The Major Depositional and Tectonic Changes Across the Near-Base Rhaetian (latest Triassic) Sequence Boundary in the Sverdrup Basin, Arctic Canada

Ashton F. Embry*
Geological Survey of Canada, Calgary, Canada
aembry@nrcan.gc.ca

Introduction

The Mesozoic succession of Sverdrup Basin (Canadian Arctic Archipelago) is about 10 km thick. Six 1st order sequence boundaries occur at the base, within, and at the top of the succession and allow it to be subdivided into five first order sequences. A 1st order sequence boundary is distinguished by a very widespread unconformity (subaerial unconformity or unconformable shoreline ravinement) which penetrates well into the basin, by substantial section loss beneath the unconformity, and, most importantly, by notable changes of the depositional regime and tectonic setting of the basin across the boundary. Such large magnitude boundaries are relatively rare in the Sverdrup Basin succession and mark times of major basin reorganization.

Near-Base Rhaetian Sequence Boundary

One of these 1st order boundaries is the near-base Rhaetian (very late Triassic) sequence boundary. It forms the top of the lowermost Mesozoic 1st order sequence which comprises latest Permian to Norian (late Triassic) strata. A prominent unconformity characterizes the boundary on all the basin flanks and it extends quite far into the basin in the lower subsidence area of the western Sverdrup. The unconformity is almost always an unconformable shoreline ravinement which is overlain by transgressive, shallow marine strata. On the south-western flank of the basin, the unconformity is overlain by a distinctive oolitic ironstone unit. In the basin-centre the boundary is a conformable, maximum regressive surface.

This sequence boundary marks one of the biggest changes in depositional regime recorded in the basin. Throughout the Triassic, the Sverdrup Basin received sediment from the extensive Canadian and Greenland shield areas to the south and east and also from an enigmatic land area to the north called Crockerland. The relative contributions from these two main source regions varied substantially. In the Early and Middle Triassic, the eastern and southern shield areas were dominant and only small, relatively local, sediment contributions came from Crockerland. In contrast, Crockerland was the dominant source area during much of the Late Triassic.

Depositional Regime Change

In the Carnian (early Late Triassic), Crockerland-derived sediments prograded southward across the entire basin in the west. In the eastern portion of the basin, shield sources remained dominant. During the subsequent Norian, Crockerland was by far the main source region for the entire basin. Thick, shallow water sandstones (Romulus Member, Heiberg Formation) prograded southwestwardly over slope and shelf shales (Barrow Formation) in the eastern and central portions of the basin from a sediment input area in eastern

Crockerland. Starved basin conditions persisted on the southwestern margin of the basin (Prince Patrick Island) and there is little indication of any sediment contribution from the shield areas on the eastern and southern basin flanks.

A relatively short-lived interval of tectonic uplift occurred near the Norian/Rhaetian boundary, exposing the basin flanks and resulting in the final progradation of the Norian sandstone. Following this, widespread subsidence occurred and the basin margins were submerged. During the subsequent regression in early Rhaetian, a huge supply of sediment came into the basin from the shield areas to the east and southeast. A large delta prograded northwards and eastwards (Fosheim Member, Heiberg Formation) and barrier island sandstones were deposited along the southwestern basin flank. This shallow marine sandstone unit (Drake Point Member, Maclean Strait Formation) is now the reservoir for two very large gas fields (9 TCF) on Melville Island.

There is no evidence of Crockerland-derived sediment in Rhaetian strata although small input areas may have occurred. In fact, Crockerland was never again a notable source area for the Sverdrup Basin and it eventually was broken up and buried with the opening of the Amerasia ocean basin from Middle Jurassic to Early Cretaceous. Notably, in contrast to the Crockerland-derived, green weathering, lithic sandstones of the Norian, the shield-derived, white-weathering, Rhaetian sandstones are very quartzose. Not surprisingly, the detrital zircon signature of the Norian sediments is markedly different from that of the Rhaetian sediments. A pronounced climate shift coincided with the source region change with a much more humid climate prevailing in the Rhaetian.

Tectonic Change

Another major change which occurred across the near-base Rhaetian sequence boundary was the demise of the Tanquary Arch, a large positive area in the northeastern portion of the basin. The Tanquary Arch originated in Permian as part of another basin-changing, tectonic episode at the base of the Kungurian. This event also coincides with the first substantial input of sediment from Crockerland. From mid-Permian until the end of the Norian, the Tanquary Arch was intermittently uplifted and a number of unconformities merge towards its crest. The final episode of uplift of the arch was at the end of the Norian and all post-Early Paleozoic strata were stripped from its crest. Following the base Rhaetian transgression, which drowned the arch and produced the unconformable shoreline ravinement of the near-base Rhaetian sequence boundary, the Tanquary Arch ceased to be a tectonic entity.

Global Tectonics

There is no doubt that the near-base Rhaetian sequence boundary of the Sverdrup Basin was generated by tectonics and is not of eustatic origin. In fact, a tectonically generated, major sequence boundary of the same age occurs in basins in many parts of the world including the western Canada, southwestern USA, Europe, Siberia, and Australia. It would seem that the major, tectonic episode at the Norian/Rhaetian boundary, which affected basins throughout the world, was generated by plate-tectonic processes likely driven by changes in the mantle. The global, plate reorganization at the Norian/Rhaetian boundary had a profound effect on the tectonic and sedimentary patterns of the Sverdrup Basin presumably through the creation of a new stress regime for the basin and the surrounding source areas.