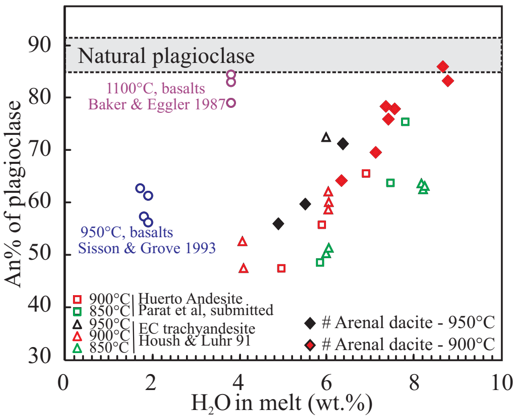
Fleurice Parat, Martin Streck[1], Franvois Holtz[2] and Renat Almeev[2]

This research was presented at the Annual Meeting of the American Geophysical Union 2006 in San Francisco.

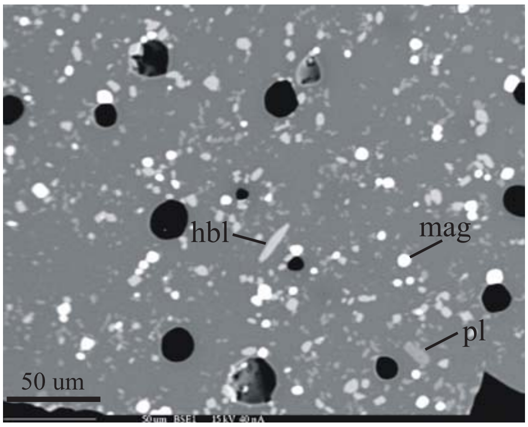
High-An plagioclase (An85-94) is ubiquitous in crystal-rich basaltic andesitic lavas of the current eruption and of the entire eruptive history of Arenal volcano, Costa Rica. An85-91 plagioclase was found to host glassy melt inclusions of dacitic composition suggesting that high An plagioclase may also crystallize in melts as silicic as ~63 wt.% SiO_2 (Streck & Wacaster, 2006). Such dacitic melt inclusion compositions resemble dacite tephra units that erupted a few times in Arenal’s history. We investigated one pumice clast from the dacitic ET2 tephra (e.g. Borgia et al., 1988) to shed light on the possibility to crystallize high An plag from dacitic melt.

The natural ET2 pumice sample is phenocryst poor (~7%) with a fine-grained, vesicular, and mostly crystalline matrix. Phenocrysts are dominated by plagioclase with subordinate amphibole, pyroxenes and oxides. Apatite occurs as accessory phase. Plagioclase cores indeed display high An between An94 to An85. On the other hand, rim compositions tend to be significantly less anorthitic (~An75 to 65).

A natural glass made from a split of the natural ET2 pumice clast was utilized as starting material for an experimental investigation into phase equilibria of this dacite magma. The first experiments were carried out at high pressure (4 kbar), high temperature (900-950°C) and water-rich conditions (4-9 wt.% H_2O_{melt}) in an internally heated pressure vessel ($\log fO_2$~NNO+3). Plagioclase with up to 86 mole % anorthite crystallizes at 900°C and for H_2O_{melt}=9 wt.% (water-saturated). An-rich plagioclase coexists with amphibole (Mg#~70) and magnetite ($X_{ulvö}$=10) in 60 wt.% SiO_2



Variation of An content of experimental plagioclase and H_2O of melt with temperature. EC: El Chichón.



Back-scattered electron photo micrograph of experimental charge at 900°C - 4 kbar - XH_2O=1. hbl: hornblende, pl: plagioclase; mag: magnetite.

melt. As expected, An content increases with increasing temperature and water content in melt. At 950°C, current experiments found plagioclase (An71) to be stable with H_2O_{melt}<6.4 wt.% (no plagioclase at water-saturated conditions, only magnetite crystallizes). We infer that plagioclase begins crystallizing at H_2O_{melt} = 8 wt.% and is stable at lower H_2O_{melt} cocrystallizing with orthopyroxene (Mg#=60-75), clinopyroxene (Mg#<76) and magnetite ($X_{ulvö}$=11-29) with the anorthite content decreasing to An55 at H_2O_{melt} = 4.9 wt.%.

Our results to date already show that water-rich dacitic melt at relatively high pressure and high temperature may indeed crystallize An-rich plagioclase at onset of plagioclase crystallization with or without amphibole depending on temperature.

Borgia et al. 1988-Bull Volcanol, 50,86-105; Streck and Wacaster, 2006-JVGR, 157, 236-253.

[1] Dept. of Geology, Portland State University, Portland, OR 97207-0751

[2] Institute of Mineralogy, Callinst. 3, D-30167 Hannover

The Oldoinyo Lengai Project

Magmatic evolution of the active carbonatite volcano Oldoinyo Lengai, Tanzania

Jörg Keller and Jurgis Klaudius

The project aims at understanding the volcanological and petrological evolution of this exceptionally peralkaline nephelinitic volcano, which finally led to the appearance of the actual natrocarbonatites. The project entered its final year of a 4-year funding period by the *Deutsche Forschungsgemeinschaft* (DFG). Dr. thesis of Jurgis Klaudius expected 2007.

The understanding of the characteristic, history and evolution of the volcano is also used as a key for hazard assessment and prediction of its possible further behavior. A number of papers have been published and submitted during 2006 (Klaudius & Keller, 2006; Keller, Zaitsev and Wiedenmann, 2006; Keller & Zaitsev, 2006; Zaitsev & Keller, 2006, Halama et al.,2006, Kervyn et al.).

In the frame of the European SYNTHESYS programme, Jurgis Klaudius was accepted for the study of radiogenic isotopes on Lengai samples at the Laboratory for Isotope Geology at the Natural History Museum, Stockholm. Results were presented at the Annual Meeting of DMG at Hannover (see below).

Jurgis Klaudius presented seminar talks at Ghent University (January), in Stockholm (March) and at the Geothermy section of the BGR Hannover (September).

