

How do we date a PBR? : A robust method using Be-10 surface exposure dating with numerical models

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Be-10 geochronology of precariously balanced rocks (PBRs) is a powerful tool for constraining unexceeded ground motions, but surface exposure dating of PBRs can only be successful if the geomorphic history of the rock is known. In order to reduce uncertainty in interpreted ages, we must develop a more accurate geomorphic model for PBR formation processes. Our approach is to (1) collect profile samples of the PBRs and pedestals at various heights above the ground surface and (2) sample saprolite and stream sediment to constrain surface denudation rates. We measured Be-10 concentrations in 30 samples from 8 PBRs along a 150-km transect near the San Andreas, San Jacinto, and Elsinore faults in southern California. In all cases, pedestal samples yield lower Be-10 concentrations than their associated PBR, and nuclide concentrations show an exponential increase with increasing height above the ground surface. This observed pattern among rock and pedestal Be-10 concentrations indicates that the exhumation history must be carefully considered. We use a forward model and compare our Be-10 data to predicted profiles for a range of surface denudation rates and exposure times. The total Be-10 concentration is the sum of nuclides produced before (i.e. subsurface) and after exhumation, with different ratios of pre- and post-exhumation erosion rates yielding different nuclide concentrations as a function of depth.

Using simplified shielding corrections and assuming rapid exhumation, our model predicts surface exposure ages for 4 PBRs that range from 23-16 ka, consistent with minimum exposure ages from varnish microlamination dating results. However, because the cosmic ray flux is only partly attenuated by the rock, to accurately interpret PBR profiles requires that the model include a shielding correction that accounts for the shape of the PBR. Three-dimensional models for PBRs were constructed using photogrammetric and terrestrial LiDAR scanning (TLS) data. Using a model with the more realistic shielding correction, one PBR gives best-fit parameters that indicate that the entire rock, including the pedestal, was exhumed rapidly at 27 ± 2 ka. Furthermore, saprolite and stream sediment samples associated with the same PBR indicate surface denudation rates of 0.1 mm/yr following rapid exhumation. To further refine our model and exposure ages, ongoing work will focus on applying our model to additional PBRs and constraining PBR rock erosion rates using in-situ C-14.

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