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Tectonic events in the Kalak Nappe Complex, Arctic Caledonides redefined through a linked structural and geochronological approach

C. L. Kirkland (1), J.S. Daly (1), E. Eide (2) and M.J. Whitehouse (3)

(1) Department of Geology, University College Dublin, Belfield, Dublin 4, Ireland, (2) Centre for Geodynamics, NGU, Trondheim, Norway, (3) Department of Geological Sciences, Natural History Museum, Stockholm, Sweden (chris.kirkland@ucd.ie)

The Caledonian allochthons in Finnmark, Arctic Norway, are an outstanding example of a thrust-assembled tectonostratigraphy. However, their evolution is contentious with multiple orogenic events being postulated, namely the Porsangerhalvøyan (D2 $>$ c. 800 Ma), Finnmarkian (c.490 Ma) and Scandian (D3, c.420 Ma). Moreover, while discrete episodic orogenic events characterize major continent-continent collisions, accretionary orogens are characterized by continuous deformation, which through strain partitioning can appear to be episodic on a local scale. Distinguishing between these scenarios depends on both sufficient geochronological control but also on the spatial distribution of events within the orogen. We present new isotopic and structural data from the Sørøy succession and the Hellefjord Schist, along with the timing and structural relations of granitic bodies that intrude them. These new data demand a radical revision of the tectonic history of the Kalak Nappe Complex (KNC), the so-called “Middle Allochthon” and identify the Hellefjord Schist as a Laurentian terrane belonging to the ‘Upper’ / ‘Uppermost Allochthon’.

D3 is the major deformational event affecting the Hellefjord Schist. D2 structures are absent. Granites intruding the Hellefjord Schist are intensely affected by D3 and yield a weighted mean U-Pb zircon age of 438 $\pm$ 2 Ma. A volcaniclastic psammite contains detrital zircons as young as 438 $\pm$ 4 Ma (Llandovery) indicating coeval deposition and granitic magmatism. Their chemistry and Sm-Nd data suggest a Laurentian affinity. Overgrowths on zircons from one of the granites constrain high-grade Scandian metamorphism to c. 428 $\pm$ 5 Ma. Thus the 490 Ma Finnmarkian Orogeny cannot have

affected the Hellefjord Schist. Because the Hellefjord Schist is infolded with the Sørøy succession on a regional scale, the majority of deformation within the KNC must be of Scandian age leaving little indication of the Finnmarkian event anywhere in the region. *In situ* UV laser-ablation Argon-Argon geochronology from muscovite samples throughout the KNC and on amphibole from the Hellefjord Schist yield c.420 Ma crystallization ages, further constraining the Scandian event but providing no evidence for the Finnmarkian. The Scandian event can be linked to the arrival of the Hellefjord Schist ('Upper' / 'Uppermost Allochthon') during thrusting associated with the collision of Baltica and Laurentia.

In contrast, the age of granite magmatism, deformation and metamorphism increase westwards and upwards within the tectonostratigraphy of the underlying KNC, suggesting an accretionary orogenic scenario, prior to the overprinting Scandian collision. Granites dated at c. 980 Ma cut Sørøy succession metasediments at lower structural levels of the KNC, probably after regional deformation, although their field relationships are less clear than structurally higher bodies, as a result of severe Scandian (D3) deformation. Deformation before 980 Ma suggests that the Porsangerhalvøyan event (if the D2 event can be correlated) may be a northern extension of the Grenville (Sveconorwegian) Orogeny. 840-830 Ma granites and pegmatites within a higher nappe clearly cut early structures (D2) affecting the Sørøy succession. The preservation of D2 structures depends on their present orientation, which reflects the mechanism of overprinting deformation. Structures now parallel to the (D3) Scandian transport direction have been rotated. They preserve earlier fabric relationships. Structures at a high angle to the transport direction have been subjected to greater simple shear and have had their fabrics sheared into parallelism thus obliterating the record of earlier deformational events. A migmatitic leucosome within the uppermost nappe of the KNC has a c.710 Ma crystallization age identical to metamorphic zircon overgrowths within the underlying nappe, suggesting that juxtaposition of these nappes pre-dated Scandian transport. Thus a distinct temporal pattern is recorded within the KNC nappes and suggests that volcanic-arc accretion occurred from Grenville times until the late Precambrian.

Collectively these results show how deconvolution of a polyphase and polyorogenic structural history can be achieved through linking of the isotopic record to deformation fabrics. These results call for a revised model of the evolution of the Scandinavian Caledonides.