Conference papers were given at the Cities-on-Volcanoes 4 conference in Quito, Ecuador (Keller, J. & Klaudius, J. Historical Activity and Volcanic Hazard at Oldoinyo Lengai, Tanzania. Abstract Cities on Volcanoes 4, Quito, Ecuador January 2006, see Abstract below). Also, the Abtracs of Klaudius, J. & Keller, J. 2006. Petrogenetic evolution of Oldoinyo Lengai silicate lavas. Berichte der DMG Beih. z. Eur. J. Mineral. Vol. 14, No.1: 81 follows. Hazard aspects emerging from a detailed analysis of the geological evolution of Oldoinyo Lengai are also discussed in a joint paper with the Ghent University group, which has been submitted (Kervyn, M., Klaudius, J., Keller, J., Mbede, E., Jacobs, P. & Ernst, G.G.J. Remote sensing study of sector collapses and debris avalanches deposits at Oldoinyo Lengai and Kerimasi volcanoes, Tanzania. International Journal of Remote Sensing, submitted 09/06.)

In cooperation with Maryland University, Lengai samples were investigated for their Li isotope composition with reference to mantle sources and Li fractionation (Halama, R., Mcdonough, W.F., Rudnic, R.L., Ash, R.D., Keller, J., Klaudius, J. & Trumbull, R. 2005. Lithium concentrations and Li isotopic compositions of carbonatitic complexes. Abstract AGU 2005). The related paper is accepted and is in press (Halama, R., Mcdonough, W.F., Rudnik, R. L., Keller, J., & Klaudius, J. (in print). The Li isotopic composition of Oldoinyo Lengai: Nature of the mantle sources and lack of isotopic fractionation during carbonatite petrogenesis.

Historical Activity and Volcanic Hazard at Oldoinyo Lengai, Tanzania

Jörg Keller and Jurgis Klaudius

This reseach was presented at the conference Cities on Volcanoes 4, Quito, Ecuador, 2006.

The present activity of Oldoinyo Lengai, Tanzania, is characterised, since about 1983, by ±continuous mild effusion of natrocarbonatite melts in the summit crater of the 3000m cone. The formerly c.100m deep crater has been continuously filled by carbonatite lavas, and overflow occurs now on three sides. The historical record of this unusual volcano starts with the first ascent in 1904 by Jaeger. During these 100 years three major explosive paroxysms occurred in 1917, 1940/41 and 1966/67, resulting in the blanketing of the area with a thick cover of mixed silicate-carbonatite ashes, with major impact on vegetation and human occupancy. A pattern emerges that these paroxysms follow periods of prolonged natrocarbonatite effusion. An explosive eruption, following the scenario of these historic events, is therefore very likely for the nearer future. The hazard assessment requires the petrological understanding of the mechanism for the observed change between rather quiet carbonatite activity and the paroxysmal interludes of a highly explosive nephelinite-carbonatite magma system. Moreover, the actual crater area shows signs of extreme instability and any hazard evaluation has to consider the sudden failure, particularly of the northern flank, with the resulting de-pressurisation of the complex magma system. Major collapse events have been identified in the younger history of the cone.

The pre-historical activity of Oldoinyo Lengai provides a record of explosivity, which dwarfs the historical observations in thickness, volume and dispersal of ash and lapilli. The volcanostratigraphic analysis of tephra profiles representing the past 2000 years shows recurrence times of only a few hundred years for major explosive events. The next important eruption predating the 1917 paroxysm produced a widespread tephra deposit, with a C-14 age of 449±41a.

At risk is a local Maasai population of an estimated ten to twenty thousand inhabitants, relying with their traditional life style entirely on cattle herding. A major explosive eruption, with the magnitude of events as documented repeatedly for the last 2000 years, threatens to annihilate the basis for Maasai persistence in the Natron rift area, the rift shoulders of the Crater Highlands and the adjacent Serengeti plains.

Petrogenetic evolution of Oldoinyo Lengai silicate lavas

Jurgis Klaudius and Jörg Keller

This research was presented at the DMG Annual Meeting, Hannover, Sept. 2006.

Highly peralkaline combeite-wollastonite nephlinite (CWN) has been recognized as dominant silicate lava type within the recent cone of the active carbonatite volcano Oldoinyo Lengai. A detailed study has led to the recognition of two major cone-building stages. An early, predominantly phonolitic stage, Lengai I, forms the southern cone. The recent nephelinitic Lengai II developed following a major sector collapse event over Lengai I. The Petrography of Lengai II lavas show that nephelinite is combeite- and wollastonite-bearing. All Oldoinyo Lengai lavas are peralkaline and highly evolved in terms of low Mg#, Ni and Cr values. Within the unique Lengai II CWN peralkalinity increases with time to extreme values ((Na+K)/Al=2.36). Mineralogical expression of peralkalinity is the presence of combeite and Na-rich clinopyroxene. In addition, exceptionally high Fe_2O_3 (up to 10.28 wt.%) in nepheline is an indicator for alumina deficiency. Combeite also shows high Fe^{3+}. Phonolite and CWN of Lengai I and Lengai II show similarly enriched LILE and LREE values and generally parallel patterns in PM normalized and REE plots. In addition, we use Sr, Nd and Pb-isotope systematics and whole rock trace element data to unravel the petrogenesis of Oldoinyo Lengai lavas.

The Li isotopic composition of Oldoinyo Lengai: Nature of the mantle sources and lack of isotopic fractionation during carbonatite petrogenesis

Ralf Halama[a], William F. McDonough[a], Roberta L. Rudnick[a], Jörg Keller[b], Jurgis Klaudius[b]

This results of this research are in press in *Earth and Planetary Science Letters*.

Lithium concentrations and Li isotope compositions are reported for natrocarbonatites and silicate lavas from Oldoinyo Lengai, Tanzania. Natrocarbonatites are characterized by very high Li contents (211–294 ppm) and a narrow range of δ^7Li values between +3.3 and +5.1. These Li isotope compositions overlap with those reported for MORB and OIB and suggest that the natrocarbonatites reflect the Li isotopic composition of their mantle source. Co-genetic silicate lavas, covering a wide compositional spectrum, show no obvious isotopic fractionation as a function of igneous differentiation or liquid immiscibility.

