Loss of U during laser-heated single-aliquot hematite (U-Th)/He dating

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Single-aliquot dating of iron-oxides has been used to quantify the time-scales of lateritic weathering, fault activity, and the development of soils and paleosols. Iron-oxide samples must be heated to ~1000°C to completely degas He, but they lose U at high temperatures. Vasconcelos et al. (2013) showed that goethite is fully degassed >900°C and loses U at 1100°C.We performed the same experiments on hematite to determine whether heating parameters (temperature, time) exist that simultaneously extract all He without U loss. We used four hematite samples, which have reproducible two-aliquot (U-Th)/He ages between 770 Ma and 1760 Ma.

Aliquots wrapped in Pt or Nb packets were heated with a diode laser and temperature was measured with a pyrometer. Each aliquot of the same sample was degassed at a different temperature between 680°C and 1200°C for 6 min. About 5% of the total helium is extracted at 680°C. More gas is extracted at increasingly higher temperatures, with 50% helium release at 1050°C and complete degassing at ~1100°C. The U concentration is constant from 680°C to 1000°C. Heating above 1000°C caused the U concentration to decline, with a complete loss of U at 1050-1100°C.

Since the samples did not have completely homogeneous U and Th concentrations, we expressed the results in terms of age. The age of aliquots degassed at 680°C is about 5-10% of the age of the sample due to incomplete He extraction. At 1000°C the ages of all samples are 40-50% of the age of the sample. Ages of aliquots degassed >1000°C are 2-8 Ga, reflecting increasing U loss. This shows that the temperatures necessary to completely degas He in these hematite samples are larger than the temperatures at which U is full retained.

In a different experiment, we degassed aliquots at 950°C for between 6 min and 6 h. Longer heating times lead to increasing U loss, but still showed incomplete helium extraction.

Based on these results, we suspect that U and/or Fe is volatilized. As hematite is heated, reduction of Fe^{3+} causes phase changes. Further reduction might possibly yield elemental Fe, which is soluable in Pt and Nd. We are currently investigating the use of sapphire tubes to contain samples during degassing to prevent direct contact between the sample and metal and to possibly capture any volatilized U or Th.

Vasconcelos et al. (2013), Geochimica et Cosmochimica Acta 117, 283-312.