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NATURAL OIL SEEPS ON THE BAFFIN SHELF, NUNAVUT, CANADA: GEOLOGY AND GEOCHEMISTRY OF THE SCOTT INLET SEEP

P.N. Moir[1], G.N. Oakey[1], R. Bennett[1], K. Dickie[1], G. Williams[1], P. Budkewitsch[2], V. Decker[2], M.G. Fowler[3], M. Obermajer[4], J.W. Haggart[5]

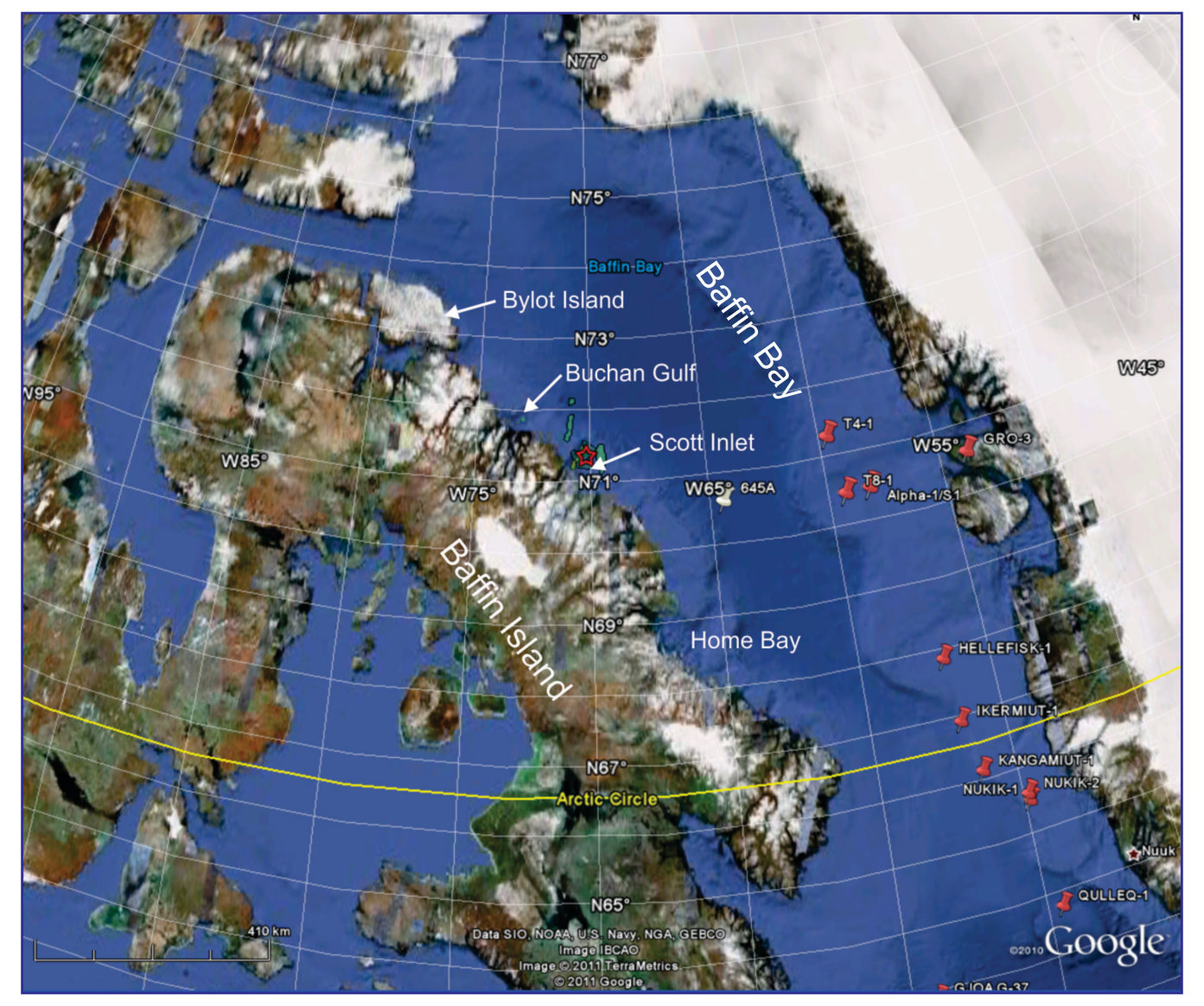


Fig 1. Location map showing Scott Inlet, Buchan Gulf and Bylot Island. Red push pins are location of petroleum exploration wells.

Fig 2. Oil slick, in foreground, observed off Scott Inlet, September 1980 (Levy and MacLean, 1981).

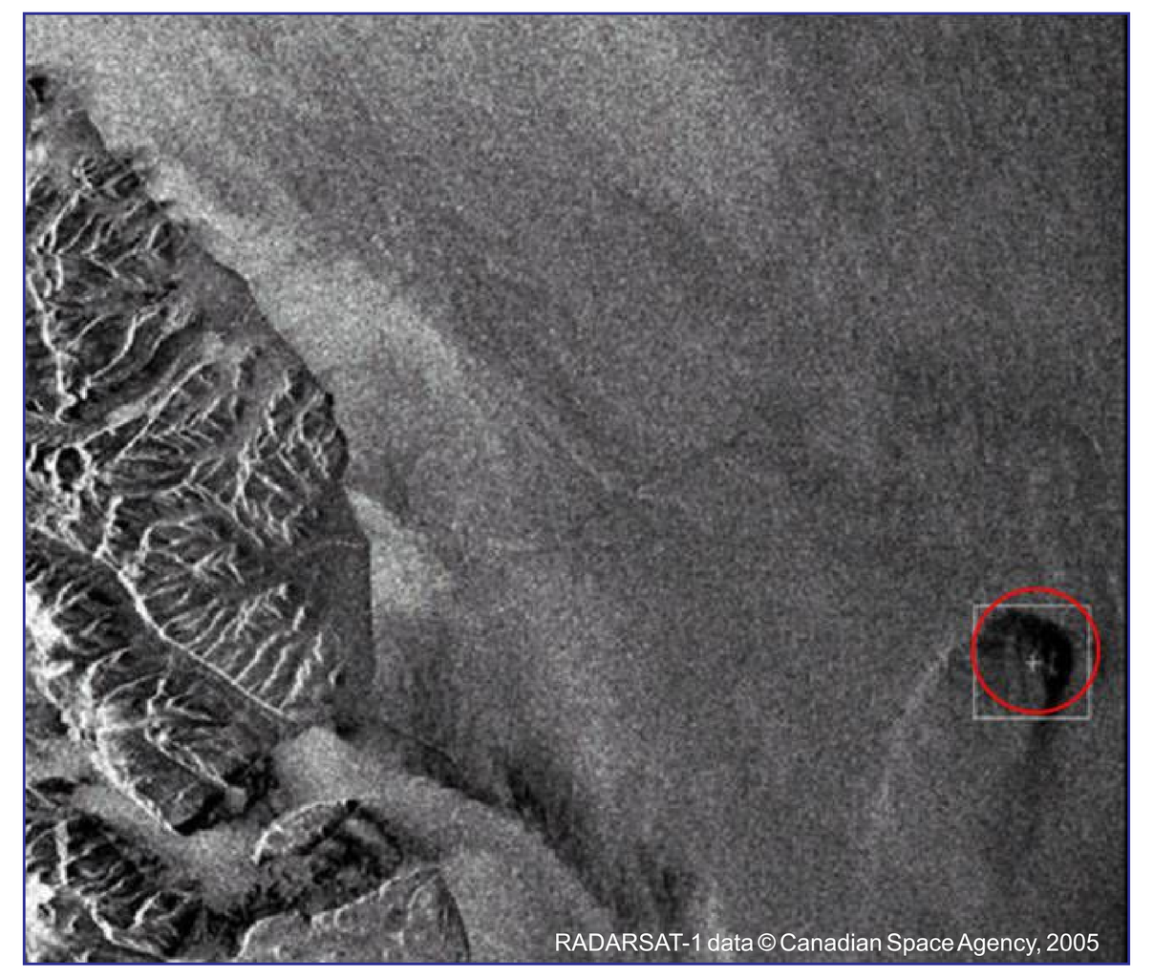


Fig 3. Sea surface slick near Scott Inlet. RADARSAT–1 acquisition date Oct. 3, 2005 (Budkewitsch 2006). Repeat sea surface mapping using satellite radar confirms the continued existence of extensive and persistent oil slicks. The investigation of possible and confirmed natural hydrocarbon seeps identified in SAR images was the focus of a study using RADARSAT-1 data in the eastern off-shore areas of Baffin Island (Budkewitsch 2006).

