Tectonically Influenced Platform Development in the Middle Devonian Winnipegosis Formation, Southwestern Manitoba

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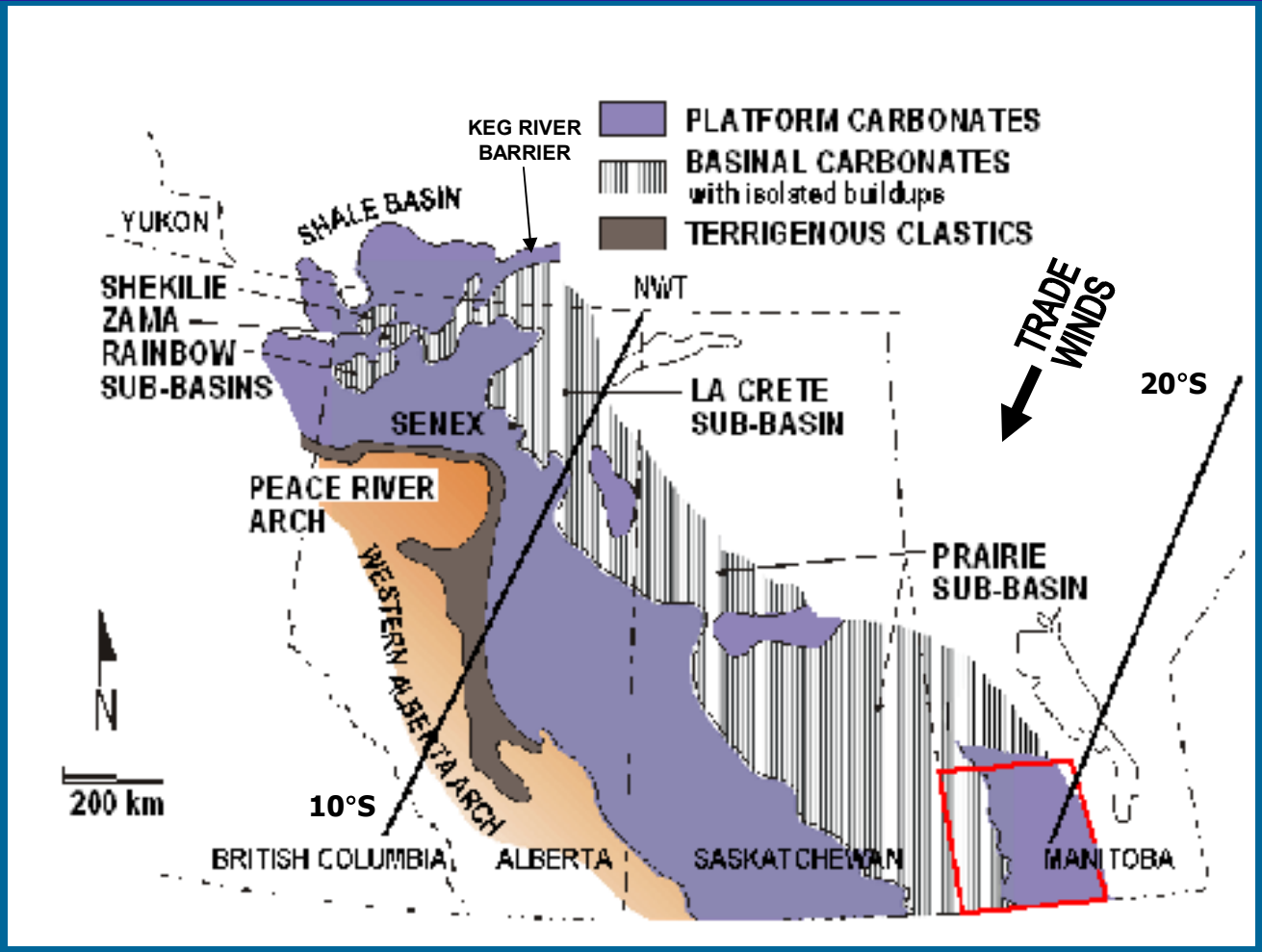
Outline

- Introduction
- Geologic Setting
- Part 1: Sedimentology
- Part 2: Organic Petrology of Bituminous Laminites
- Conclusions

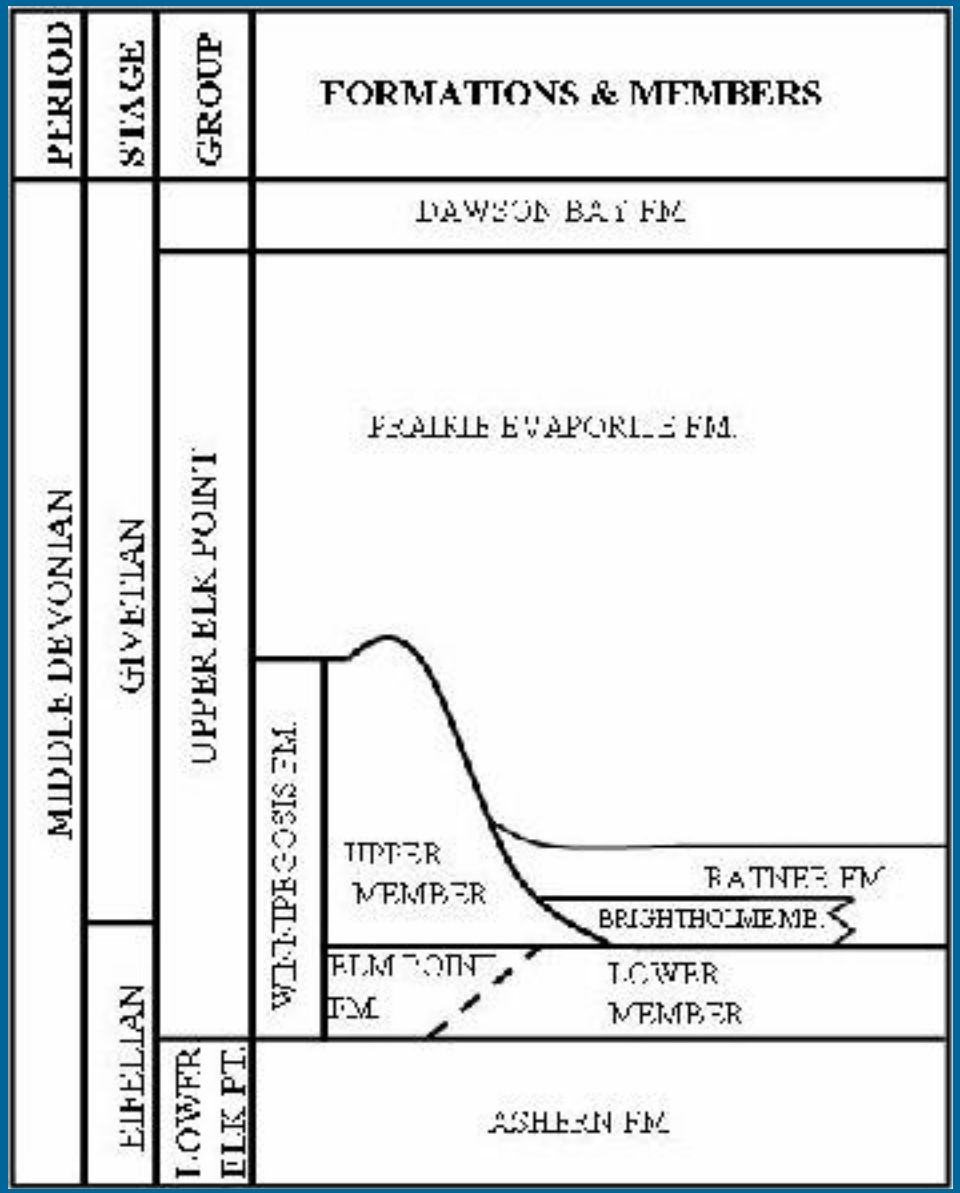
Introduction

- The occurrence of Devonian reefs in the subsurface of the Western Canada Sedimentary Basin has been of prime significance to the economy of western Canada.
- The Devonian System historically has been the most prolific oil producing interval in Western Canada.
- The Winnipegosis Formation and Devonian strata in general in Manitoba have been under-studied.

