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Zircon U-Pb-O-Hf isotope constraints on the origin of the Ketilidian Orogen in South Greenland

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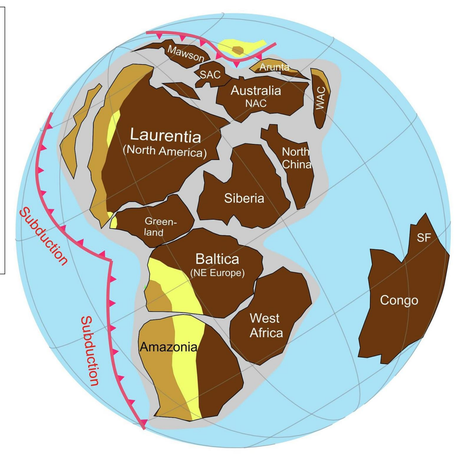
Introduction

The Paleoproterozoic Ketilidian orogeny in South Greenland (1.85-1.73 Ga) is interpreted to be the result of Cordilleran-type north-directed oblique convergent oceanic lithosphere beneath the Archaean continental crust of the North Atlantic Craton. The Ketilidian orogeny is part of the subducted-related magmatism and accretionary orogenic belt named the Great Proterozoic Accretionary Orogen (GPAO) that existed along an active margin stretching through Laurentia (North America and South Greenland) to Baltica (Northeast Europe), which contributed to the assembly of the supercontinent Columbia/Nuna. Thus, the orogeny represents part of an important episode of crustal growth and preservation in Earth's history. The Central Domain of the orogeny is dominated by plutonic remnants of a calc-alkaline magmatic arc (Julianehåb Igneous Complex (JIC), ca. 1.85-1.80 Ga). The rocks of the Southern Domain (SD) are interpreted as fore-arc deposits derived from the uplifting and unroofing of JIC during a period of ca. 1.80-1.77 Ga, to which deformation and metamorphism (amphibolite to granulite facies conditions) were contemporary. These metasediments were subsequently intruded by post-tectonic granitic rocks (including rapakivi variants) of the Ilua Plutonic Suite from ca. 1.76-1.72 Ga.

Chadwick & Garde (1996), Garde et al. (2002), Johansson et al. (2022)

Figure 1: GPAO in a Columbia/Nuna configuration of Laurentia, Baltica and Amazonia possibly existed from around 1.8-1.25 Ga by Johansson et al. (2022) and references therein.



Samples

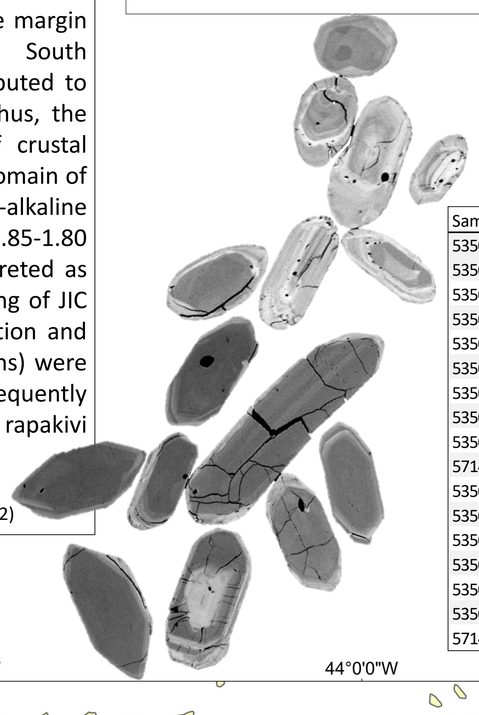
Sixty-three rocks and four fluvio-glacial deposits were sampled within SSW Greenland in a N-S traverse during fieldwork in the summer of 2020.

- Whole rock and trace element of all samples
- Whole rock Hf and Nd on selected samples
- Zircon isotopes (U-Pb-O-Hf) of selected samples (see table below)

Methods

For the determination of U-Pb-O-Hf isotopes in zircons

- SIMS at the Nordsim laboratory, Stockholm (*U-Pb-O*)
- LA-ICP-MS at UiO, Oslo (*Lu-Hf*)



