New stratigraphic units, Middle Jurassic to lowermost Cretaceous succession, Arctic Islands

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Abstract

Bajocian to Valanginian strata (Middle Jurassic to lowermost Cretaceous) in the southern and western portions of the Sverdrup Basin consist of alternating units of shale-siltstone and sandstone. The stratigraphic nomenclature for these strata is well established in this area, and the only addition proposed in this paper is the formalization of a previously recognized sandstone member in the argillaceous Deer Bay Formation, herein named the Glacier Fiord Member. To the north and west, the sandstone units disappear due to facies change and the entire succession consists of siltstone and shale. This thick shale-siltstone unit is herein named the Mackenzie King Formation. In some areas, the formation can be divided into three members – McConnell Island, Ringnes and Deer Bay – all of which have formation status in the southeastern Sverdrup Basin.

Résumé

Les couches déposées entre le Bajocien et le Valanginien (du Jurassique moyen au Crétacé très inférieur) dans les parties méridionales et occidentales du bassin Sverdrup sont composées d'unités alternantes de schiste argileux-siltstone et de grès. La nomenclature stratigraphique de ces couches est bien établie dans cette région; il est cependant proposé d'y ajouter le membre de grès de la formation argileuse de Deer Bay qui a déjà été identifié et qui serait officiellement appelé membre de Glacier Fiord. À cause du changement de faciès, les unités de grès disparaissent vers le nord et l'ouest où la succession se compose entièrement de siltstone et de schiste argileux. Cette importante unité de schiste argileux-siltstone est appelée formation de Mackenzie King. À certains endroits, la formation se divise en trois membres (McConnell Island, Ringnes et Deer Bay) lesquels constituent des formations de la partie sud-est du bassin Sverdrup.

Introduction

The Middle Jurassic (Bajocian) to lowermost Cretaceous (Valanginian) succession within the Mesozoic strata of the Arctic Islands, is an interval that has been plagued by stratigraphic nomenclatural problems. These strata are widespread in the Arctic Islands, occurring in both Sverdrup and Banks basins (Fig. 32.1) and numerous surface and subsurface control points are available for them. The strata are readily delineated over most of the area because they usually occur between two regional sandstone units, the Sandy Point Formation below and the Isachsen Formation above (Fig. 32.2). In the southern and eastern portions of the Sverdrup Basin, the succession consists of alternating sandstone and shale-siltstone units, and a reasonable stratigraphic nomenclatural system has been established on the basis of both early reconnaissance work (Souther, 1963; Tozer, 1963) and more recent subsurface-surface regional syntheses (Balkwill, 1983; Embry, 1984). The only proposed addition to the nomenclature of the strata in this area is the assignment of a formal name to a sandstone unit high in the succession. This sandstone unit has been described and mapped by previous workers (Tozer, 1963; Balkwill, 1983) and is herein named the Glacier Fiord Member of the Deer Bay Formation (Fig. 32.2).

