PALEOARCHEAN SPHERULE BEDS IN THE CT3 DRILL CORE FROM THE BARBERTON GREENSTONE BELT, SOUTH AFRICA: GEOCHEMISTRY AND OS ISOTOPIC SIGNATURES

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Introduction: Paleoarchean spherules from the Barberton area have been interpreted as condensation products from impact plumes and molten impact ejecta and/or impact ejecta that were melted during atmospheric re-entry [e.g., 1, 2]. Archean spherule layers (3.2-3.5 Ga) are important to understand the impact history of the early Earth, because no craters related to these events have yet been identified. Two recently recovered drill cores from the northern Barberton area (CT3 and BARB5) with as many as 20 spherule layer intersections of Paleoarchean age significantly enhance the number of known spherule beds and provide an outstanding opportunity to gain new insight into the early terrestrial impact bombardment. This study focuses on the CT3 drill core, from the northeastern part of the Barberton Greenstone Belt (BGB), with not less than 17 spherule layer intersections. Some of these spherule beds might be correlated to the well-known spherule horizons, or represent tectonic duplication. Therefore, we performed detailed petrographic and, to identify possible meteoritic components, bulk geochemical and Os isotope analyses.

Methods: In the CT3 drill core seventeen spherule layers and thirty-five country rock layers (mostly shales and cherts from the Fig Tree group) occur in the core depth range between 7 and 150 m. All samples were cut, thin sectioned, and the compositions of 69 sub-samples of about 150 mg were determined by instrumental neutron activation analysis [3]. Osmium isotopic investigation of selected spherule layer samples and spherule-free country rocks were performed using about 500 mg homogenized sample powders that were digested in reverse aqua-regia at ~240°C and ~130 bar for 12 h in a high pressure asher. Osmium was then separated by solvent extraction [4] from reverse aqua-regia into CCl_4 and back extracted into HBr, followed by micro distillation [5]. Isotope measurements were undertaken using a Thermo Finnigan TRITON thermal ionization mass spectrometer operating in negative mode. All analyses were performed at the Department of Lithospheric Research at the University of Vienna, Austria.

Results: Chromium, Co, and Ni abundances are on average higher in the spherule layer samples than in most of the spherule-free country rock intercalations. Notably, the concentration bimodality between spherule layers and country rocks is mirrored by significantly less radiogenic $^{187}Os/^{188}Os$ values in the spherule horizons (typically at near-chondritic values) compared to country rock samples, which exhibit significantly more radiogenic $^{187}Os/^{188}Os$ ratios that are comparable to upper continental crustal values (up to ~1.3).

Discussion: Spherules are divided into two groups by their shapes (undeformed and deformed), and have sizes ranging from 0.5 to 2.5 mm. The main mineralogy is of secondary origin and includes fine-grained phyllosilicates, K-feldspar, oxides, carbonates, and sulfide minerals. According to textural and compositional features, at least within one interval, tectonic duplication has been detected. Similar to the results obtained for the BARB5 drill core (see companion abstract by Schulz et al.), the analyzed CT3 samples (including spherule-free country rock and spherule layer samples) show a good correlation between the abundances of Cr and Ir. These values overlap with those of the other spherule layers (e.g., S1 to S4) from the Barberton area that have been confirmed to be of impact origin [e.g., 6, 7]. Only a few samples from the CT3 drill core have Cr and Ir values that exceed the highest concentrations measured for the S1 to S4 layers [7]. In the absence of ultramafic lithologies in the CT3 drill core (which could obscure a meteoritic component), the near-chondritic ^{187}Os isotopic signatures in the spherule beds, with crustal values in the country rock intercalations, might support an impact origin. Based on our preliminary data, no definite conclusion can be drawn regarding the nature of the impactor(s), although chondrites might be preferable in the light of the element and isotope trends presented here. A clear assessment of possible tectonic duplications and relations to known impact layers has to be undertaken before a meaningful reappraisal of the Paleoarchean meteorite flux and its possible relation to an extended late heavy bombardment (LHB) can be drawn [8].

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