Geophysical Research Abstracts
Vol. 17, EGU2015-6794, 2015
EGU General Assembly 2015

Joint laboratory investigations of the physical and mechanical properties of the COSC-1 drill core, Sweden

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The Caledonian orogen is an early to middle Paleozoic mountain chain with size dimension similar to the Alpine-Himalayan orogen. Parts of the Caledonian orogen have been deeply eroded and provide excellent exposure of rocks that were emplaced into the middle and lower crust during orogenesis. These exposed rock units therefore provide the possibility to study processes of mountain building that are often inaccessible in more modern orogens, and represent the targets for the Collisional Orogeny in the Scandinavian Caledonides deep drilling project (COSC-1). The main target of COSC-1 was the high grade Seve nappe complex. Temperature estimates indicate granulite facies conditions at the top of this nappe, grading to lower amphibolitic conditions downwards through the nappe. Discovery of micro-diamond included in garnets from the nearby Åreskutan mountain hints at an ultra-high pressure origin in parts of the Seve nappe complex. The COSC-1 deep drilling project presents a unique opportunity to study the laboratory physical properties of a 2.5 km drill core, which can be correlated to downhole logging measurements and for the interpretation of surface geophysical experiments.

In a joint effort that comprises five laboratories, the physical properties the COSC drill core are investigated. Measurement schemes and preliminary results from this cooperative effort are presented. The physical properties suite of measurements on the core includes (i) density, (ii) porosity, (iii) ultrasonic wave velocity and anisotropy at elevated confining pressure, (iv) seismic attenuation and (v) permeability (and anisotropy of permeability). Mechanical properties include uniaxial and triaxial compressive strength at different confining pressures, and subsequent calculation of internal and residual friction angles. The joint investigations will also serve to cross-validate and calibrate different laboratory techniques that are used to measure physical properties. The rock units investigated includes layers of gneiss, amphibolite, calc-silicates, migmatite and sparse meta-gabbro and marble. More mafic units (amphibolite and meta-gabbro) can be separated from the gneisses and migmatite based on density and sonic velocities, measured with active gamma log and full wave form sonic log. Deformation is prevalent in rocks throughout the 2500 m deep borehole, but a more than 300 m thick package of strongly sheared mylonites stands out at the bottom of the borehole. Laboratory measurements of density and ultrasonic velocities are critical on core material that comes from depths greater than 1600 m, because borehole density and sonic logs are lacking at these depths. In addition, the ultrasonic laboratory measurements serve as the only method to directly evaluate seismic anisotropy in the solid rock mass. Additional results and analysis are expected to yield data that will be useful for integration with surface and downhole geophysical data (e.g. vertical seismic profiling data), constraining the state of in-situ stress, and provide insights into the emplacement processes of the Seve nappe complex, and its relationship to the underlying lower-grade Särv and Jämtlandian nappes.