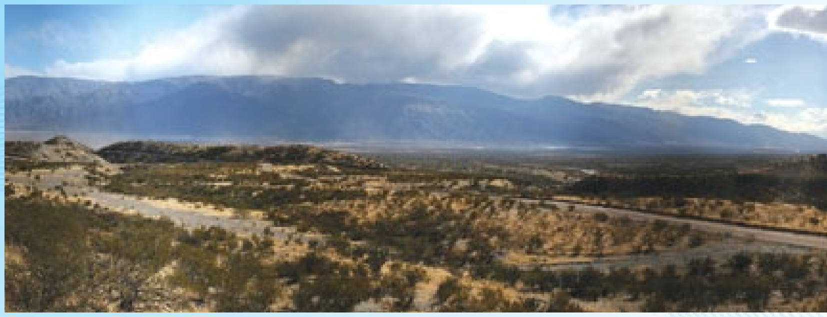

Centre for Lithospheric Research
Czech Geological Survey

CLR

CZECH GEOLOGICAL SURVEY

Who we are...

Centre for Lithospheric Research (CLR) was formed in 2012 at the Czech Geological Survey based on the initiative of the Czech Government encouraging outstanding Czech researchers living abroad to create excellent research groups of international level in the Czech Republic.

The research is centred around the project "*Relative contribution of Paleozoic accretionary and collisional orogens on growth of continental crust*" aiming at devoloping of new models of continental growth and understanding of formation mechanisms of Pangea.

- The group integrates geoscientists from a variety of research fields such as geodynamics, tectonics, metamorphic petrology, isotope geochemistry, geochronology and geophysics.

- CLR consists of an international team involving 12 specialists and is hosted by the Czech Geological Survey. The team works in close cooperation with researchers at the Charles University and the Czech Academy of Sciences.

- CLR is holding three Czech National Research Foundation grants, together with Czech Geological Survey internal grants and Ministry of Education Funding amounting in the total of 2 000 000 Euro.

- Since 2012 CLR has published more than 50 peer-reviewed papers in international journals and its members co-edited a Special Publication of the Geological Society of London on the Variscan Orogeny in Europe in 2014 and Springer Verlag Book Geochemical Modelling of Igneous Processes – Principles and Recipes in R Language in 2015.

Contact us:

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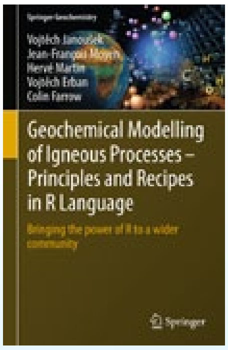
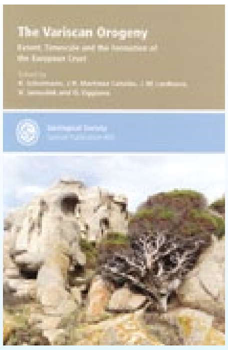




Word of director

The year of 2012 when the Centre for Lithospheric Research was established is a remarkable milestone in the recent history of the Czech Geological Survey with substantial consequences for the whole Czech geological community. This achievement is a result of Prof. Schulmann's outstanding scientific capacity and leadership, his creative international team, and conditions the Survey has been able to provide for their work. The operation of CLR has boosted the scientific research and by bringing in young colleagues both from Europe and overseas enhanced the international dimension of our work. With CLR on board, I am certain our research is flying high at the world class level.

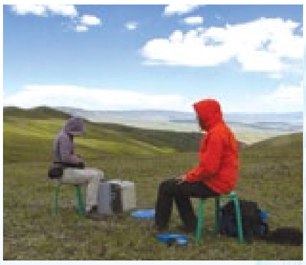
Zdeněk Venera

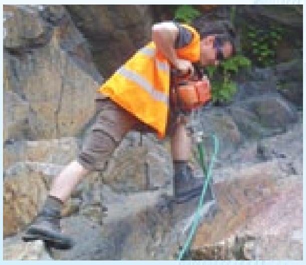
Research at CLR

Our research is based on characterization, imaging, quantification and modelling of geodynamic Earth systems related to convergent plate boundaries. Such multidisciplinary approach allows developing large scale syntheses and conceptual and numerical models of orogenic processes. CLR research is focused on two main natural laboratories: the Bohemian Massif as an example of a large hot collisional orogen and the Central Asia Orogenic Belt representing the largest accretionary system. These natural laboratories serve as a reference for understanding deep crustal processes operating in large-scale modern orogenic systems like Tibet or the western Pacific orogens.

The lithospheric structure and orogenic processes are studied by combination of three main approaches.

- Geophysical potential methods focused on imaging and modelling of the lithosphere, and paleomagnetism combined with structural geology applied on large scale kinematic models.
- Characterization and quantification of metamorphic and magmatic systems related to structural characterization of geodynamic setting.
- Numerical and analogue modelling of orogenic processes from micro to continental scales based on conceptual geodynamic syntheses.

