Stratigraphic subdivision of the Awingak Formation (Upper Jurassic) and revision of the Hiccles Cove Formation (Middle Jurassic), Sverdrup Basin, Arctic Islands

Project 750083

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Embry, A.F., Stratigraphic subdivision of the Awingak Formation (Upper Jurassic) and revision of the Hiccles Cove Formation (Middle Jurassic), Sverdrup Basin, Arctic Islands; in Current Research, Part B, Geological Survey of Canada, Paper 86-1B, p. 341-349, 1986.

Abstract

The Awingak Formation is a sandstone-dominant unit of Oxfordian to Tithonian (Late Jurassic) age and it occurs in the eastern and southeastern portion of the Sverdrup Basin. Throughout most of its extent, three members can be recognized within the formation: a lower sandstone, a medial shale/siltstone, and an upper sandstone. These three members are given formal status and are named, in ascending order: Cape Lockwood, Hot Weather and Slidre members.

Correlation of the three members of the Awingak Formation and the underlying Ringnes Formation with sections on western Melville Island and Prince Patrick Island, has revealed that strata previously assigned to the upper portion of the Hiccles Cove Formation are stratigraphically equivalent to the Ringnes Formation and the Cape Lockwood Member of the Awingak Formation. In order to achieve a consistent stratigraphic nomenclature for the Middle-Upper Jurassic succession of the Sverdrup Basin, the upper boundary of the Hiccles Cove Formation is redefined to exclude strata equivalent to the Ringnes and Awingak formations from the Hiccles Cove.

Résumé

La formation d'Awingak, qui se trouve dans les parties est et sud-est du bassin de Sverdrup, est une unité composée surtout de grès d'âge oxfordien à tithonien (Jurassique supérieur). Trois membres sont identifiés sur presque toute l'étendue de la formation: un grès inférieur, un schiste argileux et aleurolite médian et un grès supérieur. Ces trois membres officiels portent les noms suivants, donnés en ordre ascendant: Cape Lockwood, Hot Weather et Slidre.

La mise en corrélation des trois membres de la formation d'Awingak et de la formation sous-jacente de Ringnes avec des colonnes stratigraphiques dans la partie ouest de l'île Melville et dans l'île Prince-Patrick montre que les strates auparavant attribuées à la partie supérieure de la formation de Hiccles Cove sont l'équivalent stratigraphique de la formation de Ringnes et du membre de Cape Lockwood de la formation d'Awingak. Afin d'établir une nomenclature stratigraphique homogène pour la succession du Jurassique moyen à supérieur du bassin de Sverdrup, la limite supérieure de la formation de Hiccles Cove a été redéfinie de façon à exclure de cette formation les couches équivalant aux formations de Ringnes et d'Awingak.

Introduction

The Awingak Formation, defined by Souther (1963), is an Upper Jurassic sandstone-dominant unit that occurs between two shale/siltstone units, the Ringnes Formation below and the Deer Bay Formation above. The type section of the Awingak Formation is southwest of Buchanan Lake in the eastern Sverdrup Basin, and the formation has been traced along the eastern and southern portions of the basin (Fig. 37.1). To the northwest, the Awingak Formation disappears due to facies change, and stratigraphic equivalents occur within the shale/siltstone-dominant Mackenzie King Formation (Embry, 1985).

Numerous surface and subsurface sections of the Awingak Formation are available along its extent (Fig. 37.1). Regional studies have revealed that a shale/siltstone unit within the formation can be correlated through many of the sections, allowing a three-fold stratigraphic subdivision of the formation: a lower sandstone, a medial shale/siltstone, and an upper sandstone. These units are given formal member status in this paper.

Another consequence of the regional correlations of the Awingak Formation is that the delineation of the Hiccles Cove Formation, a sandstone unit occurring between the McConnell Island Formation below and Ringnes Formation above (both shale/siltstone units), has to be revised. It has been found that strata assigned to the upper portion of the Hiccles Cove Formation in the western Melville-Prince Patrick Island area (Embry, 1984) correlate with the Ringnes Formation and lower member of the Awingak Formation. Overlying argillaceous strata previously thought to be the Ringnes Formation (Embry, 1984) actually correlate with the medial shale/siltstone member of the Awingak Formation. Thus only the lower portion of the Hiccles Cove Formation as defined previously in these areas coincides with the original intent of the formation: a regional sandstone unit between the argillaceous McConnell Island and Ringnes formations. To avoid unnecessary stratigraphic overlap, the Hiccles Cove Formation is redefined in this paper.

Previous work

Souther (1963) defined the Awingak Formation from studies made during Operation Franklin in 1955, when he made a geological traverse across central Axel Heiberg Island. At the type section on east-central Axel Heiberg, Souther recognized four sandstone units separated from each other by shale/siltstone units in the 300 m thick section. Fossils collected below, within, and above the formation established it as Upper Jurassic in age (mainly Oxfordian-Kimmeridgian). Souther (1963) also recognized the Awingak Formation on western Axel Heiberg Island and he commented that the shale content was less in that area. During Operation Franklin, the Awingak Formation was also briefly described – western Axel Heiberg Island by Tozer (1963a) and Cornwall Island by Greiner (1963).

Subsequent studies of the Mesozoic succession of Ellesmere and Axel Heiberg islands by Tozer (1963b) led to the recognition of the Awingak Formation over large areas of these islands. Moore (1981) briefly described two sections of the Awingak Formation measured on northern Ellesmere Island. In the south-central Sverdrup Basin, the Awingak Formation on Cornwall and southern Amund Ringnes islands has been described by Balkwill (1983). In these areas he recognized four mappable sandstone units within the Awingak Formation and demonstrated that they all changed facies to shale and siltstone on central Amund Ringnes Island.

