Stratigraphic subdivision of the Isachsen and Christopher formations (Lower Cretaceous), Arctic Islands

Project 750083

Ashton F. Embry
Institute of Sedimentary and Petroleum Geology, Calgary

Embry, A.F., Stratigraphic subdivision of the Isachsen and Christopher formations (Lower Cretaceous), Arctic Islands; in Current Research, Part B, Geological Survey of Canada, Paper 85-1B, p. 239-246, 1985.

Abstract

The Isachsen Formation, a Lower Cretaceous sandstone-dominant unit, is herein divided into three members, named in ascending order: Paterson Island, Rondon and Walker Island. The Paterson Island and Walker Island members are sandstone-dominant units of delta front and delta plain origin and are separated by the shale-siltstone-dominant Rondon Member, which is of offshore marine shelf origin. The Christopher Formation, a Lower Cretaceous, shale-siltstone-dominant unit, which overlies the Isachsen Formation, is divided into two members, named in ascending order: Invincible Point and Macdougall Point. Both members are of offshore marine shelf origin, and the boundary between the two is placed at the top of a widespread sandstone-siltstone interval that occurs in the middle of the Christopher Formation.

Résumé

La formation d'Isachsen, unité à dominance de grès du Crétacé inférieur, se divise ici en trois membres, nommés dans l'ordre ascendant: Paterson Island, Rondon et Walker Island. Les membres Paterson Island et Walker Island sont des unités où prédomine le grès, d'origine deltaïque (front et plaine); ces deux membres sont séparés par le membre de Rondon où prédominent le schiste argileux et le siltstone d'origine sous-marine (plate-forme continentale). La formation de Christopher, unité du Crétacé inférieur où prédomine le schiste argileux et le siltstone, et qui surmonte la formation d'Isachsen, comporte deux membres, nommés dans l'ordre ascendant: Invincible Point et Macdougall Point. Les deux membres sont d'origine sous-marine (plate-forme continentale) et la limite entre les deux se situe au sommet d'un intervalle étendu de grès et de siltstone qui traverse le milieu de la formation de Christopher.

Introduction

The Isachsen and Christopher formations were recognized and defined by Heywood (1955, 1957) on the basis of fieldwork on northern Ellef Ringnes Island in 1952 and 1953. Subsequent fieldwork permitted the recognition of these units over much of the Arctic Islands, and the combined thickness of the formations commonly exceeds 1500 m. The Isachsen Formation is composed mainly of fine- to very coarse-grained, quartzose sandstone, with interbeds of siltstone, shale and coal. The overlying Christopher Formation comprises predominantly medium to dark grey shale and siltstone, with only minor sandstone content.

The two formations make up the bulk of the Lower Cretaceous succession in the Arctic Islands, and occur mainly within the Sverdrup Basin, Eglinton Graben and Banks Basin (Fig. 29.1). Small, isolated occurrences are also present as outliers on Lower Paleozoic strata to the south and east of the Sverdrup Basin. Numerous subsurface and surface sections are available for the formations (Fig. 29.1) and regional correlations have indicated that both formations can be subdivided into members that extend over much of the study area. In this paper, three members within the Isachsen and two within the Christopher are defined and described. Stratigraphic tops for these units in selected wells across the area are listed in the appendix. Chip samples, taken at 3 m intervals from the type sections of these new members, can be examined at the Institute of Sedimentary and Petroleum Geology in Calgary, Alberta, Canada.

Previous work

The Isachsen and Christopher formations were defined by Heywood (1955, 1957) from exposures on northern Ellef Ringnes Island. The Isachsen is a prominent sandstone unit that lies between two shale-siltstone units (Deer Bay and Christopher formations) whereas the Christopher is a shale-siltstone unit lying between two sandstones (Isachsen and Hassel formations). Fieldwork during Operation Franklin in 1955 extended the two formations eastward to Amund Ringnes and Axel Heiberg islands (Fortier et al., 1963). Subsequent fieldwork in the late fifties and early sixties further extended the formations and demonstrated their occurrence on Ellesmere, Melville, Prince Patrick, Mackenzie King, Eglinton and Banks islands (Thorsteinsson and Tozer, 1962; Tozer, 1963; Tozer and Thorsteinsson, 1964). More recently, the formations have been described by Stott (1969), Nassichuk and Christie (1969), Plauchut and Jutard (1976), Balkwill and Roy (1977), Miall (1979), Balkwill et al., (1982) and Balkwill (1983) as part of regional mapping studies in various parts of the Arctic Islands.

In a few cases (McLaren, 1963; Balkwill, 1983), the Isachsen Formation was subdivided into informal members on the basis of weathering pattern, but these units were of local extent only. On the other hand, the Christopher Formation has been divided into two informal members over much of its extent (Plauchut and Jutard, 1976; Balkwill and Roy, 1977; Balkwill, 1983). This subdivision is based on the occurrence of a medial sandstone and siltstone unit in the Christopher, the top of which is used as the boundary between the two informal members.

Present work

As part of a regional study of the Mesozoic succession in the Arctic Islands the author has examined numerous surface and subsurface sections of the Isachsen and Christopher formations. Correlation of these sections has led to the recognition of three, widespread members in the Isachsen and two in the Christopher.