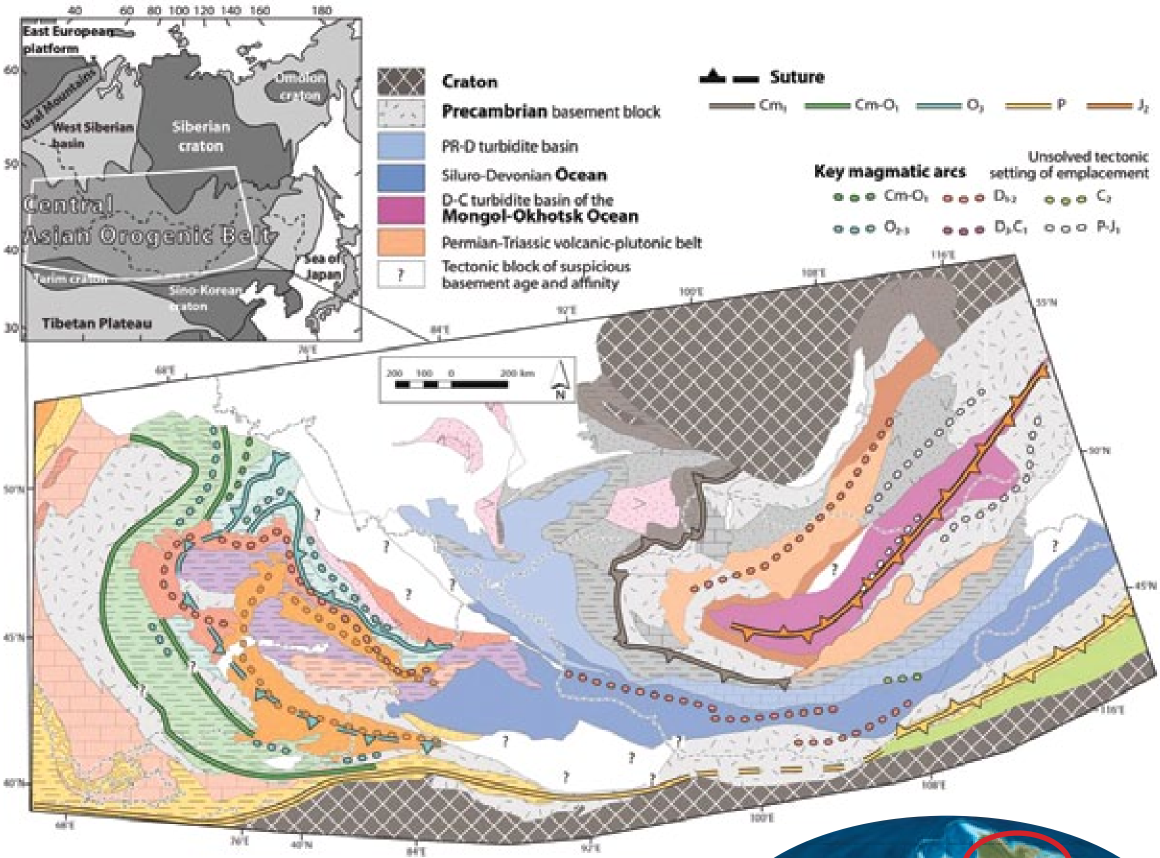




How does a continent grow?

Understanding the origin of the continental crust is one of the key objectives of Earth sciences. Changes in the volume of the continental crust and distribution of continents on the Earth‘s surface have profound effects on major geologic, atmospheric and hydrospheric processes throughout the Earth‘s history. We focus on the continental growth mechanisms of the Pangea supercontinent exemplified by the largest accretionary system in the world – the Central Asia Orogenic Belt (CAOB).

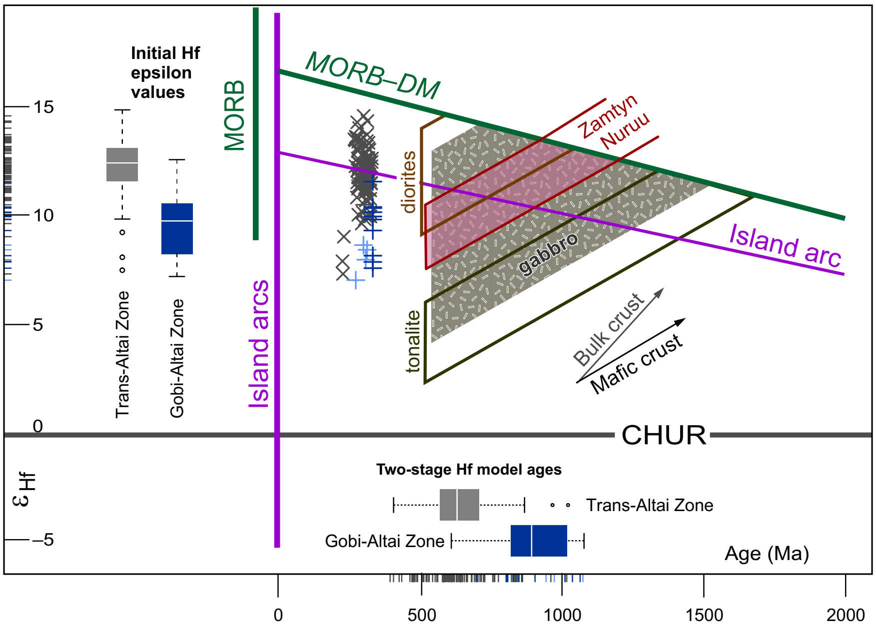
Schematic geological map of the Central Asia Orogenic Belt



Position of the CAOB in Pangea

Characterization of nature and flow of the lower crust in accretionary orogens

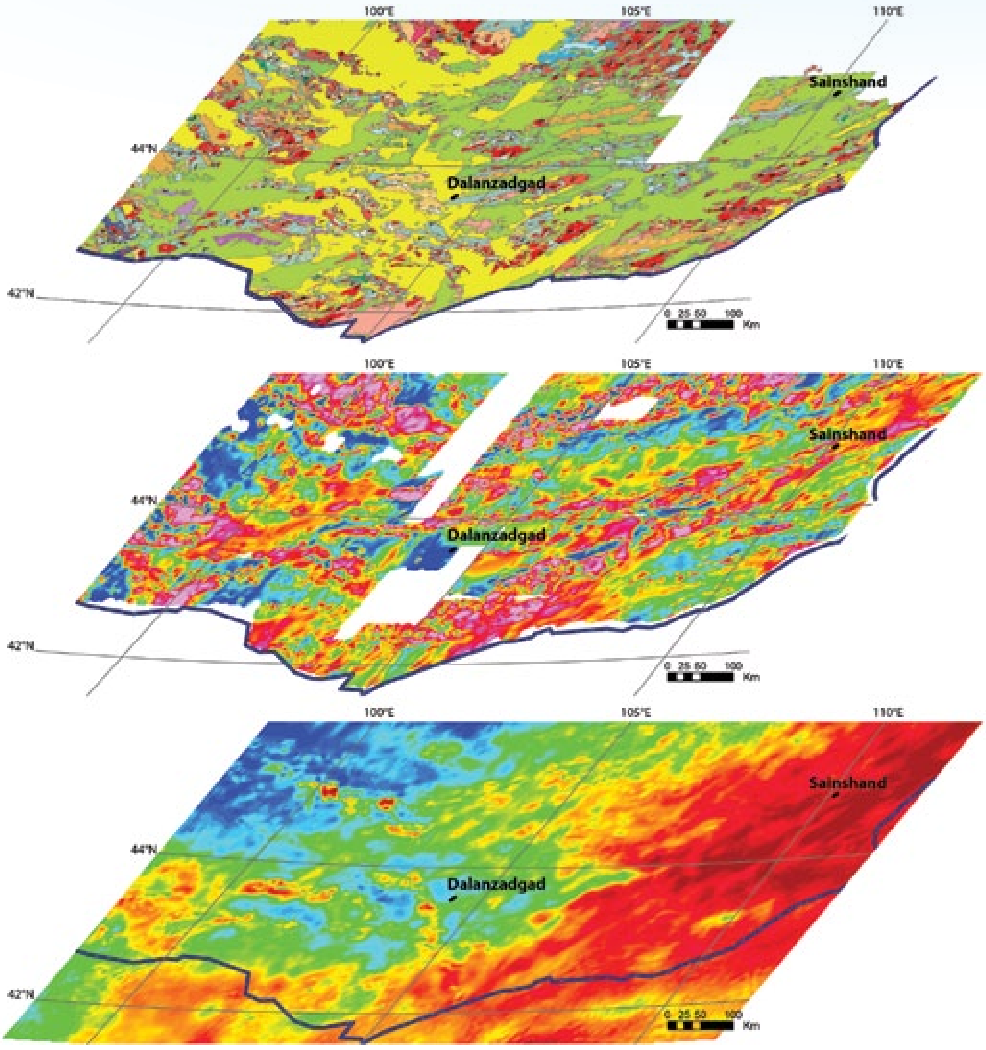
The Devonian granite in the Mongolian Altai showing melting of Cambro-Ordovician accretionary wedge.



