DEVONIAN REEF COMPLEXES OF THE CANNING BASIN, WESTERN AUSTRALIA
TONY COBAIN

This talk was given by Tony Cockbain in November 2010, on behalf of Phil Playford who was unable to attend the meeting. The talk was based on a selection of slides prepared by Phil; a small summary of the talk was published in the December 2010 Proceedings. This abstract is taken from GSWA Bulletin 145 with the above title.

The bulletin can also be purchased from Mineral House for $77.

ABSTRACT

Middle and Upper Devonian (Givetian, Frasnian, and Famennian) reef complexes are spectacularly exposed on the Lennard Shelf, along the northern margin of the Canning Basin. They form a belt of rugged limestone ranges, some 350 km long and up to 50 km wide, that is commonly known as the 'Devonian Great Barrier Reef'. The reef complexes form a northwest-trending barrier-reef system, composed of fringing reefs, atolls, and banks, that grew along the mountainous mainland shore of the Kimberley block and around rugged islands of Proterozoic igneous and metamorphic rocks. One reef complex grew on a fault block of Ordovician dolomite and shale. The maximum thickness of the Devonian rocks is estimated to be at least 2500m. In some areas the reef complexes are cut by normal faults, some of which moved during the Devonian, with associated tilting and folding, but over large areas the Devonian rocks remained almost undeformed. Conglomerates, that interfinger with or passthrough the reef complexes, were derived from the scarps of active faults in adjoining Precambrian basement rocks. Movement along some faults continued during the Carboniferous, but since then there has been little or no faulting in the area.

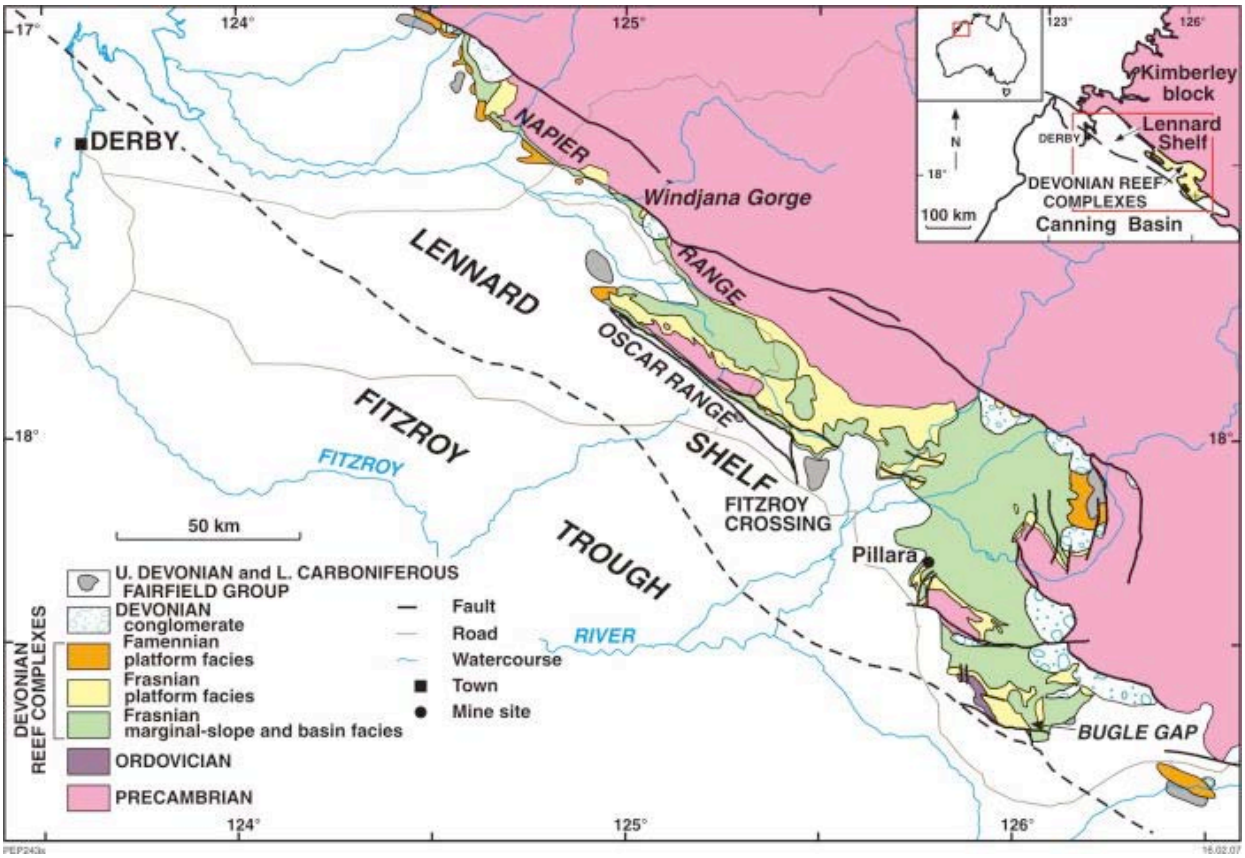

Figure 1: Geological map of the Devonian reef complexes.