A distinctive unit of medium- to dark-grey shale and siltstone of marine origin occurs within the sandstone-dominant Isachsen Formation over most of the formation's

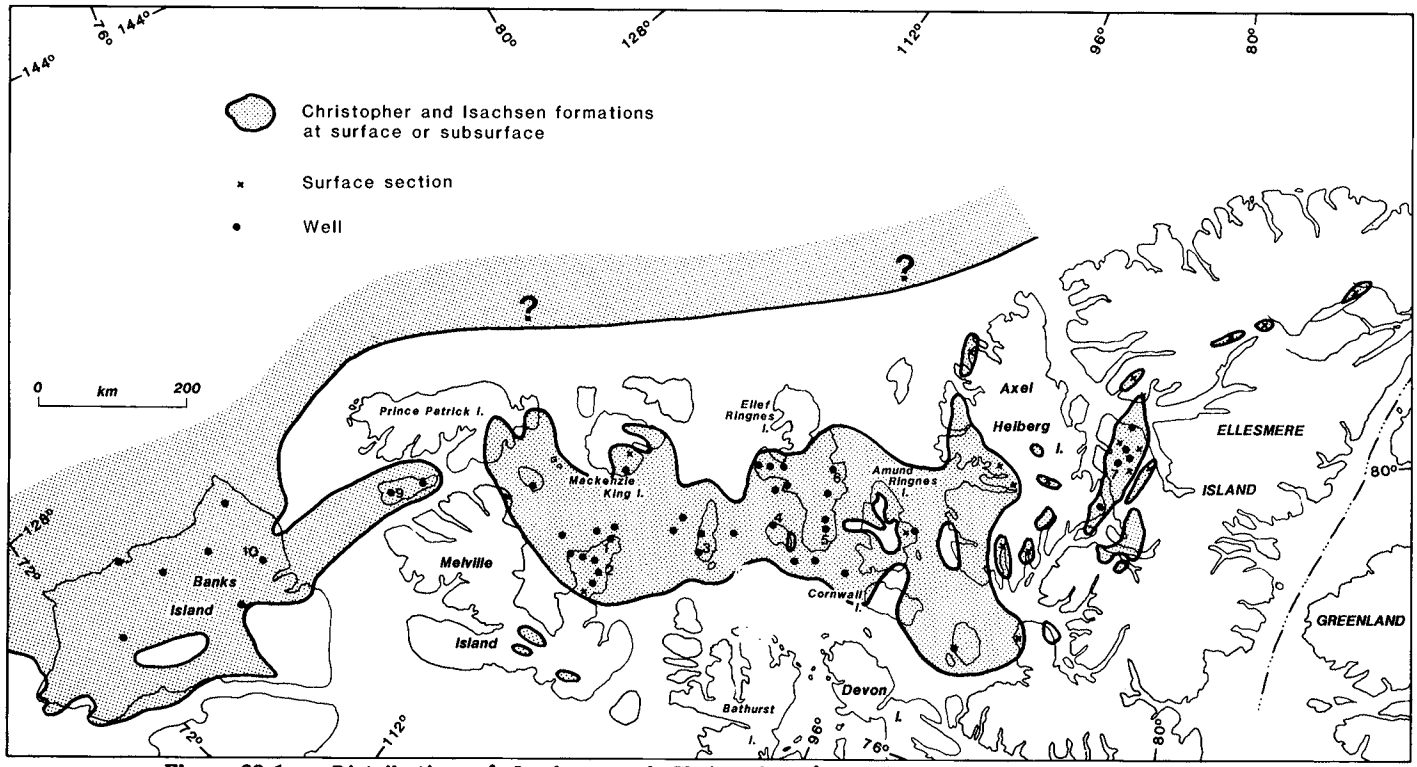

Figure 29.1. Distribution of Isachsen and Christopher formations and control points. Key to numbered wells listed in appendix: 1. North Sabine H-49, 2. Drake Point F-16, 3. Skybattle Bay C-15, 4. Wallis A-73, 5. Hoodoo Dome H-37, 6. Helicopter J-12, 7. Romulus C-42, 9. Pedder Point D-49, 10. Castel Bay C-68.

extent in the Sverdrup Basin. The existence of this unit was first noted by Balkwill et al. (1982) in a well on Lougheed Island. The delineation of this shale-siltstone unit within the Isachsen Formation allows the formation to be divided into three members: a lower sandstone, a medial shale-siltstone and an upper sandstone. These three members are formally defined herein and have been named, in ascending order, Paterson Island, Rondon, and Walker Island members.

Figure 29.2 illustrates the general stratigraphy of these three members. In some areas of the Arctic Islands (northeastern Sverdrup, southeastern basin margin, Banks Basin) the Rondon Member is absent due to facies change to sandstone, and in these areas the Isachsen Formation is undivided. In the northwestern portion of the Sverdrup Basin (Mackenzie King Island), the Walker Island Member is absent due to facies change to shale and siltstone and the Paterson Island Member comprises the entire Isachsen Formation in this area (Fig. 29.2).