Primitive olivine melilitites

(Mg#=58–70), considered to be parental magmas, contain 14–23 ppm Li and have δ^7Li values of +2.4 to +4.4. A highly differentiated, peralkaline nephelinite (Mg#=12), likely to be related to the natrocarbonatites by liquid immiscibility, has about twice as much Li as the melilitite (57 ppm), but a similar isotopic composition (δ^7Li=+3). In contrast, a phonolite with 15 ppm Li has a lighter Li isotope composition (δ^7Li=-0.4), which may reflect assimilation of isotopically light lower crustal mafic granulites, a conclusion supported by radiogenic isotope data. Clinopyroxene and olivine separates from the silicate lavas have uniformly lower Li concentrations (3–15 ppm) and lower δ^7Li values (δ^7Li=-2.9 to -0.5) than the respective whole-rocks, with Δ^7Li whole-rock-mineral between 1.4 and 6.3. This difference between whole-rock and mineral data is interpreted to reflect diffusion-driven isotopic fractionation.

[a] Geochemistry Laboratory, Department of Geology, University of Maryland, MD 20742, U.S.A.
[b] Mineralogisch-Geochemisches Institut, Freiburg, Albertstr. 23b, 79104 Freiburg, Germany

Remote sensing study of sector collapses and debris avalanches at Oldoinyo Lengai and Kerimasi volcanoes, Tanzania

M. Kervyn[a], J. Klaudius[b], J. Keller[b], E. Mbede[c], P. Jacobs[a], G.G.J. Ernst[a]

The results of this research were presented in the *International Journal of Remote Sensing*, special issue on advances in Remote Sensing of Volcanoes, Eruptions and Hazards.

Evidence for volcano collapse and debris avalanche deposits (DADs) at Oldoinyo Lengai (OL), Tanzania, has been obtained (Keller, 2002; Klaudius & Keller, 2004) from mapping and fieldwork. Field evidence indicates geologically young ages. On this basis a remote sensing (RS) study of the active carbonatite volcano OL and the surrounding rift plain is carried out, using SRTM digital elevation data, Landsat and ASTER imagery, available geological maps and aerial photographs. The SRTM DEM allows morphological characterization of OL and reassessment of the volcano volume to 41 + 5 km3. This enables to identify collapse scars, fields of large hummocks (>300 m), sharp deposit edges typical of DADs, and to estimate DADs' thicknesses. Multispectral data (ASTER, Landsat) are exploited for lithological characterizations and merged with topographic data for interpretation. RS data interpretation enables to map the extent and to estimate the volume of two sector-collapse scars and of 3 DADs. Mapped DADs extend up to 23 km from OL and have volumes between 0.1 and ~5 km3. Striking radial ridges and grooves are identified in some parts of the DADs. The morphological variability for ridges and grooves in different DADs is attributed to contrasting flow dynamics and contrasting avalanching material. The findings highlight the needs for routine monitoring of ground deformation and seismicity at OL to anticipate hazardous events including volcano collapse or explosive eruptions. The potential for future sector collapses at OL and related hazards for the local population are also briefly evaluated using RS data and field observations. In addition, a volcano collapse and a corresponding debris avalanche deposit at Kerimasi volcano has been characterized by RS.

[a] Mercator & Ortelius Research Centre for Eruption Dynamics, Department of Geology and Soil Sciences,Ghent University, Belgium.
[b] MGI, Albert Ludwigs-University of Freiburg, Germany
[c] Department of Geology, University of Dar es Salaam, Tanzania.

Geological maps

The Geological Map of Valmalenco

Volkmar Trommsdorff[1], Attilio Montrasio[2], Jörg Hermann[1,3], Othmar Müntener[1,4], Peter Spillmann[1,5], and Reto Gieré[6]

The 'Carta Geologica della Valmalenco' (Montrasio et al. 2005) is the result of a thirty five-year cooperation between ETH and University of Zürich and the University and CNR-Italia at Milano. The map covers an area of about 350 km^2 with the mapping having been carried out by over fifty people, mostly as part of students' theses. The Valmalenco area contains one of the largest ultramafic masses of the Alps, which occurs together with a well preserved, Jurassic to Cretaceous ocean floor suite. These units are sandwiched in between nappes derived from the Adriatic microplate and the European plate. The ultramafic rocks are of subcontinental origin and preserve on their top a Permian, continental, crust-mantle transition. During Jurassic rifting these rocks were exposed at the Adriatic margin of the Piemontese-Ligurian ocean basin. Two orogenic cycles affected the Adriatic margin: the first is related to Late Cretaceous nappe stacking, whereas the second is due to the Tertiary continental collision. At the end of collision, the Malenco rocks were, in their southwestern part, intruded by the calc-alkaline, Oligocene, Bergell complex. The Bergell rocks present an exceptionally rich variety of magmatic phenomena and a well-defined contact aureole. The area affected by contact metamorphism is an outstanding natural laboratory to study metamorphic and metasomatic processes. Isograds of prograde metamorphism of serpentinite and of ophicarbonate rocks were mapped for the first time in the Valmalenco, and the results integrated into a consistent petrological model.

[1] Institut für Mineralogie und Petrographie, ETH Zürich, CH–8092 Zürich,
[2] IDPA-Istituto per la Dinamica dei Processi Ambientali, CNR Milano, Via Botticelli 23, I-20133 Milano
[3] Present address: The Australian National University, Miles Road, Acton Canberra, ACT 0200, Australia
[4] Present address: Institut für Geologie, Universität Bern, Baltzerstr. 1-3, CH–3012 Bern
[5] Present address: GEOTEST AG, Grisigenstrasse 6, CH-6048 Horw
[6] Mineralogisch-Geochemisches Institut, Albert-Ludwigs-Universität, Albertstrasse 23b, D-79104 Freiburg

Mineralogy

Mineralogical composition of Mn ore from northeastern Vietnam

Duy Anh Dao, Reto Gieré

This work is research on structure and composition of Mn ore, the first stage of the project: "*Research of technology of Mn ore processing to produce high quality EMD from Mn ore of Vietnam*". These study results will be determining the way for technological experiments in next stages.

