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Article

Provenance Response to Rifting and Separation at the Jan Mayen Microcontinent Margin

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Supplementary Materials

Heavy Mineral Analysis

Samples were immersed in water and cleaned by ultrasonic probe to disperse and remove any clay adhering to grain surfaces. They were then washed through a 63 µm sieve, resubjected to ultrasonic treatment until no more clay passed into suspension, and wet sieved through the 125 and 63 µm sieves. The resulting >125 µm and 63-125 µm fractions were dried in an oven at 80°C. The 63-125 µm fraction was placed in bromoform with a measured specific gravity of 2.8 and heavy minerals were allowed to separate under gravity, with frequent stirring to ensure complete separation. The heavy mineral residues were mounted under Canada Balsam for optical study using a polarising microscope, with a split retained for mineral chemical and isotopic studies. Heavy mineral proportions were estimated by counting 200 non-opaque detrital grains using the ribbon method [1]. Identification was made on the basis of optical properties, as described for grain mounts by Mange and Maurer [2].

Clinopyroxene and Garnet Major Element Geochemistry

Major element analyses were acquired by electron microprobe analysis at Aberdeen University using a Link Systems AN10000 energy-dispersive X-ray analyser attached to a Cambridge Instruments Microscan V electron microprobe. The instrument conditions used for the analyses were as follows: accelerating voltage 15 Kv, take-off angle 75 degrees, probe current approx. 3.0 nA (approx. 2.2 nA on cobalt standard), beam diameter approx. 5 microns. Count time was 60 s for clinopyroxene and 30 s for garnet.

Apatite Trace Element Analysis

Apatite geochemistry was carried out in the School of Earth, Ocean and Planetary Sciences at Cardiff University, using a Thermo Elemental X(7) series ICP-MS coupled to a New Wave Research UP213 Nd:YAG 213 nm UV laser. Laser beam diameter was 30 µm and laser repetition rate set at 4 Hz. Helium gas was used for ablation initial transport from the laser cell and this was combined with argon outside the cell as the sample was transported to the ICP-MS. Thermo Elemental Plasmalab time-resolved analysis (TRA) data acquisition software was used with a total acquisition time of 60 s per analysis, allowing about 30 s for background followed by 25 s for laser ablation. Plasmalab was used for initial data reduction with post-processing in Excel. The calibration employed NIST614, NIST612 and NIST610 reference glasses to produce a 4 point (including the

origin) calibration curve. Data were normalised to Ca (55% CaO) and adjusted accordingly. Instrumental drift was monitored by repeat analysis of NIST612 after every 10 unknowns.

Assignation of apatite provenance was based on Sr/Y and light rare earth element (LREE) abundances using the "R" code and supplementary data available in O'Sullivan et al. [3].

Amphibole Dating

Amphibole grains were picked from the heavy mineral residues and were co-irradiated with Fish Canyon sanidine standard for 8 hours at the USGS Triga reactor in Denver. The J-value (0.0018941 +/- 2.77e^{-6}) was calculated based on a Fish Canyon sanidine age of 28.21 Ma [4] that largely removes the c. 0.7% apparent bias between U-Pb and Ar-Ar methods. Samples were run as individual grains because of the possibility of mixed ages. Samples were very small, and not all grains provided sufficient gas to obtain an age. Sample were fused with a CO_2 laser and scrubbed of active gasses with Zr-Al getters. Data were corrected for blanks, mass discrimination and nuclear interferences. Only grains that provided sufficient gas are used in the paper.

Zircon Dating

U-Pb analyses were undertaken using SHRIMP I and SHRIMP RG at The Australian National University in Canberra. The procedures employed for zircon U-Pb dating followed Williams [5] and references therein. The number of scans through the mass stations was limited to four, thereby achieving rapid data acquisition at the expense of some counting precision per analysis. Subjectivity in zircon dating was avoided by analysing all zircons encountered during the traverse of the mount, unless the grain showed evidence of being metamict or otherwise structurally compromised as determined from examination of the reflected and transmitted light photomicrographs and CL images. Normalisation of Pb/U isotopic ratios was achieved by reference to analyses of the AS3 reference zircon (1099 Ma: $^{206}Pb/^{238}U = 0.1589$ [6]). The raw SHRIMP data were processed using SQUID [7], with plots generated using Isoplot/Ex [8]. For zircon areas that are older than approximately 800 Ma, the measured $^{206}Pb/^{204}Pb$ ratios have been used to correct for common Pb and the radiogenic $^{207}Pb/^{206}Pb$ ratio used to calculate the preferred age. For zircon areas that are younger than approximately 800 Ma, correction for common Pb was made using the measured $^{207}Pb/^{206}Pb$ and ratios $^{238}U/^{206}Pb$ ratios, giving a radiogenic $^{206}Pb/^{238}U$ ratio and age following Tera and Wasserburg [9] as described by Williams [5]. For Neoproterozoic and older zircons, when an analysis is more than 20% discordant it has been excluded from the relative probability plots. For the younger zircons, the validity of the radiogenic $^{206}Pb/^{238}U$ age has been determined on the basis of a number of factors, including the amount of common Pb (that is, if the total $^{207}Pb/^{206}Pb$ ratio deviates significantly from concordance on the Tera and Wasserburg plot), the relative concentrations of U and Th, the nature of the area analysed when examined post analysis and the abundance of a particular age grouping. Stacked histogram – relative probability plots of the zircon age populations were plotted using AgeDisplay [10].

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