For the Christopher Formation, an interval of interbedded very fine grained sandstone, siltstone and shale can be recognized in the mid-portion of the formation on Ellesmere, Axel Heiberg, Amund Ringnes, Ellef Ringnes and King Christian islands. To the southwest, this interval consists mainly of coarse siltstone with only minor sandstone, but is still clearly recognizable on Lougheed, Melville, Eglinton and Banks islands. The sandstone or coarse siltstone unit is abruptly overlain by soft, clay-rich shale. This boundary is readily delineated in surface and subsurface sections, and is also a good seismic reflector over portions of the western Sverdrup (A. Densmore, personal communication, 1982). Following Balkwill (1983) this boundary is used to divide the Christopher into two members, which are formally defined herein and are named, in ascending order, the Invincible Point and Macdougall Point members.

Paterson Island Member, Isachsen Formation

Definition

The Paterson Island Member consists predominantly of fine- to very coarse-grained, pebbly sandstone with interbeds of carbonaceous siltstone, shale and coal. The type section is in the Sun Skybattle Bay C-15 well (77°14'12"N, 105°05'57"W; spudded April 1, 1971, abandoned November 23, 1971; T.D. 3658 m, K.B. 33.5 m) between 1111 m (3644 ft) and 1263 m (4144 ft), and is 152 m thick (Fig. 29.3). The name is taken from Paterson Island, which lies to the south of Lougheed Island.

Boundaries

The Paterson Island Member overlies either the Deer Bay or Mackenzie King formations, with the contact varying from unconformable on the basin margin to conformable in the basin centre. The contact is placed at the base of the first sandstone unit above which sandstone is predominant. The Paterson Island Member is usually conformably overlain by the Rondon Member of the Isachsen Formation except in the northwestern Sverdrup, where it is overlain by the Christopher Formation (Fig. 29.2). The contact is placed at the top of the highest sandstone unit above which shale and siltstone are predominant.

Lithology

In the type section (Fig. 29.3) the Paterson Island Member consists mainly of units of fine- to very coarse-grained, pebbly, quartzose sandstone that have abrupt basal contacts, and which fine upward into units of carbonaceous shale, siltstone, very fine grained sandstone, and coal. The sandstone units are up to 35 m thick, and the intervening argillaceous intervals are between 2 and 10 m thick. This lithological association is typical for the Paterson Island Formation, with the sandstones in outcrop commonly

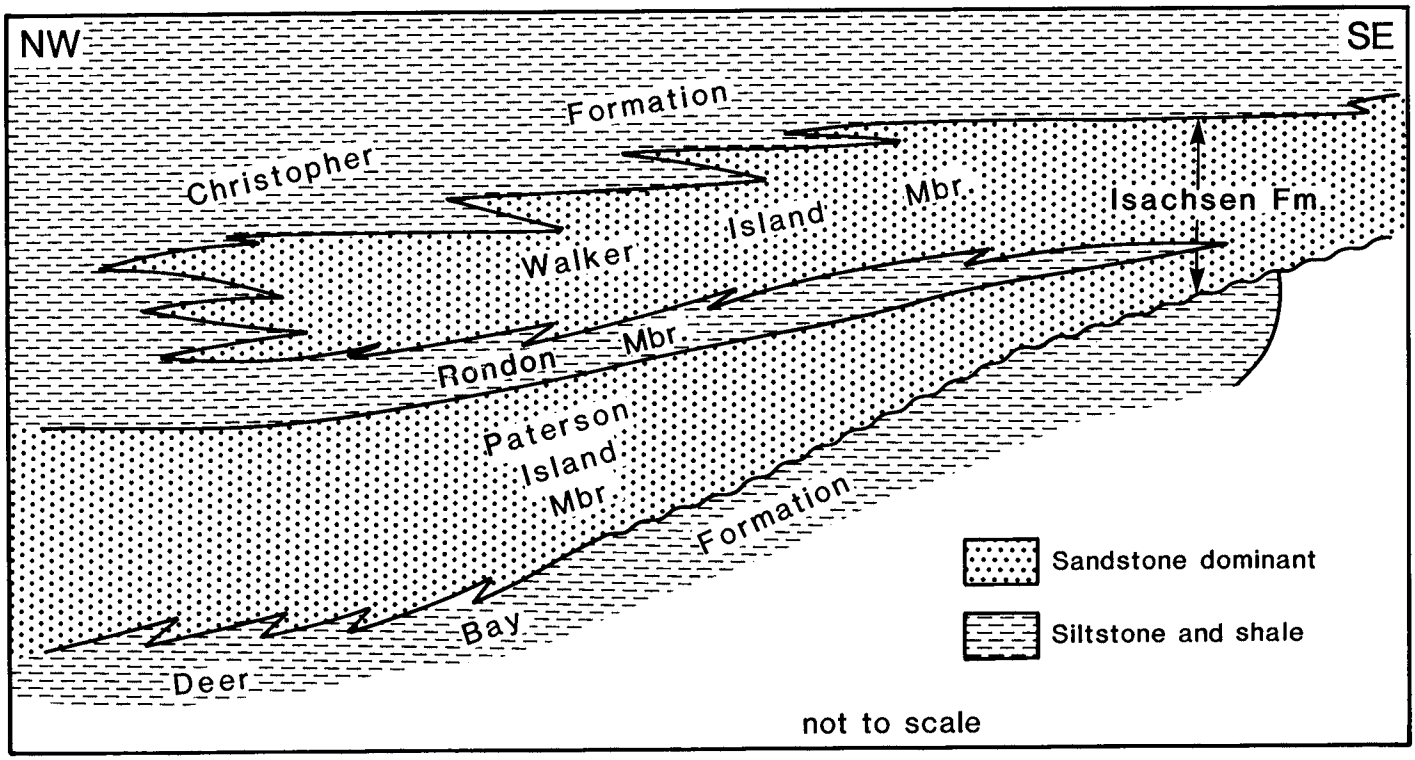

Figure 29.2. Schematic stratigraphic cross-section, Isachsen Formation, Sverdrup Basin.