The Mn ore of the Toc Tat mine as well as of the Halang Mn ore basin in northeastern Vietnam originated as neritic chemical sediment. As other rocks in the area, the ore was affected by magmatic processes and weathering after its formation. For this reason, the mineralogical composition of the studied Mn ore is very complex. Previous geological work reported more than 30 minerals belonging to different mineral groups (1). Besides minerals characteristic for a sedimentary origin, such as pyrolusite (MnO_2), many other minerals are present, including hausmannite ($Mn^{2+}Mn^{3+}{}_2O_4$), manganite ($MnOOH$), and jacobsite [$(Mn^{2+},Fe^{2+})(Mn^{3+},Fe^{3+})_2O_4$], which are typical for hydrothermal and weathering environments. Research carried out by electron microprobe analysis and X-ray diffraction shows that the Mn ore of northeastern Vietnam contains different mineral assemblages, for example: pyrolusite-manganite, or hematite-ferrihydrite ($Fe_2O_3{\cdot}0.5H_2O$) -goethite ($FeOOH$). The mineralogical composition of the ore is further complicated by the presence of solid-solutions between manganese and iron minerals such as in bixbyite $(Fe^{3+},Mn^{3+})_2O_3$, or in assemblage of jacobsite, hausmannite and magnetite.

Fig.1 shows an example of the textures exhibited by the Mn ore in northeastern Vietnam, a complex association of various ore minerals. The ore occurs as bands and as disseminated grains. The Mn minerals are associated with gangue or other heavy metal minerals and exhibit a grain size of usually several µm.

The data obtained so far by research at the Institute for Mineralogy and Geochemistry of the Albert-Ludwigs-Universität are not only in good agreement with previous studies but also provide additional detailed information that helps in understanding ore composition and in determining the best strategy for the technological experiments. For example, to achieve high efficiency during the refining process, the raw ore must be ground to the size in which the Mn phases can be separated from the gangue minerals. In addition, the best way to process Mn ore of northeastern Vietnam into the high-quality finished Mn product is the chemical route because the ore contains minerals exhib-

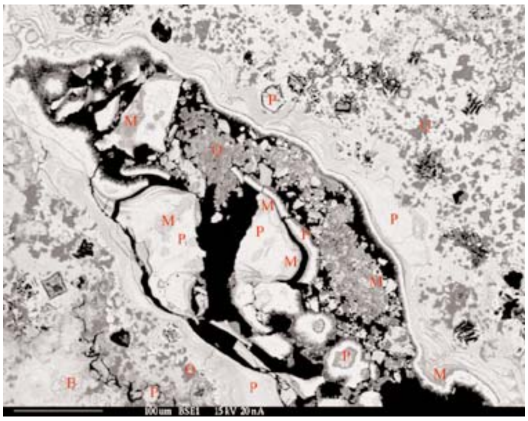


Fig. 1. P- Pyrolusite; M- Manganite; B- Bixbyite; Q- Quartz.

it very similar physical properties.

(1) Le Thac Xinh. Geology and Mineral Resources of Vietnam. Vol. 1. pp 108-112. 1988

REE Zoning in Allanite Related to Changing Partition Coefficients During Crystallization: Implications for REE Behavior in an Epidote-Bearing Tonalite.

J.S. Beard, S. Sorensen, and R. Gieré

This study is a collaboration between our Institute, the Virginia Museum of Natural History (J.S. Beard), and the Smithsonian Institution (S. Sorensen) and has been published in *European Journal of Mineralogy*.

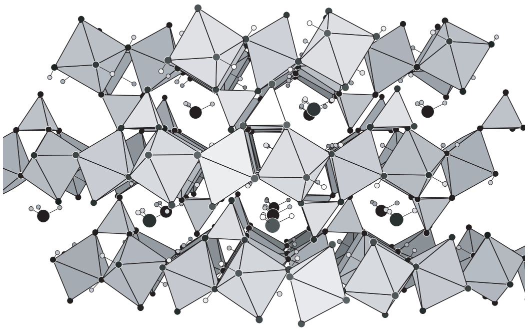
Allanite is present in most samples of the tonalitic Bell Island Pluton, with an average mode near 0.05 wt.%. Allanite occurs as cores in igneous epidote-clinozoisite and exhibits characteristic and consistent zoning patterns. REE-rich cores (All_{40-70}) grade out towards epidote-clinozoisite with REE below EMP detection limits. La, Ce, and Pr contents are highest in the REE-rich cores of zoned crystals. Nd and Sm contents both initially increase as total REE decrease and are highest in intermediate zones. Y contents are generally low throughout, but tend to be highest in analyses with All_{5-20}. The zoning behavior exhibited by the allanite, specifically the rimward increases in Nd, Sm, and Y, cannot be accounted for by simple fractionation and are best explained by increases in allanite/melt partition coefficients (Kds) for these elements during crystallization. We propose that the variation in Kds reflects modification of the allanite structure with changing REE content. These modifications are manifested by changes in color, extinction, and pleochroism within the zoned crystals and include changes in unit cell volume and dimensions. The changes in Kds are large enough to result in crossing REE patterns within single allanite crystals. Fractional crystallization of zoned allanite can have noticeable effects on LREE contents and La/Sm (and almost certainly La/Lu) in magmas. In the Bell Island pluton, 80% of La, but less than 3% of Y is contained in allanite. Although some of the variation in the LREE chemistry of the pluton is attributable to statistical sampling error, much of it appears to reflect petrogenetic processes that controlled LREE abundance and, ultimately, allanite mode. One sample of Bell Island tonalite is depleted in LREE and has low La/Lu and La/Sm. These chemical features can be modeled by fractionation of zoned allanite.

Characterization of defects and the local structure in natural and synthetic alunite $(K, Na, H_3O)Al_3(SO_4)_2(OH)_6$ by multi-nuclear solid-state NMR spectroscopy

Ulla Gro Nielsen[a], Juraj Majzlan, Brian Phillips[a], Martine Ziliox[a], and Clare P. Grey[a]

This research in in press in *American Mineralogist*.