The Awingak Formation was not recognized farther west in the Melville-Prince Patrick Island area by Tozer and Thorsteinsson (1964). Equivalent strata were interpreted to occur within the uppermost portion of a sandstone-dominant,

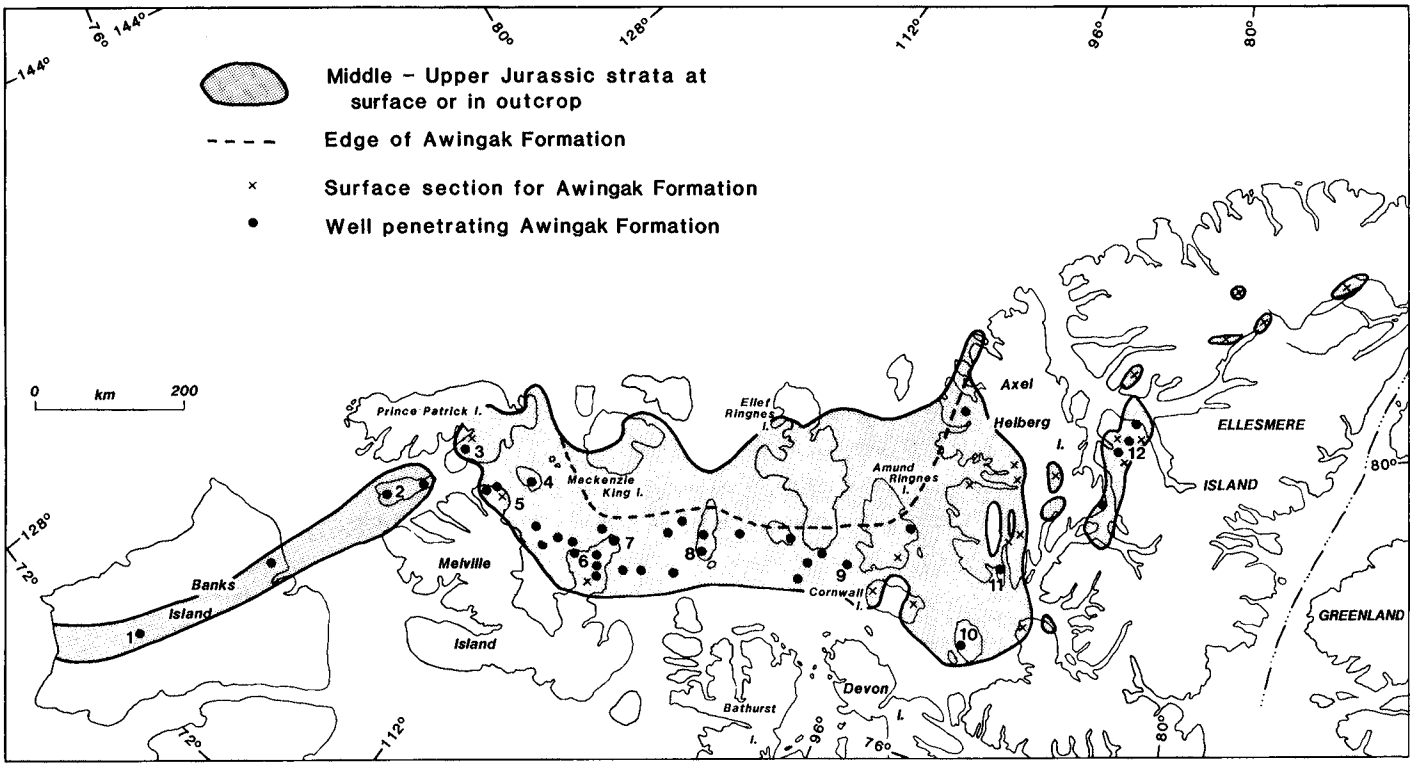

Figure 37.1. Distribution of Awingak Formation and control points. Key to numbered wells listed in the Appendix.

Lower-Upper Jurassic unit named the Wilkie Point Formation. Overlying shale and sandstone of mainly Volgian age were placed in the Mould Bay Formation.

Embry (1984) revised the Lower-Upper Jurassic stratigraphy of the Melville-Prince Patrick area. He correlated the shale unit at the base of the Mould Bay Formation with the Ringnes Formation and assigned the overlying sandstone, which composes most of the Mould Bay, to the Awingak Formation. Embry (1984) also raised the Wilkie Point to group status and the uppermost sandstone unit was named the Hiccles Cove Formation. It consists of a lower, sideritic, fossiliferous sandstone and an upper, white, carbonaceous sandstone that is devoid of fossils. The two units are separated by a thin, argillaceous siltstone unit. The lower sideritic sandstone was well dated, using ammonites, as Callovian, but the upper white sandstone did not yield any diagnostic fossils. It was interpreted to be Callovian to Early Oxfordian on the basis of its stratigraphic position.

Subsurface descriptions of the Awingak Formation include Balkwill et al.'s (1982) of the Skybattle Bay C-15 well on Lougheed Island and Balkwill's (1983) of the Linckens Island P-46 well northwest of Cornwall Island. Henao-Londono (1977) and Crane (1977) have briefly commented on the reservoir properties of the formation.

