Submarine-Cemented Pennsylvanian to Early Permian Waulsortian and Palaeoaplysinid Reefs in the Canadian Arctic*

Graham R. Davies[1]

Search and Discovery Article #51383 (2017)**
Posted June 12, 2017

*Adapted from oral presentation given at AAPG 2017 Annual Convention and Exhibition, Houston, Texas, United States, April 2-5, 2017

[1]Graham Davies Geological Consultants (GDGC) Ltd., Calgary, Alberta, Canada (gdgc@gdgc.com)

Abstract

In memory of Lloyd Pray, an external examiner for my Shark Bay doctoral thesis, and one of my 'carbonate heros' in the late 60s and 70s. Pennsylvanian (Late Carboniferous) 'Waulsortian' reefs and Pennsylvanian to Early Permian palaeoaplysinid reefs and mounds on Ellesmere Island in the Canadian Arctic Archipelago were examined by the author and associate Walter Nassichuk in the 1971 to 1974 field seasons, with some locations less than 1000 km from the north geographic pole. Palaeoaplysinid reefs also occur on Axel Heiberg Island, and collectively are similar to productive reefs in the Urals of Russia. The reef-builder *Palaeoaplysina* now is placed with the coralline red algae. 'Waulsortian' reefs on the Arctic islands are younger than classic Waulsortian buildups, but appear to be identical in composition and fabric. Many of the Arctic buildup occur in mid-shelf positions. The influence of internal waves/internal tides on reef localization must be considered. Both Arctic reef types are characterized by often spectacular submarine cements, including former isopachous Mg-calcite cements and botryoidal aragonite. Neptunian dikes/fractures in some Waulsortian reefs are lined by thick, multi-event submarine cements with microbial textures that are continuous with cements in reef cavities cut by the fractures. Very limited weathering under arid Arctic climatic conditions, and 'glacial polishing' of whole reef sections, provide extraordinary exposures in a logistically difficult setting - Lloyd would have loved it!

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Submarine-cemented Pennsylvanian to Early Permian Waulsortian & Palaeoaplysinid Reefs

in the Canadian Arctic

by

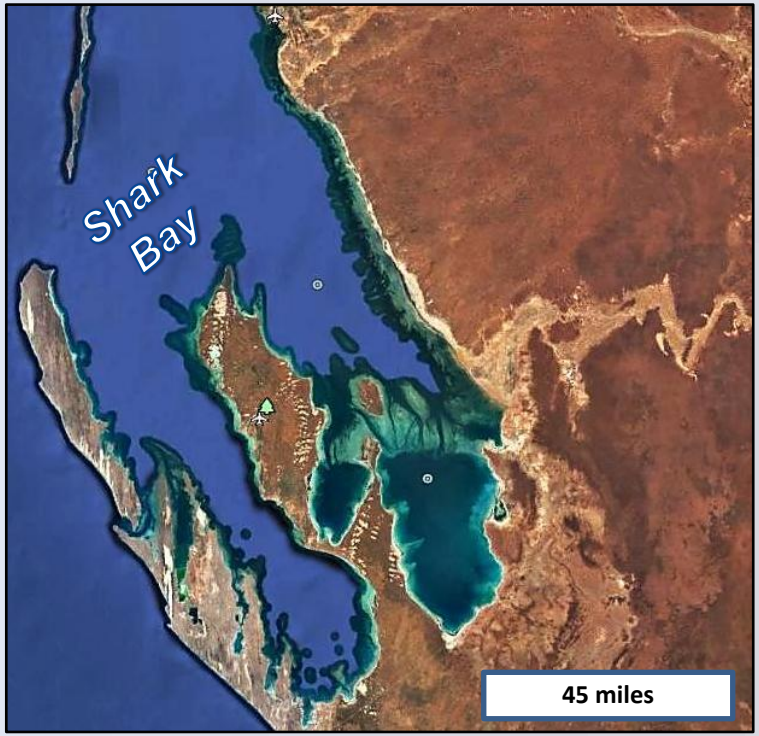
Graham R. Davies

GDGC Ltd., Calgary

Hare Fiord, Ellesmere Island : view east; mid-point 615 miles from geographic North Pole.

100 AAPG ANNIVERSARY
ACE 2017
ANNUAL CONVENTION & EXHIBITION
2-5 April 2017
Houston, TX
George R. Brown Convention Center

In Memory of Lloyd Pray



Shark Bay, Western Australia
*Ph.D. Thesis – published as AAPG Memoir *13*

One of my 'carbonate heros'

External examiners for Ph.D.* : *ca.* 1967
***(University of Western Australia)**

- **Lloyd Pray!**
- **Robin Bathurst (Dec. 2006)**
- **Richard Rezak (Dec. 2006)**

But supposed to be confidential – how did I find out?

