Title: Magnetite geochemistry as a proxy for metallogenic processes: A study on sulfide-mineralized mafic-ultramafic intrusions peripheral to the Kunene Complex in Angola and Namibia
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ESM1

Analytical techniques and settings

Scanning Electron Microscope (SEM)

Thin sections were examined through transmitted and reflected light microscopy and scanning electron microscopy (SEM). Back-scattered electron (BSE) images of the samples and semi-quantitative analyses of the minerals via energy dispersive X-ray spectroscopy (EDS) were obtained using a JEOL JSM IT300 SEM at the Metallurgy Department at the University of Pretoria.

Electron Probe Micro-analyzer (EPMA)

The major element compositions of Fe-oxides were measured using a Cameca SX100 electron probe microanalyzer (EPMA) at the Spectrum Laboratories in the Geology Department of the University of Johannesburg. The instrument settings were as follows: a beam current between 38 and 40 nA, an accelerating voltage constant of 20 kV, and an electron beam size of 2 μm. The Fe- oxides were analyzed for MgO, Al2O3, SiO2, Cr2O3, FeO total, V2O3, CaO, TiO2, MnO, CaO, NiO, and ZnO on their Kα lines, and calibrated using MgO, almandine (Al), diopside (Si), wollastonite (Ca), TiO2, V, Cr2O3, rhodonite (Mn), hematite (Fe), Co, NiO and ZnS (Zn) reference materials (those given by chemical formulae are synthetic; the rest are natural materials). Concentrations of the elements are expressed as oxides assuming common oxidation states. Detection limits were ca. 0.2 mass% and monitored using the Cameca SX100 PeakSight software. High-resolution BSE images were captured during the analyses. The full dataset of analyses is available in Online Resource 2.

Laser Ablation - Inductively Coupled Plasma - Mass Spectrometry (LA-ICP-MS)

The oxides analyzed by EPMA were also analyzed for trace elements using LA-ICP-MS at the Central Analytical Facility of the University of Stellenbosch, using an excimer laser ablation system (Resonetics Resolution S155-LR utilising a Coherent CompexPro 110 laser source emitting at 193 nm), coupled to an Agilent 7700ce quadrupole ICP-MS. Forty-eight isotopes (^{23}Na, ^{24}Mg, ^{27}Al, ^{29}Si, ^{31}P, ^{39}K, ^{43}Ca, ^{45}Sc, ^{49}Ti, ^{51}V, ^{53}Cr, ^{55}Mn, ^{59}Co, ^{60}Ni, ^{65}Cu, ^{66}Zn, ^{69}Ga, ^{73}Ge, ^{75}As, ^{89}Y, ^{90}Zr, ^{93}Nb, ^{95}Mo, ^{105}Pd, ^{118}Sn, ^{121}Sb, ^{139}La, ^{140}Ce, ^{141}Pr, ^{146}Nd, 1^{47}Sm, ^{151}Eu, ^{157}Gd, ^{159}Tb, ^{163}Dy, ^{165}Ho, ^{166}Er, ^{169}Tm, ^{172}Yb, ^{175}Lu, ^{178}Hf, ^{181}Ta, ^{185}Re, ^{195}Pt, ^{197}Au, ^{208}Pb, ^{232}Th, ^{238}U) were analyzed. The trace element data were obtained by single spot analysis using spot sizes between 25 and 40 μm, with a frequency of 6 Hz, a background acquisition time of 20 sec, an ablation time of 40 sec, and a washout time of 25 sec. Ablation was performed using a Laurin Technic S155 dual-volume ablation cell in He that was then mixed in a conical ablation cup into the argon sample gas of the mass spectrometer and N_2 as a make-up gas. The compositions of magnetite containing lamellae/blebs of exsolved ilmenite and spinel were considered to represent the initial oxide composition before subsolidus exsolution (Dare et al. 2012).

The isotope used for internal standardization was ^{57}Fe, assumed to be stoichiometric at 72.4 wt% in magnetite, and according to the average content from EPMA in Cr-Mt (46.5 wt% ^{57}Fe at Ohamaremba) and in Ferritchromite (38.8 wt% ^{57}Fe and 37.4 wt% ^{57}Fe at Ohamaremba and Ombuku South, respectively). The glass NIST610 (Jochum et al. 2011) was used as a calibration standard for As, Pd, Re, Pt and Au. External calibration was provided by BCR-2G for Ga, and BHVO-2G for all other elements (Jochum et al. 2005), with standard bracketing every 15–20 samples. The results for the standards were consistently within 2σ of the average concentrations. BCR-2G was used to monitor the data quality of all the elements, except Ga (for which we used BHVO-2G), and As, Pd, Re, Pt and Au, whose content is reported as informative as a quality control for NIST610 is not available. The data were processed using the reduction software package LADR 1.1.07 (Norris and Danyushevsky 2018).

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