ARCTIC ISLANDS: SVERDRUP AND FRANKLINIAN BASINS

Area	Arctic Stable Platform 780,000 km2 (47% onshore) Arctic Fold Belt 240,000 km² (60% onshore) Sverdrup Basin 313,000 km² (46% onshore)
Discoveries	First discovery in 1969 (Panarctic Drake Point N-67; gas): 18 subsequent discoveries (8 gas; 7 oil and gas; 3 oil)
Discovered Resources	Gas: 407 x E9 m³ Oil: 66 x E6 m³
Production	Gas: none Oil: Bent Horn 321,470 m³ to the end of 1993
Total Number of Wells	177 (192 including delineation/development wells?)
Average Well Density	1 well per 1630 km² in the Sverdrup Basin, 1 per 7000 km² in the Arctic Islands region
Seismic Coverage	44,242 km
Pipelines	None
Area under Licence	13,000 km² (or 37,500 km² if restricted areas included)

Most northerly of Canada's exploration regions, the Arctic Islands overlie one of Canada's largest petroliferous basins. Exploration activity has been extensive, but sparsely distributed, across this huge region. Nevertheless, the 160 we//s drilled to date have discovered gas resources (over 14 trillion cubic feet) equal to 20% of remaining reserves in western Canada, and two of the largest undeveloped gas fields in Canada are in the Arctic Islands. Exploitation of the oil resources of the region is already underway. Both gas and oil potential in this basin is very high and realizable given enhanced geological understanding and new exploration methods. It is likely that the vast resources of this region will become important to North America in the next century with the depletion of conventional resources in western Canada.

Geological Setting (Fig. 54)

Since the dawn of the Cambrian, deposition in the sedimentary basins of the Arctic Islands has extended the North American landmass some 1400 km seaward of the Canadian Shield and its skirt of Precambrian metasediments. The sedimentary column is divided into lower and upper sections characterized by more or less continuous subsidence and deposition, separated by major tectonic uplift – the Ellesmerian Orogeny – in the Late Devonian and Early Carboniferous. With this exception, the preserved strata span most of the Paleozoic, Mesozoic and early Tertiary.

The sedimentary strata, tectonic deformation and petroleum geology of the older pre-Ellesmerian section is discussed below under the title "Franklinian Basin". Post-Ellesmerian geology is discussed under the title of its successor, the largely superimposed "Sverdrup Basin". Finally, the geology underlying the Arctic Coastal Plain and extending under the waters of the Arctic Ocean is discussed under the heading "Arctic Continental Terrace Wedge".

Exploration History (Figs. 55, 56)

The presence of extensive sedimentary basins with thick successions of Paleozoic and Mesozoic strata in the Arctic Islands, potentially favourable for oil and gas, was demonstrated in the 1950s by geologists of the Geological Survey of Canada (examples of the work of these earlier researchers are described in Fortier et al., 1954, and Thorsteinsson, 1958).

Exploration by petroleum companies began in the early 1960s. Most seismic exploration and drilling has occurred north of latitude 75°N, that is, in the Arctic Fold Belt and Sverdrup Basin. South of this latitude, exploration of the mildly deformed Paleozoic sequences of the Arctic Platform has been very sparse, with only three wells drilled (on Prince of Wales and

