# A Tale of Two Saddle Dolomites:
# Research Continued from Earlier Work with Professor Mountjoy*

**Hairuo Qing**[1]

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## Abstract

Saddle dolomite can be associated with hydrothermal fluids, as illustrated in the Middle Devonian Pres'quile barrier reef complex, the study of which was my PhD project under the supervision of Professor Mountjoy. In this case, saddle dolomite and associated dolomitization are interpreted to be formed by hydrothermal fluids expelled by tectonic compression and sedimentary loading along the western margin of the Western Canada Sedimentary Basin. This interpretation is supported by the regional occurrence of saddle dolomite along the barrier and the corresponding trend of Sr isotopes (0.7081 to 0.7106), O isotopes (-7‰ to -16‰ PDB) and homogenization temperatures of fluid inclusions (92 to 178$^{o}$C) that exceed the ambient regional burial temperatures (60 to 160 $^{o}$C).

Saddle dolomite cement in the Ordovician Red River carbonate southeastern Saskatchewan, however, (1) is restricted to the host replacement dolomites; (2) has C isotope values (-0.2 to 0.9 ‰ PDB) overlapping with those of their host dolomite, all of which fall within the range of the expected value of Ordovician seawater; (3) produces Sr isotopic ratios (0.7082 to 0.7090) similar to those of its host replacement dolomites; and (4) displays relatively low homogenization temperatures (about 100 $^{o}$C) that can be related to the normal burial temperatures in the region. In this case, saddle dolomite cement is interpreted to be related to cannibalization of earlier replacement dolomite through chemical compaction in a relatively closed system during burial. The occurrence of saddle dolomite, therefore, is not necessarily indicative for hydrothermal activity or fluid flow.


# A tale of two saddle dolomites: research continued from earlier work with Professor Mountjoy

*Hairuo Qing*
*University of Regina*

**Notes by Presenter Below**

# Outline

- Saddle dolomite commonly formed at relatively high T that can be associated with **hydrothermal fluids**

  Case study 1: M. Devonian Presqu'ile barrier reef.

- However, **non-hydrothermal saddle dolomites** can also be precipitated during burial.

  Case study 2: Ordovician Red River carbonates in SE Saskatchewan.

- **Conclusion**: Not all saddle dolomites are necessarily related to hydrothermal fluids.

