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Discussion

Sea level changes versus hydrothermal diagenesis: Origin of Triassic carbonate platform cycles in the Dolomites, Italy—Discussion

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In a recent paper, Blendinger (2004) proposed that the limestone–dolostone couplets of the Middle Triassic Latemar carbonate platform should be interpreted as diagenetic features originating from hydrothermal processes, rather than as carbonate peritidal sedimentary cycles. Here we will show that Blendinger's (2004) hydrothermal model is inconsistent with the available data, and should be rejected. We focus on four crucial issues:

1. Interpretation of the Latemar platform interior facies

In his argument against the Latemar limestone–dolostone couplets as sedimentary cycles, Blendinger (2004) reinterprets the association of tepee structures, pendant and meniscus cements, asymmetrical pisolites, red micritic horizons and dolomitized crusts. He argues that this evidence is not uniquely associated with subaerial exposure, and can also be the result of hydrothermal diagenesis in a deep subtidal, low-energy environment. However, this argument ignores the preponderance of sedimentological evidence that has been collected from the Latemar that points directly to the contrary. The illustrations provided by Blendinger (2004; his Fig. 2) are from a different platform, the Marmolada, have no import for the Latemar, and do not contribute to an informed discussion about the Latemar.

His statement that there is "a general consensus that the sedimentary record of the Latemar platform is entirely subtidal, and only diagenetic features appear to document cyclic exposure of the platform" has been contradicted by many detailed studies. Gaetani et al. (1981), Goldhammer et al. (1987), Egenhoff et al. (1999), Preto et al. (2001a), Zühlke et al. (2003), all report vertical patterns of depositional fabrics within

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the limestone units that are consistent with sedimentation in progressively shallowing subtidal conditions. For example, in the western and southern platform sections, Goldhammer et al. (1987) found that units are composed of skeletal–peloidal wackestones and packstones with restricted faunas and reworked clasts from the underlying dolostone cap, replaced upwards by lithoclastic–skeletal–peloidal packstones and grainstones with diverse faunas, small erosional surfaces and some fining-upward layering, these frequently succeeded by inverse-graded oncolitic gravels. Similarly, Egenhoff et al. (1999), in sections from the western and northern areas of the platform, identified 5 microfacies within Latemar cycles that collectively show evidence for high-energy deposition in upward-shallowing environments.

The limestone units are always capped by dolomitic crusts containing internal features of subaerial diagenesis. The general absence of intertidal facies is typical of carbonate microtidal environments, where intertidal and shallow subtidal facies can be virtually identical (e.g., Fischer, 1991). In some cases, supratidal deposits have also been observed in Latemar cycles (Lithofacies 2 and Fig. 3B of Preto et al., 2004). This evidence for supratidal deposition and subaerial exposure conflicts at a fundamental level with Blendinger's (2004) suggestion that these facies formed in deep-subtidal, continuously submerged conditions.

Tepees of the Latemar platform are interpreted by Blendinger (2004) as subtidal tepees in which early cementation was due to pumping of supersaturated hydrothermal fluids. He suggests that early cementation and tepee maturity are not sufficient criteria for subaerial exposure. The presence of marine phreatic cements is used to support this interpretation. However, pendant and meniscus cements occur in the tepees as well, especially in the cavity fills. Horizons with 'senile' tepees (Assereto and Kendall, 1977) consist of flat-pebble breccias; even if we accept that they formed in a subtidal environment, they require a high-energy environment to form. Furthermore, Egenhoff et al. (1999) found that tepees are more abundant and mature in localities closer to the margin (e.g., Cima Valsorda) and that some grade laterally into smaller tepee horizons or even regular sedimentary cycles towards the nucleus of the platform (e.g., Cimon del Latemar). Such horizontal patterns would not arise if the tepees originated from hydrothermal fluids.

Pendant cements are one of the most robust features associated with vadose diagenesis. Blendinger (2004) suggests that pendant cements can also form in subtidal environments, where the upward flux of hydrothermal fluids presumably existed. Pendant cements occur throughout the Latemar platform interior, but have not been found in the margin or upper slope settings, which also lack the dolomitized crusts (Harris, 1996). The suggestion that laser ablation stable isotope analyses of the pendant cements could be used to determine a subtidal–hydrothermal versus vadose origin of the cements is of no help because pendant cements of the Latemar are all now substituted by a mosaic of equant, clear calcite, and their isotopic composition would yield information on burial diagenesis and not on depositional environment. One of us has observed and illustrated in a poster (Preto et al., 2001b) pendant cements within ammonoid shells in which hydrothermal fluids could not have freely seeped from below.

Pisolites form in a variety of environments, including marine low-energy subtidal settings (Demicco and Hardie, 1994). Pisolites of the Latemar, however, are often broken, and show signs of regrowth after breaking (Goldhammer et al., 1987; Preto et al., 2001a). This implies a high-energy environment. Furthermore, they are associated with dissolution vugs (Goldhammer et al., 1987; Hardie et al., 1991; Demicco and Hardie, 1994) that are compatible with subaerial exposure, and not with a constantly deep subtidal environment subjected to frequent flux of supersaturated hydrothermal fluids.

Red micritic horizons have been interpreted as either "terra rossa", i.e., residual sediments derived from the karstification of limestones (e.g., Gaetani et al., 1981), or altered volcaniclastic sands or ashes due to the sporadic occurrence of volcanic minerals (Hardie et al., 1986). Instead, Blendinger (2004) suggests that the red micritic crusts could have precipitated from hydrothermal fluids. The common occurrence of volcanic minerals in this facies, however, excludes this possibility. The red muds are more likely the result of the subaerial alteration of volcanic minerals due to pedogenetic processes. Subaerial alteration could have occurred in place, or fine red