Rock fabrics in palaeo-weathering profiles below basement-cover interfaces (AMS-study on drill cores from the Caledonian margin, Central Sweden) *Vortrag*

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Basement-cover-interfaces are important crustal boundaries. In many cases they act as detachment horizons. Criteria like pre-erosional basement characteristics, intensity of palaeo-weathering and post-erosional processes during burial stage lead to a huge variety of observable alteration and fabric features of basement-cover-interfaces, which may influence the shear-strength.

Unconformity-parallel planar fabrics in the weathering profile were facilitated by palaeo-alteration and later processes (Angerer 2005 unpubl. data). Such fabrics may be a factor for lowering the shear-strength (e.g. Wintsch et al. 1995). The probably ubiquitous existence of those fabrics at basement-cover-interfaces is investigated in case studies by means of AMS-fabric analysis, which is a sensitive indicator of rock fabric changes.

The present case study is based on sections from two drill cores across the erosional unconformity between Fennoscandian Granite (Revsund) and Cambrian Gärdsjön Fm. (Långviken SGU 73007 and Hara 79002, see Fig. 1) (petrographic descriptions in Gee, 1978 and Gee et al. 1982).

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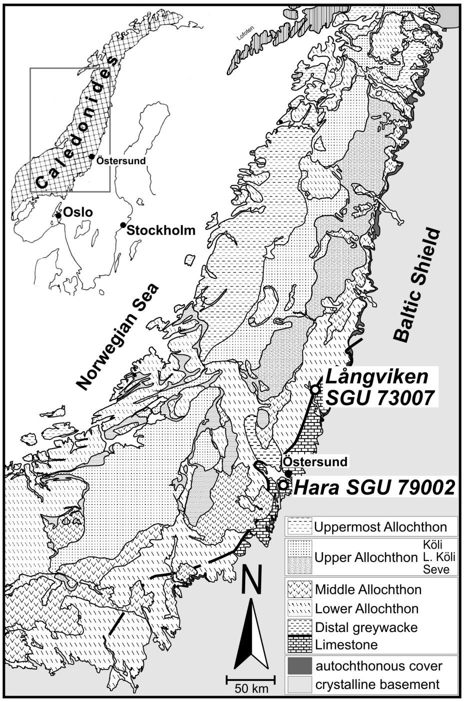

Figure 1: Geological overview of the Central Caledonides. Marked are the two drill hole localities.

Hara SGU 79002 drill core

In the Hara drill core, the basement-cover-interface is reached at 180 m drill depth. The upper part of the basement is a 5.5 m thick tectonic slice with weathered and brecciated granite. The footwall of this slice is a shear surface with a foliated cataclasite and a thin graphitic black shale horizon. Below the slice there is a gradual change downward from strongly weathered to fresher granite. This can be considered as a primary palaeo-weathering profile below an erosional unconformity. The samples are paramagnetic with very low bulk susceptibility (κ_{bulk}) values. Dark granitic samples are graphite bearing and clay rich due to weathering and/or brittle

