In : Lee, Jeffrey A. and Zobeck, Ted M., 2002, Proceedings of ICAR5/GCTE-SEN Joint Conference, International Center for Arid and Semiarid Lands Studies, Texas Tech University, Lubbock, Texas, USA Publication 02-2 p. 438

Combining ground penetrating radar (GPR) surveys and luminescence (OSL) dating to determine dune migration

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Ground penetrating radar (GPR) is a geophysical technique that produces high resolution images of the shallow subsurface. Aeolian sands and sand dunes usually have a high resistivity giving good penetration to GPR signals. They also contain large structures that can be resolved in the subsurface making aeolian sand suitable targets for GPR surveys. In aeolian sand and sand dune deposits GPR reflections can be related to bedding, sets of cross-stratification, palaeosols and bounding surfaces. Radar stratigraphy and radar facies analysis can be used to interpret GPR profiles. Horizontal and dipping reflections and cross-cutting relationships, toplap, downlap, offlap and truncation of reflections are used to establish a relative chronology. In addition, the extent of bounding surfaces and depositional units can be mapped in the subsurface. Having established the dune stratigraphy and relative chronology of depositional units, sampling for luminescence dating can be accurately targeted at stratigraphic horizons defined by GPR surveys.

Examples of GPR profiles across linear dunes in the Namib Sand Sea are used to illustrate the application of GPR to dune stratigraphy. A combination of radar facies analysis and radar stratigraphy have been used to identify large sets of cross-stratification deposited when the dune was most active and bounding surfaces formed during periods of stabilisation, non-deposition or erosion. A drilling and dating campaign has been designed on the basis of the dune stratigraphy as defined by a GPR survey. Sampling is targeted at large sets of cross-stratification formed when the dunes were most active, and to bracket bounding surfaces formed when the dunes were stable or even eroded. This will yield a well constrained chronology of dune activity and stabilisation to be integrated with palaeoclimate data.

At Aberffraw, a transgressive coastal dune field on the island of Anglesey, U.K., a GPR profile has been used to define 6 stratigraphic units at the inland edge of the dune field. The younger units have been sampled using auger boreholes. Optical dates based on measurements of the optically stimulated luminescence (OSL) signal from quartz from the younger units show that sand accumulated between 1465 and 1745 AD. Dates within stratigraphic units show close agreement and allow the chronology of dune emplacement to be accurately reconstructed.

The OSL technique is used to date the movement of aeolian sand grains by calculating the time elapsed since their last exposure to sunlight. The OSL age represents a period of sand activity and mobility, as opposed to the alternative method of radiocarbon dating organic horizons in dunes which represent periods of stability.

Combining these geophysical and geochronological methods improves interpretation of dune stratigraphy, the chronology of sand accumulation, stabilisation surfaces, erosion surfaces and the history of dune mobility.