

1. Whole rock geochemistry

Whole rock for major, minor and trace element analyses of thirty-two samples were carried out at the Activation Laboratories (ActLabs) (Ancaster, Ontario, Canada), and the results are given in supplementary table 4. A batch system is used for preparation and samples analysis, each batch contains a method reagent blank, certified reference material and 17% replicates. The Alkali fusion method is used to digest samples with 5 g of material. The fusion of samples was done in an induction furnace, using Lithium metaborate/tetraborate. The molten melt is then immediately placed into a 5% nitric acid solution with an internal standard, and it is continually stirred for about 30 minutes or until it is completely dissolved. The selected trace elements are on a combination simultaneous/sequential Thermo Jarrell-Ash ENVIRO II ICP or a Varian Vista 735 ICP. Calibration is performed using 7 prepared USGS and CANMET certified reference materials. The detection limits for the analytical procedure range from 0.01% for the majority of the major elements to 0.001% for TiO₂ and MnO.

2. Whole rock Sm-Nd isotopic data

Sm-Nd isotopic analyses of seven representative samples from the Zgounder Mine Region were also performed at the Activation Laboratories (ActLabs) (Ancaster, Ontario, Canada), and the results are given in table 2. Rock powders were accurately weighed and totally spiked with a known amount of mixed ¹⁵⁰Nd- ¹⁴⁹Sm tracer solution - this tracer is calibrated directly against the Caltech mixed Sm/Nd normal described by Wasserburg et al., (1981). Dissolution occurs in mixed 24N HF + 16N HNO₃ media in sealed PFA Teflon vessels at 160 °C for 6 days. The fluoride residue is converted to chloride with HCl, and Nd and Sm are separated by conventional cation and HDEHP-based chromatography. Chemical processing blanks are < 200 picograms of either Sm or Nd, and are insignificant relative to the amount of Sm or Nd analyzed for any rock sample. Further details can be found in Creaser et al., (1997) and Unterschutz et al., (2002).

The isotopic composition of Nd is determined in static mode by Multi-Collector ICP- Mass Spectrometry (Schmidberger et al., 2007). All isotope ratios are normalized for variable mass fractionation to a value of ¹⁴⁶Nd / ¹⁴⁴Nd = 0.7219 using the exponential fractionation law. The ¹⁴³Nd / ¹⁴⁴Nd ratio of samples is presented here relative to a value of 0.511850 for the La Jolla Nd isotopic standard, monitored by use of an in-house Alfa Nd isotopic standard for each analytical session. Sm isotopic abundances are measured in static mode by Multi-Collector ICP-Mass Spectrometry, and are normalized for variable mass fractionation to a value of 1.17537 for ¹⁵²Sm / ¹⁵⁴Sm also using the exponential law. Using the same isotopic analysis and normalization procedures above. The Geological Survey of Japan Nd isotope standard “Shin Etsu: J-Ndi- 1” (Tanaka et al., 2000) is then analyzed, which has a ¹⁴³Nd / ¹⁴⁴Nd value of 0.512107 ± 7 relative to a LaJolla ¹⁴³Nd / ¹⁴⁴Nd value of 0.511850, when normalized to ¹⁴⁶Nd / ¹⁴⁴Nd = 0.7219. The value of ¹⁴³Nd / ¹⁴⁴Nd determined for the JNdi-1 standard conducted during the analysis of the samples reported here was 0.5121095 ± 7 (2SE). Using the mixed ¹⁵⁰Nd- ¹⁴⁹Sm tracer, the measured ¹⁴⁷Sm / ¹⁴⁴Nd ratios for the international rock standard BCR-1 range from 0.1380 to 0.1382, suggesting reproducibility for ¹⁴⁷Sm / ¹⁴⁴Nd of ~ ± 0.1% for real rock powders. The value of ¹⁴⁷Sm / ¹⁴⁴Nd determined for BCR-1 is within the range of reported literature values by isotope dilution methods. Isotopic ratios of Sm and Nd were measured on a subset of whole-rock powders, and the data is presented in Table 2. More information on the procedure, accuracy and precision of ACTLABS ICP-MS analysis for whole rock and Sm-Nd isotopic analyses can be found at www.actlabs.com.

3. References for section

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