REVISITING THE EARLY DEVONIAN REEF KNOLLS OF LOWTHER ISLAND, NUNAVUT TERRITORY, ARCTIC CANADA: A RETROSPECTIVE ON THE RESEARCH OF ERIC C. PROSH

By

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Presentation Time: 5:10 PM

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BAILEY, Jack Bowman, Department of Geology, Western Illinois University, 1 University Circle, Macomb, IL 61455 and PROSH, Eric Charles, (deceased), Minerals and Petroleum Resources Division, Department of Economic Development and Transportation, Iqaluit, NU X0A 0H0, Canada, JB-Bailey@wiu.edu

Eric Charles Prosh (1957–2013) was a respected Canadian paleontologist and geologist well known for his many years of service to the government of Nunavut in the fields of mineral exploration and mining. Less widely known is his still mostly unpublished Ph.D. research on the Early Devonian reef knolls of the Disappointment Bay Formation on Lowther Island, 80 km SW of Resolute, Cornwallis Island. Because of the relative inaccessibility of the area and because Early Devonian reefs are globally uncommon, the results of his 1982–1984 field investigations of Lowther and Young Islands are of especial significance and worthy of further attention.

During the Early Emsian, Lowther Island was part of a protected, tropical marine, shallow-shelf embayment receiving limited input of clastic sediments from arid lands nearby. A deepening ocean basin lay toward Young Island, some 35 km to the southwest where the Disappointment Bay Formation consists only of a few meters of grey-black calcareous mudstone containing the chemoautotrophic solemyid bivalve, *Acharax*.

On Lowther Island the Disappointment Bay consists of upward shoaling limestones and dolomites up to 90 m thick, the upper 50 m of which crop out as exhumed reef knolls. Lying disconformably above a sequence of redbeds, the Disappointment Bay preserves a vertical succession of carbonate facies representing the growth and senescence in of a reef knoll complex in response to passive sedimentary shoaling. Nucleating on brachiopod aggregations, the vertical facies succession is as follows: F1) a basal stromatactis-rich dark mudstone-to-wackestone (~5 m); F2) an algally bound wackestone (20-30 m) with a lateral subfacies consisting of steeply dipping beds of reef-marginal, bioclastic, spill-over debris; F3) a dolomitic, stromatoporoid-tabulate coral framestone-to-rudstone (10-15 m); and F4) dolomitized crinoidal grainstone (<5m). Dolomitization, confined to F4 and the upper part of F3, is of the burial stage, partially penetrative type, affecting the reef peripheries but not their cores.

In addition to calcareous algae, stromatoporoids and tabulate corals, portions of the reef succession contain diverse shelly faunas, mostly of Old World paleobiogeographic affinities, dominated notably by brachiopods (32 species) and gastropods (30+ species).

Session No. 12

T2. Reefs and Shallow Seas: Advances in High-Resolution Stratigraphy and Paleontology in Silurian-Ordovician Rocks of North America
Monday, 18 April 2016: 1:30 PM-5:30 PM
Illinois Ballroom C (I Hotel and Conference Center)
Geological Society of America *Abstracts with Programs*. Vol. 48, No. 5
doi: 10.1130/abs/2016NC-275422

Note corrections (highlighted in yellow)

Purpose

- Give homage to Eric Charles Prosh (dec'd.), his career and contributions to Canadian geoscience.
- Promote awareness and renewed interest of his mostly unpublished 1980's field studies of the Early Devonian reef knolls of Lowther Island, Nunavut Territory, Canada.
- Comment on my own connection to Eric and his research.

Eric Prosh

ERIC CHARLES PROSH (1957–2013)

Canadian paleontologist, geologist
and civil servant

- Ph.D., University of Western Ontario, 1989
- Post-doctorate study, McGill Univ.
- Geologist, Geological Survey of Canada.
- Geologist, Spectral International, Inc., Arvada, CO
- Director of Minerals and Petroleum Resources, Department of Economic Development and Transportation, Nunavut, Canada (2006–2013)

Eric Prosh

From: *Northern Mining News*, 6(8): Aug., 2013

2015 presentation, Annual Eric Prosh Memorial Government/Organization Award (for resource development and management) to Hamlet of Arviat (Nunavut Mining Symposium, Apr 4–7, 2016)

Eric Charles Prosh: Research Highlights:

- PROSH, E. C. 1987. A Lower Devonian ammonoid, *Mimagoniatites nearcticus* n. sp. from the Canadian Arctic. *Journal of Paleontology*, 61(5): 974–981.

- PROSH, E. C, K. A. LESACK, and U. MAYR. 1988. Devonian stratigraphy of northwestern Devon Island, District of Franklin. Current Research. Part D. Geological Survey of Canada, Paper 88-ID:1-10.

→ • PROSH, E. C. 1989. A Lower Devonian Reef Sequence and Fauna, Disappointment Bay Formation, Canadian Arctic Islands. *(Unpublished Ph.D. dissertation, University of Western Ontario.)*

- BAILEY, J. B. and PROSH. 1990. The oldest solemyas: An occurrence of a new submodern species of *Solemya* Lamarck in the Lower Devonian of Arctic Canada. Abstracts with Programs, 24th Annual Meeting of the North-Central Section of the Geological Society of America, April 26-27, Macomb, IL

- PROSH, E. C. 1990. Lower Devonian reefs, Disappointment Bay Formation, Arctic Islands. Abstracts and Program, 1990 Canadian Society of Petroleum Geologists Convention, May 27–30, 1990, Calgary. *Bulletin of Canadian Petroleum Geologists*, 38(1):177.

- PROSH, E. C., and C. W. STEARN. 1993. Early Devonian age of the Detroit River Group, inferred from Arctic stromatoporoids. *Canadian Journal of Earth Sciences*, 30: 2465-2474.

- PROSH, E. C., and C. W. STEARN. 1996. Stromatoporoids from the Lower Devonian (Emsian) of Arctic Canada. *Bulletins of American Paleontology*, 109(349):1–66.

My interest: The clam connection!

My research specialties include Devonian and Carboniferous bivalves. Examples:

- BAILEY, J. B. 1983. Middle Devonian Bivalvia from the Solsville Member (Marcellus Formation), Central New York State. Bulletin of the American Museum of Natural History, 173(3):193–326.

- BAILEY, J. B. 2011. Paleobiology, paleoecology, and systematics of Solemyidae (Mollusca: Bivalvia: Protobranchia) from the Mazon Creek Lagerstätte, Pennsylvanian of Illinois. Bulletins of American Paleontology, 382:1–74.

Bailey/Prosh collaboration began in the late 1980's.

- BAILEY, J. B. & E. C. PROSH. 1990. The oldest solemyas: An occurrence of a new submodern species of *Solemya* Lamarck in the Lower Devonian of Arctic Canada. Abstracts with Programs, 24th Annual Meeting of the North-Central Section of the Geological Society of America, April 26-27, Macomb, IL

Coming Soon!!

- **BAILEY, J. B. and E.C. PROSH *(in preparation)*. New Bivalvia (Mollusca) from the Lower Devonian (Emsian) Disappointment Bay Formation, Young and Lowther Islands, Nunavut Territory, Canada.**

Getting Oriented:

Map of Nunavut Territory, Canada

Flag of Nunavut

Iqaluit,
capital of
Nunavut,
Frobisher Bay,
Baffin Island

Population: 6,699

(Courtesy, Iqualiut Tourism)

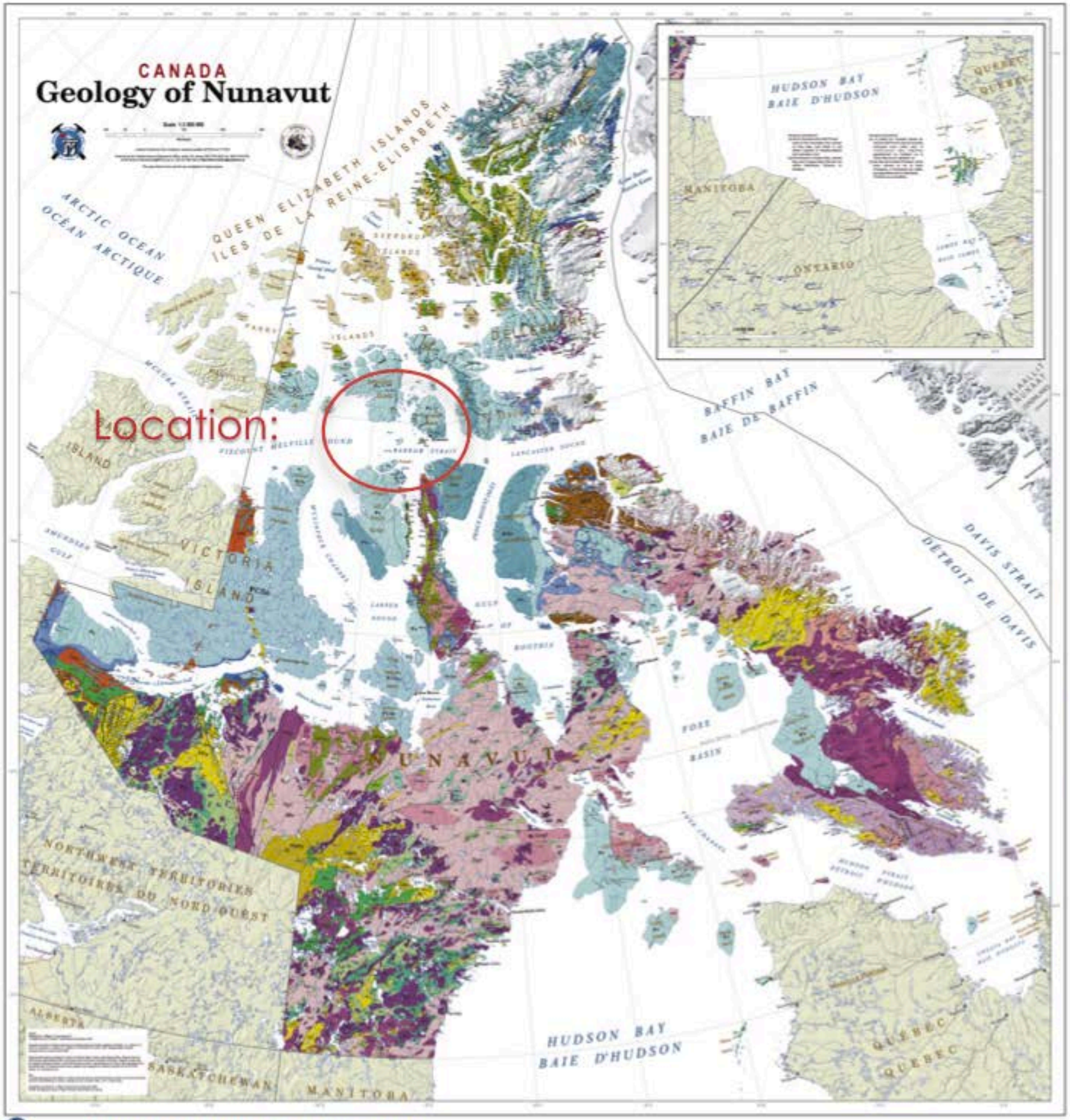
(Courtesy, Treks.org)

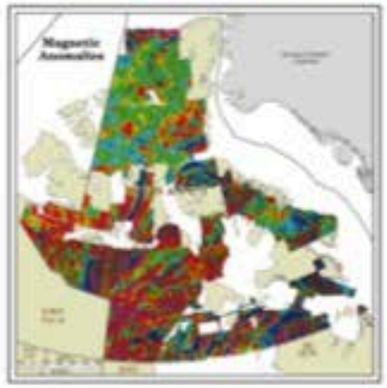
Frobisher Bay
(photo by Jean
Gaumond)

CANADA

Geology of Nunavut

Location:





(DeKamp, Gilbert & James, 2006)

Canada

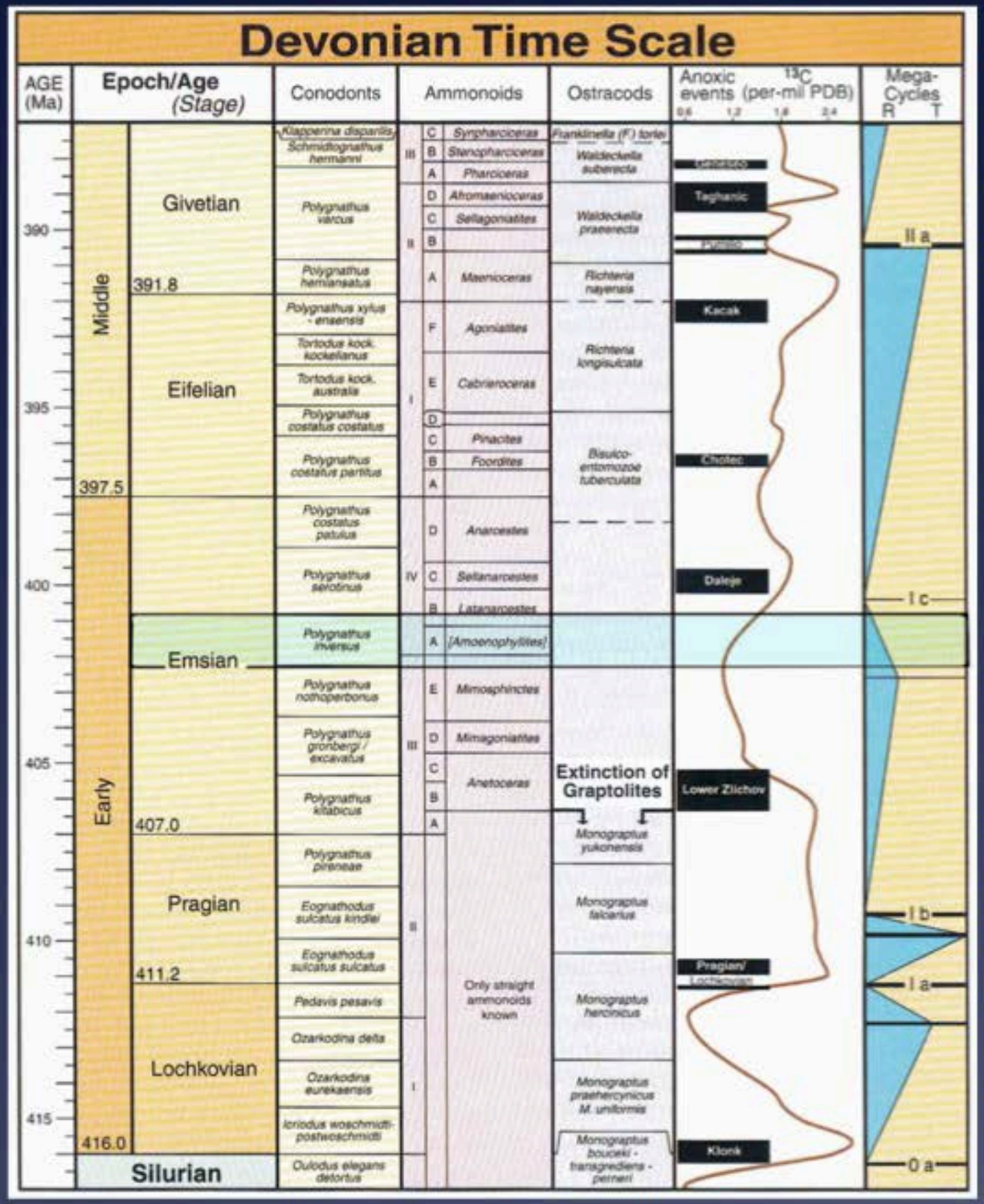
(DeKamp, Gilbert & James, 2006)

Resolute, Cornwallis Island: Base of Operations

(Population: 229)

(Courtesy, Parks Canada)


Bathurst Is.
Cornwallis Island
Resolute, NU
Lowther Island
Griffith Island
Barrow Strait
Young Island
0 10 20 30 40
km
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google earth



