DATING THE ARAGUAINHA IMPACT STRUCTURE WITH THERMOCHRONOLOGIC METHODS

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Introduction: Currently, only about 30% of the terrestrial impact structures have been dated with a precision < 10%. The main geochronological methods used are U-Pb on zircon and ⁴⁰Ar-³⁹Ar chronology, applied specially to impact melted lithologies and to neformed minerals (e.g., [2, 3]). The challenge to obtain good ages increases for eroded structures, with no preserved impact melt, glass, or rocks and minerals completely isotopically completely reset due to the impact event. In such instances, thermochemical methods might offer an alternative for dating impact structures. Thus, we have employed fission track and (U-Th)/He methods to test their applicability to obtain ages for the Araguainha impact structure, in comparison with the ages previously obtained.

The 40 km-wide Araguainha impact structure is centered at 16°47'S and 52°59'W and is one of six proven impact structures in Brazil. This eroded and complex impact structure consists of an about 6 km-wide central uplift of crystalline basement, surrounded by Devonian to Early-Triassic sedimentary rocks of the Paraná Basin sequence.

Previous dating was carried out by [4] with the K-Ar method on K-feldspar from shocked granite, obtaining a 283.6 ± 17.2 Ma age for Araguainha. The ⁴⁰Ar-³⁹Ar method was employed by [5], who obtained ages of 245.5 ± 3.5 and 243.3 ± 3.0 Ma for impact melt rock. U-Th-Pb dating of different minerals was conducted by [6], producing an age of 254.7 ± 2.5 Ma. They discussed the similarity of this age to that of the P-Tr boundary mass extinction.

Methods: Our methods included sampling and petrographic characterization, concentration of heavy minerals, handpicking and mount preparation, and thermochemical analysis. The samples were from the granitic basement and the sedimentary units (from bottom to top: Furnas, Ponta Grossa, Aquidauana, and Group Passa Dois formations). Mineral concentration procedures comprised rock crushing, sieving, and magnetic and heavy liquid separation. Selected only zircon grains with the necessary characteristics for thermochemical analysis. One sample was selected for (U-Th)/He analysis, whereas ten samples were analysed by the fission track method. The samples were collected between 1.5 and 83 km from the center of the Araguainha structure (the distal sample to provide background data).

For (U-Th)/He analysis the zircon grains were analysed according to the procedures described by [7]. About one hundred grains per sample were mounted, polished, and etched for fission track analysis. Then densities of fossil tracks were measured for a target of individual grains. Furthermore, samples were analysed by LA-ICP-MS to determine the U concentration in the same area where the fossil tracks were counted, and the age was estimated according to [8].

Results and Discussion: During the impact cratering process, the fission track and (U-Th)/He systems could be reset directly by a pulse of impact-related heating, or indirectly by uplift and subsequent steps of crater formation. The ages obtained by (U-Th)/He analysis from ten zircon grains ranged from 187.4 ± 2.7 to 262.6 ± 3.9 Ma, yielding a mean age of 222.9 ± 17.4 (2σ) Ma. Among the three basement samples analysed by the fission-track method, two presented ages of 236 ± 36 and 290 ± 64 (2σ) Ma, overlapping with the age of 254.7 ± 2.5 Ma proposed by [6]. Seven sedimentary samples yielded ages well above the reference age, in general between 500-700 Ma, which we tend to relate to the original crystalization of these zircons.

Conclusions: The ages reported here bracket the age of the Araguainha impact obtained previously. They were obtained from samples of the basement rocks exposed at the central uplift, where the highest temperatures were attained during the impact event. Regarding the level of erosion estimated by [9] to 250 to 350 m, our results are generally in agreement, also with respect to numerical models developed by one of the authors (MACV).

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