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Testing seismic hazard models with Be-10 exposure ages for precariously balanced rocks

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Currently, the only empirical tool available to test maximum earthquake ground motions spanning timescales of 10 ky-1 My is the use of fragile geologic features, including precariously balanced rocks (PBRs). The ages of PBRs together with their areal distribution and mechanical stability ("fragility") constrain probabilistic seismic hazard analysis (PSHA) over long timescales; pertinent applications include the USGS National Seismic Hazard Maps (NSHM) and tests for ground motion models (e.g., Cybershake). Until recently, age constraints for PBRs were limited to varnish microlamination (VML) dating techniques and sparse cosmogenic nuclide data; however, VML methods yield minimum limiting ages for individual rock surfaces, and the interpretations of cosmogenic nuclide data were ambiguous because they did not account for the exhumation history of the PBRs or the complex shielding of cosmic rays. We have recently published a robust method for the exposure dating of PBRs combining Be-10 profiles, a numerical model, and a three-dimensional model for each PBR constructed using photogrammetry (Balco et al., 2011, Quaternary Geochronology). Here, we use this method to calculate new exposure ages and fragilities for 6 PBRs in southern California (USA) near the San Andreas, San Jacinto, and Elsinore faults at the Lovejoy Buttes, Round Top, Pacifico, Beaumont South, Perris, and Benton Road sites (in addition to the recently published age of 18.7 +/- 2.8 ka for a PBR at the Grass Valley site). We combine our ages and fragilities for each PBR, and use these data to test the USGS 2008 NSHM PGA with 2% in 50 year probability, USGS 2008 PSHA deaggregations, and basic hazard curves from USGS 2002 NSHM data.