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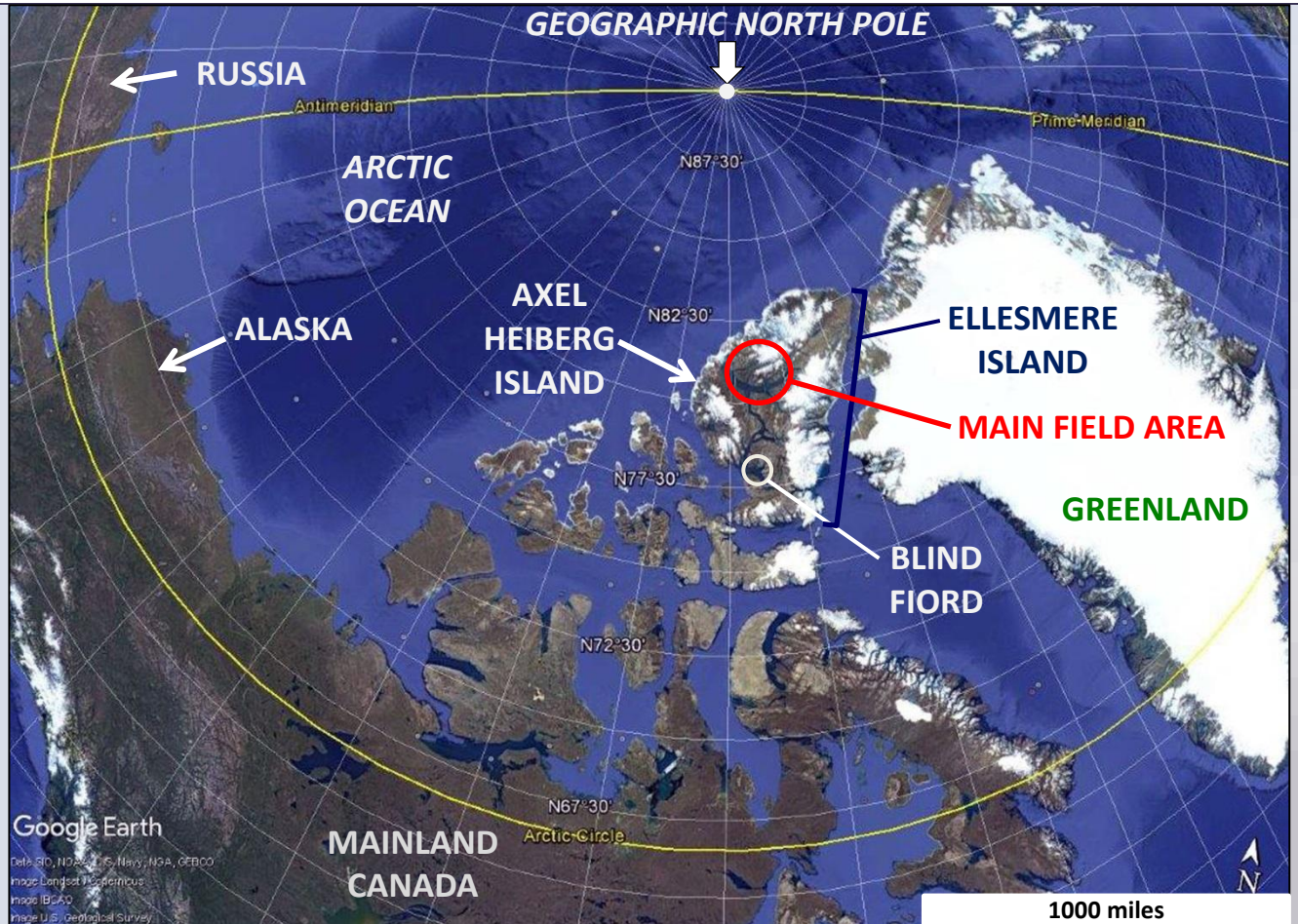
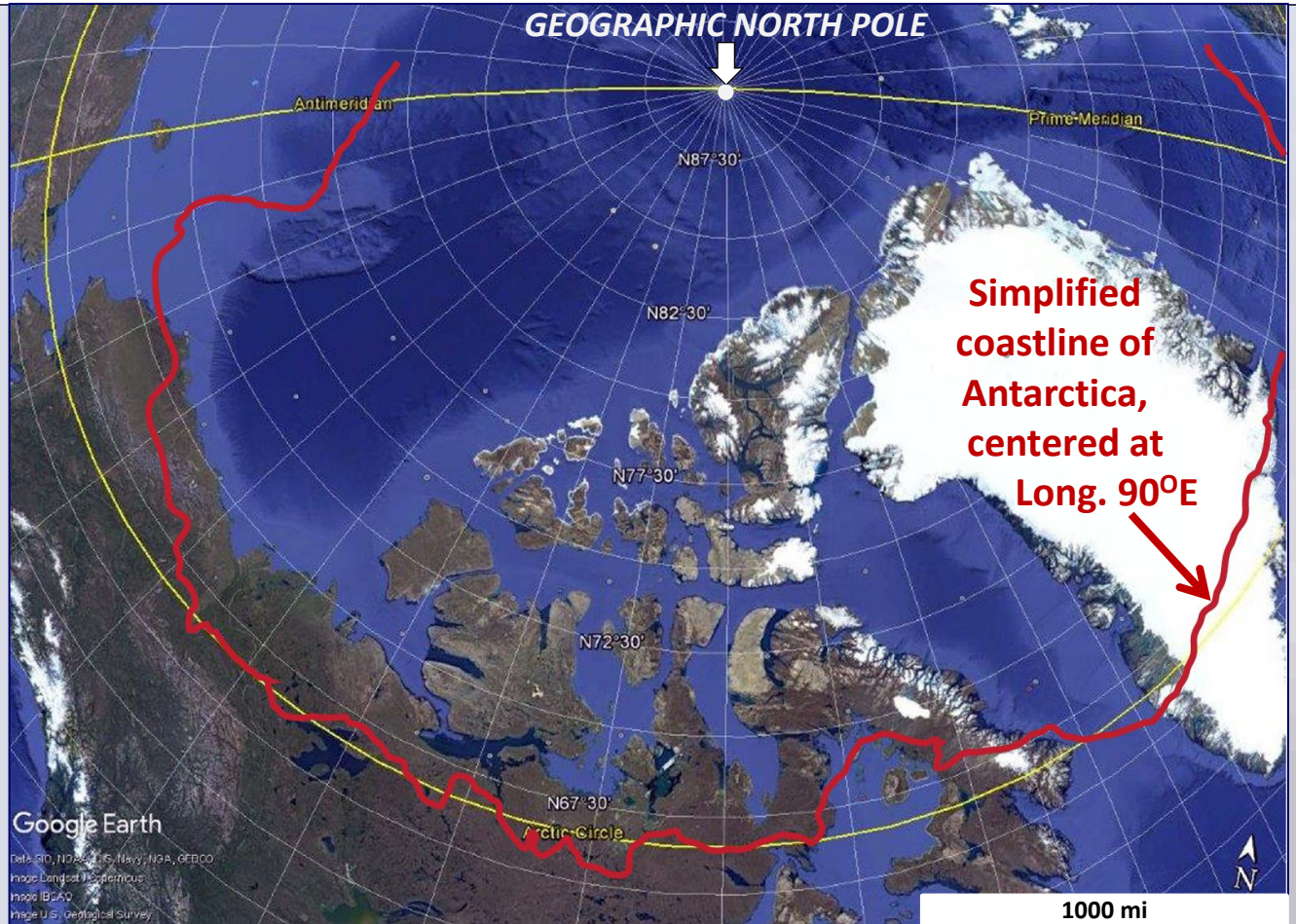
The Canadian Arctic Archipelago