Sample no.		Description	ASI	Comment on age results
535035A (n6374)	JIC	migmatitic gneiss (melanosome)	weakly peraluminous	mainly 1 concordia age, maybe Ilua Suite represented?
535035B (n6375)	JIC	migmatitic gneiss (leucosome)	metaluminous	
535036 (n6376)	JIC	biotite granite	metaluminous	1 concordia age
535045 (n6377)	JIC	biotite granite	metaluminous	1 concordia age
535052 (n6378)	JIC	granodiorite	metaluminous	1 concordia age
535059 (n6369)	JIC	aplitic leucogranite	weakly peraluminous	mainly 1 concordia age
535064 (n6370)	JIC	banded gneiss	weakly peraluminous	1 concordia age
535043 (n6383)	JIC	detrital zircons		Two JIC age peaks (Early and Late) and 1 Archaean
535085 (n6384)	JIC	detrital zircons		1 main Late JIC age and 1 Archaean
571417 (n6385)	JIC/SD	detrital zircons		1 Ilua age, 1 main Late JIC age and 1 Archaean
535068 (n6372)	SD	grt-bearing banded gneissic migmatite	peraluminous	1 Early JIC, older and 2 of Archaean age
535073 (n6380)	SD	qtz-fsp gneiss (metasandstone)	metaluminous	1 concordia age of Ilua Suite age
535079 (n6381)	SD	grt-crd-bt gneiss (metasediment)	peraluminous	1 distinctive JIC age reprentative, 3 older and 1 likely Archaean
535083 (n6382)	SD	grt-qtz-fsp gneiss (metasediment)	peraluminous	1 Ilua representative, 2 JIC (Early and Late) and older
535065 (n6371)	Ilua Suite	rapakivi granite	metaluminous	1 concordia age
535071 (n6379)	Ilua Suite	rapakivi granite	metaluminous	1 concordia age
571425 (n6386)	Ilua Suite	detrital zircons		1 concordia age