Present work

Regional correlation of the subsurface and surface sections of the Awingak Formation have led to the recognition of a three-fold subdivision of the formation along most of its extent (Fig. 37.2). A lower sandstone, a medial shale/siltstone, and an upper sandstone are recognized and are given formal member status herein. They are named, in ascending order, the Cape Lockwood, Hot Weather, and Slidre members of the Awingak Formation. The type sections of all three members are in the Panarctic Romulus C-42 well on Fosheim Peninsula, west-central Ellesmere Island (Fig. 37.1) at 79°51'05"N and 84°22'44"W. The well was spudded on January 28, 1972 and was abandoned on July 25, 1972 at a total depth of 4554 m. The elevation of the K.B. was 160 m. Chip samples taken at three metre intervals from the type sections are available for study at the Institute of Sedimentary and Petroleum Geology, Calgary, Alberta.

In many areas of the basin, the Cape Lockwood Member extends farther basinward than the Slidre Member (Fig. 37.3). Thus in more basinward sections, the Cape Lockwood Member represents the entire Awingak Formation and equivalents of the Hot Weather and Slidre members occur in the lower portion of the Deer Bay Formation (Fig. 37.3).

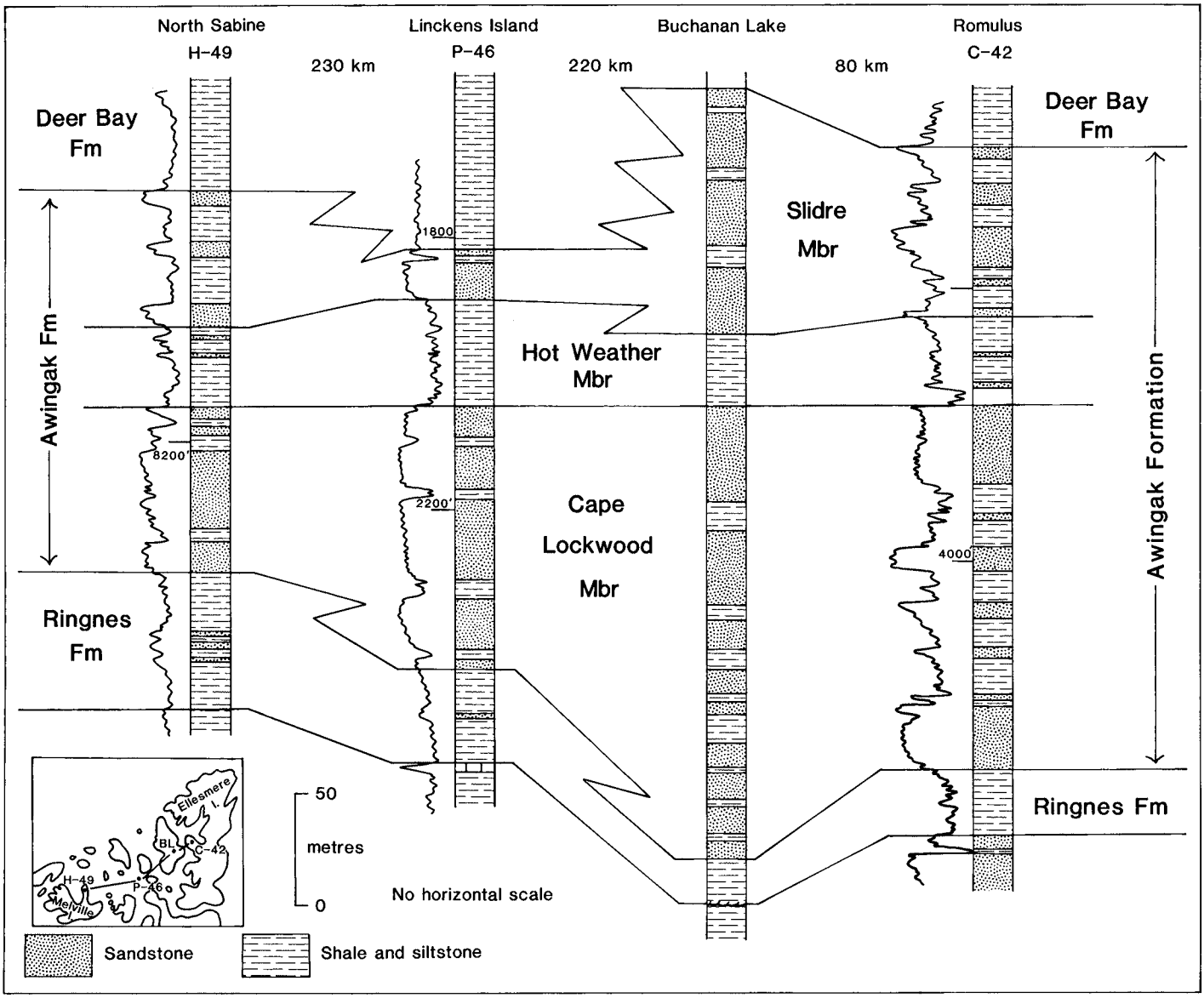

Figure 37.2. Stratigraphic cross-section, Awingak Formation, parallel to basin margin. Gamma ray logs displayed beside rock types.

Correlation of the three members of the Awingak Formation and the underlying Ringnes Formation with western Melville Island and Prince Patrick Island has revealed that the correlation proposed by Embry (1984) for this area is incorrect. Embry (1984) correlated the shale unit overlying the Hiccles Cove Formation with the Ringnes Formation, but recent data indicate this interpretation is wrong. Upper Jurassic pelecypods have been collected from the white sandstone unit of the Hiccles Cove Formation on western Melville Island (Poulton, pers. comm., 1986) and seismic interpretation indicates the equivalence of the top of the white sandstone unit on western Melville with the top of the Cape Lockwood Member of the Awingak Formation on Lougheed Island (Densmore, personal communication, 1986). Also, ammonites and pelecypods collected from the shale overlying the white sandstone are the same as those collected from the Hot Weather Member on Axel Heiberg Island. Taking all these new data into consideration, the white sandstone unit, which forms the uppermost portion of the Hiccles Cove Formation, is correlated with the Cape Lockwood Member of the Awingak Formation. The underlying argillaceous siltstone unit is correlated with the Ringnes Formation. The shale overlying the white sandstone unit, which was formerly thought to be Ringnes Formation, is now correlated with the Hot Weather Member (or lower Deer Bay Formation where the Slidre Member is absent) (Fig. 37.4, 37.5).