Nd-Hf isotopic geochemistry is used to show that the Paleozoic granitoids of the Chinese and Mongolian Altai could have originated due to melting of preexisting juvenile accreted crustal material which represents a fundamental way to form mature and vertically stratified continental crust in an accretionary orogenic system (Guy et al. 2015, Tectonics).

Imaging the deep structure of orogens

Treatment, interpretation and synthesis of large sets of potential field (gravity and magnetic) data combined with geological information (structural analysis, magmatic rock geochemistry and petrophysical data) are used to elaborate forward and inverse modelling of gravity and magnetic anomalies and to characterize deep crustal structure on orogenic scale.

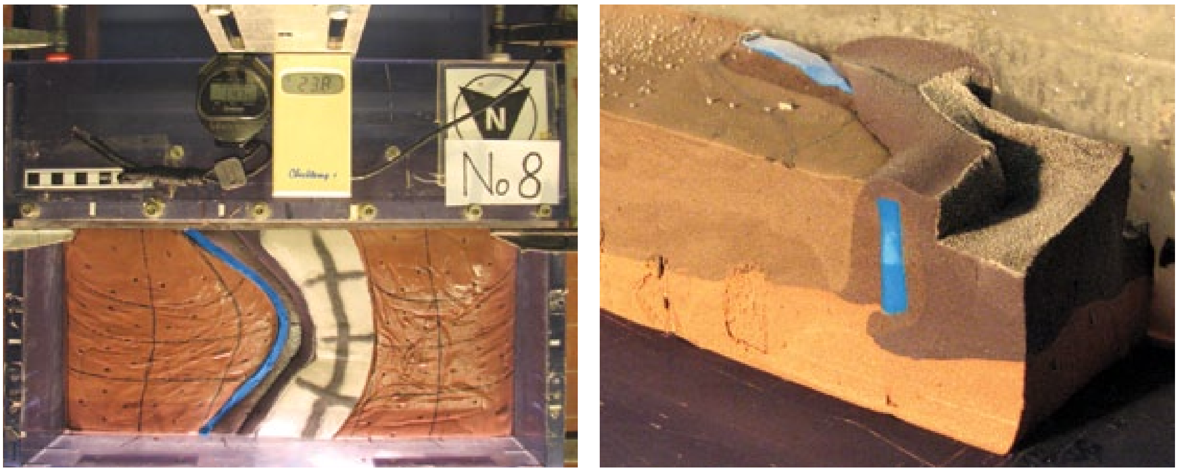


▲ Geophysical data combined with geology show different crustal levels of the Central Asia Orogenic Belt: from the surface (geological data) through the upper to middle crust (magnetic data) and to the lower crust (gravity data). These allow the investigation and modelling of the crustal architecture which is essential to determine the geodynamic evolution of an orogen (Guy et al. 2014, Journal of Geophysical Research).

Acquisition of relative gravity data during field work in Mongolia.

Modelling deformation of accretionary orogens

Using analogue materials we model crustal scale processes, as deformation of accretionary and collisional orogens.

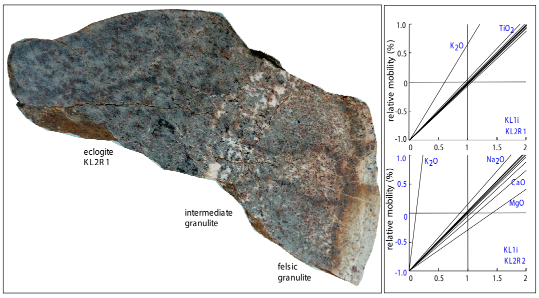


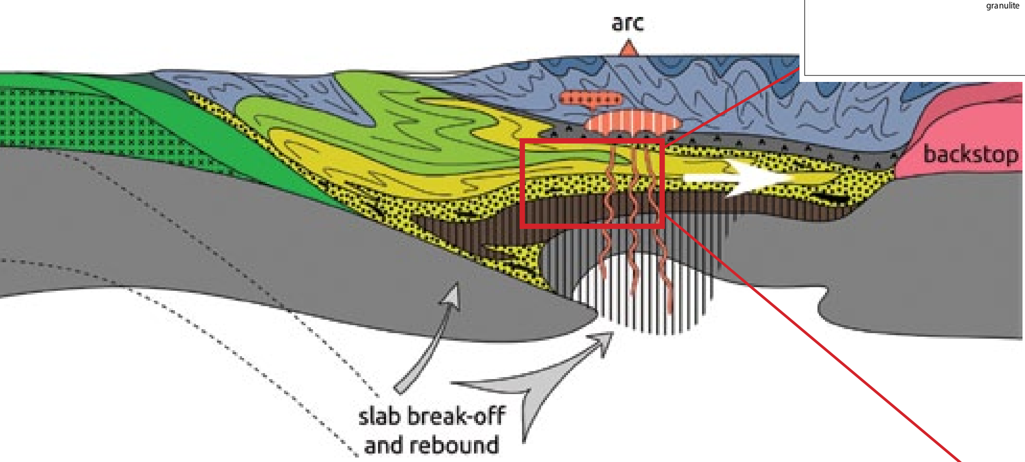
Example of analogue model, showing crustal scale oroclinal buckling and material flow as a response to horizontal continental compression (analogue modelling is done in collaboration with University Rennes, France).

Collisional orogens and comparison with modern analogues

Collisional orogens are characterized by reworking and recycling of older crustal material and formation of thick and hot partially molten crust. During subduction, material from one plate is redistributed under the other one forming extensive relamination zone where material of both plates is mixed. The Bohemian Massif is an excellent example of such a hot collisional and deeply eroded fossil orogen.

