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Development of a new surface-exposure dating method based on luminescence

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There are many examples of rock surfaces, rock art and stone structures whose ages are of great importance to the understanding of various phenomena in geology, climatology and archaeology. Optically stimulated luminescence (OSL) dating is a well-established chronological tool that has successfully determined the depositional age of a wide variety of fine-grained sediments, from several years to several hundred thousands of years. However, there is no routine OSL dating method applicable to larger clasts such as cobbles, boulders and other rock surfaces.

We develop a technique of surface-exposure dating based upon the characteristic form of an OSL bleaching profile beneath a rock surface; this profile evolves as a function of depth and time. Our model takes into account the effect of both bleaching (energy release due to daylight exposure) and dose-rate (energy accumulation due to environmental radioactivity). As a field illustration of this new method, a fossil exposure age of $\sim$700 years was determined for a buried rock sample at Canyonlands, Utah, USA, which allowed us, for the first time, to constrain the time frame for the creation of the Barrier Canyon Style rock art to 800-1500 years B.P. In another application of the model to quartzite cobbles from the Tapada do Montinho archaeological site (east-central Portugal), we were able to identify four events in the history of a single cobble; two exposure events of different time lengths and two burial events of 26 ka and 19 ka. In a more recent study, our preliminary results on high-elevation low-relief bedrock surfaces in western Scandinavia, suggest that surfaces at higher elevations may have been exposed for longer periods compared to those at lower elevations. This information could provide a direct quantitative constraint on the timing of the processes responsible for these surfaces in Sognefjord area, Norway.

The new OSL surface-exposure dating method appears to have the potential to complement CN dating. By including simultaneous light exposure and irradiation, the new method also offers a practical approach to the establishment of a recent exposure chronology for non-terrestrial surfaces, such as on Mars.