Early bombardment of earth and the absence of $\Delta^{17}O$ anomalies from 3.8 Ga apatite from Isua, Greenland

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Thanks to the heroic efforts of Apollo Astronauts to return lunar samples to Earth and to the research of geochemists, it is known that intense, repeated, catastrophic impacts on the Moon ended at 3.8 Ga. Search for evidence of extraterrestrial impacts in Early Archean Earth rocks correlated with the time of lunar "late heavy bombardment" has met with mixed results. Direct evidence is lacking because ancient craters have been erased by Earth's active plate tectonics. The discovery of tungsten isotope anomalies in ca. 3.8 Ga metamorphosed sediments from the Isua Greenstone Belt, Greenland, and of chromium isotope anomalies in 3.2 Ga micro-spherule beds from Barberton Mountain Land, South Africa, demonstrates the existence of geochemical signatures of impacts in Archean rocks. Oxygen isotope anomalies carried by meteorites may be preserved in terrestrial deposits associated with early bombardment. The present study was motivated by the availability of apatite samples from ca. 3.8 Ga banded iron formation from the Isua Supracrustal Belt, Greenland. Analyses of REE suggest that apatites are of primary, sedimentary origin, a potential host for ^{17}O anomalies (Lepland et al., 2002). It cannot be excluded, however, that the amphibolite-facies metamorphism of Isua may have erased isotope anomalies through dilution.

The slope and intercept of a linearized $\delta^{17}O$ vs. $\delta^{18}O$ plot for 44 samples of orthophosphate is 0.527 ($\pm$0.008) and -0.046‰ ($\pm$0.045), respectively, extending over a range in $\delta^{18}O$ from -18 to $+20$‰ with an R^2 of 0.9975. The same values for a linear regression of 24 samples (excluding Isua) are 0.527 and -0.035. These comparisons, together with measured values of $\Delta^{17}O$ demonstrate that no contribution from meteorite impactors can be seen in the oxygen isotope composition of Isua apatite.

Reference

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Enrichment features and significances of Ag and dispersed elements in the ores in the Huize Carbonate-hosted Zn–Pb–(Ag–Ge) District, Yunnan, China

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The Huize district is a typical representative in the Sichuan–Yunnan–Guizhou metallogenic region, and contains three deposits which are overlain by Upper Sinian and Palaeozoic rocks. The ore minerals are dominated by galena, sphalerite, and pyrite, with minor chalcopyrite and hopeite. Gangue minerals mainly are calcite and dolomite, with minor barite, gypsum, and quartz. Concentrations of these elements typically are Ag (up to 200 ppm); Ge (up to 81.34 ppm); Cd (up to 488.0 ppm); In (up to 2.55 ppm); Ga (up to 1.93 ppm); and Tl (up to 11.85 ppm). Silver and dispersed elements in the major ore minerals are unevenly distributed. The contents of Ag are the highest (76–144 ppm) in galena and are associated with Tl and Cd, as well as a minor Ge. Sphalerite mainly contains Cd, Ge, and Ag and trace amounts of In, Ga, and Tl. The different varieties of sphalerite contain different concentrations of Ge and Ag. The early-phase sphalerite has the highest concentrations of Ge and Cd (Ge: 115 to 178 ppm; Cd: 770–1048 ppm), and higher concentrations of Ag (18–67 ppm). Concentrations of Ge and Ag in the late-phase sphalerite range from 1–88 ppm to 6–35 ppm, respectively. Pyrite contains mainly Tl and Ag. The first early-stage pyrite contains low concentrations of Tl and Ag (Tl: $<$1.61 ppm; Ag: $<$6.4 ppm); the second- and third-stage pyrites contain high concentrations of Tl and Ag (up to 3234 ppm Tl and 17.14 ppm Ag). In summary, galena is the major carrier of Ag, and a partial carrier of Tl and Cd; sphalerite is the major carrier of Ge and Cd and a partial carrier of Ag, In, and Ge. The second- and third-stage pyrites are the major carriers of Tl and a partial carrier of Ag.

According to Titley (1996) and the unique geological characteristics of Huize deposits, the deposits can be classified as deformed carbonate-hosted MVT-type deposits.

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Reference

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