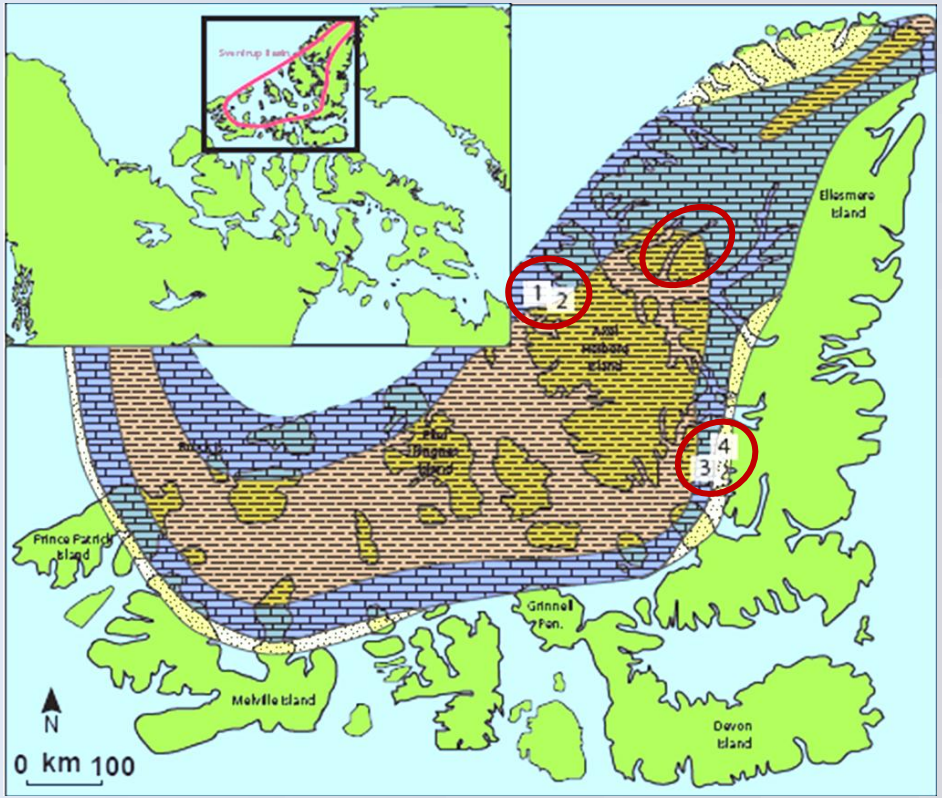


The Canadian Arctic Archipelago

with Antarctica overlay



Sverdrup Basin, Arctic Archipelago



From Embry & Beauchamp (2008), courtesy Kaylee Anderson, 2017

PENNSYLVANIAN – EARLY PERMIAN FACIES TRENDS:
RIFT PHASE

MAJOR CLUSTERS OF WAULSORTIAN, PALAEOAPLYSINID BUILDUPS

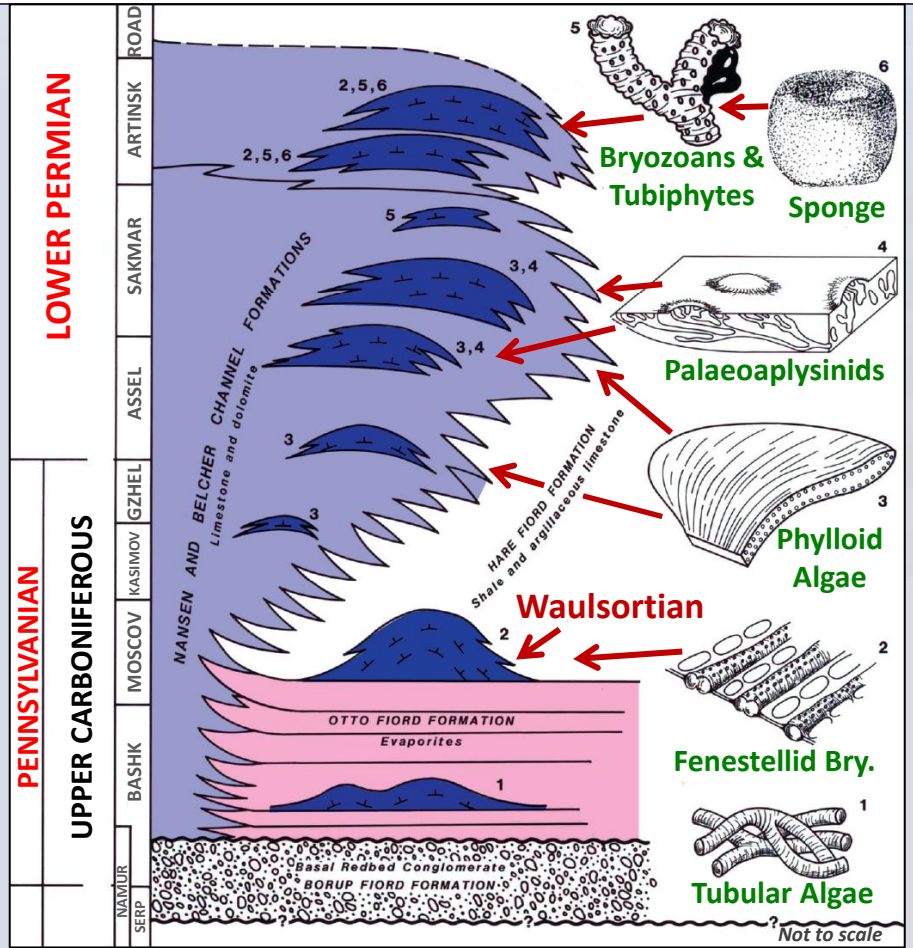
CARBONATE
(shallow shelf)

