



## Brackish to hypersaline lake dolostones of the Mississippian

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Flat-lying ferroan dolomite beds are common in the Mississippian and occur along the southern margin of Laurasia, from Kentucky USA to Poland. These rocks are important as they record shallow marine to coastal plain environments that may have acted as a pathway or refugia for animals that were radiating into freshwaters such as tetrapods, fish, molluscs and arthropods.

This study is a contribution to the TW:eed Project (Tetrapod World: early evolution and diversification), that examines the rebuilding of Carboniferous ecosystems following a mass extinction at the end of the Devonian. The project focuses on the Tournaisian Ballagan Formation of Scotland, which contains rare fish and tetrapod fossils. The formation is characterised by an overbank facies association of siltstone, sandstone and palaeosols, interbedded with dolostone and evaporite units, and cut by fluvial sandstone facies associations of fining-upwards conglomerate lags, cross-bedded sandstone and rippled siltstone.

Two sites are used as a case study to describe the sedimentological, faunal and ichnofaunal diversity of these dolostones. More than 270 dolostone beds are recorded in each of the 500 metre depth Norham Core (near Berwick-upon-Tweed) and from a 520 metre thick field section at Burnmouth. The beds are laterally extensive, over ~1 km, although individual units do not appear to correlate between the core and the field site. In the Norham Core dolostones comprise up to 14% of the succession. 17% of the beds contain marginal marine fossils: *Spirorbis*, rare orthocones, brachiopods and putative marine sharks. More common fauna include ostracods, bivalves, plants, eurypterids, gastropods and sarcopterygian fish, which are interpreted as brackish to freshwater tolerant. Bioturbation is fairly common with *Serpula* colonies within dolostone beds and *Chondrites* burrowing down from the base of dolostone beds. Some rare units in the field section have a bulbous bed surface and preserve tree root traces, and 9% of all dolostone beds in the Norham Core are pedogenically altered. The isotopic composition of dolomite beds is  $\delta^{18}\text{O}$   $-3.6\text{‰}$  to  $-1.7\text{‰}$  and  $\delta^{13}\text{C}$   $-2.6\text{‰}$  to  $1.6\text{‰}$  which is consistent with a brackish as opposed to marine origin.

The dolostones are categorised by their sedimentary composition: Facies 1: Cemented siltstone and sandstone; Facies 2: Homogeneous micrite to micro-crystalline dolomite, within a clay matrix; Facies 3: Bedded dolomite and siltstone; Facies 4: Mixed calcite and dolomite; Facies 5: Dolomite with gypsum and anhydrite. Formation processes are diverse, and include diagenetic cementation (Facies 1), deposition in saline (brackish) lakes (Facies 2), deposition in saline lakes with clastic sediment input (Facies 3), lagoonal to shallow-marine carbonate deposition (Facies 4), and hypersaline lake to sabkha environments (Facies 5). 60% of the beds are facies 2 or 3 and their sedimentology, fauna, ichnofauna and isotopic composition indicate a brackish-water origin. Other Mississippian dolostones from around the world also contain a fairly restricted fauna and have been interpreted as brackish water deposits. The mechanism of dolomite formation under these conditions is discussed. These dolostones provided extensive coastal lakes that may have been an important habitat for tetrapods and other transitional groups during the Mississippian.