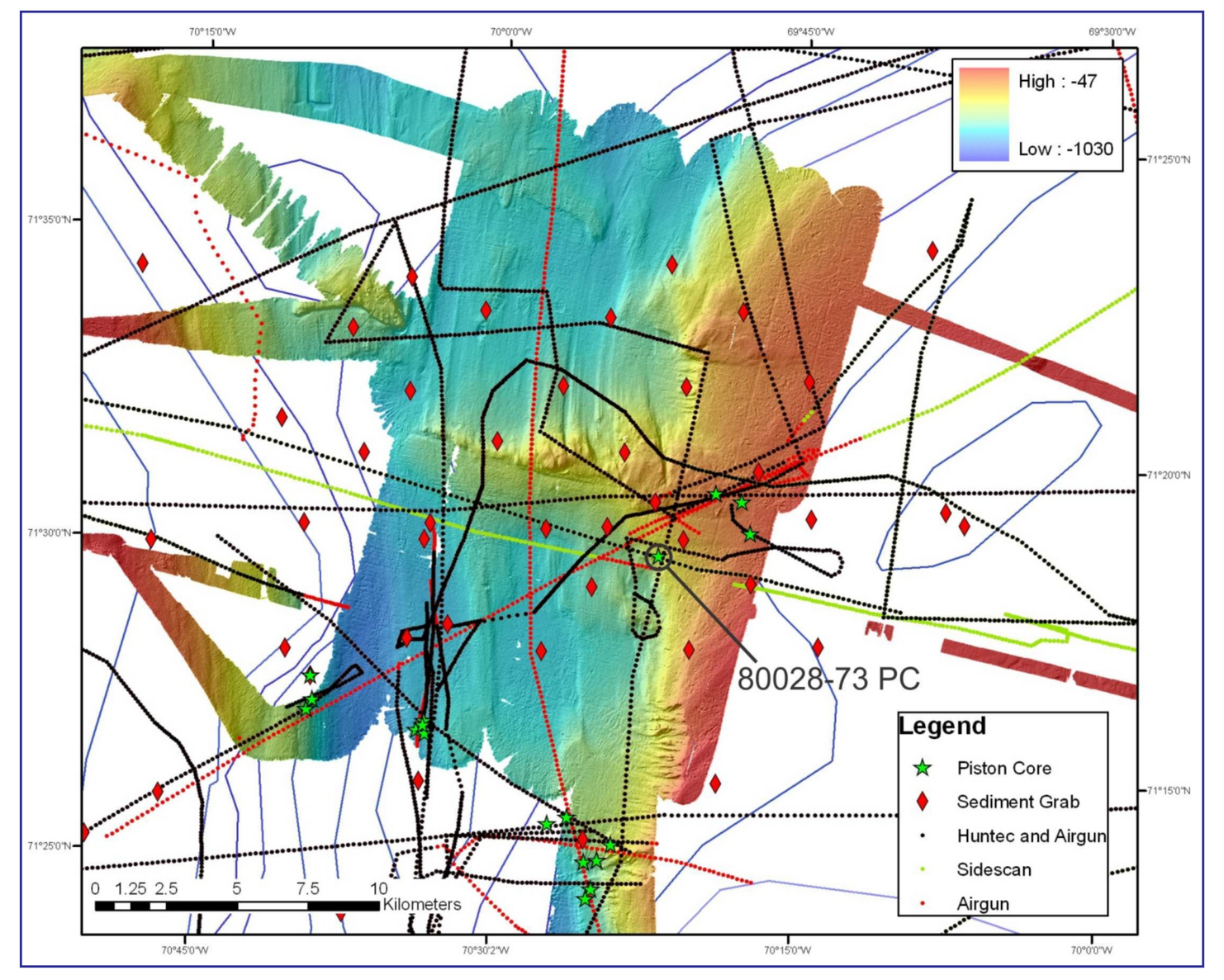


Fig 5. Multibeam, geophysics, and sample data coverage in Scott Trough.

INTRODUCTION

Oil slicks were first recorded on the sea surface offshore Scott Inlet, Baffin Island, in 1976 by a scientific team from the Geological Survey of Canada (Loncarevic and Falconer, 1977). Several detailed studies were undertaken over the following 10 years to examine the petroleum residues in the surface slick, water column, and surficial bottom sediments, and to map the geology of the area (Levy, 1978, 1979a, b; MacLean, 1978; MacLean and Falconer, 1979; Levy and MacLean, 1981). A comprehensive review of investigations was published by MacLean et al. (1981).

The Pisces IV submersible was used in 1981 and 1985 to visually examine the sea floor and collect targeted samples (Grant et al., 1986). This work confirmed that oil and gas were indeed seeping from several locations. Video footage showed areas with distinctive white *Beggiatoa* bacteria-encrusted sediments, locally solidified into a carbonate crust which was trapping oil beneath it. In addition, extensive surface slicks were mapped and observed in several locations off Scott Inlet and Buchan Gulf.

The petroleum industry had also taken interest in the Baffin Bay region with several seismic surveys completed in the 1970s. However, very little new work was undertaken until a resurgence of exploration activity on the West Greenland margin in 2007, resulting in extensive, modern seismic and aeromagnetic surveys and drilling in 2010.

Thirty five years after the initial slick discovery, many elements of the active petroleum system at Scott Inlet are still unknown. However, several new data sets and interpretations provide new insight into the active petroleum system that exists in Scott Inlet basin. This poster highlights 6 of these new data sets.

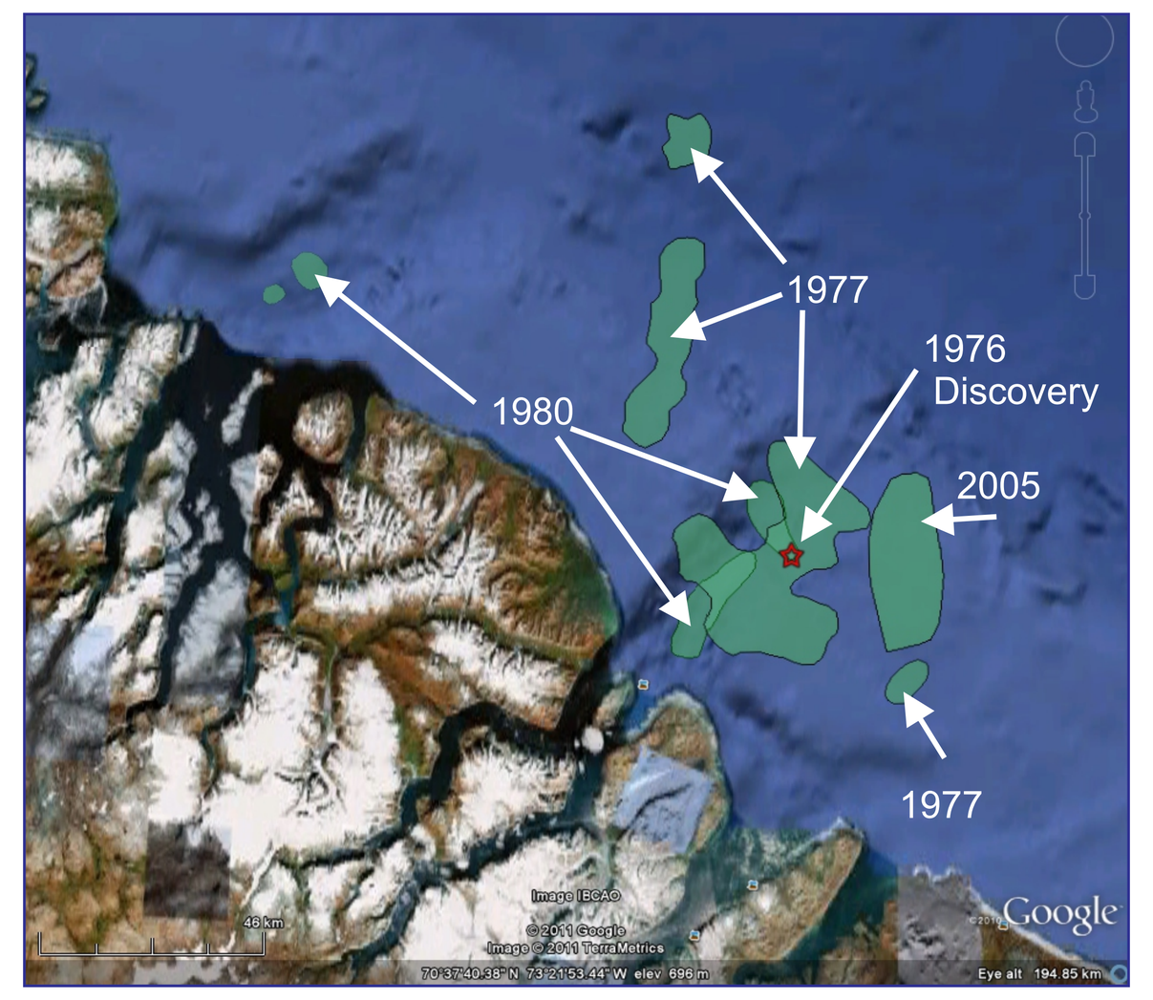


Fig 4. Scott Inlet and Buchan Gulf area with oil slick outlines. 1977 slicks mapped by Levy (1978), 1980 slicks mapped by Levy and MacLean (1981), 2005 slick extent from Budkewitsch (2006).

