The Melville Project, 1984-85: progress report

Project 840048

R.L. Christie
Institute of Sedimentary and Petroleum Geology, Calgary

Christie, R.L., The Melville Project 1984-85: progress report; in Current Research, Part A, Geological Survey of Canada, Paper 86-1A, p. 795-799, 1986.

Abstract

A second field season of the two-year Melville Project, a field and laboratory study of Melville Island, has been completed. The project comprises a broad spectrum of research, and several reports are in preparation. A review of Melville Island geology in the light of accumulated information allows some new interpretations for potential hydrocarbon-bearing reservoirs.

Résumé

Dans le cadre du programme Melville de deux ans, une deuxième campagne d'étude sur le terrain et en laboratoire de l'île Melville a été effectuée. Le programme comprend toute une gamme de recherches, plusieurs rapports sont en préparation. Une étude de la géologie de l'île Melville, basée sur les renseignements accumulés, permet de jeter un nouvel éclairage sur les réservoirs éventuels d'hydrocarbures.

Introduction

A new field study of Melville Island, Arctic Archipelago, was begun in 1984 and completed in 1985 as part of the Geological Survey's ongoing program to map all parts of Canada at a scale of 1:250 000.

Melville Island includes parts of three Arctic geological provinces, each with petroleum potential: the Arctic Platform, the Franklinian Geosyncline (the Parry Islands Fold Belt), and the Sverdrup Basin (Fig. 1). Vigorous exploration for petroleum has taken place both on Melville Island and in the nearby offshore areas, and some 50 wells have been drilled. Both oil and gas fields have been delineated: Drake Point and Hecla fields are each estimated by the operator, Panarctic Oils Limited (1985), to contain more than 3 trillion cubic feet (84 billion m^3) of gas. In addition, a small but important discovery of oil was made in the Bent Horn well on Cameron Island (nearby, but outside the area discussed here).

Some features of the sedimentary rocks of the region were noted during early geographic exploration (outlined later in this paper). The initial, or reconnaissance geological surveys delineated the sedimentary basins and indicated their petroleum potential. The Arctic Islands' first wildcat well, Winter Harbour No. 1, tested, in 1962, noncommercial rates of gas flow (1700 m^3/day) from the Middle and Upper Devonian Weatherall and Hecla Bay formations. New concepts useful to exploration, and many prospective targets, were subsequently established through geophysical surveys and more detailed geological studies, and these led directly to the active phase of exploration drilling from 1970 to 1980.

Most of the drilling – and the success – has occurred in the Sverdrup Basin. The Melville Project provides an opportunity to review and restudy both surface and subsurface data on hand, and to collect new stratigraphic and sedimentological information. These data may be especially useful when dealing with the lower Paleozoic folded province, where new syntheses are required to arrive at models that account for facies distribution, structure, and geological history of this, a petroleum-prospective part of the Franklinian Geosyncline.

Field data and rock and fossil collections from 1984, 1985, and earlier field seasons are being studied at the Institute of Sedimentary and Petroleum Geology and at other centres, and reports are in preparation. This note is intended to call attention to ongoing work related to the Melville Project.

Melville Project, logistics and acknowledgments

Field work in 1984 was based at Nias Point, on the south shore of Hecla and Griper Bay. The base camp for the 1985 field season was located near Ibbett Bay, in the northwestern part of the island. The Panarctic Oils Ltd. airport and station at Rea Point was used as a shipping and transit point, and on occasion, as a base for fieldwork. Each field season began in late June and ended about mid-August. Air support was provided by Quasar Helicopters (Bell 206B Jet Ranger) and by Bradley Air Services (de Havilland Twin Otter), both services provided by contract through the Polar Continental Shelf Project of the Department of Energy, Mines and Resources. Drummed fuel for aircraft had been shipped by sea to Rea Point a year before each field season. Aviation fuel, in addition to considerable other materials for field support, was also purchased from Panarctic Oils Ltd. at Rea Point. Food for the field camps was supplied by Dorval Food Market Inc., Montreal, and by Star Meat and Fish Company Ltd., Edmonton.