SANDSTONE
(shallow subtidal)

MUDROCK
(slope & deep basin)

OVER BASIN-CENTRE EVAPORITES, INCLUDING DIAPIRIC HALITE

Pennsylvanian to Lower Permian Reefs,
Canadian Arctic Archipelago



Most with former Mg-calcite and aragonite submarine cements :

- Davies, 1977, *Geology*, summary
- Davies & Nassichuk, 1990, GSC Bulletin

From Davies & Nassichuk (1986, 1988)

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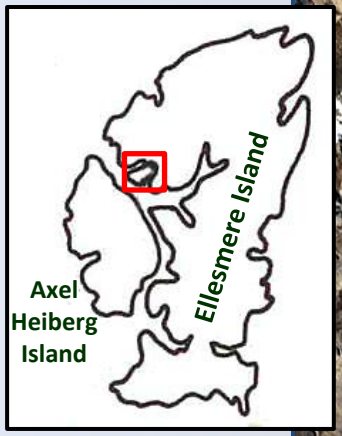
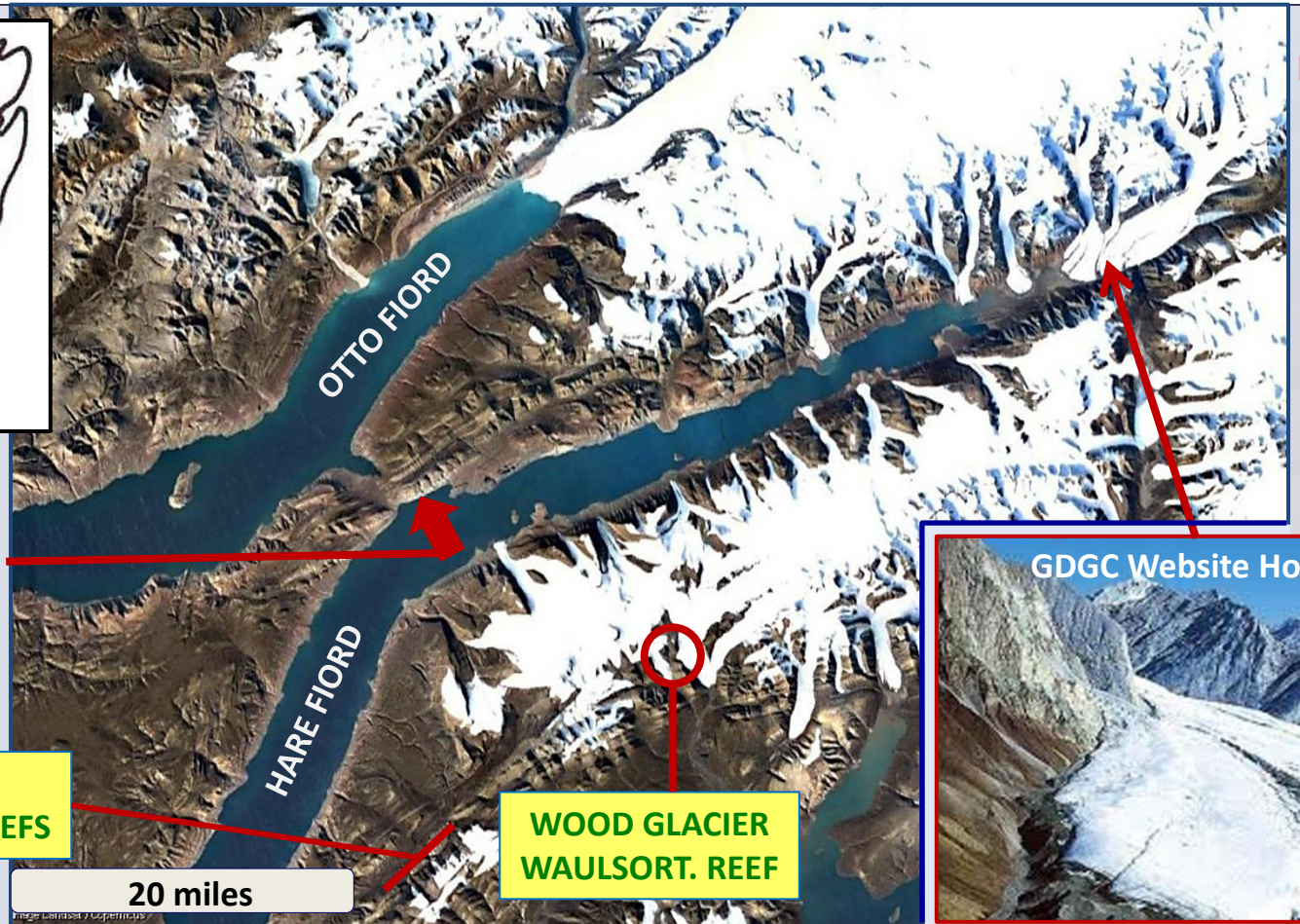
North-central Ellesmere Island