1. Repeat sea surface mapping from ship and satellite radar confirm the continued existence of extensive and persistent oil slicks near Scott Inlet and Buchan Gulf (Figs 2, 3, 4).

2. A series of multibeam seismic surveys conducted between 2006 and 2010 over Scott Trough (Fig 5) have illuminated new details of the surficial geology, petroleum escape features, and the surface expression of the underlying bedrock (Figs 6–10).

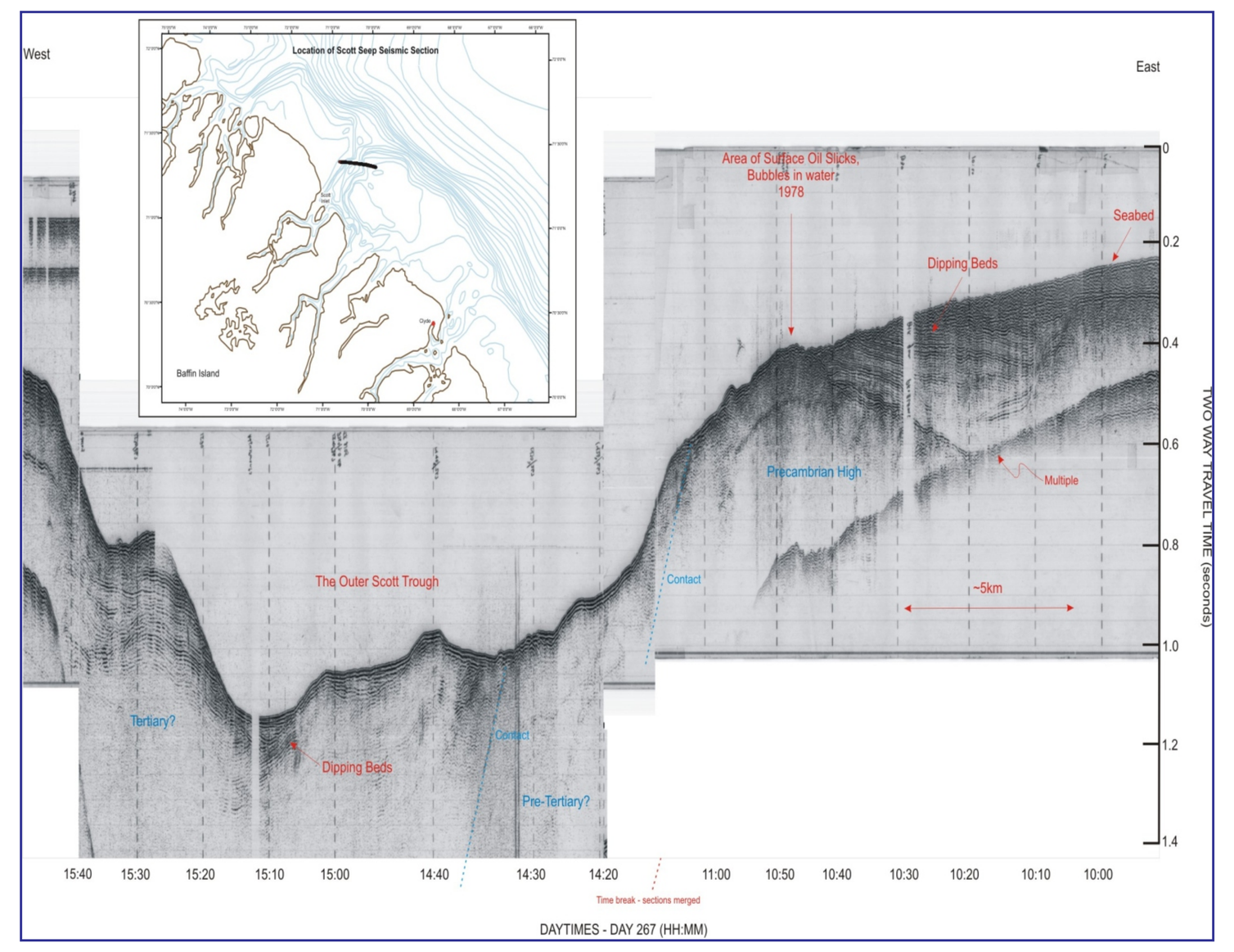


Fig 6. Seismic reflection profile across Scott Trough and the location where hydrocarbons were observed on the sea surface (Blasco et al., 2010).

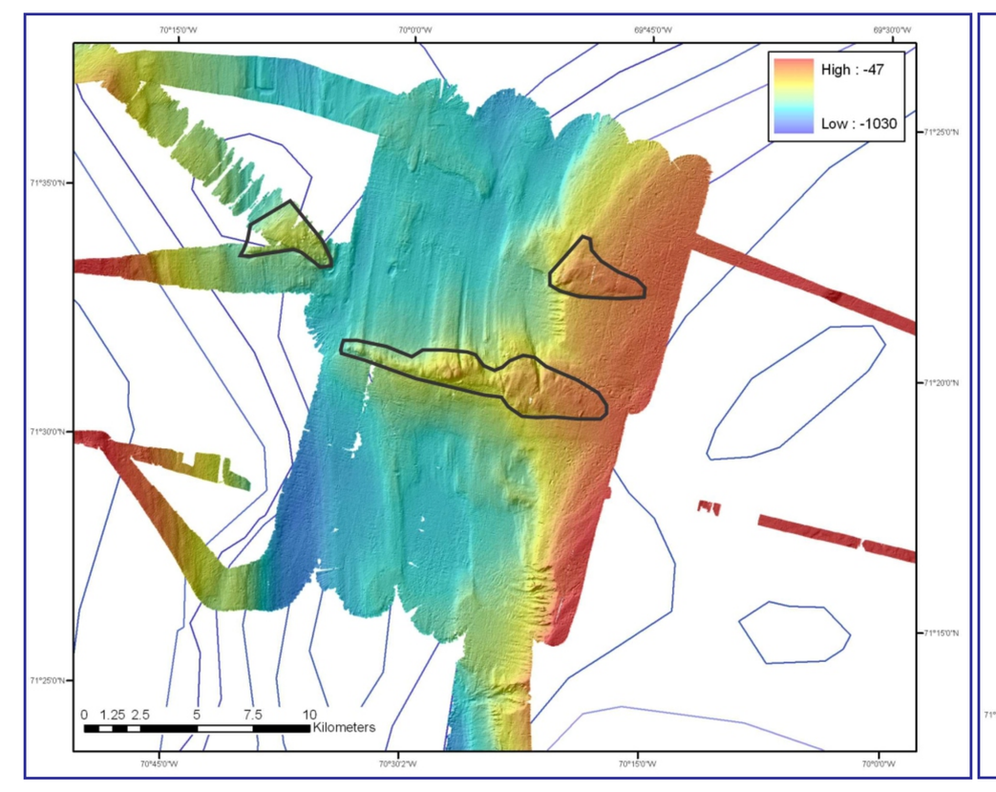


Fig 7. Seabed expression of bedrock in the Scott Trough area.