Characterization of thermal and mechanical interactions of deep rocks

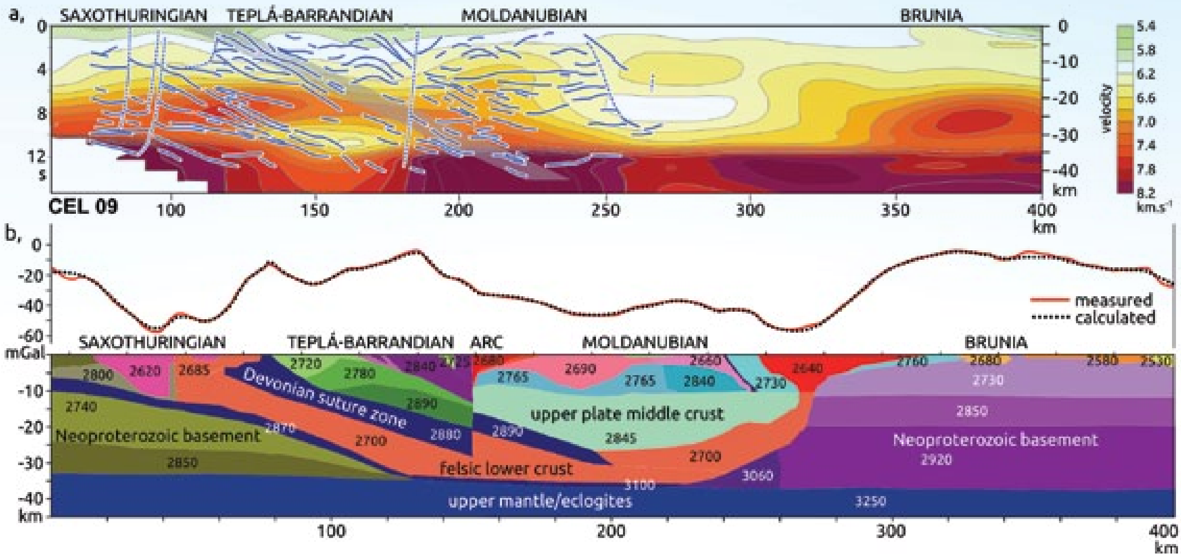




▲▼ Interaction of mafic and felsic material has profound consequences for rock composition and structure and influences isotopic record in accessory minerals used for geochronology (Štípská et al. 2014, Journal of Metamorphic Geology).

▲ Combination of metamorphic petrology, geochemistry and geochronology is used to understand the fate of light subducted material and its interaction with mafic upper plate crust and underlying upper mantle (Schulmann et al. 2014, Geology).

Imaging deep structure of collisional orogens

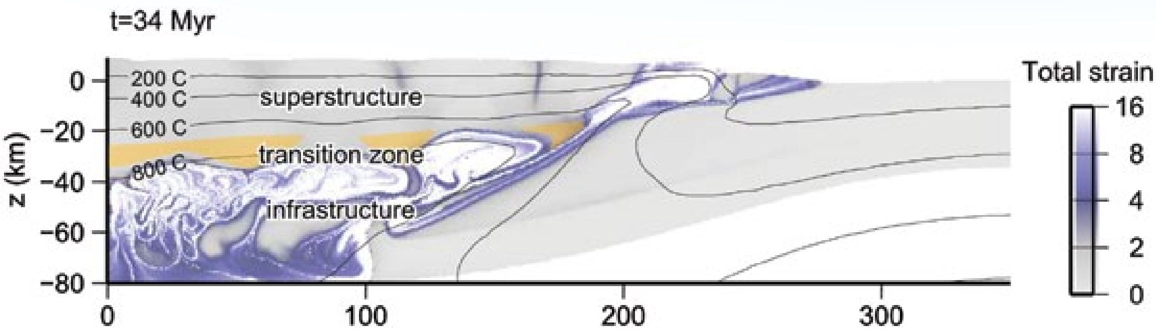


▲ Deep structure of the Bohemian Massif is imaged using compiled seismic reflection and refraction profiles (data from Růžek et al. 2007), gravity forward modelling and petrophysical field data. The modelling shows the possibility of relaminated lower crustal allochthon in the deep root, structure of the back stop continent and of the Devonian suture zone (Schulmann et al. 2014, Geology).

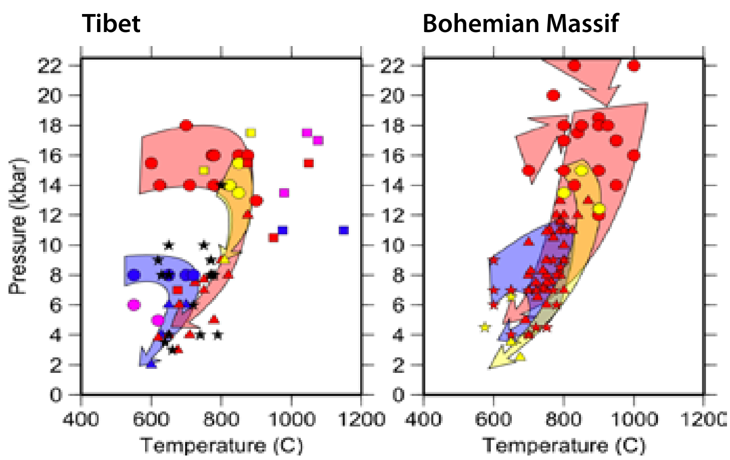
▲ Migmatites in NW Argentina – example of hot partially molten crust.

Modelling of structure of large hot orogens

The Bohemian Massif represents a natural laboratory of deeply eroded collisional orogen which shows polyphase evolution of orogenic root from continental subduction, relamination of felsic allochthon, laterally forced overturns and orogenic channel flow. Orogenic channel flow and extrusion of hot infrastructure were firstly recognized in southern Tibet and Himalayas. Thermal and tectonic evolution of the Bohemian Massif is compared with modern Tibet.

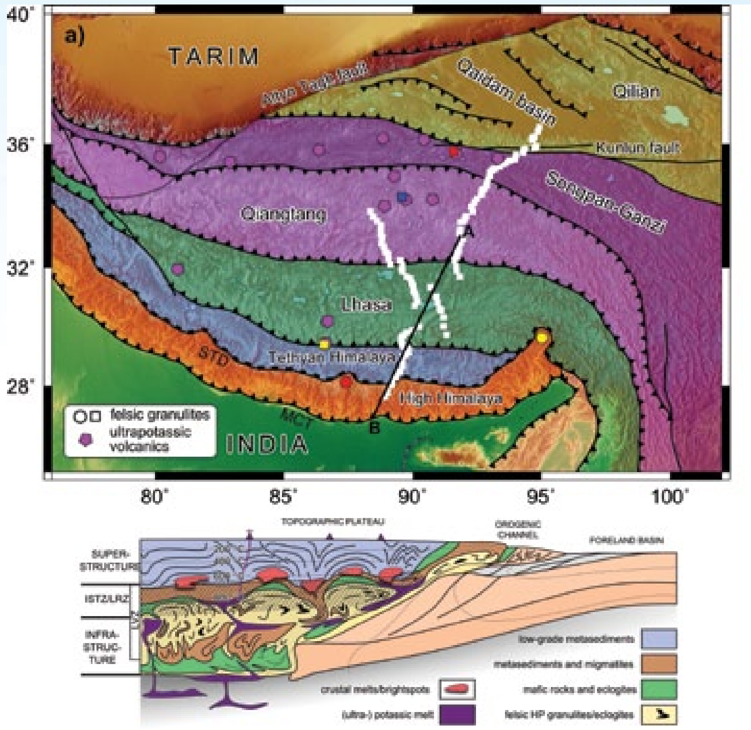


A numerical model reproducing the tectonic scenario proposed for the Variscan evolution of the Bohemian Massif. In this model the vertical exchange of felsic lower crust with overlying high-density material is followed by development of a major mid-crustal zone of partially molten rock. This observation is correlated with low resistivity and velocity zone underneath Tibet.