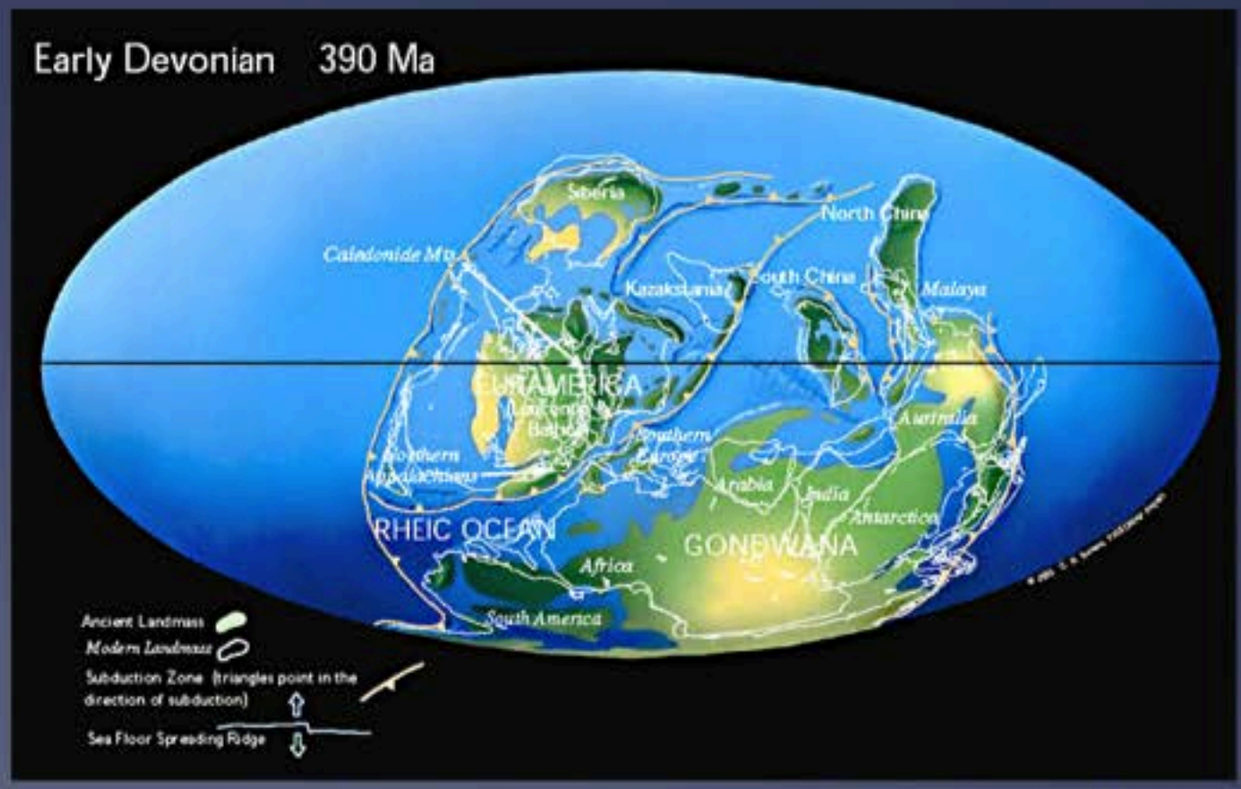
(From Ogg et al., 2008)

(OGG, J., G. OGG, & F. GRADSTEIN. 2008. The Concise Geologic Time Scale.Cambridge Univ. Press, 177 p.)

(RAASCH, G. O. 1982. Lower and Middle Devonian Faunal Zones in the Canadian Archipelago. Proc 3d Int'l Symp Arcic Geol Mem 8.)

Disappointment Bay Formation in time and space

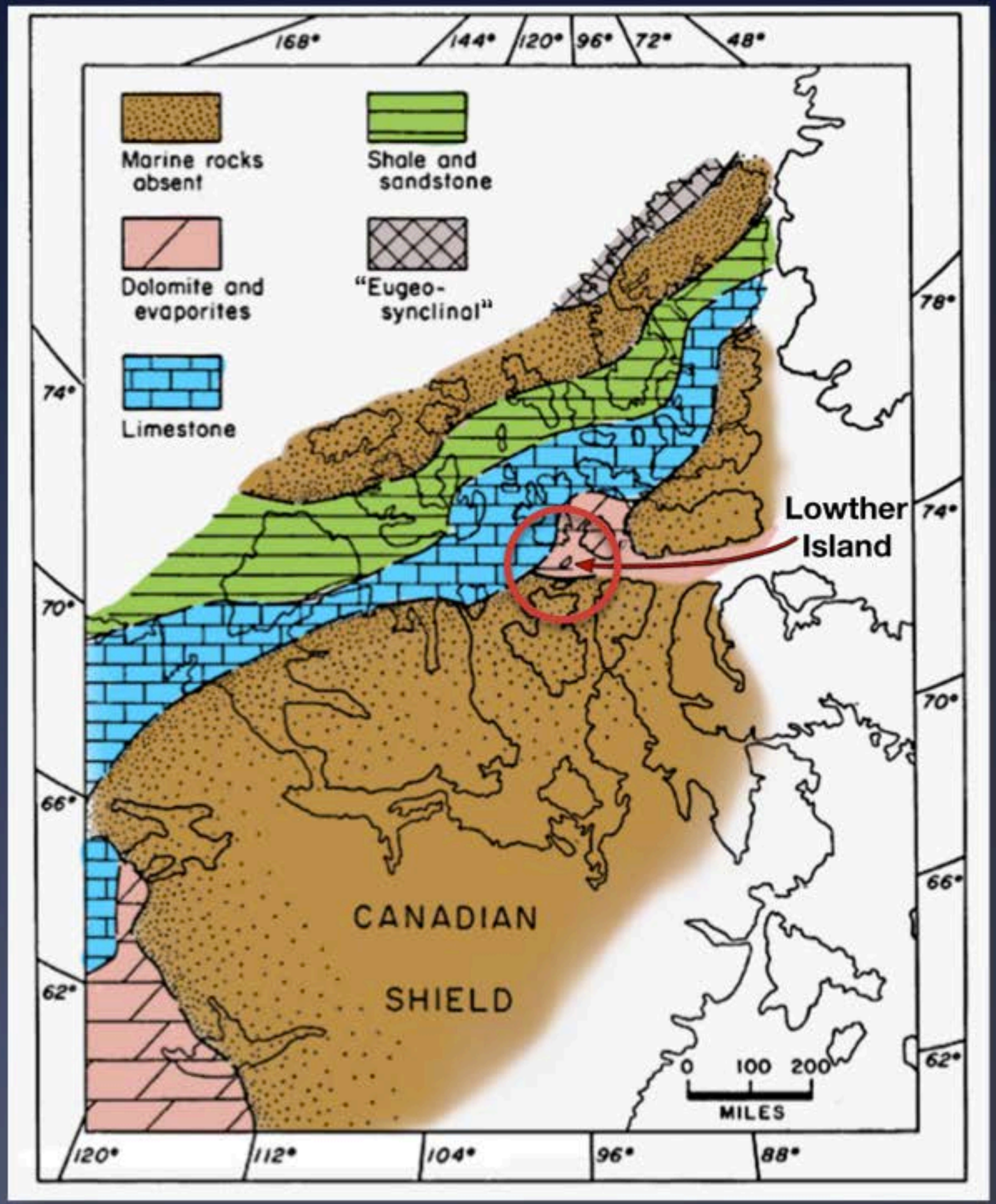
- *Polygnathus inversus* conodont biozone: Lower Devonian (Emsian)
- Brachiopod fauna (Johnson, 1975): Lower Devonian (Emsian)
- Lower and Middle Devonian Faunal Zone studies of Raasch (1982)
- Low paleolatitude (equatorial)
- Global sea level low. Reefs rare prior to a eustatic sea-level rise (Smith, 1985)



(SCOTESE, C. R. 2001. PALEOMAP Project)

Lower Devonian Lithofacies
(after Johnson, 1975)

- Reefs at Lowther located in a shallow shelf embayment near a tropical, arid shoreline, with deepening water to the southwest toward Young Island.



JOHNSON, J. C. 1975. Late Early Devonian Brachiopods from the Disappointment Bay Formation, Lowther Island,Arctic Canada. *Journal of Paleontology*, 49(6):947–978.

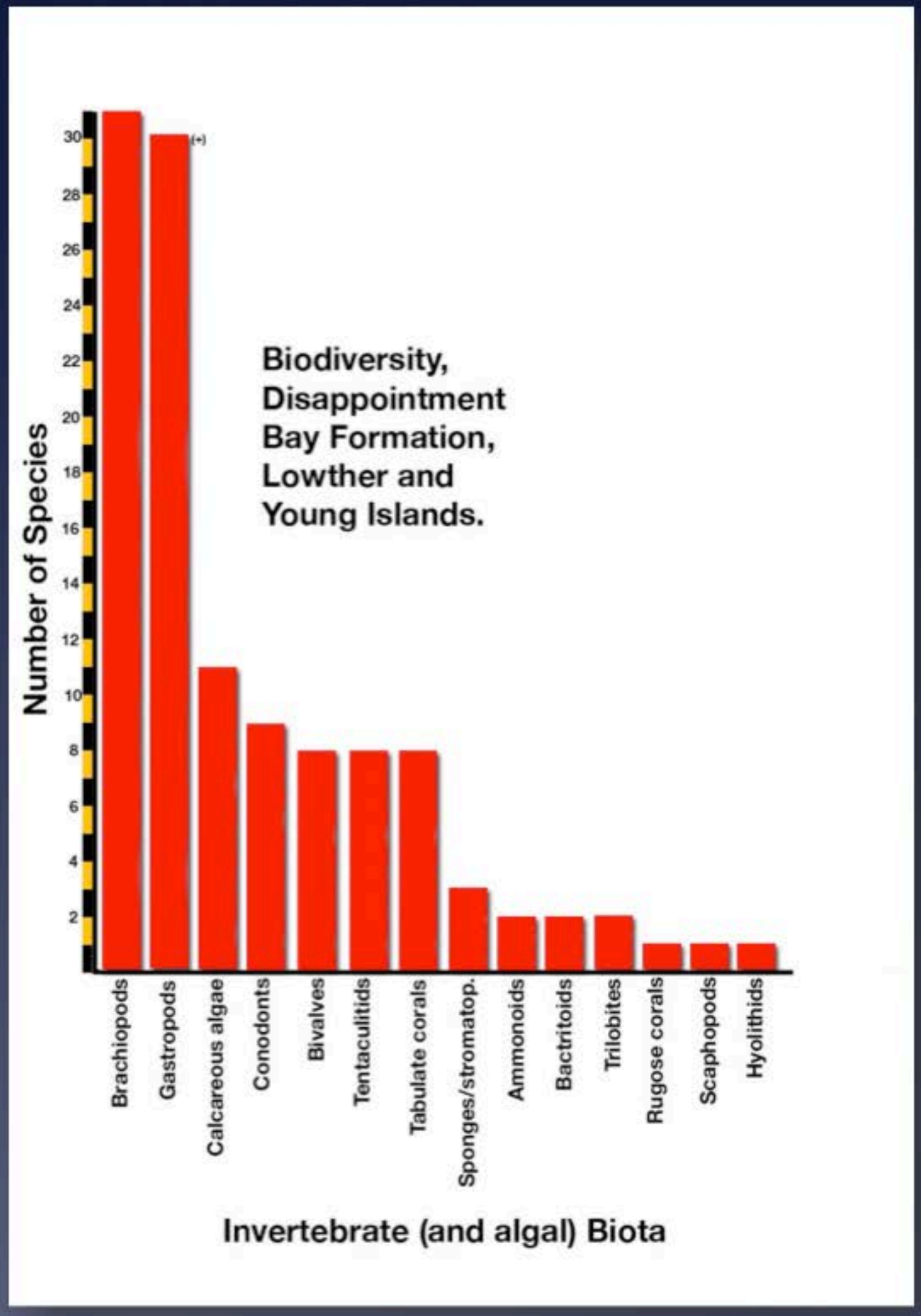
Total species biodiversity (reef and interreef combined) Lowther and Young Islands, Disappointment Bay Fm.

Highest species diversity:

- Brachiopods (31 sp) (Johnson, 1975)
- Gastropods (30+ sp) (Prosh, unpub.)
- Calc. algae (11 sp) (Prosh, unpub.)
- Conodonts (9 sp) (Prosh, unpub.)
- Bivalves (8 sp) (Bailey & Prosh, unpub.)
- Tentaculitids (8 sp) (Prosh, unpub.)
- Tabulate corals (8 sp) *(etc.)*

Eclectic paleobiogeographic affinites:

- Brachiopods: Old World Realm (N. Urals), Nevada Province (E. Americas Realm) (Johnson, 1975)
- Gastropods cf. W. Canada Province of the Old World Realm; also Farewell Terrane, Alaska (Fryda et al., 2002; Fryda & Blodgett, 2008)



JOHNSON, J. C. 1975. Late Early Devonian Brachiopods from the Disappointment Bay Formation, Lowther Island,Arctic Canada. *J. Paleont.*, 49(6):947–978.

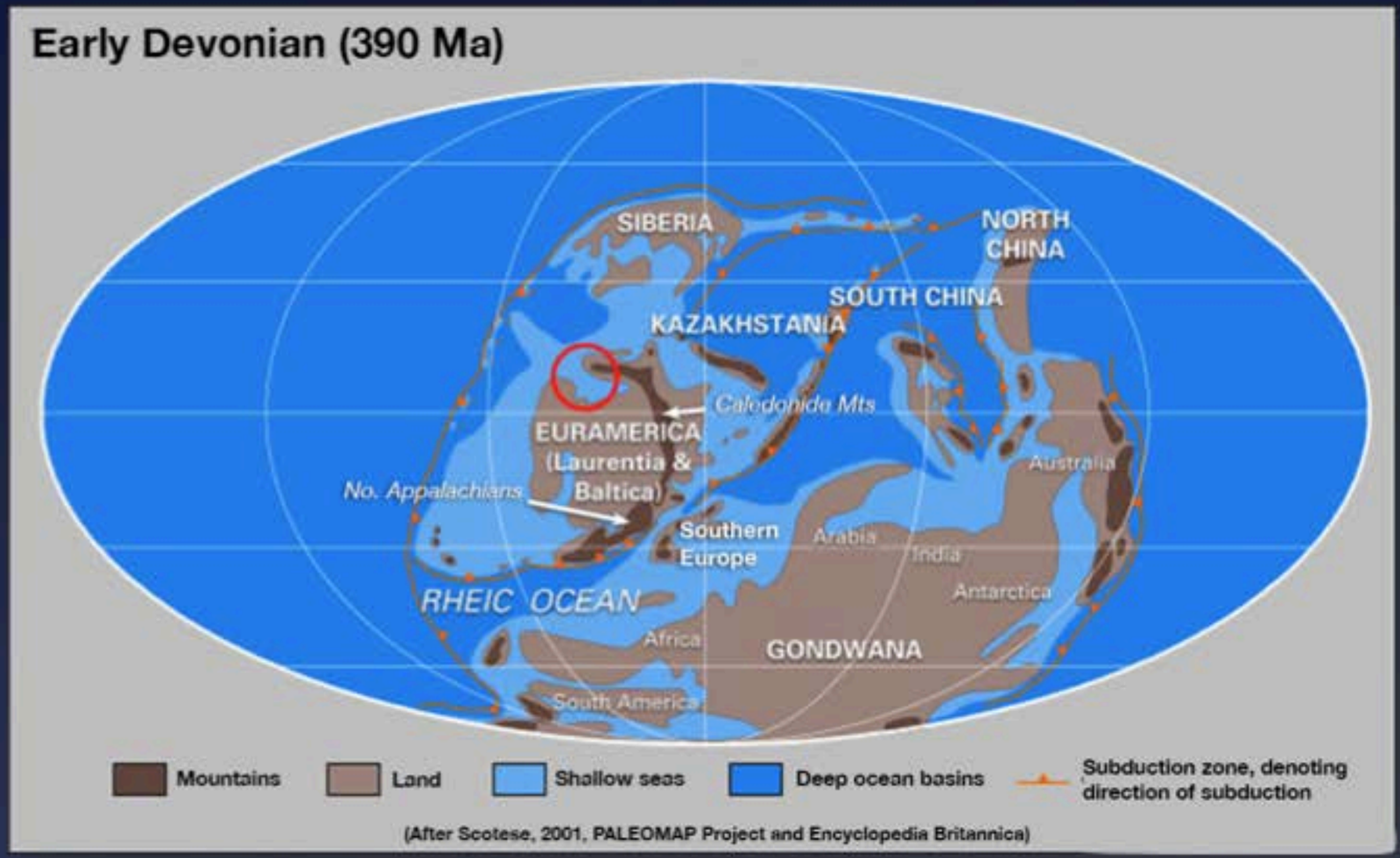
FRYDA, F., R BLODGETT & A. LENZ. 2002. New Early Devonian Gastropods from...Royal Creek area, Yukon Territory, Canada. *J. Paleont.*, 76(2):246–255.