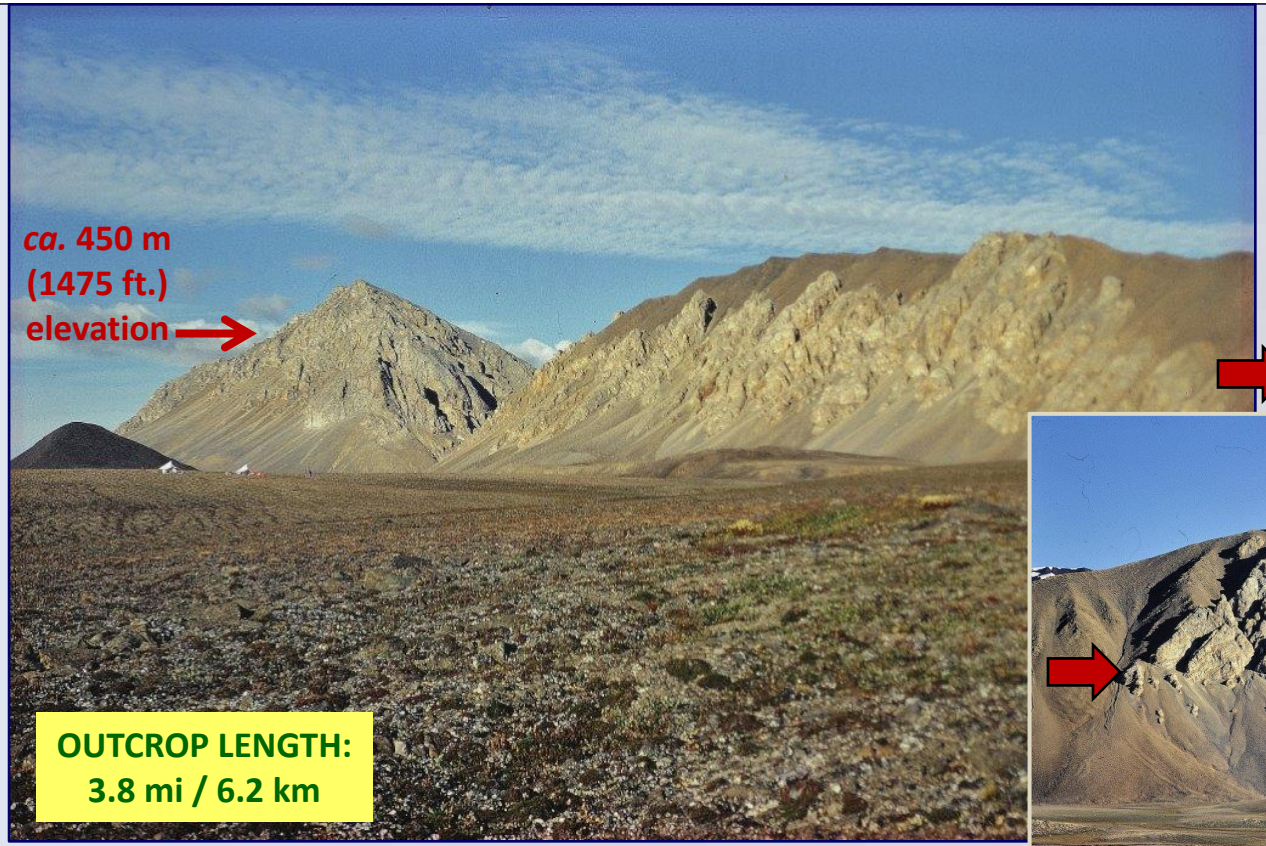
FIELD SEASONS: 1971-1974 (July only)