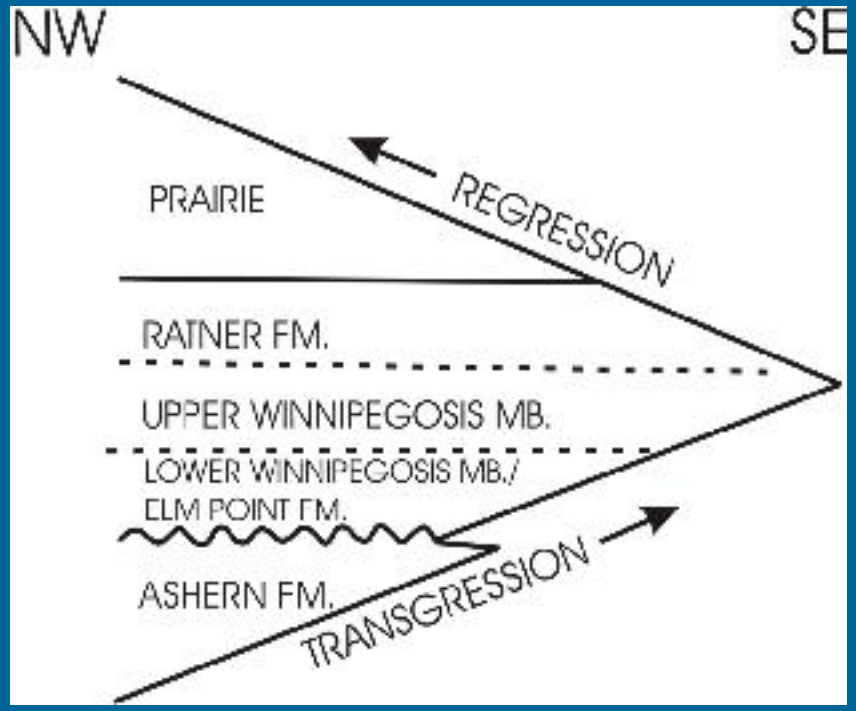
Geologic Setting



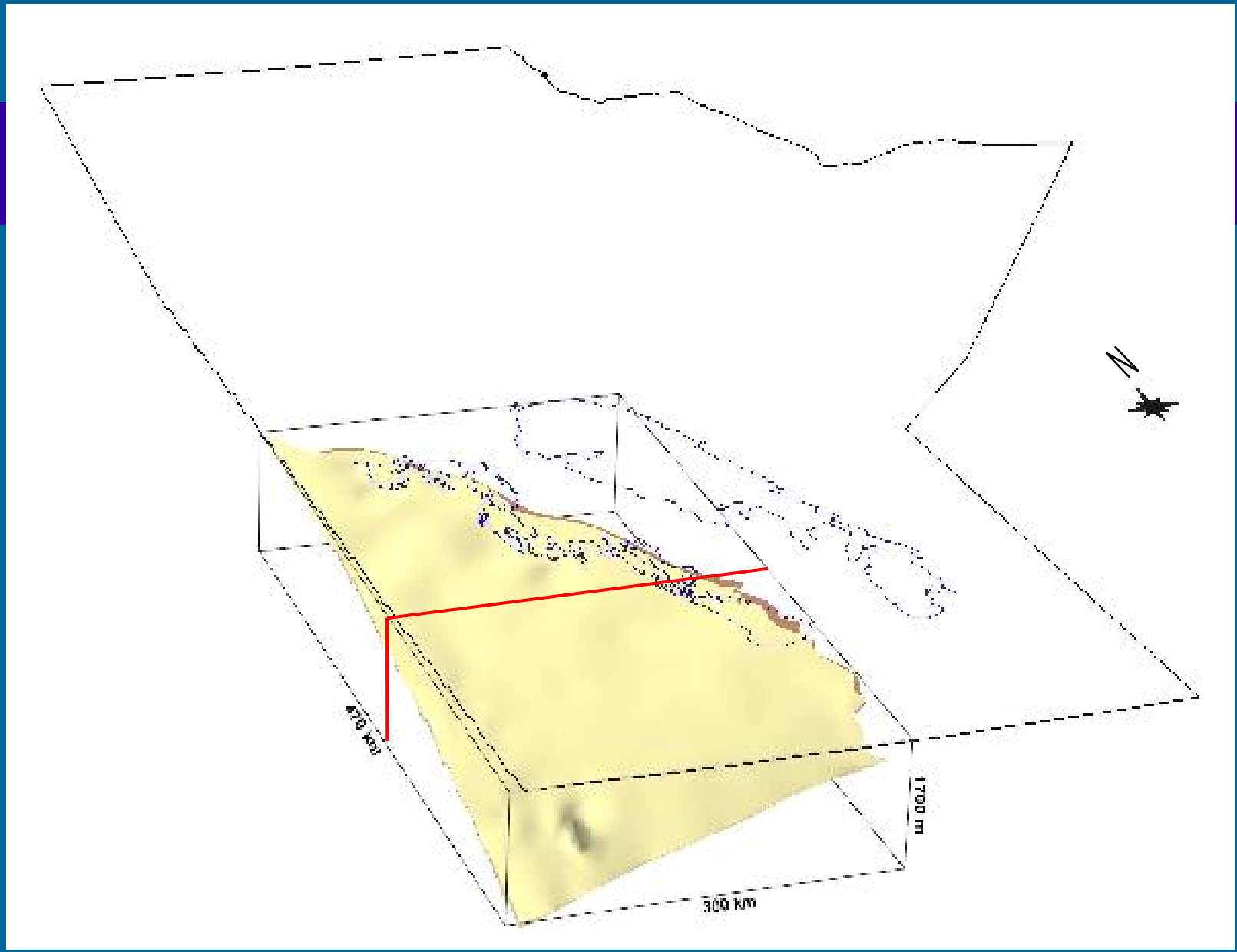
Paleogeographic map of the Elk Point Basin (from Chow et al., 1995). Paleolatitude lines and tradewind direction from Heckel and Witzke (1979).



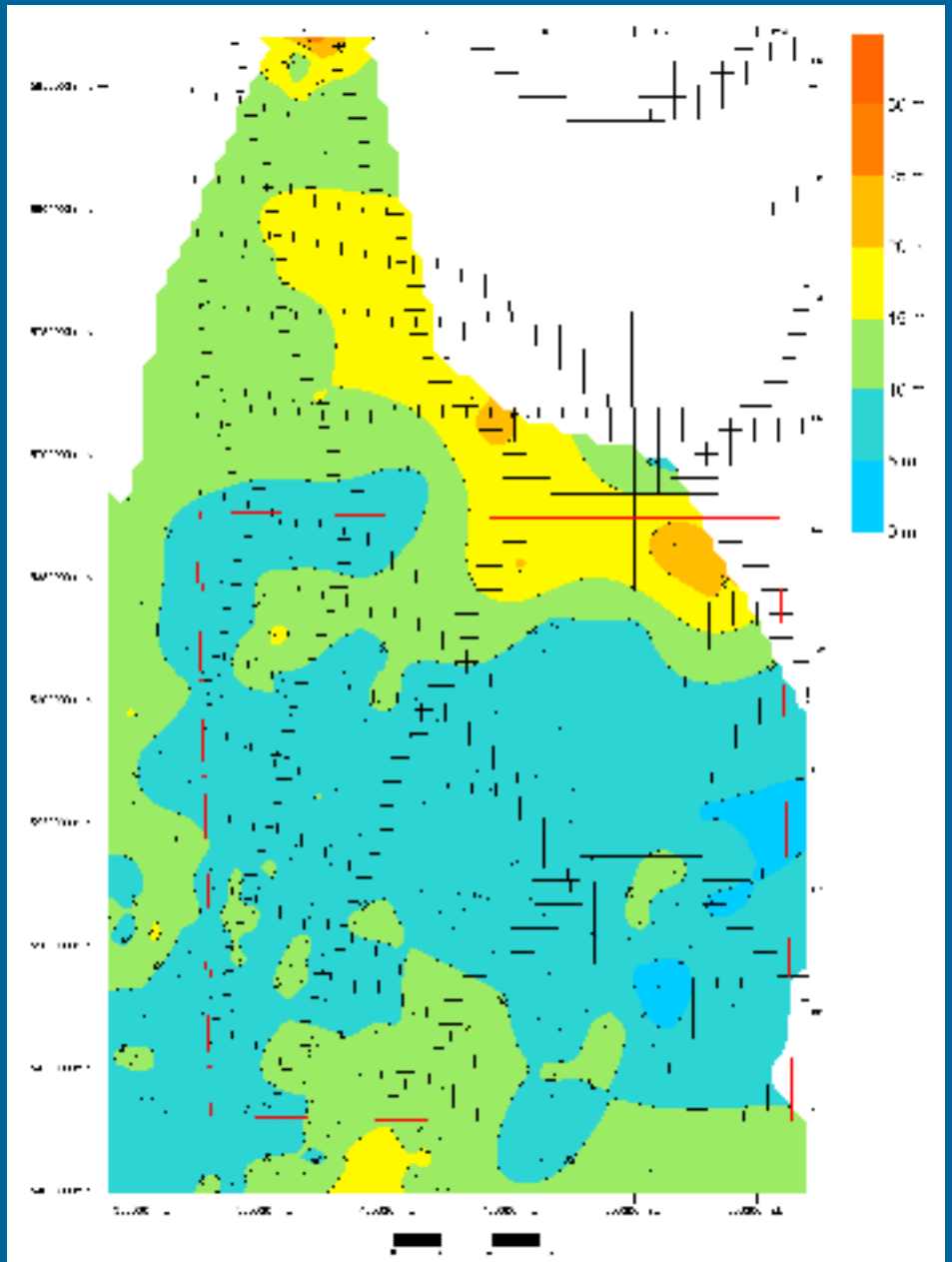
Stratigraphic column of the Elk Point Group (modified from Reinson and Wardlaw, 1972; Norris et al., 1982; Jin and Bergman, 2001).



Schematic representation of deposition (modified from Perrin, 1982).

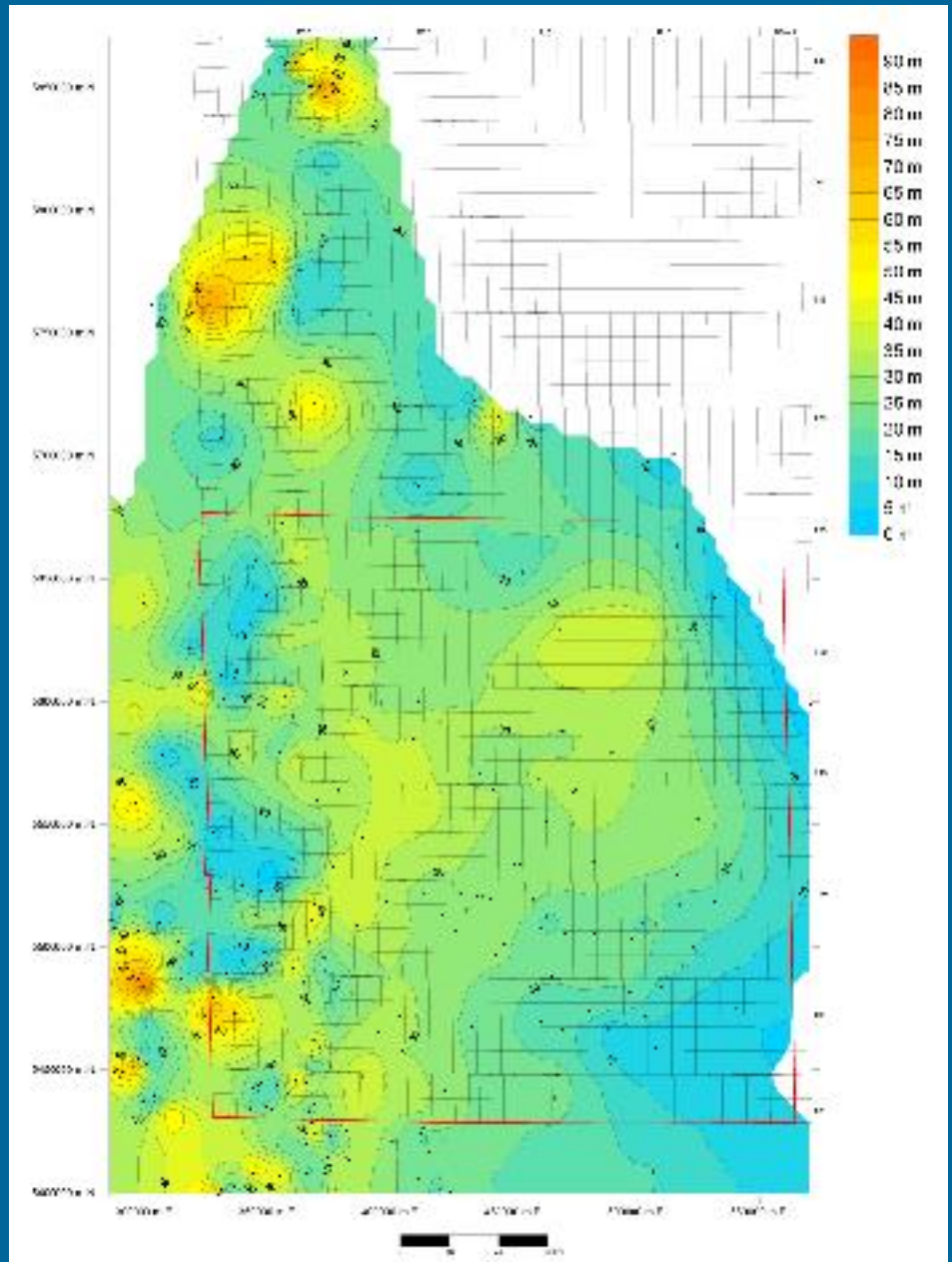


3D diagram illustrating the present configuration of the Winnipegosis Formation (G. Keller and G. Matile, unpublished data, 2006). V.E. 50X