In order to achieve a consistent stratigraphic nomenclature for the Middle-Upper Jurassic succession of the Sverdrup Basin, the Hiccles Cove Formation is herein redefined to include only the lower sideritic sandstone unit. The overlying siltstone unit and white sandstone unit are excluded from the Hiccles Cove Formation and assigned to the Ringnes and Awingak formations. Revised well tops that stem from these changes are included in the Appendix.

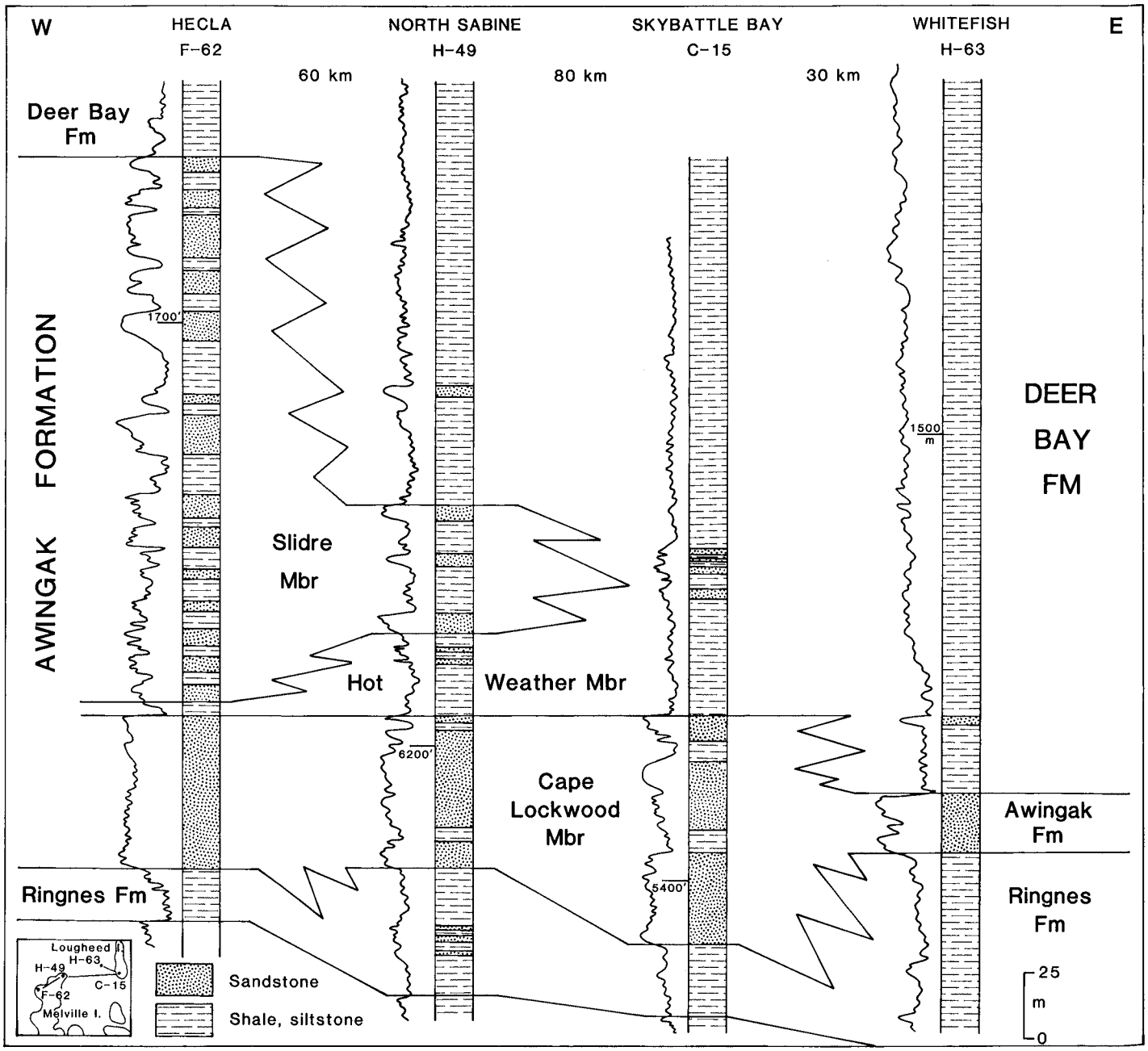

Figure 37.3. Stratigraphic cross-section, Awingak Formation, western Sverdrup Basin. Gamma ray logs displayed beside rock types.

Cape Lockwood Member, Awingak Formation

Definition

The Cape Lockwood Member consists of interbedded very fine to medium grained sandstone, siltstone and shale; sandstone is the dominant rock type. The type section is in the Romulus C-42 well between 1149 m (3770 ft) and 1311 m (4302 ft) and is 163 m thick. The name is taken from Cape Lockwood, which is on the north coast of Fosheim Peninsula.

TOZER AND THORSTEINSSON 1964		EMBRY 1984	EMBRY THIS PAPER	
MOULD BAY FM.	UPPER SHALE	DEER BAY FM.	DEER BAY FM.	
	MIDDLE SANDSTONE	AWINGAK FM.	AWINGAK FM.	SLIDRE MBR.
	LOWER SHALE	RINGNES FM.		HOT WEATHER MBR.
WILKIE POINT FM.	UPPER MEMBER	HICCLES COVE FM.		CAPE LOCKWOOD MBR.
			RINGNES FM.	
	LOWER MEMBER		HICCLES COVE FM.	
		McCONNELL ISLAND FM.	McCONNELL ISLAND FM.	

