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Ancient Pb and Ti mobilization revealed by Scanning Ion Imaging

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Zircons from strongly layered early Archean ortho- and paragneisses in ultra-high temperature (UHT) metamorphic rocks of the Napier Complex, Enderby Land, East Antarctica are characterized by complex U-Th-Pb systematics [1,2,3]. A large number of zircons from three samples, Gage Ridge, Mount Sones and Dallwitz Nunatak, are reversely discordant (U/Pb ages older than 207Pb/206Pb ages) with the oldest date of 3.9 Ga [4] (for the grain from Gage Ridge orthogneiss). To further investigate this process, we utilized a novel high spatial resolution Scanning Ion Imaging technique on the CAMECA IMS 1280 at the Natural History Museum in Stockholm. Areas of 70 μm x 70 μm were selected for imaging in mono- and multicollection modes using a $\sim$2 μm rastered primary beam to map out the distribution of 48Ti, 89Y, 180Hf, 232Th, 238U, 204Pb, 206Pb and 207Pb. The ion maps reveal variable distribution of certain elements within analysed grains that can be compared to their CL response. Yttrium, together with U and Th, exhibits zonation visible on the CL images, Hf shows expected minimal variation. Unusual patchiness is visible in the map for Ti and Pb distribution. The bright patches with enhanced signal do not correspond to any zones or to crystal imperfections (e.g. cracks). The presence of patchy titanium is likely to affect Ti-in-zircon thermometry, and patchy Pb affecting 207Pb/206Pb ages, usually considered as more robust for Archean zircons.
Using the WinImage program, we produced 207Pb/206Pb ratio maps that allow calculation of 207Pb/206Pb ages for spots of any size within the frame of the picture and at any time after data collection. This provides a new and unique method for obtaining age information from zircon. These maps show areas of enhanced brightness where the 207Pb/206Pb ratio is higher and demonstrate that within these small areas (μm scale) the apparent 207Pb/206Pb age is older, in some of these patches even > 4 Ga. These data are a result of ancient Pb mobilization, which is independent of the degree of metamictisation, oxygen isotope and REE content of the zircons [5].
The Antarctic zircons experienced ancient Ti and Pb mobilization and redistribution, most likely caused by polyphase metamorphism at $\sim$2.8 Ga and $\sim$2.5 Ga, the latter documented as reaching temperatures of >1100ºC [5].

References:
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