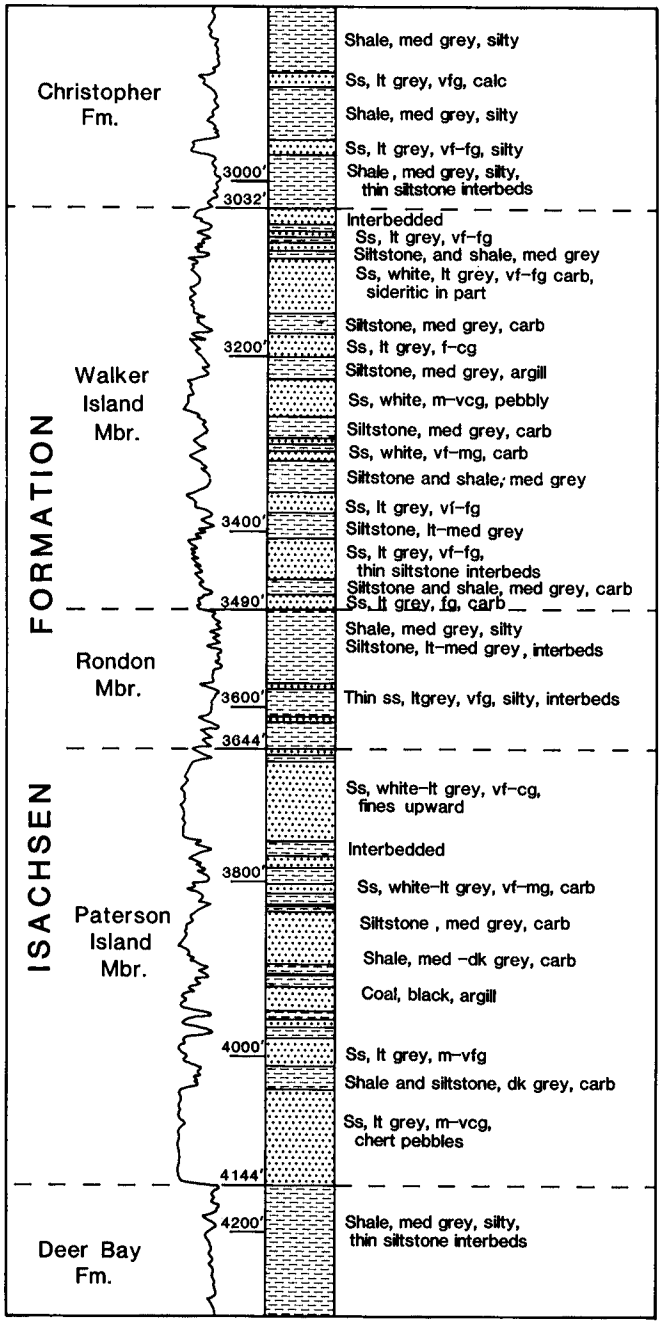

Figure 29.3. *Lithology (from samples) and gamma ray curve for type sections of Paterson Island, Rondon, Walker Island members. Isachsen Formation, Skybattle Bay C-15 well.*

exhibiting trough and planar crossbedding. Ripple cross-lamination, root casts, and parallel lamination occur in the very fine grained sandstone and siltstone units. In the basin centre area, where the basal contact of the member is conformable, coarsening-upward cycles of shale, siltstone and very fine- to coarse-grained siltstone occur in the basal portion of the member.

Thickness and distribution

The Paterson Island Member occurs over most of the Isachsen Formation's extent in the Sverdrup Basin, with the exception of the areas previously noted. The member is usually thin (<20 m) on the basin margins and thickens basinward to a maximum recorded thickness of 880 m on eastern Ellef Ringnes Island.

Age

Late Valanginian pelecypods occur in the basal portion of the member in basinal sections (Balkwill, 1983), and the overlying Rondon Member is dated as Barremian. Thus, within the basin, the member is late Valanginian to early Barremian in age. Seismic records indicate that much of the marginward thinning of the member is due to onlap onto a basal unconformity (A. Densmore, personal communication, 1982) and thus marginal sections have a far shorter age range (mainly late Hauterivian to early Barremian).

Environment of deposition

The bulk of the member is interpreted to be of delta plain origin, with both channel and overbank environments represented (fining-upward cycles, coal). The coarsening-upward cycles in the basal portion of the member in basinal sections are of delta front origin.