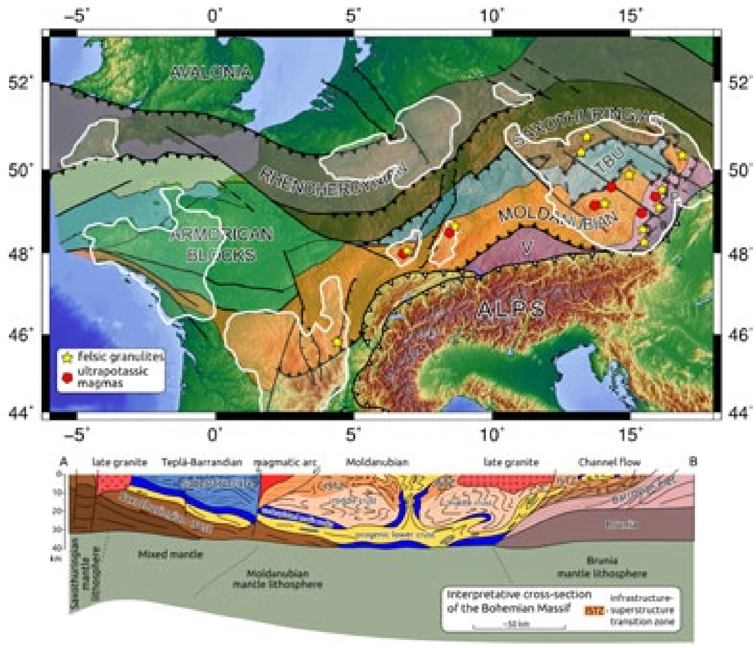


PT evolution of crustal xenoliths from central Tibet compared to lower crustal rocks of the Bohemian Massif. The P-T-t and tectonic evolutions are correlated through numerical modelling.

Tibet



European Variscan belt

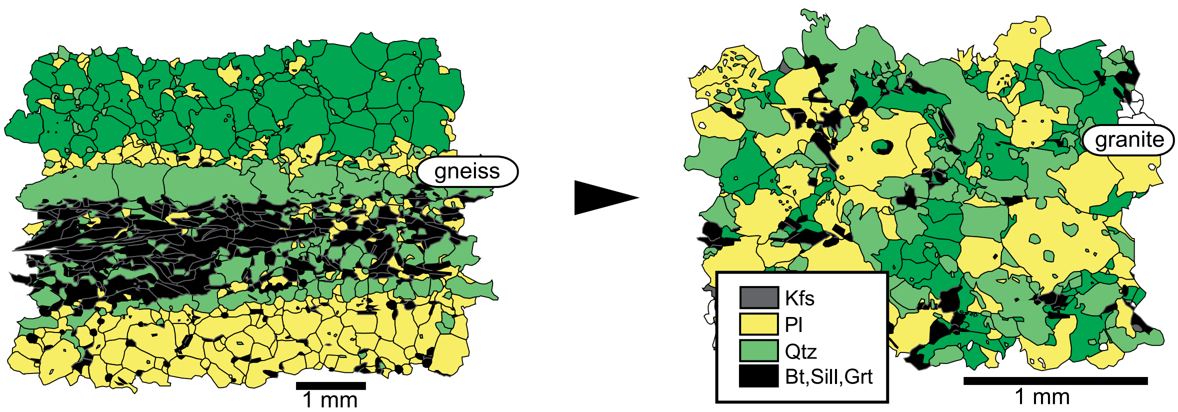


▲ Map of Tibetan terranes and the European Variscan belt with indicated positions of high Mg-K volcanics/plutons and granulites. Schematic sections show conceptual model of the deep crustal architecture of the Tibetan type orogen in comparison to the Bohemian Massif tectonic model based on geology and geophysical data.

Melt generation and transfer in crust

Pervasive melt migration

Magma migration is the key process underlying the chemical and thermal structure of the lithosphere and has therefore been the focus of much interest. So far research has mainly focused on melt flow in extraction pathways or on transport of large volumes of magma via dykes or diapirs. We developed a new model where we argue that pervasive microscopic flow may be a regional mode of melt migration in suprasolidus crust. We postulate that subsurface melt flow occurs at mid-crustal levels in modern orogens like Tibet and Andes.

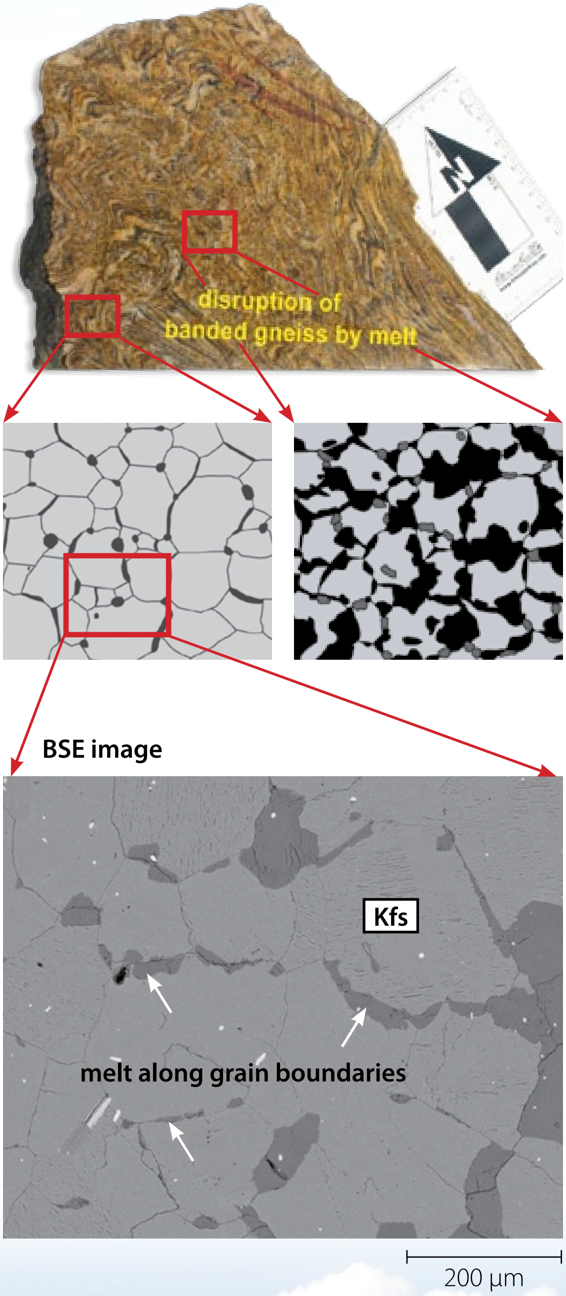


▲ Fabric disintegration at microscale caused by pervasive melt migration in orthogneiss (Hasalová et al. 2008, Journal of Metamorphic Geology).

Melt migration in channels versus cryptic pervasive melt migration in migmatites.