Figure 37.4. Past and present nomenclature of Middle-Upper Jurassic stratigraphy, Prince Patrick-Melville Island.

Synonyms

1. Lower three sandstone and two shale units of type Awingak Formation (Souther, 1963).
2. Upper member, Wilkie Point Formation, Melville and Prince Patrick islands (Tozer and Thorsteinsson, 1964).
3. Lower two map units of Awingak Formation, Cornwall and southern Amund Ringnes islands (Balkwill, 1983).
4. Upper portion, Hiccles Cove Formation, Melville and Prince Patrick islands (Embry, 1984).
5. Hiccles Cove Formation, Orksut I-44 well, Banks Island (Embry, 1985).

Boundaries

The Cape Lockwood Member conformably overlies the Ringnes Formation. The contact is placed at the base of the lowest sandstone unit above which sandstone becomes the predominant rock type. The member is overlain by the Hot Weather Member of the Awingak Formation or Deer Bay Formation and the contact is placed at the top of the highest sandstone above which shale and siltstone become predominant. In most areas, this contact is conformable, but on Prince Patrick Island the contact becomes unconformable southward and the Hot Weather Member oversteps the Cape Lockwood Member.

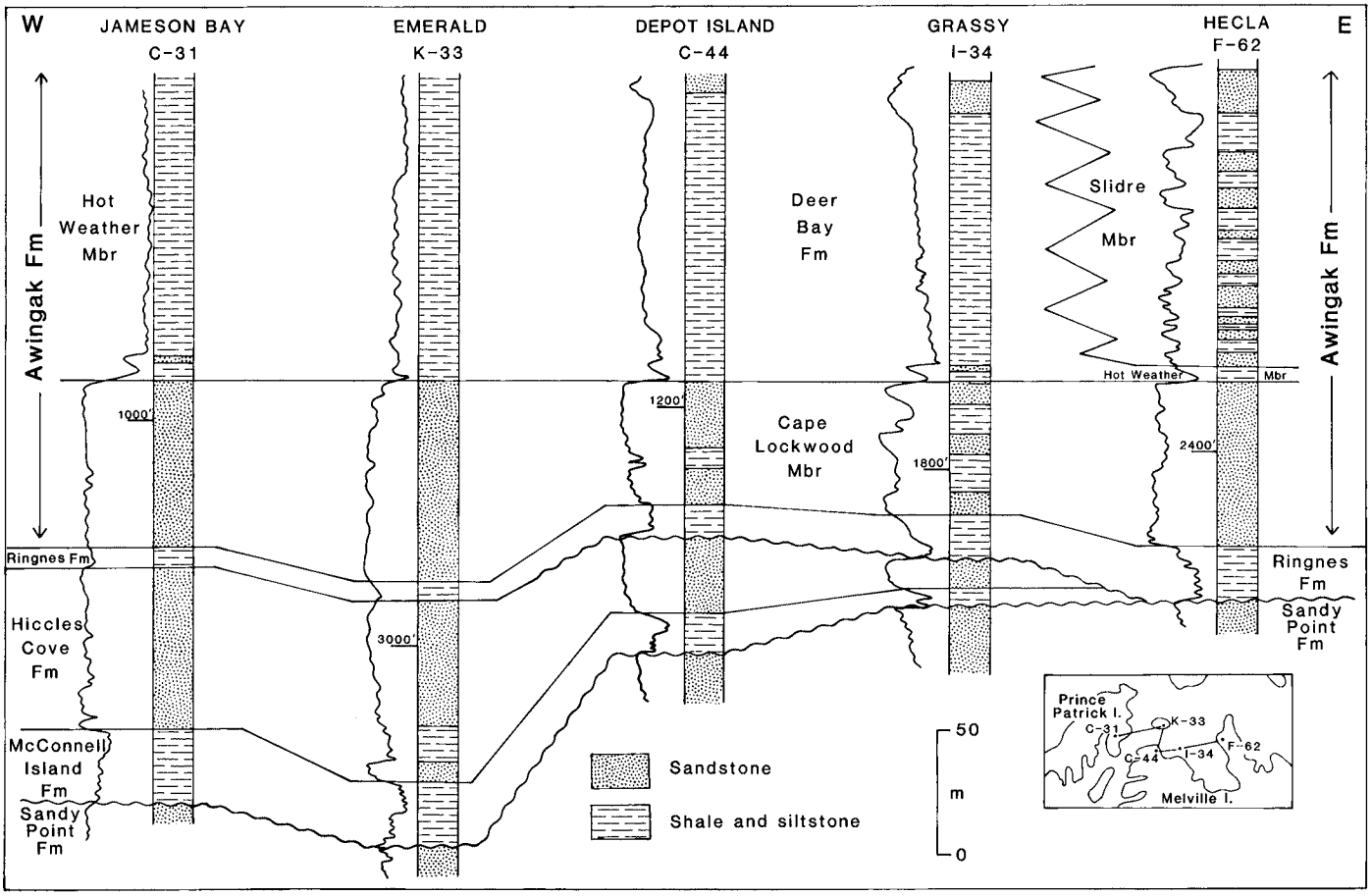

Figure 37.5. Stratigraphic cross-section, Middle-Upper Jurassic strata, Prince Patrick-Melville Island. Gamma ray logs displayed beside rock types. Compare with Figure 33.2 of Embry (1984).