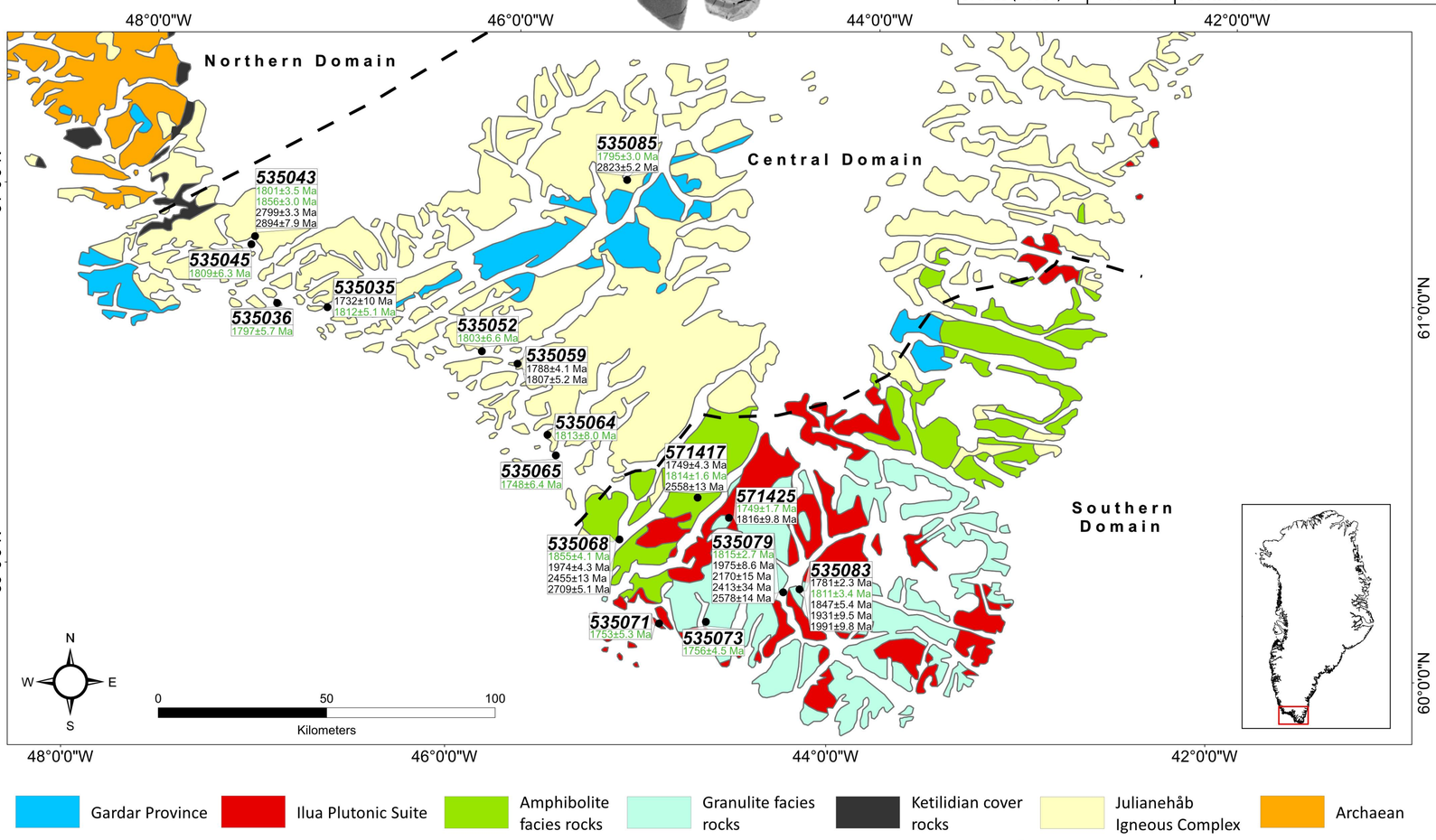


Figure 2: Simplified geological map showing the major divisions of the Ketilidian orogen in South Greenland modified from Allaart (1975), Escher & Pulvertaft (1995) and Steenfelt et al. (2016), together with this study's sixteen sample localities and U-Pb zircon ages. The dominant/peak age(s) of the sample is highlighted in green. Ages as expected, although it is interesting to note that only three samples are 1.85 Ga (Early Ketilidian), contrasting with previous mapping of the region.

Questions

1) How does the new zircon U-Pb data compare to previous studies?
2) Is JIC truly juvenile or does the magmatic source involve reworked older crustal components?
3) How useful are detrital zircon studies in glacial sediments and do they depict the geological history of a wide geographic area in South Greenland?

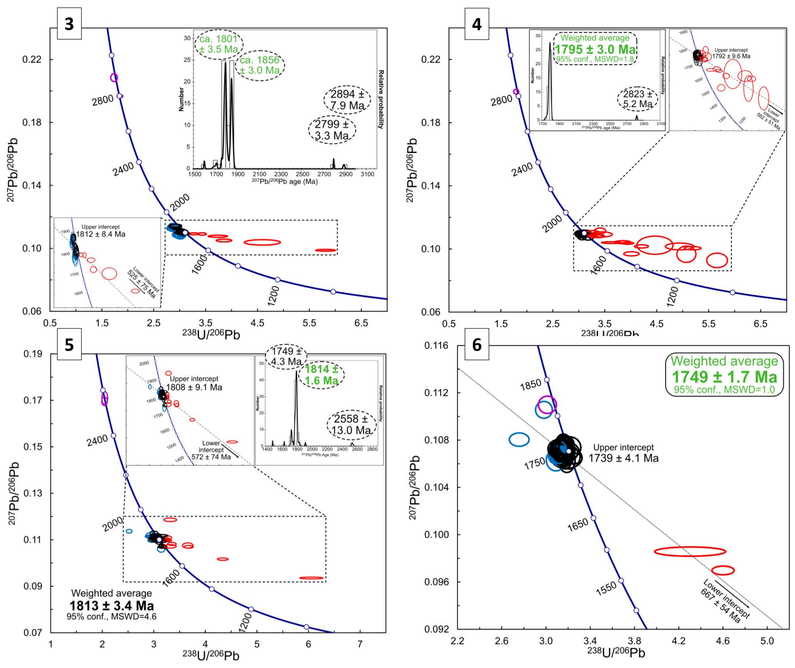


Figure 3-6: Tera-Wasserburg Concordia plots showing zircon results (2σ error ellipses) with red ellipses denoting discordance due to Pb loss, blue reverse discordance and purple "outliers" from the main cluster on the Concordia curve respectively of detrital samples 535043, 535085, 571417 and 571425