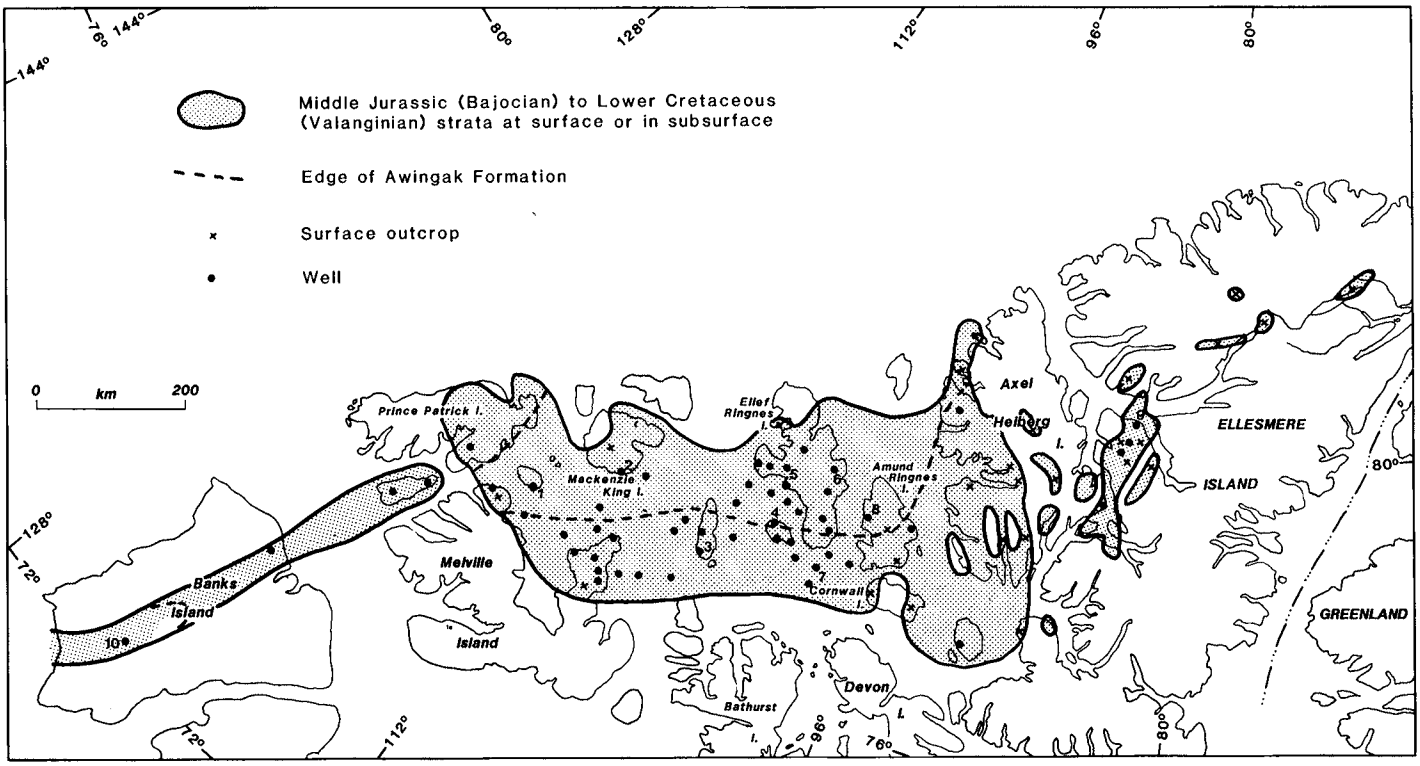
To the northwest, in the Sverdrup Basin, the sandstone units disappear due to facies change to shale and siltstone, and the succession consists almost entirely of these two rock types (Fig. 32.2). Previous workers have given this thick interval of argillaceous strata a variety of names, none of which is deemed suitable for reasons discussed below. In this paper a new formal name, Mackenzie King Formation, is proposed for the Bajocian-Valanginian shale-siltstone unit of the Arctic Islands. Tops for the stratigraphic units of the Bajocian-Valanginian interval in selected wells (Fig. 32.1) are listed in the appendix.

Previous work

The nomenclatural problems for this interval stem mainly from the early reconnaissance fieldwork, at which time authors did not have the benefits of subsurface data and a regional framework. Heywood (1955, 1957) conducted fieldwork on northwestern Ellef Ringnes Island in 1952 and 1953. He defined the Deer Bay Formation from exposures of medium- to dark-grey shale that underlie the sandstone-dominant Isachsen Formation. Unfortunately, Heywood did not observe the base of the formation and did not designate a type section. Fossils collected from the Deer Bay strata by Heywood were all of Valanginian age.

In 1955, a shale unit, which lies between the sandstone-dominant Awingak Formation (Upper Jurassic) and the Isachsen Formation, on Axel Heiberg Island, was assigned to the Deer Bay Formation (Souther, 1963). This usage was later extended to other portions of Axel Heiberg Island (Fricker, 1963; Tozer, 1963).

Tozer and Thorsteinsson (1964) mapped Mackenzie King Island in 1958. The entire Bajocian-Valanginian shale-siltstone unit that outcrops on the island was assigned to the



1. *Emerald K-33;*
2. *Cape Norem A-80;*
3. *Skybattle Bay C-15;*
4. *Wallis K-62;*
5. *Kristoffer Bay B-06;*
6. *Helicopter J-12;*
7. *Char G-07;*
8. *West Amund I-44;*
9. *Halcyon O-16;*
10. *Orksut I-44.*

Figure 32.1. *Distribution of Bajocian-Valanginian strata and control points. Key to numbered wells listed in appendix.*