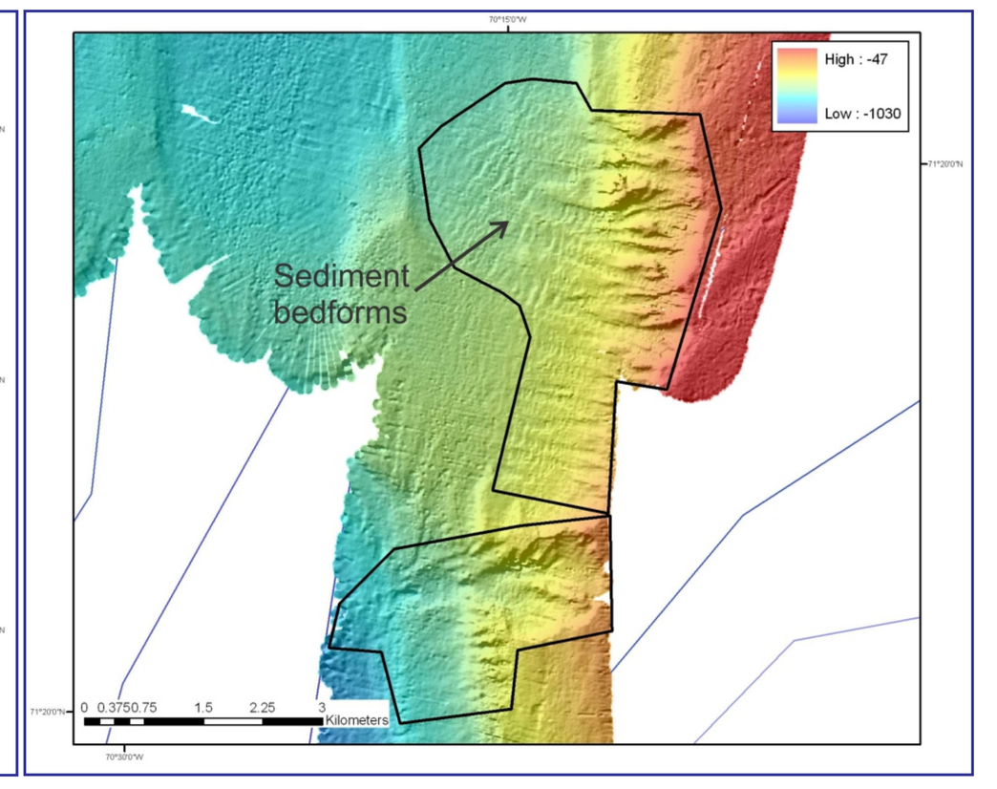
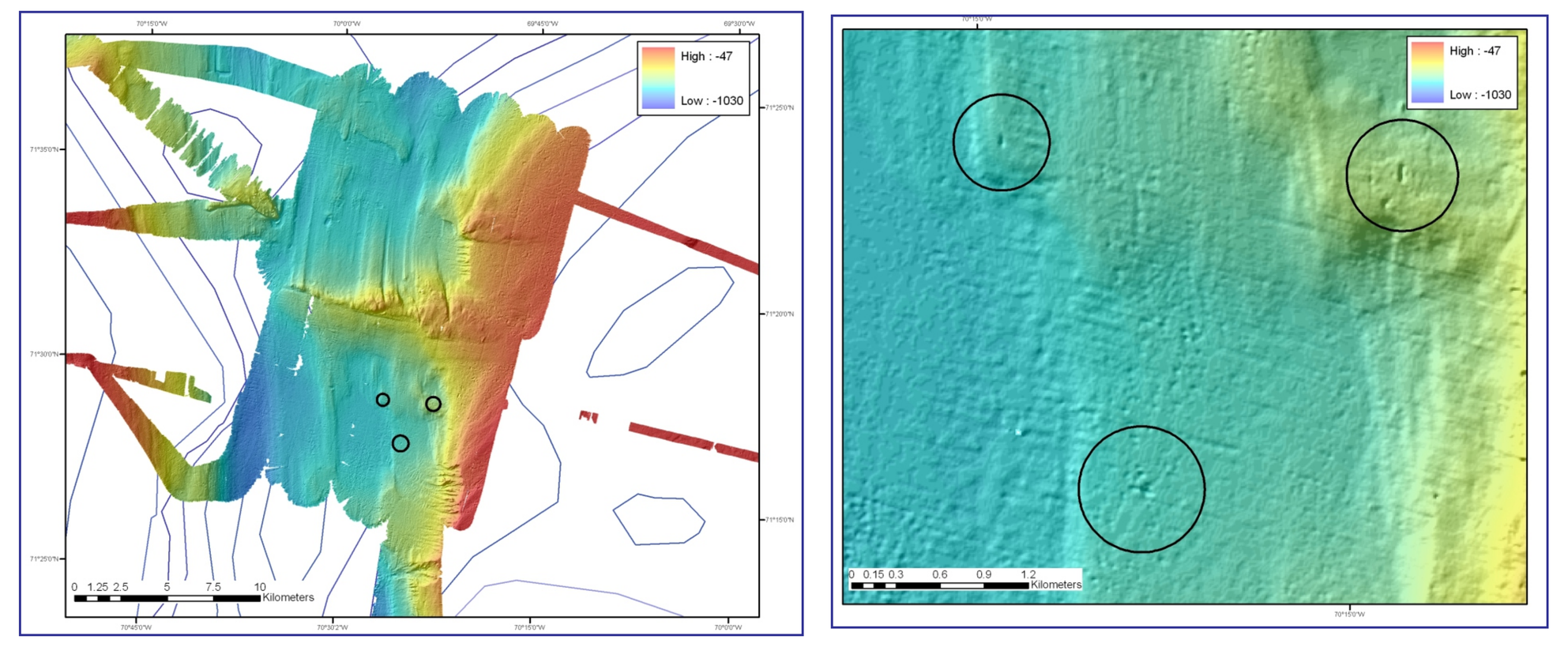


Fig 8. Canyons and sediment bed forms along the southern margin of Scott Trough.



Figs 9 & 10. Pockmark distribution in Scott Trough (shown in polygons outlined in black). The three identified are up to 130 m wide and 11 m deep. Other pockmarks may be present that are smaller than the 10 m horizontal resolution of the mutlibeam collection system.

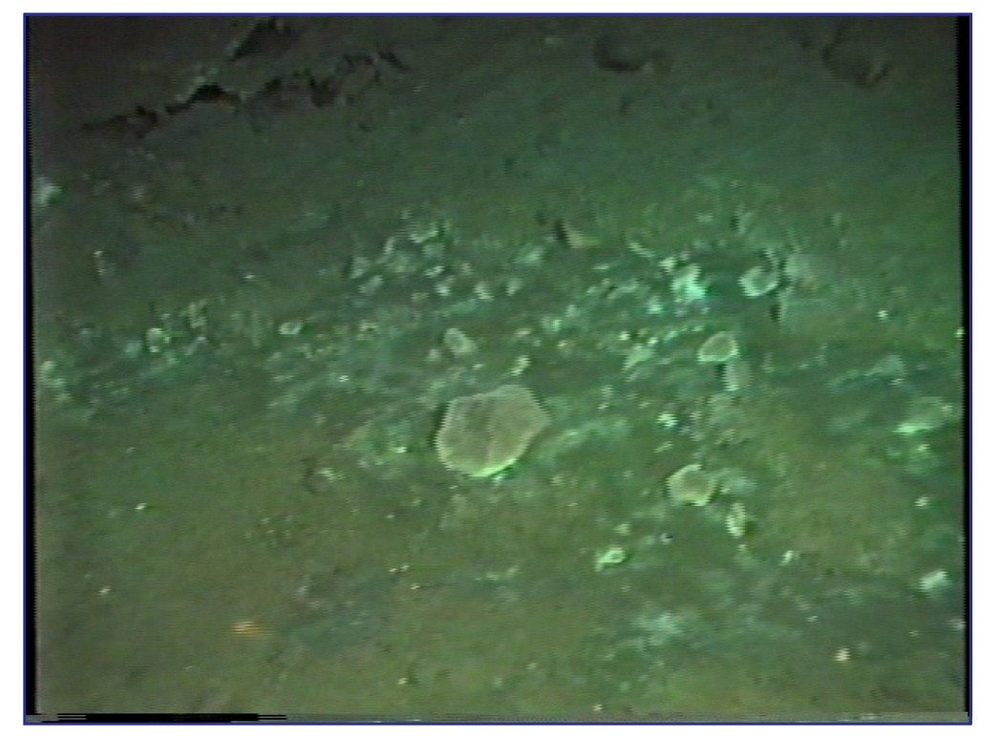


Fig 11. Seabed covered in white bacterial carbonate crust observed during the Pisces IV 1985 dive.

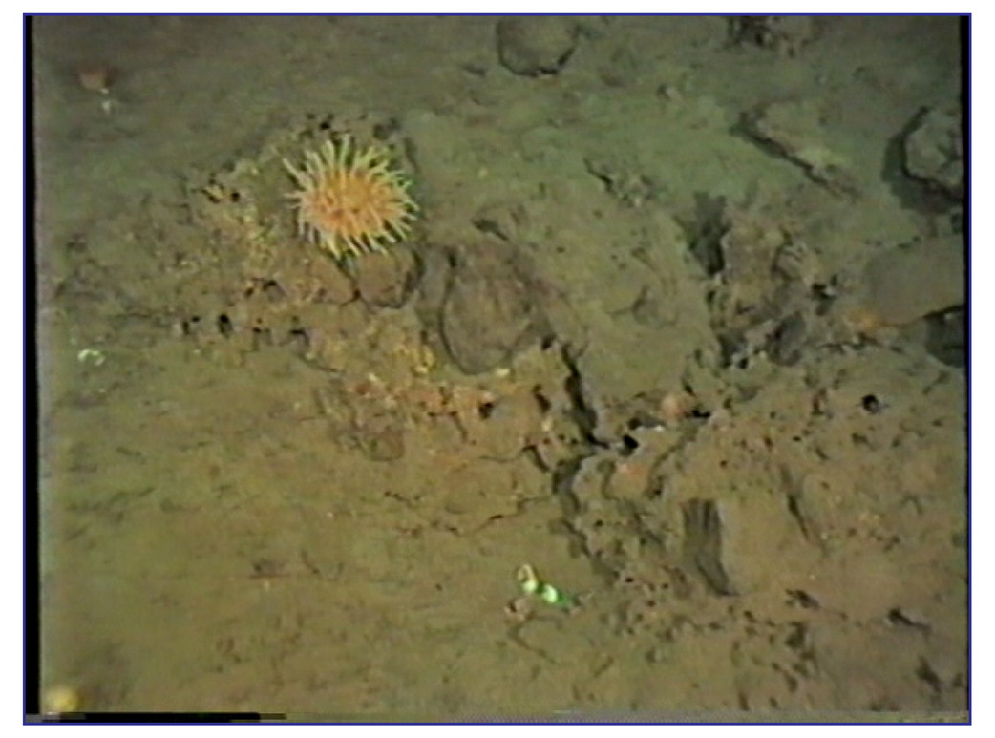


Fig 12. Carbonate crust viewed by the Pisces IV 1985 submersible dive.

