**ESM1 ANALYTICAL TECHNIQUES**

**Keimoes Suite**

**Whole rock geochemistry**

Major and minor element contents for all representative samples were determined by X-ray fluorescence (XRF) spectrometry at the Council for Geoscience (CGS) in Pretoria. Glass beads were prepared from a 0.2 g sample following a lithium metaborate/tetraborate fusion and dilute nitric acid digestion. Loss on ignition (LOI) was calculated by the weight difference after ignition to 1 000 °C. Powdered whole-rock samples were mixed with flux for a sample-to-flux (lithium tetraborate) ratio of 1 : 10. Thirty-two USGS and GSJ standard reference samples were used for calibration of the instrument.

The trace and rare earth element (REE) abundances were determined using Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) at the Central Analytical Facilities (CAF) at Stellenbosch University following the same procedure as for the whole rock analyses but with a separate 0.5 g split digested in Aqua Regia and analysed by ICP-MS. Fusion disks were prepared for XRF analysis by an automatic Claisse M4 Gas Fusion instrument and ultrapure Claisse Flux, using a ratio of 1 : 10 sample : flux. These were coarsely crushed and a chip of sample mounted along with up to 12 other samples in a 2.4 cm round resin disk. The mount was mapped, and then polished for analysis. A Resonetics 193 nm Excimer laser connected to an Agilent 7500ce ICP-MS is used in the analysis of trace elements in bulk rock samples at CAF, Stellenbosch University. Ablation is performed in HE gas at a flow rate of 0.35 L/min, then mixed with argon (0.9 L/min) and nitrogen (0.004 L/min) just before introduction into the ICP plasma. For traces in fusions, 2 spots of 173 μm are ablated on each sample using a frequency of 10 Hz and 100 mJ energy. Trace elements are quantified using NIST612 for calibration and the percentage SiO2 from XRF measurement as internal standard, using standard sample bracketing. Two replicate measurements are made on each sample. The calibration standard was run every 12 samples. A quality control standard is run at the beginning of the sequence as well as with the calibration standards throughout. BCR-2 or BHVO 2G, both basaltic glass certified reference standards produced by the USGS (Dr Steve Wilson, Denver, CO 80225), is used for this purpose. A fusion control standard from certified basaltic reference material (BCR-2, also from the USGS) is also analysed at the beginning of a sequence to verify the effective ablation of fused material. The precision and accuracy of the results are 2%–5% (1*σ*) for most elements. Detection limits of most trace elements are 0.1 ppm, except for Th and Co (0.2 ppm), Sr (0.5 ppm), Sc and Zn (1 ppm), and V (8 ppm). Most REE have detection limits less than or equal to 0.05 ppm, the exceptions being La and Ce (0.1 ppm), and Nd (0.3 ppm).

Plotting of the geochemical data into various graphs and diagrams was done using IOGAS 64 software and GCDkit version 4.1 (Janoušek et al., 2006).

**Isotope geochemistry**

Rb-Sr and Sm-Nd isotope analysis for the eight Keimoes Suite samples were done at the Department of Geological Sciences, University of Cape Town (UCT). Following concentration analysis, separation of Sr and Nd fractions in the sample dissolutions were undertaken by chromatographic techniques as described by Míková and Denková (2007), after that described by Pin and Zalduegui (1997) and Pin et al. (1994). The Sr fractions were separated using Eichrome Sr resin beds, and the aqueous solution was diluted in 2 mL 0.2% HNO3, ready for Sr isotope ratio determination. The remaining portions were converted to salts, dried down and further dissolved to extract the REEs using AG50W cation resin columns. The REE portions were converted to nitrate, dried down and then diluted in 0.05 M HNO3 to collect Nd using Eichrome Ln resin coluimns. These portions were dried down and diluted in 1.5 mL 2% HNO3 for Nd isotope ratios determination.

The determination of Rb, Sr, Sm and Nd concentrations in each sample was performed on a Thermo XSeries II ICP-MS at UCT following dissolution with concentrated HF and HNO3, and dilution with 5% HNO3 containing an internal standard. Concentrations were determined in duplicate for each sample. The international standard BHVO-2 was analysed with every batch of samples as a measure to assess accuracy and precision.

Sr is analysed as a 200 ppb 0.2% HNO3 solution. All Sr isotope analyses of unknowns are referenced to bracketing analyses of the NIST SRM987 reference standard, using a reference value for 87Sr/86Sr of 0.710255. The international reference material BHVO-2 gave a value of 0.703 490±0.000 015 relative to a value of 0.703 479±0.000 020 reported by Weis et al. (2006). The long-term UCT average is 0.703 479±0.000 022 (*n*=47). All Sr isotope data are corrected for Rb interference using the measured signal for 85Rb and the natural 85Rb/87Rb ratio. Instrumental mass fractionation is corrected using the exponential law and a 86Sr/88Sr value of 0.119 4.

