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Search of paleo-atmospheric signatures in impactites from the 380 Ma-old Siljan impact structure (Sweden)

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The 380 Ma-old Siljan impact structure in Sweden is the largest one recognized in western Europe (50-65 km) [1-5]. Planar deformation features (PDFs) in quartz can be used to estimate shock pressures recorded in shocked rocks from the structure. The lowest pressures (2 to 5 GPa) are recorded near the margin of the structure's central plateau, while the highest pressure of up to 20 GPa occurs at the center [4-5]. PDFs are occasionally decorated with fluid inclusions, such as in Siljan samples [4-5], thus, offering the opportunity to evaluate if decorated PDFs-bearing quartz grains record the composition of fluids circulating in the impact structure shortly after the impact. If this is the case and if the fluid shows an atmospheric signature, such samples could be considered as paleo-atmospheric proxies.

We measured the elemental and isotopic composition of noble gases (Ne, Ar, Kr, Xe) contained in a set of samples from Siljan previously investigated [4-5]. This approach enabled us to track the origin of the fluid contained in fluid inclusions and to compare PDF-rich and PDF-free samples.

The isotopic composition of neon reflects a mixing between atmospheric and nucleogenic neon. Argon presents excesses in radiogenic ^{40}Ar. For xenon, $^{124-131}$Xe/^{130}Xe ratios are air-like but excesses in ^{134}Xe and ^{136}Xe isotopes are present due to spontaneous fission of ^{238}U. For most samples, relative elemental abundances of noble gases fall between those of Air and Air Saturated Water. For one sample located at the crater center, enrichments in heavy noble gases relative to light ones may be related to the influence of a sedimentary component. Overall, no clear relationship can be established between the relative abundance of PDFs in samples and their elemental or isotopic signatures for noble gases. Future studies of noble gases contained within shocked quartz crystals from other impact structures will unveil if such samples are suitable paleo-atmospheric proxies.

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