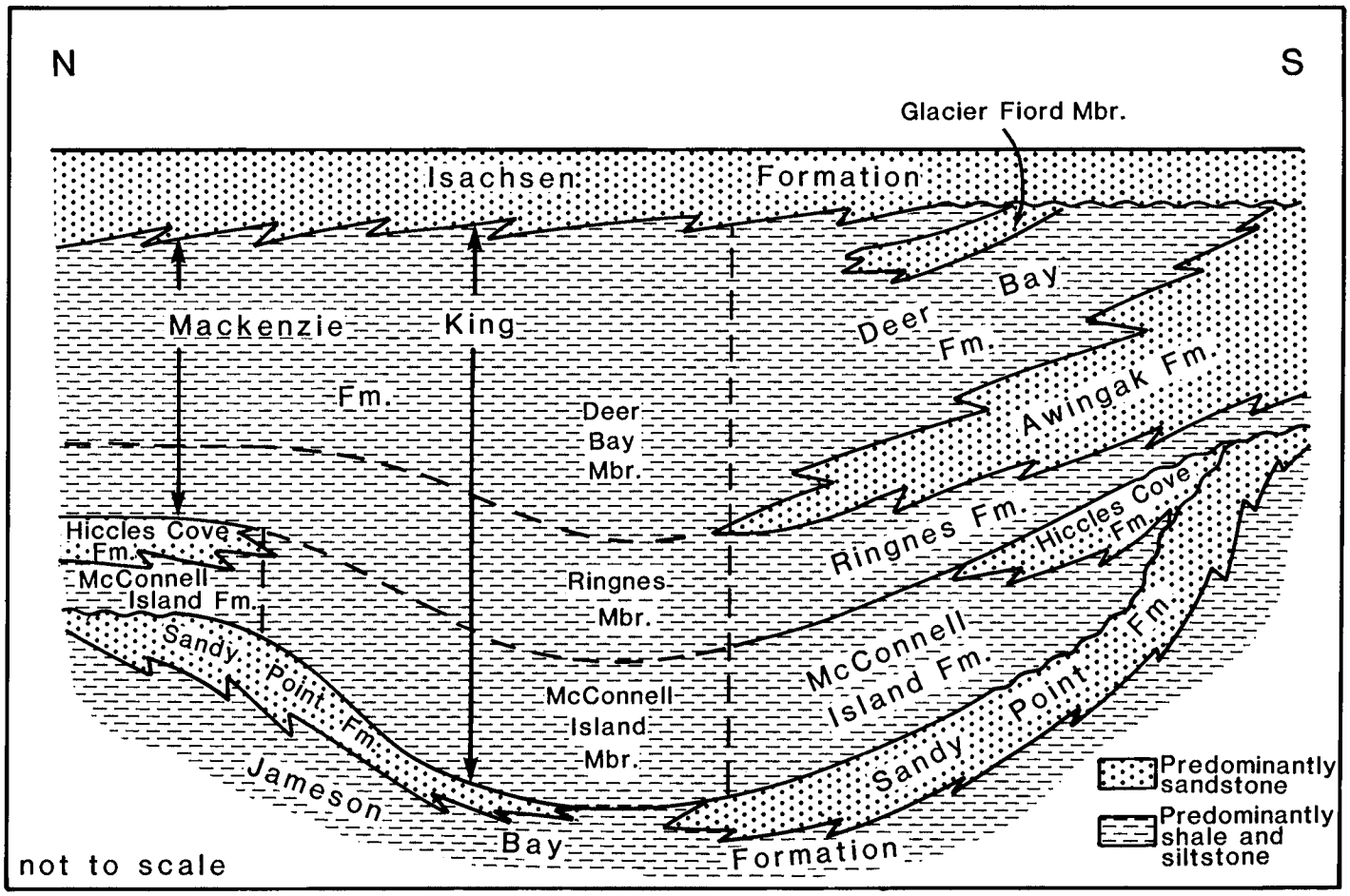


Figure 32.2. *Schematic stratigraphic cross-section, Bajocian-Valanginian strata, Sverdrup Basin.*

Mould Bay Formation, a sandstone-dominant unit with a type section on Prince Patrick Island. This assignment was made on the erroneous interpretation that the interval on Mackenzie King consists mainly of sandstone. In fact, it is almost entirely shale and siltstone.

In 1967, Stott (1969) mapped Ellef Ringnes Island and placed the base of the Deer Bay Formation at the top of a Callovian (late Middle Jurassic) sandstone that he assigned to the Wilkie Point Formation (Hiccles Cove Formation of Embry, 1984). Subsequent drilling in the Ellef Ringnes Island area further complicated the matter, because over most of the area it was found that shale and siltstone were continuous from the base of the Isachsen Formation to the top of an Aalenian sandstone unit usually referred to as Jaeger (Sandy Point Formation of Embry, 1984). Henao-Londono (1977) referred the entire shale-siltstone unit to the Deer Bay Formation. Thus the term Deer Bay became commonly applied to two different shale units, one between the Isachsen and Awingak formations, and the other between the Isachsen and Sandy Point formations. The Lower Cretaceous shale originally described as Deer Bay by Heywood was common to both these units.