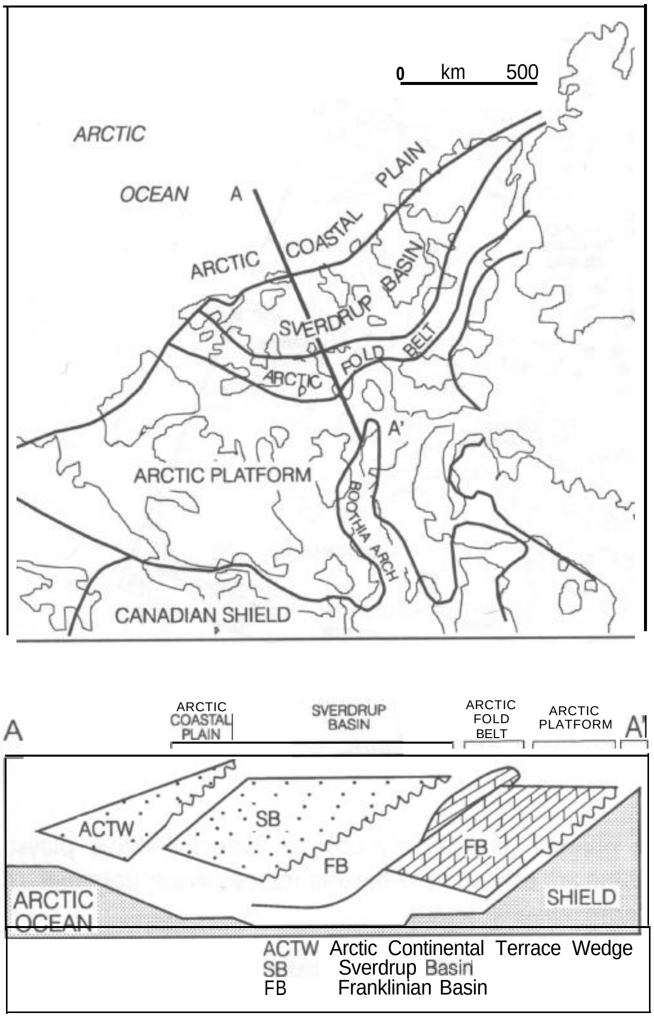

Figure 54. Tectono-stratigraphic elements of the *Arctic Ishnds.*

Somerset islands). The presence of the permanent ice cap and the extreme remoteness of the region have caused exploration of the Arctic continental terrace wedge to be equally limited.

The first Arctic Islands exploratory well was spudded in 1961 at Winter Harbour, Melville Island. Dome et al. Winter harbour No. 1 A-09 drilled Lower Paleozoic strata to a total depth of 3823 m. The well penetrated sandstones and siltstones of the Middle to Late Devonian clastic wedge in the up-hole section; these swabbed gas at low unsustained rates during a completion test. No hydrocarbons were tested from the thick carbonate section lower in the well and no significant porous zones were noted.

Since the drilling at Winter Harbour, a total of 19 discoveries have been made; three oil, 12 gas, and five oil and gas. Discoveries of oil alone have tended to be small with the larger accumulations containing gas, or gas with associated oil. The offshore discovery at Cisco is an exception: the large proportion of oil to gas found in this structure holds promise for other oil accumulations in the large and major categories. Discoveries are listed in Table 6 and the cumulative discovery curve (in barrels of oil equivalent) shows no diminution of discovery size with exploration to date (Fig. 57).

In the early 197Os, industry turned to the north coast of Melville Island where thick Mesozoic sequences were known to be present in the Sverdrup Basin. Panarctic Drake Point N-67 well, drilled in *1969* to 2577 m on the Sabine Peninsula of Melville Island, was the first major discovery in the Arctic Islands. This giant gas field has been delineated by 14 wells, (including the discovery well and two relief wells drilled to control blowout of the discovery well). The delineation program discovered a major offshore extension to the field at East Drake I-55. Combined resources in the main Drake Point pool and the East Drake extension are quoted by the Geological Survey at 98.5 x E9 m^3 (3.5 tcf). A second giant gas field was discovered soon afterwards at Hecla, 50 km along structural trend to the west of the Drake Point Field. In 1978, the smaller Roche Point gas discovery was drilled north of Hecla and just offshore of northwest Sabine Peninsula.

Early in their exploration program, Panarctic Oils Ltd. pioneered drilling offshore locations from artificially thickened sea ice. This proved an economic and efficient way of testing the numerous offshore structures in the central Sverdrup Basin, which lie in water depths of up to 500 m. A succession of discoveries followed near Lougheed Island, on the southwestern coast of Ellef Ringnes Island, on King Christian Island, and in the intervening waters. The first of these discoveries by Panarctic in the central Sverdrup Basin was King Christian in 1970, followed by Thor, Kristoffer, Jackson Bay, Whitefish, Char, Balaena, Cisco, Skate, Maclean, Sculpin, Cape Macmillan and finally Cape Allison in 1985. Dome and partners added Wallis to the tally in *1973.*

Over this period, drilling also continued along the southern margin of the basin with success at Bent Horn on Cameron Island in 1974. This is the sole discovery in Paleozoic carbonates of the Franklinian Basin. It is also the only discovery in the Arctic Islands under production.

Drilling in the far northwest of the Sverdrup Basin on the Fosheim Peninsula also had limited success, recording a single discovery by Panarctic at Romulus.