Fig 13. Sample of oil-coated Scott Trough carbonate crust collected during the Pisces IV 1985 dive.

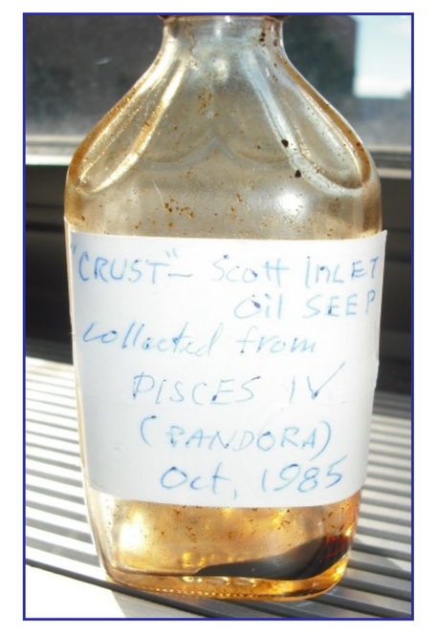


Fig 14. 2010 photo of remaining oil collected in 1985 from the oil-coated carbonate crust shown in Fig 13.

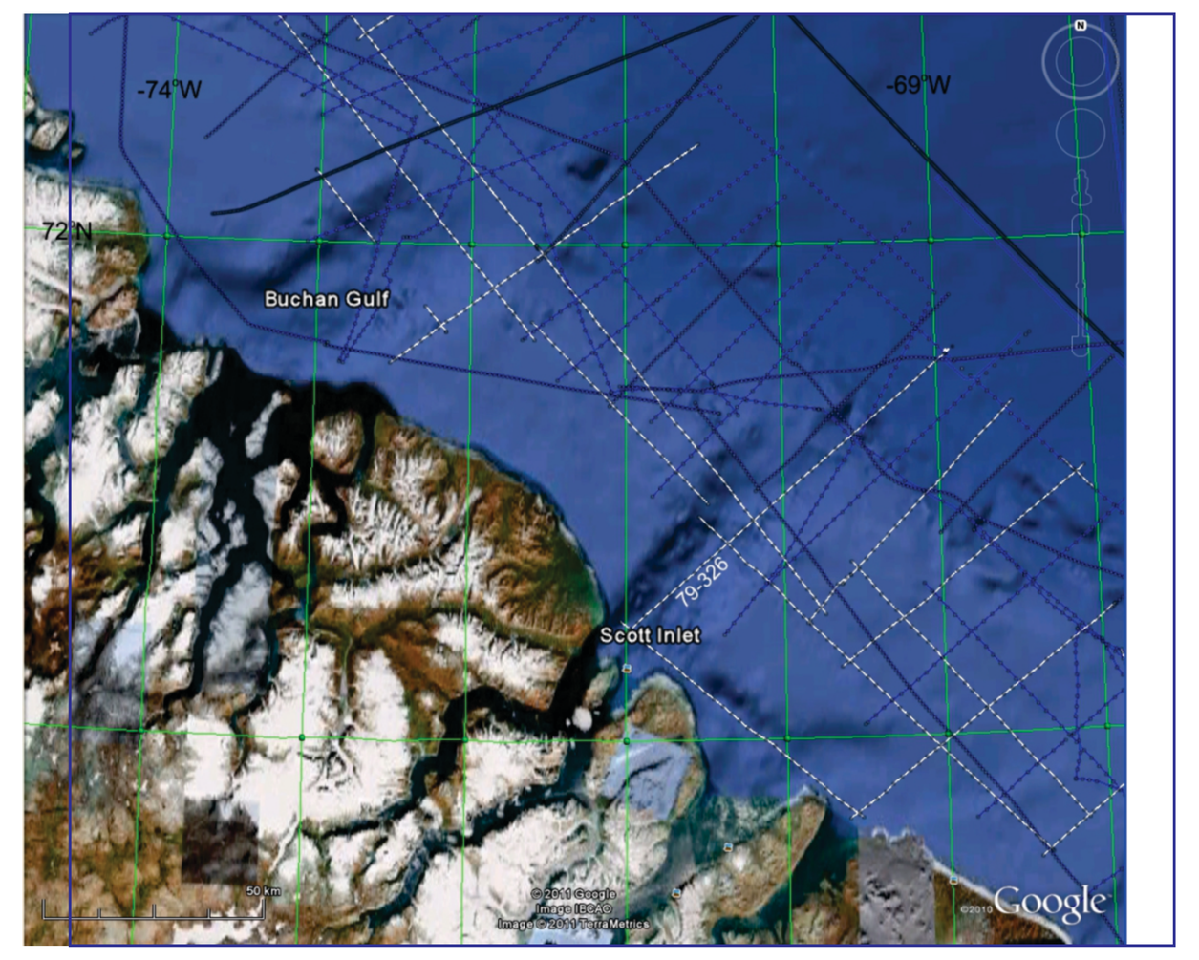


Fig 15. Shot-point lines of multichannel seismic lines shot by industry from 1971-1979. Lines in white were shot in 1979 for Petro-Canada (NEB project 246-09-12-00165).

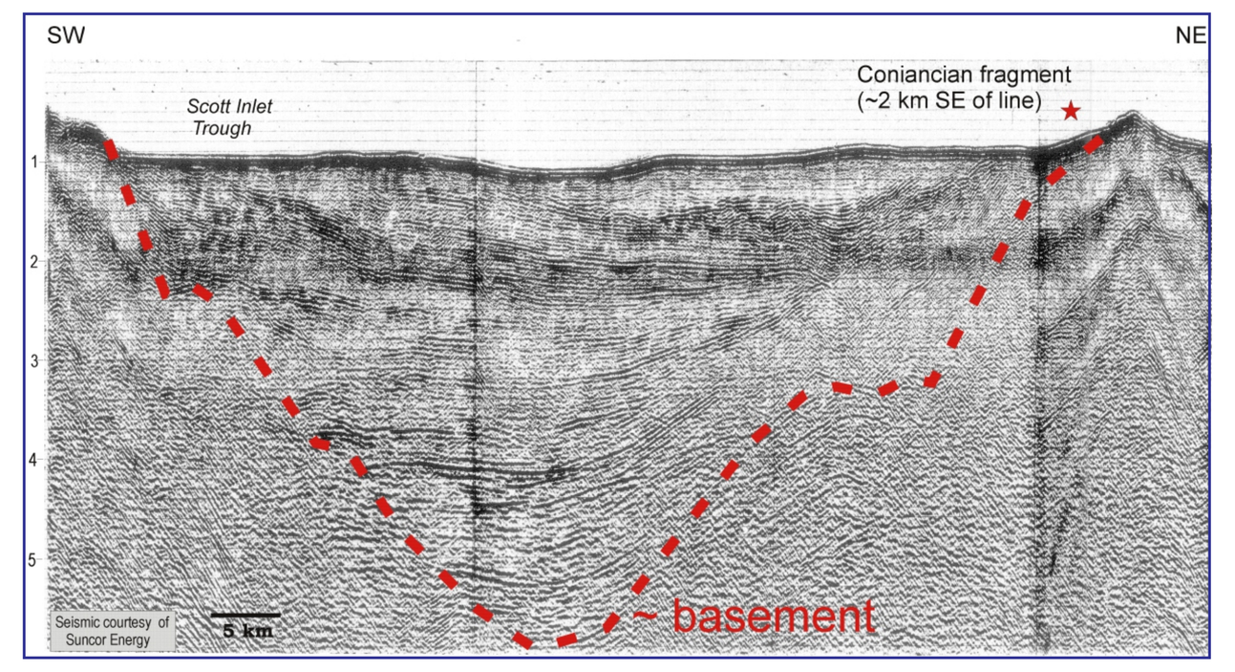


Fig 16. Basement outline of Scott Inlet basin - Petro-Canada Line 79-326 (Courtesy of Suncor Energy). Location shown in Fig 15.

