Heavy-mineral concentrations as proxies of high-energy events along sandy coasts

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Sediment-rich coastal sequences have the potential of preserving long-term records of regional-scale erosional events. Among the most diagnostic features of erosion are steep berm and dune scarps, regional unconformities (discontinuities), layers of coarse sediment or shell hash, as well as extensive accumulations of heavy minerals (magnetite, ilmenite, garnet, zircon, hornblende, etc.). These heavy mineral concentrations (HMCs) are found in many parts of the world and occur in thin layers or thick placer deposits (Fig. 1A). Their formation is due primarily to selective density sorting during the waning stages of storms (Komar and Wang, 1984; Peterson et al., 1986; Kurian et al., 2001). The HMCs can therefore be used as proxies for high-energy events along sandy coastal regions, and have been attributed to storm or tsunami-induced erosion in a number of studies (Smith and Jackson, 1990; Nichol, 2002; Buynevich et al., 2004; Dougherty et al., 2004). Substantial contrast in electromagnetic properties between sands enriched in ferromagnesian heavy minerals and quartz-rich background sediments is responsible for the sharp nature of subsurface reflections (Meyers et al., 1996; Buynevich et al., 2004) making HMCs some of the most prominent horizons in ground-penetrating radar (GPR) profiles (Fig. 1B). By combining high-resolution geophysics for mapping subsurface erosional indicators with radiocarbon or optical dating of individual erosional horizons, it is possible to reconstruct the long-term history of coastal hazards in various parts of the world.

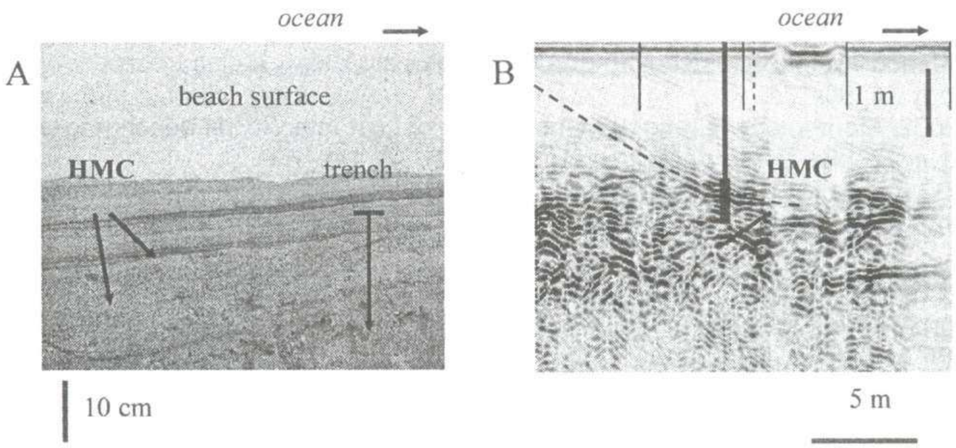

Fig. 1. A) Shallow trench exposing centimeter-scale heavy-mineral concentrations (HMC) preserved within a beach sequence in southern New England, USA. The picture was taken following a hurricane and quartz-rich sands already began to cover the most recent HMC; B) Shore-normal GPR profile of a buried erosional scarp (dashed line) in southern Brazil illustrates the diagnostic geometry of this feature. Sediment core shown in the middle of the image penetrated a layer rich in heavy minerals at a depth of 2.5 m.

In addition to reconstructing the geometry of erosional paleo-shorelines, the textural properties of the HMCs and similar lag deposits can be used for quantitative analysis of threshold conditions responsible for sediment removal, selective transport, and deposition. Based on textural characteristics and concentration of specific minerals, it is possible to calculate threshold entrainment stresses (as a function of near-bottom wave velocities) responsible for the selective sorting sand during individual erosional events (Madsen and Grant, 1975; Kurian et al„ 2001).

Along the Black Sea coast, heavy-mineral fractions of both onshore and offshore sediments have long been used for provenance analysis and sediment transport studies. Rivers, landslides, cliff erosion, and offshore sources all contribute assemblages of heavy minerals to the HMCs in the coastal zone (Pazyuk et al., 1966; Tsvetkova-Goleva, 1992). In coastal barrier and sandy terrace sequences, the HMCs are further separated by hydrodynamic or aeolian processes and may shed light on the history of erosional events, such as severe storms or tsunamis which have been known since pre-historic times (Altinok, 1999). Future efforts will focus on identification and mapping of regional erosional unconformities and heavy-mineral deposits to complement other studies aimed at paleoenvironmental reconstruction of the Black Sea - Mediterranean Corridor.

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