DOES REIDITE FORMATION RESET U-Pb AGES: DIRECT MEASUREMENTS FROM ROCHECHOUART IMPACT STRUCTURE.

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Introduction: Shock effects in zircon have great potential to yield information about impact cratering events, including through their use as geo- barometers, thermometers, and chronometers. Previous isotopic work [1] has not been able to directly and exclusively sample natural reidite, the high-pressure polymorph of zircon, because it is most commonly found in nanometer-sized lamellar form. Reidite has recently been discovered at Rochechouart impact structure (~207-204Ma) in large quantities, and in previously unknown massive forms by Plan et al. [2]. While reidite was once considered extremely rare, it has been found at more impact structures in recent years. Therefore, understanding the geochemical changes associated with the zircon-reidite transformation during impact events has the potential to not only increase our understanding of small-scale impact processes in general but also to lead to new dating techniques.

Samples and Methods: The Chassenon suevitic breccia at Grosse Piece quarry within the Rochechouart impact structure, previously reported to contain significant reidite, was sampled for this work. Thin sections were made and polished to 0.5µm for BSE imaging on a JEOL JXA-8530F electron microprobe at Arizona State University (ASU). BSE imaging contrast, large-area WDS mapping, and EDS spots were used to identify potential reidite. Thin sections were then polished for 3 hours with 60nm colloidal silica on a vibratory polisher. Grains suspected of containing reidite were confirmed using Raman spectroscopy and selected for diffraction and fabric analysis using EBSD on a Zeiss Auriga FIB/SEM at ASU. EBSD analysis followed established protocol for shocked zircon (ex:[3]). EBSD data processing was limited to the removal of wild spikes.

Four grains containing sections of massive reidite (at least 10µm in size) were cut from thin sections using a wire saw, then mounted together with AS3 age standards using Buehler EpoxiCure 2. No further polishing was done on the epoxy mount. These grains were confirmed to contain reidite using Raman spectroscopy. The CAMECA ims-1290 SIMS instrument at UCLA was used to obtain U-Pb isotopic information. To monitor common Pb, ^{204}Pb was measured, and a correction using San Diego sewage common Pb composition was applied. In situ AS3 age standards were analyzed throughout the session, then used to calibrate the dataset.

Results: All reidite-bearing grains were initially recognized as such from the contrast of BSE images. Reidite was found in sub-micron wide parallel sets of lamellae, <5 µm granules, <5 µm blades, <10 µm wedges, and massive areas greater than 10 microns in size (as described by Plan et al. 2021).

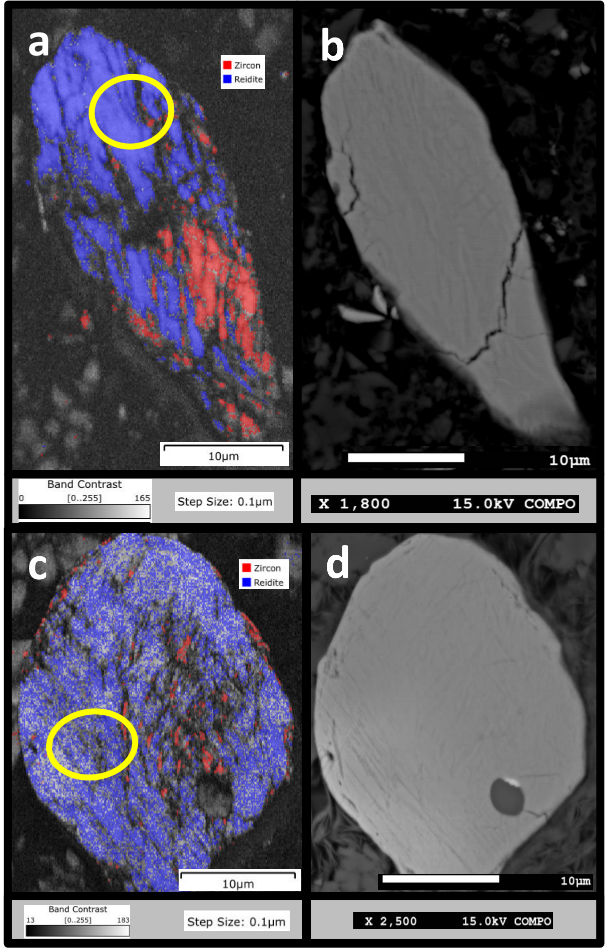

Figure 1. EBSD phase maps and BSE images of targeted grains, with locations of SIMS analyses shown in yellow circles. (a-b) Z3R1, (c-d) Z2R3

