(U-Th)/He apatite constraints on the erosional history of the southwestern Colorado Plateau and implications for Early Tertiary uplift and carving of a "proto-Grand Canyon"

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Resolving the timing and relationships between regional unroofing, canyon incision, and topographic uplift in continental plateaus is a challenging problem. The regional unroofing history of the Colorado Plateau, and its relationship to Grand Canyon incision (up to 1.5 km) and plateau uplift (~1.9 km) since the Late Cretaceous, is controversial. We used (U-Th)/He apatite thermochronometry (36 samples, 230 single-grain analyses) across the southwestern quadrant of the Colorado Plateau to address these issues. Our data document overall southwest to northeast unroofing from plateau margin to plateau interior, during denudation phases in the Late Cretaceous/Early Tertiary (80 to 55 Ma), mid Tertiary (28 to 16 Ma), and Late Tertiary (<6 Ma). Distributions of apatite dates modeled using the radiation damage trapping model [1,2] suggest that eastern Grand Canyon samples from the basement and the Kaibab surface nearby had similar Early to mid-Tertiary thermal histories, despite their ~1500 m of stratigraphic separation. If these models are correct, they indicate that a significant (≥ 1000 m deep) paleo-Grand Canyon was carved in post-Paleozoic sediments in this region during Early Tertiary time. Evidence for kilometer-scale topographic relief would require substantial uplift during Sevier/Laramide time, preceding regional unroofing of this portion of the plateau interior. Although the data do not preclude additional post-Laramide uplift, the subsequent regional unroofing phases could be explained by drainage reorganization associated with rift-related lowering of adjacent regions without additional elevation gain of the plateau.

References

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A Comparison of the elemental composition of Wild 2 grains with other extraterrestrial materials

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NASA's Stardust spacecraft passed through the dust coma of Comet 81P/Wild 2 at a speed of ~6 km/s in January 2004, collecting dust particles in low-density silica aerogel and as impact residue in craters in Al-foil. These samples, which were delivered to Earth on January 15, 2006, provided the first opportunity to analyze material from the Kuiper Belt, the presumed source of short–period comets like Wild 2. The elemental compositions of twenty-three particles captured in aerogel and the residue in seven craters in Al-foil were determined during the Stardust Prelimnary Examination (Flynn *et al.*, 2006). The results were generally consistent with the more limited elemental composition data obtained on grains from Comet 1P/Halley, an Oort cloud comet, which were analyzed by impact-ionization mass spectrometers on the Giotto and VEGA spacecraft which flew through the Halley coma in 1986.

To first-order, the mean elemental composition of the Wild 2 particles agrees with the composition of the CI carbonaceous meteorites, which are believed to represent the initial composition of the Solar System, for the refractory elements. However the Fe/Si ratio is somewhat lower than CI in the Wild 2 particles. In addition, S is depleted relative to the CI abundance and several moderately-volatile minor elements (Cu, Zn, Ga, and Ge) are enriched in the Wild 2 samples over the CI meteorite abundances.

Both the depletion of Fe and the enrichment of moderately-volatile elements were previously reported in the fine-grained, anhydrous IDPs, some of which have inferred atmospheric entry speeds suggesting a cometary origin (Brownlee *et al.*, 1993). The CI meteorite element abundances are taken to represent the Solar Nebula composition for non-volatile elements because of the good agreement between CI abundances and the composition of the Solar photosphere, measured by spectroscopy. These preliminary results on the Wild 2 material suggest that the outer region of the Solar Nebula, where comets such as Wild 2 are believed to have formed, may have contained higher concentrations of some moderately-volatile elements and lower Fe than the inner region of the Solar Nebula, where the meteorites formed. Alternatively, since the abundances of Cu, Zn, and Ga are not well-determined in the Solar photosphere, it is possible that abundances of these elements in the Wild 2 particles and the anhydrous IDPs may better reflect the composition of the Solar Nebula for these moderately-volatile elements than does the composition of the CI meteorites.

References

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