Rondon Member, Isachsen Formation

Definition

The Rondon Member comprises interbedded medium- to dark-grey shale, siltstone and very fine grained sandstone. The type section is in the Sun Skybattle Bay well between 1064 m (3490 ft) and 1111 m (3644 ft), and is 47 m thick (Fig. 29.3). The name is taken from Cape Rondon, on the east coast of Lougheed Island.

Boundaries

As previously described, the Rondon Member conformably overlies the Paterson Island Member. The Rondon is conformably overlain by the Walker Island Member of the Isachsen Formation, with the contact placed at the base of the first sandstone unit above which sandstone is predominant (Fig. 29.3).

Lithology

The Rondon Member is composed predominantly of dark grey, silty shale and siltstone with minor interbeds of very fine- to fine-grained sandstone. In outcrop, the sandstones are usually burrowed and ripple crosslamination is also present. Shales and siltstones are parallel laminated to burrowed. The lithotypes are commonly arranged in coarsening-upward cycles 5 to 10 m thick.

Thickness and distribution

The Rondon Member occurs over most of the Sverdrup Basin except in the areas previously noted. It is very thin (5-10 m) along the basin margin, and usually falls within the 30 to 70 m thickness range within the basin.

Age

The strata comprising the Rondon were previously tentatively dated as Aptian on the basis of micropaleontology (Balkwill et al., 1982). More recent palynological studies have indicated that the Rondon is Barremian in age (McIntyre, personal communication, 1984; Kosta, personal communication, 1985).

Environment of deposition

The rock types and flora of the Rondon indicate an offshore marine shelf environment of deposition.

Walker Island Member, Isachsen Formation

Definition

The Walker Island Member is made up of interbedded very fine- to coarse-grained sandstone, siltstone, shale and minor coal. The type section is in the Sun Skybattle Bay C-15 well between 924 m (3032 ft) and 1064 m (3490 ft), and is 140 m thick (Fig. 29.3). The name is taken from Edmund Walker Island, which lies immediately south of Lougheed Island.

Boundaries

As previously described, the Walker Island conformably overlies the Rondon Member. The member is conformably overlain by the Christopher Formation, with the contact placed at the top of the highest sandstone bed above which shale and siltstone predominate.

Lithology

The Walker Island Member is composed predominantly of very fine- to coarse-grained sandstone with interbeds of medium- to dark-grey, carbonaceous siltstone, shale and minor coal. Coarsening-upward cycles up to 30 m thick occur in the lower and uppermost portions of the member, with fining-upward cycles and associated coal occurring in the mid-portion of the member. Individual sandstone units are up to 25 m thick, and shale-siltstone units are usually less than 10 m thick. Sandstones capping the coarsening-upward cycles are commonly horizontally bedded to ripple crosslaminated. Trough and planar crossbeds occur in sandstone units that fine upward.

Thickness and distribution

The member has the same distribution as the underlying Rondon Member and occurs over most of the Sverdrup. On the basin margins, the member is 20 to 100 m thick. It thickens to a maximum of about 500 m on eastern Ellef Ringnes Island.

Age

No age-diagnostic fossils have been identified from the Walker Island Member, but it is bracketed by a Barremian age below and an Aptian age above. Thus the member is tentatively dated as late Barremian to early Aptian. Stratigraphic relationships suggest that the top of the member becomes younger toward the basin margins.

Environment of deposition

The lithotypes and cyclicity of the member indicate that its lower and middle portion represent a regressive delta front to delta plain succession. The coarsening-upward cycles of the uppermost portion represent transgressive delta front to marine shelf deposits.

Invincible Point Member, Christopher Formation

Definition

The Invincible Point Member comprises mainly dark grey shale and siltstone with interbeds of very fine grained sandstone. The type section is in the Panarctic North Sabine H-49 well (76°48'15"N, 108°45'11"W; spudded May 2, 1974, abandoned July 8, 1974; T.D. 3787 m, K.B. 60 m) between 1435 m (4708 ft) and 1856 m (6088 ft), and is 421 m thick (Fig. 29.4). The name is taken from Invincible Point on the eastern side of Sabine Peninsula, Melville Island.

Synonyms

1. Lower unit, Christopher Formation, Banks and Eglinton islands, Plauchut and Jutard (1976).
2. Lower member, Christopher Formation, King Christian Island, Balkwill and Roy (1977).
3. Lower member, Christopher Formation, Amund Ringnes Island, Balkwill (1983).

