GEOLOGICAL SURVEY OF
WESTERN AUSTRALIA

Record 2011/20

Programme & Abstracts: The XVII International Congress on the Carboniferous and Permian

Edited by

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Perth 2011

Unusal skip marks from the early Viséan Molignée Formation (Mississippian) of southern Belgium

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The early Viséan-aged Molignée Formation occurs in the Namur-Dinant Basin (Belgium) where it is developed only in the central part of the Dinant sedimentation area (DSA) between a prograding platform to the north and a Waulsortian complex running along the border between the DSA and the Avesnois sedimentation area to the south. This lithostratigraphic unit (*c.* 60 m in thickness) consists of a succession of thin-bedded, commonly laminated black limestones that alternate with thick-bedded, dark-grey limestones. Some levels of black limestone included in the Molignée Formation were extensively and manually quarried at the end of the 19th century and at the beginning of the 20th century for the production of ornamental stone, well-known as the 'black marble' of Denée. These levels have yielded remarkably preserved but rare fossils such as giant echinoderms, dendroid graptolites and fishes. Besides these exceptional macrofossils, several types of skip marks produced by broken shells of molluscs have been also recovered as well as ichnofossils (e.g. *Zoophycos*, meandering pascichnia). The first type, which is preserved as skip mark moulds, probably results from the repeated impact of a shell bearing large tubercles which are a reminiscent of those occurring in the gastropod genus *Porcellia*. The second type corresponds to a skip mark mould which is repeated four times over a distance of more than one metre and which has been produced by the shell cut in half of a large-sized cephalopod reaching about 18 cm in diameter. The third type corresponds to a series of three identical horseshoe-shaped skip marks which are deeply engraved in a lime mudstone that was most likely endowed with some plasticity at the origin. The fourth type, probably the most spectacular, corresponds to the repetition over a distance exceeding three metres of a pattern which is composed of three different skip mark moulds produced by the saltation of a mollusc shell. Moreover, the interpretation of several skip marks is still dubious as the objects which produced them are still unidentified. However, the presence of skip marks confirms the existence of bottom currents strong enough to move large fragments of shell and corroborate the turbiditic origin of some deposits of the Molignée Formation.

Late Pennsylvanian to Middle Permian reef succession on Panthalassan oceanic atolls

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The Carboniferous-Permian atoll carbonates in the Akiyoshi accretionary complex of SW Japan contain a continuous record of the evolution of Panthalassan reefs. Throughout this interval, the earth system experienced global cooling from the Pennsylvanian to the earliest Permian, and warming in the remaining Early and Middle Permian. These climatic changes are thought to have strongly influenced the prosperity and turnover of the Panthalassan reef community. We here report on Late Pennsylvanian to Middle Permian reef communities from the Panthalassan Akiyoshi and Taishaku limestones.

Palaeoaplysina flourished as the main reef-builder on the mid-Panthalassan Akiyoshi atolls during Gzhelian–Asselian time, acting as a frame-builder in a high-energy, reef-core environment. *Palaeoaplysina* was associated with abundant binders, including *Tubiphytes*, *Archaeolithoporella*, micrite crust-forming microbes, and cystoporate bryozoans. Fenestrate and cryptostomate bryozoans were sediment-bafflers and sediment-producers, but also acted as a frame-builder (as well as *Palaeoaplysina*) in association with microencrusters.

The biotic succession since the Sakmarian is still less clearly constrained, but sponge–microencruster boundstones, which include sphinctozoan and inozoan sponges, *Tubipytes*, and microbes forming micrite crusts, have been reported from a Murgabian to Midian back-reef succession of the Akiyoshi Limestone (Nakazawa et al., 2009). Although more detailed examination is necessary, the *Palaeoaplysina*–microencruster community was possibly turned over by the sponge–microencruster community on the Akiyoshi atolls during Sakmarian to Bolorian time.

Paleogeographically, *Palaeoaplysina* is well-known as a boreal element and was distributed mainly along the northern margin of Pangea. The global cooling during Gzhelian-Asselian time probably contributed to its migration to the tropical or subtropical Akiyoshi atolls of the mid-Panthalassa Ocean. The *Palaeoaplysina*–microencruster community was succeeded by the sponge–microencruster community in the late Early Permian. This biotic turnover corresponds in timing to a change of climate regime from icehouse to greenhouse conditions, and also coincides with a superplume activity (Ichiyama et al., 2008) beneath the mid-Panthalassa Ocean.