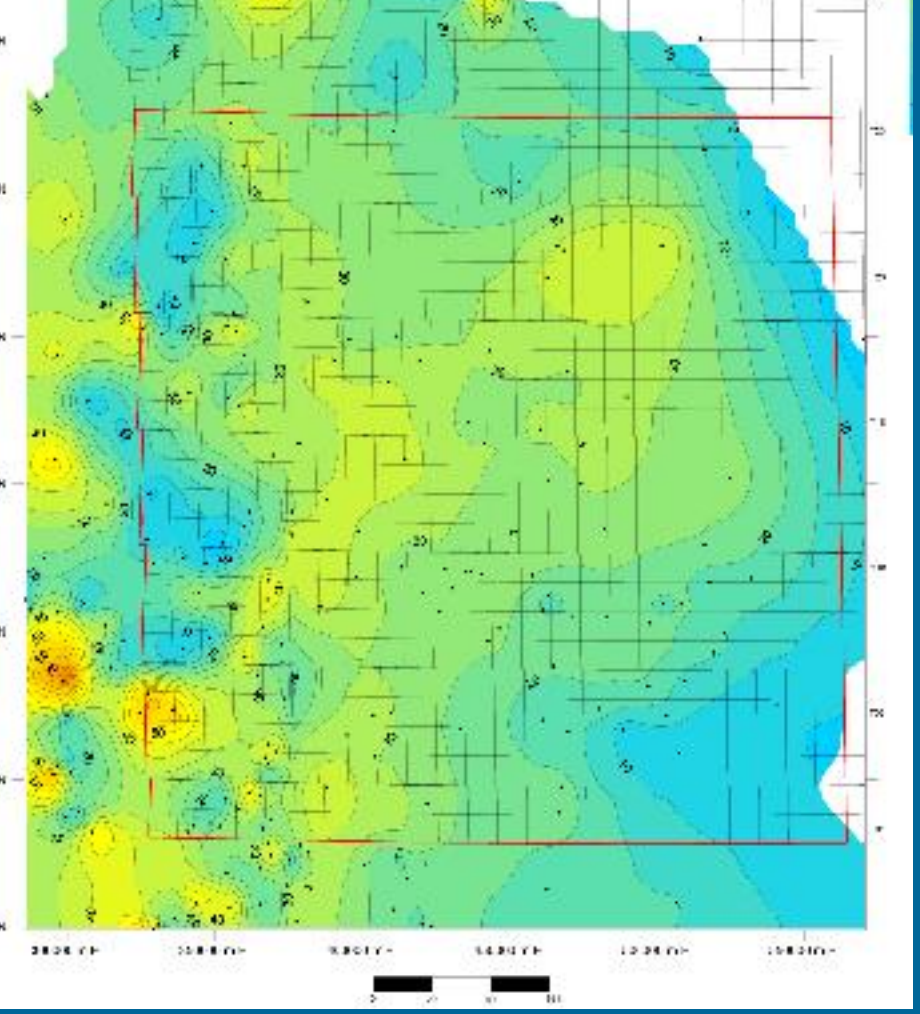
Winnipegosis Formation (Lower Member) Isopach Map

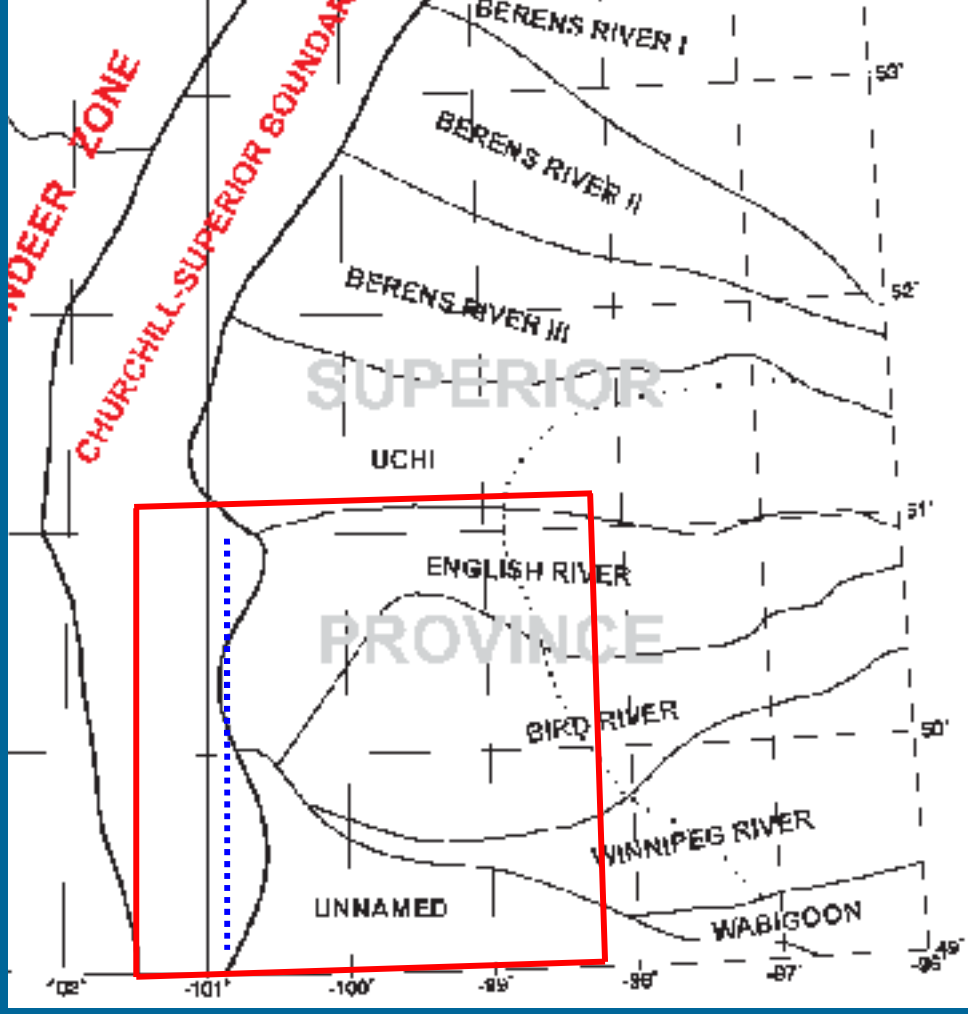
Projection: UTM, Zone 14U, NAD 83.
Isopach contour interval: 5 m.
Study area outlined in red.



Winnipegosis Formation (Upper Member) Isopach Map

Projection: UTM, Zone 14U, NAD 83.
Isopach contour interval: 5 m.
Study area outlined in red.

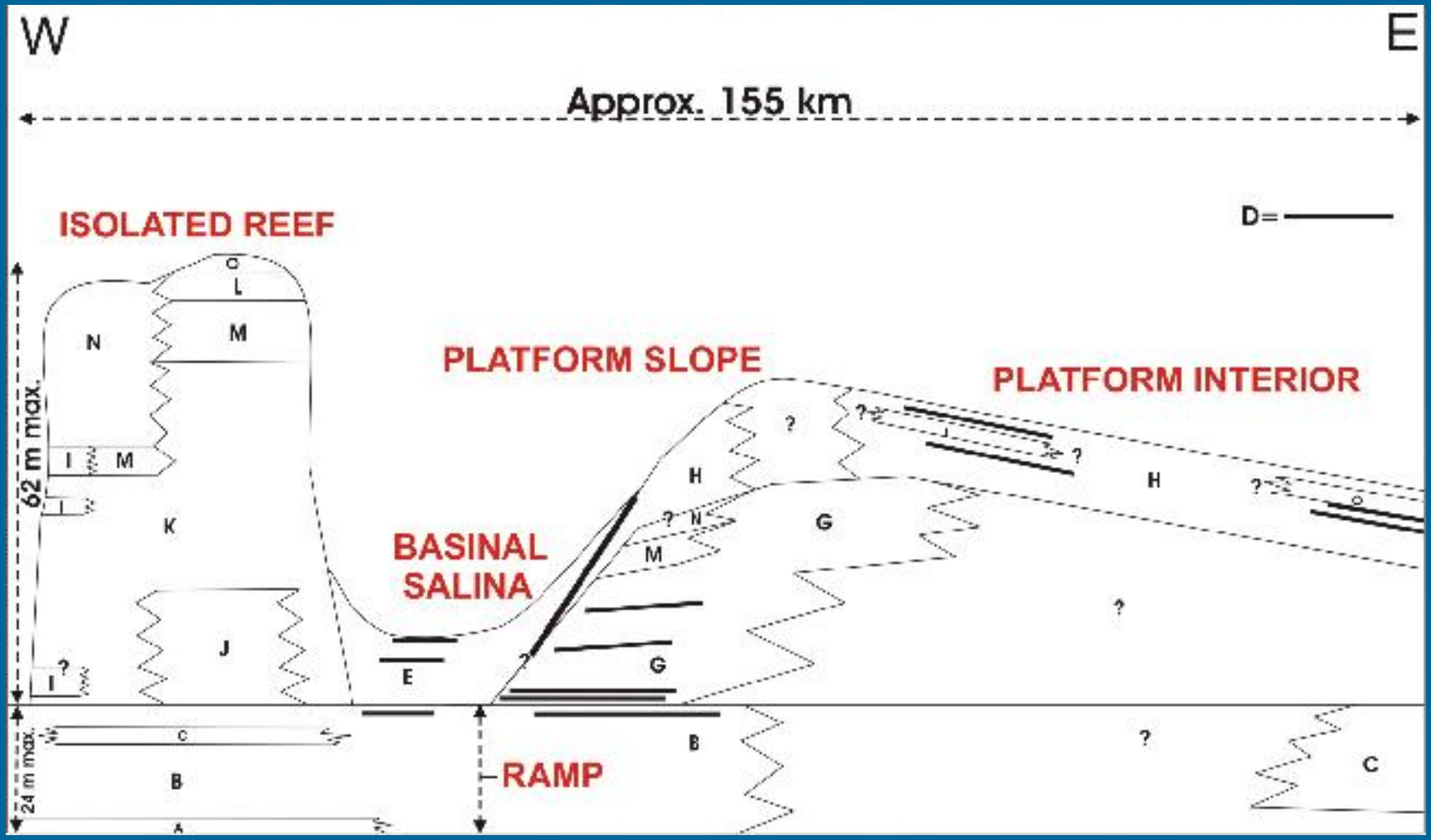




Modified from TGI II (http://www.gov.mb.ca/stem/mrd/geo/willistontgi/downloads.html).

