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Cliff-top boulders on coastal platforms at Little Beecroft Head, southeast Australia – Holocene tsunami deposits or ancient relics of platform weathering?

David Fink (1), Ann Felton (2), Adam Switzer (3), and Keith Crook (2)

(1) Institute for Environmental Research, Australian Nuclear Science and Technology Organisation, Sydney, Australia(fink@ansto.gov.au), (2) School of Earth Sciences, Australian National University, Canberra, Australia, (3) Earth Observatory of Singapore, Nanyang Technological University, Singapore

Coastal cliffs are widely held to be geologically young features undergoing fast erosion, resulting in surface ages of a few tens to perhaps hundreds of years. It follows that boulders resting on cliff-top platforms must also be young, driving the view that cliff-top boulders found on headlands along the southeast Australian coast were emplaced by Holocene tsunami overwash. A limiting factor in quantifying the temporal evolution of these features has been the lack of numerical dates that constrain surface ages of cliff-top platforms and associated boulders. In this study we apply the technique of in-situ cosmogenic surface exposure dating with 10Be and 26Al to determine the ages of coastal landforms along the south-eastern perimeter of the Australian continent relating to a study of long-term denudation rates and the origin of these boulders. The site lies at an elevation of approximately 32 m above present mean sea level at the south-east end of Little Beecroft Head south of Wollongong. Previous studies have concluded that these quartz sandstone boulders, $\sim$ 1x1 m, thickness $\sim$35 cm, positioned $\sim$2-3 m from the cliff edge, were deposited at LBH following detachment and transport during a wash-over event capable of overtopping the headland and transporting clasts landwards.

Our 10Be and 26Al cosmogenic exposure ages of these remnant cliff-top boulders and the platform upon which they sit demonstrates that these features are ancient remnants of formerly overlying strata and products of long-term erosion. Simple (zero-erosion) exposure ages range from $\sim$260ka to $\sim$340 ka whilst the contemporary platform has an apparent exposure age of $\sim$145 ka. Corresponding 26Al exposure ages are concordant with 10Be ages indicating no prolonged period of burial or partial cover by sediment. Old boulders resting on young platforms can be explained by a reduced cosmic ray exposure dose to the platform due to now removed overlying material via selective rapid weathering. Under this hypothesis, the depressed 10Be platform concentration is related to the 10Be concentrations of the boulder surfaces in such a manner as to be consistent with preservation of in-situ boulder formation $\sim$0.5m thick adjacent to areas of boulder-free platform surfaces. This must deal with the details of the exhumation of both boulders and platform from the overlying sandstone bed and its initial form. Our study unequivocally demonstrates that boulders atop coastal cliffs at Little Beecroft Head, in south-eastern Australia were formed in-situ as the result of differential weathering, block fracturing and denudation of the parent platform and that their upper surfaces have been sub-aerially exposed for at least the past $\sim$300 ka. These results clearly show the long term survival of boulders surfaces and slow denudation rates of these cliff-top platforms. They challenge the paradigm that landforms at the land-sea interface are geologically young, affirm the erosion-resistant nature of the sandstone coastal landforms of southeastern Australia and provide an alternative mechanism for the presence of cliff-top boulders as contemporary relics of a degrading surface as opposed to transport and deposition during the Holocene .