Why Are There No Glendolites In The Western Australia Permian?

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At a recent PESA Monthly meeting in Perth several students spoke of their research, in part funded by PESA Scholarships. Abstracts of these talks are included in this issue (see pages 15 to 16). One talk in particular engendered some later discussion over a glass of red wine or two. Matthew Dixon's talk on the Early Permian Callytharra Formation, Merlinleigh Sub-basin of the Carnarvon Basin was concerned in part with the palaeoenvironment during deposition of this marine unit. Matthew concluded that the Callytharra Formation was deposited below fair weather wave base but above storm wave base in a marine environment. He went on to discuss what type of sea the unit was deposited in, how cold the water was and what was the relative influence of warming versus salinity changes on the conformable transition from the underlying, largely unfossiliferous shales and siltstones of the Carrandibby Formation to the fossil-rich Callytharra Formation shales and minor limestones. He concluded that the Callytharra was most likely deposited in a cool-water regime but there was no significant amelioration of the glacially influenced climate needed to account for the thin limestone interbeds.

This prompted the question, were there any glendonites known from the unit, as glendonites are developed in a particular type of coldwater environment (Fig. 1. Photograph of a glendonite from southern Sydney Basin). Arthur Mory (WA Geological Survey) then made the observation that in his experience, glendonites were unknown in the marine Permian strata of WA. A quick, but by no means exhaustive, literature search later backed up this observation.

However, glendonites are widespread in contemporaneous Early Permian strata in eastern Australia, and common enough to be tourist attractions in Jervis Bay (NSW). Glendonites also are found in the Cretaceous Bulldog Shale of the Eromanga Basin. In both of these marine settings, the glendonites are accompanied by ample evidence of ice rafting (dropstones).

Palaeoenvironmental reconstructions show that during Callytharra time (mid to late Sakmarian), Australia lay closer to the southern pole (Fig. 2, modified from Baillie et al., 1994, WABS 1). The type section of the Callytharra was at a latitude of about 52° S, a similar latitude to that of the Bowen Basin of Queensland, where the glendonite-bearing Cattle Creek Formation crops out. The lower part of the Cattle Creek Formation is a time correlative of both the Callytharra and the Pebbley Beach Formations, and is a marine glacigenic deposit. The Pebbley Beach

Fig. 1. Photograph of a glendonite from southern Sydney Basin.

Formation (dropstones) from the Sydney Basin of eastern Australia contains common glendonites. At the same palaeolatitude as the Pebbley Beach Formation in the northern Perth Basin is the correlative marine unit of the Callytharra, the Fossil Cliff Member of the upper Holmwood Shale. As most geological graduates of Perth universities know, the Holmwood is one of the few shaly Permian units that crops out in the Perth Basin, and it contains dropstones. However, no glendonites.

What are Glendonites?

Glendonites are pseudomorphs after the mineral ikaite ($CaCO^3.6H^2O$), which forms in specific cold water, near-freezing to sub-zero water bottom environments with a source of calcium and carbonate ions, in the presence of a calcite nucleation inhibitor (possibly phosphate or organic carbon) which prevents the formation of calcite. Ikaite forms naturally in two modes: as individual, often large, displacive crystals in organic-rich muds or as free growing crystals in solution. These organic-rich sediments are highly alkaline, reducing (microbial decomposition) and have a high hydrostatic pressure. While such conditions for the precipitation of ikaite are quite specific, they are not uncommon as shown by the widespread occurrence of glendonites. While ikaite is most commonly found in cold water marine deposits (deep sea marine fans to estuarine muds on polar coastlines), it can also occur onshore in tufas and around saline springs, in both of these environments associated with frigid winter weather. Glendonites have also been reported from tectonically active shear zones where they are intimately associated with high concentrations of methane gas-venting in very cold water on the Sakhalin Shelf. Interestingly, ikaite is a clathrate and its genesis may have some connection with the formation of methane hexahydrates ($CH^4.6H^2O$), which also form within very coldwater sea bottom sediments.

Having established a common thread for ikaite formation, that is frigid bottom waters with organic-rich reducing sediments, we can speculate on the apparent lack of glendonites in marine strata from contemporaneous Western Australian basins compared to eastern Australian basins. The simplest answer is that despite similar palaeolatitudes from the southern pole, the western basins were in warmer climes, or the waters were not as deep. Alternatively, the west Australian glacigene sediments were less organic-rich than their eastern correlatives. Perhaps a clue to the apparent differences lies in the palaeogeography (Fig. 2). Note that the eastern basins opened to Panthalassa (the global ocean), whereas the western basins abutted the Cimmerian continental blocks. Of course, this is all speculation, but fruitful research into the origin of Permian source rocks may be suggested.

Most of the information discussed above can be found on the Internet. A bibliography can be supplied on request.

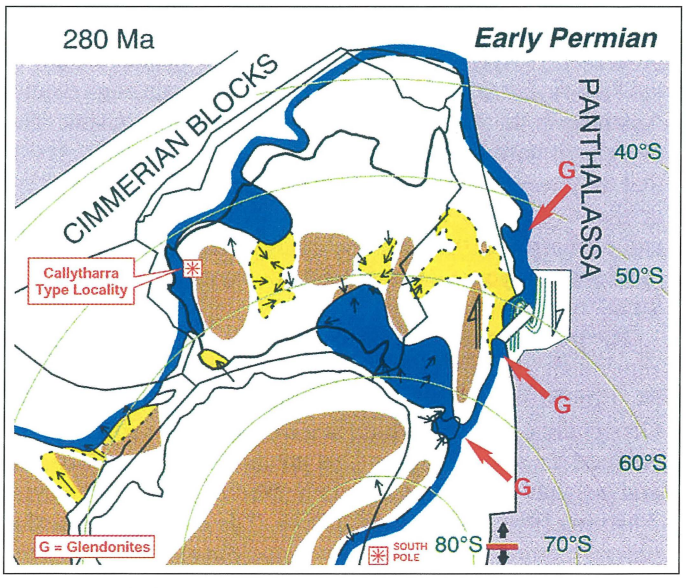

Fig. 2. Modified from Baillie et al., 1994, WABS 1.

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