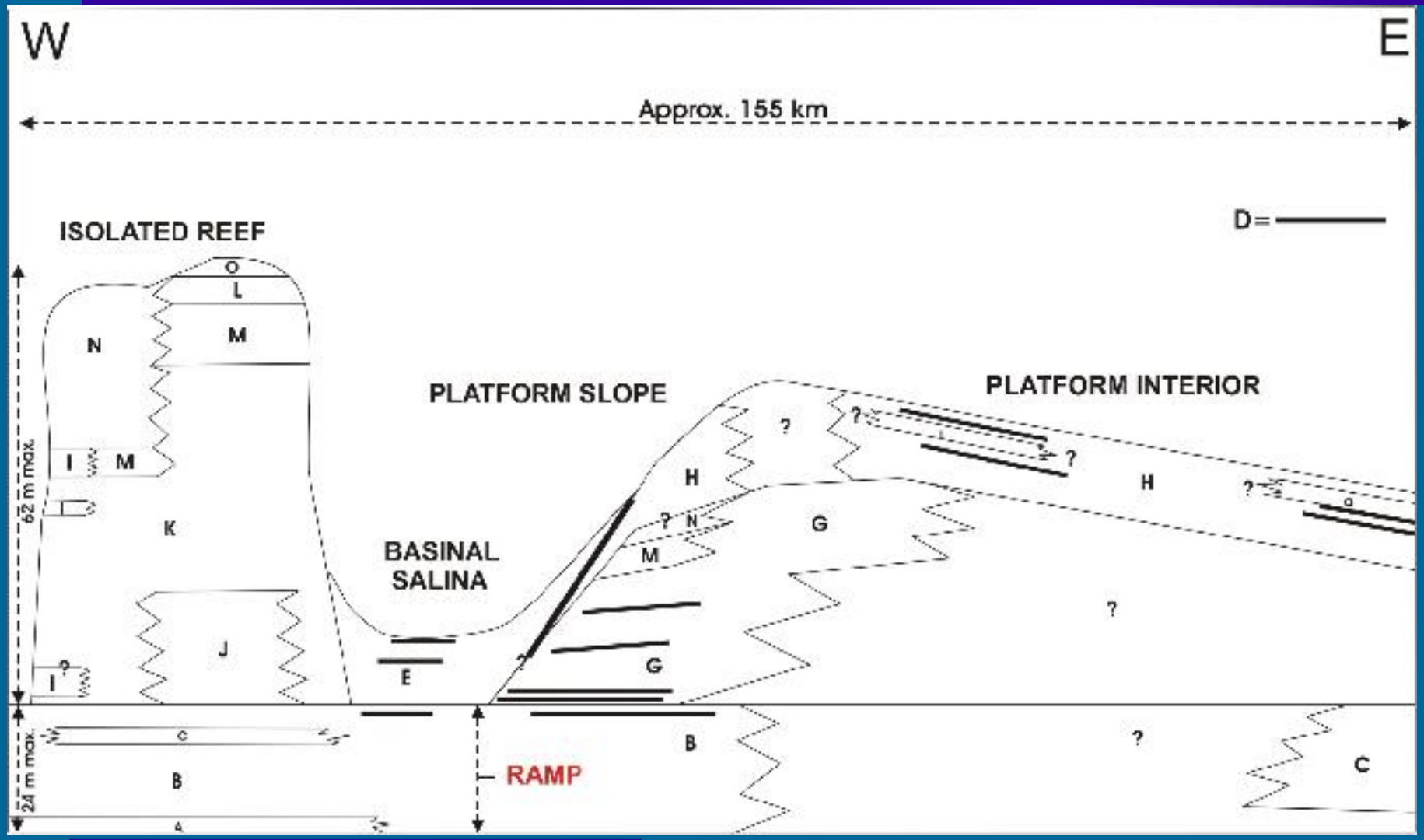
- Western platform margin = Birdtail – Waskada axis.
- Northern platform margin = English River – Uchi domain contact.
- Basin differentiation tectonically controlled?

Part 1: Sedimentology



- Fifteen lithofacies identified from cores/thin sections.
- Lithofacies grouped into five lithofacies associations.

Ramp Lithofacies Association



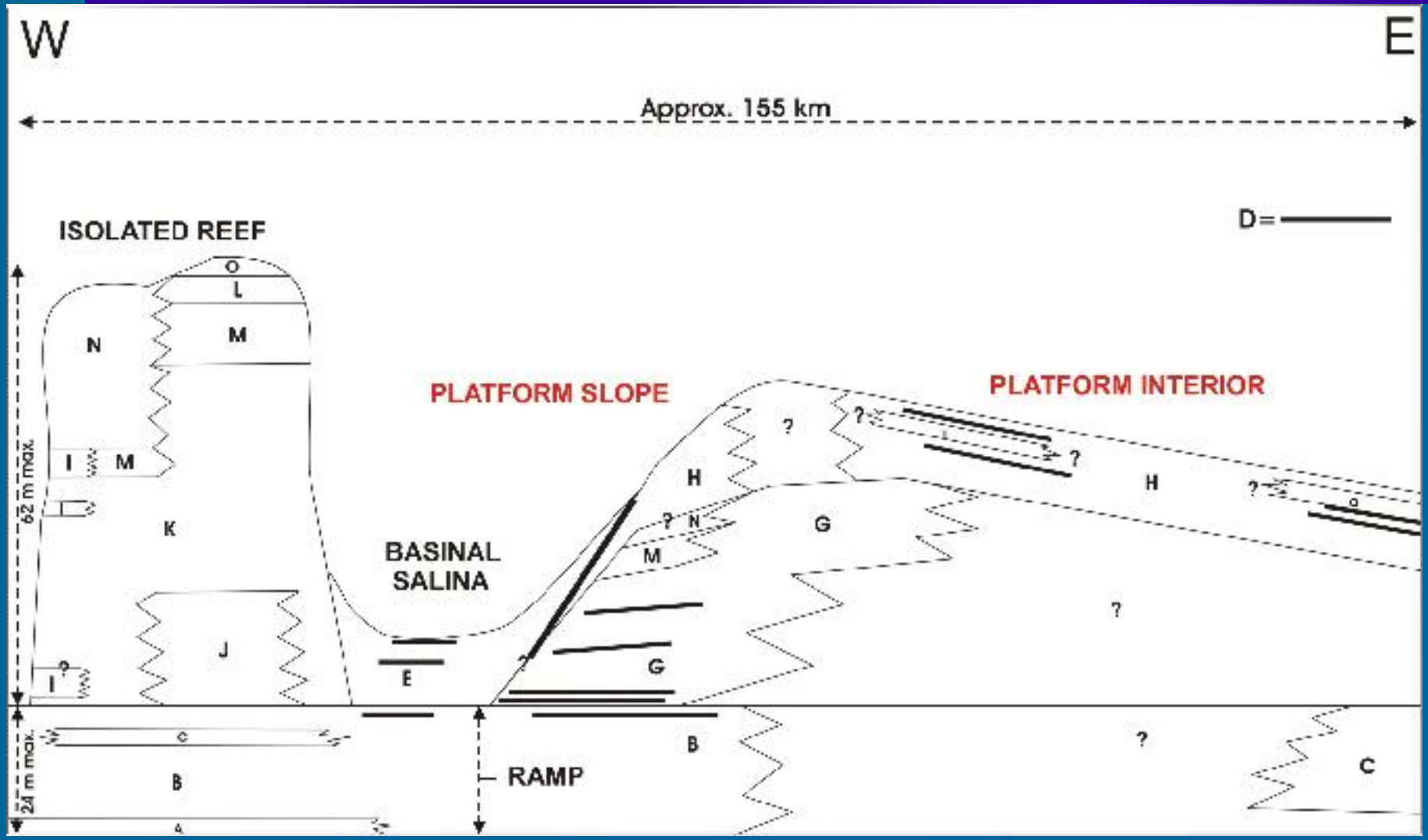
Lithofacies B: Mottled-Nodular Skeletal Wackestone-Mudstone

•Elm Point Formation

•Lower Winnipegosis Member

- Most common facies, up to 24 m thick.
- Dominantly crinoid & brach. fragments where present.
- Variable arg./bit. content.
- Open subtidal environment.