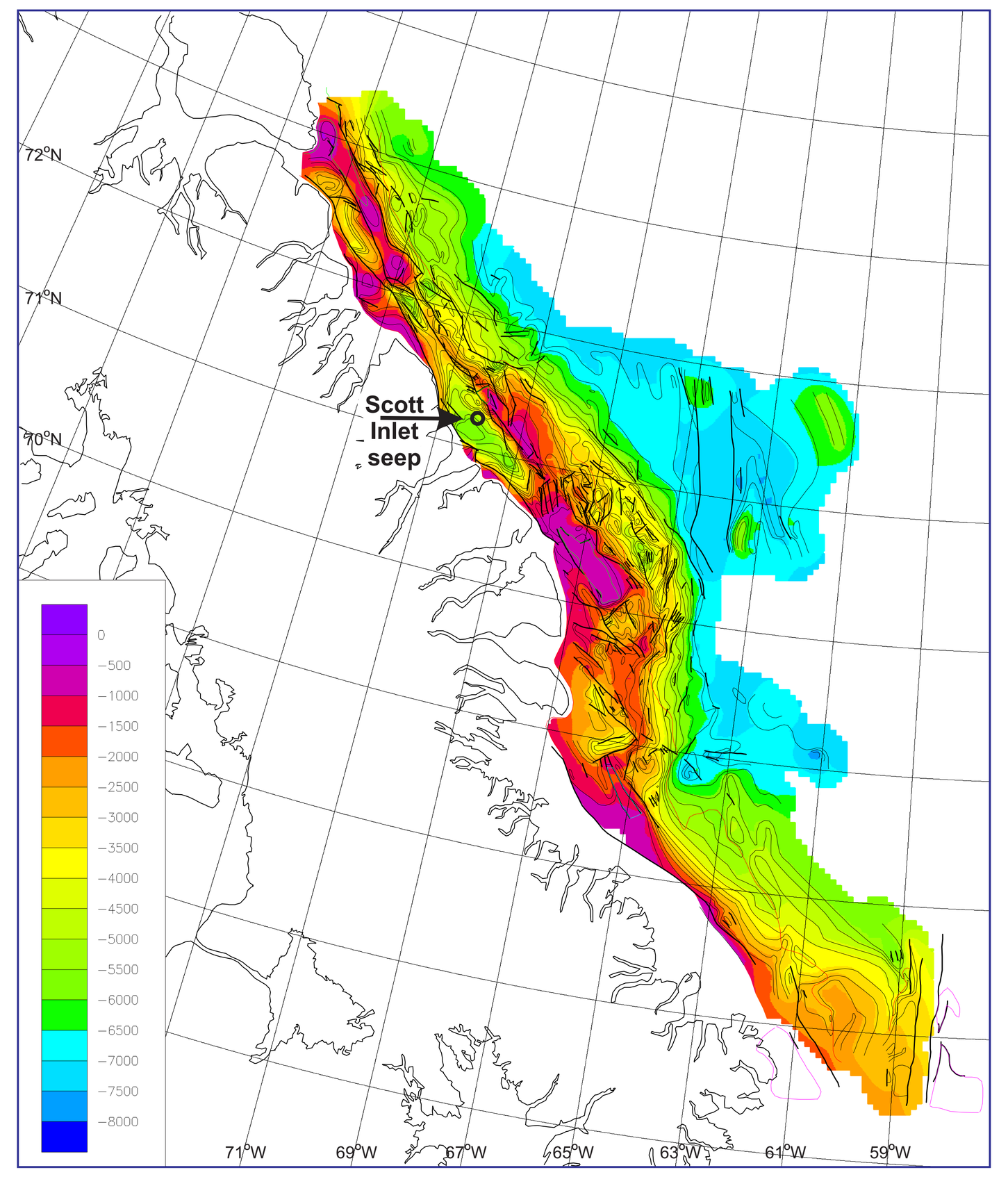


Fig 17. Depth structure on top of basement map, modified from Petro-Canada map (Sullivan 1984).

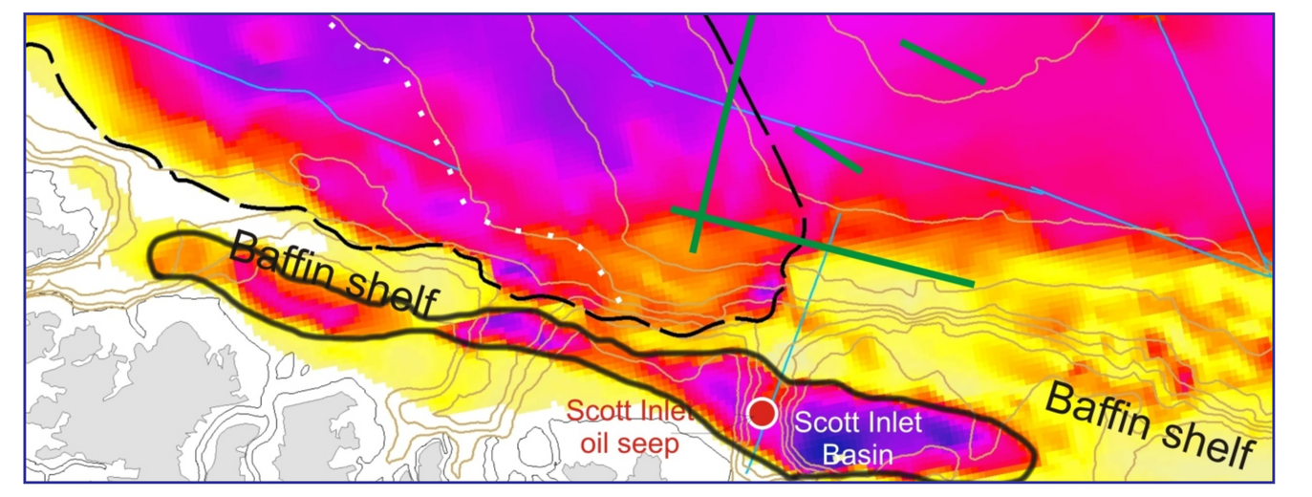


Fig 18. Depth to basement map after Harrison et al. (2011), showing approximate outline of Scott Inlet basin.

3. Work completed by the oil industry from 1971 to 1979 is no longer confidential and can be viewed at the National Energy Board (NEB). Regional mapping using 2D seismic reflection and refraction profiles reveal an elongate (200–300 km by 25–50 km wide), NW-SE-striking graben, named the Scott Inlet basin. It is thought to contain at least 6 km of Cretaceous and younger sedimentary strata (Figs 15–18).

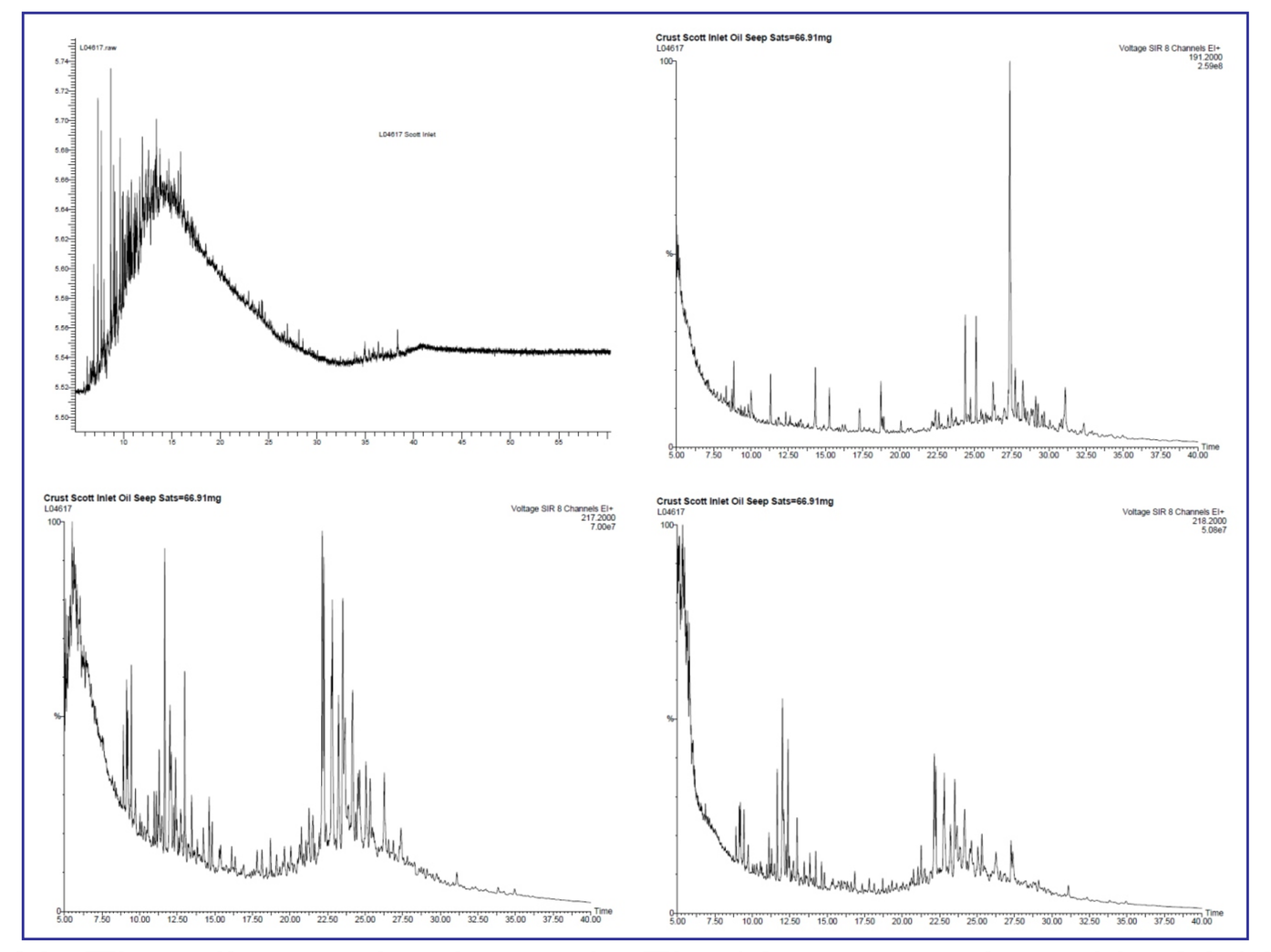


Fig 19. The oil sample shown in Fig 13 was analyzed in 2010 by liquid chromatography, gas chromatography, and gas chromatography-mass spectrometry (GC GC/MS).