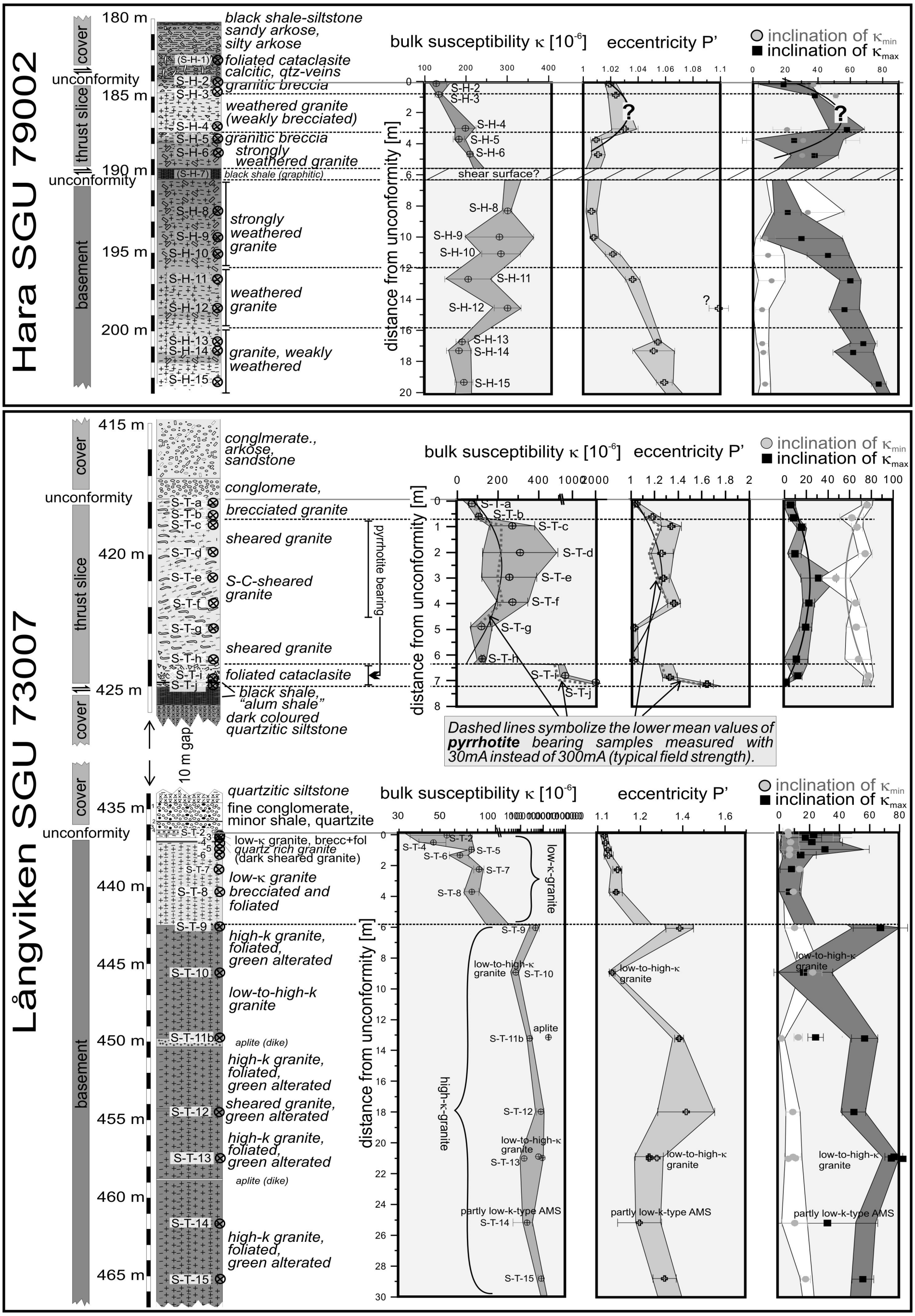

Figure 2: Compilation of the AMS-parameters bulk susceptibility (κ_{bulk}), eccentricity (P') and inclination of magnetic foliation (κ_{min} = surface pole) and magnetic lineation (κ_{max}) in dependance of distance from unconformity.

brittle deformation. The feldspar-to-clay alteration during weathering is a process that increased the bulk susceptibility. Both magnetic foliation and lineation are steep in the granite. Whereas the foliation inclination remains relatively stable, the lineation inclination decreases considerably together with eccentricity P' and shape factor T (latter not visualized here) towards the black shale horizon. These changes of parameters, especially the systematic lowering of the lineation inclination, can be best explained with a multi-phase superposition of unconformity-related fabrics (see Fig. 2, upper part).

Långviken SGU 73007 drill core

The autochthonous granite in the Långviken drill core below 437 m drill depth is divided into a more strongly weathered and brecciated zone down to 6 m below the unconformity (low-κ-granite) and a relatively fresher zone further below (high-κ-granite). The transition is rather discrete. However, there are parts of low-κ- inside the high-κ-granite. The high-κ-granite is magnetite bearing (large crystals of up to 2 mm), whereas the low-κ-granite is free of magnetite, but bearing Fe-clay and hematite as the susceptibility-dominating phases.