Lithology

In the type section, the member consists of interbedded dark grey shale, siltstone and very fine to medium grained sandstone. The rock types are arranged in coarsening-upward cycles up to 60 m thick (Fig. 37.6). The strata are variably carbonaceous. In outcrops, bioturbation dominates the shale, siltstone and lower portion of the sandstone units. The upper portions of the sandstones commonly are horizontally bedded or massive, with crossbedding occurring infrequently. In the Melville Island-Prince Patrick Island area, the Cape Lockwood Member consists almost entirely of white, fine to medium grained, carbonaceous sandstone with a few thin coal seams near the top.

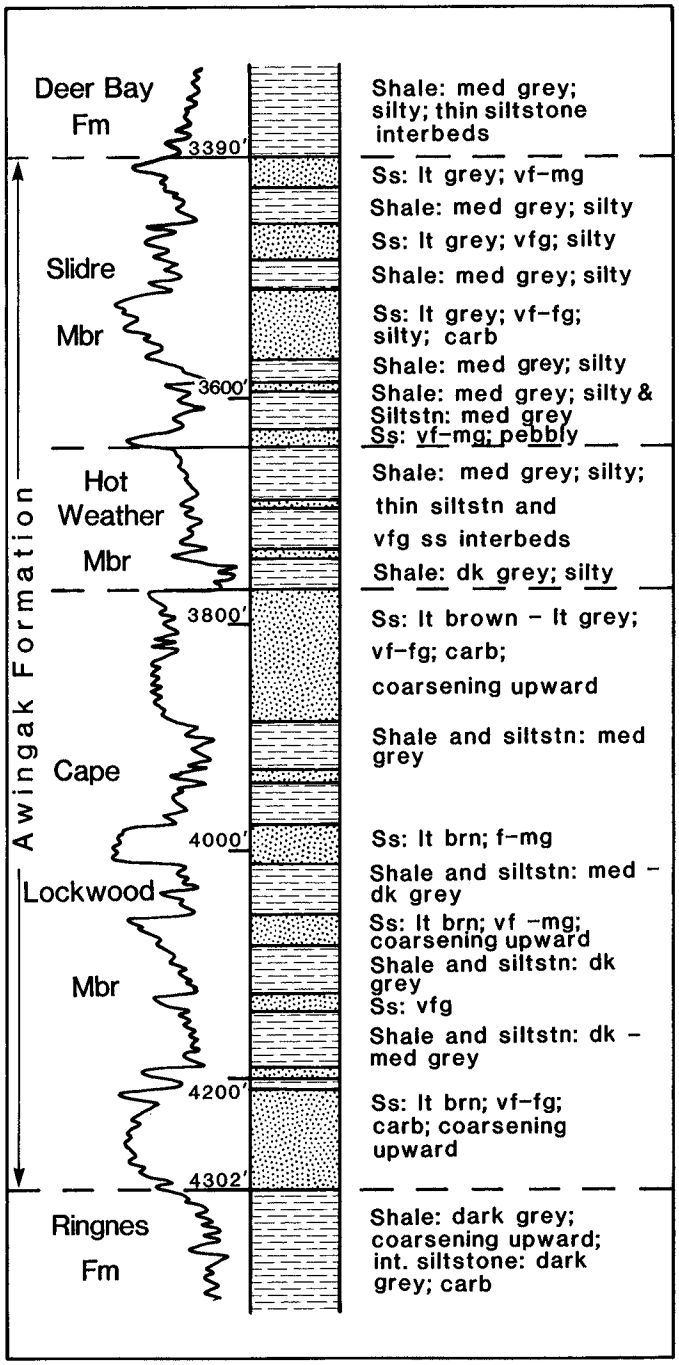

Figure 37.6. Lithology (from samples) and gamma ray curve for type sections of the Cape Lockwood, Hot Weather and Slidre members of the Awingak Formation; Romulus C-42 well.

Thickness and distribution

The Cape Lockwood Member is recognized along the extent of the Awingak Formation except on the southeastern basin margin, where the Awingak Formation is undivided. The maximum recorded thickness is 300 m. The member thins basinward and eventually disappears due to facies change to shale and siltstone.

Age

The member is dated as Oxfordian on the basis of the occurrence of early Oxfordian ammonites in the underlying Ringnes Formation and early Kimmeridgian ammonites and pelecypods in the overlying Hot Weather Member. Early to late Oxfordian dinoflagellates occur within the member (unpublished paleontological reports).

Environment of deposition

The lithology, sedimentary structures and fauna of the coarsening-upward cycles are typical of prograding outer shelf to shallow shelf deposits. In the western Sverdrup, where massive sandstone and coal are present, shallow shelf, strandline and lagoonal environments are represented in the member.

Hot Weather Member, Awingak Formation

Definition

The Hot Weather Member consists of medium to dark grey shale and siltstone with minor very fine grained sandstone. The type section is in the Romulus C-42 well between 1111 m (3644 ft) and 1149 m (3770 ft) and is 38 m thick (Fig. 37.6). The name is taken from Hot Weather Creek on Fosheim Peninsula.

Synonyms

1. Upper shale member, type Awingak Formation (Souther, 1963).
2. Lower shale unit, Mould Bay Formation, Prince Patrick and Melville islands (Tozer and Thorsteinsson, 1964).
3. Ringnes Formation, Prince Patrick Island (Embry, 1984).

Boundaries

The Hot Weather Member overlies the Cape Lockwood Member as previously described and is conformably overlain by the Slidre Member of the Awingak Formation. This upper contact is placed at the top of the uppermost shale/siltstone unit above which sandstone becomes the predominant rock type.