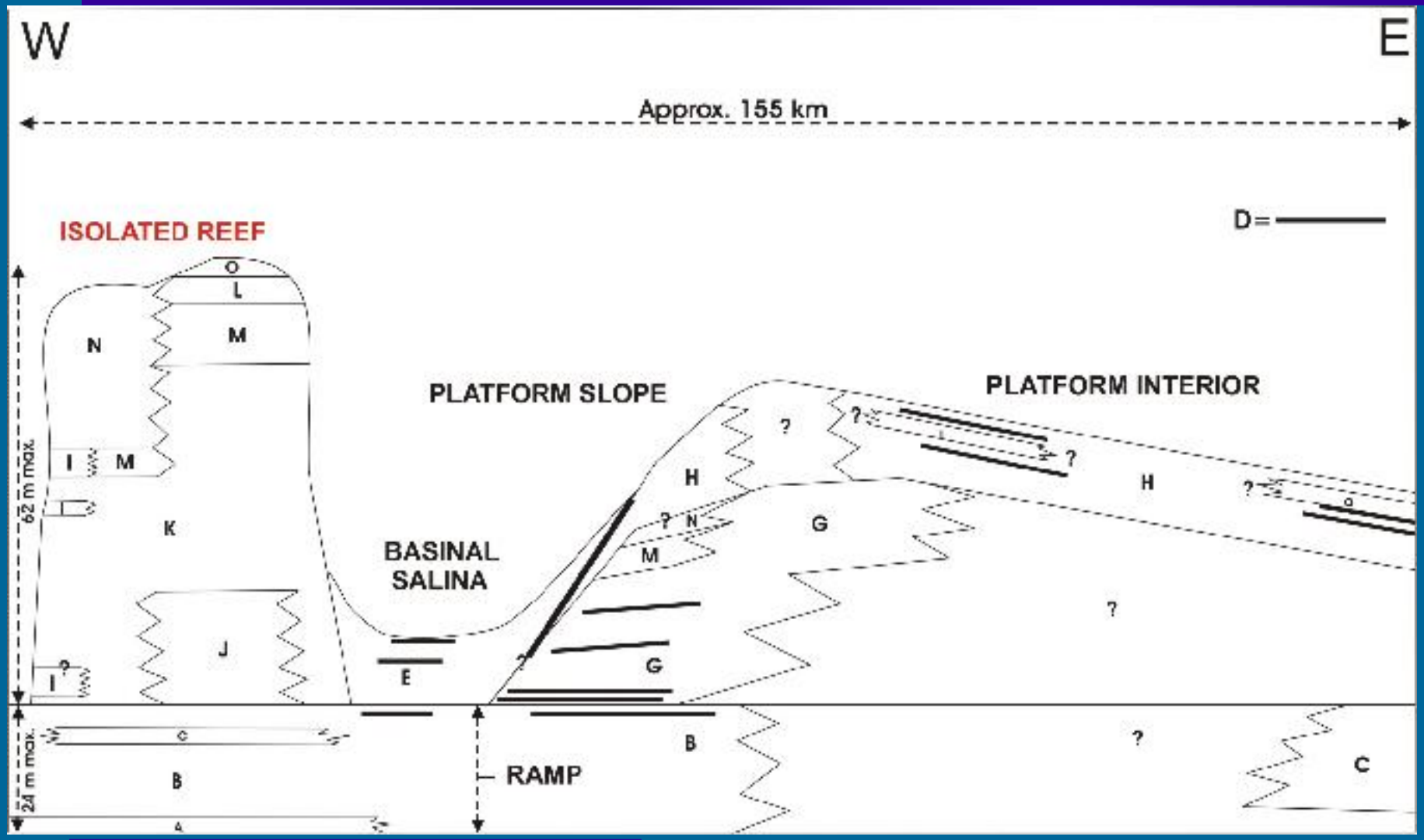
Platform Slope & Interior Lithofacies Associations

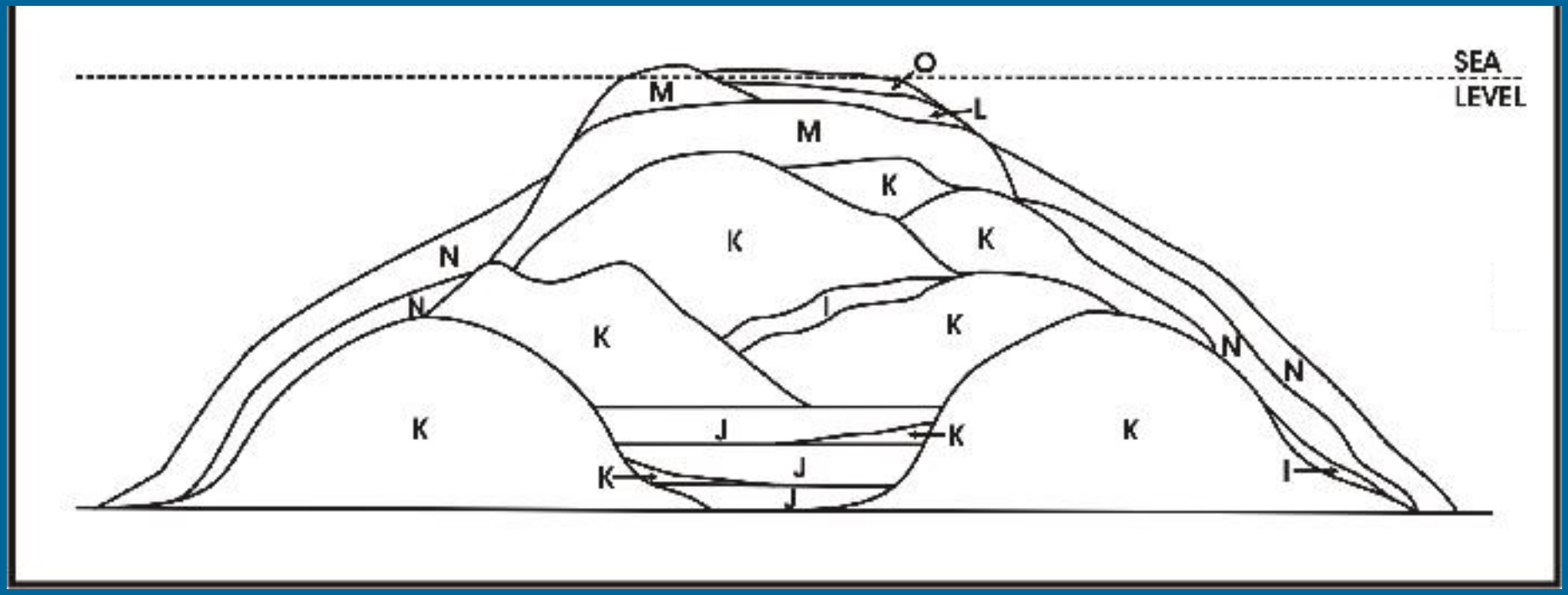


Lithofacies H: Bedded-Mottled Peloidal Packstone

- Dominantly peloidal, minor skeletal components.
- Laminated to thickly bedded, locally mottled.
- 0.2 to >26 m thick.
- Variably bituminous.
- Dominant facies in platform interior & upper half of platform slope successions.
- Low energy, subtidal setting between fair-weather and storm wave base, open to slightly restricted.

Isolated Reef Lithofacies Association



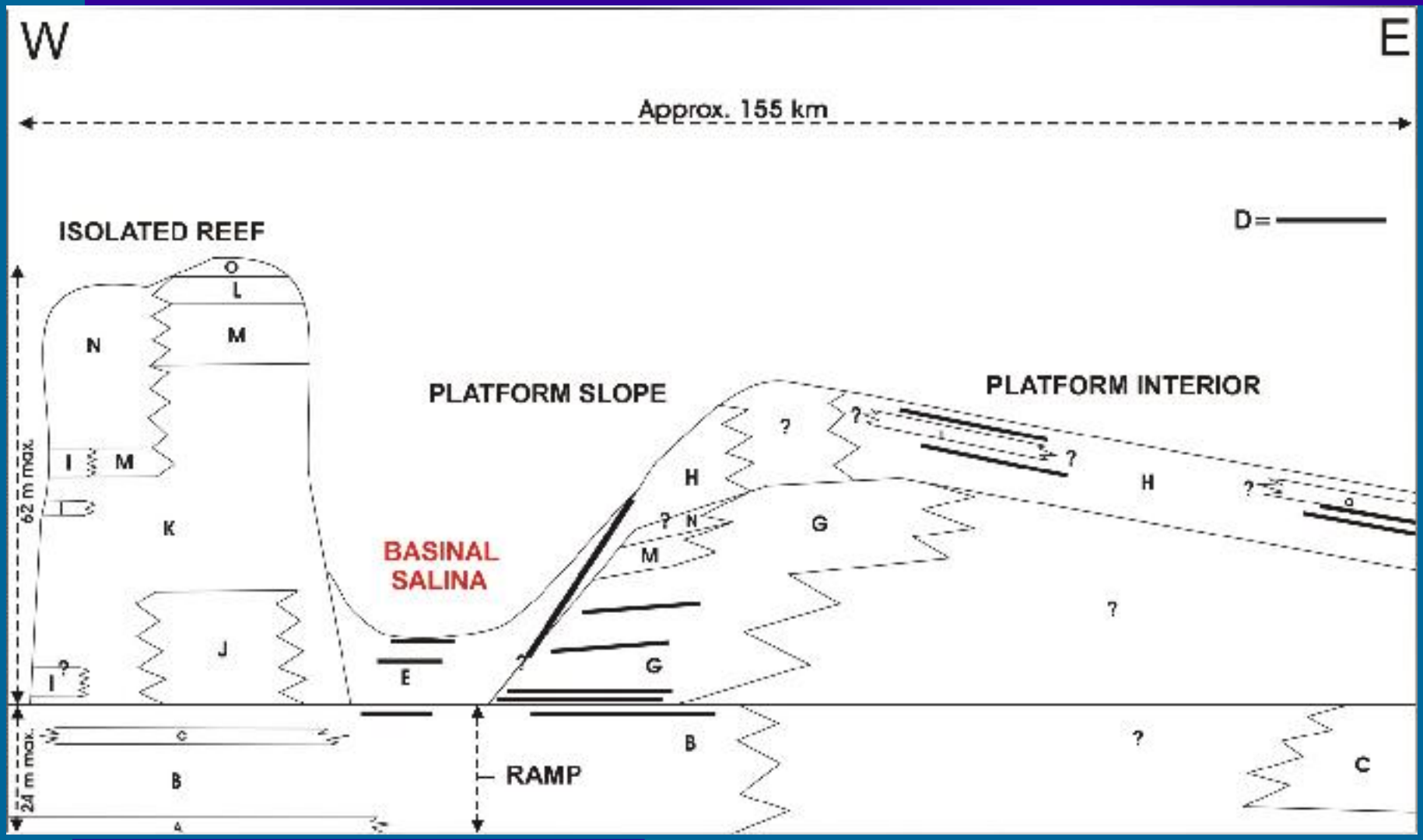


Isolated Reef (study area)

Lithofacies M: Coral – Stromatoporoid Rudstone - Framestone

- Massive tabulate coral & encrusting/tabular stromatoporoid fragments.
- 0.2-4.7 m thick.
- Normal marine, moderate to high-energy, subtidal environment above fair-weather wave base.

