MICRO-XRF ANALYSIS OF ARCHEAN SPHERULE LAYERS AND HOST ROCKS FROM THE CT3 DRILL CORE, BARBERTON GREENSTONE BELT, SOUTH AFRICA

D. Hoehnel[1,2], R.Tagle[3], A. Hofmann[4], W.U. Reimold[1,5], T. Mohr-Westheide[1,6], J.Fritz[7], and U. Altenberger[2]; [1]Museum für Naturkunde – Leibniz-Institut für Evolutions- und Biodiversitätsforschung, Invalidenstrasse 43, 10115 Berlin, Germany, E-Mail: Desiree.Hoehnel@mfn-berlin.de; [2]Univ. Potsdam, Institut für Erd- und Umweltwissenschaften, Karl-Liebknecht-Strasse 24-25, 14476 Potsdam-Golm, Germany; [3]Bruker-Nano GmbH, Am Studio 2D, 12489 Berlin, Germany; [4]Dept. of Geology, Univ. of Johannesburg, Johannesburg, RSA; [5]Humboldt-Univ. zu Berlin, Unter den Linden 6, 10099 Berlin, Germany; [6]Freie Univ. Berlin, Institut für Geowissenschaften, Malteserstrasse 74-100, 12249 Berlin, Germany. [7]Saalbau Weltraum Projekt, 64646 Heppenheim, Germany.

Introduction: Archean spherule layers (SL) from 3.47-3.2 Ga old marine metasediments of the Barberton Greenstone Belt (BGB) in South Africa [1] and similar layers from the Pilbara craton in West Australia, are regarded as the oldest known remnants of large impacts onto Earth. Study of these Archean SL is currently the only way to obtain a better understanding of the impact history of the early Earth. Spherules are interpreted as condensation products from impact plumes, molten impact ejecta or as ejecta from impact craters that were melted during atmospheric re-entry [2]. After deposition the SL and host sediments were extensively modified by sedimentary, diagenetic, and metamorphic processes and experienced significant tectonic folding [3]. One of the major questions regarding the Archean SL concern the number of individual impact events represented by them (also see companion abstract by Hoehnel et al. [4]). Samples for this study are derived from the CT3 drill core, obtained in the course of exploration activity in the northeastern part of the BGB. The core contains not less than 17 SL intersections in the first 150 m depth interval.

Methods: SL and host rock samples were studied with the Bruker M4 Tornado micro-XRF scanner, a micro-X-ray fluorescence spectrometer (µ-XRF) with a focused X-ray beam supplied by a Rh anode operated at 50 kV, for non-invasive high-spatial resolution (< 25 µm) scans. X-ray elemental maps of all samples were generated for Si, Al, Fe, Ca, K, Mg, Ti, Mn, P, S, Cr, Zn, Ni, and As.

Results: The SL and their host rocks (laminated chert, black and carbonate bearing shale) can be easily distinguished by their significant differences in elemental distribution maps. The black and the carbonate-bearing brown shales are both enriched in Fe, Ca, Mg, and Mn. They mainly differ in their variable Fe and Ca concentrations with black shale being enriched in Fe and carbonate-bearing shale enriched in Ca. Laminated chert contains a high concentration of Si and minor As. Millimeter-thin laminae in a zone between and perpendicular to chert layers show similar element concentrations as those found for the black and carbonate-bearing shales and can be interpreted as secondary fracture fills.

SL are composed mainly of Si, Al, K, Mg, Ti, with minor contributions from P, Cr, Ni, and As. Silicium, Al and K are mainly concentrated within the spherules and are related to K-feldspar. Iron and other siderophile elements such as S, Zn, Cr, and Ni are mostly concentrated in the groundmass between spherules. Calcium and Mg are rarely concentrated within spherules, they are predominantly concentrated in the matrix. Titanium always occurs as narrow rims around spherules, together with Fe. Manganese occurs generally in the groundmass between spherules and within former vesicles, and in the host rocks. Phosphorous is always associated with Ca and, thus, points to the presence of fluorapatite. Sulfide mineralization increases with depth in the core and appears to be of secondary origin, likely related to hydrothermal overprint. A spatial correlation between Cr and Ni is characteristic for the occurrence of Ni-Cr-spinel in and near SL. Nickel without Cr association but with S is observed in some thin bands with secondary mineralization. Zinc concentration is frequently observed next to Cr and Ni-rich layers and likely relates to secondary overprint.

One major result of this study is that locally elemental distribution maps show layering and indicate distinct folding at the centimeter scale that had been recognized neither by visual inspection of the core nor by petrographic thin section analysis. Detailed micro-chemical characterization by non-invasive µ-XRF scanning provides a first-order spatial distribution of many elements in rock samples and allows lithological distinction and process interpretation at a scale between mesoscopic core logging and microscopic textural and mineralogical analysis.

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