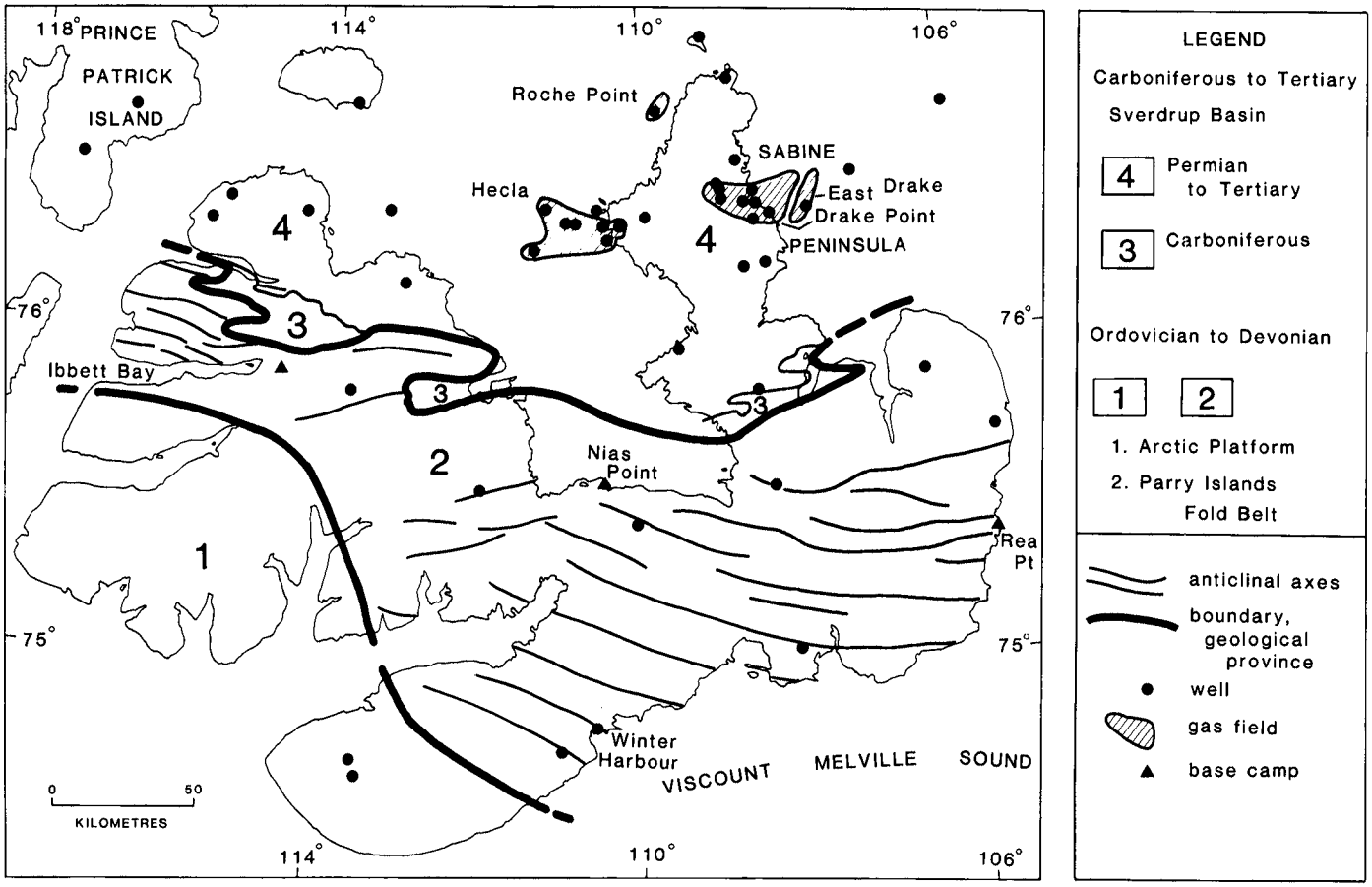

Figure 1. *Geological provinces of Melville Island.*

Helicopters were used for areal mapping and spot checking of geology during both field seasons; several traverses on foot also were made. Stratigraphic sections were measured from small 'fly' camps set out by helicopter.

A preliminary geological map had been completed from photo-interpretation (by J.C. Harrison) before the first field season. This map was continually refined through field checking and the addition of new interpretations. Some 50 stratigraphic sections were measured during the two-year project.

Stratigraphic studies were carried out by O.H. Goodbody (University of Alberta), R.L. Christie (Institute of Sedimentary and Petroleum Geology), and (in 1985) by C. Riediger (University of British Columbia). M.J. Robson (University of Western Ontario) studied lower Paleozoic 'shale basin' units on the northwestern part of the island. J.C. Harrison was responsible for structural-stratigraphic mapping.

Field assistance was provided in 1984, by Jane Bracken, Todd Cross, Sabine Feulgen, and Kathi Higgins; in 1985, by David Christensen, Sabine Feulgen, Linda Haid, Ben Lawson, and Rory McIntosh.