Basinal Salina Lithofacies Association



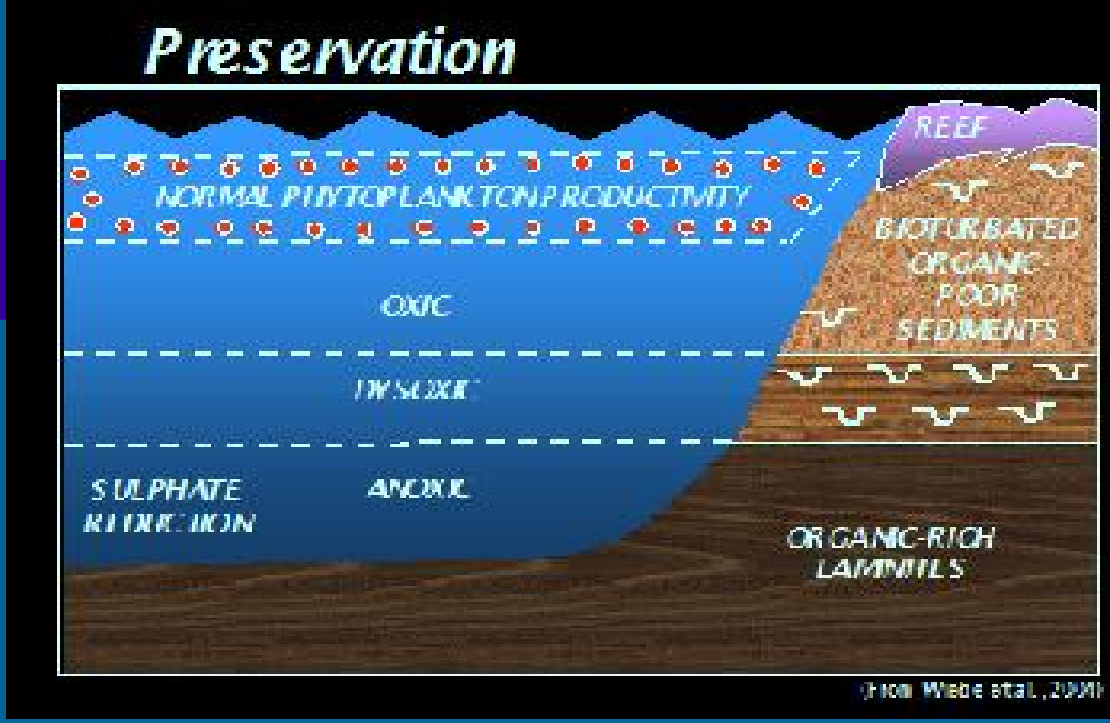
Lithofacies E: Interlaminated Mudstone -Anhydrite

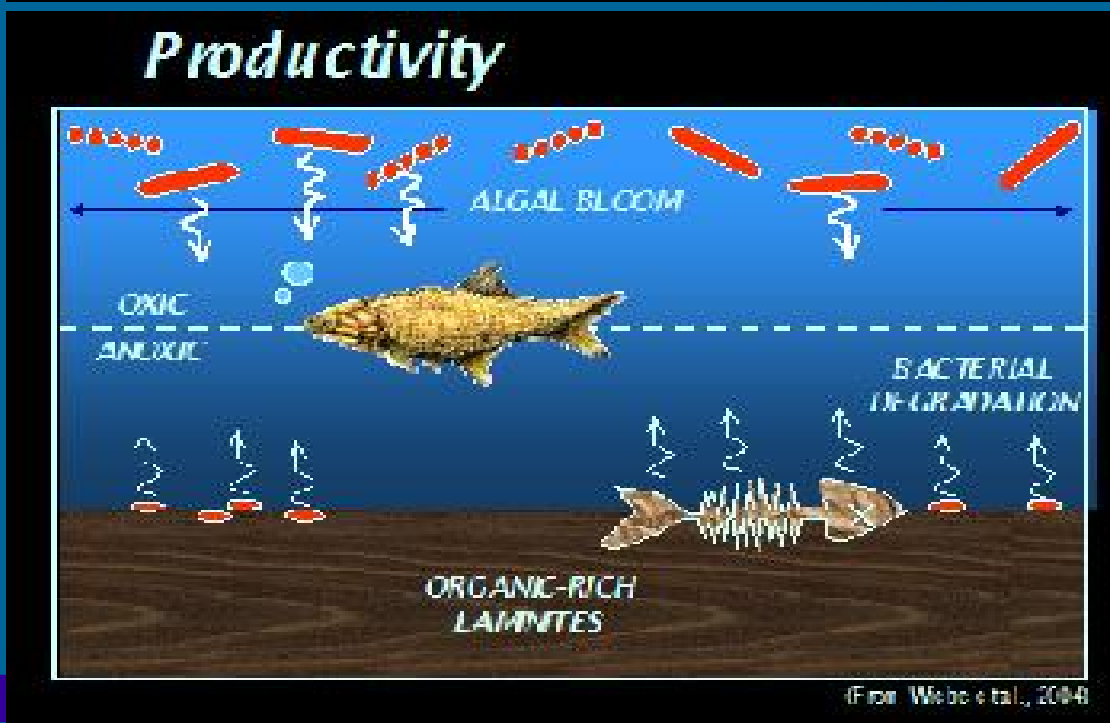
- Dominantly mudstone at base, dominantly anhydrite at top.
- 0.2-6.5 m thick.
- Best developed in truly basinal areas, weak expression on platform slope.
- Evaporitic lagoonal/salina environment.

Part 2: Organic Petrology of Bituminous Laminites

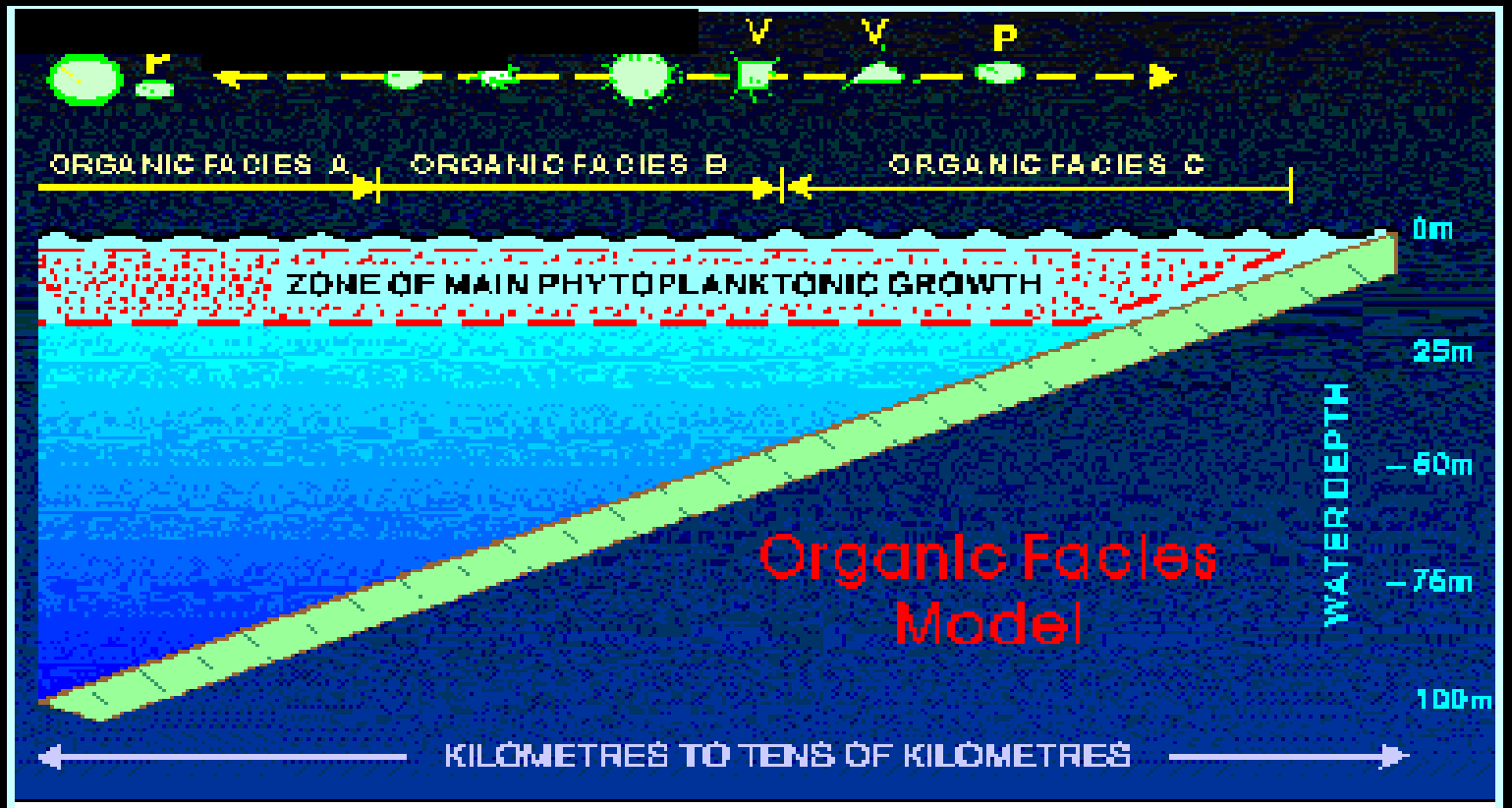
- Organic petrology - the branch of geology dealing with the origin, occurrence, structure, and history of sedimentary organic matter.
- Whole rock samples mounted in epoxy resin to form pellets.
- Pellets are ground and polished.
- Incident light, oil immersion microscopy using UV fluorescence and reflected white light.
- Macerals are the microscopically identifiable, individual components of organic matter which are analogous to minerals in rocks.

- Organic petrology can help determine primary control on organic matter accumulation (preservation vs. productivity).





Organic Facies (normal productivity)



(From Wiebe et al., 2004)