The local structural environments in a series of natural and synthetic alunite samples (ideally $AAl_3(SO_4)_2(OH)_6$, A = H_3O^+, D_3O^+, Na^+, and K^+) have been probed by solid-state ^{1}H, ^{2}H, ^{23}Na, ^{27}Al, and ^{39}K NMR spectroscopy. The natural alunite ($KAl_3(SO_4)_2(OH)_6$) and synthetic hydronium alunite samples contain few structural defects, whereas the synthetic natroalunite and alunite samples have ca. 10 % Al vacancies based on ^{27}Al NMR. A new ^{27}Al local environment (Al_D) was observed and assigned to Al with one Al vacancy in the first cation sphere. Three different proton environments, Al_2-OH, Al-OH_2, and H_3O^+ are detected by ^{1}H and ^{2}H MAS NMR. The hydronium ion (H_3O^+) is only observed in hydronium alunite, and is associated with the stoichiometric regions of the sample. It was not detected in ^{1}H and ^{2}H NMR spectra of alunite and natroalunite despite K (Na) occupancies of significantly less than 100%, as determined from elemental analysis. Thus, our NMR results suggest that the common assumption, namely that an *A* vacancy and an Al^{3+} vacancy are compensated by adding an H_3O^+ and 3 H^+ (creating 3 Al-OH_2 groups), respectively, is too simplistic. Instead, a significant fraction of the Al^{3+} vacancies are compensated for by 4 H^+ ions, resulting in 4 Al-OH_2 groups per vacancy. This substitution is accompanied by the simultaneous deprotonation of a H_3O^+ ion present on the *A* site. The resultant H_2O molecule is unnecessary for charge balance, accounting for the *A*-site deficiency often observed. The presence of Al^{3+} and A^+ vacancies appears closely correlated based on NMR.



Polyhedral representation of the crystal structure of hydronium alunite ($(H_3O)Al_3(SO_4)_2(OH)_6$) viewed along the a axis and illustrating the porous structure of this compound.

[a] Department of Chemistry and Center for Environmental Molecular Science, SUNY Stony Brook, Stony Brook, NY 11794-3400.

Recommended nomenclature of epidote-group minerals

Th. Armbruster , P. Bonazzi, M. Akasaka, V. Bermanec, C. Chopin, R. Gieré, S. Heuss-Assbichler, A. Liebscher, S. Menchetti, Y. Pan, M. Pasero

This work has been a multi-national collaboration and has been published in *European Journal of Mineralogy*. It represents the final document of the work performed by the subcommittee on epidote of the International Mineralogical Association.

Epidote-group minerals are monoclinic in symmetry and have topology consistent with space group $P2_1/m$ and the general formula $A_2M_3[T_2O_7][TO_4](O,F)(OH,O)$. Zoisite is an orthorhombic polymorph of clinozoisite $Ca_2Al_3[Si_2O_7][SiO_4]O(OH)$ and is thus not considered a member of the epidote-group. Epidote-group minerals are divided into three subgroups. (1) Members of the clinozoisite subgroup are derived from the mineral clinozoisite $Ca_2Al_3[Si_2O_7][SiO_4]O(OH)$ by homovalent substitutions only. The key cation- and anion-sites are A1 = M^{2+}, A2 = M^{2+}, M1 = M^{3+}, M2 = M^{3+}, M3 = M^{3+}, O4 = O^{2-}, O10 = $(OH)^-$. In other words, the dominant valence as listed above must be maintained. (2) Members of the allanite subgroup are REE-rich minerals typified by the eponymous mineral allanite. This subgroup may be derived from clinozoisite by homovalent substitutions and one heterovalent substitution of the type ${}^{A2}REE^{3+} + {}^{M3}M^{2+} \rightarrow {}^{A2}Ca^{2+} + {}^{M3}M^{3+}$. Thus the valences on the key sites are: A1 = M^{2+}, A2 = M^{3+}, M1 = M^{3+}, M2 = M^{3+}, M3 = M^{2+}, O4 = O^{2-}, O10 = $(OH)^{-}$. (3) Members of the dollaseite subgroup are REE-rich minerals typified by the eponymous mineral dollaseite. This subgroup may be derived from clinozoisite by homovalent substitutions and two heterovalent substitutions of the type ${}^{A2}REE^{3+} + {}^{M3}M^{2+} \rightarrow {}^{A2}Ca^{2+} + {}^{M3}M^{3+}$ and ${}^{M1}M^{2+} + {}^{O4}F^{-} \rightarrow {}^{M1}M^{3+} + {}^{O4}O^{2-}$. Thus the valences on the key sites are: A1 = M^{2+}, A2 = M^{3+}, M1 = M^{2+}, M2 = M^{3+}, M3 = M^{2+}, O4 = F^{-}, O10 = $(OH)^{-}$.

The key cation-sites M3 and A1 (and, in principle, M2) determine the rootname. In both clinozoisite and allanite subgroups no prefix is added to the root name if M1 = Al. The prefixes ferri, mangani, chromo, and vanado indicate dominant Fe^{3+}, Mn^{3+}, Cr^{3+}, and V^{3+} on M1, respectively. In the dollaseite subgroup no prefix is added to the root name if M1 = Mg. Otherwise a proper prefix must be attached; the prefixes ferro and mangano indicate dominant Fe^{2+} and Mn^{2+} at M1, respectively. The dominant cation on A2 (other than Ca) is treated according to the Levinson suffix-extension. This simple nomenclature requires renaming of the following approved species: Niigataite (old) = clinozoisite-(Sr) (new); Hancockite (old) = epidote-(Pb) (new); Weddillite (old) = manganipiemontite-(Sr) (new). Minor modifications are necessary for the following species: Strontiopiemontite (old) = piemontite-(Sr) (new); Androsite-(La) (old) = manganiandrosite-(La) (new). Before a mineral name can be assigned, the proper subgroup has to be determined. The determination of a proper subgroup is made by the dominating valence at M3, M1, and A2 expressed as M^{2+} and or M^{3+}, not by a single, dominant ion (i.e., Fe^{2+}, or Mg, or Al). In addition, the dominant valence on O4: X^{-} or X^{2-} must be ascertained.

$[M^{2+}]_{A2} > 0.50$, $[M^{3+}]_{M3} > 0.50 \rightarrow$ clinozoisite subgroup

$[M^{3+} + M^{4+}]_{A2} > 0.50$, $[M^{2+}]_{M3} > 0.50 \rightarrow$ allanite subgroup

$\{[M^{2+}]_{M3+M1} - [M^{3+} + M^{4+}]_{A2}\} > 0.50$ and $[X^{-}]_{O4} > 0.5 \rightarrow$ dollaseite subgroup.