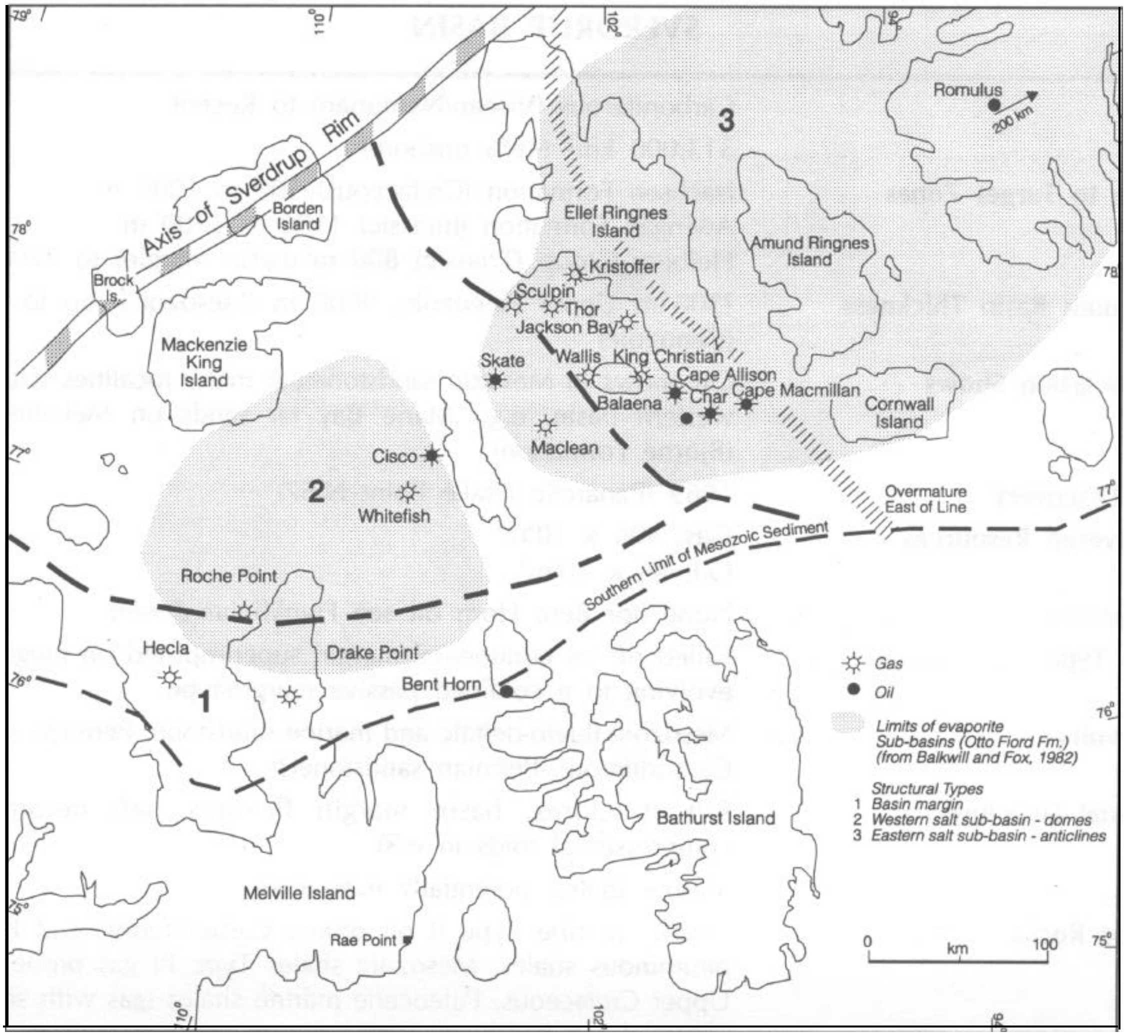

Figure 58. *Tectonic elements of the Sverdrup Basin.*

The northwestern margin of the developing basin was sub-parallel to the developing rift system. Horsts and grabens developed along this margin, but overall subsidence along this "Sverdrup Rim" was consistently less than in the basin depocentre. Since the inception of Mesozoic-Cenozoic spreading in the Canada Basin, the Sverdrup Rim has remained structurally high, more or less effectively separating the Sverdrup Basin from the Arctic Ocean.