Balkwill (1983) attempted to resolve this problem of dual usage by recognizing three, separate stratigraphic units within the Bajocian-Valanginian argillaceous succession: the Deer Bay and Ringnes formations and the "Upper Savik". Each unit consists mainly of shale and siltstone, but the units were distinguished from one another on the basis of colour, silt content and the character of associated concretions. This subdivision allowed Balkwill (1983) to redefine the Deer Bay Formation as the Upper Jurassic-Lower Cretaceous shale unit that lies between the Isachsen Formation and either the Awingak Formation or its shale-siltstone equivalent, the Ringnes Formation. However, as noted by Balkwill (1983), a drawback to this nomenclatural scheme was that the three shale-siltstone units could not always be objectively delineated in subsurface sections.

The sandstone unit that occurs in the Deer Bay Formation and which is given formal nomenclature in this paper, was first described by Tozer (1963). He outlined its distribution on southern Axel Heiberg Island and dated it as Early Valanginian. Balkwill (1983) recognized the same unit on southern Amund Ringnes Island and mapped it as Member D of the Deer Bay Formation.

Present work

The writer's surface and subsurface studies of the Bajocian-Valanginian interval has led to the assignment of the thick, argillaceous succession that comprises the interval in the northwestern Sverdrup to a single formation. Because the name Deer Bay has been redefined as discussed above, and the term Mould Bay was inappropriate in the first place, a new name, Mackenzie King Formation, is proposed for this rock unit. It is acknowledged that separate shale-siltstone units can be distinguished in most outcrop sections and in

some wells (Upper Savik, Ringnes and Deer Bay of Balkwill, 1983) and these units are given member status (McConnell Island, Ringnes, Deer Bay members) (Fig. 32.2). Formation status for these units in the northwestern Sverdrup is presently inappropriate because of the difficulty of objectively delineating them in subsurface sections. However, it is important to note that the type Ringnes and Deer Bay are still valid at these localities, although they are members rather than formations as originally defined.

The sandstone member of the Deer Bay Formation was examined on southern Axel Heiberg Island in 1983. It is a readily recognizable unit in this area as described by Tozer (1963). Because it is such a distinctive unit in the Deer Bay Formation and is a potential hydrocarbon reservoir in the subsurface, it is herein formally named the Glacier Fiord Member of the Deer Bay Formation.

The relationships of the newly defined units with previously designated units are shown in Figure 32.3.

Mackenzie King Formation

Definition

The Mackenize King Formation consists mainly of medium- to dark-grey shale and siltstone with a few, very fine grained, sandstone interbeds. The type section is in the Cape Norem A-80 well (77°29'13"N, 110°27'05"W; spudded April 19, 1970, abandoned August 27, 1970; T.D. 2970 m, K.B. 14 m) between 192 m (630 ft) and 1009 m (3310 ft), and is 817 m (2680 ft) thick (Fig. 32.4) The name is taken from Mackenzie King Island upon which the type well was drilled. Chip samples taken at 3 m intervals from the type section can be examined at the Institute of Sedimentary and Petroleum Geology, in Calgary, Alberta.

Synonyms

1. Deer Bay Formation, northern Ellef Ringnes, Heywood (1955, 1957).
2. Mould Bay Formation, Mackenzie King and northwestern Melville, Tozer and Thorsteinsson (1964).
3. Deer Bay Formation, Ellef Ringnes, Stott (1969), Henao-Londono (1977).
4. Wilkie Point and Mould Bay formations, Banks Island, Miall (1979).
5. Upper Savik, Ringnes Formation and Deer Bay Formation, central Amund Ringnes, Balkwill (1983).

Boundaries

The Mackenize King Formation usually conformably overlies the Sandy Point Formation, and the contact is placed at the lowest shale-siltstone unit above which shale and siltstone are predominant. In the central portion of the Sverdrup Basin, the Sandy Point is absent due to facies change, and the Mackenzie King conformably overlies the

