THE CASE FOR AN IMPACT AT THE GARDNOS IMPACT STRUCTURE AT 385 MA.

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Introduction: The Gardnos Impact Structure is an approximately 6 km diameter structure in Hallingdal, Norway, first identified and described by Dons and Naterstad [1] and confirmed as an impact structure by French et al. [2]. While Gardnos has a large suite of clastic impact breccias, there is a very limited amount of melt-rocks exposed or found in drill core. Because of difficulties of dating melt-poor impact lithologies, the age of the Gardnos impact event has remained unclear despite multiple attempts to date the structure. Based on stratigraphy minimum and maximum ages of ~380-400 Ma and 900 Ma have be defined [2], but the authors prefer an older age. $^{40}Ar/^{39}Ar$ experiments on plagioclase separates from the melt-breccia [3] yielded an age of 385 ± 5 Ma. This was interpreted to represent Caledonian overprinting rather than the age of the impact. U-Pb ages of zircons from polymict melt-bearing breccias [4] yielded a discordant array of zircons dates spanning 385 to 1300 Ma. Consequently the 385 Ma ages have been dismissed as a regional overprint, and an age between 385 and 900 has been accepted.

These previous studies have interpreted effects of regional metamorphism due to the Caledonian Orogeny; however the field and geochronologic evidence in the rocks immediately adjacent to Gardnos is not well characterized. Here we present U-Pb zircon geochronology (ID-TIMS technique) and $^{40}Ar/^{39}Ar$ analyses of feldspars from a pluton slightly outside (~7 km) of the Gardnos impact structure, close enough to "feel" regional metamorphic overprinting and far enough away to not have been disturbed by the impact event.

Methods: $^{40}Ar/^{39}Ar$ analyses were conducted in the Argon Geochronology for the Earth Sciences (AGES) Laboratory and Columbia University's Lamont-Doherty Earth Observatory using a Micromass VG 5400 mass spectrometer. Samples were co-irradiated with Fish Canyon sanidine monitor and an additional internal standard. Plagioclase samples were packaged in Ta tube, and incrementally heated with a diode laser. Zircons were separated, chemically abraded, and U-Pb analyses were conducted on a VG Sector 54 mass spectrometer in the Isotope laboratory at MIT.

$^{40}Ar/^{39}Ar$ Results: Step-heating experiments of the feldspars yield a Mesoproterozoic plateau age that shows no evidence of Caledonian disturbance. Zircon weighted mean $^{206}Pb/^{238}U$ dates are also ~1300 Ma and do not show evidence of metamorphic overprinting.

Discussion: Our results significantly limit the degree of regional metamorphic overpriting in adjacent undisturbed rocks near Gardnos. Based on this, it is difficult to explain the 385 Ma age (seen in both previous U-Pb zircon and $^{40}Ar/^{39}Ar$ feldspar data) as a Caledonian orogenic age. The most likely explanation for this age is the impact event. While French et al., preferred an older age, the 385 Ma age is at the lower stratigraphic bound, but still allowable within broader regional age constraints.

The absence of Caledonian overprinting and a implied impact age of 385 Ma may shed light onto the illusive souce of organic carbon in the melt-bearing breccias at Gardnos [2,5]. The most likely source (albeit, not perfect geochemical match) of the carbon is the Cambrian age Alum Shale [5]. If Gardnos is 385 Ma the Alum Shalewould have been present, and therefore deserves futher consideration as a source of the carbon.

References: [1] Dons J. A. and Naterstad J. (1992). Meteoritics 27, 215. [2] French et al., (1997) GCA 61, 873-904. [3] Grier et al., (1999) MAPS 34 803-807. [4] Kalleson et al., (2009). GCA 73 3077-3092 [5] Gilmore et al., (2003) GCA 67 3889-3903.