High-resolution U-Pb chronology of ancient martian zircons

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Mars offers a unique possibility to study terrestrial planet-formation processes given its relatively simple geologic history as a stranded planetary embryo as well as the wealth of information from martian meteorites and spacecraft exploration. The discovery of ancient martian zircons suggest that crust formation on Mars may have occurred by 4,428±50 Ma, perhaps contemporaneously with the formation of Earth's first crust [1]. However, the large uncertainty on the age of the martian zircons limits our knowledge of the tempo of crust formation on Mars, which precludes a meaningful comparison with Earth and the Moon.

We report on a systematic search for zircons from the NWA 7034 martian meteorite aimed at identifying grains suitable for concomitant high-resolution U-Pb chronology, REE determinations as well as ^{176}Lu-^{176}Hf and ^{92}Nb-^{92}Zr systematics using solution-based methods. Approximately 10 g of material was crushed, sieved, processed through a magnetic separator and, finally, concentrated using heavy liquids. A total of ~70 zircons were extracted from which a subset of 24 zircons were selected for U-Pb age determination by thermal ionization mass spectrometry. Their sizes ranged from ~30 to ~100 μm and they were found to represent different morphologic types, including irregular anhedral pieces, euhedral with well-defined faces and a flat prismatic shape and, finally, rounded in shape. Common to all of them was the general absence of fractures and inclusions, as well as any evidence for radiation damage. We obtained meaningful and mostly concordant U-Pb ages for 19 individual zircons, returning ^{207}Pb/^{206}Pb ages ranging from 4476.3±0.9 Ma to 4429.7±1.0 Ma. The better than ten-fold improvement in precision allows us to establish that zircon production occurred in multiple igneous events over ~45 Myr. Eight zircons define an age cluster at ~4475 Ma, which is significantly older than the age of ~4430 Ma inferred from earlier studies [1,2]. One concordant zircon from this population records an age of 4476.3±0.9 Ma and, as such, represents the oldest directly dated material from Mars. This age is ~100 Myr older than the oldest dated terrestrial zircons [3], implying that the record of crust formation on Mars is much older than that on Earth. Thus, these zircons provide a unique window into the earliest history of the planet.

[1] Humayun, M. *et al.* (2013) *Nature* **503**, 513. [2] McCubbin, M. *et al.* (2016) *JGR* **121**, 2120 [3] Whitehouse M.J. *et al.* (2017) *Gond. Res*. **51**, 78.