Estimating alluvial fan surface ages using Landsat 8 multispectral imagery

Mitch D'Arcy, Philippa J. Mason, Alexander C. Whittaker, and Duna C. Roda Boluda
Imperial College London, Earth Science & Engineering, South Kensington, United Kingdom
(mitchall.darcy06@imperial.ac.uk)

Accurate exposure age models are now essential for geomorphological and stratigraphic field research, and generally depend on laboratory analyses such as radiocarbon, cosmogenic nuclide or luminescence approaches. However, these techniques cannot be deployed in situ in the field, meaning other methods are needed to produce a preliminary age model, map depositional surfaces of different ages, and select sampling sites for the types of laboratory analyses outlined above. With the widespread availability of high-resolution multispectral imagery, a promising approach is to use remotely sensed data to discriminate depositional surfaces with different ages. Here, we use new Landsat 8 Operational Land Imager (OLI) multispectral imagery to characterise the reflectance of 35 alluvial fan surfaces in the semi-arid Owens Valley, California. These surfaces have been mapped in detail in the field, have similar granitic compositions, and have well-constrained exposure ages ranging from modern to ~ 125 ka, measured using a high density of 10-Be cosmogenic nuclide samples. We identify a clear age signal recorded in the spectral properties of these surfaces. With increasing exposure age, there is a predictable redshift effect in the reflectance of the surfaces across the visible and short-wave infrared spectrum. Simple calculations, such as the brightness ratio of red/blue wavelengths, produce sensitive power law relationships with exposure age for at least 125 ka, meaning Landsat 8 imagery can be used to estimate surface exposure age remotely, at least in this calibrated dryland location. The ability to remotely sense exposure age has useful implications for field mapping, selecting suitable sampling sites for laboratory-based exposure age techniques, and correlating existing age constraints to previously un-sampled surfaces. We present the uncertainties associated with this spectral approach to exposure dating, evaluate its likely physical origins, and discuss its applicability in other locations and with other remotely sensed datasets.