Three main facies are recognized in the reef complexes: platform, marginal-slope, and basin facies. The reefal platforms, which stood tens to hundreds of metres above the adjacent sea floor, were constructed by shallow-water organisms, especially stromatoporoids, corals, and microbes. Many platforms were rimmed by rigid wave-resistant reefs. The platform facies is subdivided into reef-margin, reef-flat, pinnacle reef, and back-reef subfacies. Where no reef is developed around a platform margin, the platform is regarded as a bank and its deposits as bank sub facies.

The platform deposits were laid down essentially horizontally, in shallow subtidal to intertidal and supratidal environments. The reef-margin and reef-flat deposits were mainly formed in shallow water depths, but in some places the reef grew in water estimated to have been up to a few tens of metres deep. The back-reef areas ranged from supratidal to subtidal, with estimated water depths of up to 10 m. Cyclicity is evident in many of the back-reef deposits

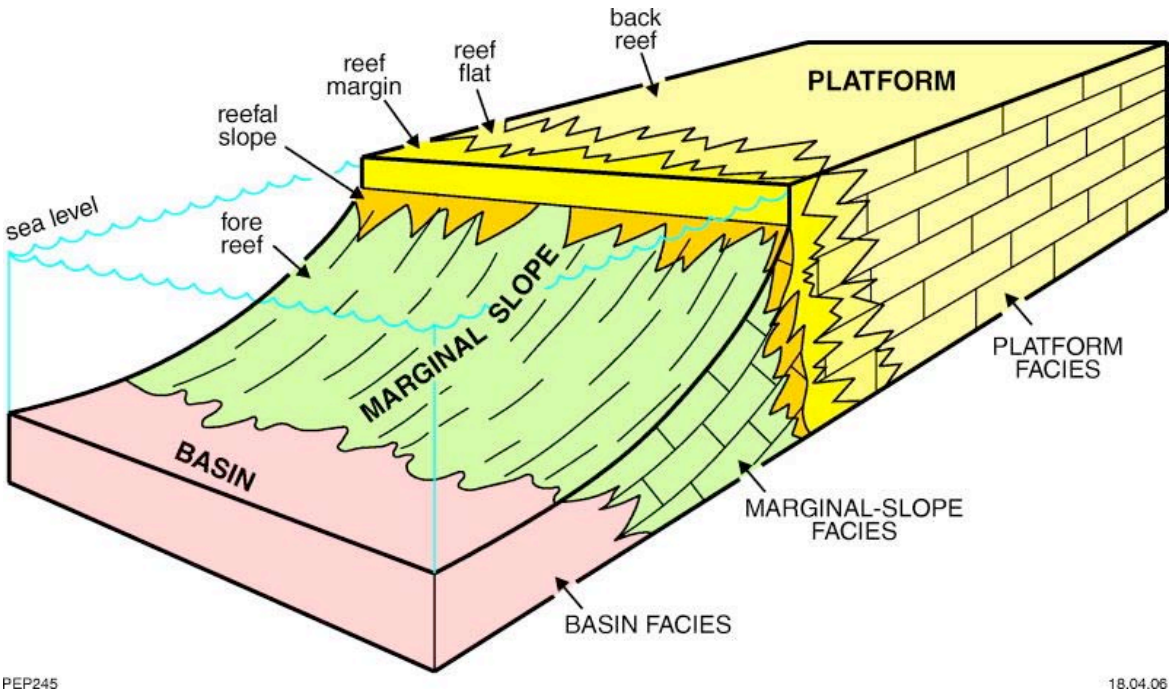

Figure 2: Morphology diagram of the reef complexes.

Marginal-slope deposits were laid down on slopes in front of the platforms, descending to water depths of up to several hundred metres. The marginal-slope facies in front of a reefal platform is subdivided into reefal-slope and fore-reef subfacies. Where the platform is a bank the slope deposits are regarded as fore-bank facies.

