GRANULAR TITANITE IN GRANITOID FROM THE ROTER KAMM CRATER- A PRODUCT OF REGIONAL METAMORPHISM, NOT METEORITE IMPACT

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Introduction: Accessory minerals with granular texture are ideal geochronological tools for U-Pb dating of meteorite impact events. Granular texture results from recrystallization during post-impact heating; the polycrystalline microstructure typically consists of neoblasts that expel radiogenic Pb, and are thus ideal for age dating. Granular zircon and monazite have been demonstrated to preserve impact ages [1,2,3], however few dating studies have been conducted on granular titanite. We report granular textured titanite from ~2020 Ma granitoid basement rock in the rim of the 4-5 Ma Roter Kamm impact structure, Namibia. Orientation mapping by electron backscatter diffraction (EBSD) identifies two distinct titanite populations: one defined by strained/deformed grains, and the other defined by granular grains consisting of strain-free neoblasts. *In situ* U-Pb geochronology shows that most grains from both populations yield U-Pb ages of ca. 1025 Ma, consistent with formation during the Mesoproterozoic Namaqua Orogeny. An older age component of ca. 1875 Ma is preserved in some strained grains. None of the titanite grains record the 2020 Ma crystallization age previously established from zircon in the same sample [4], and no age-resetting related to the 4-5 Ma Roter Kamm impact event was detected. The granular texture and near-complete Pb-loss in Roter Kamm titanite record a Paleo- to Mesoproterozoic polymetamorphic history, rather than Miocene age shock-related processes, despite the similarity of the granular microstructure to other minerals with established impact provenance. These results highlight the potential for misinterpreting inherited microstructures as impact-related phenomenon in target rocks with a complex geological history.

Sample/Methods: The 2.5 km diameter Roter Kamm crater formed 4-5 Myr ago [5,6]. Titanite grains were analyzed from a sample of Roter Kamm granite from the crater rim that yielded a zircon U-Pb age of 2020±35 Ma [4]. EBSD analysis and laser ablation inductively coupled plasma mass spectrometry (LAICPMS) U-Pb dating of titanite was performed in the John de Laeter Centre at Curtin University.

Results: Two types of titanite were identified. Granular titanite grains consist of unstrained neoblast aggregates that preserve oscillatory zoning (Fig. 1). Most grain boundaries for adjacent neoblasts are >10°, and form triple junctions. Strained titanite grains (non-neoblastic) preserve complicated internal zoning patterns, and some have $\{\bar{1}11\}$ lamellar twins [7].

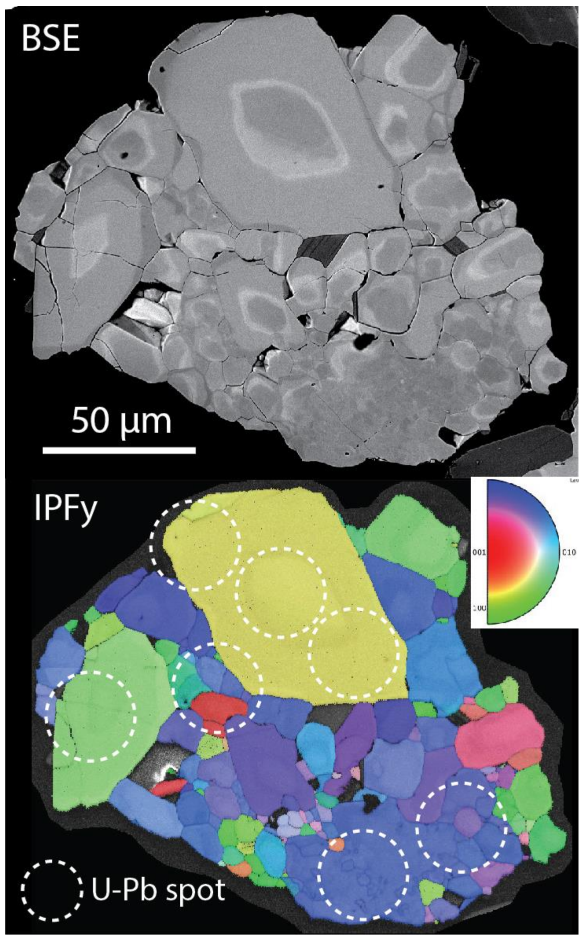

Figure 1. Granular titanite grain in Roter Kamm granite. Top: Backscattered electron image, showing polycrystalline microstructure, with oscillatory zoned neoblasts. Bottom: Orientation map (inverse pole figure, IPFy), showing neoblast orientations and U-Pb analysis spots.