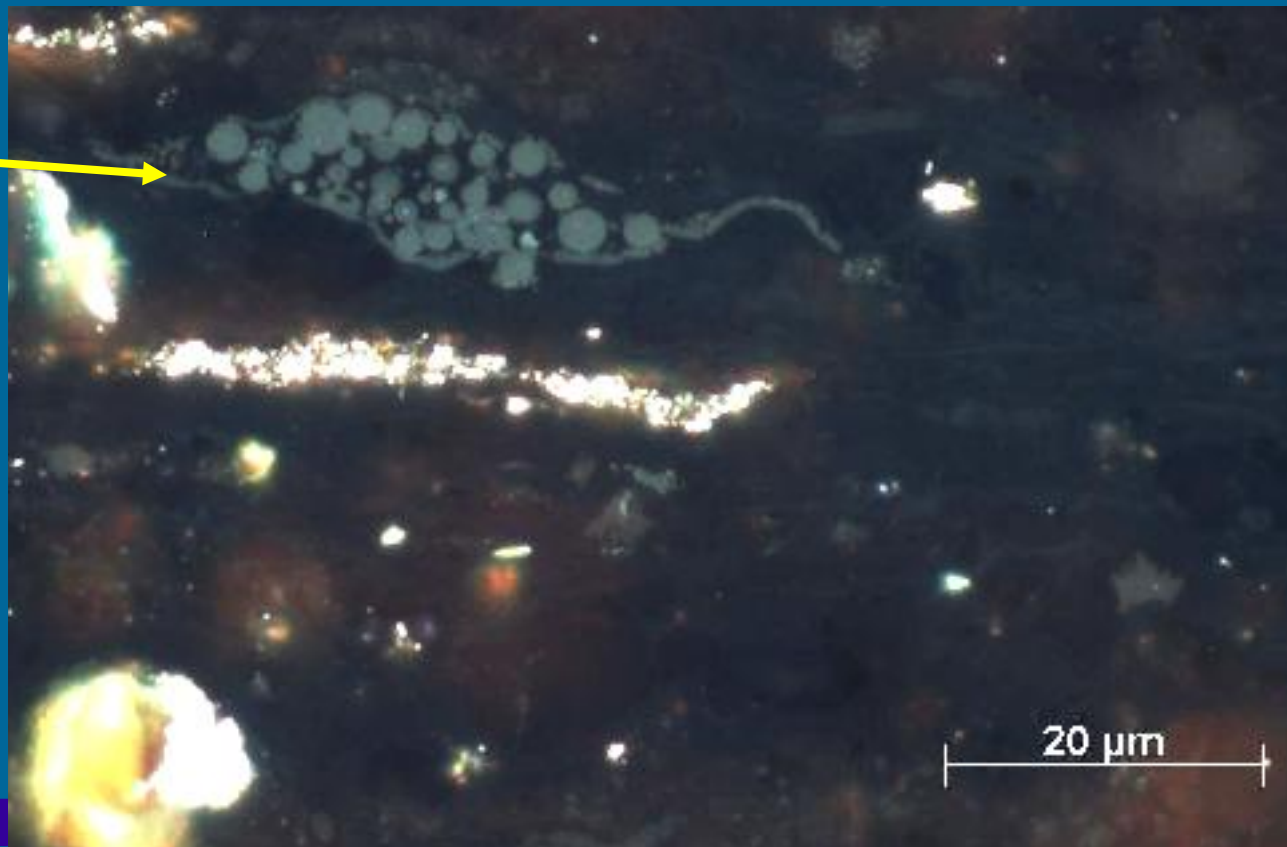
Key Macerals in the Winnipegosis Formation

Maceral Group (after ICCP)	Maceral	Maceral Variety
Liptinite	sporinite	
	amorphinite	hebamorphinite fluoramorphinite
	alginite	prasinophytes filamentous
	acritarchs	
Zooclast (informal group)	chitinozoan conchostracan cricoconarids	

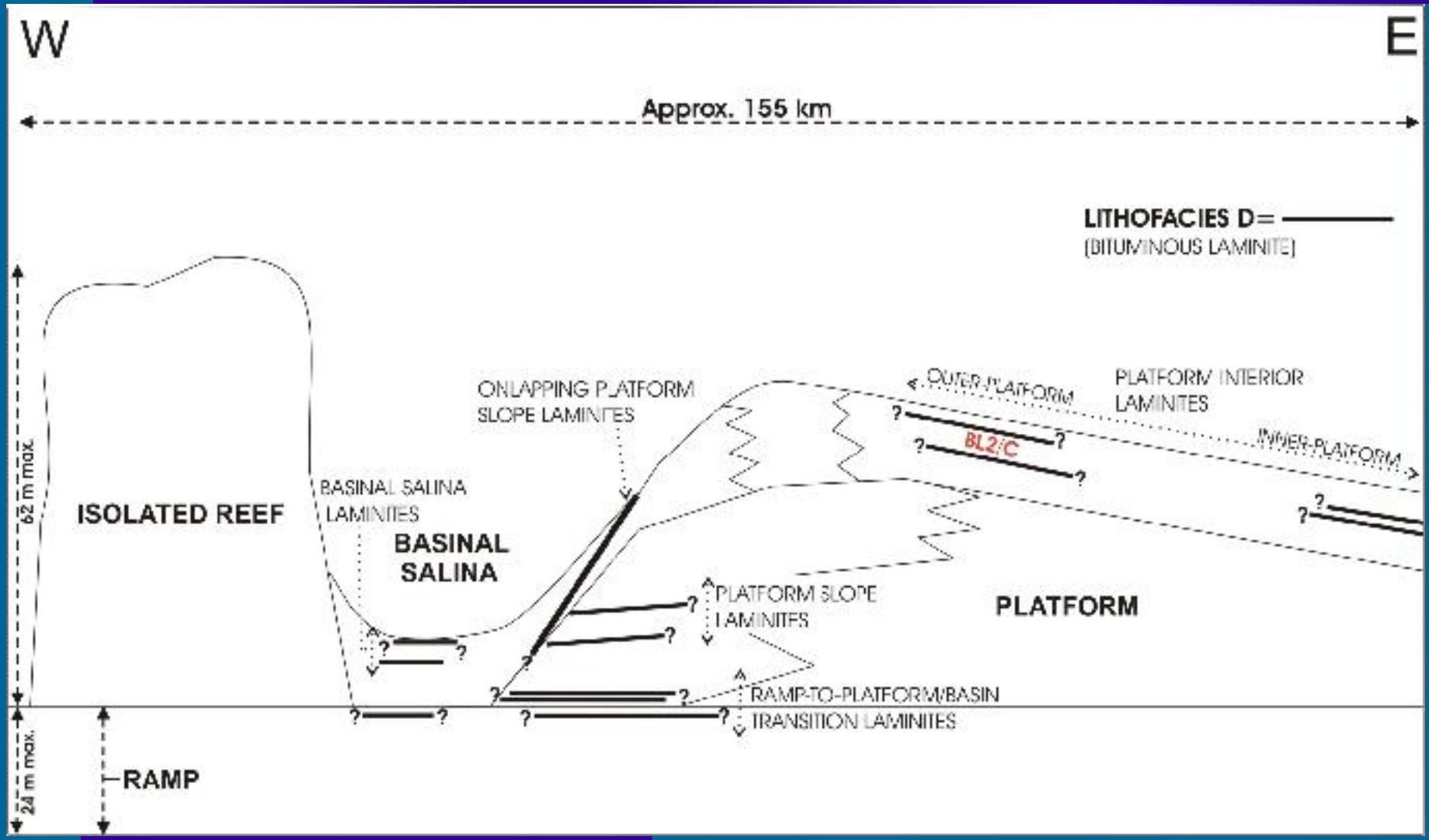
Modified from Stasiuk,

Bloom Facies (elevated productivity).

- Large prasinophytes in shallow water.
- Akinete cells.
- Abundant zooclasts.



Example 1: Platform Interior Laminite



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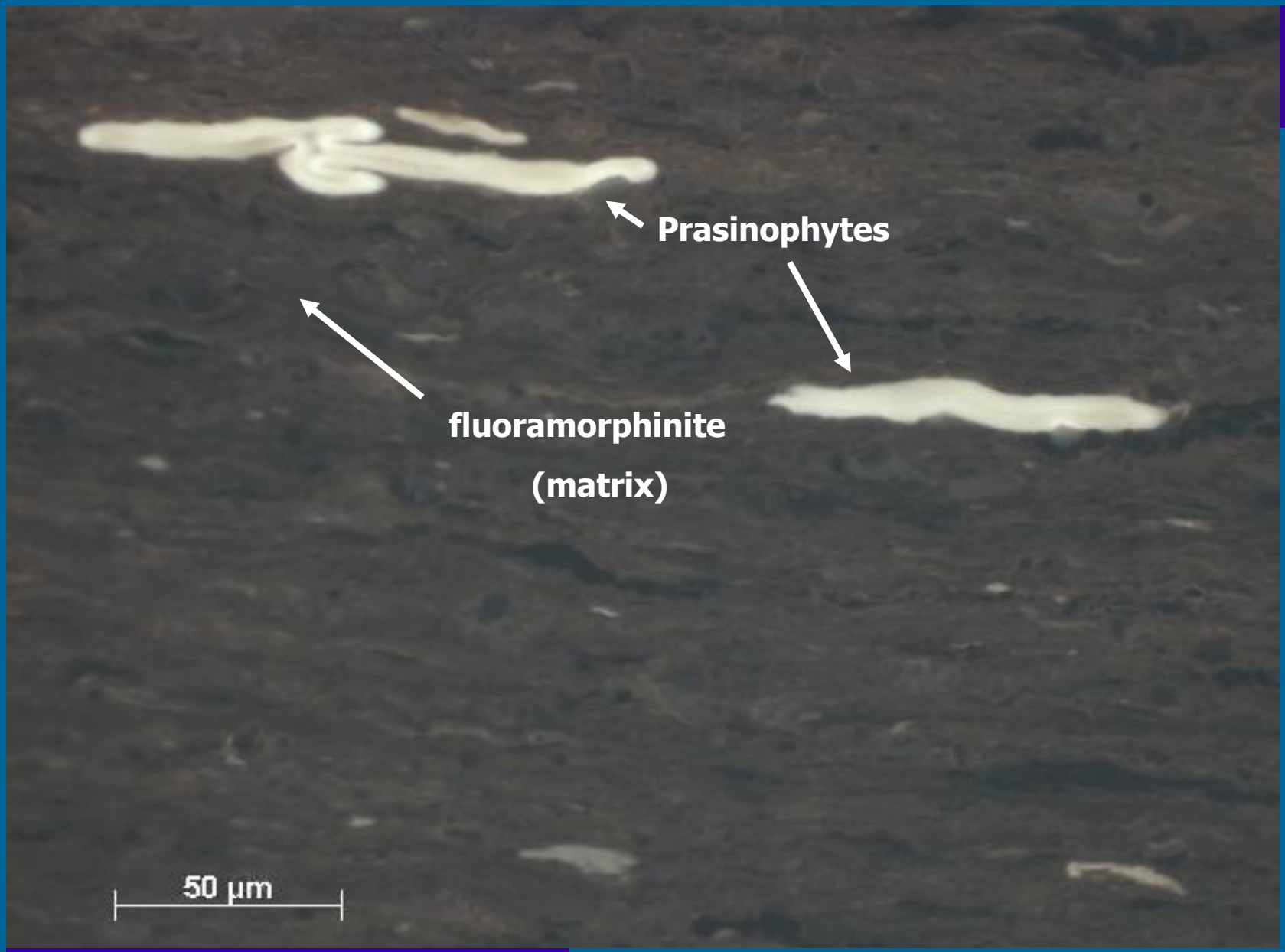
TOC=6.77%

