Structural Analysis of the Exhumation of the Gastern Granite and the Effect of Hydrothermal Fluid Circulation

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Introduction & aims

The Gastern granite intruded 303 Ma ago (Schaltegger, 1993; Krayenbuhl & Steck, 2009) and is outcropping in the northern part of the Aar Massif; in the Gasterntal, on the Lötschenpass and the mountains eastward. The area experienced multiple deformation phases in which the sediments of the Doldenhorn basin were first thrusted on the Gastern granite before the nappe stack and the basement underneath were uplifted (Herwegh & Pfiffner, 2005).

The structural mapping combined with the analysis of the veins will allow to investigate the relationship between the deformation of the granitic body and the fluid circulation along the fault structures.

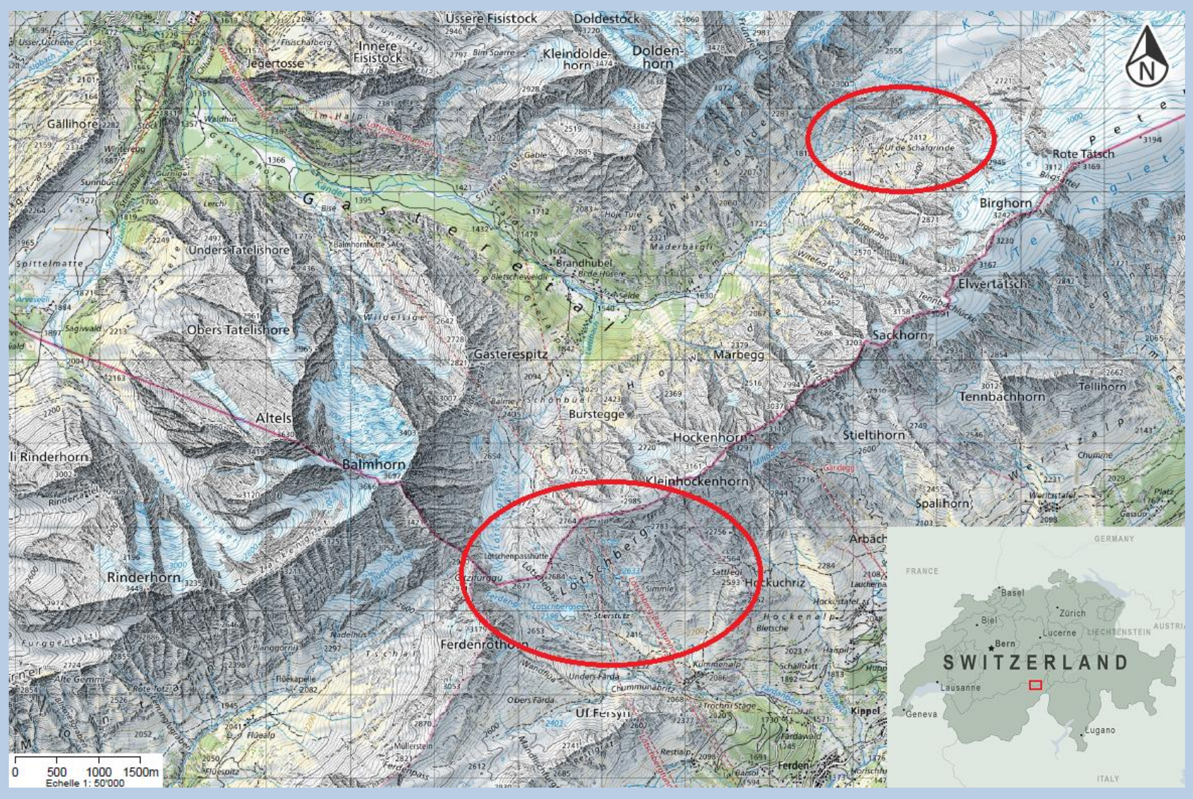

Figure 1: Localisation of the study areas where field work was done. Top circle: Gasterntal, bottom circle: Lötschenpass. Source: Swisstopo

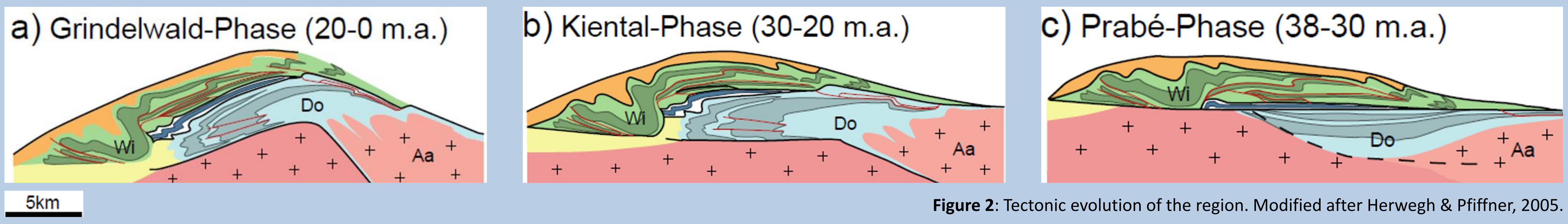

Figure 2: Tectonic evolution of the region. Modified after Herwegh & Pfiffner, 2005.

