

Attacking a Nunatak (West Greenland)

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One of Greenland's largest bodies of Archaean (meta)sedimentary rocks occurs on a nunatak (an isolated island of land in the icesheet) at $\sim 65^{\circ}31'N$ $49^{\circ}54'W$, that was last visited for reconnaissance geological surveying in 1977. This nunatak is a missing piece in reconstructing the Archaean geology of West Greenland – a key terrane for understanding the early evolution of Earth's crust:

- (1) Are the nunatak's rocks a continuation of the Isua ≥ 3700 Ma (millions of years old) volcanic and sedimentary rocks with the world's oldest evidence of life, that occur at the Inland Ice edge 35 km to the south?
- (2) Do they record ejecta from a purported ~ 3000 Ma impact structure 90 km to the west?
- (3) Do they belong to the nearby 3200-3000 Ma Akia terrane?

The nunatak was visited by helicopter (B212) flyover reconnaissance on 20th July 2017, with geological observations and sample collection at 2 landing sites. A following programme of petrology and zircon U-Pb dating resolved the origin of these rocks.



The western end of the nunatak field location

The nunatak is dominated by brown rocks derived by the metamorphism of sedimentary rocks, with lesser amounts of black rocks representing metamorphosed submarine basalt lava flows. Petrography confirmed the metasedimentary origin of the brown rocks – with diagnostic

minerals such as kyanite and staurolite being present. Despite being of sedimentary origin, two samples of these rocks only yielded a very few tiny zircons (<100 microns long) with well-formed crystal shapes. This is unusual, because detrital sedimentary rocks usually carry a larger number of zircon grains of diverse shape – denoting origin of such grains from the erosion of diverse older rocks. U-Pb dating of the tiny nunatak zircons using the large ion microprobe SHRIMP-RG in ANU indicates a uniform age of 3057 ± 7 Ma (95% confidence). Therefore, the sedimentary rocks are interpreted to have been laid-down during a period of basaltic to andesitic volcanism, with the rare uniform-aged zircons acting as a proxy as the time of deposition. Consequently, the nunatak's enigmatic rocks are correlated with the Akia terrane, which is known to contain ~3060 Ma volcanic rocks.

However, as it turns out, this is not the most interesting result of the project. It was seen that the nunatak's surface is littered with blocks of white tonalite – an igneous rock. Tonalites do not form any of the bedrock of the nunatak, and hence these blocks are exotic, deposited there by Greenland's ice sheet. This is shown in the clearest fashion by the glacial moraine at the eastern end of the nunatak, which is comprised almost entirely of tonalite blocks.



Terminal moraine (behind heli) dominated by white tonalite blocks, eastern end of nunatak

The zircons from a glacial erratic tonalite block are typical igneous (magmatic) prismatic grains – 100 to 200 μm long. They have a surprisingly very old age of 3833 ± 6 Ma, which is interpreted as the igneous age of the tonalite. The dating of this sample demonstrates that there is a considerable expanse of the world's oldest surviving crust continuing north from Isua, but is hidden under the icecap.