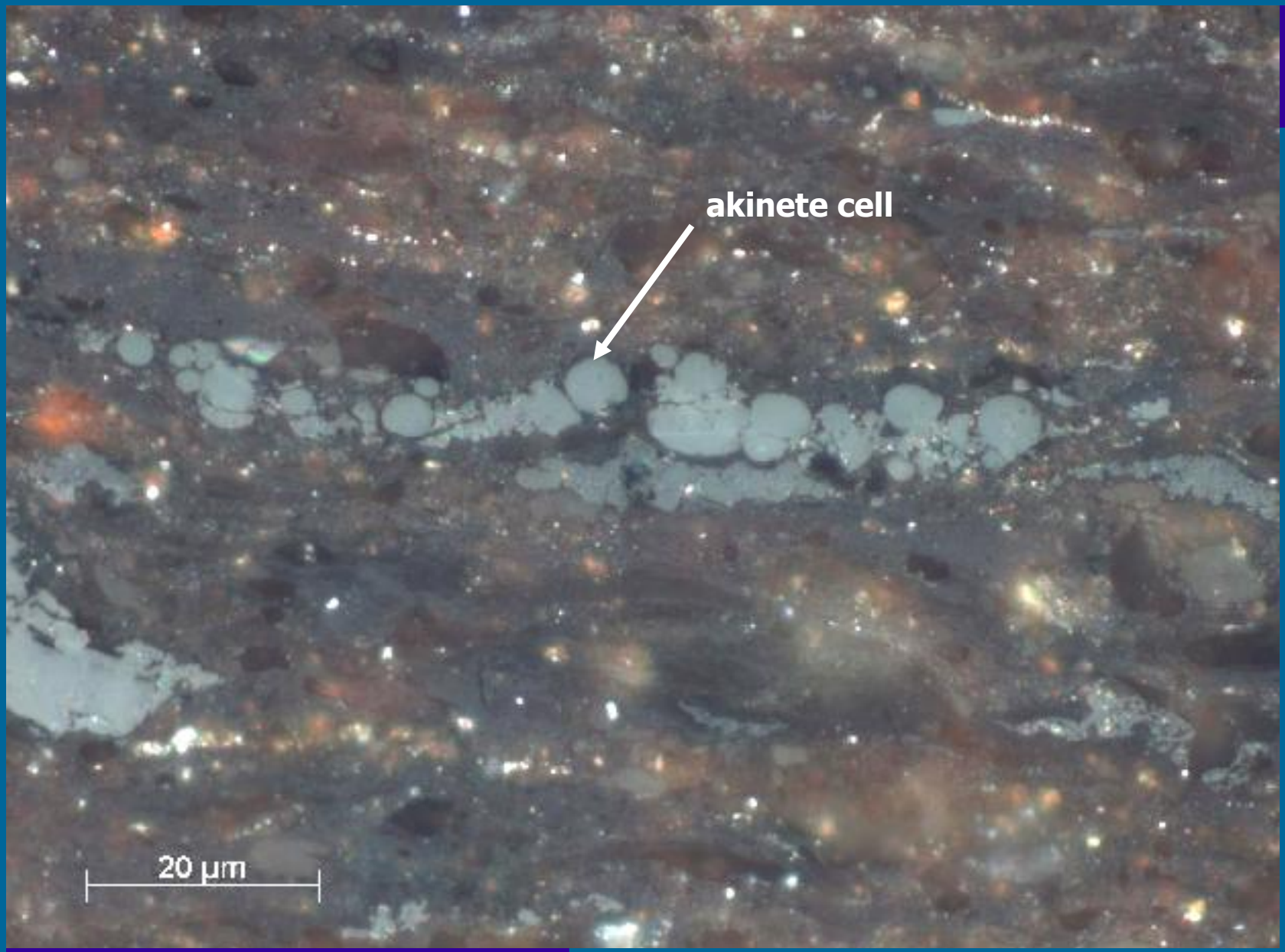
1154 m depth

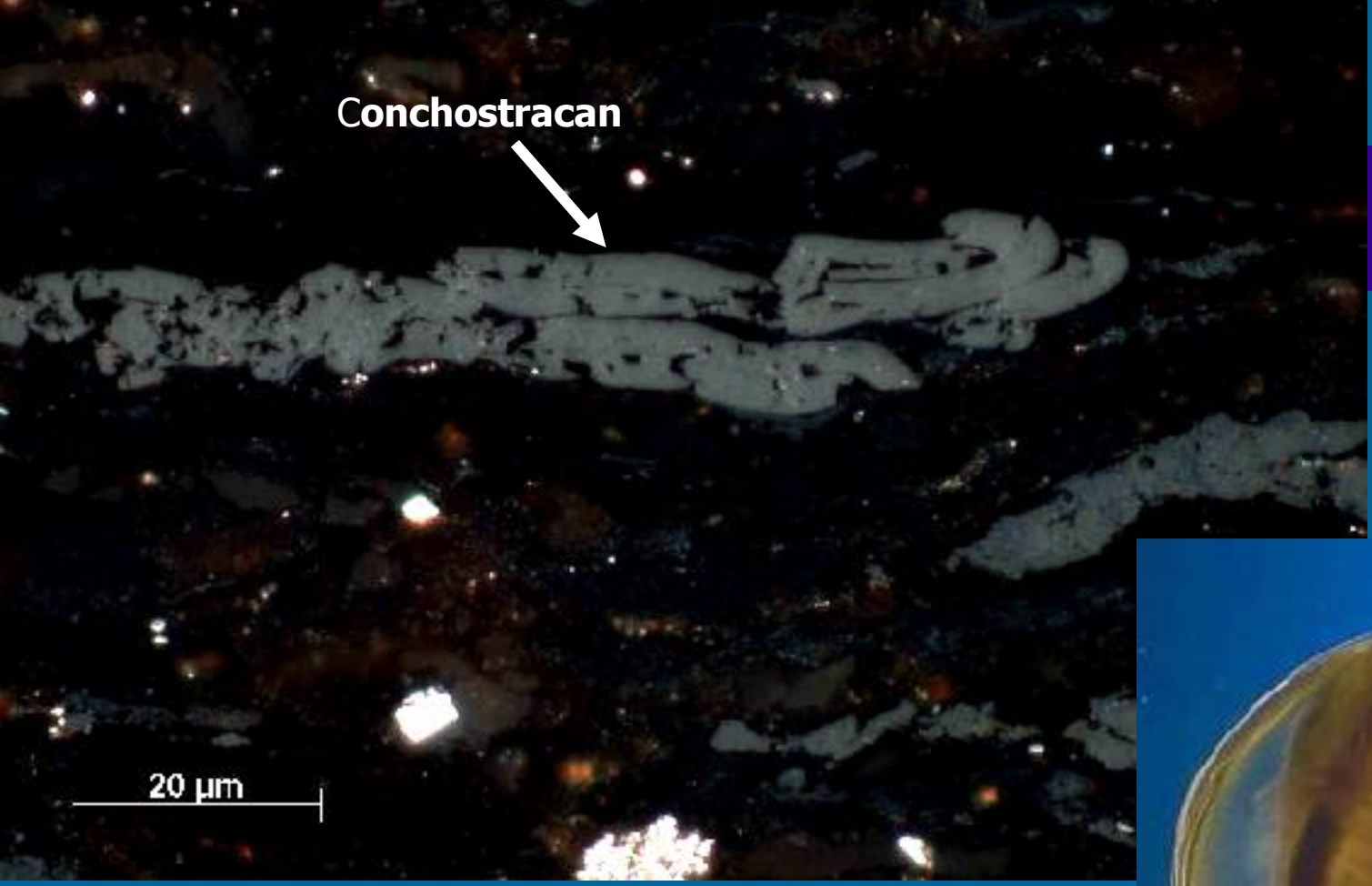
- Primary Organic Facies: BL2 (bloom).
- Secondary Organic Facies: C (near shore).

UV Fluorescence



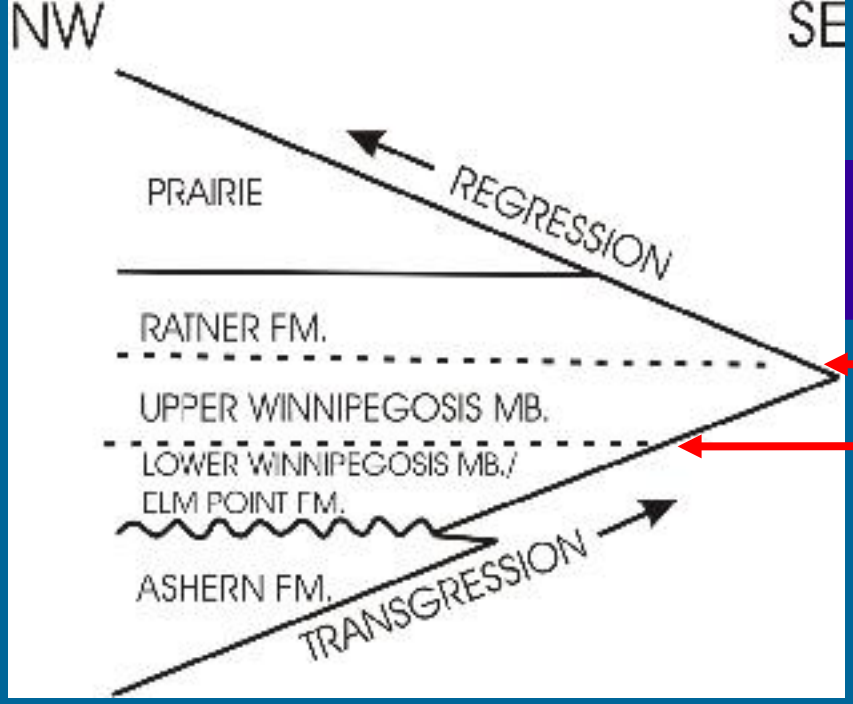
Reflected Light





Extant clam shrimp (Conchostraca)

(From BioMEDIA Associates, ebiomedia.com.)



Schematic representation of deposition (modified from Perrin, 1982).

BLOOM TRIGGERS

Regression= ↑ salinity?

Transgression & Basin Differentiation=

↑ nutrients & Δ circulation pattern?

- Algal blooms are transient in time & space.
- Bituminous laminites (source rocks) in the Winnipegosis/Elm Point Formation should not be assumed to be stratigraphically correlative, nor maximum flooding surfaces.

Conclusions

- Fifteen lithofacies were grouped into five lithofacies associations.
- The ramp association comprises the Lower Winnipegosis Member/Elm Point Formation & represents a carbonate ramp succession.
- The platform interior & platform slope associations comprises the Upper Winnipegosis Member in part & represents a fringing carbonate platform succession.
- The carbonate platform may have had tectonically imposed outer boundaries.
- The isolated reef association comprises the Upper Winnipegosis Member in part & represents isolated reef successions in basinal areas.

- Isolated reef associations are problematic.
- The basinal salina association comprises the Ratner Formation & represent an evaporitic salina succession.
- Almost all bituminous laminites in study area show evidence for a bloom origin (productivity=primary control on accumulation & preservation).