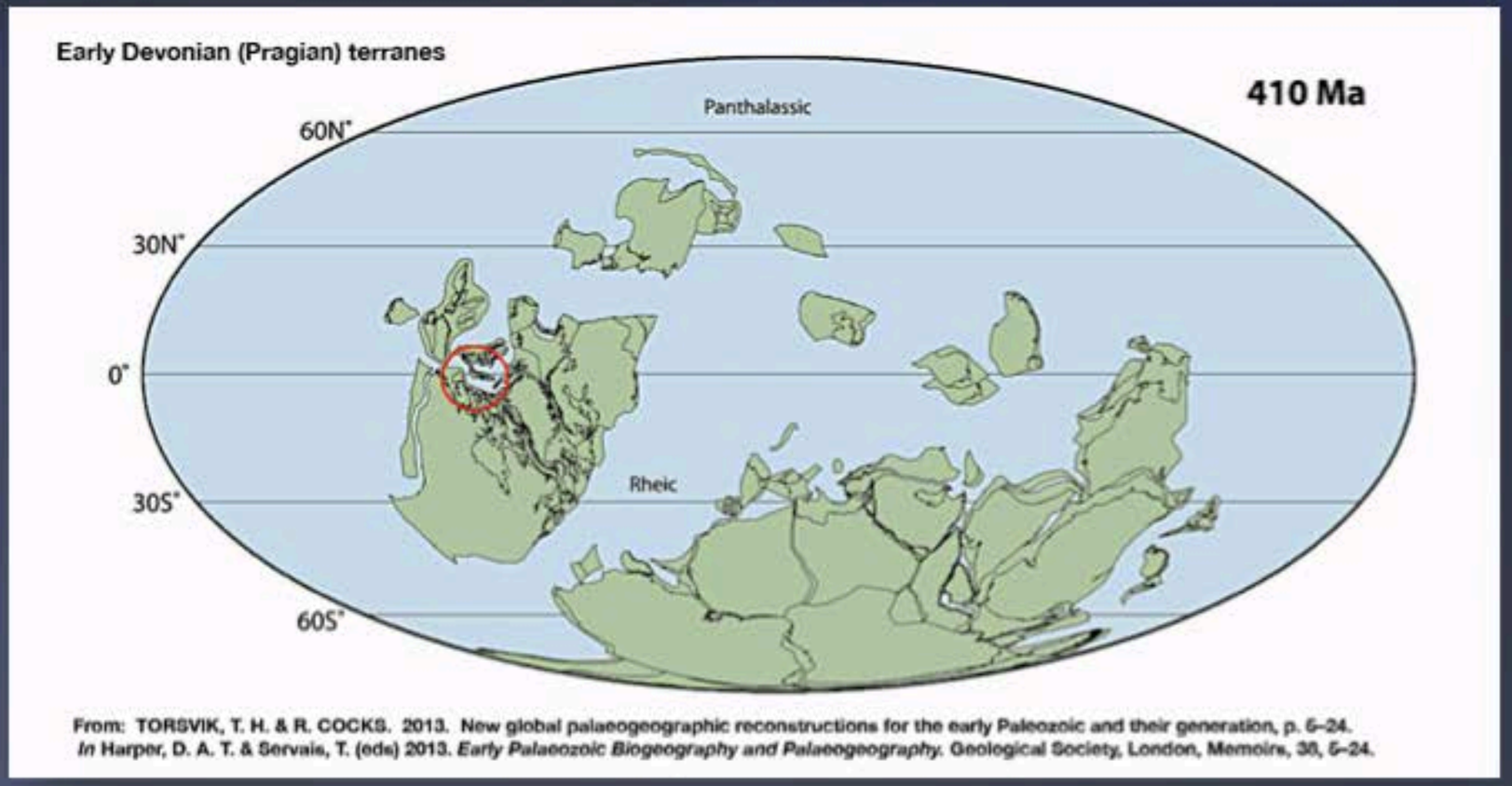
FRYDA, F. & R. BLODGETT, 2008. Paleobiogeographic affinities of Emsian (late Early Devonian gastropods from Farewell terrane, west-central Alaska. Geol. Soc. Am. Sp. Paper, 442:107–120.

Early Devonian Paleomaps

Biogeographic relations of study area to faunal realms:

- Old World Realm
- Eastern Americas Realm
- Alaska Farewell Realm

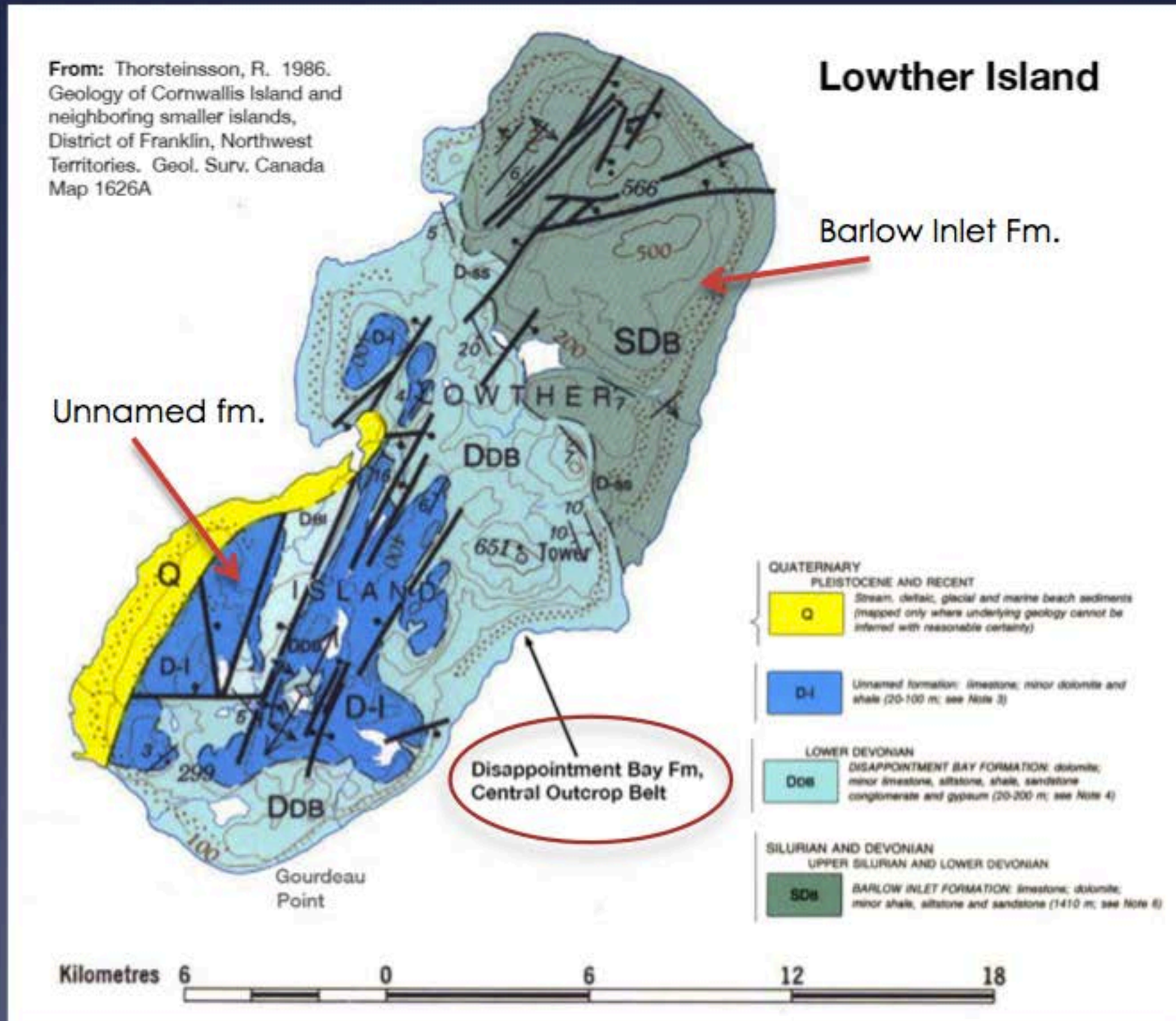




Geology of Lowther Island

THORSTEINSSON, R. 1986. Geology of Cornwallis Island and neighboring smaller islands, District of Franklin, Northwest Territories. Geological Survey of Canada Map 1626A

From: Thorsteinsson, R. 1986. Geology of Cornwallis Island and neighboring smaller islands, District of Franklin, Northwest Territories. Geol. Surv. Canada Map 1626A

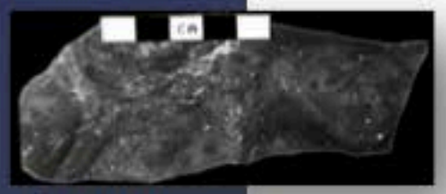


Disappointment Bay Formation:

Correlation of Stratigraphic Sections and Young and Lowther Islands (not to relative scale)

(after Prosh, 1989, unpublished)

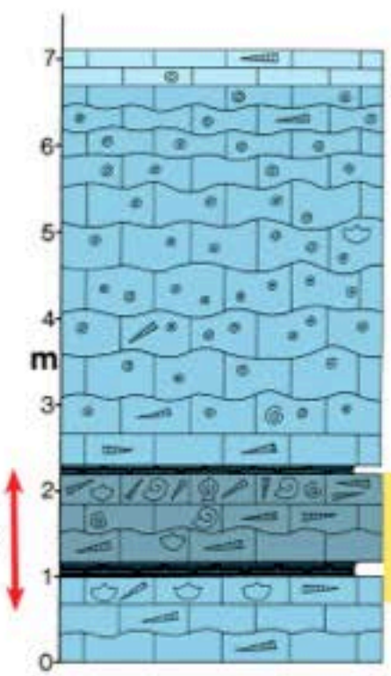
nodular bedding



burrows

Acharax sp.

(hosts sulfur-oxidizing bacteria in gills)



distance: 30+ km SW

transported crinoidal debris

low oxygen chemoautotrophic bivalves (solemyids) with burrows

tentaculite/ammonoid marker horizon

Young Island

Slow deposition (deep basin) (siliclastics absent)

Thickness: 7 m

Legend

- calcareous siltstone or shale
- nodular-bedded limestone
- limestone
- dolomite
- sandstone
- sandy
- calcareous
- dolomitic
- cross-bedded
- brachiopods
- tentaculites
- ammonoids
- bivalves
- gastropods
- crinoids
- bryozoa

unnamed fm.
(dolomite with anhydrite)

siliclastic sands

reef burial

reef senescence

crinoidal grainstones

regular bedding

nodular bedding

m

80
70
60
50
40
20
10

REEFS

reef growth begins

very low oxygen
- no fossils,
- no burrows,
- no bioturbation

unfossiliferous laminated limestone (no outcrop)

disconformity

Silurian RED BEDS (with gypsum)

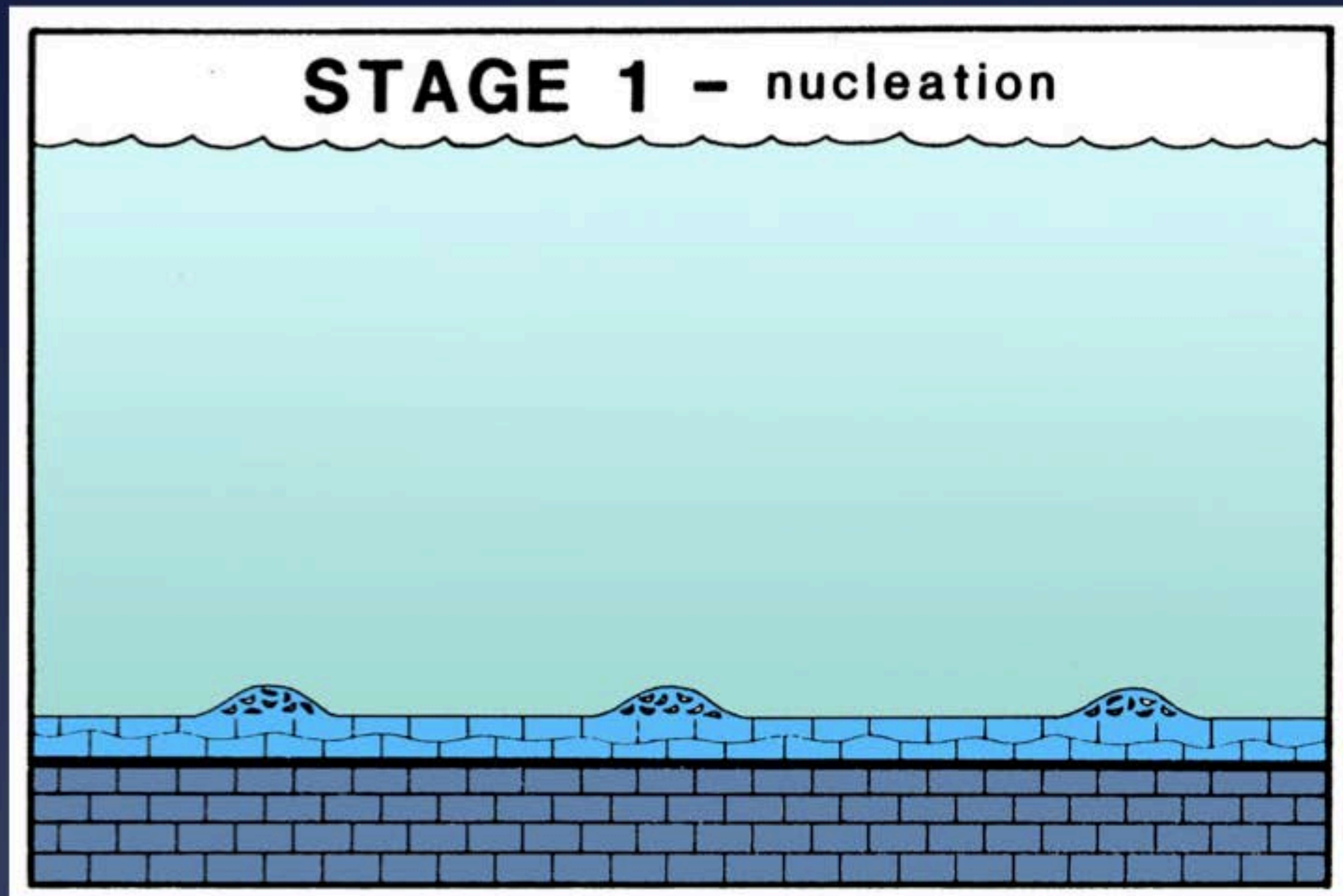
Lowther Island

(generalized composite section)

Upward shoaling carbonates in a near-shore embayment (with siliclastic admixture)