Four zircon grains were analyzed for ^{238}U, ^{235}U, ^{207}Pb, and ^{207}Pb. Eleven spots were analyzed, targeting reidite, zircon, and combinations of both phases. Nine of the spots had <81% radiogenic ^{206}Pb. Grain-mounted AS3 standards were also analyzed during the session and showed no significant common Pb. Common Pb did not significantly decrease as the analysis pits got deeper.

Two spots (Z2R3 and Z3R1) had 81.64% and 84.68% ^{206}Pb, respectively. Locations of the SIMS pits were determined from SEM images and overlayed on EBSD maps of the transformed zircons (Fig. 1). Both analysis spots were placed almost entirely on reidite. A concordia plot from these spots shows concordant ages (Fig 2).

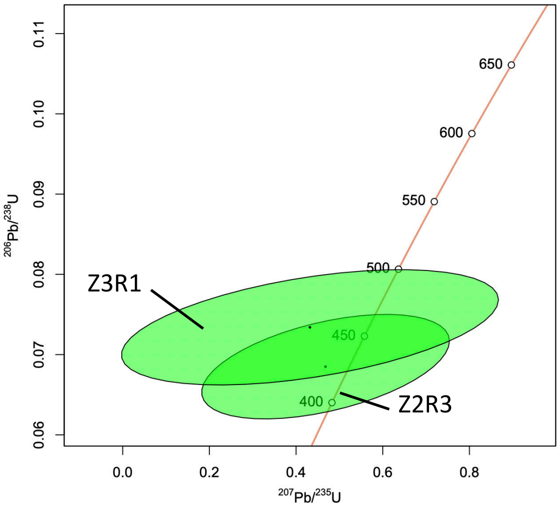

Figure 2. Concordia diagram for SIMS analyses

Discussion: The reidite microstructures observed in our samples are very similar to those described by Plan et al. 2021. EBSD orientation analysis of our reidite indicates relatively few orientation variants. More work is necessary to determine the full range of zircon -reidite orientation relationships.

The very high common Pb content of these grains is confounding. The nearly uniform measured common Pb over the course of each individual analysis indicates that it is not surface contamination. This is supported by the lack of common Pb measured from the in-situ standards. The high common Pb concentrations were measured from both phases individually as well as from combinations of the two, and zircons from target rocks do not show such high common Pb, so incorporation during initial formation of the zircon is unlikely. This is also supported by the not-unusual common Pb composition of the region [4]. Other U-Pb analyses of shocked zircon from Rochechouart [1] did not report such anomalously high common Pb. However, these studies did not analyze impact-formed reidite, so a detailed comparison with our results is difficult. Common Pb incorporation during reidite formation is possible and must be further considered.

These are the first known direct analyses of massive natural reidite. These preliminary results do not indicate partial or complete resetting of the U-Pb system caused by the transformation of zircon to reidite. Previous U-Pb measurements from zircon grains containing nm-wide reidite lamellae [1] found relatively concordant and un-reset ages, but the fraction of reidite in the zones was <5%.

Atom Probe work by Montalvo et al. [5] has shown enrichment of trace elements at zircon-reidite boundaries of lamellar reidite, indicating that some short-range diffusion does occur during reidite formation, but this study did not report any spatial enrichment or depletion of U or Pb.

A lack of U-Pb resetting, as seen in Z3R1 and Z2R3, would support an interface-controlled growth of reidite rather than a diffusion-controlled reaction, but more microstructural data is needed to confidently draw such a conclusion. This data aligns with results from experimentally synthesized reidite [6], which shows no statistically significant U-Pb resetting. More work is necessary to understand the mechanisms and implications of the zircon-reidite transformation reactions.

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