Muddying the waters: Quaternary incision of the Grand Canyon, USA

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Atlantic Geology, 2009, Volume 45, Number 1

The 150 year controversy regarding the incision history of the Grand Canyon (GC) has been rejuvenated with the recent application of numerical modeling and geochronological techniques developed in the last 20 years. Rates of incision based on fill terraces and incised basalt lavas reveal that the western GC (60 ± 20 mm/ka, uncertainty reflects range) has incised faster than the eastern GC (150 ± 20 mm/ka), possibly due to the inhibiting effect of subsidence by normal faulting in the western reach. However, these rates are too slow to have carved the entire canyon since the 6 Ma integration of the Colorado River over the Kaibab Plateau.

Cosmogenic nuclide exposure dating of canyon cliffs is used, for the first time, to directly measure stream incision rate. Twenty-seven samples collected from River Mile 75 (Shinumo Quartzite, eastern GC) and 229 (Vishnu, western GC) were analyzed for ^{10}Be in quartz using AMS. The ^{10}Be production rate was adjusted for reductions in cosmic ray flux by topographic shielding and foreshortening on the dipping sampled surfaces. Ages range from 12.1 ± 1.2 ka to 208 ± 22 ka (1σ internal + external error). The corresponding apparent incision rates range from 5500 to 95 mm/ka. Most of sampled surfaces were varnished fracture faces but some exhibited stream polishing. Using the data to delimit a maximum age-elevation relationship, which removes young ages (high incision rates) due mainly to block falls long after the river incised past the surface, we established the incision history of the two locations. At River Mile 75 (eastern GC) the rates range from 406 to 95 mm/ka over 209 ka (n = 6). At River Mile 229 (western GC) the rates range from 441 to 316 mm/ka over 60 ka (n = 4). The average incision rates are 270 and 372 mm/ka at eastern and western GC, respectively. These rates are higher than rates determined by other methods and do not support previous observations that the rate of Quaternary incision was faster in eastern GC. Additional samples currently being processed from higher on the cliff walls may help rationalize the disparity.