Geophysical Research Abstracts, Vol. 7, 07907, 2005
SRef-ID: 1607-7962/gra/EGU05-A-07907

Red-coloured phylloid-algal mounds in the margin of a steep-fronted Pennsylvanian carbonate platform (Picos de Europa Province, NW Spain)

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Phylloid algal build-ups were abundant during late Palaeozoic, forming extensive complexes in relatively shallow, near-shelf edge settings and ramps, and have been widely reported in the SW of North America, the Canadian Archipelago, and the Carnic Alps. The red-coloured cement-rich algal mounds described here formed at margins of a steep-fronted carbonate platform (uppermost part of the Picos de Europa Formation, see Bahamonde *et al.,* 2000) during the early Kasimovian (Upper Pennsylvanian). The contrast between the pinkish, cement-rich and massive mound-core facies and the red and well-bedded flank deposits (dipping up to 23º) allows recognizing conspicuous mound morphologies. Individual algal mounds range from a few to 15 m in thickness and from several to tens of metres in lateral extent, but the third dimension is unknown due to inadequate exposure.

The mound core shows a complex fabric constituted of patches of biocementstones (*sensu* Webb, 1996) and massive areas made of pinkish peloidal micrite with scarce phylloid algal thalli. Biocementstones consist of large phylloid-algal fronds (lacking preserved microstructure) with a cup-shaped growth form. The volumetrically important intergranular and shelter porosity is filled with botryoidal cement and multiple generations of radiaxial fibrous cement alternating with dark micritic microbial encrustation. The peloidal fabric shows primary cavities filled with radial and radiaxial fibrous cement and scarce embedded skeletal components (mainly foraminifers). Geopetal fillings of red homogeneous micrite, including rare minute bioclasts, are also present.

Flank beds are made of red homogeneous micrite, displaying a mud to- wackestone texture lacking early marine cement. The flank beds include *Osagia* oncoids, large crinoids, which in parts form rudstone intervals, and *in-situ* flat-shaped colonies of chaetetid sponges. Flank beds thin up-wards and thicken downwards towards the inter-mound areas.

The conspicuous syndepositional relief developed for some of these phylloid algal-dominated mounds, together with the described internal fabrics of the mound facies, seem to agree upon the model proposed by Samankassou and West (2002) that interpreted similar mounds as the result of active constructional algal growth, in contrast to the passive role assigned to phylloid algae in previous models.

Comparable well-bedded alternations of irregular bryozoan-brachiopod biocementstones with crinoidal packstone and spiculitic wackestones, both including slightly clotted red-stained micrite, were deposited on the upper slope of this platform (Sierra del Cuera outcrops, towards the north) during lower Moscovian (see e.g. Kenter *et al.,* 2003; Della Porta *et al.,* 2003; Bahamonde *et al.* 2004). In the Sierra del Cuera, the red-stained intervals record sparse boundstone production during rapid relative sea-level rises (Della Porta *et al.* 2003) based on comparison to the deeper facies of the late Tournasian Waulsortian banks (see e.g. Less & Miller, 1995) and the Moscovian biocementstones in the Canadian Artic Archipelago (see e.g. Davies & Nassichuk, 1990), both developed at depths of 300 m. In the mounds of the present study, however, the presence of phylloid algae as dominant biota and the abundance of botryoidal cement point to a shallow depositional environment and warmer conditions compared to those of the Sierra del Cuera red layers. In analogy to the Frasnian red-coloured stromatactics mounds in Belgium (Bourque & Boulvain, 1993; Boulvain *et al.,* 2001), the red pigmentation is attributed to the metabolic activity of iron bacteria in aphotic and dysaerobic microenvironments (Della Porta *et al.*, 2003).

Southwards, the algal mounds appear locally brecciated. In the outcrops corresponding to southernmost settings (belonging to other tectonic units), the lower Kasimovian succession is made of 300-350 m of clast-supported breccias (with a red matrix), in which most of the clasts and boulders are derived from algal mounds. This rapid lateral change between algal mounds and red-matrix breccias possibly record the boundary between the outer platform/margin and slope/toe-of-slope environments. The composition of the red-matrix breccias points to the existence of gravitational failure processes and repetitive collapse episodes, suggesting an erosive type of platform margin.

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