Lithology

At the type section, the basal 7 m consist of dark grey shale, and the overlying 31 m consist of interbedded siltstone and silty shale with minor, very fine grained sandstone. Basinward, dark grey to black shale becomes the main rock type. In some areas, dolomitic concretions up to 4 m across occur within the member.

Thickness and distribution

The Hot Weather Member occurs throughout most of the Awingak Formation's extent. It is absent due to facies change to sandstone in the southeast. It is also not recognized when the overlying Slidre Member is absent, and equivalents occur in the Deer Bay Formation. Its maximum recorded thickness is 210 m.

Age

Ammonite and pelecypod evidence from the member indicates for it a Kimmeridgian age (Souther, 1963; unpublished paleontological reports).

Environment of deposition

The argillaceous lithologies and open marine fauna indicate an offshore marine shelf environment of deposition for the member.

Slidre Member, Awingak Formation

Definition

The Slidre Member consists of interbedded very fine to medium grained sandstone, siltstone and shale. The type section is in the Romulus C-42 well between 1033 m (3390 ft) and 1111 m (3644 ft) and is 77 m thick (Fig. 37.6). The name is taken from Slidre Fiord on west-central Fosheim Peninsula.

Synonyms

1. Uppermost sandstone member, type Awingak Formation (Souther, 1963).
2. Middle sandstone member, Mould Bay Formation, Prince Patrick Island (Tozer and Thorsteinsson, 1964).
3. Upper two Awingak Formation map units, Cornwall and southern Amund Ringnes islands (Balkwill, 1983).
4. Awingak Formation, Prince Patrick Island (Embry, 1984).

Boundaries

The Slidre Member conformably overlies the Hot Weather Member as previously described and is conformably overlain by the Deer Bay Formation. This contact is placed at the top of the uppermost sandstone unit above which shale and siltstone become the predominant rock types.

Lithology

At the type section, the member consists of interbedded grey shale, siltstone and very fine to medium grained sandstone arranged in coarsening-upward cycles up to 30 m thick. Bioturbation is the predominant sedimentary structure and ripple crosslamination and horizontal bedding occasionally occur in the uppermost portions of sandstone units. On Cornwall Island, fining-upward cycles with thin coal seams occur in the upper portion of the member (Balkwill, 1983). In the western Sverdrup the sandstones commonly contain thin pebble layers in basin margin sections.

Thickness and distribution

The Slidre Member occurs along the southern and eastern margins of the Sverdrup Basin. It is not recognized in the southeast (e.g. Graham Island area) where the Awingak Formation is not subdivided. It is also absent on northwestern Melville, and stratigraphic equivalents occur in the Deer Bay Formation. The maximum recorded thickness of the member is 270 m.

Age

The member is interpreted to be mainly Tithonian (Volgian) in age on the basis of pelecypods found within it (Tozer, 1963b; Tozer and Thorsteinsson, 1964; Balkwill, 1983). In basin margin sections, the age of the member may extend down into the late Kimmeridgian and upward into the Berriasian.

Environment of deposition

The rock types, sedimentary structures and fauna of the coarsening-upward cycles are typical of prograding inner to outer marine shelf deposits. The interval with fining-upward cycles and thin coal beds on Cornwall Island represents lower delta plain deposits (Balkwill, 1983).

Hiccles Cove Formation (redefined)

Definition

The Hiccles Cove Formation consists mainly of very fine to fine grained sandstone which is often sideritic and glauconitic. The type section is in the Elf Jameson Bay C-31 well (76°40'12"N, 116°43'45"W; spudded March 11, 1971; abandoned May 18, 1971; T.D. 2539 m; K.B. 63 m) between 369 m (1210 ft) and 442 m (1451 ft) and is 73 m thick (Fig. 37.7). The name is taken from Hiccles Cove on the eastern side of Intrepid Inlet, Prince Patrick Island.

Synonyms

1. Units 5 to 7, Wilkie Point Formation, Intrepid Inlet section, Prince Patrick Island (Tozer and Thorsteinsson, 1964).
2. Jaeger Formation, northern Ellef Ringnes Island (Stott, 1969).
3. Medial sandstone unit, Upper Savik, Cornwall Island (Balkwill, 1983).
4. Lower portion, Hiccles Cove Formation, Prince Patrick and western Melville Island (Embry, 1984).

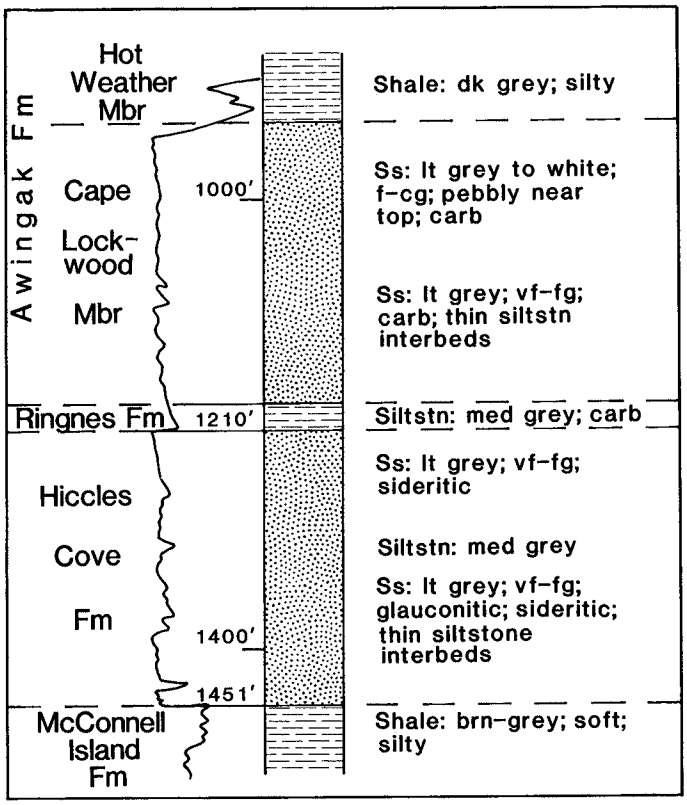

Figure 37.7. Lithology (from samples) and gamma ray curve for the revised type section of the Hiccles Cove Formation; Jameson Bay C-31 well.