Thickness: ~86 m

Lowther Island Vertical Stacked Lowther Reef Facies

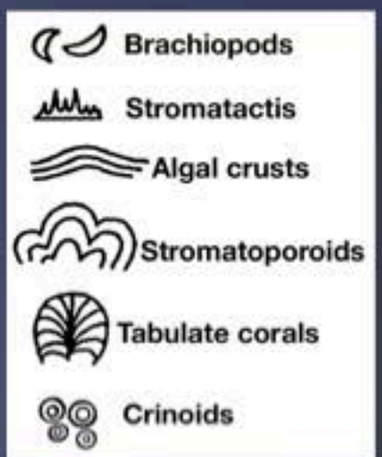


Nodular bedding

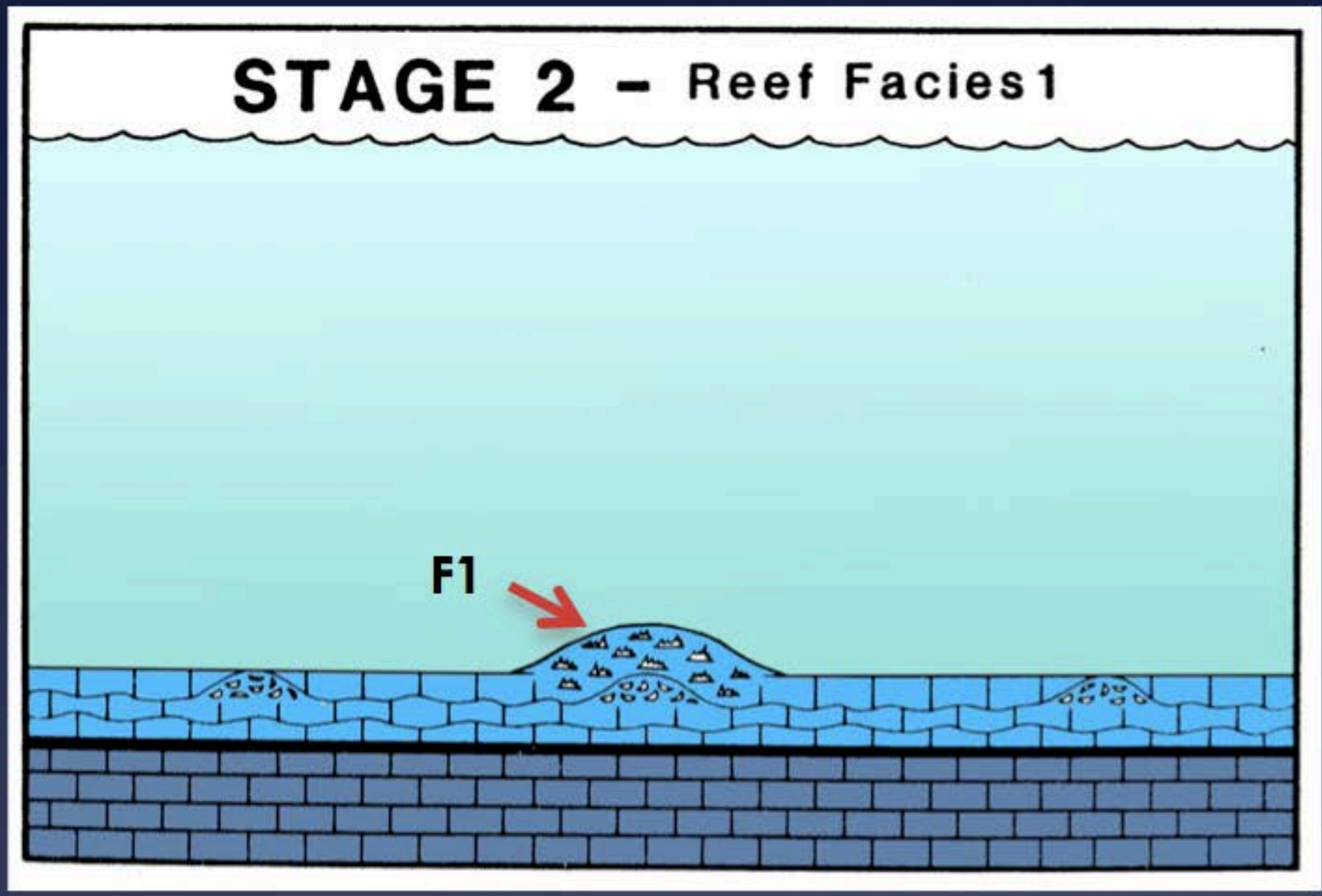
C. Nodular-bedded lime wackestone with reef nucleation on brachiopod bioherms *(e.g., Elythyna transversa)*

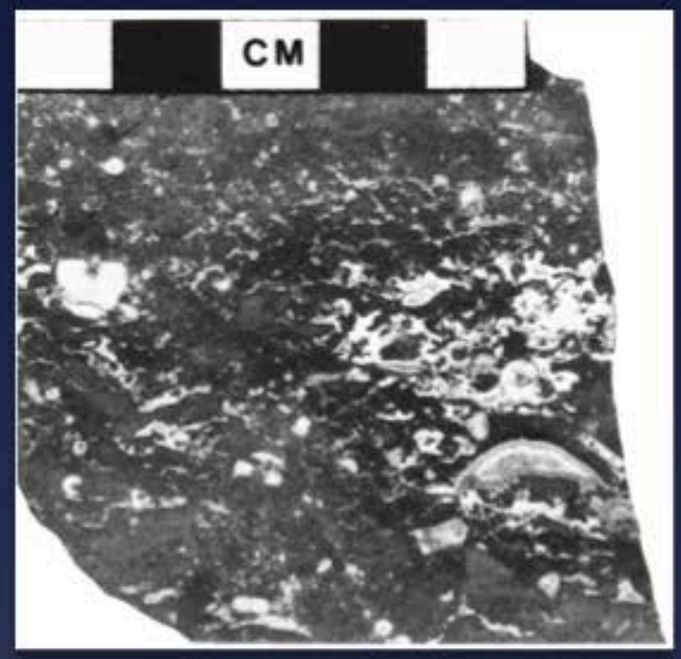
B. Tentaculite marker horizon (reef base)

A. Silty, unfossilferous, laminated lime mudstones and wackestones (quiescent background deposition in moderately deep water)



(After Prosh, 1989, unpublished)



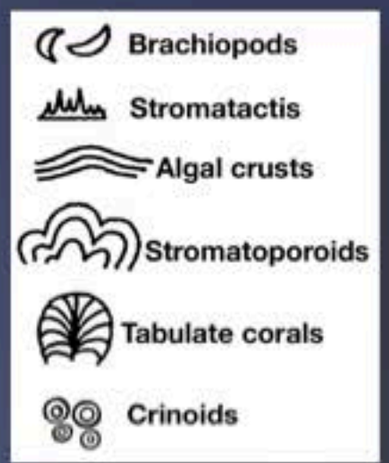


stromatactis

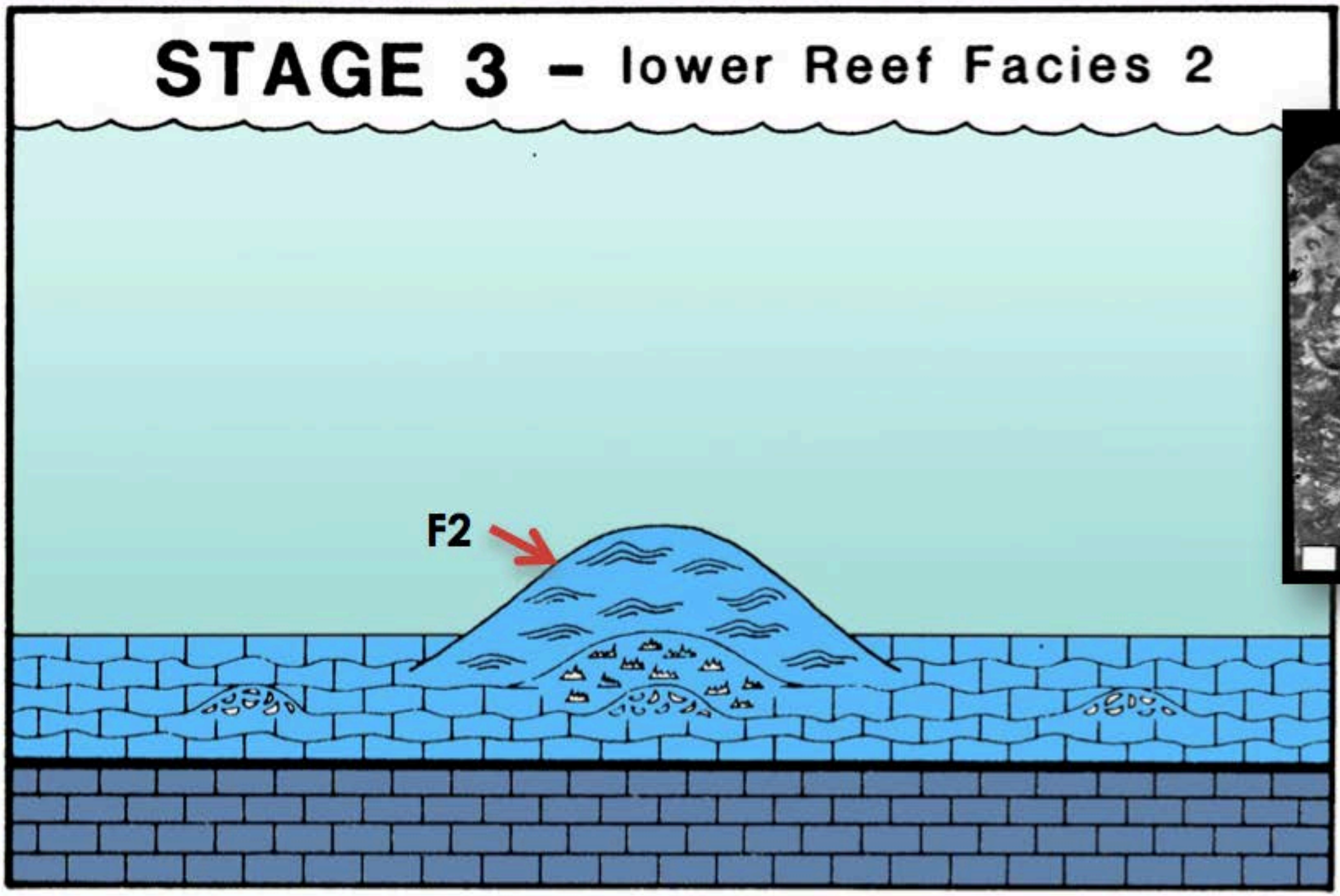
(After Prosh, 1989, unpublished)

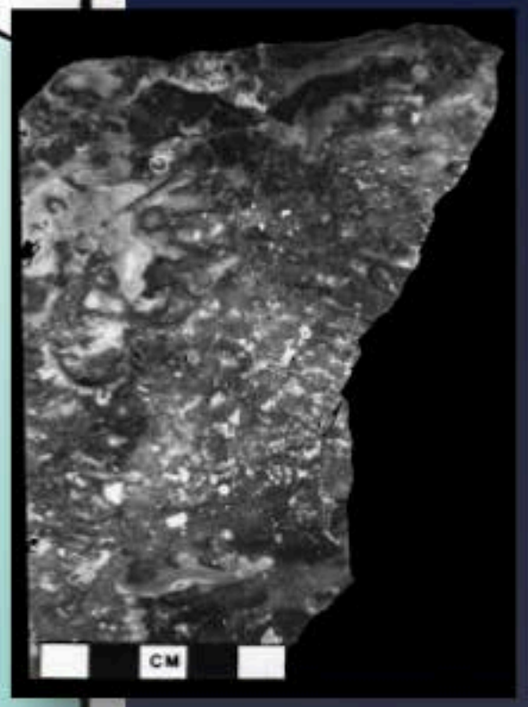
FACIES 1 : ~ 5m. Basal stromatactis-rich dark mudstone-to-wackestone, nodular bedded.

- Analogous to classical carbonate "mud mounds" interpreted as quiet, deep-marine basin deposition, possibly hypoxic conditions beneath photic zone.
  (e.g., Ordovician of Sweden; Devonian of Australia, Carboniferous, UK; Emisan of Morocco)
  (Bathurst, 1980; Riding, 2002; Aitken et al., 2002).
- Possible microbial/algal precursors to stromatactis
- Mud mounds and reef growth initiated by a eustatic sea-level rise (Smith, 1985)



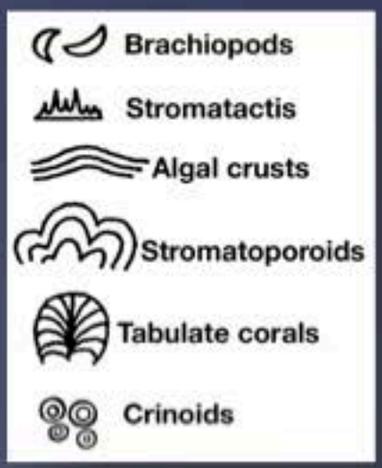
STAGE 3 – lower Reef Facies 2



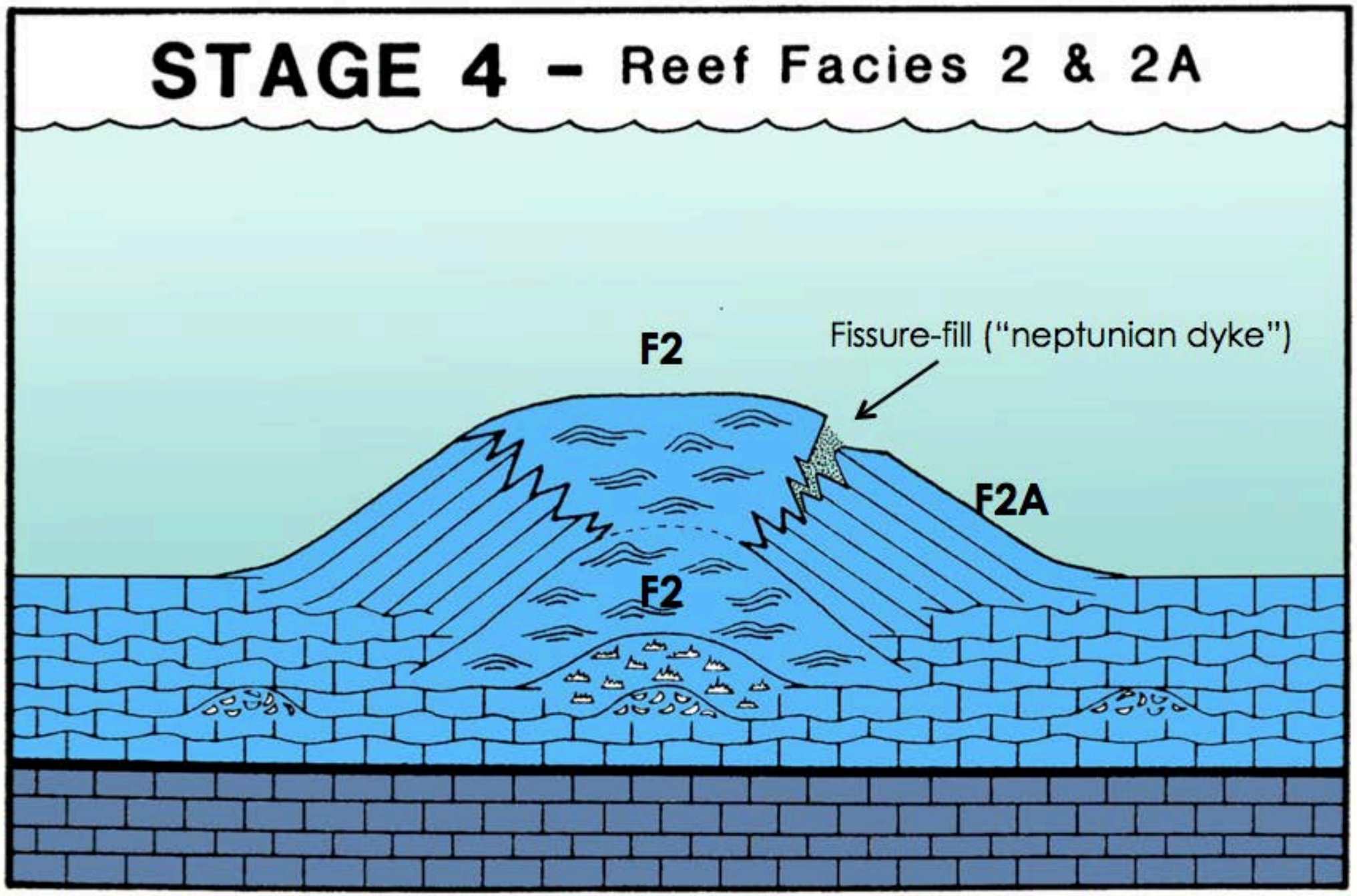


Lower FACIES 2: Algally bound wackestone (20-30 m) with abundant fibrous calcite after non-skeletal algae and inclusions of skeletal algae (e.g., *Renalcis*).

