Stratigraphy of the Early Cretaceous Isachsen Formation, Sverdrup Basin and Postulated Sandstone Occurrence on the Arctic Continental Shelf

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Introduction

The Isachsen Formation occurs in both the Sverdrup Basin and Banks Basin of the Canadian Arctic Archipelago and is a sandstone-dominated unit of Early Cretaceous age (late Valanginian to early Albian). It lies between two shale-siltstone dominated formations, the Deer Bay Formation below and the Christopher Formation above. The formation represents a major influx of siliciclastic sediment into the Arctic region. Facies and paleocurrent data demonstrate that the sediment came from the cratonic areas to the south and east.

The Isachsen Fm ranges in thickness from a few tens of metres on the margins of the two basins to about 1500 metres in the centre of the Sverdrup Basin (Ellef Ringnes Island). The major thickness changes are due mainly to truncation and onlap associated with three, major subaerial unconformities which occur within or at the base of the formation throughout its extent. These unconformities allow the formation and adjacent shale-dominant strata to be subdivided into four depositional sequences which, in ascending order, are dated as Valanginian, Hauterivian to early Barremian, late Barremian to mid-Aptian and late Aptian to early Albian.

Sequence Stratigraphy

The Valanginian sequence is present over almost all of Sverdrup Basin but appears to be absent in Banks Basin. It is truncated on the basin margin and the upper sandstone-dominant portion of the sequence, which forms both the basal portion of the Isachsen Fm and the upper portion of the regressive systems tract (RST), is found only well within the basin. In most cases, these strata consist of delta front deposits but, in the basin centre, coastal plain strata with very coarse grained, channel deposits are preserved beneath the earliest Hauterivian unconformity.

The Hauterivian to early Barremian sequence is found within the more central areas of Sverdrup Basin and has not been identified in Banks Basin. It consists mainly of coastal plain deposits often dominated by very coarse grained, fluvial channel deposits with common vein quartz pebbles. Thin coal units are present in most sections and an interval of marine strata which contains the maximum flooding surface (MFS) sometimes occurs near the top of the sequence. In most sections, the sequence consists almost entirely of a transgressive systems tract (TST). The TST fluvial strata onlap the basal unconformity towards the southern and eastern basin flanks.

The late Barremian to early Aptian sequence is more widespread and forms the basal portion of the Isachsen Formation on the southern and eastern flanks of the Sverdrup Basin and within Banks Basin. The lower TST portion of the sequence consists of an overall fining-upward succession of coastal plain strata which give way to shallow marine strata. The MFS occurs within a widespread shale-siltstone unit which is present in almost all sections. The RST of the sequence consists of marine shelf shale and siltstone which coarsen and shallow-upward through a succession of delta front and delta plain strata. Once again, very coarse, pebbly sandstones characterize channel deposits.

The uppermost portion of the Isachsen Formation consists of TST deposits of the late Aptian to early Albian sequence. These range from coarse-grained, fluvial channels and coal-bearing, fine-grained overbank deposits at the base, to interbedded sandstone, siltstone and shale of delta front and shallow shelf origin. The MFS occurs in the overlying shale and siltstone of the Christopher Formation and the TST strata can be up to 500m thick indicating both high supply and high subsidence at this time. These strata are also found south and east of the Sverdrup Basin margins where they rest with profound unconformity on folded Paleozoic strata.

Depositional and Tectonic History

The four sequences record the depositional and tectonic history of the Arctic Islands throughout most of the Early Cretaceous. Sediment supply to the Sverdrup Basin started to increase following late Berriasian-earliest Valanginian uplift and a delta prograded into the basin. Uplift in latest Valanginian-earliest Hauterivian occurred throughout the basin and truncated the underlying strata. With the resumption of widespread subsidence and base level rise, coarse-grained fluvial deposits onlapped the basin flanks and eventually a shallow marine environment was widespread. The delta plain eventually prograded basinward followed by uplift and base level fall in mid-Barremian. This uplift was accompanied by major upward movement of salt structures and the formation of a salt canopy in the Axel Heiberg region.

Renewed subsidence in late Barremian led to transgression, flooding of Banks Basin and the eventual occurrence of a widespread, offshore marine shelf over much of the Sverdrup Basin. Deltaic sediments again prograded basinward from the south and deposition was halted by uplift throughout the Arctic Archipelago in mid-Aptian. Renewed subsidence and transgression occurred from late Aptian to earliest Albian and the deltaic shoreline gradually retreated southward. Sverdrup and Banks basins were part of a very widespread, mud-dominated, marine shelf by early Albian.

Continental Shelf Sandstone Units

The intervals of uplift, as reflected in the regional unconformities, appear to be related to global tectonic processes, presumably driven by mantle/crust interactions. At these times the cratonic areas to the south and east were uplifted and copious quantities of

siliciclastic sediments were funneled into the Sverdrup Basin. To the northwest of the Sverdrup Basin, the oceanic Amerasia Basin was opening by sea floor spreading at this time. Thick clastic wedges prograded onto the continental shelf of this new ocean during the times of major uplift and exposure of the Sverdrup Basin. Thus, it is predicted that thick, progradational, marine sandstone units of latest Valanginian-earliest Hauterivian, early Barremian and mid-Aptian are likely present on the continental shelf. These units are potential petroleum reservoirs all along the Arctic continental shelf, especially north of the Ringnes islands, the focal point of clastic influx. Within the Sverdrup Basin itself, a few minor oil and gas pools have been found in the Isachsen Formation but for the most part the formation is too shallow to be considered an exploration target.