Boundaries

The Hiccles Cove Formation conformably overlies the McConnell Island Formation. The contact is placed at the base of the lowest sandstone unit above which sandstone is dominant. The formation is overlain by the Ringnes Formation, and the contact varies from conformable to unconformable. The contact is placed at the top of the highest sandstone unit above which shale and siltstone are predominant.

Lithology

In the type section, the formation consists of interbedded, very fine to fine grained sandstone arranged in coarsening-upward cycles. Beds of ironstone are common and glauconite is a common assessory mineral. Farther basinward, shale and siltstone occur within the formation at the base of the cycles. Burrows, ripple crosslamination and horizontal bedding are the predominant sedimentary structures.

Thickess and distribution

The Hiccles Cove Formation occurs along the basin margins and is up to 70 m thick. Basinward, the formation changes facies to shale and siltstone of the McConnell Island Formation. On the basin edges it is truncated by the Ringnes Formation.

Age

The formation is dated as Callovian on the basis of ammonites collected on Prince Patrick and Ellef Ringnes islands (Tozer and Thorsteinsson, 1964; Stott, 1969).

Environment of deposition

The arenaceous lithologies, sedimentary structures and fauna indicate an inner to mid-shelf environment of deposition for the formation.

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APPENDIX

Selected well tops, Awingak, Ringnes and Hiccles Cove formations, Sverdrup Basin. Location of wells shown on Figure 37.1.

Deminex Orksut I-44		
Deer Bay Formation	1457 m	(4781 ft)
Awingak Formation		
Cape Lockwood Member	1813 m	(5948 ft)
Cape de Bray Formation (Devonian)	1828 m	(5998 ft)
Panarctic Pedder Point D-49		
Awingak Formation		
Slidre Member	1085 m	(3560 ft)
Hot Weather Member	1441 m	(4728 ft)
Cape Lockwood Member	1610 m	(5282 ft)
Ringnes Formation	1710 m	(5610 ft)
Hiccles Cove Formation	1714 m	(5622 ft)
Weatherall Formation (Devonian)	1725 m	(5658 ft)
Elf Jameson Bay C-31		
Awingak Formation		
Slidre Member	spud	
Hot Weather Member	76 m	(250 ft)
Cape Lockwood Member	287 m	(942 ft)
Ringnes Formation	359 m	(1178 ft)
Hiccles Cove Formation	369 m	(1210 ft)
McConnell Island Formation	442 m	(1451 ft)
BP Emerald K-33		
Deer Bay Formation	447 m	(1466 ft)
Awingak Formation		
Cape Lockwood Member	798 m	(2618 ft)
Ringnes Formation	883 m	(2898 ft)
Hiccles Cove Formation	896 m	(2940 ft)
McConnell Island Formation	975 m	(3200 ft)
Panarctic Depot Island C-44		
Awingak Formation		
Cape Lockwood Member	354 m	(1160 ft)
Ringnes Formation	408 m	(1340 ft)
Hiccles Cove Formation	422 m	(1384 ft)
McConnell Island Formation	457 m	(1500 ft)
Panarctic Hecla F-62		
Awingak Formation		
Slidre Member	440 m	(1444 ft)
Hot Weather Member	695 m	(2280 ft)
Cape Lockwood Member	701 m	(2301 ft)
Ringnes Formation	771 m	(2528 ft)
Sandy Point Formation	797 m	(2615 ft)

Panarctic North Sabine H-49		
Awingak Formation		
Slidre Member	2385 m	(7825 ft)
Hot Weather Member	2444 m	(8020 ft)
Cape Lockwood Member	2483 m	(8147 ft)
Ringnes Formation	2557 m	(8390 ft)
McConnell Island Formation	2618 m	(8590 ft)
Sun Skybattle Bay C-15		
Awingak Formation		
Cape Lockwood Member	1568 m	(5145 ft)
Ringnes Formation	1674 m	(5491 ft)
McConnell Island Formation	1711 m	(5612 ft)
Sun Linckens Island P-46		
Awingak Formation		
Slidre Member	554 m	(1818 ft)
Hot Weather Member	576 m	(1890 ft)
Cape Lockwood Member	628 m	(2060 ft)
Ringnes Formation	732 m	(2400 ft)
McConnell Island Formation	814 m	(2670 ft)
BP Graham C-52		
Awingak Formation (undivided)	978 m	(3210 ft)
Ringnes Formation	1272 m	(4174 ft)
Hiccles Cove Formation	1279 m	(4196 ft)
McConnell Island Formation	1318 m	(4325 ft)
Jameson Bay Formation	1329 m	(4360 ft)
Imperial Sherwood P-37		
Awingak Formation		
Cape Lockwood Member	spud	
Ringnes Formation	269 m	(882 ft)
McConnell Island Formation	305 m	(1000 ft)
Sandy Point Formation	363 m	(1192 ft)
Panarctic Romulus C-42		
Awingak Formation		
Slidre Member	1034 m	(3390 ft)
Hot Weather Member	1111 m	(3644 ft)
Cape Lockwood Member	1149 m	(3770 ft)
Ringnes Formation	1311 m	(4302 ft)
Sandy Point Formation	1350 m	(4428 ft)