Thermal structure of the northeastern Lepontine dome and consequences regarding the tectono-metamorphic evolution of Ultrahelvetic and Northpenninic nappes

Wiederkehr, Michael; *Bousquet, Romain; *Ziemann, Martin; Schmid, Stefan, M.; **Berger, Alfons & ***Abart, Rainer.

GeoSciences Department, University of Basel, Bernoullistr. 30, 4056 Basel, Switzerland; (m.wiederkehr@unibas.ch)
* Institut für Geowissenschaften, Universität Potsdam, Karl-Liebknecht-Str. 25, 14476 Potsdam-Golm, Germany;
** Institute of Geological Sciences, University of Bern, Baltzerstr. 1, 3012 Bern, Switzerland;
*** Institute for Geological Sciences, Freie Universität Berlin, Malteserstrase 74-100, 12249 Berlin, Germany.

The metasediments of the Ultrahelvetic and Northpenninic units around Olivone/TI show a remarkable metamorphic gradient: Carpholite bearing assemblages in the east indicate pressure dominated metamorphism under blueschist facies conditions, while the units are characterized by a temperature dominated Barrow event under amphibolite facies conditions (Lepontine metamorphism) further west. The relationship between these two metamorphic events clearly shows that a separate Barrowian/Lepontine event overprints an earlier HP/LT event. To document this late thermal overprint Raman spectroscopy of carbonaceous material was performed along an east-west section between Safien valley and Pizzo Molare. Between 15 and 20 Raman spectra were obtained from each sample from a total of over 65 localities. The principle of this method is based on the progressive transformation of organic matter into graphite during metamorphic processes. The degree of crystallization of carbonaceous material is mainly temperature dependent and can therefore be used as a geothermometer (Beyssac et al., 2002). A “normal” Raman spectrum of graphite shows the Graphite peak (G band) and three defect bands (D1, D2 and D3 bands) in the so-called first order region. The latter are assigned to defects in the graphitic structure. The peak height of these defect bands corresponds to the degree of organization of the graphite structure, which is actually dependent on temperature: The cooler the metamorphic conditions are the poorer the ordering of carbon and hence the higher the peaks related to the defects.
The degree of organization of carbonaceous material appears not to be affected by the retrogression and hence is believed to record peak metamorphic conditions. This has been quantified by the relative area of the defect bands, which shows a linear correlation between the height of the defect bands and the peak-temperature, the so-called R2 ratio (Beyssac et al., 2002). The uncertainty on temperature is +/- 50 °C due to uncertainties on petrological data used for the calibration. The relative uncertainties regarding temperature are much smaller, at around 10 – 15 °C (Beyssac et al., 2004), allowing for an accurate estimate of the field thermal gradients.
The following conclusions result from this study:

- The temperature increases continuously from east to the west, starting at around 350 °C in the Safien Valley and reaching 530-540 °C at the Pizzo Molare. There are no jumps or discontinuities in the temperature distribution pattern.

- The strongest field thermal gradient can be found in the east-west trending Luzzone valley, where the temperatures increase from 420 °C in the east to 520 °C in the west over a distance of approximately 5 km. This transitional zone represents the northeastern border of the Lepontine thermal dome.
- The "isotherms" cut through all D1 nappe contacts and subsequent D2-structures (e.g. the Lunschania-Antiform). This independently shows that D2 deformation definitely predates the "Lepontine-heating event", consolidating clear microstructural evidence.

This new temperature distribution map clearly shows the progressive thermal/Barrowian overprint of HP/LT metasediments form east to the west. Combined with structural data and analysis of microstructures in thin sections we interpret this thermal event as a separate heating pulse which have occurred after nappe stacking (Ferrera phase) and a first nappe refolding stage (Domleschg phase) but before and in the beginning stages of a second nappe refolding event (Chièra phase).

REFERENCES

Beyssac, O., Goffé, B., Chopin, C. & Rouzaud, J. N. (2002): Raman spectra of carbonaceous material in metasediments: a new geothermometer. Journal of metamorphic Geology, 20, pp 859-871.

Beyssac, O., Bollinger, L., Avouac, J-Ph. & Goffé, B. (2004): Thermal metamorphism in the lesser Himalaya of Nepal determined from Raman spectroscopy of carbonaceous material. Earth and Planetary Science Letters, 225, pp 233-241.