The Sverdrup Basin was a major depocentre through much of the late Paleozoic and Mesozoic. Rapid subsidence, initiated by rifting in the Carboniferous and Early Permian, was followed by thermal subsidence at a more sedate rate, in passive margin fashion. From the Late Jurassic to the mid-Cretaceous, subsidence rates and deposition in the basin were influenced by events leading to the rifting and formation of new oceanic crust in the Canada Basin to the northwest. Widespread volcanism in the northern part of the Sverdrup Basin in the mid-Cretaceous coincides with the main rifting in the proto-Canada Basin, and occurs where the north-northeast-striking late Paleozoic rifts of the Sverdrup Basin intersect the northeasterly trending rifted margin of the Canada Basin.

The early Paleogene saw the growing influence of orogenic events in the east coupled to the widening of the northern North Atlantic, and, in particular, to accommodate sea-floor spreading in Baffin Bay. The Eurekan Orogeny folded the eastern half of the Sverdrup Basin, much of which is uplifted and exposed on Ellemere Island. The influence of this compression affected strata as far west as Lougheed Island. In the western Sverdrup Basin, subsidence continued as a result of differential loading of Carboniferous salt and the development of diapir fields. However, during the Tertiary, the focus of deposition shifted west to the Arctic Continental Terrace Wedge, beyond the confines of the Sverdrup Basin.

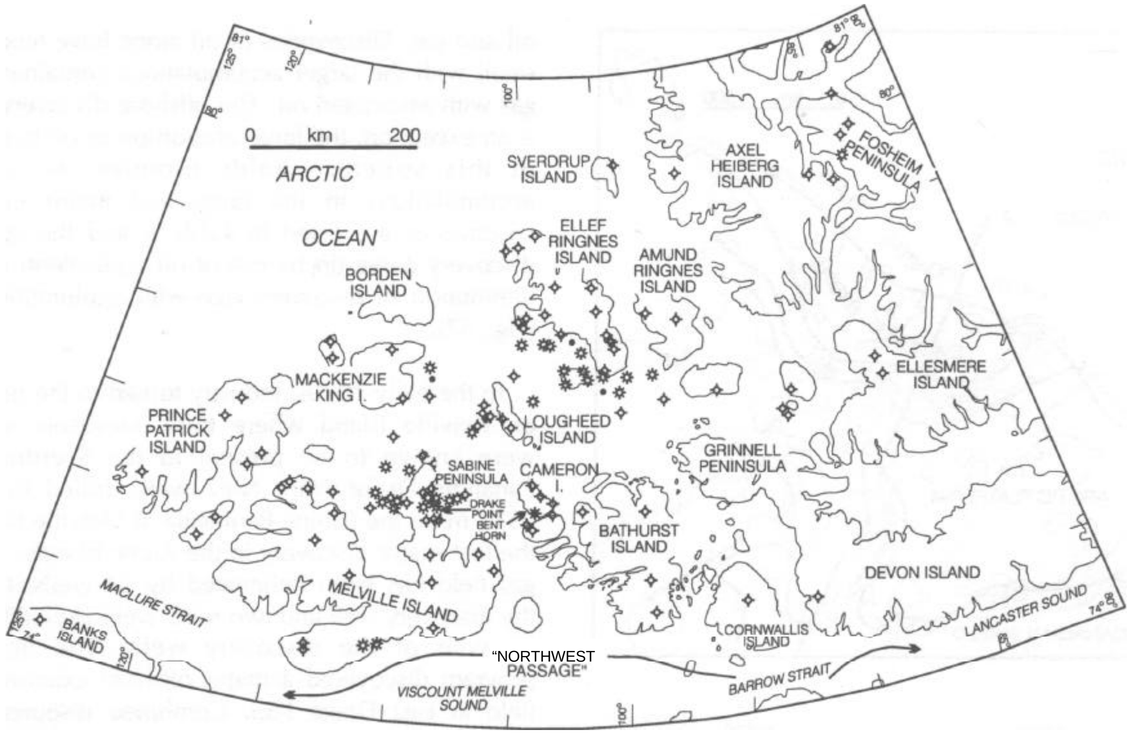

Figure 55. *Well locations in the northern Arctic Island*

Oil and condensate of various gravities and some gas were tested from Triassic and Jurassic sandstones. Although good to excellent permeability was inferred from several of the drillstem tests, pressure declines indicated reservoirs of limited extent and productive capability. The eight other wells drilled in this part of the basin were unsuccessful.

