Shock devolatilization of terrestrial impactites: Loss of fluid inclusions due to impact processing

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While impacts provided the flux of materials needed for planetary accretion, shock processing may have significantly reduced the volatile content of early planetismals. Fluid inclusions, which are abundant in terrestrial rocks, have only been observed in a few meteorites. In the past, the apparent lack of fluid inclusions has ben interpreted as a lack of fluids on the parent body. However, recent experiments demonstrate that low to moderate shock pressures can effectively erase any evidence of fluid inclusions (Elwood Madden et al 2004).

This research investigates the effects of impact processing on fluids trapped in planetary materials by examining fluid inclusions in terrestrial impactites. Samples of crystalline basement rocks (granitic rocks and gneisses that experienced varying degrees of shock metamorphism) were collected from the Ries Crater and sedimentary rocks (Coconino Sandstone) were collected from Meteor Crater. Each lithology was then analyzed to determine its degree of shock-metamorphism and the percentage of quartz grains with fluid inclusions.

In both the crystalline basement and sedimentary rocks, fluid inclusions were abundant in quartz grains within samples that contained no shock features. Rocks containing planar fractures also contained fluid inclusions. Fluid inclusions were not observed, however, in samples with shock lamellae and diaplectic impact glass or in samples of partially melted Ries Crater crystalline basement rocks. However, fluid inclusions were observed within quartz grains entrained in glass in melted samples of Coconino Sandstone.

The correlation between shock and loss of fluid inclusions, plus examples of planar fractures offsetting solid inclusions, indicate volatiles trapped in fluid inclusions were lost from the rocks as a result of moderate shock deformation. This suggests that impact processing may lead to the loss of fluid inclusions and devolatilization of planetary materials.

Reference

Elwood Madden M.E., Horz F., and Bodnar R.J., (2004). Can. Min. 42, 1357-1367.

Oceanic temperatures recorded by the isotopic compositions of Precambrian cherts?

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"*The world's oldest sedimentary rocks are cherts*" [1]. As discovered by Knauth and Lowe [2] the least metamorphosed Precambrian cherts exhibit a regular increase in their $\delta^{18}O$ since 3.5 Gyr. that they attributed to the progressive cooling of the oceans.

Likely Precambrian cherts formed by the direct precipitation from seawater of amorphous silica, later transformed in micro quartz during sedimentary burial. As attested by the wide range of $\delta^{18}O$ for a given geological *formation*, the original isotopic signature of the amorphous silica may not be preserved during this transformation. Indeed, several isotopic exchange processes can modify the $\delta^{18}O$ of silica after its oceanic precipitation.

Since it is firmly established that all exchanges yield a decrease in $\delta^{18}O$, it has been proposed that the highest $\delta^{18}O$ values can be used as a proxy for oceanic temperatures. However it cannot be ruled out that cumulative post-depositional isotopic effects have progressively erased the original isotopic compositions of the cherts. Accordingly, the thermometric validity of oxygen isotopes in Precambrian cherts is considered by many workers as an open issue.

Cherts are made of silicon and oxygen (SiO_2). If an oxygen isotopic exchange took place between chert and water during diagenesis, its counter part for silicon isotopes can be evaluated. To try to make progress in this debate, we have measured the $\delta^{18}O$ and $\delta^{30}Si$ at a micrometer scale with the 1270 Ion-microprobe in some of the Precambrian cherts having the highest known $\delta^{18}O$. We will show that (i) $\delta^{30}Si$ correlates with the highest $\delta^{18}O$ and that (ii) this correlation can be used to discuss the paleotemperatures of the archean oceans.

References

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