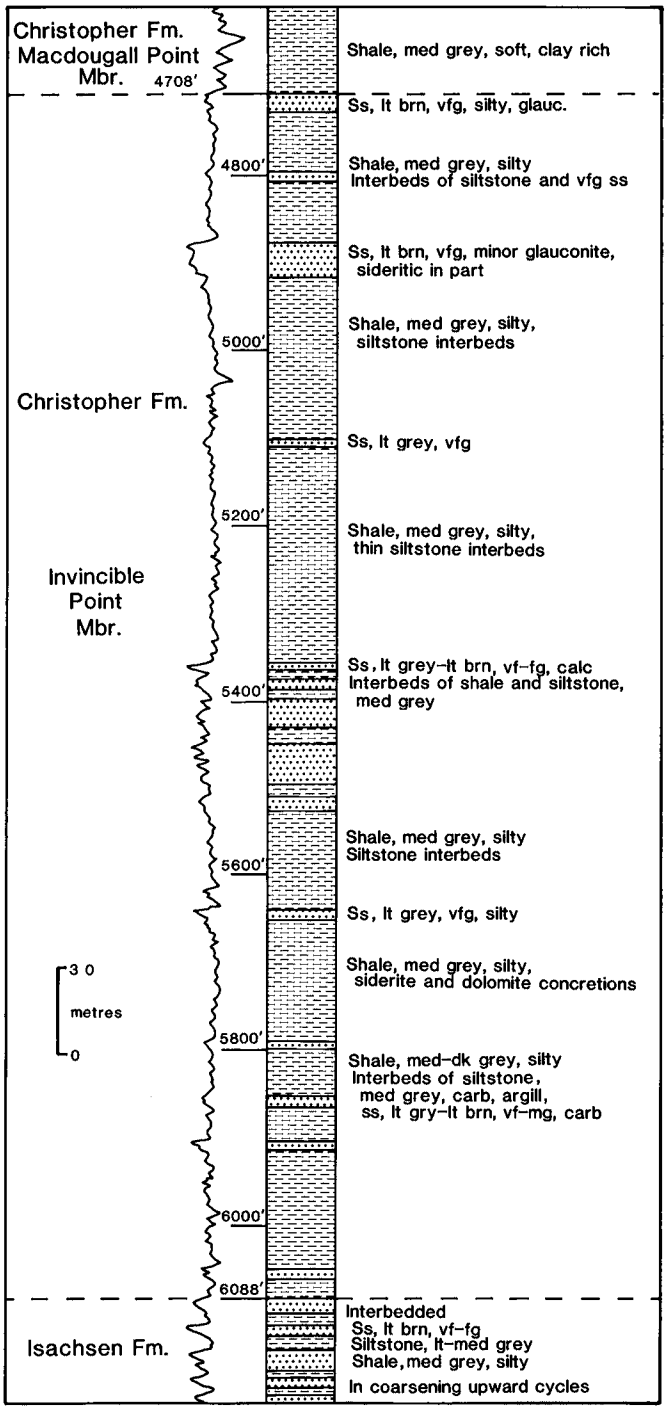

Figure 29.4. *Lithology (from samples) and gamma ray curve for type section of Invincible Point Member, Christopher Formation; North Sabine H-49 well.*

Boundaries

The Invincible Point Member conformably overlies the Isachsen Formation, and the contact is placed at the base of the lowest shale-siltstone unit above which shale and siltstone are predominant. The member is conformably overlain by the Macdougall Point Member of the Christopher Formation. The contact is placed at the base of a dark grey to black, clay-rich shale unit, which abruptly overlies sandstone or siltstone of the uppermost Invincible Point.

Lithology

At the type section (Fig. 29.4), the Invincible Point Member is composed of medium- to dark-grey, silty shale and siltstone with interbeds of very fine- to fine-grained, silty sandstone. The sandstone units are usually less than 4 m thick and occur in the lower and uppermost portions of the member. Basinward from the type section, sandstone units become less common and occur mainly in the lowermost and uppermost portions of the member. Sandstone units in the uppermost portion of the member are most common and thickest in the south-central portion of the basin (southern Axel Heiberg, Amund Ringnes). These sandstone units are up to 15 m thick and usually contain thin beds of shale and siltstone. Hummocky crossbedding, ripple crosslamination and burrows are the main sedimentary structures in these sandstones as seen in outcrop and/or core. Glauconite is a common assessory mineral. In the southwestern part of the basin, sandstones are rare in the uppermost portion of the member, but coarse siltstones occur in this interval.

Petrified wood and a variety of concretions occur within the shale and siltstone units, and pelecypods and ammonites occur most frequently in the uppermost portion of the member.

Thickness and distribution

The member has been delineated over the extent of the Christopher Formation although its identification in the Eglinton Graben and Banks Basin must be regarded as tentative. The maximum recorded thickness of the member is about 850 m on southern Axel Heiberg Island.

Age

The basal beds of the member range in age from Barremian on Mackenzie King Island, to Aptian over most of the Sverdrup, to early Albian on Banks Island (Plauchut and Jutard, 1976; Balkwill, 1983). The uppermost beds are dated as latest early Albian, based on ammonite evidence (Balkwill, 1983).

Environment of deposition

The rock types and fauna of the member indicate an offshore marine shelf environment of deposition. The sedimentary structures of the sandstone units suggest that the sands were deposited below fair weather wave-base by storm-generated currents.

Macdougall Point Member

Definition

The Macdougall Point Member consists predominantly of dark grey shale and siltstone with minor interbeds of very fine- to fine-grained sandstone. The type section is in the Panarctic North Sabine well between 899 m (2950 ft) and 1435 m (4708 ft), and is 536 m thick (Fig. 29.5). The name is taken from Macdougall Point, on the western side of Sabine Peninsula, Melville Island.