Nd isotopes are analysed as 50 ppb 2% HNO3 solutions using a Nu Instruments DSN-100 desolvating nebuliser. JNdi-1 is used as a reference standard, with a 143Nd/144Nd reference value, with a 143Nd/144Nd reference value of 0.512 115, corresponding to the La Jolla standard (Tanaka et al., 2000). The BHVO-2 reference material gave values of 0.512 981±0.000 010, relative to a value of 0.512 984±0.000 011 reported by Weis et al. (2006). All Nd isotope data are corrected for Sm and Ce interference using the measured signals for 147Sm and 140Ce, and the natural Sm and Ce isotope abundances. Instrumental mass fractionation is corrected using the exponential law and a 146Nd/144Nd value of 0.721 9. The initial 87Sr/86Sr and 143Nd/144Nd ratios were calculated using decay constants of 1.42×10-11 y-1 (Steiger and Jäger, 1977) and 6.54×10-12 y-1 (Begemann et al., 2001), respectively.

Measurements of standards BHVO-2 (Weis et al., 2006) and JNdi-1 (Tanaka et al., 2000) for samples S188, 367 and 815 of the Friersdale Charnockite yielded 143Nd/144 values of 0.512 987±0.000 009 and 0.512 115±0.000 007 respectively. The long-term UCT average for BHVO-2 (*n*=44) is 0.512 985±0.000 015 relative to the value of 0.512 984±0.000 011 (Weis et al., 2006). Sr isotope measurements of BHVO-2 and reference material NIST987 for the same samples yielded 87Sr/86Sr values of 0.704 375±0.000 013 and 0.710 255, respectively. Measurements of standards BHVO-2 and JNdi-1 for samples Me1, Mcol3, Mkn4, Ml5, Mkb6, Mc8, Mkl3 and Mka6 yielded 143Nd/144Nd values of 0.512 981±0.000 010 and 0.512 115±0.000 007 respectively. Sr isotope measurements of BHVO-2 and reference material NIST987 for the same samples yielded 87Sr/86Sr values of 0.704 390±0.000 015 and 0.710 255, respectively.

**Koras Group**

**Whole rock geochemistry**

The methods used to obtain the whole rock geochemistry of samples of the Koras Group are those of Bailie et al. (2012).

Samples of the central and northern domains of the Koras Group were selected for whole rock geochemical analyses. Glass beads were prepared by fusing powdered rock samples in oxidized form into a borate glass using flux containing 50% Li-metaborate and 50% Li-tetraborate with LiNO3 as oxidant. XRF measurements were conducted with a Phillips Magix wave dispersive equipment housed at the University of Johannesburg and controlled by both internal and external standards. Rare earth element abundances and trace element abundances from the same powders were determined using inductively coupled plasma mass spectrometry (ICP-MS) which was done by Acme Laboratories in Vancouver, Canada. Rare earth and refractory elements were determined on a 0.2 g sample using a Lithium metaborate/tetraborate fusion and dilute nitric acid digestion. Loss on ignition (LOI) was calculated by the weight difference after ignition to 1 000 °C. The precious and base metals were determined by ICP-MS following the same procedure as for the REE analyses but with a separate 0.55 g split digested in Aqua Regia.

Plotting of the geochemical data into various graphs and diagrams was done using GCDkit version 4.1 (Janoušek et al., 2006).

**Isotope geochemistry**

The methods used to determine isotopic ratios for the Koras Group samples are from Bailie et al. (2012).

The Nd isotopic compositions of selected samples of the Koras Group were determined at the Research School of Earth Sciences (RSES), Australian National University (ANU), Canberra, Australia using a Finnigan MAT 261 multi-collector thermal ionization mass spectrometer. Single HF/HNO3/HClO4 dissolutions of ~350 mg of whole rock powders spiked with approximately 0.20-0.30 g of Sm-Nd ANU-1 spike were used for measuring Nd isotopic compositions. The 143Nd/144Nd ratios were corrected for fractionation using 146Nd/144Nd=0.721 90 (O’Nions et al., 1977) and normalized to 143Nd/144Nd=0.511 840 for the La Jolla standard. A value of 0.512 638 for 143Nd/144Nd is used in the calculation of chondritic uniform reservoir (*T*CHUR) model ages. For determination of depleted mantle reservoir (DM) model ages the depleted mantle curve of DePaolo (1981) was used. Time *t* (zirc) is taken to be 1 130 Ma for the lower succession based on the U-Pb dating by Mothibi (2016), and 1 100 Ma for the upper succession based on the Pb-Pb zircon ages of Bailie et al. (2012) and Pettesson et al. (2007).

Additional Sr-Nd isotopic analyses fro samples K8. K11, K12, K23 and K37 were run at the Department of Geological Sciences at UCT, using the technique described for the Keimoes Suite granitoids. The BHVO-2 standard, with a measured 143Nd/144Nd ratio of 0.512 984±0.000 011 (Weis et al., 2006), gave a value of 0.512 973±0.000 023 for the analyses. The UCT long-term average is 0.512 987±0.000 019 (*n*=120), and 0.512 980±0.000 012 (GEOREM). Reference standard JNdi-1 (Tanaka et al., 2000) gave a value of 0.512 115±0.000 007. BHVO-2 gave a value of 0.703 493±0.000 014 compared to a measured value of 0.703 479±0.000 020 (Weis et al., 2006). The long-term UCT average Is 0.703 489±0.000 044 (*n*=124, exclude 6). The NIST987 reference gave a value of 0.710 255 for the analyses.

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