Results (cont.): LAICPMS U-Pb data for neoblastic titanite grains (n=12) and strained grains (n=16) yields overlapping ages of 1047±12 Ma (n=85, MSWD = 22) and 1032± 9 Ma (n=72, MSWD = 21), respectively (Fig. 2). A minor age component of 1819±75 Ma (n=4, MSWD = 4) is preserved in some strained grains, but not in neoblastic grains.

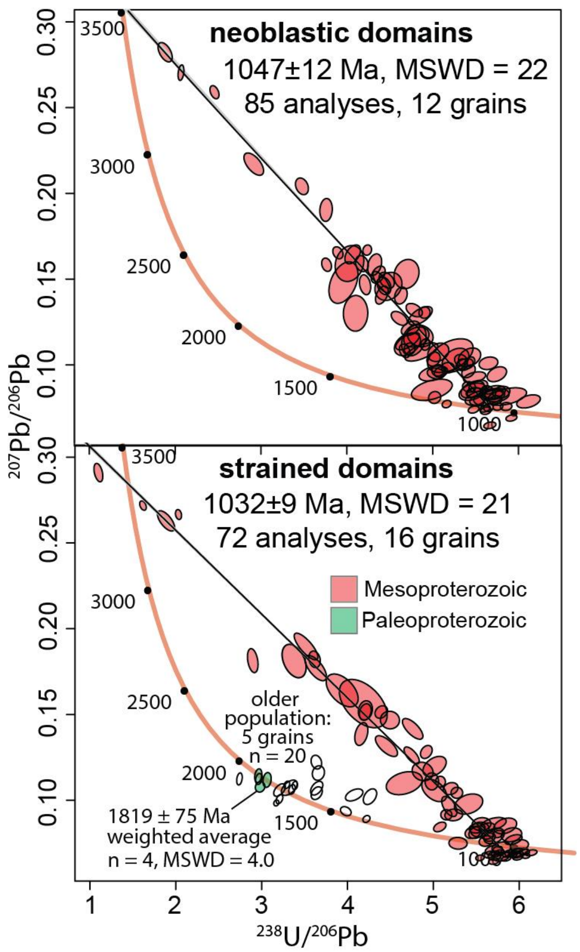

Figure 2. LAICPMS U-Pb results for titanite in Roter Kamm granite. Top: data from neoblastic domains. Bottom: data from strained (non-neoblastic) domains.

High-density LAICPMS analysis of two large titanite grains yielded one with a unimodal age population of 1014±28 Ma (n=103, MSWD = 5.9), and the other with a bimodal age population, including a dominant younger domain of 984±19 Ma (n=63, MSWD = 6.3) and a minor older age component of 1875±31 Ma (n=22, MSWD = 0.9).

As for other minerals, no planar microstructures were identified in quartz, and no kink bands were found in biotite. EBSD mapping of 238 zircon grains identified no anomalous deformation features.

Discussion: Two examples of granular titanite from impactites have been previously reported [8,9], both from the 1850 Ma Sudbury impact structure in Ontario, Canada [10]. In both cases, U-Pb dating demonstrated that the Sudbury granular textured titanite record U-Pb ages suggesting formation during processes that significantly post-date the impact event. In contrast, age data presented here show that the granular titanite aggregates from the Roter Kamm granite formed in the Mesoproterozoic, which significantly pre-dates the impact; the granular microstructure is thus inherited, and unrelated to the 4-5 Myr old Roter Kamm crater-forming event.

The absence of ca. 2020 ages [4] among the titanite analyzed (Fig. 2) indicates that titanite either formed after igneous crystallization, or was pervasively age-reset. The 1875 Ma age domains in some strained grains are the oldest ages determined, and record formation of titanite during Paleoproterozoic metamorphism, likely associated with the 1910-1860 Viooldrif magmatic suites [4,11]. The ca. 1000-1050 Ma ages in all grains records the event which triggered some grains to recrystallize into neoblasts, and reset U-Pb ages in nearly all grains. The Mesoproterozoic ages are attributed to the waning phase of the amphibolite-to-granulite facies ca. 1200-1000 Ma Namaqua Orogeny [4,12].

No definitive evidence of shock deformation was identified in the Roter Kamm granite. The $\{\bar{1}11\}$ lamellar twins identified in some strained titanite grains were also found in shocked granitoid from the Chicxulub peak ring that experienced 16-18 GPa shock conditions [7]. Given the absence of planar features in quartz, the titanite $\{\bar{1}11\}$ twins in Roter Kamm granite either formed at conditions below that which form planar features in quartz (e.g., < 5 GPa), or they are formed earlier, and are unrelated to impact processes.

References:

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