Dating of Sand Dunes Using Cosmogenic Chlorine-36: An Example From the Nebraska Sand Hills, USA

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The large-scale mobility of sand dunes in continental dune fields is largely controlled by climactic conditions; warm and dry conditions typically inhibit the growth of grasses and plants that would otherwise stabilize unconsolidated sediments. Reconstruction of the history of a dune field can therefore, provide a proxy climate record derived from the continental plains region. Alternatively, relating historic dune activity to known climactic conditions can provide a better understanding of the factors responsible for causing the en masse mobilization of these landforms. Traditional methods for dating sand dunes, e.g. stratigraphic and radiocarbon dating, are indirect because they rely on the use of secondary material. We have investigated a direct method for dating sand dunes based on the accumulation of cosmogenic chlorine-36 in sand grains. The concentration of chlorine-36 in a stable sand dune primarily depends on the length of time the dune has been exposed to cosmic rays, depth below the exposed surface of the dune and the chemical composition of the sand. By assuming a simple conceptual model for dune dynamics, i.e. homogenization during major periods of mobility and isolated erosion events during minor periods of activity, the chlorine-36 concentration profile measured in a dune can be related to the dune age. To test the practicability of the chlorine-36 dating technique, samples were collected at two sites in the Nebraska Sand Hills, USA. The results obtained from these samples indicate that periods of landscape stability in the Sand Hills began at least 10.6 kyr, <4.3 kyr, 2.0 kyr and <0.7 kyr ago. These ages are in agreement with those obtained previously by other investigators using alternative dating techniques. This research indicates that the proposed method shows significant potential for further investigations of sand dunes. Future work is required to constrain erosion rates and incorporate more realistic models of dune mixing to obtain higher precision estimates of dune ages.

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