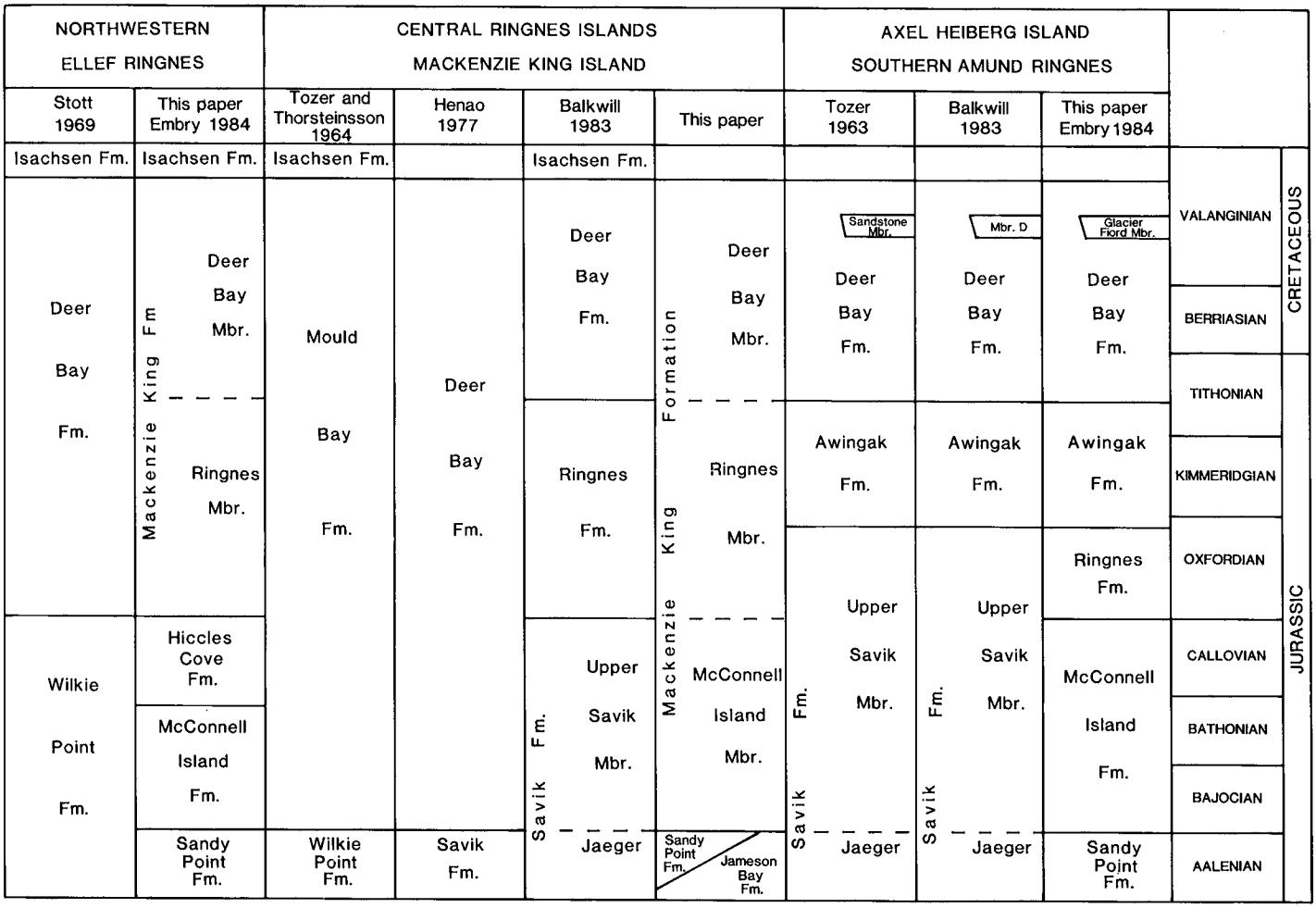


Figure 32.3. *Past and present nomenclature of Bajocian-Valanginian strata, Sverdrup Basin.*

Jameson Bay Formation (Fig. 32.2). The contact at these localities is placed at the base of a soft, clay-rich shale unit that abruptly overlies the uppermost siltstones of the Jameson Bay Formation. In a few sections on the northwestern and southwestern margins of the Sverdrup and on south-central Banks Island, the Mackenzie King conformably overlies the Hiccles Cove Formation. The contact is placed at the base of the first shale-siltstone unit above which shale and siltstone are predominant (Fig. 32.2).

The Mackenzie King Formation is overlain by the Isachsen Formation. The contact varies from conformable within the Sverdrup Basin, to unconformable on the basin flanks and on Banks Island, and is placed at the base of the first sandstone unit above which sandstone is predominant.

The name Mackenzie King ceases to be used in sections in which the Awingak Formation can be recognized (Fig. 32.2).