Other fieldwork supported by the project included: Jurassic biostratigraphy, T. Poulton (Institute of Sedimentary and Petroleum Geology); Pennsylvanian-Permian biostratigraphy, J. Utting, A.C. Higgins (Institute of Sedimentary and Petroleum Geology) and P. von Bitter (Royal Ontario Museum) in 1984; and collection of plesiosaur and other vertebrate remains, D.A. Russell and Clayton Kennedy (National Museum of Natural Sciences, Ottawa) in 1985. S.A. Edlund (GSC, Ottawa) completed geobotanical studies begun on the island in earlier years. D.A. Hodgson (GSC, Ottawa) and L. Dyke (Queen's University) studied aspects of surficial and glacial geology in 1985, with Gary Parkin and Suzanne Szojka, assistants.

Exploration and earlier geological studies

The first wintering by Europeans in the high Arctic Islands of Canada took place in 1819-20 at Winter Harbour, Melville Island. William Parry's was a remarkable achievement for the time; in the course of the first penetration of the islands by ship, he reached the northwestern part of the Arctic Archipelago.

Melville Island was explored by Parry and, along with Prince Patrick and nearby islands, was explored more fully in the 1850's, during the British Admiralty search for Sir John Franklin. The islands remained untouched for half a century following the Franklin search, until visits between 1906 and 1910 by Capt. J.E. Bernier in the **CGS Arctic**. Winter Harbour was again a haven for a ship - the **Arctic**, through the winter of 1908-1909 – and on this occasion the "whole Arctic Archipelago" was annexed to Canada in a formal ceremony, and a commemorative plaque was unveiled. Vilhjalmur Stefansson, leader of the Canadian Arctic Expedition of 1914-17, travelled the coasts of Melville and Prince Patrick islands en route to and returning from his exploration of more northerly islands. Melville Island was visited briefly by sledge, aircraft, and ship on occasion in the 1930's and 40's.

Systematic geological study of the region began in 1954, when E.T. Tozer explored parts of Prince Patrick, Eglinton, and Melville islands by dog team from Mould Bay Weather Station on Prince Patrick Island. Tozer mapped an area of Sabine Peninsula on Melville Island during the helicopter-supported project, Operation Franklin, and he and R. Thorsteinsson continued the mapping in 1958, using a Piper Super-Cub to cover the entire group of the Western Queen Elizabeth Islands (Tozer and Thorsteinsson, 1964). The stratigraphic nomenclature established by Tozer and Thorsteinsson has formed a basic framework for studies since that time.

Exploration for petroleum began in 1960, when geologists of the J.C. Sproule group began work in the Queen Elizabeth Islands. In 1962, the Arctic's first wildcat well, Dome Winter Harbour No. 1, was completed. A show of gas was obtained from Upper Devonian (Hecla Bay Formation) sandstone. H.P. Trettin studied the tar sands (Lower Triassic, Bjorne Formation) of northwestern Melville Island in 1964 (Trettin and Hills, 1966). The newly formed Panarctic Oils drilled its first hole on Melville Island in 1969, and in 1970 the company's Drake Point L-67 well came in – and blew out of control. Gas had been found in Jurassic sandstone (see Jones, 1981). Several gas fields have now been outlined in the northeastern part of the island and offshore (Fig. 1).

From stratigraphic studies and collections of ammonoids from Permian beds in 1964 and 1967, W.W. Nassichuk refined the correlations of Permian formations of Melville Island (Nassichuk, 1965, 1975).

Seismic exploration began on Melville Island in 1968, and the surveys were extended to offshore areas in the early 1970's. Some elements of the subsurface structure were reported and illustrated by Fox (1983, 1985) and by Texaco Canada Resources Ltd. (1983).

The stratigraphic nomenclature and the sedimentary environments of lower Paleozoic beds of Melville Island were described by Embry and Klovan (1976), and Embry (1976) after a study of the Middle and Upper Devonian 'clastic wedge' of the Arctic Islands. New stratigraphic divisions for the Middle Triassic to Lower Cretaceous beds of the Sverdrup Basin, which extends onto northern Melville Island, have been erected by Embry (1983; 1984a, b, c; 1985a, b) from the subsurface information now available from the many wells.

The surficial deposits and glacial features of parts of Melville Island were studied in 1962 by W.E.S. Henoch, and by several others since that time. A detailed account of the surficial materials of central Melville Island by Hodgson, Vincent, and Fyles (1984) includes a review of earlier studies of Quaternary material.

Mapping and reporting of the vegetative cover has been carried out by Edlund (1982).

Results of geological studies, Melville Project

Significant refinements or revisions in surface stratigraphic nomenclature that have been made over the past twenty years were reviewed by Harrison, Goodbody and Christie (1985), who also outlined some highlights of the regional mapping program of 1984. Robson (1985), Utting (1985), and Edlund (1985) have reported on aspects of the project. Following are further notes on activities by various researchers allied with the Melville Project.