Heterovalent substitutions in epidote-group minerals require a special application of the so-called 50% rule in solid-solution series. (1) Clinozoisite subgroup: The dominant trivalent cation on M3 determines the name, whereas the A2 cation appearing in the suffix has to be selected from among the divalent cations. (2) Allanite and dollaseite subgroups: For the sites involved in the charge compensation of a heterovalent substitution in A2 (i.e. M3 in the allanite subgroup; M3 and M1 in the dollaseite subgroup), identification of the relevant end-member formula must take into account the dominant divalent charge-compensating octahedral cation (M^{2+}) and not the dominant cation in these sites.

Formal guidelines and examples are provided in order to determine a mineral “working name” from electron-microprobe analyses.

Laboratories of the MGI

Scientific Instrumentation at MGI

Gerät	**Analysenmöglichkeit**	**Kontakt**
Elektronenstrahl-Mikroanalytik		
Elektronenstrahlmikrosonde Cameca sx100, 5 Spektrometer, 14 Kristalle Elementanalyse im Mikrobereich (Elemente Be bis U), Antikon, Cl-Detektor, EDS Oxford Link ISIS • Kohlenstoffbedampfungsgerät Edwards Auto 306, FTM7 Schichtdickenbestimmung • Au-Sputtergerät: Commonwealth Scientific Mini-Coater	hochgenaue automatisierte Elementanalyse im Mikrobereich	Dr. H. Müller-Sigmund - 6388, -6392
Röntgenanalytik		
Röntgenfluoreszenzspektrometer Philips 2404 mit 108-Probenwechsler • Geräte zur Probenpräparation (Presslinge, Schmelzlinge)	qualitative und quantitative chemische Materialanalyse (ab F), im speziellen Vollanalyse von Gesteinen	I. Schmidt - 6401
Röntgenphasenanalytik		
Röntgenpulverdiffraktometer mit 9-fach Probenwechsler Bruker AXS D8	Strukturanalyse von kristallinen Festkörpern, im speziellen zur Mineralidentifikation	I. Schmidt - 6401
Atomabsorptionsanalytik		
Atomabsorptionsspektrometer (AAS) Analytik Jena - Vario 6	quantitative Elementanalyse von Lösungen und Fest-stoffen, Analysen im ppm-Bereich	S. Hirth-Walther - 6397
Atomabsorptionsspektrometer Perkin-Elmer 4110 ZL Zeeman	quantitative Elementanalyse von Lösungen und Fest-stoffen, Analyse im ppb-Bereich	S. Hirth-Walther - 6397
Wasseranalytik		
Ionenchromatograph Dionex DX-120 mit Probensampler	Anionen- und Kationen-Konzentrationsbestimmungen (im ppm-Bereich), Leitfähigkeitsbestimmungen, Ionenbilanzen	S. Hirth-Walther - 6397
Photometer Perkin Elmer Lambda 40 UV/VIS	photometrische Konzentrations-Bestimmung in wässrigen Lösungen	S. Hirth-Walther - 6397
Titrationsanlage Metrohm	Säure/Basen, Redox- und Leitfähigkeitstitrationen	S. Hirth-Walther - 6397
Geländegeräte zur Wasseranalytik	Messung von Wasserparametern (pH, Eh, Leitfähigkeit etc.) im Gelände	S. Hirth-Walther - 6397
Kalorimetrie		
Kalorimeter CSC Isothermal Microcalorimeter IMC-4400	Messung der Reaktionsenthalpien (vorwiegend der Lösungswärme in geeigneten Lösungsmitteln) zur Bestimmung thermodynamischer Eigenschaften anorganischer Festkörper	Dr. J. Majzlan - 6416

Sonstige Analytik		
Multiphasen C/H/H_2O-Analysator Leco RC-412	fraktionierte Analyse von Kohlenstoff und Wasser in organischen und anorganischen Substanzen sowie auf Oberflächen	S. Hirth-Walther - 6397
C- und S-Analysator Leco SC-144DR	fraktionierte Analyse von Kohlenstoff und Schwefel in organischen und anorganischen Substanzen	S. Hirth-Walther - 6397
Kammerofen Heraeus KR 170 E	Erhitzen, Ausglühen von Proben bei T = 100-1150 °C	S. Hirth-Walther - 6397
Aufschluss-Mikrowelle MLS mPREP-A	schnelles Aufschließen von festen Stoffen	S. Hirth-Walther - 6397
Pyknometer	Bestimmung von Dichte, Porosität und Wasseraufnahme von Mineralen und Gesteinen	Dr. H. Müller-Sigmund - 6388
Mikroskopische Untersuchungen		
Fluideinschlussmikroskop mit heiz- und kühlbarem Probentisch Fluid Inc.	Bestimmung von Phasenüber gängen in Flüssigkeits- und Gaseinschlüssen in Festkörpern	Dr. J. Majzlan 6416
Kathodolumineszenzmikroskop Luminoscope ELM-3 mit Photometer	Beobachtung des Lumineszenzverhaltens von Mineralen	Dr. H. Müller-Sigmund 6388
Verschiedene Polarisationsmikroskope für Durchlicht- und Auflichtuntersuchungen • Digitalkamera • Vickers-Mikrohärte • Lichtbrechungsbestimmung • Medenbach Kristallbohrgerät	Identifikation und Charakterisierung von Mineralen im durchgehenden und im reflektierten Licht	Dr. H. Müller-Sigmund 6388
Gesteins- und Mineralpräparation		
Geräte zur Aufbereitung und Mineraltrennung • Frantz Magnetscheider • Nassschüttelherd KHD • Kugelmühle KHD • Scheibenschwingmühlen Retsch und Siebtechnik • Diverse Backenbrecher, Schüttelsiebe usw. • Minikern-Bohrmaschine • Sandstrahlgeräte Sandmaster FG 3-92 und FG 2-94	Mineralseparation und Aufbereitung von Gesteinsproben für die Analytik	D. Flemming -6400, -8689
Geräte zur Präparation von Gesteinen, Erzen und Mineralen • Logitech GTS1 • Logitech LP 30 • Logitech LP 50 • Logitech PM5 • Leica DMLM mit BF, DF, IC • Div. Schleif-, Läpp- und Poliermaschinen • Eingießapparaturen	Herstellung von Dünnschliffen, Anschliffen und Spezialpräparaten	M. Katt - 6410

Elektronenstrahlmikrosonde

Report by Hiltrud Muller-Sigmund

Between January and December 2006, the electron microprobe Cameca SX100 was used 820 hours. Of these hours, 30% of the time was spent for customers outside the Institute, 65% for research purposes within the Institute, and 5% for student education.

