

Optically Stimulated Luminescence Dating in the Langebaanweg Environs

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Introduction

The Cenozoic sediments of the west coast, especially in the Saldanha/Langebaan environs, are richly endowed with archaeological and palaeontological remains, ranging in age from the Miocene to the Holocene. The diverse Mio-Pliocene fauna at the Langebaanweg phosphate quarry itself, the Early/Middle Pleistocene Hopefield site, where the partial cranium of early archaic *Homo sapiens* (Saldanha Man) was found (Singer and Wymer, 1968) along with ESA artifacts, and several Middle to Late Pleistocene sites have attracted international attention. Many of these sites remain poorly dated, constraining their value in unraveling the paleoenvironmental evolution of the region. In recent times powerful new techniques have become available with the potential to resolve these chronological challenges.

Rationale and Objectives

Whereas the main fossil bearing horizons at Langebaanweg have been faunally dated to the basal Pliocene by the rich palaeontological archive, the age of the younger overlying, chiefly aeolian sediments remains uncertain. Until recently, the 'Calcareous Sand Member' was included in the Varswater Formation and is itself fossiliferous, containing mammalian, reptilian, terrestrial molluscan and marine microfossil remains. At the 'highwall' intense pedogenesis (soil forming processes) at the contact with the underlying MPPM involving ferruginisation, calcification and phosphatisation took place prior to the influx of coastal calcareous sand dunes, now the cross-bedded Langebaan Formation. This indicates a lengthy but unknown time break between the two units. Near Anyskop south of 'E' Quarry, Hendey (1981a,b) reported Plio-Pleistocene fossils in the Langebaan Formation aeolianites, which appear to rest on the underlying MPPM with a less pronounced unconformity than at the 'highwall'. ESA and MSA artefacts are cemented into the top of the aeolianites, forming part of the natural heritage at Langebaanweg and suggesting a younger age than the 'Late Pliocene' mammalian fossils reported by Hendey (1981). These deposits in turn are overlain by the reddish unconsolidated sands of the Springfontyn Formation, a formation widespread in the Western Cape but which has never been dated. Significant palaeoclimatic inferences can doubtless be drawn from these deposits, which may indicate regional aridity during an unknown time interval.

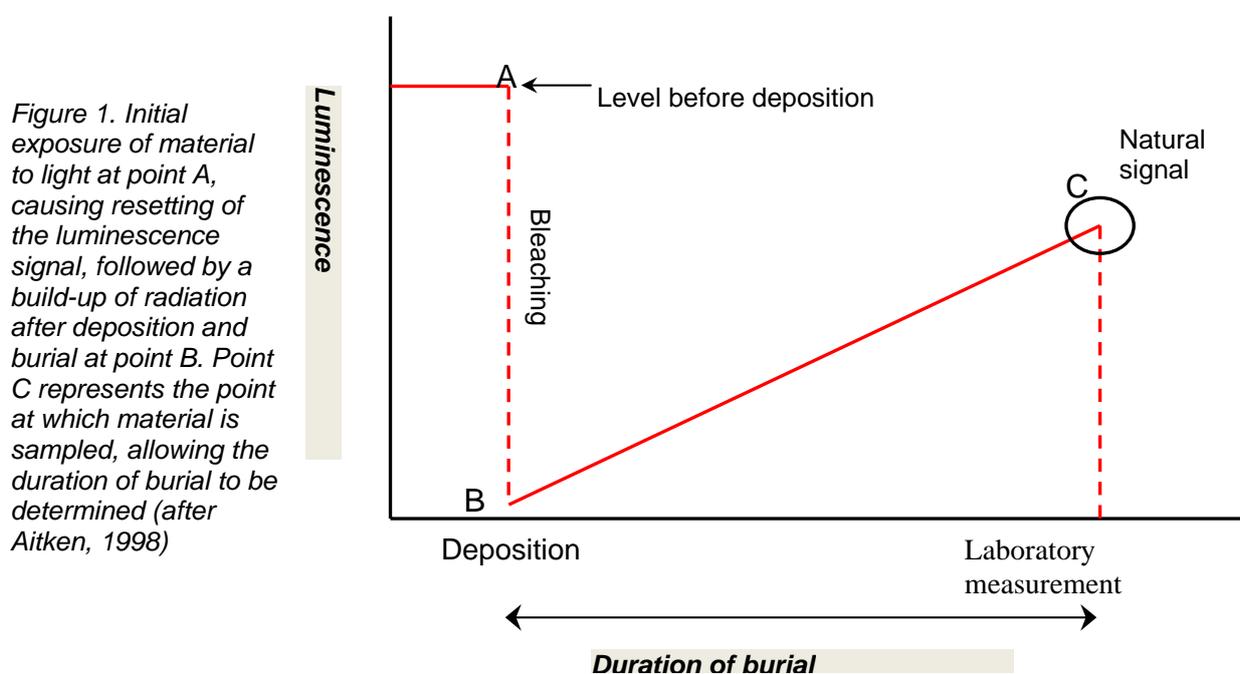
The diverse Mio-Pliocene fauna at Langebaanweg has provided a vivid snapshot of early Pliocene palaeoenvironments. Questions as to the length of time that the fauna persisted in the Western Cape and how they adapted to changing conditions by migration or transformation remain largely unanswered. Hints are provided by sites such as Elandsfontein, where sivatheres and members of other extinct groups common to Langebaanweg were found (e.g. Singer and Wymer, 1968), but whose chronology remains obscure (age estimates have ranged from Early to Middle Pleistocene). Other important fossils pertinent to this topic found by various researchers in west coast aeolianites and marine deposits constitute further examples of the limitations placed on well preserved material by poor or absent chronologies (Pether et al., 2000).