There are two main types of transport of melt in partially molten rocks: melt migration in channels and cryptic pervasive melt migration. Both styles result in very different microstructural and macrostructural features, as depicted below.

Characteristic appearauce of pervasive melt migration in felsic crust (Závada et al. 2007, Journal of Geophysical Research).



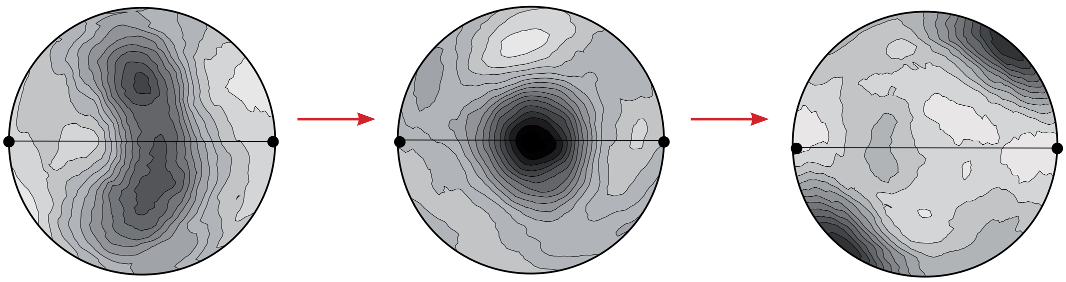
Melt migration in channels as foliation parallel leucosomes, shear bands and axial planes of folds (examples from Himalaya, Finch et al. 2014, GSAB).

Fluid or melt assisted deformation in the crust

Deformation of continental crust is strongly dependent on presence and distribution of fluid/melt. We use detail quantitative microstructural analysis and observations to examine deformation in hot crust.

▲ Sheared granodiorite with mafic enclaves (example from Kangaroo Island, Australia; Symington et al. 2014, GSAB).

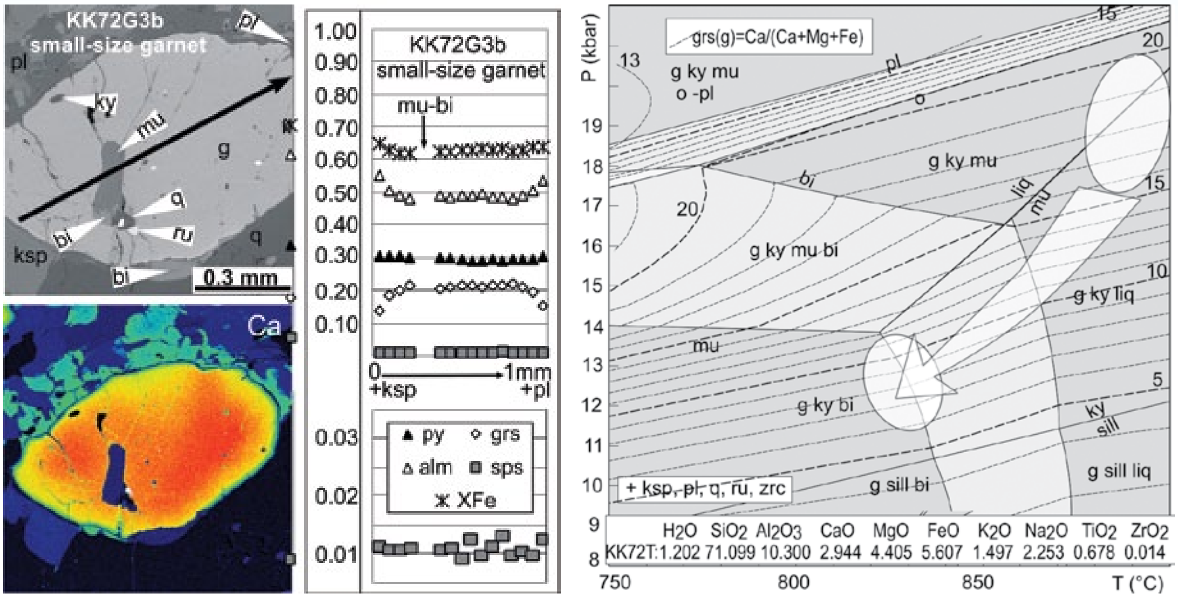
▼ Example of textural changes related to increasing deformation in a high T shear zone in Argentina. Note decreasing grain size, increasing rock homogenization and change of deformation mechanisms with increasing mylonitisation (Finch et al. 2015, Journal of Structural Geology).



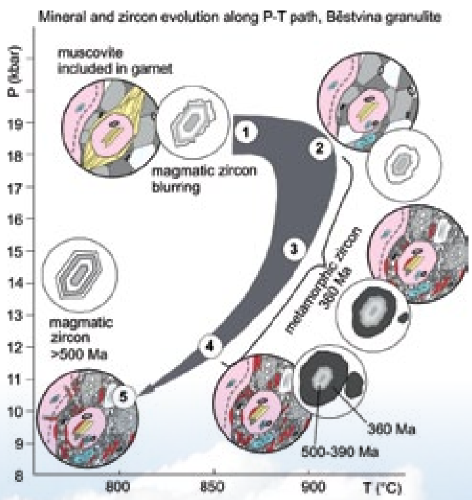
▲ Quartz fabric, depicted as quartz c-axis orientation. Different c-axis maxima suggest different deformation T and/or intensity.

P-T-t-d evolution of orogens

We combine methods of metamorphic petrology, structural geology and geochronology, to derive pressure-temperature-deformation-time (P-T-t-d) paths of rocks. Such complete information performed on regional scale is a base for the understanding of geological processes and serves as a source for numerical and analogue modelling.



▲ The PT paths are deciphered by combination of observation of microtextures and successions of mineral assemblages, their chemistry and modal abundances with thermodynamic modelling by means of pseudosections (e.g. petrological maps constructed for a specific bulk rock composition).