To check the quality of our analytical work, our Institute participates in regular external interlaboratory standard tests. These tests are organized by the International Association of Geoanalyst (IAG) and the last one was conducted in December 2006.

Dünnschliff Präparation

Report by Melanie Katt

Von Dezember 2005 bis Ende November 2006 wurden insgesamt 732 Proben in unserem Dünnschliff Labor bearbeitet.

Folgende Präparate wurden erstellt:

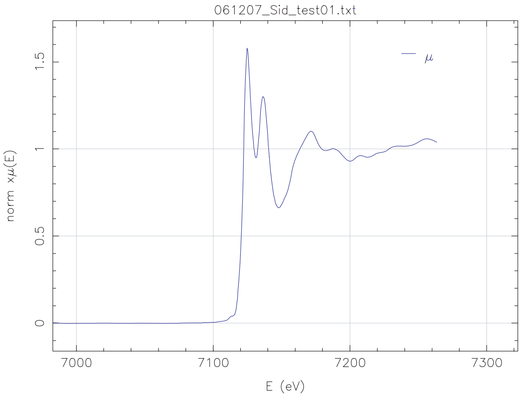
- 249 abgedeckte Dünnschliffe
- 128 polierte Dünnschliffe
- 93 polierte Anschliffe (incl. Erzanschliffe)
- 91 polierte Körnerpräparate
- 12 abgedeckte Körnerpräparate
- 20 abgedeckte Trockenschliffe
- 8 polierte Trockenschliffe
- 14 beidseitig polierte ultradünne Präparate
- 4 polierte Handstücke
- 113 sonstige Präparationsarbeiten

Ca. 17 % der Präparate wurden von externen Institutionen und Privatpersonen in Auftrag gegeben.

Die Entwicklung eines neuen Präparationsverfahrens für ultradünne, beidseitig polierte Spezialpräparate stellte in diesem Jahr eine große Herausforderung dar.

Bei den Proben handelte es sich um sehr kleine, Fe-reiche Schmelzen aus ultrabasischen Xenolithen der unteren Kruste.

Die Wertigkeit des enthaltenen Eisens sollte an einem Röntgenstrahlgenerator, dem Synchrotron der Uni Karlsruhe, gemessen werden. Um mit dem Synchrotron ein möglichst gutes Ergebnis zu erzielen, müssen die Proben theoretisch der Dicke einer Röntgenstrahlenabsorptionslänge (7,8µm) entsprechen.

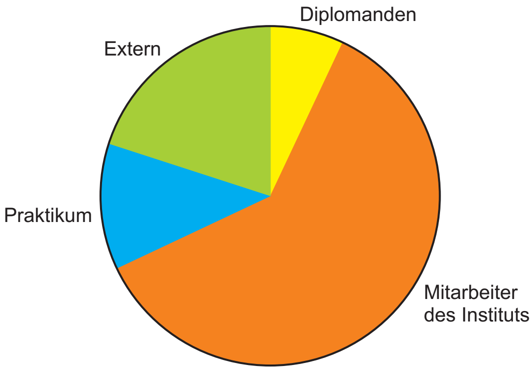


Normalized X-ray absorption spectrum of siderite collected on the ultra-thin slide.

Nach einigen Probeläufen ist letztendlich eine kostengünstige und gut funktionierende Methode realisiert worden, mit der sehr gute Ergebnisse erzielt wurden.

Wasserlabor

Report by Sigrid Hirth-Walther



Unser modernes und gut ausgestattetes Wasserlabor wurde von Diplomanden und Doktoranden während ihrer Forschungsarbeit genutzt. Einige Forschungsschwerpunkte 2006 waren :

- Vergleich der Oberflächen- und Tiefenwässer aus der Alp-Transit Bohrung (NEAT)
- Analyse verschiederner Thermalwässer aus Rumänien
- Bodenuntersuchungen zur Feststellung der Antimonkontamination in Schießständen
- Optimierung des Aufbereitungsprozeßes für Manganerz
- Analyse von Wässern aus chinesischen Salzseen

Neben der Betreuung dieser Projekte ist die Durchführung von verschiedenen Praktika, in denen den Studenten das analytische Arbeiten nahegebracht werden soll, ein großer Teil der Laborarbeit.

Ferner ist der Ansstieg von Analysen für andere Institute ein sehr erfreulicher Aspekt des Jahres 2006 gewesen.

Röntgenlabor

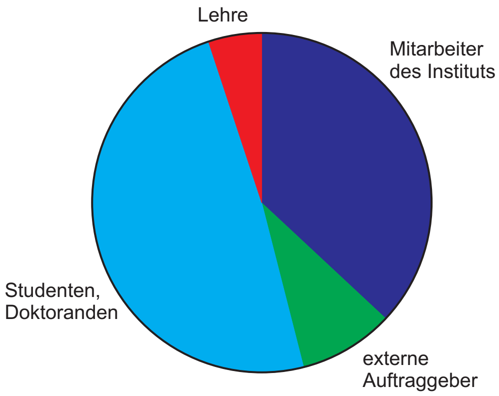
Report by Isolde Schmidt

Von Januar bis Dezember 2006 wurden im Röntgenlabor insgesamt 375 Proben präpariert und mit dem Röntgenfluoreszenspektometer gemessen. Davon waren 202 Silikatgesteine, 56 Karbonatgesteine und 117 Preßtabletten zur Analyse von Spurenelementen.

Am Röntgendiffraktometer wurden in diesem Jahr 329 Proben gemessen,.

