Shelf Margin to Deep Water Depositional Environments in the Mississippian System of the Northern Williston Basin

By
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ABSTRACT

It has become increasingly evident that criteria initially employed to identify terrigenously-derived clastics deposited in deep water can also be used as indicators of similar depositional conditions for carbonate sediments. In the past decade, deep water carbonates have been described from several ancient continental margin settings (Garrison and Fischer, 1969; Thomson and Thomasson, 1969; Tyrrell, 1969; and most of the papers in Cook and Enos (Editors), 1977). In addition, in the 1950's several investigators working in the Williston Basin area interpreted the rocks of the lower part of the Mississippian System as having been deposited in deep water. More recently two papers, by Wilson (1969) and by Smith (1977) describe some of the criteria that may be employed to interpret the deep water origin of these Mississippian carbonates.

Across the entire basin there appears to be a cyclic succession of sediments from shallow to deep and finally back to shallow water. The oldest shallow water sediments are marked by the clastic rocks of the Bakken Formation as well as a thin, but persistent, interval of skeletal lime mudstone at the base of the Madison Group. In the northern part of the basin, the sequence above the basal carbonate interval can be divided stratigraphically and areally into zones of rocks representing deposits laid down in various water depths. These zones may be described as anaerobic, dysaerobic and aerobic suggesting that the type of sediment and indigenous organic remains are related to the amount of dissolve oxygen present at different depths in the ancient sea.

The anerobic deposits consist of alternating dark and lighter coloured, finely laminated, bituminous lime mudstone; the variation in colour depends on the amount of bituminous material present. Main sedimentary structures of the sequence are small scour channels, truncated laminae and rare small scale planar crossbedding. The dysaerobic rocks include two basic lithologic types which appear to have formed at slightly different positions on the basin slope. The lower slope deposits, that is, those closest to the anerobic zone, are dark gray, burrow-mottled, pyritiferous, argillaceous lime mudstone. Those from slightly higher on the slope are non-argillaceous lime mudstone that essentially lack any macro-fossil remains with the exception of intervals rich in spicules or spines. The two lithologies are gradational and interdigitate with one another and where they intermix there is evidence of disruption of the sequence by slumping.

The aerobic zone is represented by a variety of shallow water sediment types beginning with those interpreted as representing shelf margin deposits, passing through a sublittoral environment and ending in littoral sediments. The shelf margin rocks include crinoidal bank and bank foreslope deposits; the former are made up of several tens of feet of crinoidal calcirudite and calcarenite and, in contrast, the latter are interbedded thin crinoidal calcirudities and calcarenites and skeletal lime mudstone. Load and slump structures are particularly common in the bank foreslope deposits. On the landward side of the bank the rocks consist of calcarenites and lime mudstone containing a variety of skeletal remains and this lithology passes into an oolite-pisolite shoal. Immediately back of the shoal, the rocks are interpreted as belonging to a sublittoral environment in which peloidal lime mudstones and calearenites, skeletal calcarenites, cryptalgal lime mudstones and calcarenites and lithoclastic and lithoskeletal lime mudstones are the dominant rock types. The littoral environment is marked by typical supratidal flat deposits including nodular and mosaic anhydrite and extremely, finely crystalline dolomite as well as bedded and interlaminated dolomite and anhydrite and vertical crystal growths of that mineral; all of the latter three are typical of deposition in standing bodies of water such as salinas of maritime lakes.

Although all of the previously described lithologies do not appear to be present everywhere across the northern flank of the Williston Basin, there is sufficient continuity of rock types that the anerobic, dysaerobic and aerobic zones appear to trace roughly arcuate patterns from east to west through the area. These patterns follow the present trend of the erosional limit of the Mississippian and although most of the littoral environment rocks in the lower Mississippian appear to have been removed by erosion, there is sufficient evidence in the remaining rocks to indicate that the paleo-shoreline in early Mississippian time was no more than 160 kilometers beyond the present erosional edge and that it mimicked the trend of that edge.

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REFERENCES

Cook. H.E., and Enos, P. (Editors), 1977, Deep-water carbonate environments: Soc. Econ. Paleon. and Mineral Spec. Publ. No. 25, 336 p.

Garrison, R.E. and Fischer, A.G., 1969, Deep-water limestone and radiolarities of the Alpine Jurassic: in Friedman, G.M. (Editor) Depositional environments in carbonate rocks: Soc. Econ. Paleon. and Mineral Spec. Publ. No. 14, p. 20-54.

Smith, D.L., 1977. Transition from deep-to shallow-water carbonates, Paine Member, Lodgepole Formation, Central Montana: in Cook, H.E. and Enos, P. (Editors) Deep-water carbonate environments Soc. Econ. Paleon. and Mineral Spec. Publ. No. 25, p. 187-202.

Thomson, A.F. and Thomasson, M.R., 1969. Shallow to deep water facies development in the Dimple Limestone (Lower Pennsylvanian), Marathon Region, Texas: in Friedman, G.M. (Editor) Depositional environments in carbonate rocks: Soc. Econ. Paleon. and Mineral Spec. Publ. No. 14, p. 57-77.

Tyrrell, W.W., Jr., 1969. Criteria useful in interpreting environments of unlike but time-equivalent carbonate units (Tansill-Capitan-Lamar) Capitan Reef Complex, West Texas and New Mexico: in Friedman, G.M. (Editor) Depositional environments in carbonate rocks: Soc. Econ. Paleon. and Mineral Spec. Publ. No. 14, p. 80-97.

Wilson, J.L., 1969. Microfacies and sedimentary structures in "deeper water" lime mudstones: in Friedman, G.M. (Editor) Depositional environments in carbonate rocks: Soc. Econ. Paleon. and Mineral Spec. Publ. No. 14, p. 4-16.