Following the peak drilling year of 1973 when 37 wells were drilled, drilling declined precipitously to a mere four wells in 1980. The early 1980s saw some recovery as companies worked new exploration licences across the basin. However, drilling continued to decline through the mid-eighties with the last exploratory well spudded in 1986. Panarctic unsuccessfully sidetracked an existing delineation well to further delineate the Bent Horn pool in 1987. Since that time, the basin has seen no exploration activity and has been ignored despite its potential for further major discoveries.

Outlook

The Geological Survey of Canada estimates the potential of the Arctic Islands at 686 x E6 m^3 oil and 2257 x E6 m^3 gas (average expectation). Both gas and oil potential are highest in the Sverdrup Basin, in both Mesozoic and late Paleozoic rocks. Future exploration may target deeper parts of the Mesozoic succession and a number of relatively untested late Paleozoic plays: these are estimated to have at least as much potential as those already tested.

Although much of the past exploration focus (and success) has been in the central Sverdrup Basin, future efforts may target the southern rim of the basin and the Arctic Fold Belt. The Bent Horn field lies within this latter region of structural complexity and there is considerable potential along this trend. More importantly, relative proximity to shipping lanes through the Northwest Passage make exploitation of discoveries along the southern rim of the Sverdrup Basin a more economically attractive proposition.

Throughout the Arctic islands region there are many untested plays, most of which would be under intense exploration if they were located in southern Canada. Although development costs are high, resources discovered per metre drilled have been greater in the Arctic than in western Canada. Transportation cost, not petroleum potential, is clearly limiting the development of this remote region. In the late 1970s, various routes for a gas pipeline to southern Canada were studied and abandoned (Polar Gas Pipeline Project). Liquefaction and shipping of gas from Sabine Peninsula was also considered as an alternative to an extremely long and costly pipeline (Arctic Pilot Project). Tanker transport of oil, and possibly of liquefied natural gas certainly command greatly superior economics to any pipeline

