PETROGRAPHY OF ARCHEAN SPHERULE LAYERS FROM THE CT3 DRILL CORE, BARBERTON GREENSTONE BELT, SOUTH AFRICA

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Introduction: Archean spherule layers (SL; 3.47-3.2 Ga; S1 to S8 [1]) in the Barberton Greenstone Belt (BGB) in South Africa are considered the earliest evidence of large impacts onto Earth. Spherules in these layers are thought to be molten impact ejecta and condensation products from impact plumes, or ejecta from impact craters that were melted during atmospheric re-entry [2, 3]. In drill core CT3 from the northeastern BGB, not less than 17 SL intersections with densely packed, sand-sized, and rounded or - when deformed - elongated spherules have been investigated over a stratigraphic interval of 150 m. The SL are intercalated with black or brownish shale and laminated chert. SL in the BGB have been extensively modified due to sedimentary, diagenetic, alteration, and metamorphic processes. In addition, the core interval in question shows extensive evidence for mechanical alteration, due to compaction and localized shearing [4]. One of the questions to be addressed in this core is about the actual number of impact events represented by these many SL. We have carried out a comprehensive study of sedimentary, petrographic, and chemical characteristics of the SL in drill core CT3.

Methods: The CT3 core interval of interest for this work was logged in great detail. Petrographic characterization of SL included determination of the sizes, shapes and types of individual spherules, as well as the bulk mineralogy by X-ray diffraction. Thin sections were studied by transmitted and reflected light microscopy, scanning electron and cathodoluminescence microscopy, and chemical information was obtained by µ-X-ray fluorescence spectrometry (see companion abstract by Hoehnel et al. [5]).

Results: All 17 SLs are pervasively altered to a K-feldspar, phyllosilicate, siderite, dolomite/ankerite, quartz, Ti- and Fe-oxide, and apatite assemblage. Ti-oxides always form rims around spherules and are rarely found inside a spherule. In addition, carbonaceous material is present in all SL groundmasses and along spherule rims. Secondary sulfide mineralization increases with depth. Primary signatures include spherule size, round shapes, crystallization textures, and the presence of Ni-Cr spinel – and occasionally some zircon grains obviously derived from the target(s). The 0.3-2.6 mm sized spherules were categorized into six types: 1. completely recrystallized spherules with secondary K-feldspar, phyllosilicate, or zoned compositions; 2. spherules including central or marginal vesicles – sometimes with collapsed rims; 3. spherules containing randomly or radially oriented fibrous and micro-lath-dominated textures of K-feldspar; 4. spherules completely filled with Ti- and Fe-oxides or Ni-Cr-spinel, or where Ti- and Fe-oxides form rims around spherules; 5. deformed and sheared spherules; and 6. interconnected spherules. Type 6 has not been described before. Vesicles within spherules are filled with phyllosilicate masses resembling the overall groundmass, or they are filled with calcite and dolomite/ankerite. Fluorapatite crystals occur in some spherules that are otherwise completely replaced by phyllosilicate. Presence of relict primary textures such as detrification textures, or fibrous and radial growth textures provide strong evidence for quenching of melt. SL 15 around 144,4 m depth represents a unique, 15 cm long, size-sorted deposit with gradation of spherule sizes, which is indicative of settling of fallout through a water column. The host rocks and soft sedimentary structures suggest a deep-water depositional environment in the Fig Tree Group of the Barberton Supergroup [2]. Considering the question about how many impact event(s) this SL suite represents, depending on which aspects of the core one considers most important (core intervals with SL; similar spherule material; layering; etc.), one can group the 17 SL intersections into 3 to 12 packages - each corresponding to possible impact events. It is possible that SL 1 and SL 2; SL 3 and SL 4; SL 8 and SL 9, and SL 16 and SL 17 belong together. In addition, SLs 16/17 show inverse sorting of spherule sizes, which might represent duplication of SL 15. It is hoped that detailed trace element analysis of these layers might be able to shed further light on this intriguing, multi-layer situation.

References: [1] Lowe D. et al., 2014. Geology, 42:747-750. [2] Johnson, B.C. & Melosh, H.J., 2014. Icarus, 228:347-363. [3] Mohr-Westheide T. et al., 2015. Geology, 43:299-302. [4] Hofmann A. & Harris C., 2008. Chem. Geol., 257:224-242. [5] Hoehnel D. et al., companion abstract, 79th Ann. Meet. Meteorit. Soc., Berlin.