Lithology

In the type section, the three members of the Mackenzie King Formation can be distinguished (Fig. 32.4). The basal member, the McConnell Island, consists of soft, light to medium green-grey shale and siltstone with ironstone concretions. The overlying Ringnes Member consists of dark grey to black, silty shale and siltstone with dolomitic concretions. The Deer Bay Member, which comprises the bulk of the formation, consists of medium- to dark-grey,

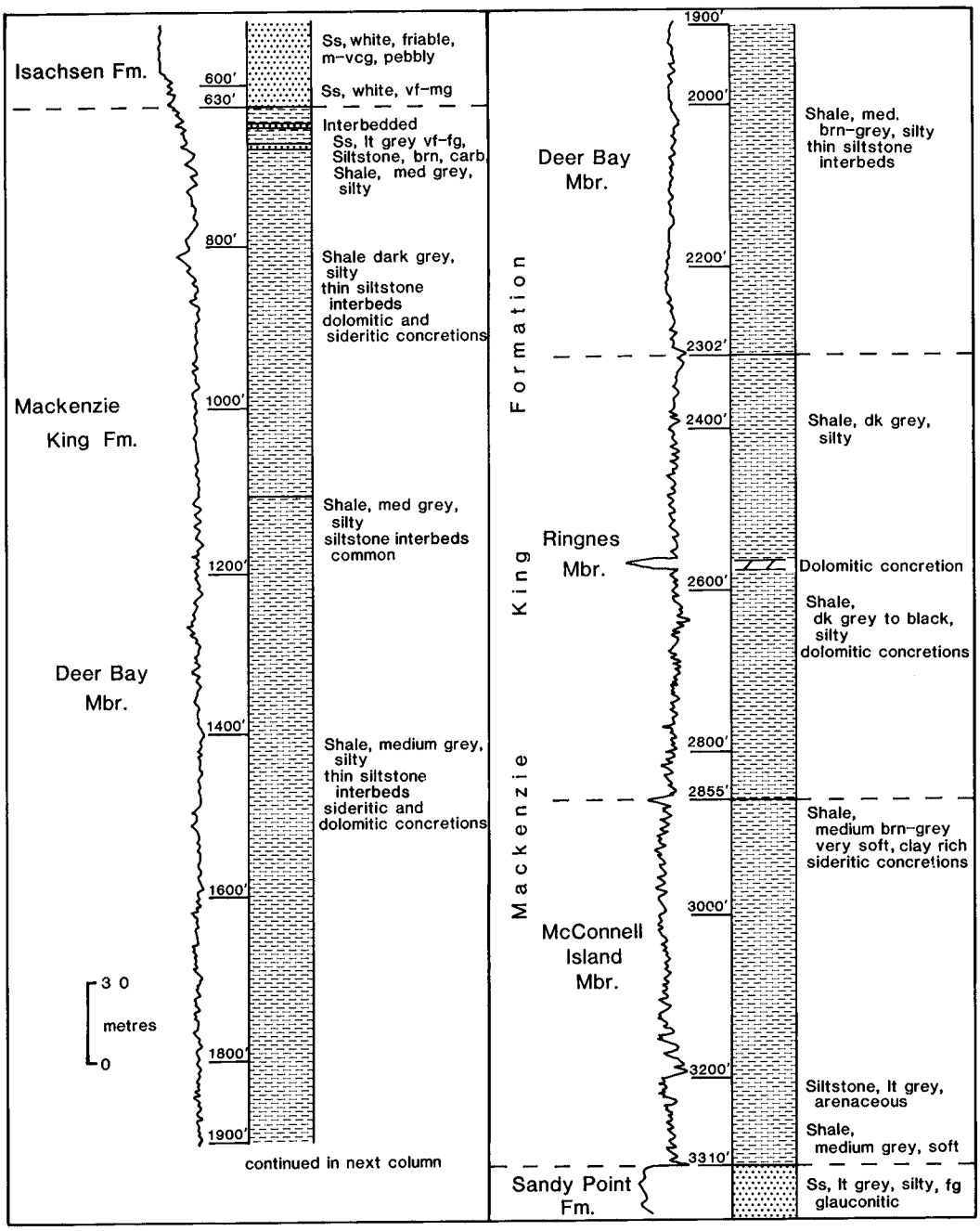


Figure 32.4. *Lithology (from samples) and gamma-ray curve for type section of Mackenzie King Formation; Cape Norem A-80 well.*

silty shale and siltstone with interbeds of very fine grained sandstone in the uppermost portion. This lithologic subdivision of the Mackenzie King characterizes the formation over its extent, although basinward, the shales of the McConnell Island Member become darker and are difficult to distinguish from the Ringnes strata. Sandstone units become more common in the Deer Bay Member toward the basin margins, and consist of very fine- to fine-grained, burrowed sandstone. Marine fossils, mainly pelecypods, occur in all members.