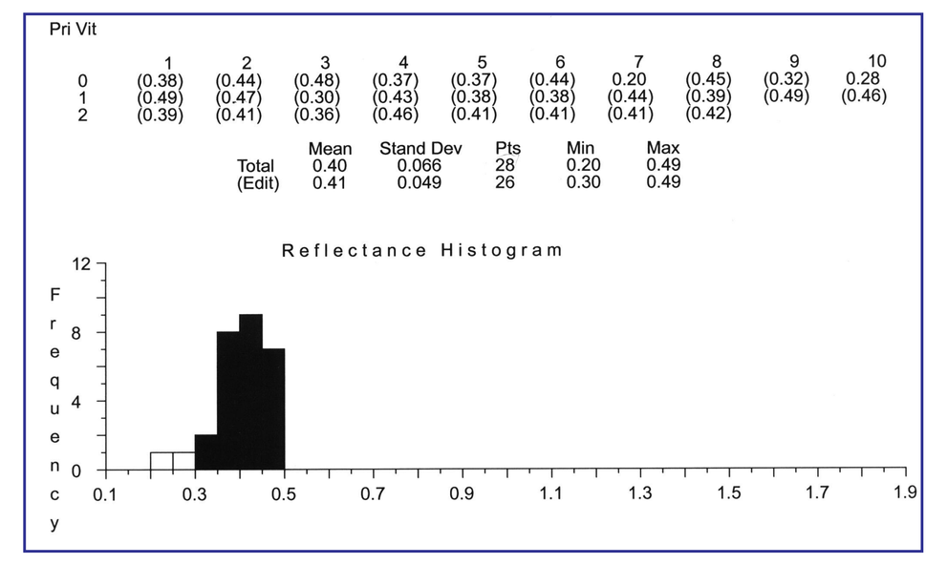


Fig 23. Vitrinite Reflectance results from shale samples selected from the Scott Inlet 80028-73 piston core at the 207-208 cm level.

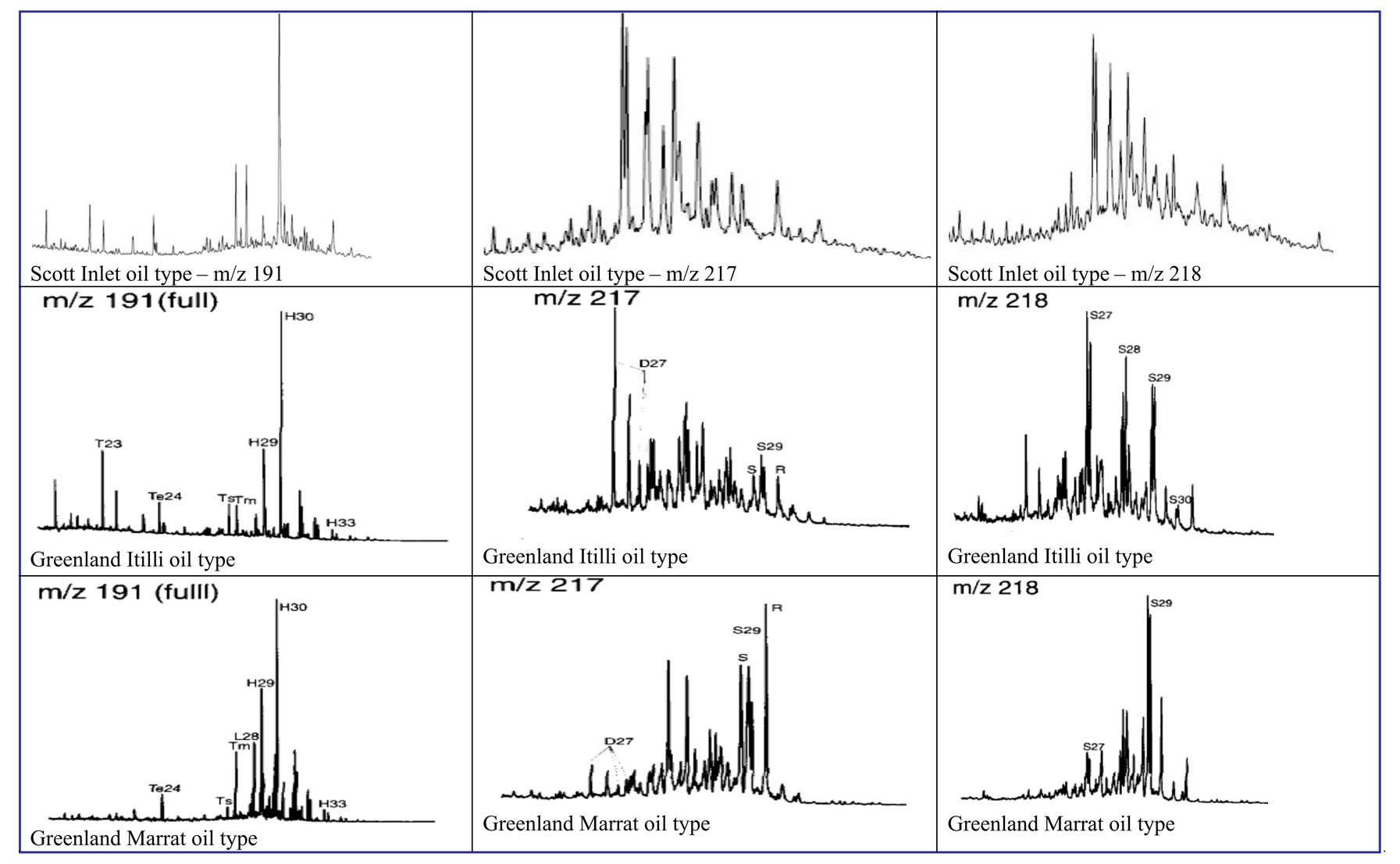


Fig 20. Comparison fragmentograms from Scott Inlet oil, Greenland Itilli oil, Greenland Marrat oil. Compared to five oils identified by Bojesen-Koefoed et al. (1999), the Scott Inlet oil is most like the Itilli type, which is suggested as sourced from Cenomanian-Turonian age marine shales.

4. New analysis of Scott Inlet oil collected from the 1985 submersible (Figs 11–14) experiment confirms biodegraded, mature oil with biomarkers indicative of an Upper Cretaceous marine source, as suggested by Fowler et al. (2005). This oil is similar to the Itilli oil type identified in West Greenland, which has been proposed to be generated from Cenomanian to Turonian marine shale (Figs 19–22).

5. Upper Cretaceous mudstone and shale cored at several locations on the NE Baffin Shelf were originally dated as Campanian in age. Palynological work completed in 2011 (MacLean et al., 2011) provides a more precise age of Turonian to Coniacian for the mudstones of Home Bay and Buchan Gulf and the black shale cored at Scott Inlet (location 80028-73 in Fig 5). These strata are thus equivalent to strata present on Bylot Island, approximately 300 km NW of Scott Inlet, as well as possible marine Cenomanian-Turonian source rocks identified on Ellesmere Island and West Greenland. The black shale collected in core 80028-73 has a Vitrinite Reflectance measurement of .41 (Fig 23), indicating that shales near the surface of Scott Trough are marginally mature and that 1.5 km or more of sediment may have been removed by recent glaciation or a Cenozoic erosional event.