(After Prosh, 1989, unpublished)



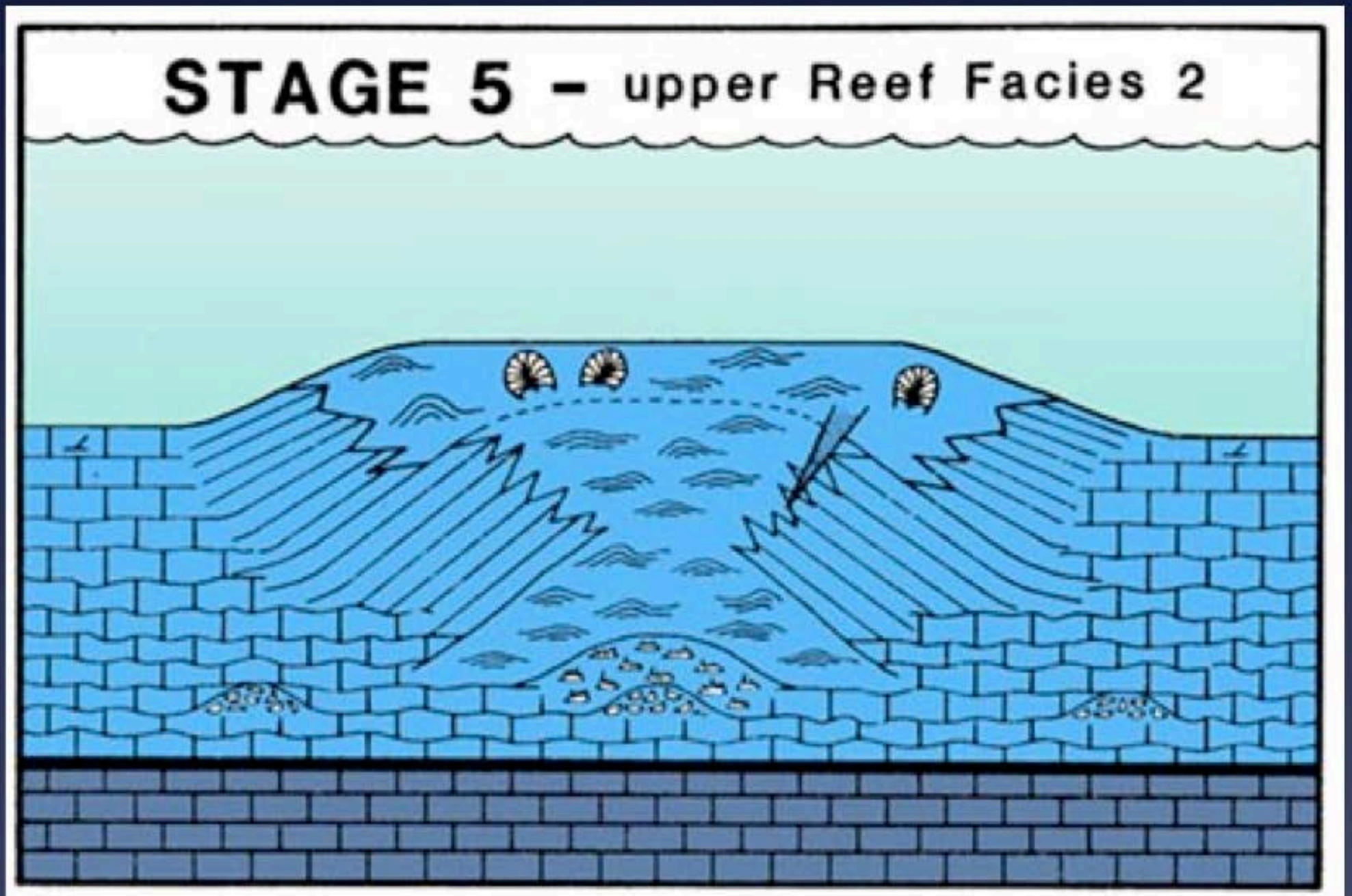
STAGE 4 – Reef Facies 2 & 2A



Lower FACIES 2 continues.

FACIES 2A: Lateral subfacies consisting of steeply dipping beds of reef marginal, bioclastic spill-over debris. Gravity-induced detachment with fissure fills (i.e., "neptunian dykes").

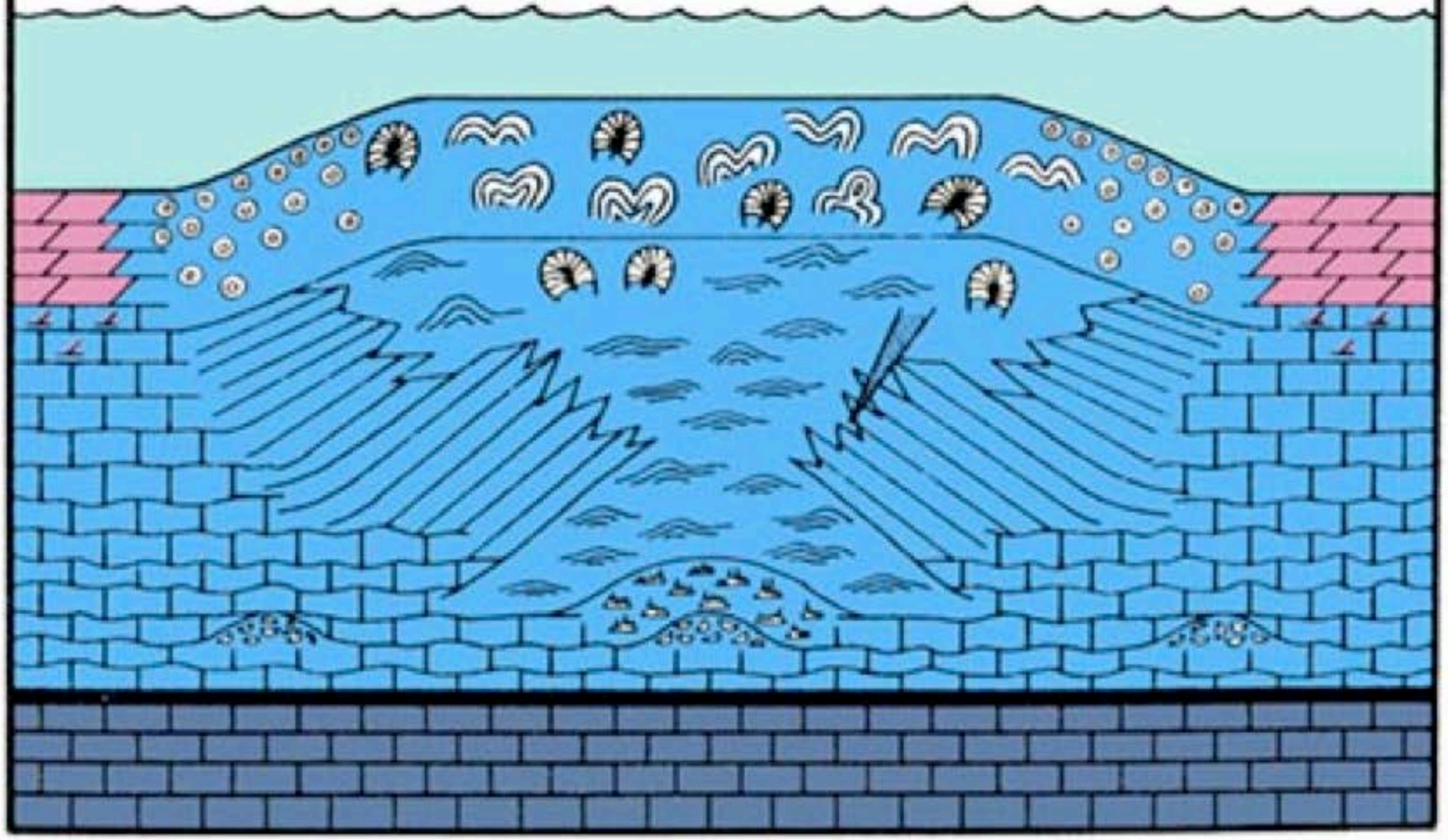
(After Prosh, 1989, unpublished)

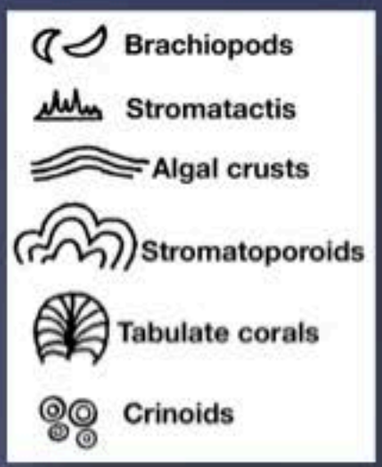


Upper FACIES 2: Algally bound wackestone with tabulate corals (*Alveolites, Favosites*, etc.)

(After Prosh, 1989, unpublished)

STAGE 6 – Reef Facies 3



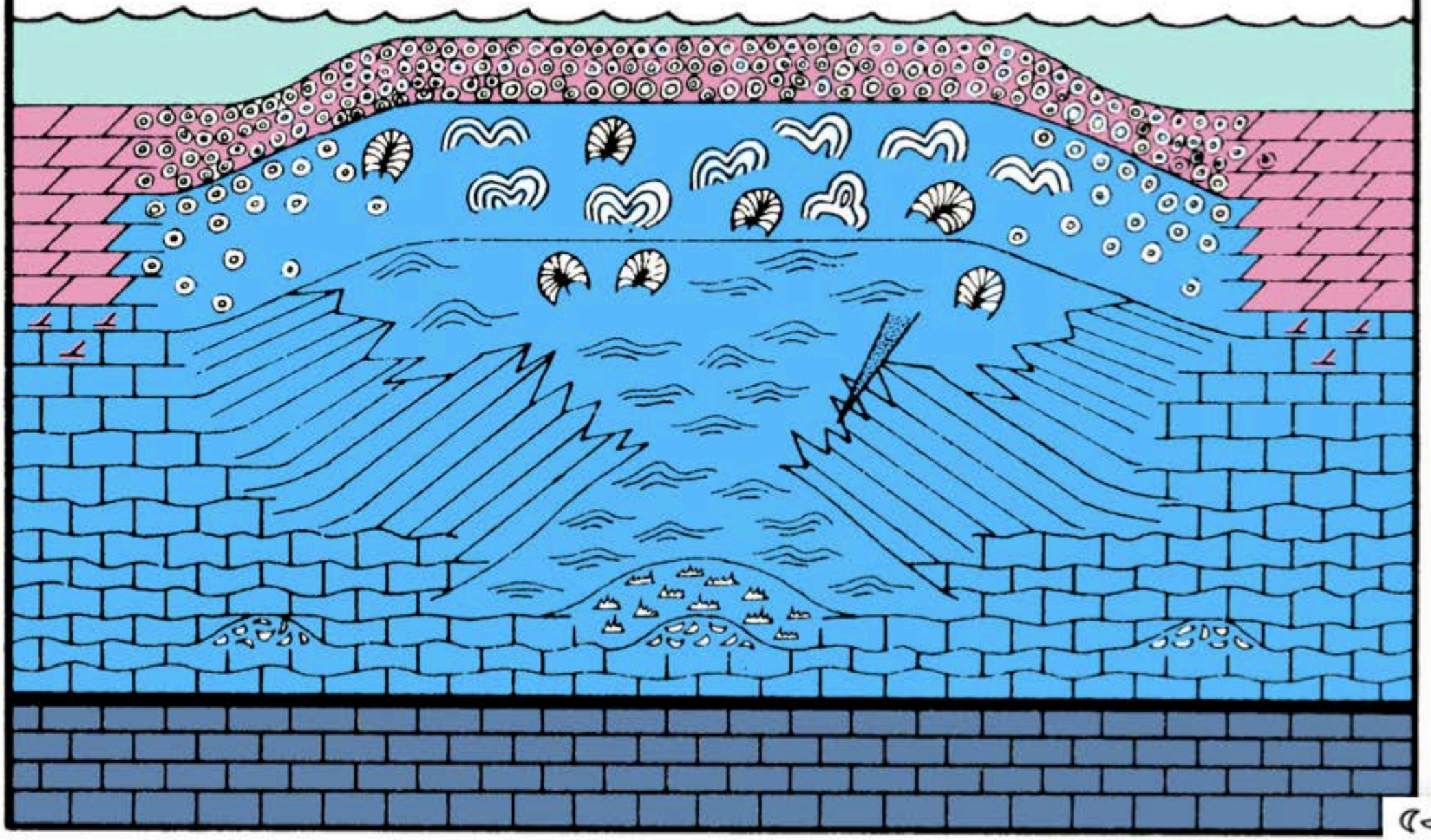


FACIES 3: ~10-15 m. Dolomitic stromatoporoid-tabulate coral framestone-to-rudstone

- Stromatoporoids: *Salairella, Clathrodyction*
- Tabulate corals: *Alveolites, Favosites*)

(After Prosh, 1989, unpublished)