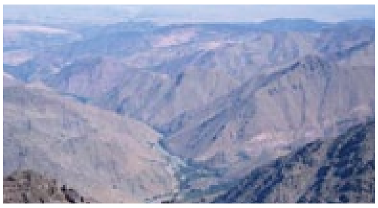


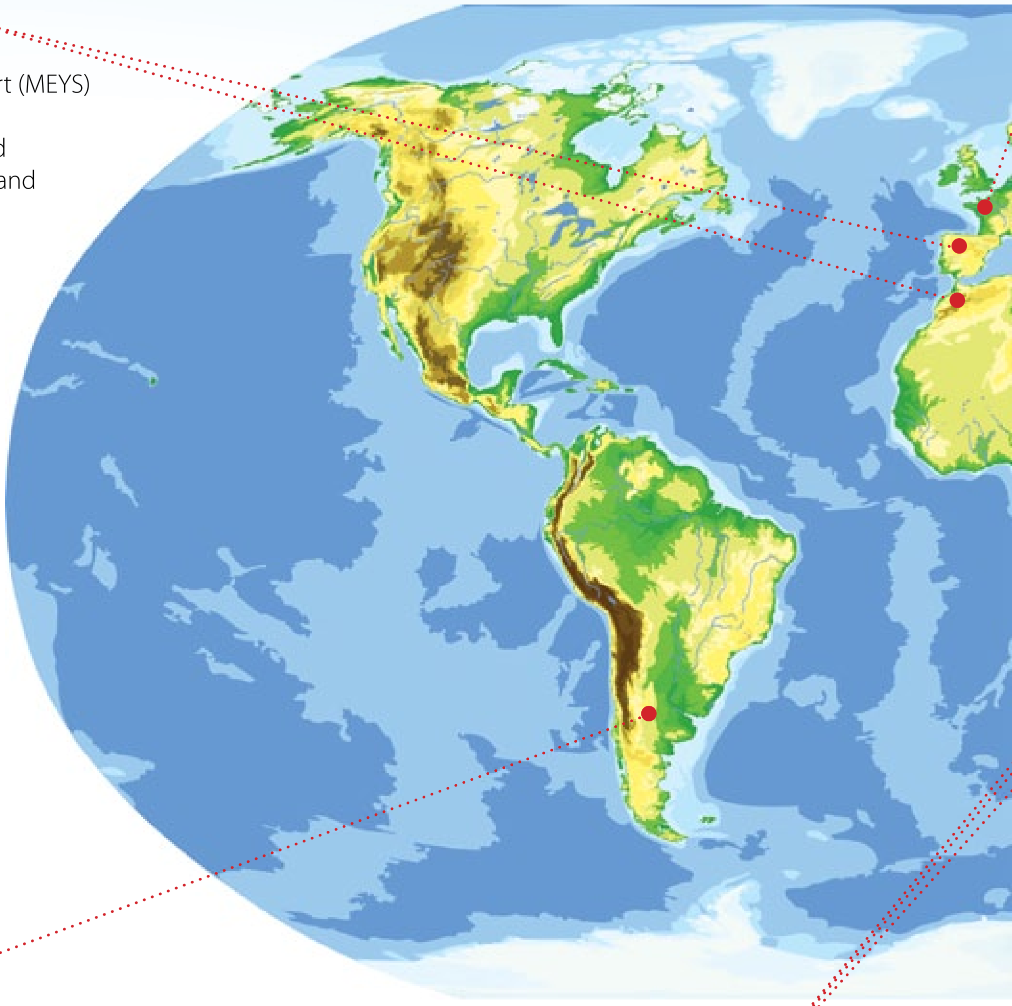
◀ The example from the Běstvina felsic granulite in the Bohemian Massif shows mineral assemblage evolution and processes of zircon (re) – crystallization along the prograde path related to burial and heating and retrograde path related to exhumation along a vertical channel (Nahodilová et al. 2014, Gondwana Research).

Where we are working

Morocco and Spain

Ministry of education, youth and sport (MEYS)
(LK11202, 2012–2016)
The role of Paleozoic accretionary and collisional orogens on the formation and growth of continental crust





Argentina

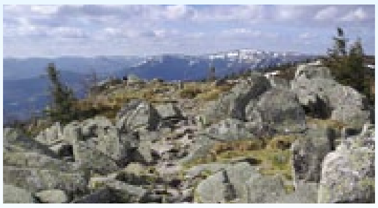
Czech Science Foundation (CSF)
(14-25995S, 2014-2016)
Tracking magmas from source to pluton: new insight into granites diversity

Himalaya – Tibet and India

ANR DSP
(Tibet, 2013–2017)
Study of deep and surface processes in Central Tibet

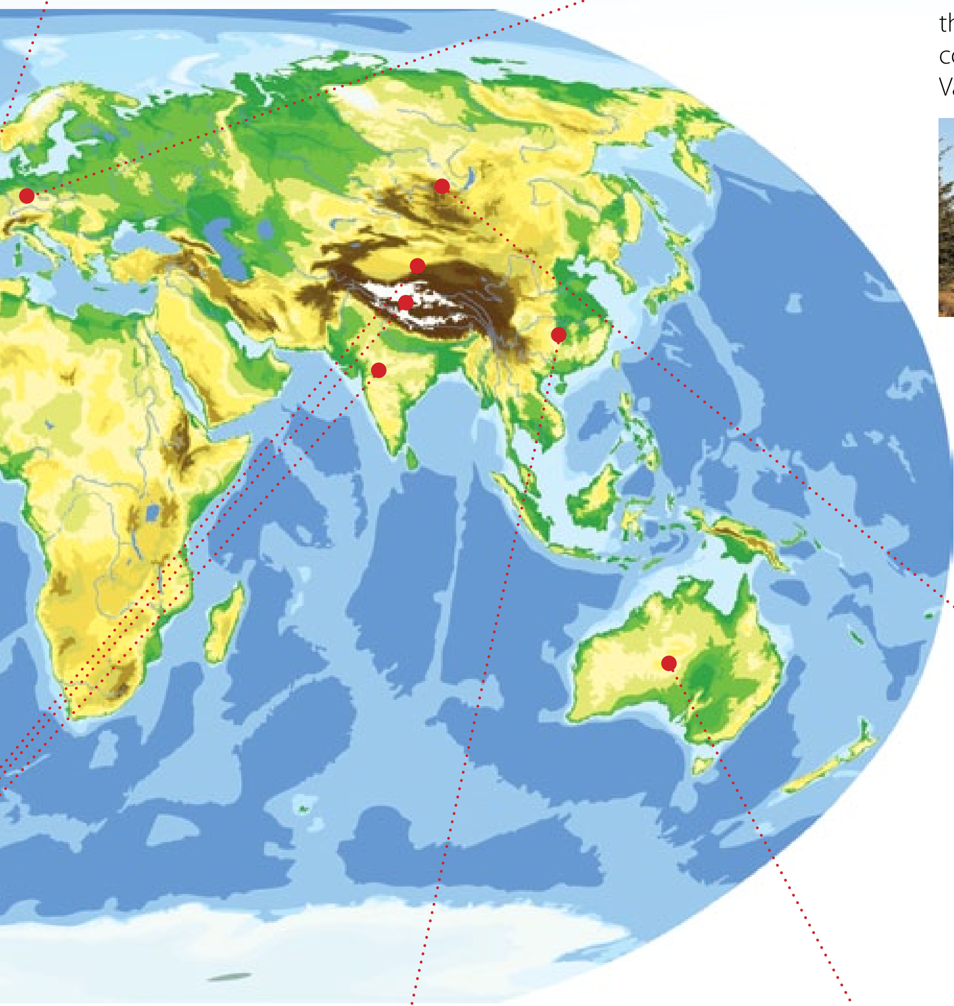
France

Institutional CGS and BRGM
(321250, 2013-2014)
Microstructural and chemical reappraisal of mineralogical inheritance in partially molten rocks: implication of AMS resetting in granitoids in Central Vosges



Czech Republic

Czech Science Foundation (CSF)
(13-16315S, 2013-2016)
Prograde metamorphism, crustal thickening and lower crustal flow: new concept of building of crustal root in Variscan orogen



Mongolia

Czech Science Foundation (CSF)
(P210/12/2205, 2012-2015)
Crustal growth and construction of continental crust exemplified by Central Asia Orogenic Belt

China

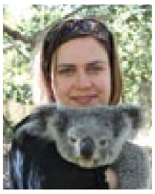
PROCORE
(France-Hong Kong, 2014-2015)
Tectonothermal history of the high-grade metamorphic rocks in the southern Altai Range, Central Asia

Australia

Australian Research Council (ARC)
**(CI Prof. Weinberg,
Monash University, 2011-2014)**
Water-fluxed continental melting.