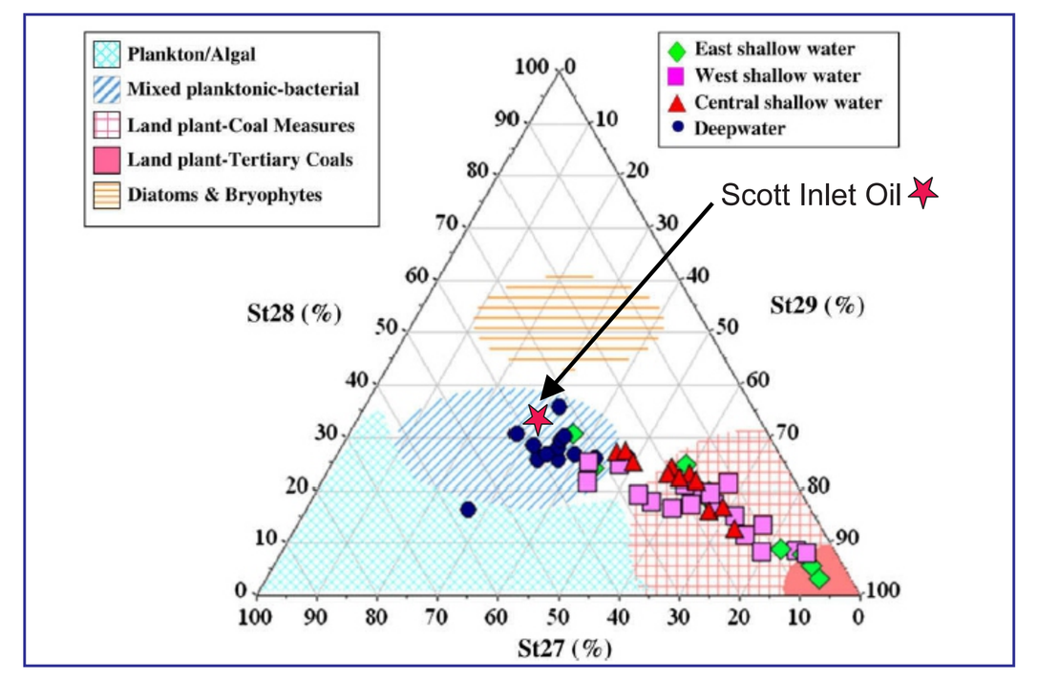


Fig 21. Scott Inlet oil superimposed on ternary diagram by Samuel et al. (2009) showing the plot of C27, C28, and C29 steranes from the Niger Delta. Interpretational overlay from IGI software based on worldwide known crude oils and source rock sterane data. Overlays modified after Huang and Meinshein (1979).

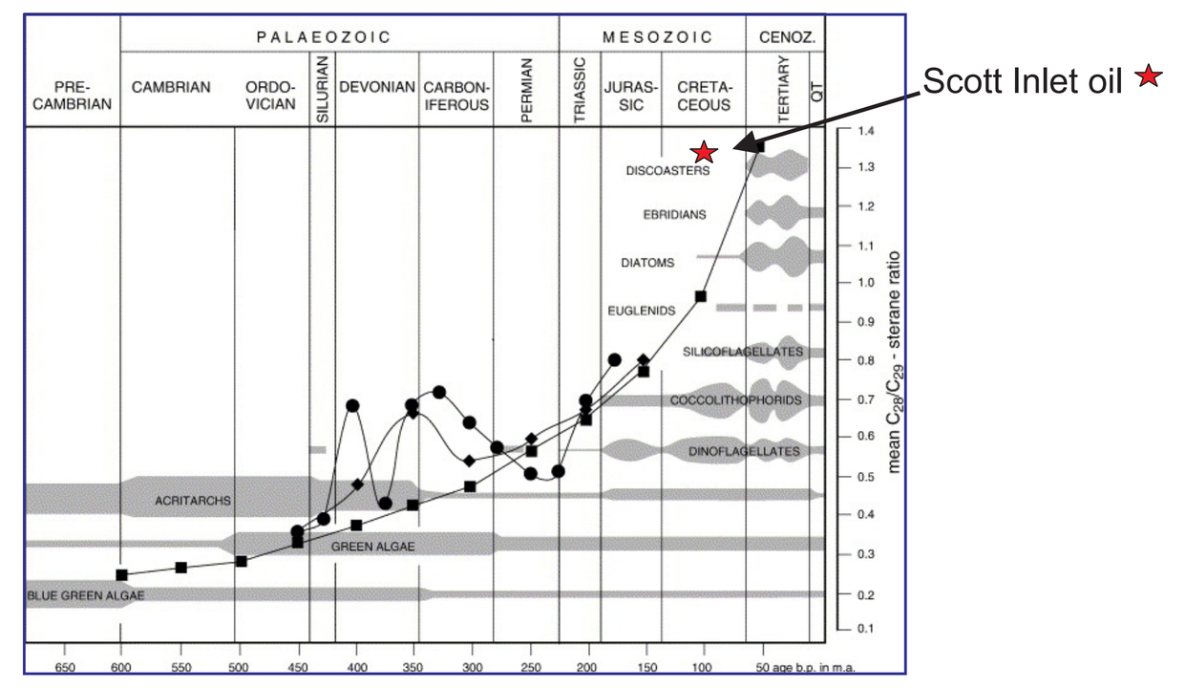


Fig 22. Scott Inlet oil superimposed on C28/C29-sterane ratio by Schwark and Empt (2006). The Scott Inlet oil falls approximately on the Late Cretaceous part of the curve.

6. Recent geological mapping on Bylot Island provides clues to the stratigraphy of Scott Inlet basin. Oldest strata there are Albian to possibly Turonian coarse sands with coal, suggesting correlation with the Hassel Formation of the western Arctic. Younger strata contain floral and molluscan assemblages indicative of Coniacian, Santonian, Campanian(?), Maastrichtian, early(?) Paleocene, and late Paleocene ages, correlative with hydrocarbon-bearing sequences on the West Greenland shelf. A thick (500 m), coarse-grained sandstone widespread on Bylot Island grades laterally into deep marine mudstone (Fig 24) and may be a possible coeval equivalent for a Scott Inlet basin reservoir rock.

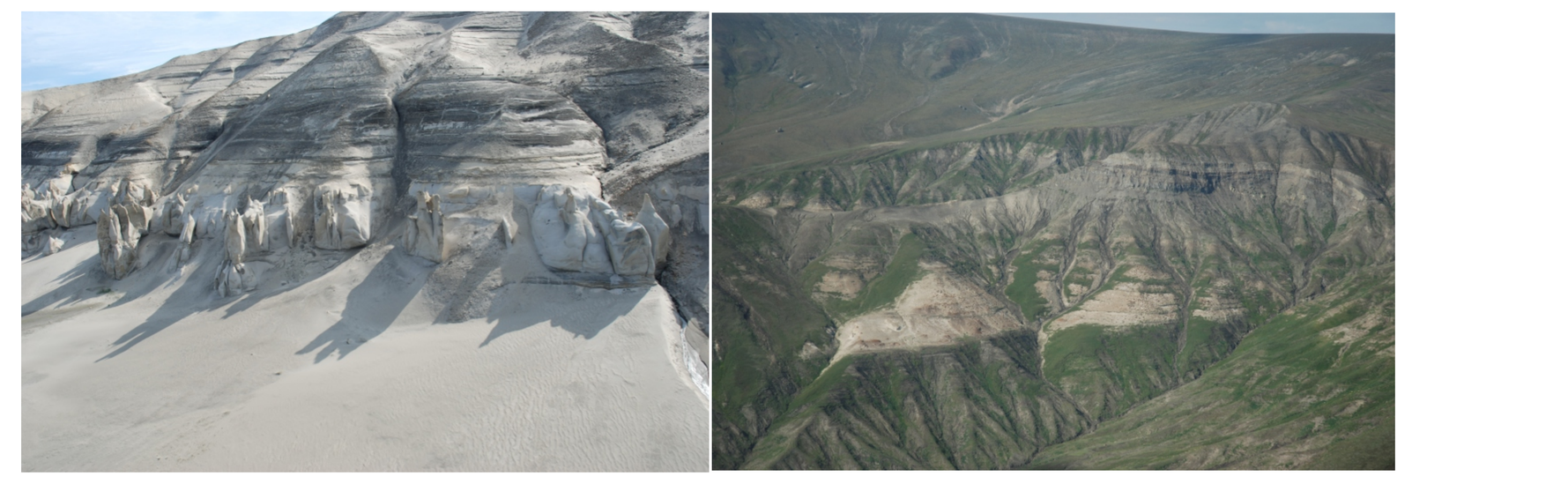


Fig 24. Thick sandstones on Bylot Island grade laterally into mudstone facies and may form hydrocarbon reservoirs.

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[1]Geological Survey of Canada, 1 Challenger Drive, Dartmouth, Nova Scotia B2Y 4A2
[2]Canada Centre for Remote Sensing, 588 Booth Street, Ottawa, Ontario K1A 0Y7
[3]Talisman Energy Inc., 888-3rd Street SW, Calgary, Alberta T2P 5C5
[4]Geological Survey of Canada, 3303-33rd Street NW, Calgary, Alberta T2L 2A7
[5]Geological Survey of Canada, 605 Robson Street, Vancouver, British Columbia V6B 5J3

For more information, please contact J.W. Haggart (Jim.Haggart@NRCan.RNCan.gc.ca).

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