Thickness and distribution

The Mackenzie King Formation occurs mainly in the northwestern portion of the Sverdrup Basin (Fig. 32.1) and is bounded by facies change to the southeast and erosion to the northwest. The formation was penetrated in a well on south-central Banks Island but its distribution in this area is probably limited, as it is absent in surrounding wells. The thickest occurrences of the formation occur on eastern Ellef Ringnes Island and central Amund Ringnes Island, where it is about 1350 m thick.

Age

Pelecypods and ammonites collected from surface exposures range in age from Callovian to Valanginian (Balkwill, 1983) but the lowermost beds have not yielded macrofossils. Stratigraphic relationships suggest the basal beds are Bajocian and Bathonian in age (Embry, 1984). The ages of the members are interpreted to be: McConnell Island – Bajocian to Callovian; Ringnes – Oxfordian to Kimmeridgian; Deer Bay – Tithonian to Valanginian (Balkwill, 1983).

Environment of deposition

The rock types and fauna of the formation are indicative of an offshore marine shelf to prodelta environment of deposition.

Glacier Fiord Member, Deer Bay Formation

Definition

The Glacier Fiord Member consists of very fine- to medium-grained sandstone. The type section is located on southern Axel Heiberg Island, 5 km east-northeast of the head of Glacier Fiord (78°37'20"N, 89°46'W) on the north side of a prominent glacier. The member is named for Glacier Fiord, which is close to the type section.

Synonyms

1. Sandstone member, Deer Bay Formation, south Axel Heiberg Island, Tozer (1963).
2. Member D, Deer Bay Formation, southern Amund Ringnes Island, Balkwill (1983).

Boundaries

The Glacier Fiord Member is conformably underlain and overlain by shale and siltstone of the Deer Bay Formation. The lower contact of the member is placed at the base of the first sandstone unit above which sandstone becomes predominant. The upper contact is placed at the top of the highest sandstone above which shale and siltstone are predominant.

Lithology

At the type section, the member displays a coarsening-upward trend. The basal 6 m are composed of light grey, very fine grained, burrowed sandstone. The overlying 22 m comprise interbedded burrowed sandstone and very fine- to fine-grained, hummocky to horizontally bedded sandstone. The upper 12 m consist of white, massive to horizontally bedded, fine- to medium-grained sandstone. Balkwill's (1983) description of the member on southern Amund Ringnes