**Notes by Presenter**

**Note high Sr in dolomite suggest recrystalization in a open system (due to high K in dolostones);**

**Low Sr in limestone indicate recrystalization in a closed system.**

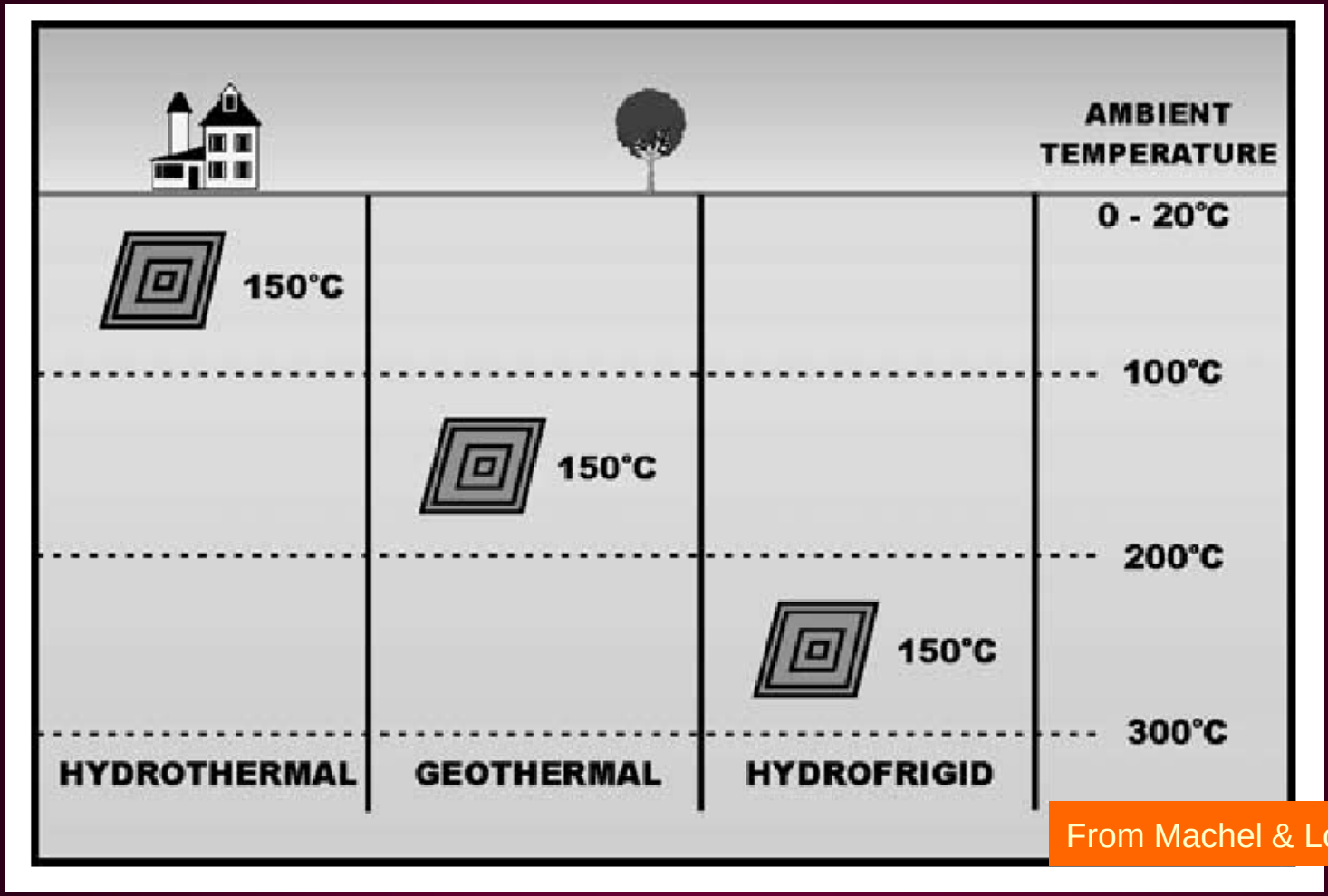
**In my talk today, I'll, first, summarize oil production from RR in SE SK;**

**It shows there was a significant increase in oil production since 1996.**

**then, I’ll show you petrology and petrophysics of RR reservoirs;**

**I’ll show dolomitzed matrix is the best reservoir and development of porosity is related to dolomitization and dissolution.**

**I’ll discuss the possible evidence of basement controls on oil pools in SK; and finally I'll summarize our current understanding on source(s) for Ord pools.**




From Machel & Lonnee (2002)

**High T is NOT necessarily hydrothermal!!!**

Hydrothermal: formed @ T (20-30ºC>) the surrounding rocks.

Geothermal: formed in thermal equilibrium with the surrounding rocks.

