EVALUATING THE USE OF DECOMPOSED ZIRCONS FOR THE IDENTIFICATION OF IMPACT AND AIRBURST GLASSES

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Introduction: The identification of impact/airburst glass objects can be challenging due to the existence of many other glasses produced on the Earth's surface, magmatic or not [1,2]. Evidence of their origin can be recorded in the glass for the presence of geothermometers, such as decomposed zircon. Zircon ($ZrSiO_4$) decomposes forming baddeleyite (ZrO_2) and silica (SiO_2), typically with a coronitic rim (Fig. 1), at temperatures that exceed the ones normally reached by magmatic and metamorphic processes (except for fulgurites) on the Earth's surface (~1670°C) [3]. This work aims to test the reactivity of zircons at lower temperatures (≤ 1000 °C), achievable with other common geological processes, in the presence of an alkaline-rich environment.

Materials and methods: A homogeneous batch of zircon crystals has been put in condition to react in the presence of NaCl and caliche soil from the Atacama Desert, Chile (composed almost exclusively of gypsum, $CaSO_4$ $2H_2O$), and a combination of the two. The experiments were conducted in a silica vessel, in dry conditions, at 800, 900, and 1000 °C, at P = 1 bar, for 6 hours, and exposed to air. We characterized the mineralogy of the rims resulting from the experiments using Field Emission Gun Scanning Electron Microscopy (FEG-SEM) coupled with Energy Dispersive Spectroscopy (EDS), Raman spectroscopy, and Transmission Electron Microscopy (TEM) on thin foils prepared using Focused ion beam (FIB).

Results and discussion: At T = 900 - 1000°C, in the combined presence of caliche and NaCl, zircons decomposed forming the coronitic rims. The mineralogy of the experimental rims was investigated using Raman and TEM. At 1000 °C the rims are made of baddeleyite (ZrO_2) + Ca_2SiO_4; at 900 °C the rims are made of another ZrO_2 polymorph, i.e. cubic zirconia, hosting 10% of CaO in the crystal structure. Partial decomposition forming baddeleyite was also documented in experiments with only NaCl at 1000 °C.

The formation of decomposed rims in an alkaline-rich environment shows how reagents like NaCl and caliche can act as fluxes, i.e. they lower the temperature at which decomposition ideally occurs. The use of NaCl and caliche has been chosen referring to the case of the so-called Pica glass. Pica glass is a surface glass layer found in the Atacama Desert, in Chile, whose formation has been attributed to fire propagation in salt-rich and silica-rich plants soil litter [4] or airburst event [5]. One of the arguments supporting the latter is the occurrence in the glass of decomposed zircons (whose formation is attributed to T > 1670 °C). With our experiments, we reproduced the conditions expected in such a fire within salt-loaded soil, such as the one found in the Atacama Desert, at T ≤ 1000 ℃.

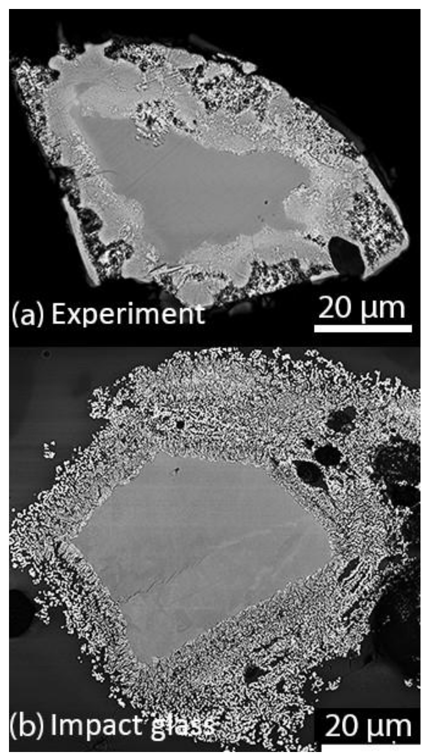

Figure 1 – Backscattered images of decomposed zircons: (a) resulting from one experiment at 1000 °C, in the presence of caliche and NaCl, composed of baddeleyite + Ca_2SiO_4; (b) from the Aouelloul impact glass [6].

Conclusion: The experiments successfully reproduced the decomposition of zircons to baddeleyite with coronitic texture and mineralogy similar to natural ones but at conditions less extreme than the ones expected (T ≤ 1000 °C), which are achievable with other common processes on the Earth's surface. Therefore, decomposed zircons cannot be used as unequivocal evidence for the identification of impact and airburst glasses.

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