doi:10.1130/G33046Y.1

Forum Reply

Large-scale glaciation and deglaciation of Antarctica during the late Eocene

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Wadi Al-Hitan is a UNESCO World Heritage site in the Western Desert of Egypt, famous for fossil whales and excellent exposures of middle and upper Eocene strata (Gingerich, 1992). Underwood et al. (2012) question our evidence for a major fall in relative and eustatic sea level during Priabonian late Eocene time (Peters et al., 2009; 2010). The Priabonian stage has a sequence boundary at the base (Pr-1), two within (Pr-2 and Pr-3), and another at the top (Pr-4; Haq et al., 1987; Hardenbol et al., 1998).

Three marine formations, Gehannam, Birket Qarun, and Qasr el-Sagha, span the Priabonian here. GPS mapping and three-dimensional projection of formation boundaries show strata to strike N 42.8°E and dip 0.69°NW. Down-dip projection of bed traces (Fig. 1) indicates erosional relief on the underlying carbonate-rich Bartonian-stage Gharaq Formation, consistent with Pr-1 separating the Bartonian and Priabonian. Overlying formations are clastic. The Gehannam is thin and glauconite-rich, as expected for an initial stage of transgression. The Birket Qarun is thicker, with bioturbated sandstones thinning and shales thickening offshore to the north. The Qasr el-Sagha Formation is thickest, with stacked parasequences having mollusk-rich tops resistant to erosion.

Qasr el-Sagha parasequences are laterally extensive, but incised and filled with conspicuously different cross-bedded strata at two levels. Sequence boundary Pr-2, mapped continuously for 12 km, is near the base and cuts through into the underlying Birket Qarun Formation in places (Fig. 1). This incised valley fill (IVF) unit has well-preserved bedding, unidirectional current features, and land-mammal remains at many places, making it conspicuously different from enclosing bioturbated shoreface parasequences. The IVF includes inclined heterolithic strata with remnant imbricated clast conglomerates on valley flanks. These amalgamate into a single lower bounding interval, indicating multiple phases of filling, cutting, and reworking characteristic of incised valley sequences (Zaitlin et al., 1994).

Abdel-Fattah et al. (2010) constructed a composite section of the Priabonian from two places: Wadi Al-Hitan and Qasr el-Sagha. Their section at Wadi Al-Hitan did not extend high enough to intersect Pr-2, and their section at Qasr el-Sagha did not extend low enough (Abdel-Fattah et al., 2010, their figure 12). They put Pr-2 at what we agree is a maximum flooding surface, but this cannot be Pr-2.

A second, higher Qasr el-Sagha incision, Pr-3, is at the base of the Dir Abu Lifa Member (Bown and Kraus, 1988). This can be traced for more than 80 km and the IVF is very similar to that of Pr-2. Depth of the Pr-3 incision, like that of Pr-4 at the Priabonian-Rupelian boundary, is not yet well constrained.

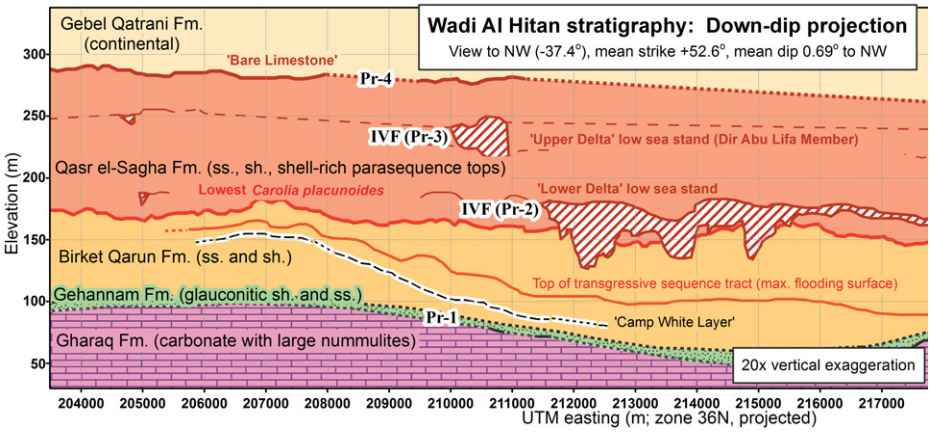

Figure 1. True-scale computed cross section of Wadi Al-Hitan stratigraphy projected from three-dimensional GPS mapping of bed traces (view down-dip, vertical exaggeration 20x). Elevation traces are 3-point running averages. Priabonian disconformities Pr-1 through Pr-4 correspond to global low sea stands. Incised valley fill (IVF) deposits are hatched to represent cross-bedding. Pr-2 is documented in Peters et al. (2009). Abbreviations: Fm.—Formation; sh.—shale; ss.—sandstone.

ACKNOWLEDGMENT

Field research was supported by National Science Foundation grant EAR-0920972.

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