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Early terrestrial impact events: Archean spherule layers in the Barberton Greenstone Belt, South Africa

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In addition to the oldest known impact structure on Earth, the 2.02-billion-year-old Vredefort Structure in South Africa, the evidence of Early Earth impact events are Archean spherule beds in South Africa and Australia. These spherules have been interpreted as condensation products from impact plumes and molten impact ejecta or/and impact ejecta that were melted during atmospheric re-entry [e.g., 1,2]. The 3.2-3.5 Ga spherule layers in the Barberton Greenstone Belt in South Africa currently represent the oldest known remnants of impact deposits on Earth. Aiming at identification of extraterrestrial components and to determine the diagenetic and metamorphic history of spherule layer intersections recently recovered in the CT3 drill core from the northeastern part of the Barberton Greenstone Belt, we have studied samples from these layers in terms of petrography and geochemistry.

All samples, including spherule layer intersections and intercalating country rocks, were studied for mineral identification by optical and electron microscopy, as well as electron microprobe analysis (EPMA) at Natural History Museum Vienna and Museum für Naturkunde Berlin (MfN). Major and trace element compositions were determined via X-ray fluorescence spectrometry at MfN and instrumental neutron activation analysis (INAA) at University of Vienna. Os isotopes were measured by thermal ionization mass spectrometry (N-TIMS) at University of Vienna.

Eighteen spherule beds are distributed over 150 meter drill core in CT3. Spherules are variably, deformed or undeformed. The high number of these layers may have been caused by tectonic duplication. Spherule beds are intercalated with shale, chert, carbonate, and/or sulfide deposits (country rocks). The size range of spherules is 0.5 to 2 mm, and some layers exhibit gradation. Shapes of spherules differ from spherical to ovoid, as well as teardrops, and spherules commonly show off-center vesicles, which have been interpreted as a primary characteristic pointing toward an impact origin [3]. Mineralogical and petrographic studies indicate that most of the mineralogy of the spherule layers is secondary due to secondary overprint by alteration and metamorphism. The mineral assemblages comprise quartz, K-feldspar, various muscovite types, phyllosilicates, Mg-siderite, Ti/Fe-Ti oxides, sulfides such as pyrite, pyrrhotite, chalkopyrite, sphalerite, and galena. INAA data show that some spherule layer intersections have extremely high siderophile element contents, with up to 1.60 wt% Ni, 0.69 wt% Cr, 0.05 wt% Co, 2.06 ppm Ir and 0.02 ppm Au, which is considered extraterrestrial component. This is further supported by their chondritic to slightly supercondritic 187Os/188Os ratios (ranging from 0.11 to 0.19), contrasting more radiogenic values of the spherule layer intercalations in comparison to country rocks, and Os concentrations up to $\sim$4312 ppb.

References: [1] Artemieva, N.A., and Simonson, B.M., 2012, LPSC 43, abstract #1372. [2] Johnson, B.C., and Melosh, H.J., 2014, Icarus, 228, 347-363. [3] Glass, B.P. and Simonson, B.M., 2012, Elements 8, 15-60.