The key to the paleoenvironmental evolution of the lower west coast lies in the history of the cold Benguela upwelling tongue, generally agreed to mediate the west coast climate (Siesser, 1977; Dingle et al., 1983; and many others). The inception of the Benguela System is linked to the Oligocene separation of South America from Antarctica, allowing free flow of the Circumantarctic Current. Since this time, the system has fluctuated but generally strengthened (Siesser, 1977), but a detailed picture is lacking (Pether, 1994a,b; Roberts and Brink, 2002). Late Tertiary to Pleistocene

onshore shallow marine and aeolian deposits have the capacity to fill these voids, but again the lack of a detailed and robust chronology (Pether, 1994a,b; Roberts et al., 2007a) hampers progress.

Research Methods

The proposed project involves the application of Optically Stimulated Luminescence (OSL) dating. OSL dating works on the principle that, after burial, grains of sand are exposed to a weak flux of naturally-occurring radiation from the decay of Uranium, Thorium, Potassium and Rubidium, as well as from cosmic radiation. Each grain accumulates a charge that is proportional to duration of burial and which is released by exposure to light or heat. By measuring the charge acquired by a sample and the environmental dose rate, date of last deposition can therefore be calculated (Figure 1). Recent refinements to the technique, such as single aliquot and single grain analysis, have increased the precision of derived ages and enabled a fuller understanding of sediment depositional dynamics (e.g. the incorporation of eroded and reworked material into younger deposits (e.g. Bateman et al. 2004; 2007; Carr et al. 2007).



Over a long period of time, or where radiation levels are high, all traps may be filled, leading to a state where the grain is said to be saturated – i.e. it cannot absorb any more radiation, and therefore can no longer be used for dating purposes. This has previously prevented the application of OSL dating to quartz samples older than c. 300,000 years. However, a recent major break-through, which may extend the maximum limit of dating by an order of magnitude, is the development of Thermally-Transferred OSL (TT-OSL). Numerous workers have observed that after optical bleaching and heating of a sample, a measurable residual signal remains (e.g. Huntley et al., 1985; Aitken and Smith, 1988), an effect known as recuperation (Aitken, 1998). Recent work has established the source of this recuperated signal as thermally unstable, relatively optically insensitive ('refuge') traps that release charge into the main OSL traps during heating after optical bleaching (Wang et al., 2006; Pagonis et al., in press). These refuge traps are emptied by exposure to sunlight and have a far higher radiation dose capacity than the main OSL traps (Wang et al., 2007); recent experimental work suggests that TT-OSL can be used to measure burial dose up to between 2500 and 4500 Gy (Wang et al., 2006; Pagonis et al., in press). In most settings, this would equate to an age of between approximately 2.5 and 4.5 Ma, but given the extremely low environmental radiation dose in Cenozoic west coast calcarenites (Roberts et al., submitted), TT-OSL should be capable of extending the chronological record to unprecedented depths of time. Its recent successful application in the context of South African coastal strata was demonstrated by the dating of the Middle Pleistocene Marine

Isotope Stage 11 shallow marine deposits at Mossel Bay, where previous attempts using conventional OSL failed (Roberts et al., 2007b). Sampling will be carried out preferentially on continuous sedimentary sequences at a number of sites, with initial primary focus on Langebaanweg itself.

Supervision

It is envisaged that the primary supervisor of the proposed AOP postdoc project will be Dr M. D. Bateman, who is Director of the Sheffield Centre for International Drylands Research, runs the luminescence facility in Sheffield University (UK), and has a long standing research interest working to date aeolian sediments in southern Africa (Bateman et al., 2003; 2004; Carr et al., 2007). Dr D. Roberts would be co-supervisor, assisting mainly with devising the sampling program and geological interpretation of results. He has extensive experience in Coastal Cenozoic research with a focus on Neogene global change (e.g. see references above). This research will bring together a team of experts with two internationally recognised researchers in the fields of OSL geochronology (MDB, CHB) as well as sedimentology, sea-level fluctuations and climate change (DLR, MDB). It will also facilitate a greater understanding of the sensitivity and dynamics of these coastal deposits, which may be particularly relevant given predications of future sea level change, and the increasing encroachment of modern humans on the environment.

Deliverables

The results of the study will form the basis of peer review journal articles, conference abstracts and information for community based projects. It is envisaged that at least one paper will be produced in the first year (2008) and should the project continue into a second year, a further paper will be delivered.

Preliminary results were presented at two conferences: The 12th International Conference on Luminescence and Electron Spin Resonance Dating" at Peking University in Beijing from the 18-22nd September 2008, and Windy Day at King's College, London on the 24th October 2008.

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