Subsurface data obtained by petroleum exploration companies from wells and seismic surveys are being used in the Melville Project with two goals in mind: first, to elucidate the subsurface structures; and second, to relate subsurface and surface sedimentary units. Toward these ends, F.G. Fox (Panarctic Oils Limited, retired) and A.A. Densmore (Institute of Sedimentary and Petroleum Geology) have contributed a written study (see list of papers 'in preparation', below).

T. Poulton reports a "new" ammonite fauna in material he collected in 1984 at East Kitson River; the "new" fossil forms were found in the Opalinum Zone of the basal Aalenian (Wilkie Point Group).

Palynological collections from Silurian and Devonian beds are being studied by D.C. McGregor (GSC, Ottawa), and he has reported on collections by Goodbody, Christie, and Harrison. A notable feature of the material examined to date is an apparent absence of marine microfossils in shales of the Weatherall and Hecla Bay formations.

Palynological collections from upper Paleozoic beds are under study by J. Utting, who is making a systematic description of species from the Sabine Bay and Assistance formations. Carboniferous and Permian microfossils (conodonts) are being examined by A.C. Higgins and P. von Bitter. The work of Utting, Higgins, and von Bitter is dedicated to determining the relationship of upper Paleozoic stratigraphic units, both surface and subsurface, to the equivalent, well-documented units of Ellesmere Island.

Silurian conodonts are being worked on by A.D. McCracken (Ottawa), a Research Fellow with the Geological Survey of Canada.

Rock material from wells throughout the Arctic has been sampled by L. Brodylo, and measurement of the Thermal Alteration Index (TAI) of pollen and microfossils by J. Utting and J. Dougherty is in progress. Sampling of lower and upper Paleozoic beds is complete, and sampling of Triassic beds has begun. TAI measurement is also being carried out on surface samples collected during fieldwork. This work is being done in conjunction with F. Goodarzi (Institute of Sedimentary and Petroleum Geology).

The stratigraphy and sedimentology of the lower Paleozoic clastic units are being studied by Q. Goodbody (research fellow), and R.L. Christie. A report on the lower Paleozoic 'shale basin' is in preparation by J. Robson, under a Research Agreement. C. Riediger, research assistant, is working on stratigraphic material and data collected from Carboniferous and Permian beds in 1985.

The plesiosaur skeleton discovered in 1984 was examined by D. Russell who excavated and collected the skull in 1985. Two ichthyosaur 'bone-groups' were identified in nearby beds by the vertebrate paleontologists.

A report on the surficial deposits and glacial features of western Melville Island is in preparation by D.A. Hodgson; publication will follow completion of certain age-determinations.

J.C. Harrison's structural-stratigraphic studies on Melville Island are being carried out in collaboration with A.W. Bally and J.S. Oldow (Rice University, Houston, Texas), who are engaged in a wide-ranging project to test hypotheses concerning the opening of the Canada Basin. Both projects will combine surface, geological, and reflection seismic data to aid in interpretation of the kinematic-dynamic problems inherent in the geometry of the basin.

Structural and sedimentary geology, and implications for oil and gas exploration

The stratigraphic succession on Melville Island comprises some 2500 m of Lower Ordovician to Middle Devonian carbonates and equivalent basinal shales, 4500 to 5000 m of Middle and Upper Devonian clastic beds (Ellesmerian foreland basin, or 'clastic wedge'), and up to several kilometres of Carboniferous, Permian, and Mesozoic carbonates, evaporites, and clastic rocks.

The following points, in part speculative, are a result of the restudy and review of Melville Island geology, and draw attention to the potential for petroleum discoveries (J.C. Harrison, pers. comm., 1985).

1. Promising source and reservoir rocks of Silurian and younger Paleozoic ages clearly exist on Melville Island, but both the facies relationships and the tectonic history are more complex than previously thought, and this may account for the general lack of past success in petroleum exploration of these rocks.
2. Several formations, including both black shale and carbonate units of early Paleozoic age were confirmed as containing potential source beds judging by their generally organic or petroliferous characteristics.
3. Structural features in the southern marginal zone of the Parry Islands (Ellesmerian) Fold Belt were studied in 1985, and interpretation of these features is now in progress. It is possible that hydrocarbon reservoirs of the pre-Middle Devonian carbonate-to-basin transition belt, perhaps telescoped by thrust faults (a triangle zone?), may exist in the marginal zone.
4. Structural complexity in both the Canrobert Hills and the Weatherall Bay areas is evident from a study of slickenside lineations, en echelon giant carbonate veins, parasitic folds, thrust faults, and east-striking wrench faults. New interpretations of seismic data and well stratigraphy, in areas that include proven petroleum reservoir units, now seem possible.
5. Sedimentological and structural data for Carboniferous and Permian units of northern Melville Island suggest that a sequence of pull-apart basins developed along the southern margin of the Sverdrup Basin, and that faulting and transpressional folding (Melvillian Disturbance) took place.

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