MONAZITE, CRICHTONITE, AND AESCHYNITE IN THE CHICXULUB IMPACT CRATER PEAK RING.

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Introduction: A recent drilling into the peak ring of the K-Pg Chicxulub impact structure recovered granitic basement lithologies with zircon U-Pb crystallization ages between 315 and 330 Ma [1,2] and an average shock metamorphic overprint of 17±1 GPa [3]. This study reports the first descriptions of monazite-(Ce), crichtonite-group, and aeschynite-group minerals from the Chicxulub impact crater with implications for their petrogeneses.

Samples and Methods: I used the JEOl JXA-8530F electron microprobe at ASU to generate X-ray intensity maps for petrographic thin sections from 27 samples of granitic basement rocks of the Lower Peak Ring section [747–1335 meters below sea-floor (mbsf)] in the IODP-ICDP Expedition 364 drillcore M0077A [4]. Quantitative wavelength dispersive spectrometry analyses were performed after confirming the presence of all major and minor cations in the targeted minerals. Monazite analyses followed a modified analytical protocol of [5] using the Probe for EPMA software, including the calculation of (U,Th)-Pb ages.

Results: Monazite occurs as a strongly fractured, 20 µm grain intergrown with allanite and epidote in a granite sample at 1201.3 mbsf, and as a strongly fractured, 60 µm grain in the granite portion of a sample at 952.75 mbsf, ca. 2 cm distance to an impact melt vein. A cluster of euhedral, 5 µm to 30 µm monazite grains in cataclased aplite dike sample at 1196.61 mbsf is associated with allanite, epidote, and thorite. Well preserved, 50 to 170 µm monazite-(Ce) crystals were only found in aplite dike sample at 875.68 mbsf; they are associated with epidote and exhibit two to three sets of planar fractures. EMPA spot analyses indicate compositions of $(Ce_{0.26–0.38}Th_{0.16–0.33}U_{0.01}Pb_{0.00–0.01}Y_{0.03–0.05}La_{0.11–0.20}Ca_{0.04–0.08}Pr_{0.03–0.04}Nd_{0.13–0.17}Sm_{0.03–0.05}Gd_{0.02–0.04}Dy_{0.01})_{\sum 1.02–1.14}(P_{0.69–0.87}Si_{0.11–0.26})_{\sum 0.91–0.98}$ and crystallization ages of 315 Ma ± 13 Ma (2σ, n=11) for monazite in an aplite dike at 875.68 mbsf.

Crichtonite-group minerals have been found in 3 samples (875.68, 916.9, and 111.52 mbsf). Crichtonite $[Sr_{0.58–0.62}(La_{0.07–0.08}Ce_{0.08–0.10}Dy_{0.10–0.11}Pb_{0.09–0.10})_{\sum 0.35–0.37}Ti_{13.28–13.52}Fe_{5.79–6.03}Mn_{0.77–0.84}(V_{0.07–0.09}Si_{0.03–0.21}Ca_{0.04–0.08}Sc_{0.34–0.41}Na_{0.04–0.07}Al_{0.05–0.19}Mg_{0.00–0.15}Zn_{0.21–0.22})_{\sum 0.85–1.28}O_{38}]_{n=3}$ occurs in two samples, where the fractured 15 µm crystals are associated with chlorite and titanite; crushed, 10 to 30 µm grammacioliite-(Y) $[(Pb_{0.26–0.52}Sr_{0.23–0.38}U_{0.00–0.02})_{\sum 0.62–0.89}(Y_{0.14–0.32}Mn_{0.22–46}La_{0.00–0.06}Ce_{0.04–0.19}Pr_{0.00–0.03}Nd_{0.02–0.09}Sm_{0.01–0.04}Ca_{0.26–0.61}K_{0.01–0.09}Zr_{0.00–0.06})_{\sum 1.04–1.40}(Ti_{13.25–13.75}Zn_{0.13–0.24}V_{0.04–0.25}Al_{0.07–0.18}Nb_{0.03–0.06}Na_{0.04–0.09}Si_{0.07–0.42}Fe^{2+}_{1.59–2.05}Fe^{3+}_{3.59–4.39})_{\sum 20\ Total \sum 21.93–22.06}]_{n=8}$ displays up to 3 sets of planar fractures in one sample.

Aeschynite-group minerals $[(Ca_{0.35–0.47}Th_{0.06–0.20}U_{0.04–0.09}Y_{0.02–0.08}La_{0.02–0.03}Ce_{0.13–0.19}Pr_{0.02–0.04}Nd_{0.11–0.20}Sm_{0.02–0.04}Eu_{0.00–0.01}Gd_{0.01–0.02}Dy_{0.00–0.02}Er_{0.00–0.01})_{\sum 1.03–1.17}(Nb_{0.60–0.79}Ta_{0.01–0.04}Ti_{0.75–0.93}Si_{0.30–0.41}Fe^{3+}_{0.13–0.29}Mn_{0.01–0.01}Na_{0.00–0.06}Cl_{0.01–0.10})_{\sum 2.13–2.26\ Total \sum 3.19–3.31}]_{n=34}$ occur in aplite dike sample 875.68 mbsf as euhedral, fragmented, altered and likely hydrated 10 to 150 µm crystals with allanite and rutile that contains up to 2.4 wt% Nb and 0.4 wt% Ta. Their Ce# and Nb# [6] indicate compositions of aeschynite-(Nd), aeschynite-(Ce), and nioboaeschynite-(Nd).

Discussion: The accessory minerals described here occur well preserved in a few samples of pegmatite and aplite dikes that were emplaced in close temporal association with their host granite [1,2] ~315 Ma ago. Crichtonite has only been described from late-magmatic stage mineralizations tied to tensile fissures and metasomatism [7,8]; grammacioliite-(Y) can crystallize at ~400 °C under metamorphic conditions [9]; this may indicate formation in shrinkage cracks that were exploited as pathways for granitic melt, pneumatolytic and hydrothermal fluids. Brittle fracturing of monazite, crichtonite, grammacioliite-(Y), and aeschynite suggests these phases experienced shock metamorphism during the Chicxulub impact. Because crichtonite and aeschynite-group minerals typically form as secondary minerals, they are evidence for the localized metasomatic and hydrothermal alteration of the granitic Chicxulub peak ring rocks prior to the impact 66 Ma ago. Alteration of aeschynite-group minerals may be tied to the hydrothermal system that was triggered by the Chicxulub impact [10]. Metasomatic and hydrothermal mineral assemblages that predate the impact complicate the interpretation of impact-related hydrothermal mineral assemblages and add complexity to the interpretation of radioisotopic disturbances in mineral chronometers in Chicxulub Lower Peak Ring granitic rocks.

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