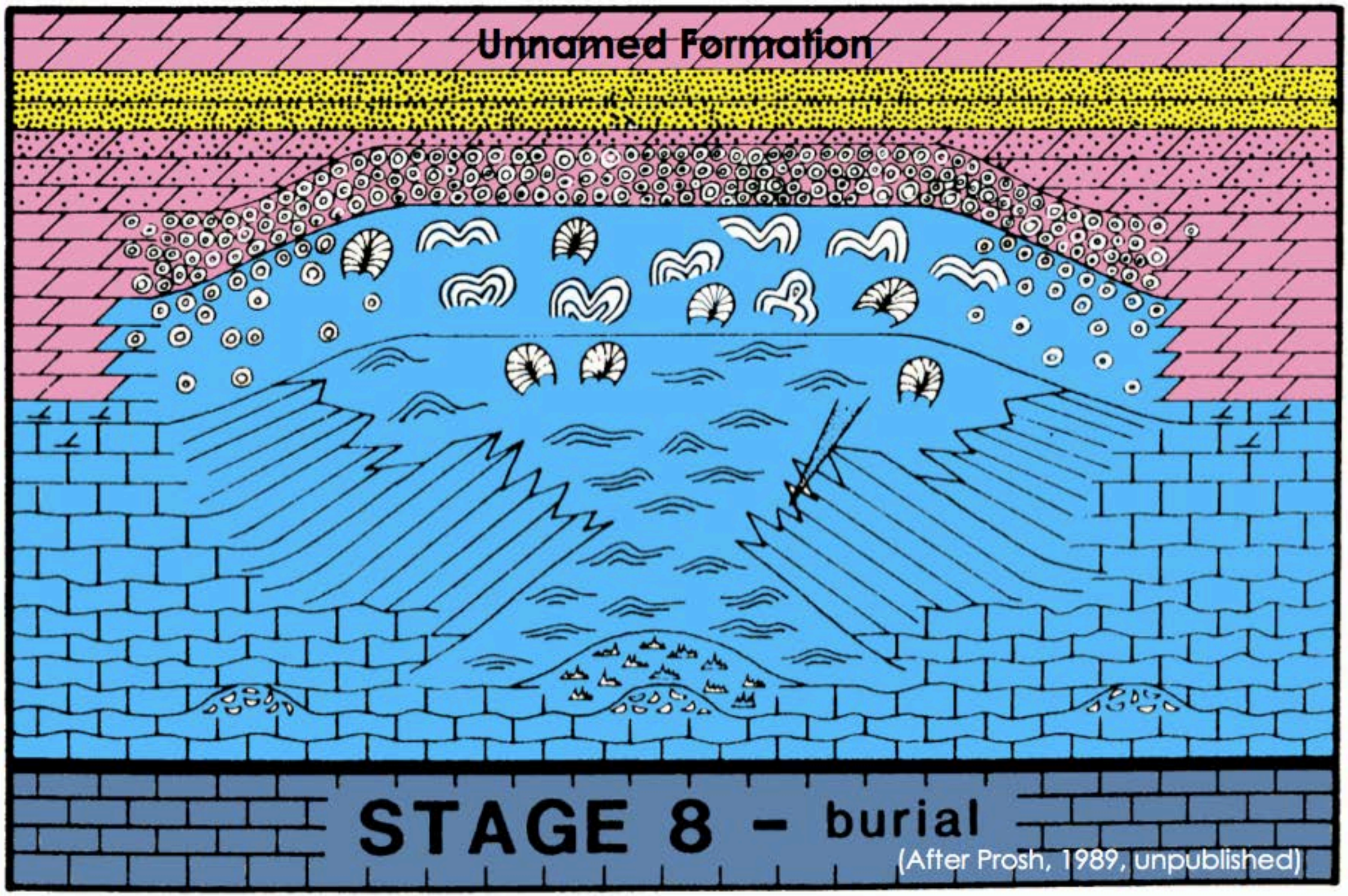
STAGE 7 – Reef Facies 4



Brachiopods
Stromatactis
Algal crusts
Stromatoporoids
Tabulate corals
Crinoids

FACIES 4: <5m. Dolomitized crinoidal grainstone/packstone cap

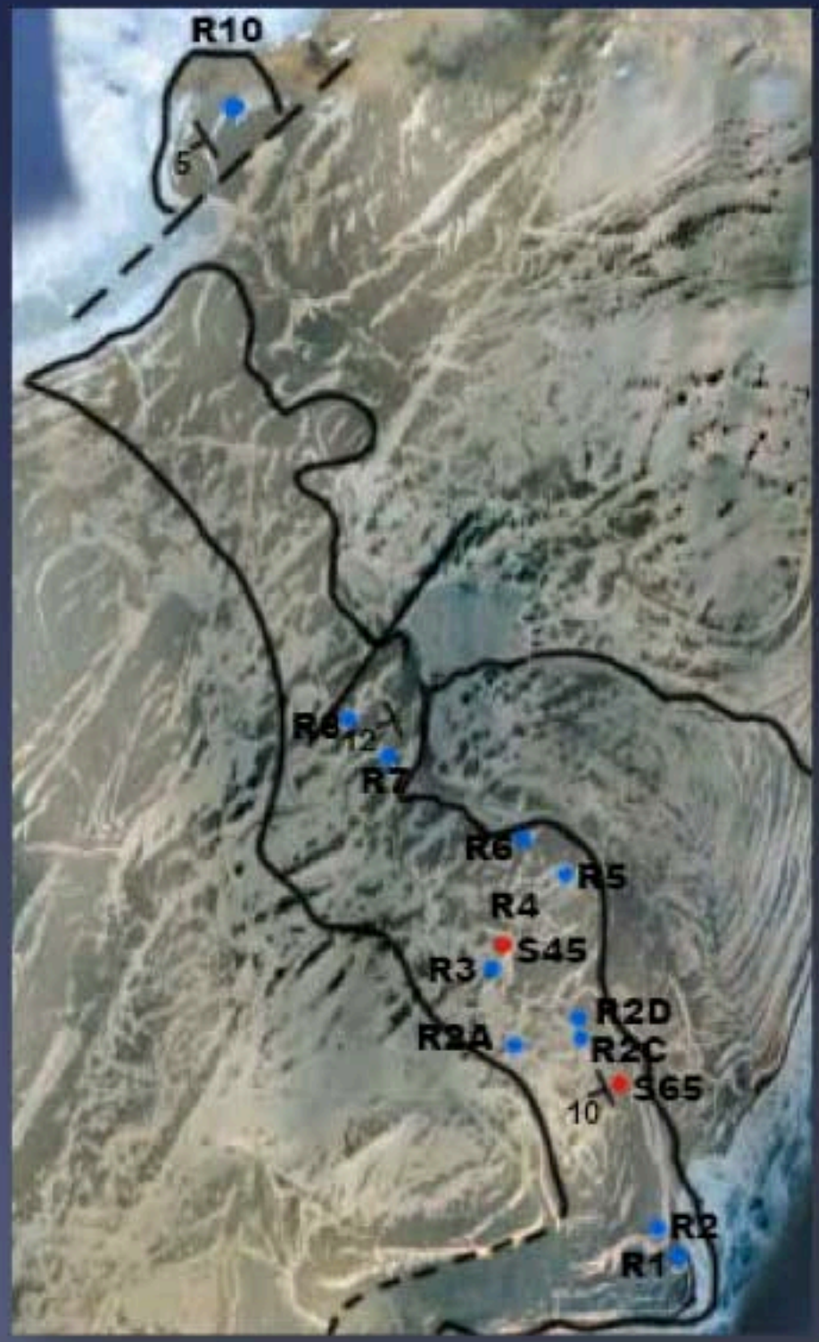
(After Prosh, 1989, unpublished)

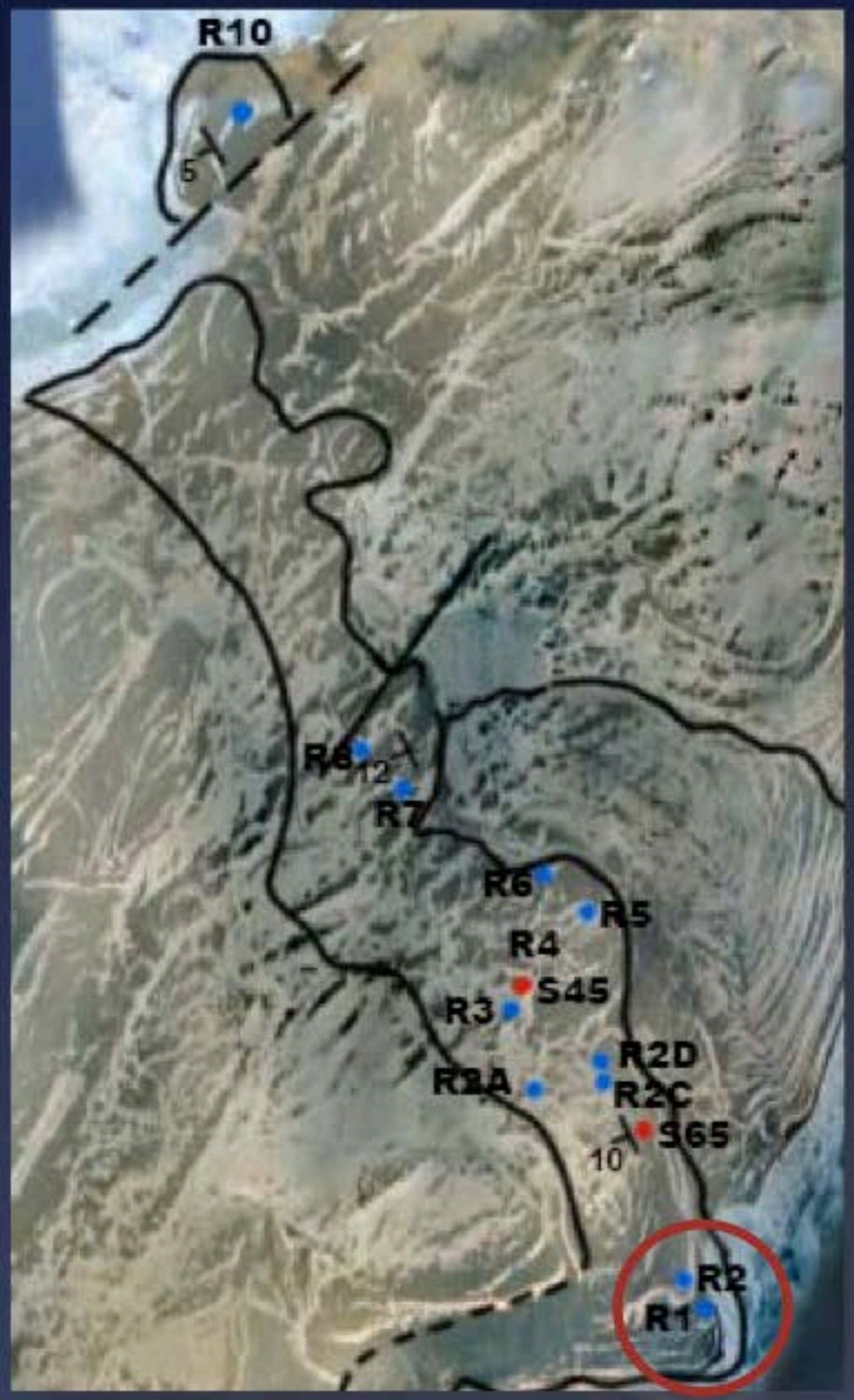


- Sandy dolomite/quartz sandstone forms a transitional boundary into overlying unnamed formation.
- Dolomitization (confined to F3 and upper F3 is of the burial stage, partially penetrative type, affecting reef peripheries but not their cores.

Quick Tour:

Unpublished reef knoll photos, Disappointment Bay Fm., Central outcrop belt, Lowther Island



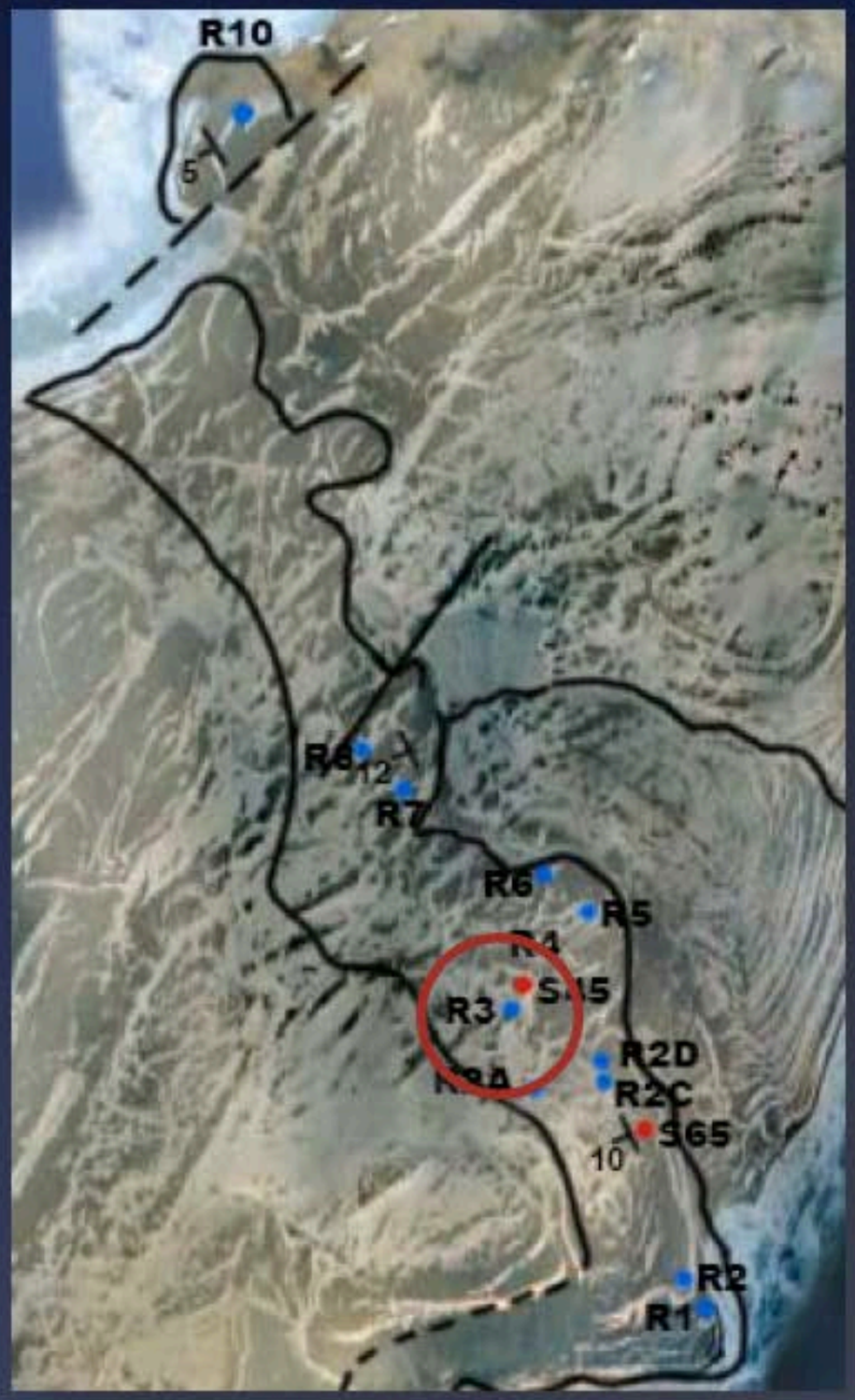


Exhumed Reef Knolls, R1 & R2
Lowther Island. Disappointment
Bay Formation (photos by Prosh, 1989)

(Blue arrow = field assistant)

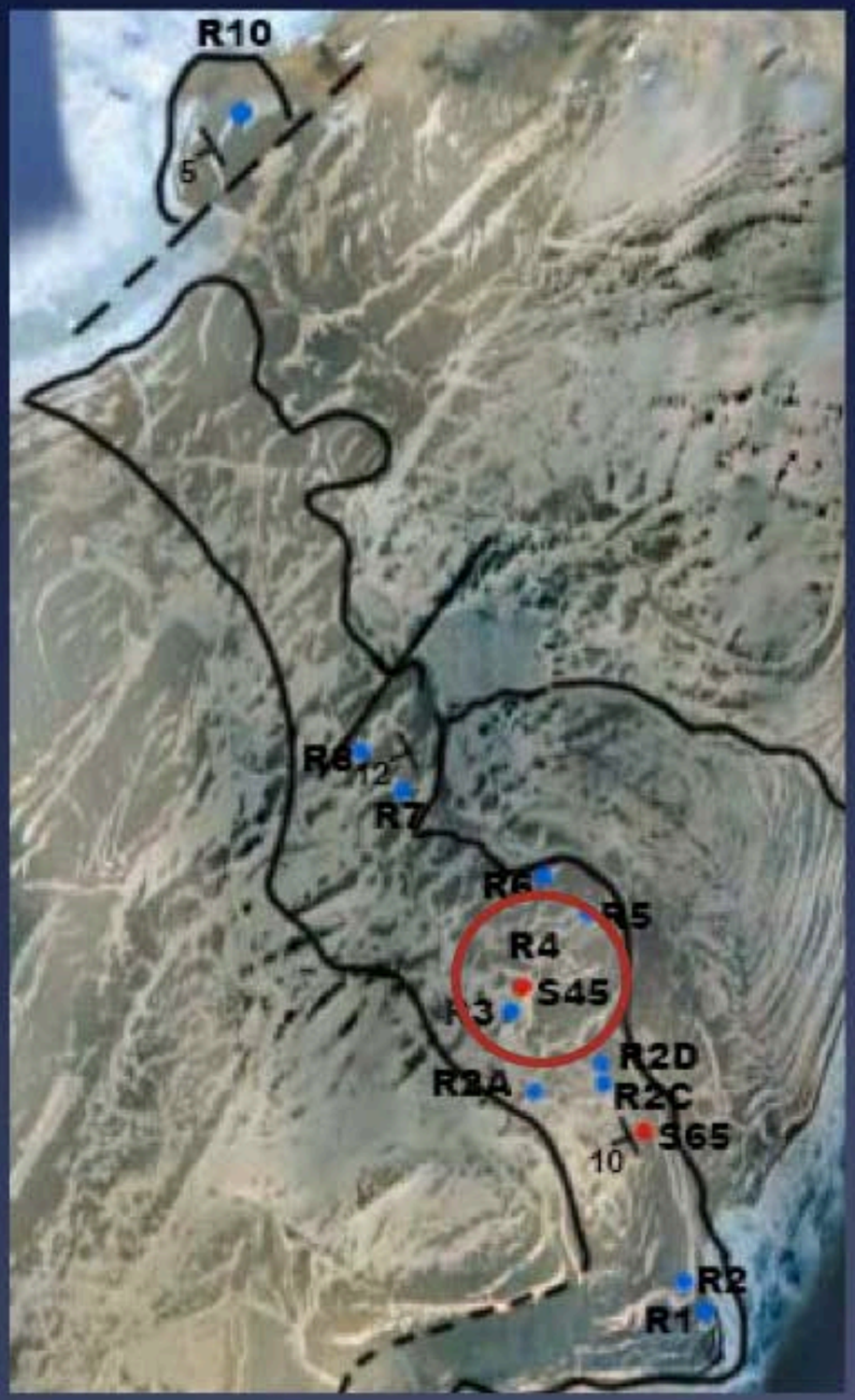
100 m (Length), heavily eroded and dolomitized.

100 m (Length) x 20 m (Height). Dolomitized with relict structures.