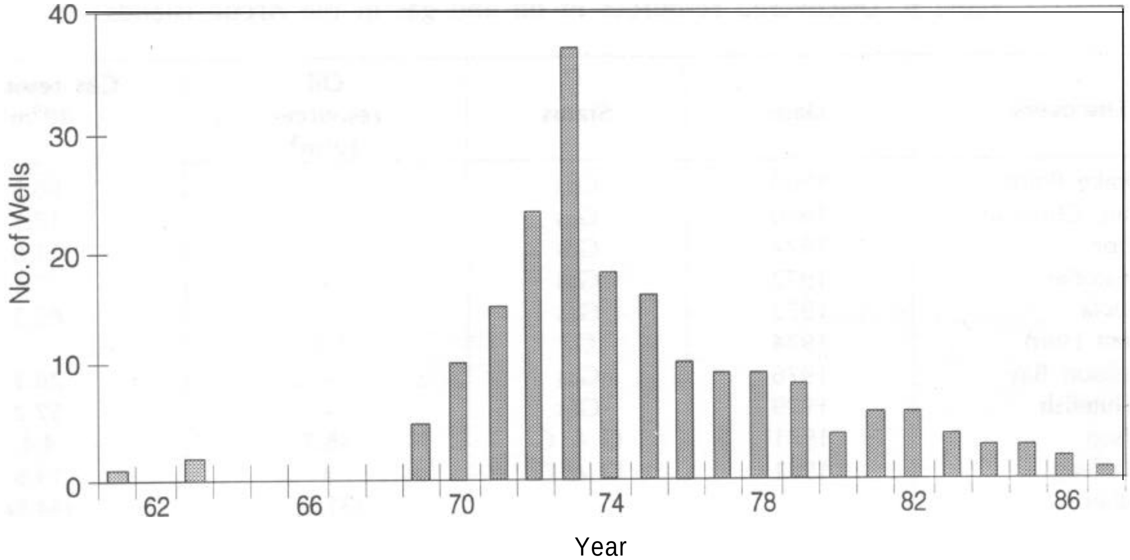

Figure 56. *Drilling history, Arctic Islands.*

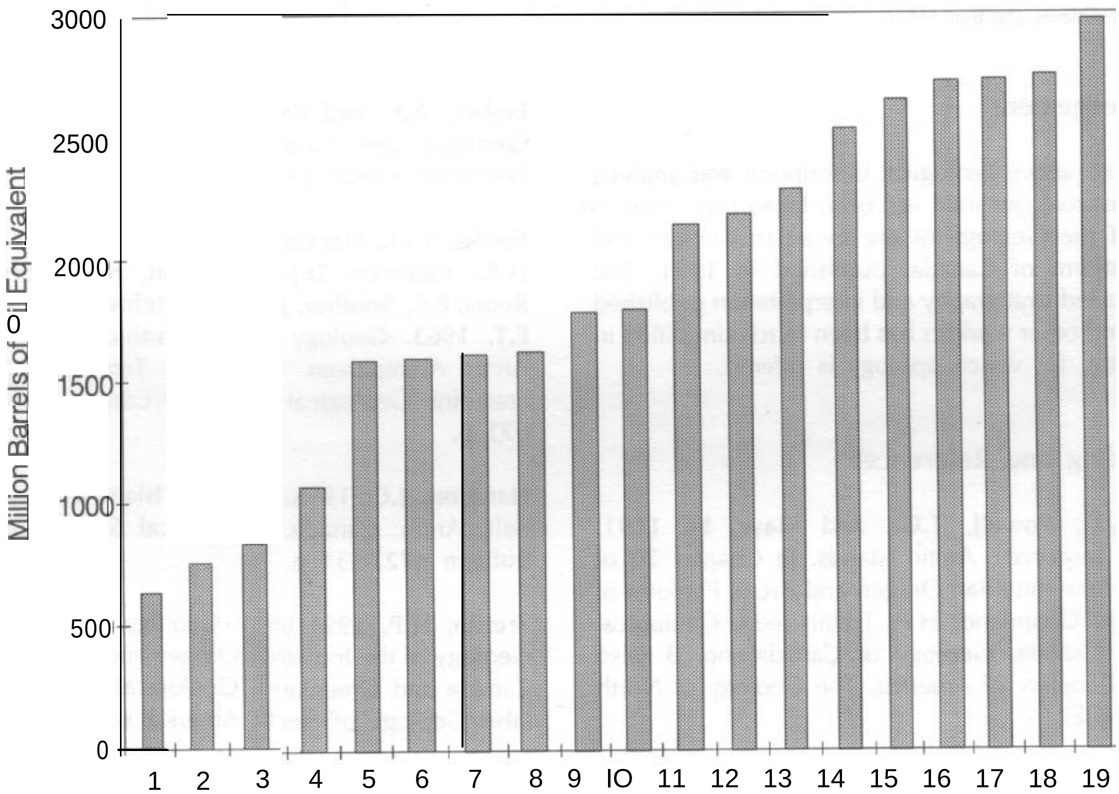

Figure 57. Cumulative discovered resources in the Arctic Islands by sequence of discovery.

project and allow for increments to supply without the major market perturbation inevitable with new supply from a large capacity pipeline. Further oil development awaits the discovery of new fields along the southern margin of the basin, and for gas exploitation, the capability of major gas consuming countries to greatly expand their ability to import LNG.

Table 6. Discovered resources of oil and gas in the Arctic Islands

Discovery	Date	Status	Oil resources E6 m^3	Gas resources E9 m^3
Drake Point	1969	Gas		98.5
King Christian	1970	Gas	-	17.3
Thor	1972	Gas		11.9
Kristoffer	1972	Gas	-	27.1
Hecla	1972	Gas		85.5
Bent Horn	1974	Oil	1.0	
Jackson Bay	1976	Gas		28.3
Whitefish	1979	Gas		57.2
Cisco	1981	O & G	48.7	4.4
Maclean	1981	O & G	3	13.6
Other			(31.5)	(44.6)
	TOTAL	=	66	406 (14.3 tcf)

Notes: Discoveries in the category "other" include Romulus (1972, oil), Wallis (1973, gas), Roche Point (1978, gas), Char (1980, oil and gas), Balaena (1980, heavy oil), Skate (1981, oil and gas), Sculpin (1982, gas), Cape MacMillan (1983, oil and gas), and Cape Allison (1985, oil and gas).

Source: GSC (1983) for individual fields; NEB (1994) for "other" and basin totals includes unpublished revisions to discovered resource estimates and Bent Horn.

Acknowledgement

Much of the above geological description and analysis of the Paleozoic potential has been taken from various authors of the Geology of the Innuitian Orogen and Arctic Platform of Canada, published in 1991. The highly detailed stratigraphy and interpretation published by these and other workers has been much simplified in this account, for which apology is offered.

Key Reading and References

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