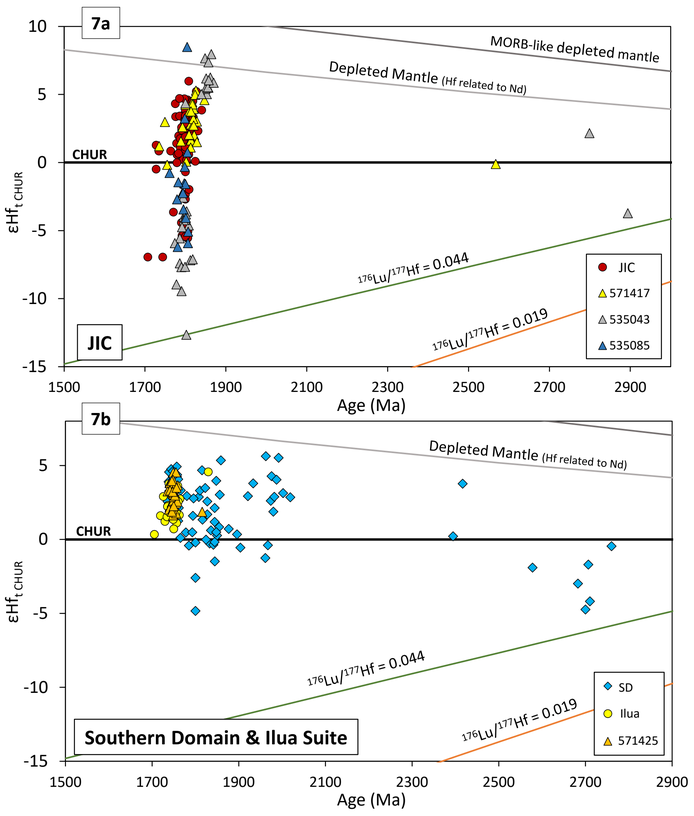


Figure 7a-b: Time versus εHf plots respectively of zircons derived from JIC and the Southern Domain (SD) including the Ilua Plutonic Suite. MORB-like DM line after Griffin et al. 2000, Hf related to Nd DM curve after Vervoort et al. 2011 and crustal evolution line Lu/Hf=0.019 after Kemp et al. 2009 representative of Greenland Archaean crust. CHUR = Chondritic Uniform Reservoir.

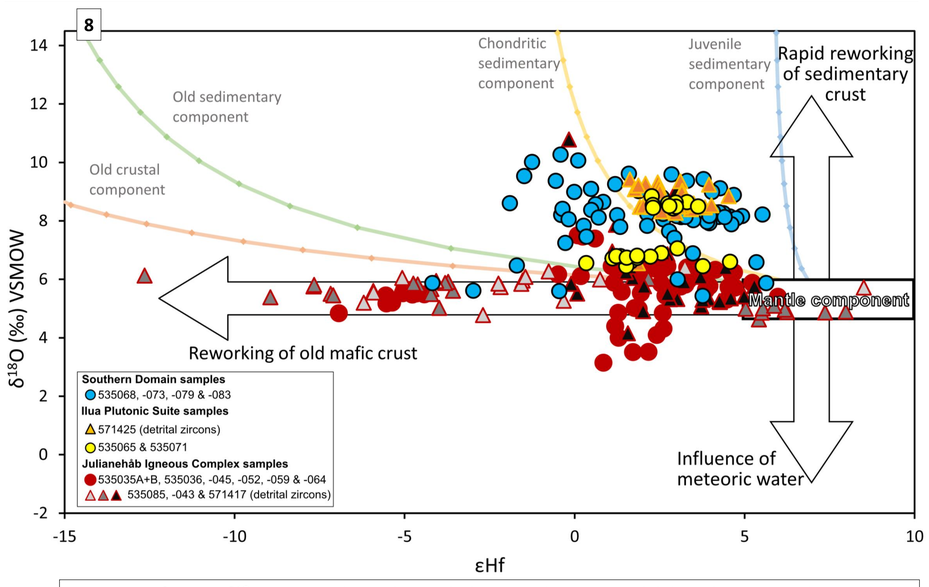


Figure 8: εHf versus $\delta^{18}O$ presented together with theoretical mixing model describing mixing between between juvenile (mantle) component and potential crustal components with εHf endmembers between -15 and 6 representing old and juvenile crustal components and $\delta^{18}O$ of 5.7‰ and 14‰ representing crust with mantle-like $\delta^{18}O$ and sedimentary rock values respectively (inspired by Petersson et al. 2018)

Conclusions and to be continued..

- Obtained ages are consistent with previous studies, however the 1.85 Ga (Early Ketilidian) age is not prominent; only represented in three samples (two Southern Domain metasediments and one detrital sample within JIC).
- Previous studies have interpreted JIC as juvenile, but our O-Hf zircon data (being the first O-Hf data from South Greenland) suggests a more complex source that is not strictly juvenile.
- Our detrital zircon data is surprisingly restricted to mainly one or two age groups, whether this truly reflects the age in a wide geographic area is uncertain.
- Ongoing work includes whole rock Hf and Nd, whole rock and trace element data, and a correlation with the Makkovik Province in Newfoundland-Labrador, Canada.

References:
Johansson et al. 2022. Precambr Res. 371, p. 106463. **Petersson** et al. 2018. Chem Geol. 479, p. 259-271. **Steenfelt** et al. 2016. Ore Geol Rev. 77, p. 194-245. **Vervoort** et al. 2011. Geochim Cosmochim Acta. 75, p. 5903-5926. **Kemp** et al. 2009. Chem Geol. 261, p. 244-260. **Garde** et al. 2002. Can J Earth Sci. 39, p. 765-793. **Griffin** et al. 2000. Geochim Cosmochim Acta. 64, p. 133-147. **Chadwick** & Garde 1996. J Geol Soc, London. 112, p. 179-196. **Escher** & Pulvertaft 1995: *Geological Map of Greenland, 1:2 500 000*. Geological Survey of Greenland. **Allaart** 1975: *Geologiske kort over Grønland, 1:500000, sheet 1, Sydgrønland*. Grønlands Geologiske Undersøgelse.