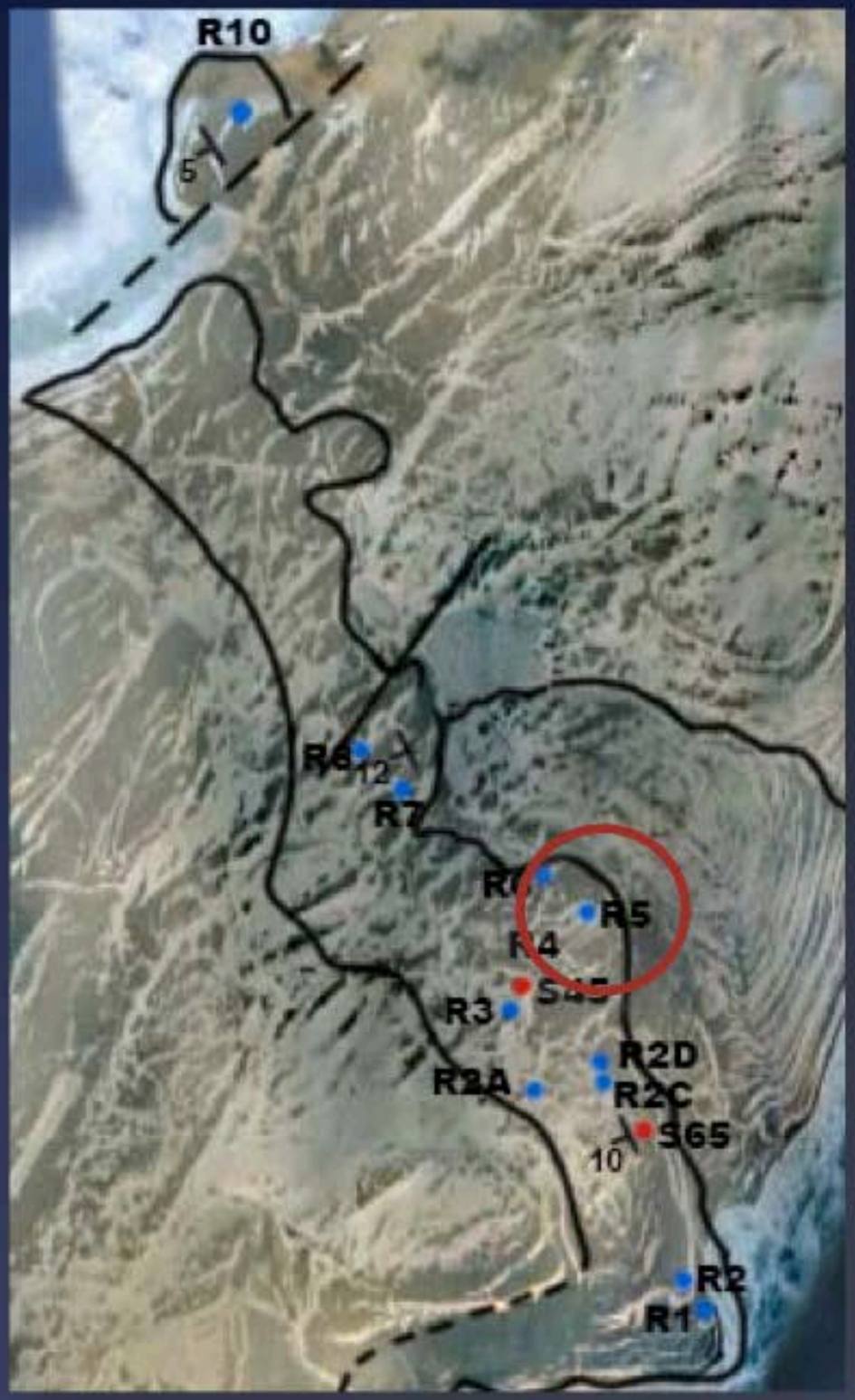
Exhumed Reef Knoll, R3
Lowther Island, Disappointment Bay Formation (photos by Prosh, 1989)

150 m (L) x 20 m (H). Lower (F1/F2) reef facies; locally dolomitized.



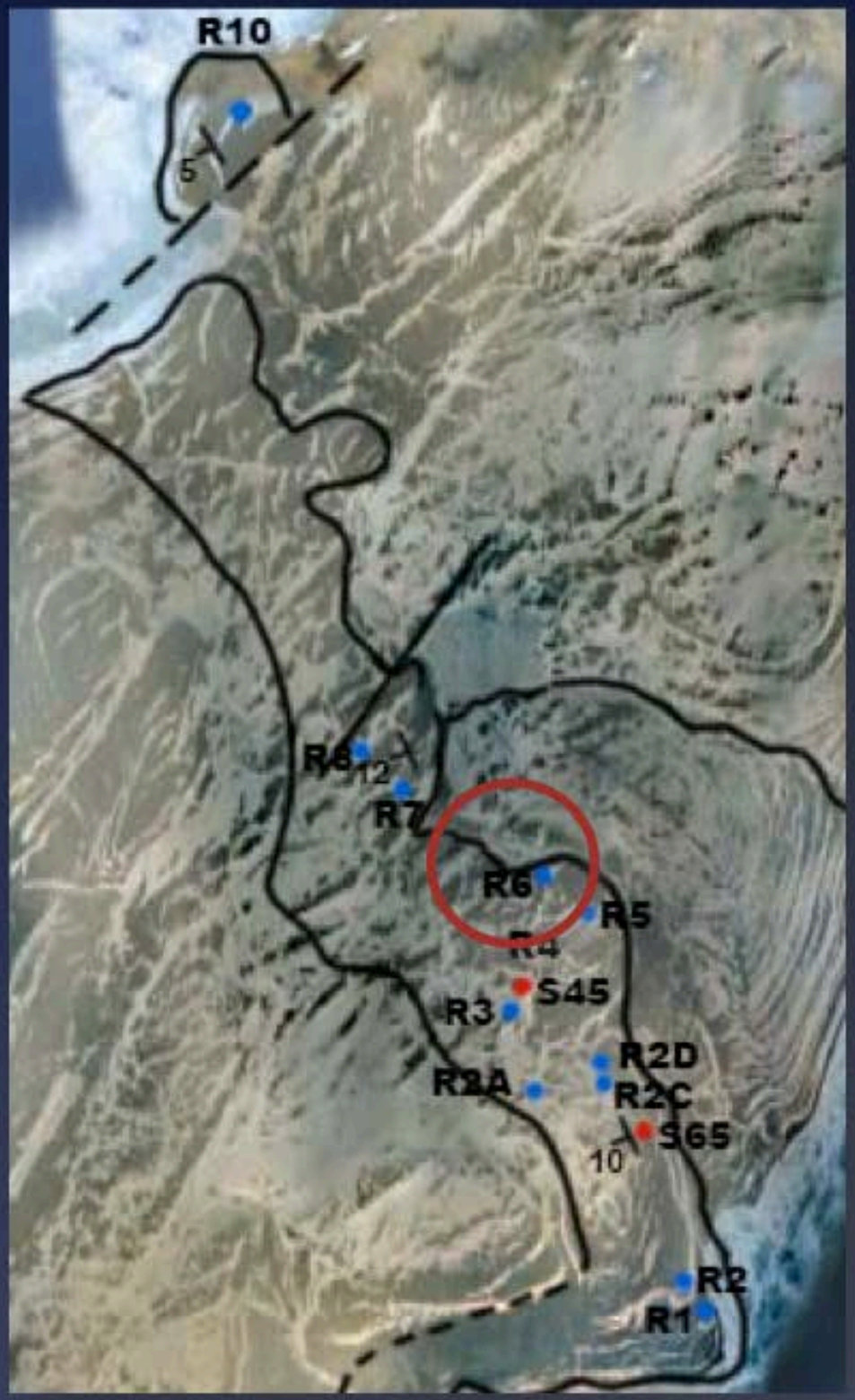
Exhumed Reef Knoll, R4
Lowther Island, Disappointment Bay Formation (photos by Prosh,1989)

125 m (L) x 25 m (H). Upper reef F3 (framework) facies.

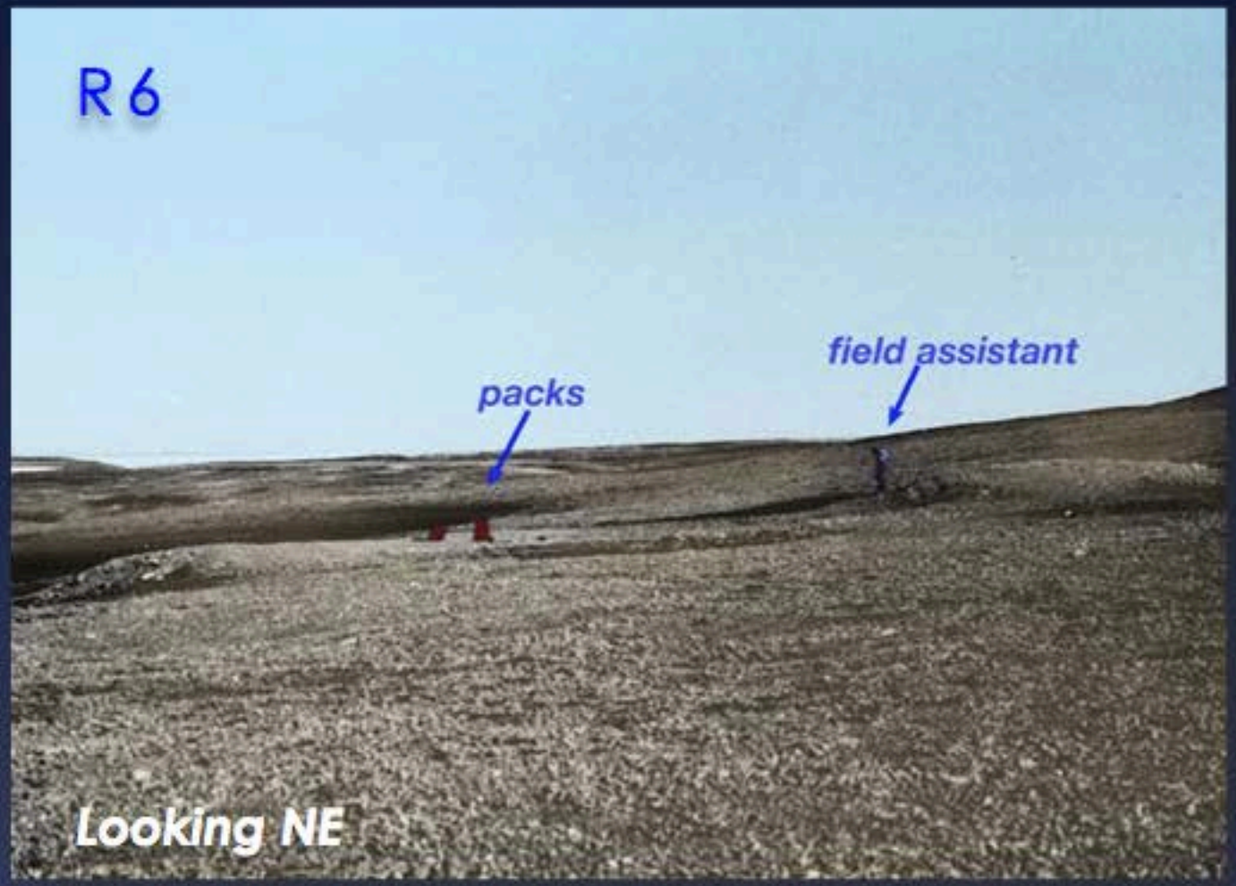


Exhumed Reef Knoll, R5
Lowther Island, Disappointment Bay Formation (photos by Prosh,1989)

150 m (L). Horseshoe shape; low relief; badly eroded.
Lowest (F1) reef facies exposure.

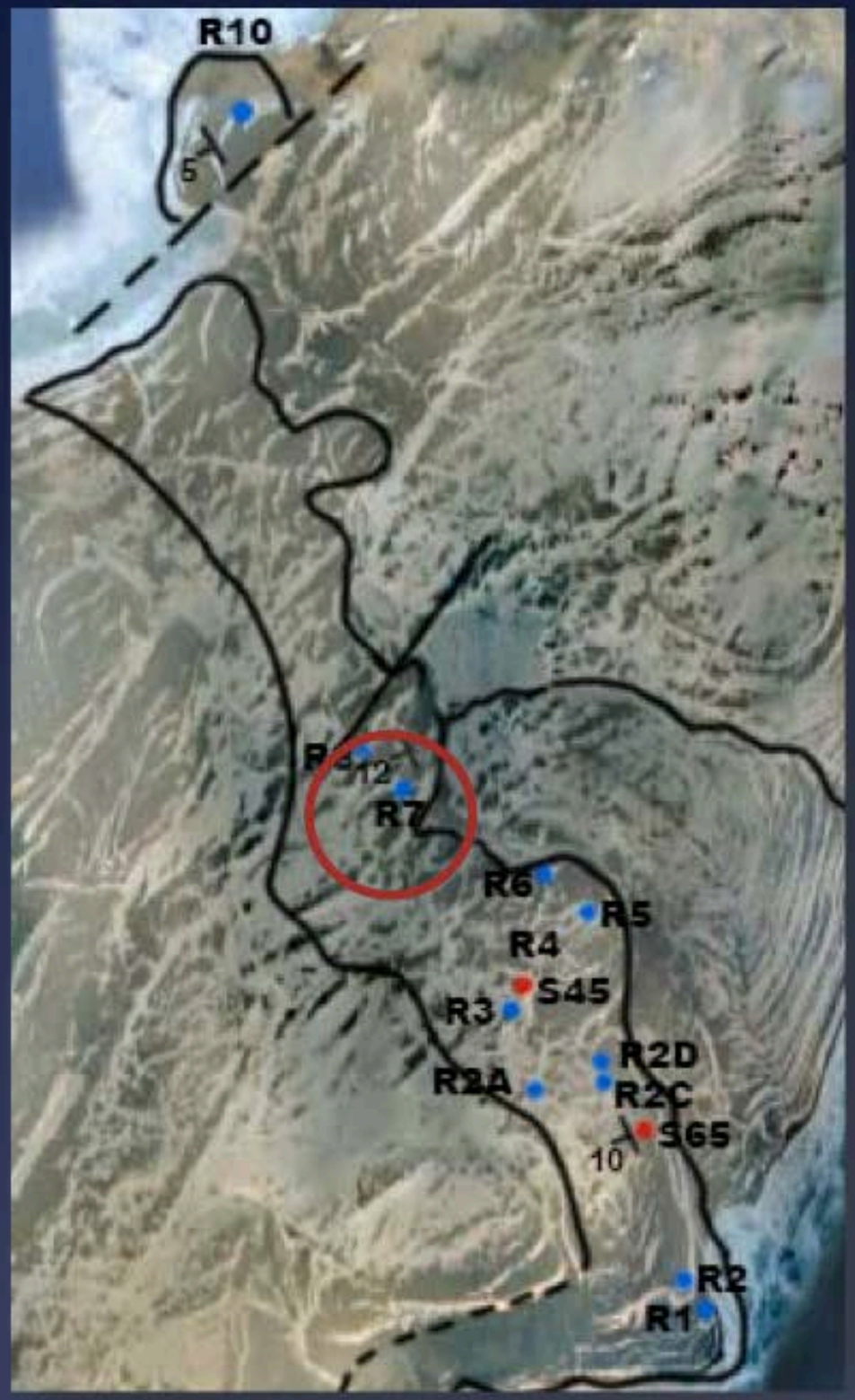


Exhumed Reef Knoll, R6
Lowther Island, Disappointment Bay Formation (photos by Prosh,1989)



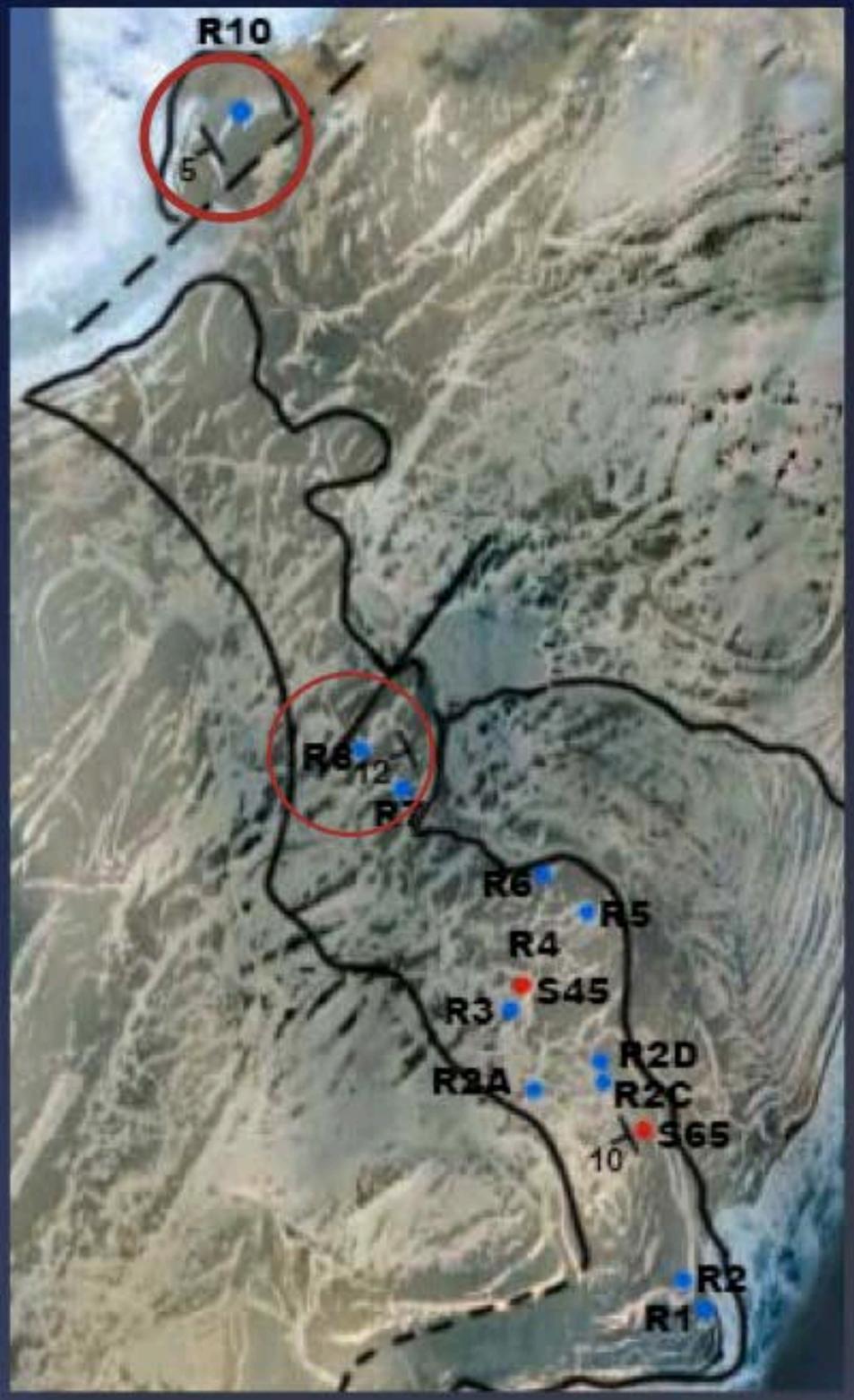
40 m (L). Severely denuded. Lowest (F1) reef facies exposure.