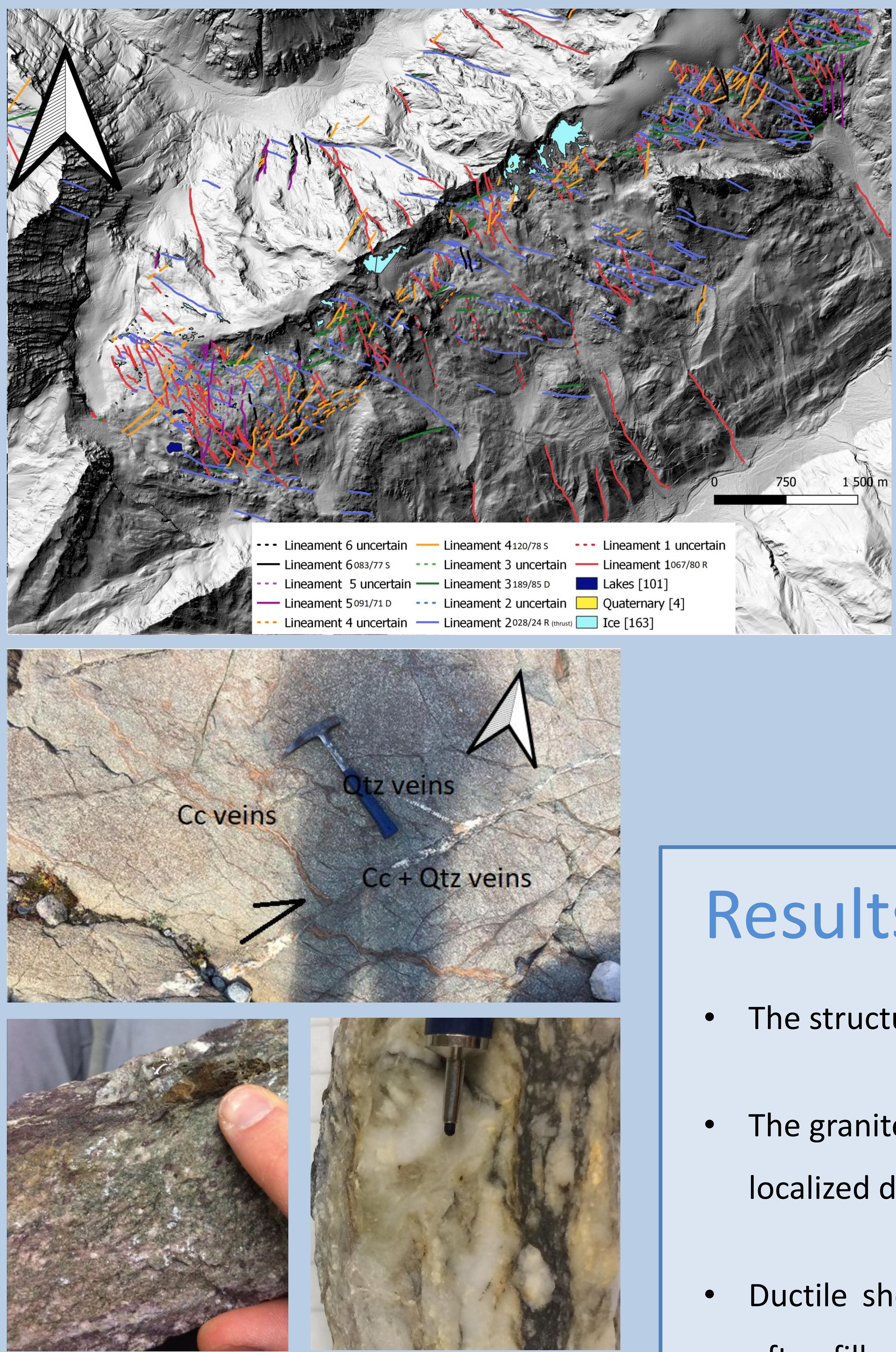

Figure 3: top: lineament map. Read the legend as follow: fracture family number, mean azimuth/dip, sense of movement (R = reverse faulting, D = dextral, S = sinistral). Middle: veins in the Gasterntal. Bottom left: carbonatic vein in a brittle reactivated shear zone. Bottom right: calcite vein from which powder is collected for isotope analysis.