Reef-margin and reef-flat boundstones and back-reef biostromes were built by microbes, stromatoporoids, and corals during the late Givetian and early Frasnian, microbes and stromatoporoids during the late Frasnian, and microbes alone in the Famennian. The reefal-slope subfacies consists of microbial boundstone that accreted at the tops of the marginal slopes. The reefal-slope deposits show depositional dips ranging from nearly vertical to about 40°, and they pass downwards into fore-reef subfacies.

The fore-reef deposits consist largely of platform-derived debris, and include debris flows and isolated allochthonous blocks of reef, together with indigenous fossil organisms and terrigenous clastic material. Depositional dips in the fore-reef subfacies decline progressively from about 40° at the top of a slope to a few degrees at the foot, where the fore-reef subfacies interfingers with basin facies. Fore-bank deposits generally lack steep depositional dips, and they interfinger directly with bank deposits at the top of the slope and with basin facies at the base.

Figure 3: Classic face at Windjana Gorge.

The basin facies, which was laid down essentially horizontally in water depths from a few tens to several hundreds metres, consists largely of calcareous shale, siltstone and sandstone, with some interbedded turbidites and debris-flow limestones. Most basin deposits have undergone major post-burial mechanical compaction (up to about 75%).

The reef complexes range in age from Middle Devonian (late Givetian) to Late Devonian (Frasnian and Famennian). Most exposed reefs are Frasnian and Famennian in age. The most precise dating of the reef complexes is based on conodonts and ammonoids in basin and marginal-slope deposits. Conodonts are absent and ammonoids are rare in platform deposits. Two second-order sequences are recognised in the reef complexes: the Givetian-Frasnian Pillara Sequence and the Famennian Nullara Sequence. The boundary between them is a unconformity in platform and upper marginal-slope deposits and a conformity in deeper marginal-slope and basin deposits. The fall in sea level that caused this unconformity is estimated to have been about 50 m. The Frasnian-Famennian boundary marks the culmination of a global mass extinction of metazoan organisms that apparently began during the late Frasnian. Microbes survived the mass extinction virtually unscathed. Among those microbes, *Renalcis* is especially prominent as a reef builder in both Frasnian and Famennian platforms, but non-skeletal microbes were even more important as reef builders.

Deep-water stromatolites are conspicuous features of some marginal-slope deposits, above and just below the Frasnian-Famennian boundary. They may have thrived at that time because the extinction event removed metazoans that would otherwise have consumed the stromatolite-building microbes.

The rigid early-cemented reef-margin and reef-flat limestones were subjected to fissuring in response to earthquake shaking, slippage along underlying marginal-slope deposits, and differential compaction of underlying basin deposits over basement topography. The fissures were filled with sediment, calcite cement, and organic growths, forming networks of neptunian dykes. Masses of terrigenous conglomerate interfinger with and extend through the reef complexes at various localities along the outcrop belt. They are highstand deposits that interfinger with platform, marginal-slope, and basin deposits and were laid down as alluvial-fan, fan-delta, and submarine-fan deposits in front of the scarps of active faults. Large volumes of sand and mud poured into basins adjoining the conglomerate bodies, so that the resulting basin deposits are largely terrigenous.

Figure 4: Napier Range at Windjana Gorge.

The area was subjected to glaciation by continental ice sheets during the Late Carboniferous and Early Permian. The erosive action of the ice sheets and associated subglacial water had profound effects on the Devonian rocks. The tops of the limestone ranges were planed off by 'dirty' ice and were extensively karstified by the corrosive action of subglacial water under high pressures and sub-zero temperatures. Major cave systems formed in the limestones at that time.

Economic deposits of zinc and lead sulfides have been mined in several places along the reef belt, mainly in the southeastern part, at Pillara, Cadjebut, and Goongewa. These

deposits are thought to have been carried into the Devonian limestones by hot fluids expelled from shales deep in the Fitzroy Trough. They follow faults and hydrothermal caverns in the limestones. The age of this epigenetic mineralization is Early Carboniferous (Tournaisian).

Small oilfields have been located in late Famennian reef limestone and overlying deposits in the subsurface of the northwestern Lennard Shelf. The Famennian reef margin has been well defined in this area through conventional seismic surveys. Although Frasnian reef complexes are known from drilling to occur below the Famennian carbonate rocks in this area, their detailed distribution cannot be delineated by such surveys. It is believed that Frasnian reef complexes have the best prospects for future oil discoveries, and it is likely that they can be successfully delineated using 3-D seismic techniques.