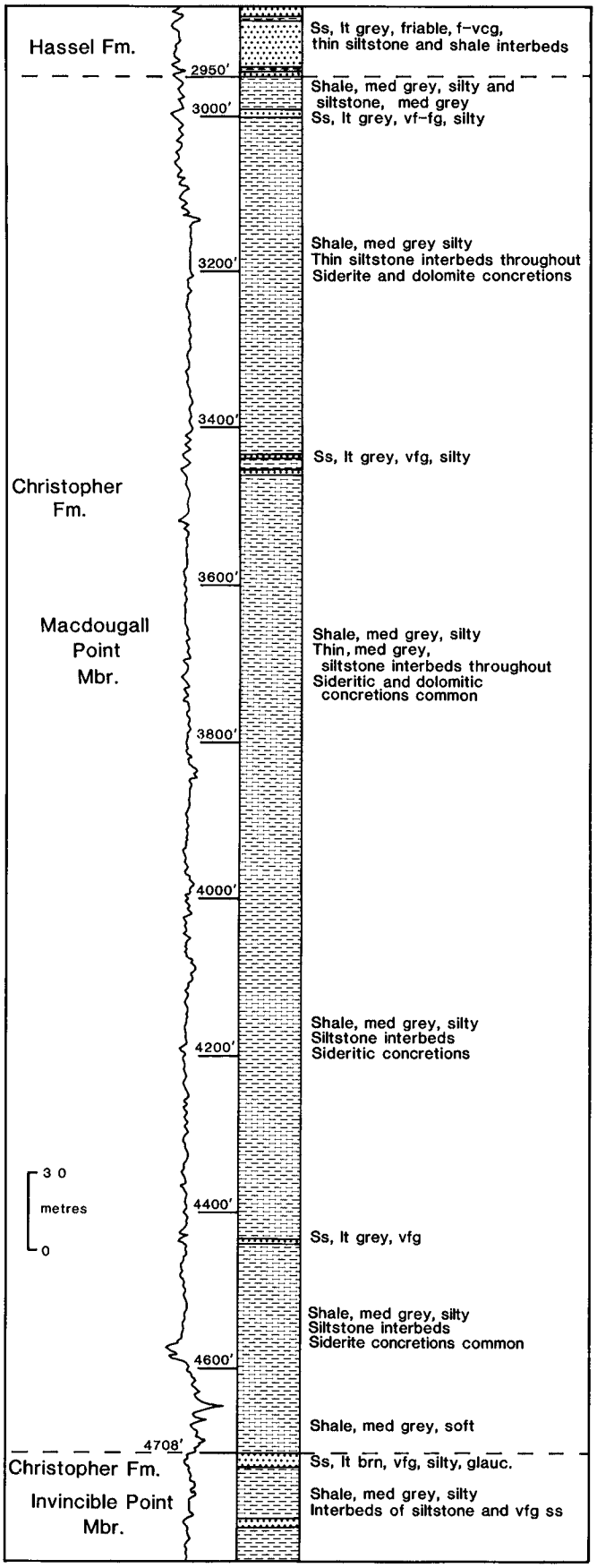

Figure 29.5. *Lithology (from samples) and gamma ray curve for type section of Macdougall Point Member, Christopher Formation; North Sabine H-49 well.*

Synonyms

1. Upper unit, Christopher Formation, Banks and Eglinton islands, Plauchut and Jutard (1976).
2. Upper member, Christopher Formation, King Christian Island, Balkwill and Roy (1977).
3. Upper member, Christopher Formation, Amund Ringnes Island, Balkwill (1983).

Boundaries

The Macdougall Point Member conformably overlies the Invincible Point Member, as previously stated. The Hassel Formation conformably overlies the Macdougall Point, with the contact placed at the base of the first sandstone unit above which sandstone is the predominant rock type.

Lithology

The Macdougall Point is composed mainly of dark grey to black shale and siltstone with interbeds of very fine- to fine-grained sandstone occurring in the uppermost portion of the member. The basal portion of the member consists of very dark to black, clay-rich shale. Silt content increases upward. A variety of concretions occur throughout the member.

Thickness and distribution

The member has been identified over the extent of the Christopher Formation. The maximum recorded thickness is 536 m (type section).

Age and environment of deposition

Ammonites and foraminifera from the member indicate a Middle Albian age (Balkwill, 1983; Wall, 1983).

The lithotypes and fauna of the member indicate an offshore marine shelf to prodelta environment of deposition.

References

Balkwill, H.R.
1983: Geology of Amund Ringnes, Cornwall and Haig-Thomas islands, District of Franklin; Geological Survey of Canada, Memoir 390.

Balkwill, H.R. and Roy, K.J.
1977: Geology, King Christian Island, District of Franklin; Geological Survey of Canada, Memoir 386.

Balkwill, H.R., Hopkins, W.S. Jr., and Wall, J.H.
1982: Geology, Lougheed Island, District of Franklin; Geological Survey of Canada, Memoir 395.

Fortier, Y.O., Blackadar, R.G., Glenister, B.F., Greiner, H.R., McLaren, D.J., McMillan N.J., Norris, A.W., Roots, E.F., Souther, J.G., Thorsteinsson, R., and Tozer, E.T.
1963: Geology of the north-central part of the Arctic Archipelago, Northwest Territories (Operation Franklin); Geological Survey of Canada, Memoir 320.

Heywood, W.W.
1955: Arctic piercement domes; Canadian Institute of Mining and Metallurgy, Bulletin, v. 48, p. 59-64.