Methods

From large scale to microscopic scale

Lineament map -> (drone) -> field observation -> sample description -> microscopic analysis of thin sections

- Lineament map and modelling. The next step will be to model the area in 3D using MOVE.
- Field work for structural analysis of orientation, kinematics and relative age of deformation structures.
- Sampling and thin section analysis to link micro-scale deformation with large-scale-structures.
- C and O isotopic analysis. In order to assess the paleofluid origin (deep within the crust or meteoric).

Results

- The structures can be grouped into 6 fault families according to their orientation.
- The granite itself shows little internal deformation (lineation, schistosity, etc) but contains localized deformation features such as faults with cataclasites and fault gouges.
- Ductile shear zones were reactivated in a brittle manner. The resulting tectonites are often filled with quartz (Qtz) + carbonate (Cc).
- There exist 3 type of veins distinguished by their mineralogy (Qtz, Cc, Qtz + Cc).

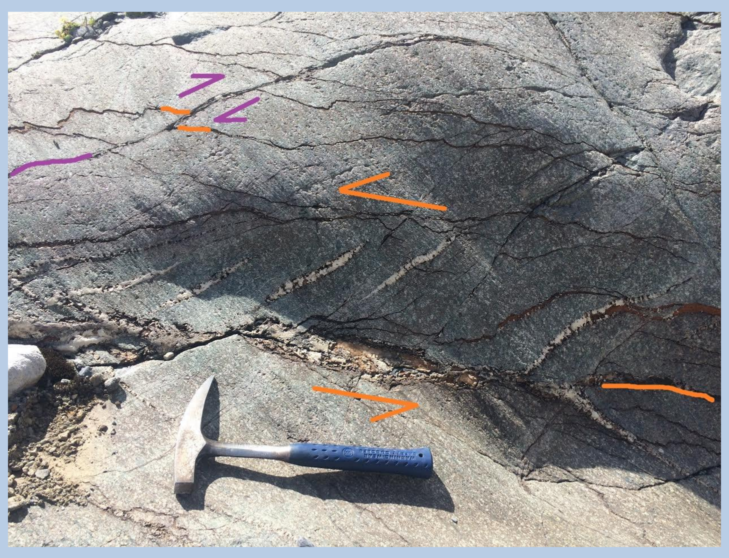

Figure 4: structural relationship between the orange and the purple structures along with "en échellon" veins. Brittle overprint allowed fluid circulation.

Preliminary conclusion

Ductile shear zones (lineaments in fig. 3) were reactivated during the exhumation of the Gastern granite along with fluid circulation (orange, green, purple and black structures, see figure 3 top), resulting in Cc+Qtz veins.

Crosscutting relationships between the veins have been observed. Based on these field evidences 3 different pulses of fluid-assisted fracturing are thought to have occurred (Qtz – Cc – Qtz+Cc).

The exhumation of the Gastern granite occurred mainly by brittle reactivation of old ductile shear zones. Mineral precipitations and veins are mainly documented in or near fault gouges.

Crosscutting relations indicate a younger brittle fracturing (blue and red). These fractures have no mineral infill and are interpreted as the result at a late exhumation stage.

A preliminary relative chronology of the tectonites and the veins occurrence is shown in figure 6.

Figure 5: Different veins in the Gasterntal. Cc (orangish) "eats" the Qtz veins.

	Old							Young
Qtz veins	X							
Cc veins		X		?				
Qtz + Cc veins			X			X		
(red)								O
(blue)							O	
(orange)			X			B		
(green)				X				
(purple)						?		
(black)					X	B		

X = ductile def. (shear zone) O = brittle fracturing B = brittle reactivation

Figure 6: Preliminary attempt to make a relative chronology of events according to crosscutting relationships.

References

M. Herwegh, O.A. Pfiffner (2005): Tectono-metamorphic evolution of a nappe stack: A case study of the Swiss Alps, *Tectonophysics 404*, 55– 76.

T. Krayenbuhl, A. Steck (2009): Structure and kinematics of the Jungfrau syncline, Faflertal (Valais, Alps), and its regional significance, *Swiss Journal of Geoscience 102*, 441 – 456.

U. Schaltegger (1993): The evolution of the polymetamorphic basement in the Central Alps unravelled by precise U-Pb zircon dating, *Contrib Mineral Petrol 113*, 466-478.

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