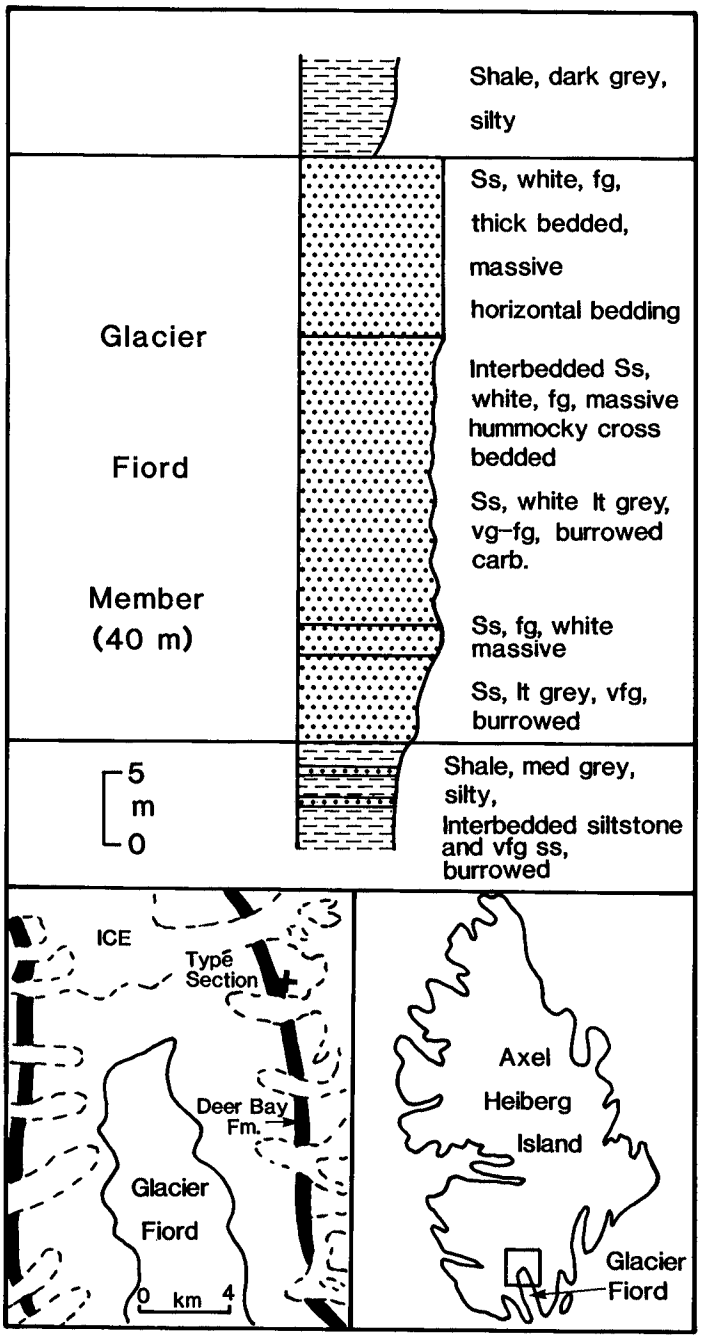


Figure 32.5. Lithology (from outcrop) for type section of Glacier Fiord Member, Deer Bay Formation; Glacier Fiord area, southern Axel Heiberg Island.

is similar, and he records thin, chert-pebble beds in the uppermost portion. Northward, the massive to hummocky crossbedded strata disappear, and the member is composed entirely of burrowed, very fine grained sandstone.

Thickness and distribution

The member occurs on southern Axel Heiberg Island (Tozer, 1963) and southern Amund Ringnes Island (Balkwill, 1983). The member is limited in the north by facies change to shale and siltstone and in the south by truncation beneath the sub-Isachsen Formation unconformity. The member probably extends along the eastern and southern margins of the basin and it has been encountered in one well south of Ellef Ringnes Island and one well on Fosheim Peninsula, Ellesmere Island (Fig. 32.1, appendix). Coarse grained siltstones stratigraphically equivalent to the member occur in a number of wells. The maximum recorded thickness is 40 m (type section).

Age environment of deposition

Pelecypods from below, within, and above the member are Early Valanginian in age (Tozer, 1963; Balkwill, 1983).

The lithotypes, sedimentary structures, and fauna indicate a shallow marine shelf environment. Burrowed sandstones were probably deposited below storm wave base, and the hummocky to horizontally bedded sandstones deposited above storm wave base.

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APPENDIX

Stratigraphic tops from selected wells, formations of Bajocian-Valanginian succession, Arctic Islands. Location of wells shown on Figure 32.1.

	metres	feet
BP Emerald K-32		
Mackenzie King Formation	447	(1466)
Hiccles Cove Formation	798	(2618)
McConnell Island Formation	975	(3200)
Sandy Point Formation	1003	(3290)
Elf Cape Norem A-80		
Mackenzie King Formation	192	(630)
Sandy Point Formation	1009	(3310)
Sun Skybattle Bay C-15		
Deer Bay Formation	1263	(4144)
Awingak Formation	1571	(5154)
Ringnes Formation	1674	(5492)
McConnell Island Formation	1711	(5612)
Sandy Point Formation	1767	(5797)
Dome Wallis K-62		
Mackenzie King Formation	1084	(3558)
Jameson Bay Formation	1755	(5758)
Panarctic Kristoffer Bay B-06		
Mackenzie King Formation	372	(1220)
Jameson Bay Formation	1106	(3630)
Panarctic Helicopter J-12		
Mackenzie King Formation	1316	(4316)
Sandy Point Formation	3139	(10300)
Panarctic Char G-07		
Deer Bay Formation	985	well
Glacier Fiord Member	1014	
underlying Deer Bay Formation	1043	logged
Awingak Formation	1314	
Ringnes Formation	1415	in
McConnell Island Formation	1439	
Sandy Point Formation	1477	metres
Panarctic West Amund I-44		
Mackenzie King Formation	spud	
Sandy Point Formation	687	(2254)
Panarctic Halcyon O-16		
Deer Bay Formation	1239	(4066)
Glacier Fiord Member	1244	(4083)
underlying Deer Bay Formation	1273	(4178)
Awingak Formation	1519	(4983)
Ringnes Formation	1806	(5925)
Hiccles Cove Formation	1847	(6060)
Sandy Point Formation	1880	(6169)
Deminex Orksut I-44		
Mackenzie King Formation	1457	(4781)
Hiccles Cove Formation	1813	(5948)
Cape de Bray Formation (Devonian)	1828	(5998)