PENNSYLVANIAN OTTO FIORD 'ALGAL' MOUNDS

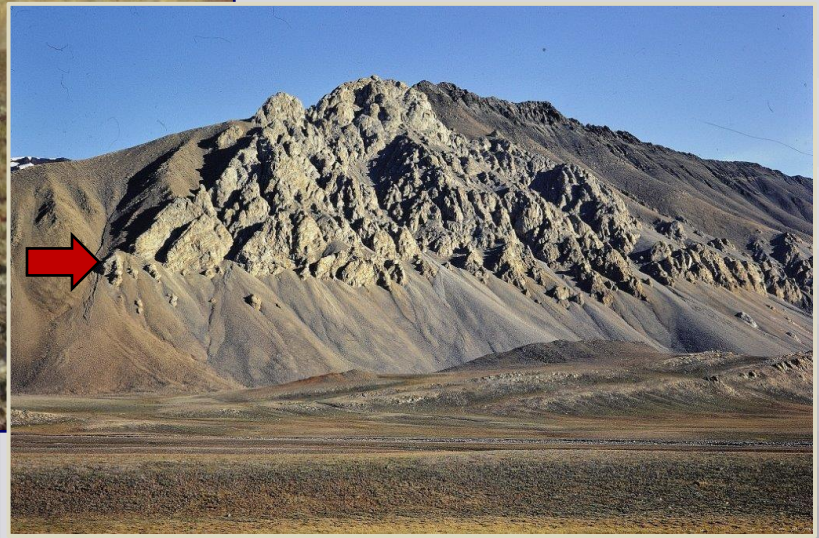
BLUE MTN WAULSORT. REEFS

WOOD GLACIER WAULSORT. REEF

Pennsylvanian Waulsortian Reefs,
Blue Mountains, Ellesmere Island

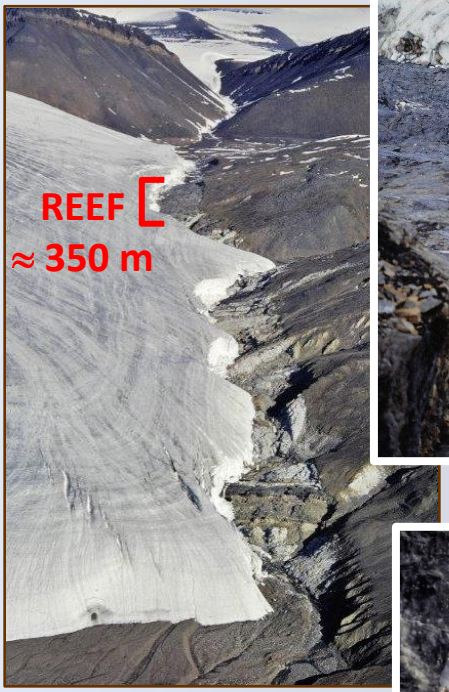


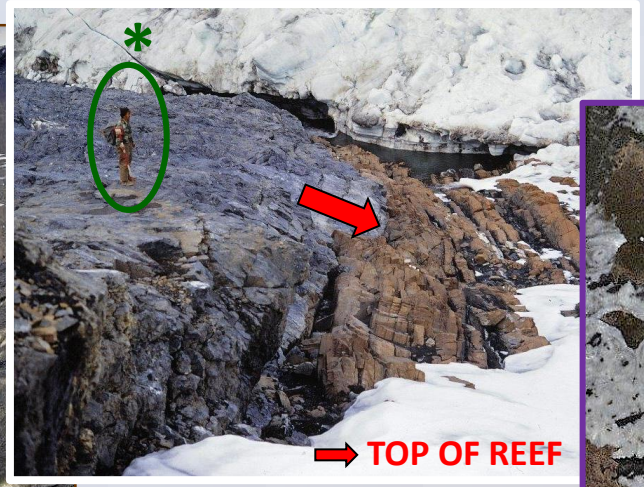
THRUST FAULT AT BASE



OVERLYING ANHYDRITE EVAPORITES OF PENNSYLVANIAN OTTO FIORD FM, BURIED BY HARE FIORD 'SHALES'

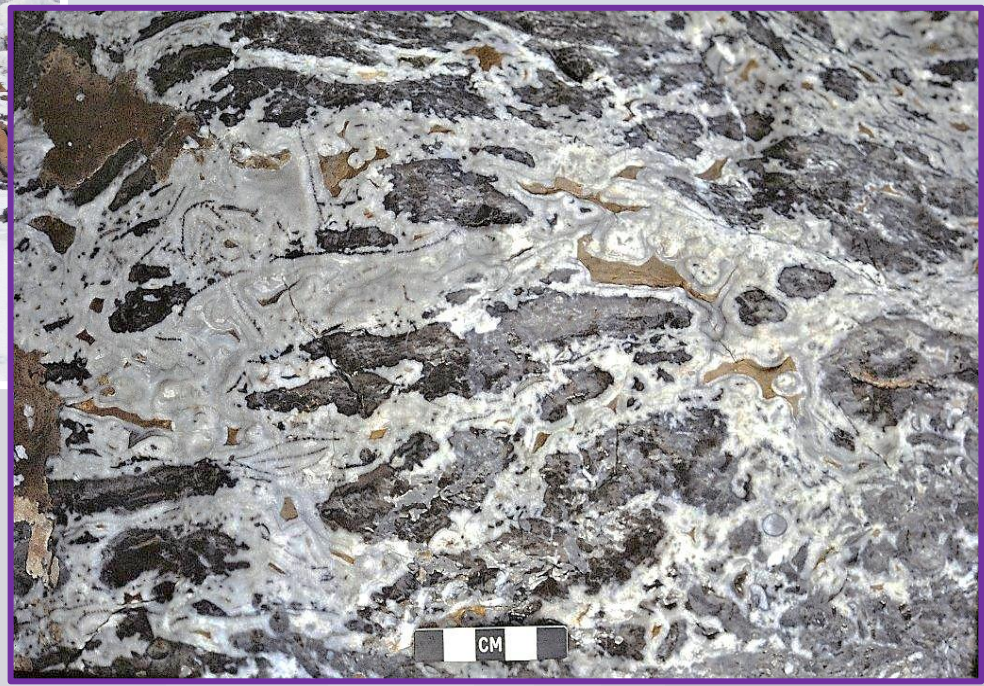
Glacially–Polished Waulsortian Reef,
Wood Glacier, Ellesmere Island





* Walter Nassichuk
(later, Director,
GSC Calgary)

