Geology, Geophysics & Environment 2015, vol. 41 (1): 90–91

The Helags Mountain, Sweden: Another piece in the Caledonian puzzle

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The Scandinavian Caledonides formed due to the closure of the Iapetus Ocean in Ordovician time, a process that likely involved several subduction-eduction events before the subsequent collision between the palaeocontinents Laurentia and Baltica in Silurian and Early Devonian time (e.g. Gee et al. 2008). However, there are still uncertainties regarding the evolution and timing of the orogenic processes involved in the formation of the Caledonian orogen. To further investigate the time constraints on the key orogenic events, detailed studies of different high-pressure lithologies and mylonites are required. Such high-pressure lithologies are found in Jämtland, central Sweden, to occur in the Lower and Middle Seve Nappe Complex (SNC). Recent studies of the SNC have revealed not only higher PT-conditions than previously thought, but also revised the time constraints on the main collision event (Majka et al. 2012, Janák et al. 2013, Klonowska et al. 2014).

The Åreskutan Mountain in Jämtland, central Sweden, is a key locality in the studies of high-pressure metamorphism in the Scandinavian Caledonides. The so called Åreskutan Nappe belongs to the Seve Nappe Complex (SNC). This study focuses on the Helags Mountain area, mapped as an equivalent to the Åreskutan Nappe, but not yet studied in any detail. In order to add to the knowledge of the evolution of the Scandinavian Caledonides the aim of the study has been to formulate a P-T-t-D model for the Helags Mountain area. This is done by structural studies, P-T estimates and monazite geochronology.

A total of eight samples were collected from five localities in the area, each sample representative of the mineralogical and textural variations seen within the different lithologies of the study area. Two samples of special interest were selected for detailed petrological and mineralogical studies: one mylonite sample and one representative non-sheared sample.

The mylonite sample was collected from a shear (thrust) zone in the northern part of the area, and investigated for kinematic indicators on microscopic scale. The main mineral assemblage of this sample is quartz + plagioclase + biotite + white mica, with accessory rutile + zircon + monazite. The foliation is well-developed and marked by biotite and white mica. Plagioclase grains occur as deformed porphyroclasts with fine grained feldspar and quartz having crystallized in pressure the shadows. In addition, sheared out quartz lenses with elongated biotite grains outline a C-type fabric that indicates a top-to-the-northeast movement. This is in agreement with the general direction of emplacement of the nappes in the Scandinavian Caledonides.

The second selected sample is a garnet bearing mica schist collected in the vicinity of the same shear zone. Based on mineralogy this sample was deemed suitable for determination of peak P-T conditions. The main mineral assemblage consists of quartz + plagioclase + biotite + muscovite + phengite + garnet + carbonates, with accessory ilmenite + monazite + zircon. The small, >0.5 mm, subhedral to anhedral garnet is of dominantly almandine composition, and occurs distributed randomly in the matrix. In general, the garnets show cores with numerous tiny inclusions, of which some give strong carbon EDS peaks. Surrounding the inner core areas of inclusions are areas free of such inclusions. These outer core areas exhibit an euhedral shape towards the rim areas. These two zones of the core are not clearly seen in the chemistry of the garnets, which in the core region is rather constant with slight variations in all end-members. This lack of zonation between areas with and without inclusions may possibly be the result of homogenizing of the core regions at high temperatures (c.f. Florence & Spear 1991). The rim areas on the other hand show a distinct change in chemistry from the cores, with a decrease in almandine, spessartine, and pyrope matched by an increase in grossular. Multiphase inclusions (25–50 μm in diameter) in some garnets show negative crystal shape, and are composed of plagioclase + quartz + K-feldspar ± epidote ± chlorite ± ilmenite. These inclusions are interpreted as so called nanogranites (c.f. Cesare et al. 2009), indicative of the presence of melt at the time of garnet growth.

Both selected samples carried accessory monazite and were therefore selected for dating by U-Th-total Pb method. Two different ages were obtained for the two studied samples: 426 ± 4.5 Ma and 438 ± 6.9 Ma, respectively. These ages are comparable with those obtained by Majka et al. (2012) for Åreskutan. In that study, monazites of c. 439 Ma were interpreted as recording an event of partial melting related to decompression. A younger monazite age of c. 424 Ma was believed to represent the timing of emplacement of Åreskutan onto the Lower Seve Nappe. A preliminary conclusion is therefore that the rocks of the Helags Mountain area record a similar history to that of the Åreskutan Nappe. A record of an earlier history of high-pressure metamorphism remains to be seen but so far these preliminary results points towards the Helags Mountain area indeed being equivalent to the key locality of the Åreskutan Nappe. This also shows that studies of the Helags Mountain area can shed further light on the geological history of the Seve Nappe Complex, and can add another piece to the Caledonian puzzle.

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