Field relations of two largest reef knolls, R7 and R8.



Exhumed Reef Knoll, R7,Lowther Island, Disappointment Bay Formation (photos by Prosh,1989)

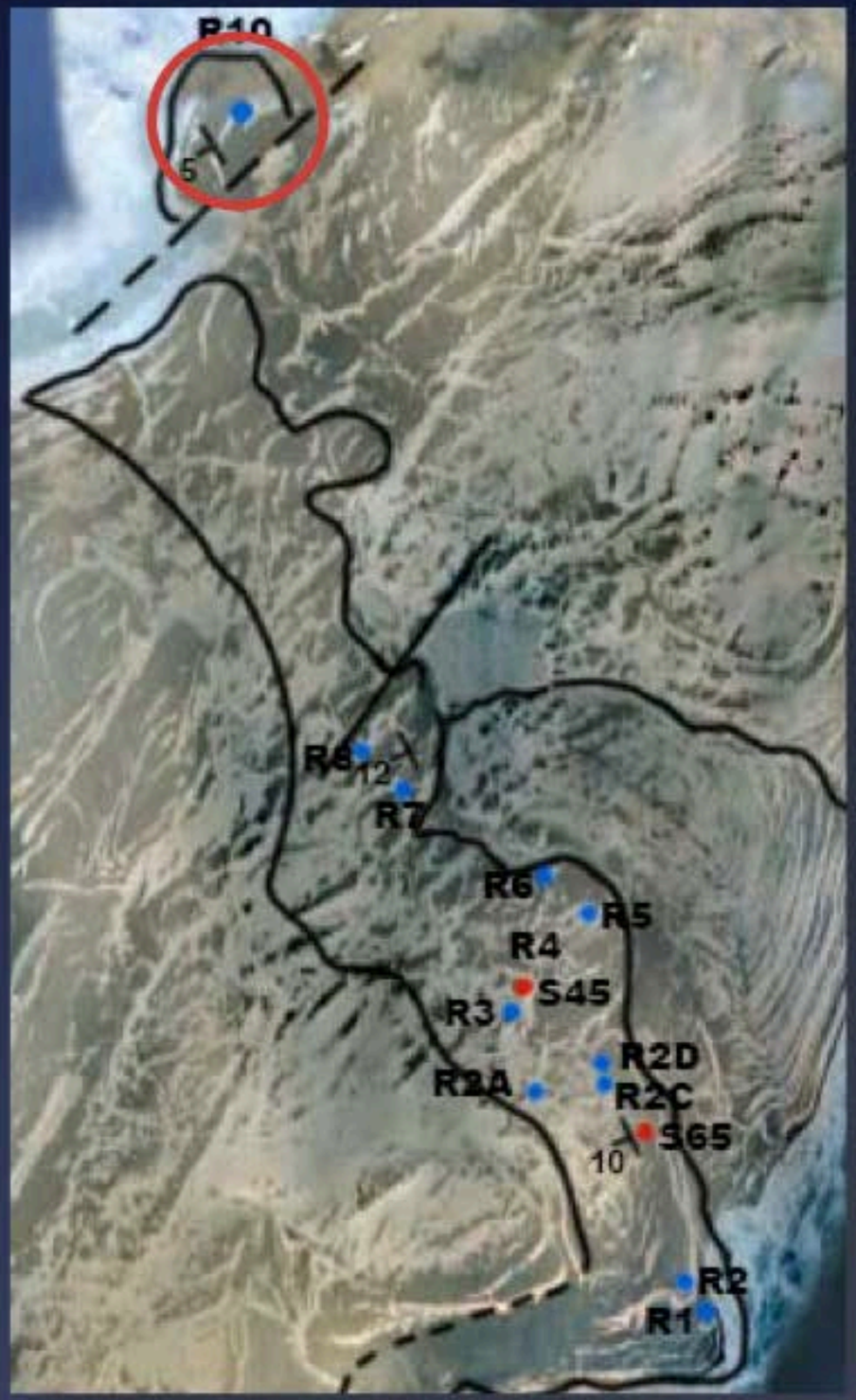
300 m (L) x 30 m (H). Largest and most intact reef. Upper Disappointment Bay Fm. draped by overlying unnamed fm.



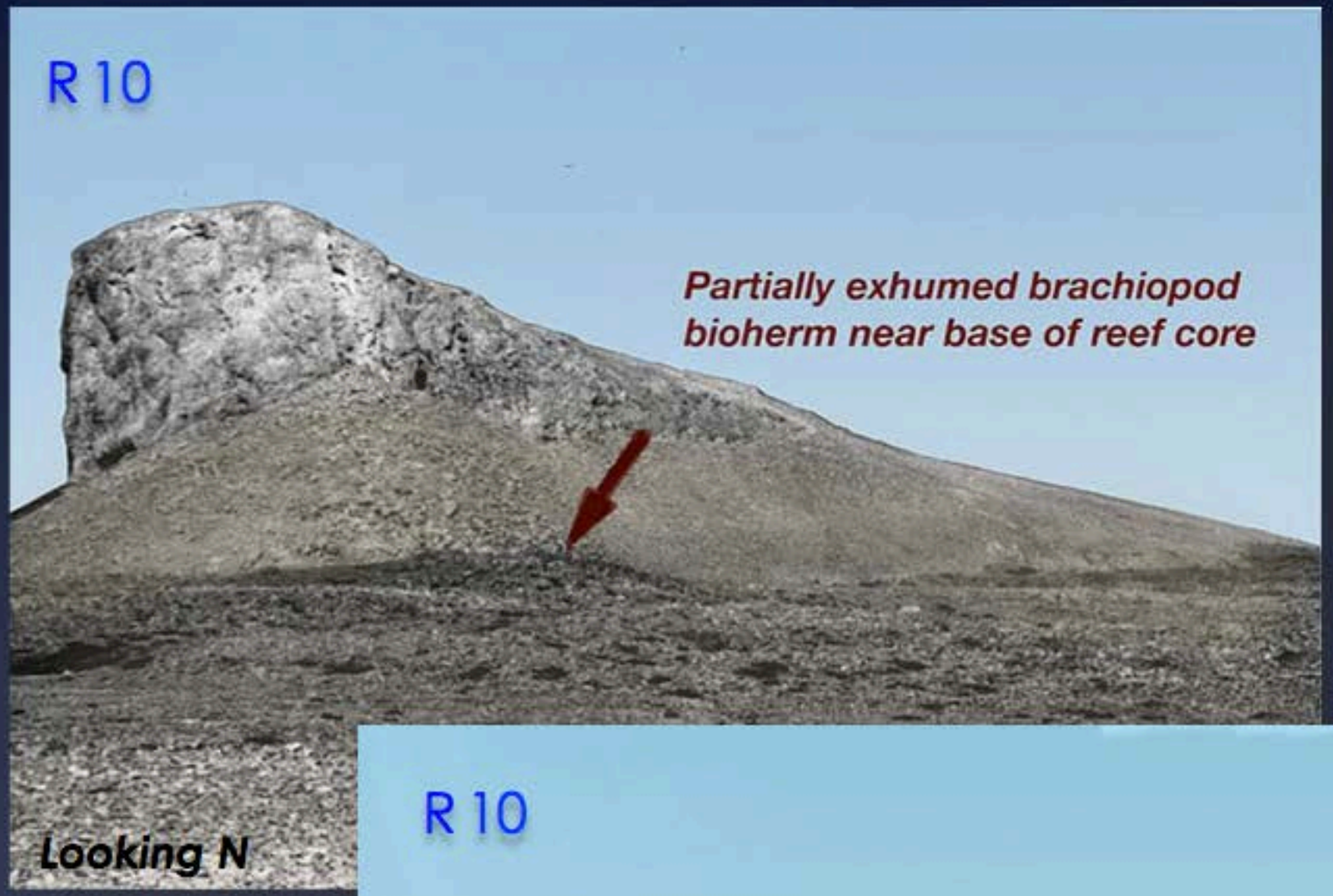
Exhumed Reef Knolls R8 & R10, Lowther Island, Disappointment Bay Formation (photos by Prosh,1989)

250 m (L) x 25 m (H). Second largest, mostly intact reef. Upper Disappointment. Bay Fm. draped by overlying unnamed fm.

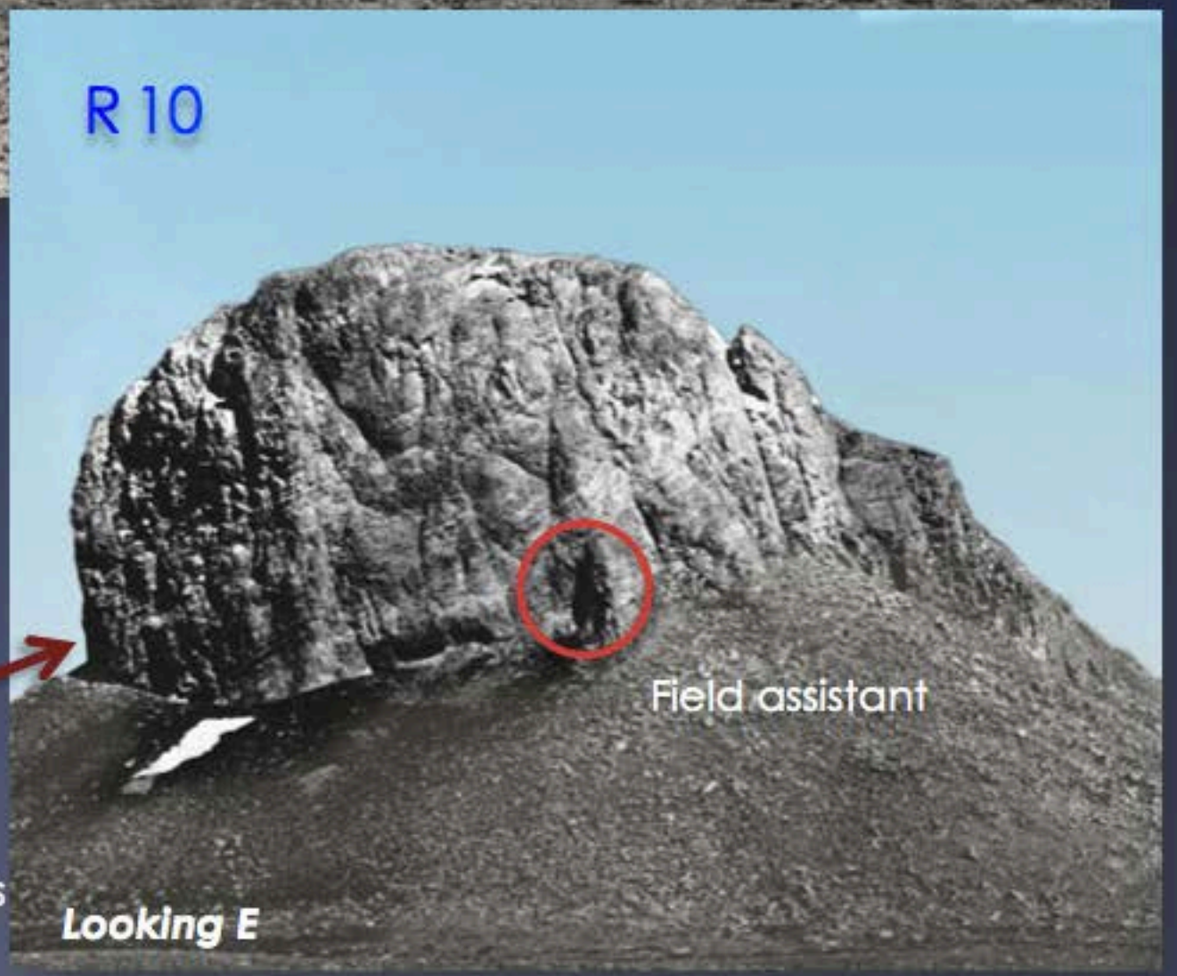
50 m (L) x 15 m (H). Upper reef remnant. Well-preserved, undolomitized.



Exhumed Reef Knoll R10, Lowther Island, Disappointment Bay Fm.
(photos by Prosh,1989)



Steeply dipping, well-bedded reef-flank debris, i.e. F2A lateral subfacies



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Midnight Sun in Resolute

(anonymous photo)

References

AITKEN, S. A., C. M. HENDERSON, C. J. COLLOM, & P. A. JOHNSTON. 2002. Stratigraphy, paleoecology and origin of Lower Devonian (Emsian) carbonate mud buildups, Hamar Laghdad, eastern Anti-Atlas, Morocco, Africa. *Bulletin of Canadian Petroleum Geology*, 50(2):217-243.

BATHURST, R.G.C. 1980. Stromatactis-origin related to submarine-cemented crusts in Paleozoic mud mounds. *Geology*, v. 8, p. 131-134.

DE KAMP, E. A., C. GILBERT, and D. T. JAMES. 2006. Geology of Nunavut [Map]. Geological Survey of Canada, Canada-Nunavut Geoscience Office.

FRYDA, J., R. BLODGETT, and A. LENZ. 2002. New Early Devonian gastropods from the families Crassimarginatidae (New Family) and Scoliostomatidae (new family), Royal Creek area, Yukon Territory,Canada. *Journal of Paleontology*, 76(2):246–255.

FRYDA, J. and R. BLODGETT, 2008. Paleobiogeographic affinities of Emsian (late Early Devonian) gastropods from Farewell Terrane (west-central Alaska). *Geological Society of America Special Paper*, 442:107–120.

JOHNSON, J. C. 1975. Late Early Devonian Brachiopods from the Disappointment Bay Formation, Lowther Island, Arctic Canada. *Journal of Paleontology*, 49(6):947–978.

OGG, J., G. OGG, and F. GRADSTEIN. 2008. *The Concise Geologic Time Scale*. Cambridge University Press, 177 p.

RAASCH, G. O. 1982. Lower and Middle Devonian faunal zones in the Canadian Archipelago. *Proceedings of the Third International Symposium of Arctic Geology, Memoir*, 8.

RIDING, R. 2002. Structure and composition of organic reefs and carbonate mud mounds: concepts and categories. *Earth-Science Reviews*, 58:163-231.

SCOTESE, C. R. 2001. Atlas of earth history, volume 1, paleogeography, PALEOMAP Project, Arlington, Texas. 52 p.

SMITH, G. P. 1985. The distribution and significance of Lower Devonian carbonate buildups in time and space. *Bulletin of Canadian Petroleum Geology*, 33(4):479–482.

THORSTEINSSON, R. 1986. Geology of Cornwallis Island and neighboring smaller islands, District of Franklin, Northwest Territories. Geological Survey of Canada Map 1626A.

TORSVIK, T. H., and L. R. M. COCKS. 2013. New global palaeogeographic reconstructions and their generation, p. 5–24. *In*, Harper, D. A. T. and T. Servais (eds.), *Early Palaeozoic Biogeography and Palaeogeography*, Geological Societyof London, Memoir, 36.