> 70% submarine cement

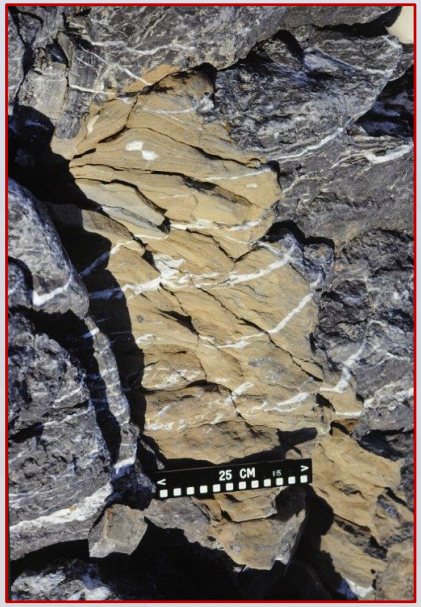


GLACIALLY-POLISHED SURFACE

‘Neptunian’ Fractures w/ Sediment Infill, Submarine Rim Cements

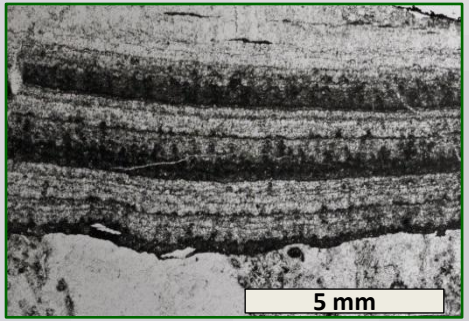
Waulsortian Reefs, Ellesmere Island

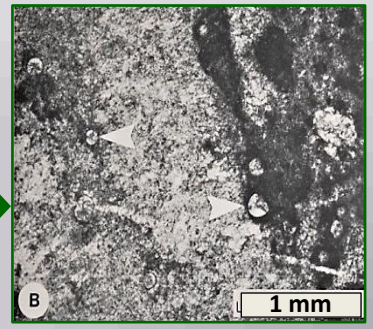
BLUE MTNS



WOOD GLACIER

microbial fracture-lining cements →

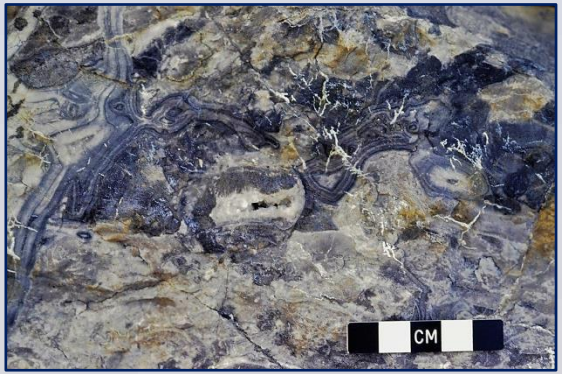


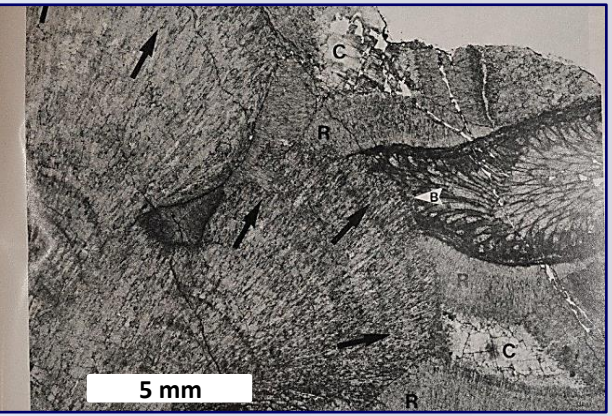


Calcite Arrays After Botryoidal Aragonite

Waulsortian Reefs, Ellesmere Island

7480 ± 1240 ppm Sr to 10,700 ppm (microprobe)
7800, 8300 ppm Sr (atomic absorption spectroscopy)





replacive aragonite arrays, now calcite

Holocene analogs: botryoidal aragonite in Belize reef cavities (courtesy Noel James). Image width : 6 cm

Palaeoaplysinid – Phylloid Algal Buildups

Arctic Archipelago

West Blind Fiord, Ellesmere Island
(courtesy B. Beauchamp)

Outcrop, Ellesmere Island

phylloid algae

*Palaeoaplysina**

Polished block, Ellesmere Is., w/ ponded sediments, submarine cements

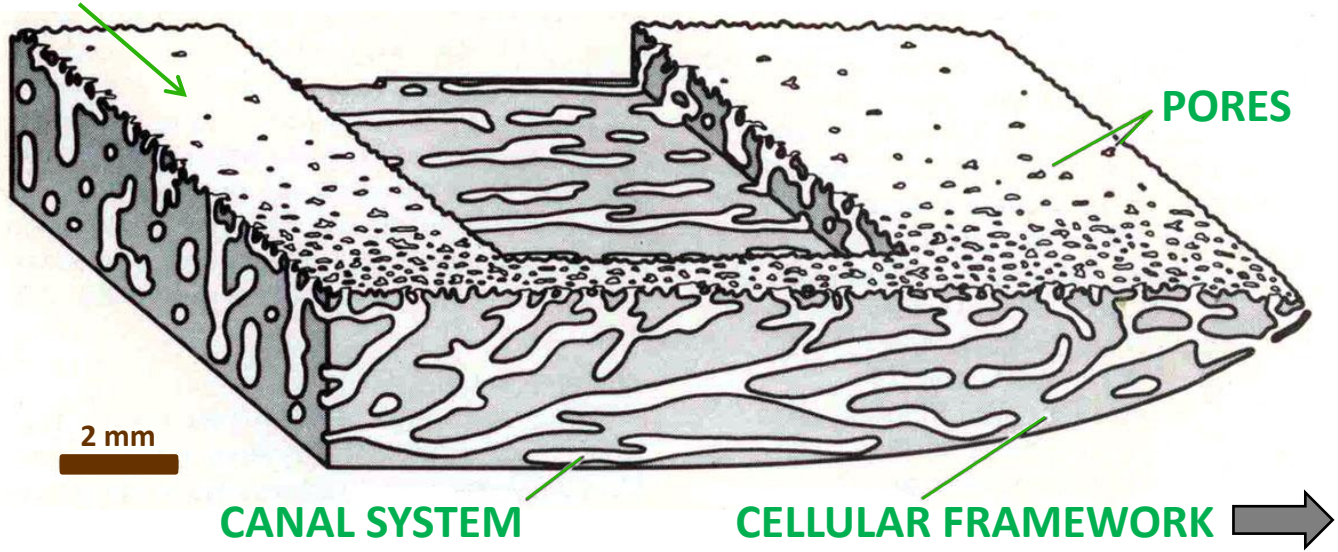
Anderson and Beauchamp, 2014: *aragonitic red alga (*Eopalaeoaplysina daviesi* ng/ns)

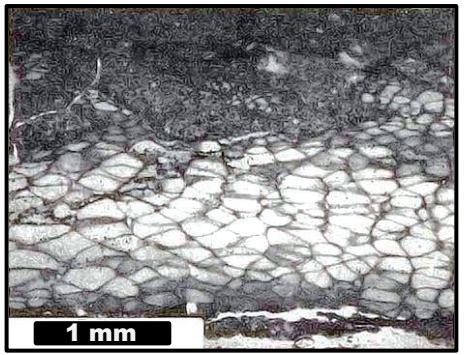
Palaeoaplysina sp.

‘CANAL’ MORPHOLOGY BASED ON SERIAL HORIZONTAL AND VERTICAL THIN-SECTIONS :

Davies, 1971 (L. Permian, Yukon)

‘MAMELONS’
(not shown)