1957: Isachsen Area, Ellef Ringnes Island, District of Franklin, Northwest Territories; Geological Survey of Canada, Paper 56-8.

McLaren, D.J.
1963: Meteorologist Peninsula dome, Ellef Ringnes Island; in Fortier et al., Geology of the north-central part of the Arctic Archipelago, Northwest Territories; Geological Survey of Canada, Memoir 320, p. 552-558.

Miall, A.D.
1979: Mesozoic and Tertiary Geology of Banks Island, Arctic Canada; Geological Survey of Canada, Memoir 387.

Nassichuk, W.W. and Christie, R.L.
1969: Upper Paleozoic and Mesozoic stratigraphy in the Yelverton Pass region, Ellesmere Island, District of Franklin; Geological Survey of Canada, Paper 68-31.

Plauchut, B.P. and Jutard, G.G.
1976: Cretaceous and Tertiary stratigraphy Banks and Eglinton islands and Anderson Plain, Northwest Territories; Bulletin of Canadian Petroleum Geology, v. 24, p. 321-371.

Stott, D.F.
1969: Ellef Ringnes Island, Canadian Arctic Archipelago; Geological Survey of Canada, Paper 68-16.

Thorsteinsson, R. and Tozer, E.T.
1962: Banks, Victoria and Stefansson islands, Arctic Archipelago; Geological Survey of Canada, Memoir 330.

Tozer, E.T.
1963: Mesozoic and Tertiary stratigraphy, western Ellesmere Island and Axel Heiberg Island, District of Franklin; Geological Survey of Canada, Paper 63-30.

Tozer, E.T. and Thorsteinsson, R.
1964: Western Queen Elizabeth Islands, Arctic Archipelago; Geological Survey of Canada, Memoir 332.

Wall, J.H.
1983: Jurassic and Cretaceous foraminiferal biostratigraphy in the eastern Sverdrup Basin, Canadian Arctic Archipelago; Bulletin of Canadian Petroleum Geology, v. 31, p. 246-281.

Appendix

Stratigraphic tops from selected wells, Isachsen and Christopher formations.
Location of wells shown on Figure 29.1.

Panarctic Drake F-16		
Christopher Formation		
Macdougall Point Member	spud	
Invincible Point Member	131 m	(430 ft)
Isachsen Formation		
Walker Island Member	425 m	(1395 ft)
Rondon Member	527 m	(1728 ft)
Paterson Island Member	565 m	(1854 ft)
Deer Bay Formation	576 m	(1890 ft)
Panarctic North Sabine H-49		
Christopher Formation		
Macdougall Point Member	899 m	(2950 ft)
Invincible Point Member	1435 m	(4708 ft)
Isachsen Formation		
Walker Island Member	1856 m	(6088 ft)
Rondon Member	1992 m	(6535 ft)
Paterson Island Member	2025 m	(6645 ft)
Deer Bay Formation	2063 m	(6767 ft)
Sun Skybattle Bay C-15		
Christopher Formation		
Macdougall Point Member	240 m	(787 ft)
Invincible Point Member	638 m	(2092 ft)
Isachsen Formation		
Walker Island Member	924 m	(3032 ft)
Rondon Member	1064 m	(3490 ft)
Paterson Island Member	1111 m	(3644 ft)
Deer Bay Formation	1263 m	(4144 ft)
Dome Wallis A-73		
Christopher Formation		
Invincible Point Member	spud	
Isachsen Formation		
Walker Island Member	344 m	well
Rondon Member	556 m	logged
Paterson Island Member	616 m	in
Mackenzie King Formation	1078 m	metres
Panarctic Hoodoo Dome H-37		
Christopher Formation		
Invincible Point Member	spud	
Isachsen Formation		
Walker Island Member	412 m	(1352 ft)
Rondon Member	600 m	(1970 ft)
Paterson Island Member	652 m	(2138 ft)
Mackenzie King Formation	1132 m	(3714 ft)
Panarctic Helicopter J-12		
Isachsen Formation		
Walker Island Member	spud	
Rondon Member	455 m	(1492 ft)
Paterson Island Member	552 m	(1810 ft)
Mackenzie King Formation	1315 m	(4314 ft)
Panarctic Romulus C-42		
Christopher Formation		
Macdougall Point Member	246 m	(807 ft)
Invincible Point Member	436 m	(1429 ft)
Isachsen Formation		
Walker Island Member	813 m	(2667 ft)
Rondon Member	869 m	(2850 ft)
Paterson Island Member	875 m	(2870 ft)
Deer Bay Formation	900 m	(2952 ft)
Panarctic Pedder Point D-49		
Christopher Formation		
Macdougall Point Member	285 m	(936 ft)
Invincible Point Member	326 m	(1068 ft)
Isachsen Formation		
Walker Island Member	604 m	(1982 ft)
Rondon Member	1058 m	(3471 ft)
Paterson Island Member	1085 m	(3560 ft)
Deer Bay Formation	1165 m	(3823 ft)
Panarctic Castel Bay C-68		
Christopher Formation		
Macdougall Point Member	1453 m	(4767 ft)
Invincible Point Member	1500 m	(4920 ft)
Isachsen Formation undivided	1688 m	(5537 ft)
Awingak Formation	1862 m	(6110 ft)