Cangas: self-healing protective covers that inhibit the erosion of deeply weathered banded iron-formations

Paulo Vasconcelos[1], Hevelyn Monteiro[1], Kenneth Farley[2], Carlos Spier[3]

(1) The University of Queensland, Brisbane, Austrália.
(2) California Institute of Technology, Pasadena, EUA.
(3) BHP Billiton, PO Box 22, Leinster, 6437, Western Australia

Weathering profiles overlying banded iron-formations (BIF) are among the oldest preserved surfaces exposed on Earth. These profiles are generally deep, reaching up to 400-500 m, and they are composed of friable hematite and weathered BIF at depth. The profiles are generally overlain by goethite-cemented iron-caps (canga) at the surface, particularly on the highest elevation plateaus formed by weathered BIFs. The contact between the canga blankets and the underlying weathered BIF is sharp and identifiable by an abrupt change in color and induration. Invariably, the cangas are more strongly cemented than the underlying friable weathered BIF and are more resistant to erosion. When cangas are removed, the underlying weathered profile is rapidly incised and eroded. $^{40}Ar/^{39}Ar$ dating of supergene Mn-oxides suggests that the weathering profiles have undergone a history of continuous exposure exceeding ca. 60 Ma. If this geochronological evidence is correct, the longevity of exposure of these weathering profiles requires a protective mechanism that effectively prevents the erosion of the underlying weathered BIF. To test whether the canga blankets are as old as the underlying weathering profiles and whether they offer the protective cover necessary to inhibit the erosion of the underlying BIF, we dated goethite cements in cangas by the (U-Th)/He method.

(U-Th)/He dating of 50 goethite grains, extracted from 10 canga samples collected at various depths (0.2-5 m) in weathering profiles overlying BIFs in the Quadrilátero Ferrífero, Minas Gerais, Brazil, reveals predominantly young results. The geochronological data show a large number of ages ranging from 18.3 ± 1.8 to 10.4 ± 1.0 Ma (n=8) and a prominent population ranging from 9.9 ± 1.1 and 0.40 ± 0.04 Ma (n=38). Several grains (up to 8) analyzed from a single hand specimen show good internal reproducibility (e.g., seven grains from sample Pic-06-25A show average age of 7.7 Ma and standard deviation of 1 Ma), suggesting that the results record reliable precipitation ages. Some grains, however, yield older results. For example, grain /7 from sample Pic-06-25A yields a questionable apparent age of 1492 Ma. The much higher ^{4}He content for this grain and evidence for incomplete dissolution in HCl during U and Th analysis reveal the presence of hematite, suggesting that older results reflect the presence of hypogene inclusions.

The predominantly young (U-Th)/He ages for the Quadrilátero Ferrífero canga samples suggest three possibilities: goethite grains in cangas undergo ^{4}He loss due to solar heating or bush fires; cangas are relatively young features in the landscape; or cangas undergo repeated dissolution-reprecipitation throughout their evolution. Young results obtained for samples at the surface (ca. 0.2 m) and for samples at depth (ca. 5m) suggest that He loss by solar heating or bush fires is unlikely. The presence of reproducible ages in excess of 10 Ma for several grains from the same sample, free of any visible contaminants, attests to the relative longevity of cangas. Therefore, we interpret the preponderance of young results as suggestive that cangas undergo repeated dissolution-reprecipitation throughout their history. We infer from our field and petrographic observations and the (U-Th)/He results that cangas derive from the progressive reductive dissolution of magnetite and hematite and previously precipitated goethite and from the local reprecipitation of newly formed goethite, resulting in a continual renewal of the weathering profile at the near-surface environment. This long-term process provides a resistant self-healing protective cap that prevents the erosion of the underlying friable weathered BIF.