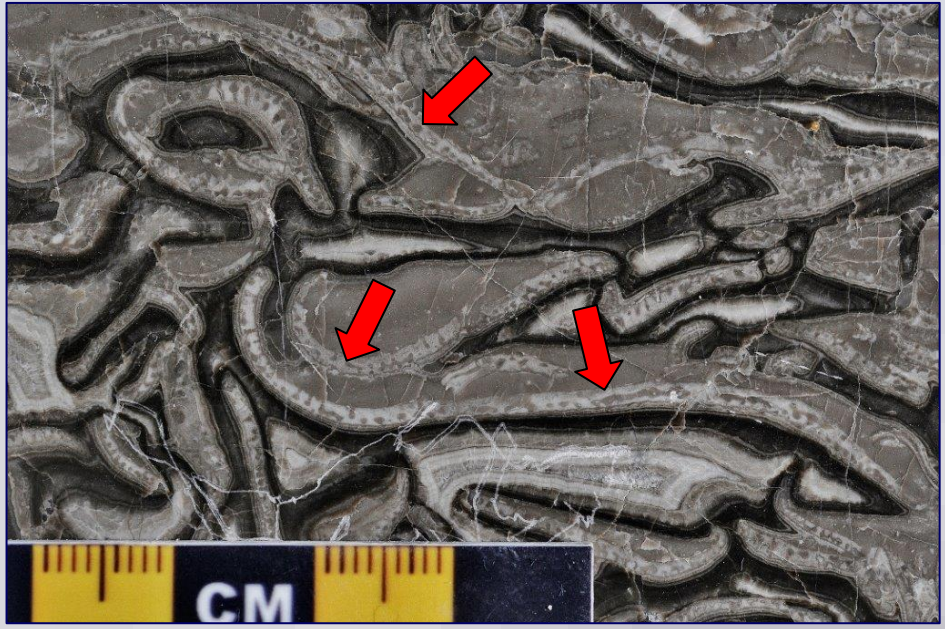




LATEST TAXONOMIC CLASSIFICATION (Anderson & Beauchamp, 2014) :
aragonitic red algae (Class Rhodophyceae, Order Archaeolithophyllales)

Eopaleoaplysina *daviesi* ng/sp

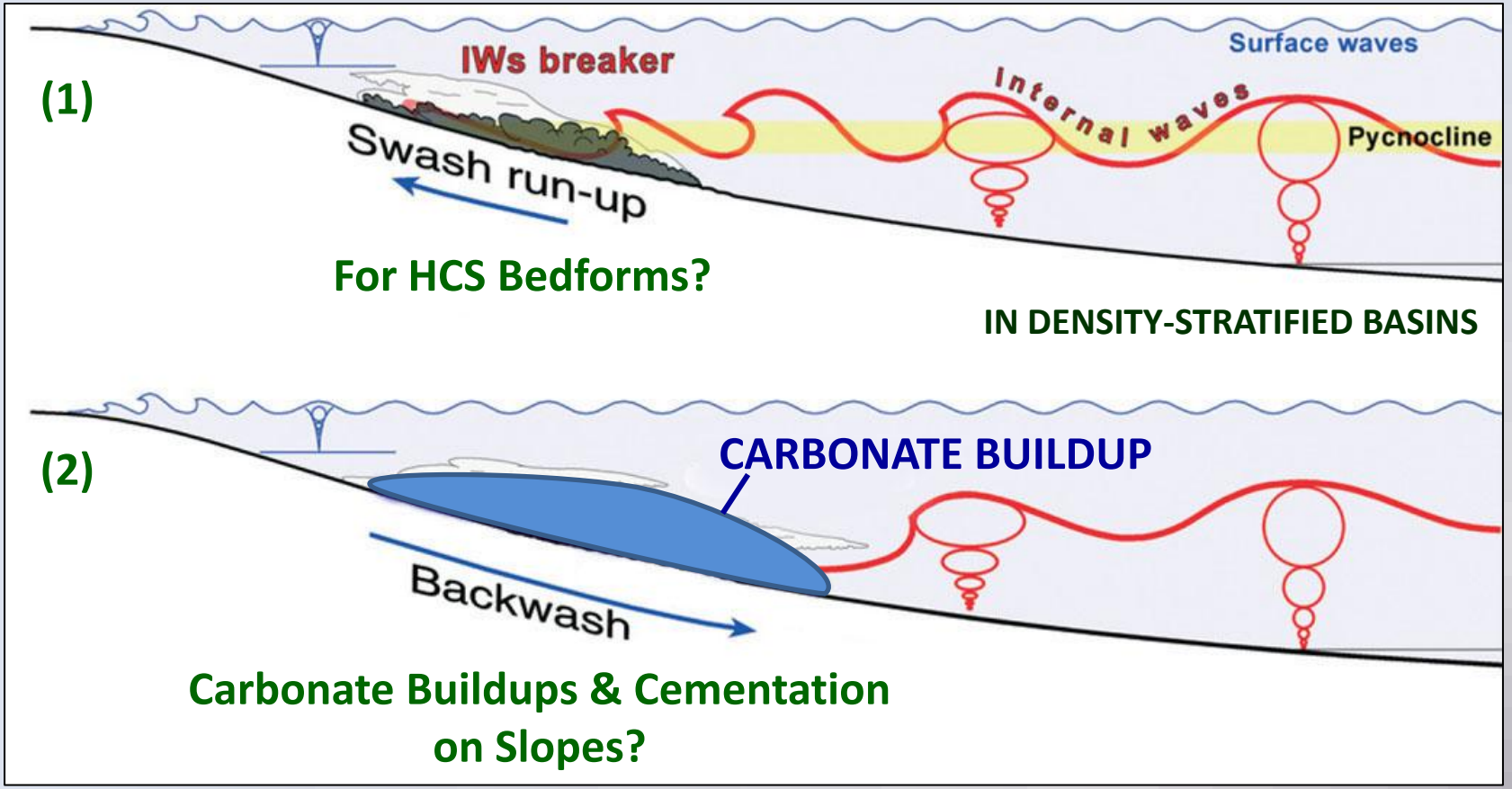
with ponded sediments, submarine cements



mid Pennsylvanian, Ellesmere, Axel Heiberg Islands

Anderson and Beauchamp, 2014

Internal Wave/Tide Localization of Carbonate Buildups & Marine Cementation on Slopes?



Modified from Morsilli and Pomar (2012)

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Exploration Significance (not exhaustive)

- **Sverdrup Basin, all buildup types:**
  - **none drilled**
- **Productive Palaeoaplysinid-algal buildups:**

  Volga-Ural, Timan-Pechora Basins, Russia

  Barents Sea, offshore Norway?
- **Productive Waulsortian or related buildups:**

  Western Canada, US- many states

Lloyd : Thank You For The Inspiration!