Um die Qualität unser Analysen zu überprüfen, beteiligt sich unser Institut regelmäßig an externen Ringversuchen, organisiert von der International Association of Geoanalyst (IAG). Im Rahmen dieser Ringversuche haben wir die Probe GEOPT19/MGR-N im Juni 2006 und die Probe GEOPT20/OPY-1 im Dezember 2006 analysiert.

Sowohl die Messungen mit dem Röntgenspekrometer als auch die mit dem Röntgendiffraktometer dienen dem Zweck der Lehre und Forschung in unserem Hause, stehen aber auch für externe Auftäge zur Verfügung.



Student field trips

Field Trips Organized by the Staff of MGI in 2006

Dates	Destination	Leader	Number of participants
May 1	Kaiserstuhl	Geyer	18
May 6	Süd-Schwarzwald	staff	45
May 12-13	Vogesen	Müller-Sigmund	17
June 8-11	Finero-Baveno	Gieré	12
June 15	Kaiserstuhl	Geyer	22
June 17-18	Hegau	Geyer	18
June 24-25	Lukmanier (Bsc) Gruppe I	Gieré	25
July 1-2	Lukmanier (Bsc) Gruppe II	Bucher	17
July 1-2	Campolungo	Gieré	13
July 8-10	Reusstal/Gotthard	Bucher	9
Jul 31-Aug 4	Oberpfalz/Bayerischer Wald	Müller-Sigmund	16
August 5-12	Oslo-Kartierkurs	Rahn/Selbekk	25
September 8-12	Zermatt	Bucher	14
September 18-24	Slovakia	Majzlan	17
November 11-12	Finero	Gieré	18

Zermatt Excursion

September 8-12, 2006

Report by Tobias Weisenberger

This excursion exposed twelve undergraduate students to study minerals, rocks and metamorphic textures that were previously learnt in class. The high pressure metamorphic rocks of the Zermatt region are classical and know worldwide. The excursion group was lead by Kurt Bucher, accompanied by field-assistant Tobias Weisenberger. Additional three guests auditor accompanied the excursion group: Lifei Zhang and Li Xuping from Peking University, China and Derrill Kerrickfrom Pennstate University, US.

The Excursion started with a half-day excursion on the Gornergrat ridge, which were reached by the rack railway. On the ridge serpentinits and Triassic meta-sediments were studied, following the introduction about the general geology of the Zermatt area. On our second day we investigated the Zermatt ophiolites up to Pfulwe Pass. On the way up to the pass, we visited matagabbros, eclogites and blueschists with pillow structures, which indicates pillow basalts as source rock. The excursion day ended with mineral collection on the Pfulwe Pass. The students used their magnets to collect magnetite crystals, up to 5 mm, which where weathered out from the serpentinites host rock. The third day was in point of interest of new outcrop, which were cover by glaciers, still a few years ago. The area between the mountain station and the Matterhorn south wall consists of serpentinits, metabasic rocks and garnet-mica-schist. On the fourth day, the excursion group went up to Hörnli hut (3260 m.a.s.l.). On the way up to the Matterhorn base camp, the excursion group reached outcrops of the Combine zone. Here we examined greenschist, intercalated serpentinites and soapastone and Mesozoic meta-sediments, such as marl, quartzite and dolomite.

A wonderful excursion accompanied by superb weather conditions ended with observing the contact between the Zermatt ophiolite-nappe and the overlying Dent-Blanche-nappe, along the track up to the Schönbiel mountain hut.

Slovakia Excursion

September 18-24, 2006

Report by Justus Tonn

This excursion, led by Juraj Majzlan and Sonia Ackermann, presented an overview of the regional geology and current environmental challenges resulting from more than 2,000 years of Slovakian mining history. The fifteen students explored for example typical hydrothermal ore deposits (e.g. gold, antimony) and discussed their observations within the context of the formation of the Western Carpathians.

Before entering the coal mine in Handlová

During the first three days the excursion was accompanied by Ondrej Ďurža, head of the Department of Geochemistry at Comenius University in Bratislava, and his colleagues Jan Milička, Lubo Jurkovič, and Peter Glasnak.

The first localities were the oil spring at Turzovka, where Jan Milička gave an introduction to West Carpathian geology, and the natural bitumens at Nezbúdska Lúčka.

During the next two days the students examined the active brown coal mining area of Handlova in central Slovakia. Lubo Jurkovič presented the massive surface damages caused by the collapse of mined seams. The group measured heavy metal contents of sewage waters from mining waste deposits and discussed the risk of imminent environmental pollution by the arsenic bearing brown coal. The subsequent visit to the Handlova mine itself certainly was one of the highlights of the excursion.

Ecological problems could also be observed at the aluminium plant in □iar nad Hronom as a high fluorine contamination required dishausing a complete village (Horné Opatovce) in 1969.

Day four of the excursion led the participants to the famous ore mining region around Banská Štiavnica, where one of the worlds oldest mining colleges. The city is placed inside the caldera of a former stratovolcano within the Western Carpathians neogene neovolcanic belt. At Hodrusa the medieval gold mine “Alte Allerheiligen” was visited where the students collected practical experiance mapping ore veins. It was also possible to gain an insight into the flotation process, which is applied for producing a gold-enriched concentrate. At the well known quartzite mine (ceptre quartz) in Šobov acute acidification of natural waters by weathering of high sulphidic rocks was observed.

On the following days the worm summer weather invited to trips to the Lower Tatra region, which is characterized by granitoides and metamorphic rocks of variscan and alpidic origin. The group examined the old dumps of Magurka, a hydrothermal antimony and gold deposit. During gold washing inside a torrent close to the ore deposit the students were able to prove the existance of natural gold. At Vyšná Boca-Kliesňová (siderite) and Jasenie-Soviansko (galena) two typical hydrothermal deposits were investigated and the ore forming processes could be reconstructed. Finally the participants went to Ľubietová (Libethen), where copper mining already started at prehistoric times. Many examples of the secundary copper mineralization (e.g. libethenite) as well as the primary ore could be observed.

The excursion ended with a visit of the mineral collection at Banská Štiavnica and a stop at the rhyolithe landslide at Vyhne before the group drove back to Bratislava.