People

Prof. Karel Schulmann
Head of the CLR. Professor
Structural geology and tectonics



Dr. Pavlína Hasalová
Research Fellow
Metamorphic petrology and microstructures

Dr. Ondrej Lexa
Associate Professor
Structural geology and tectonics

Dr. Petra Maierová
Research Fellow
Numerical modelling of deformation and thermal processes

Dr. Vojtěch Janoušek
Associate Professor
Modelling geochemical data from igneous and metamorphic complexes

Dr. Tomáš Magna
Research Fellow
Isotopic geochemistry and geochronology

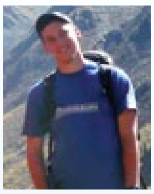
Dr. Yingde Jiang
Post-doctoral Fellow
Metamorphic petrology and geochronology

Dr. Pavla Štípská
Associate Professor
Metamorphic petrology

Dr. Alexandra Guy
Research Fellow
Geophysical and geological characterization of the crust

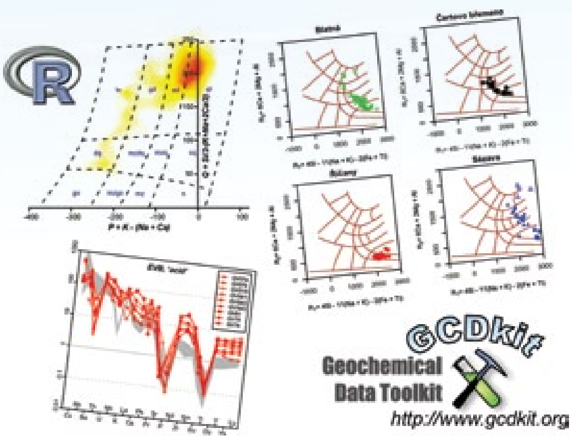
Dr. Prokop Závada
Research Fellow
Analogue modelling

Pauline Wernert
Research Fellow
Metamorphic petrology

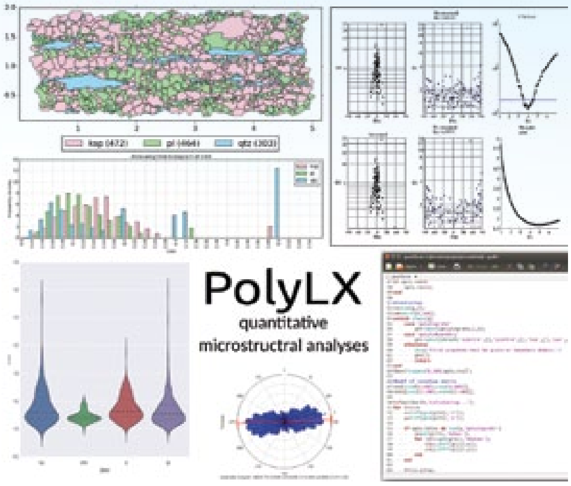


Jeremie Soldner
Research Fellow
Tectonics and microstructures

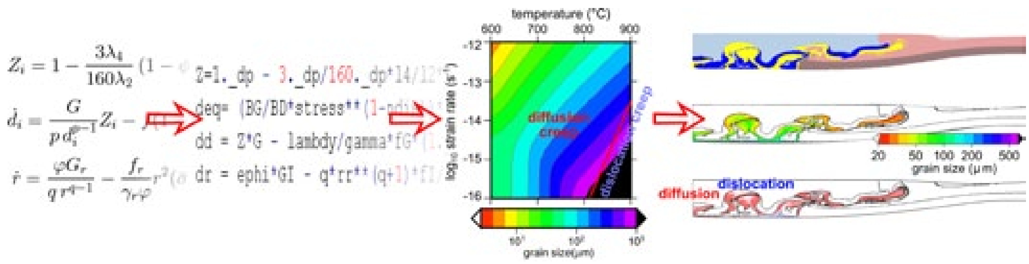
Skills/expertise



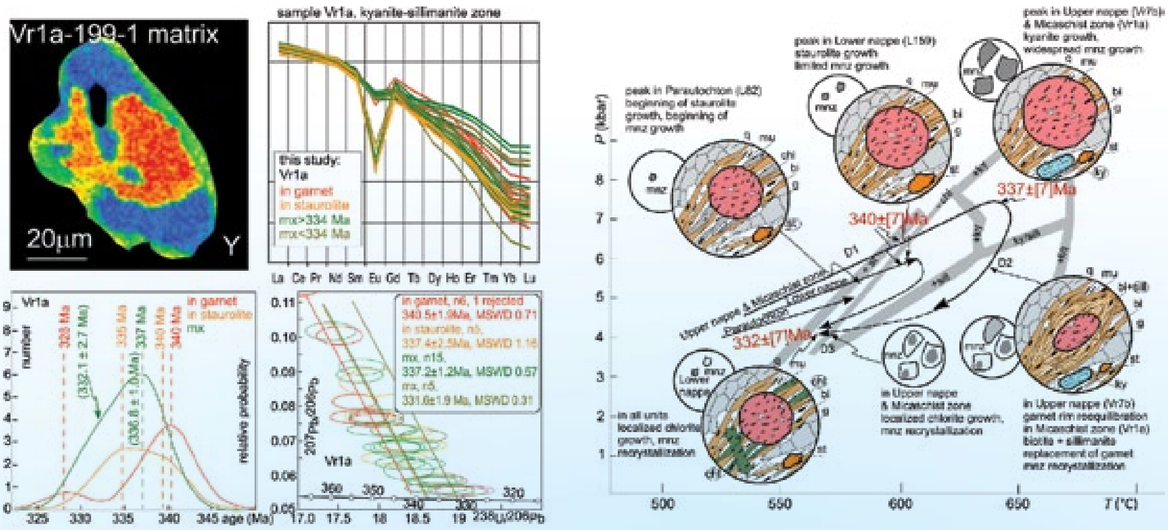
▲ Geochemical modelling



▲ Quantitative microstructural analyses



▲ Numerical modelling



▲ Determination of PT conditions and ages of orogenic fabrics http://petrol.natur.cuni.cz/clr