With the decrease of κ_{bulk}, P' decreases, as well. The magnetic lineation is steep in the high-κ-granite and changes to shallow in the low-κ-granite (see Fig. 2, lower part.) The magnetic foliation remains sub-parallel to the steep primary gneissic foliation. The change of the magnetic fabric towards the unconformity reveals characteristics like in the Hara drill core, therefore similar superposition processes can be assumed.

In the Långviken drill core, 12 m above the basement-cover-unconformity, the sequence is cut by a thrust, which transported a slice of granitic basement (7 m thick) with overlying cover sediments. It is a detached uppermost part of the autochthonous granite. Pyrrhotite appears dispersed in the deformed matrix of the central part and the cataclastic part in form of small irregular crystals (0.02 mm). This has an impact on κ_{bulk} and P', because of the magnetic field dependence of pyrrhotite. However, the AMS-ellipsoid shaping effect of pyrrhotite is not important compared to the rock fabric defining shear-deformation.

Through the entire slice the granite is sheared in a ductile way and altered with a green colour. Both footwall and hanging-wall of the granite are cataclastically deformed. The distinct rock foliation is pronounced and flat-lying towards the top and bottom. Magnetic foliation parallels the main petrographic foliations. In the centre part of the sheared granite, fabrics are slightly steeper and partly composed by two sets of surfaces. The deformation gradient through the slice can be traced by κ_{bulk}, by P', which reaches 70% in the lower cataclasite, and by the inclination of the magnetic lineation. Towards both rims of the sheared granite, the magnetic lineation becomes shallow, which is clearly caused by simple shear deformation (see Fig. 2, middle part).

Systematic unconformity-related magnetic fabrics

The results show how useful AMS is to trace even cryptic flat-lying fabrics in weathered granite, which apparently can be developed below basement-cover-interfaces. In both profiles unconformity-related fabric change is

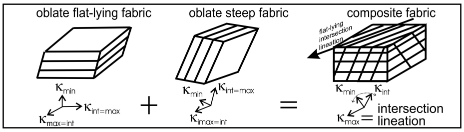

Figure 3: This sketch explains the change of AMS trajectories when a secondary fabric superposes a primary one. Here, the primary fabric is a flat-lying diagenetic feature and the secondary is the steep Caledonian gneissic foliation. In case of the Långviken allochthonous slice, the secondary fabric is a flat-lying fabric, which was induced by simple shear during thrust tectonics.

traceable: towards the unconformity the magnetic lineation decreases its inclination, whereas magnetic foliation stays stable and AMS-ellipsoid shapes become less pronounced (general decrease of eccentricity P'). The AMS fabrics resulted from a superposition of a prominent steep fabric (gneissic foliation) and a cryptic flat-lying one (see Fig. 3). The flat-lying fabric is a diagenetic pure shear feature (flattening), produced during the burial stage. It was facilitated by palaeo-weathering, which produced mainly clay minerals.

The AMS-trends are independent of κ_{bulk}, which behaves differently in the two cores, due to the different alteration properties of the paramagnetic (Hara) and ferromagnetic *s.latu* (Långviken) phases. The allochthonous basement slices are examples for the detachment of the uppermost basement parts, featuring unconformity parallel slip. The flat-lying fabric may have facilitated propagation of Caledonian detachments sub-parallel with this fabric during orogenic deformation. Apparently, burial compaction (pure shear) and lateral slip (simple shear) can produce quite similar AMS-fabrics.

References

Gee DG, Kumpulainen R & Thelander T (1978) The Tasjön Décollement, central Swedish Caledonides. SGU Serie C Nr. 742: p 35

Gee DG, Snäll S & Stejskal V, (1982) SGU Alunskifferprojektet - Prospecteringsrapport BRAP 82502.

Wintsch RP, Christofferson R & Kronenberg AK (1995) Fluid-rock reaction weakening of fault zones. J Geophys Res 100(B7):13021–13032