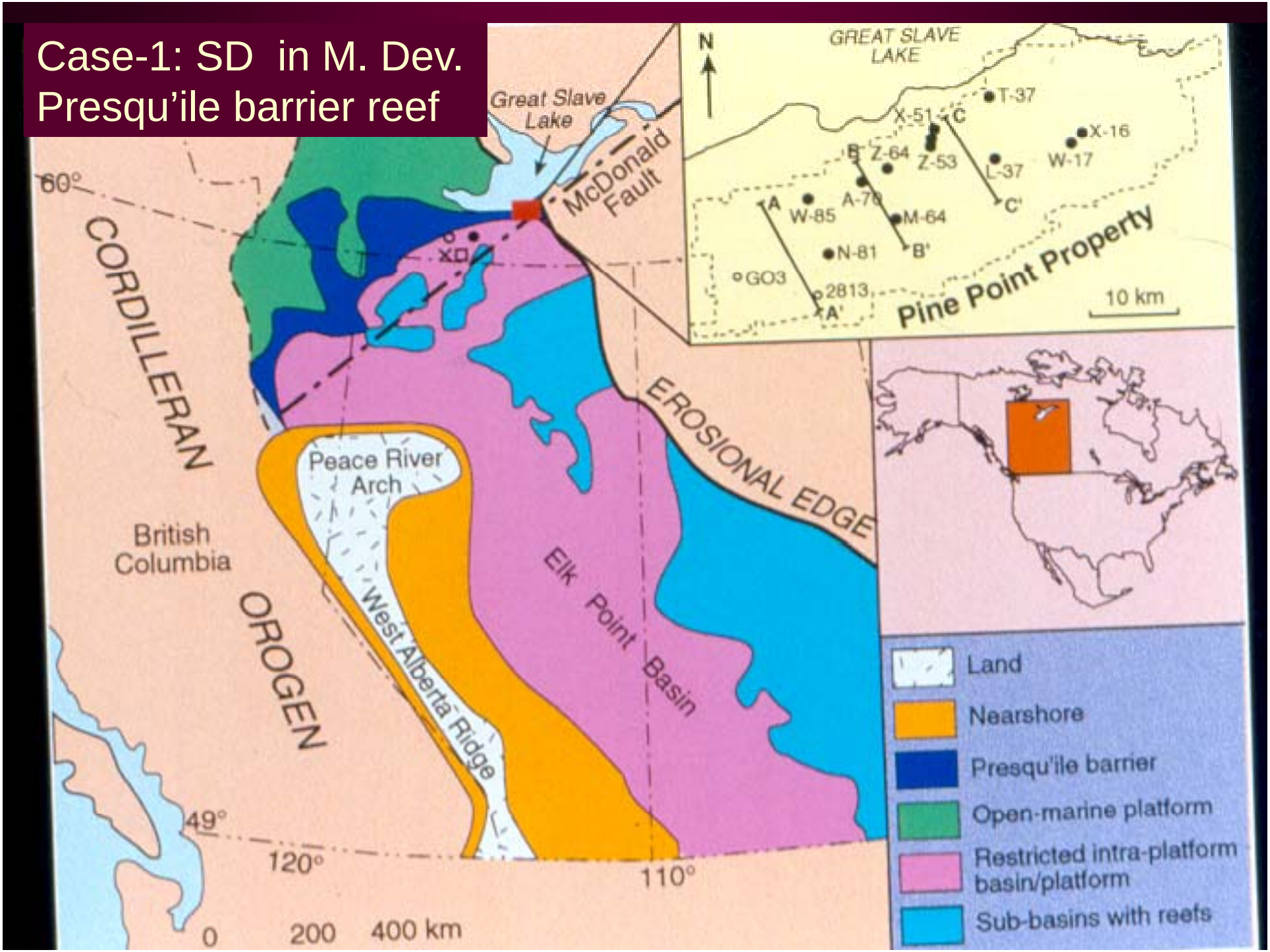
**It's all relative!!!**

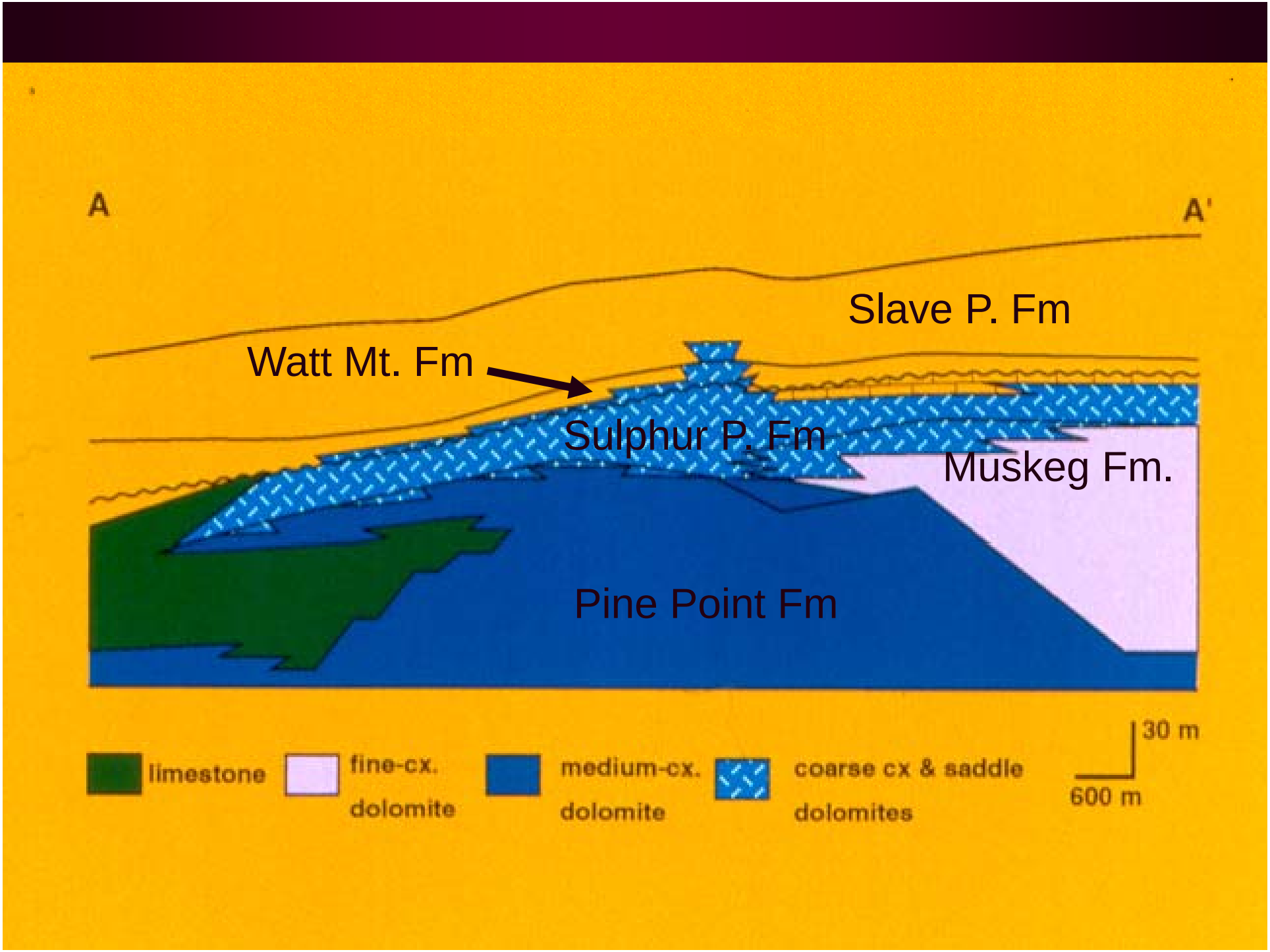
**Notes by Presenter**

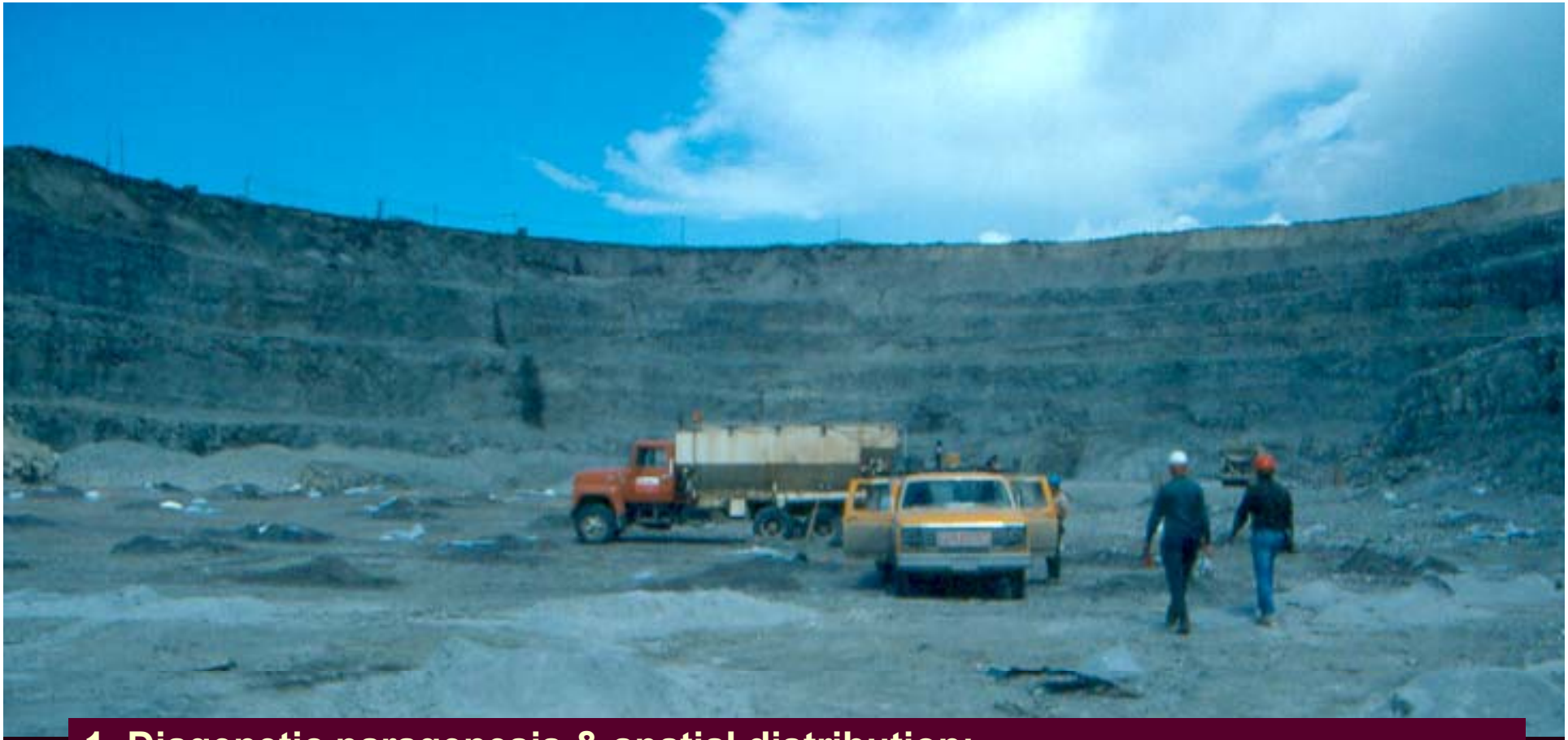
**It is all relative: like income index, you (from oil patch) might be poor if you are a guest of Bill Gates; but rich if you are my guest (professor).**

**Fig. 1. Hydrothermal, geothermal (formed in thermal equilibrium with the surrounding rocks), and hydrofrigid mineral formation.**

# Case-1: SD in M. Dev. Presqu'ile barrier reef




A
A'
Slave P. Fm
Watt Mt. Fm
Sulphur P. Fm
Muskeg Fm.
Pine Point Fm
limestone
fine-cx. dolomite
medium-cx. dolomite
coarse cx & saddle dolomites
30 m
600 m



**1. Diagenetic paragenesis & spatial distribution:**

- cross cut formation boundaries; & locally associated with dolomite chimneys (or prismatic orebodies);
- postdate stylolitization; and
- overlapped with MVT mineralization.

**2. Geochemical constraints:**

The regional trends of O-Sr-Th suggest that dolomitization is related to eastward migration of **hydrothermal fluids** along the Presqu'ile barrier reef.

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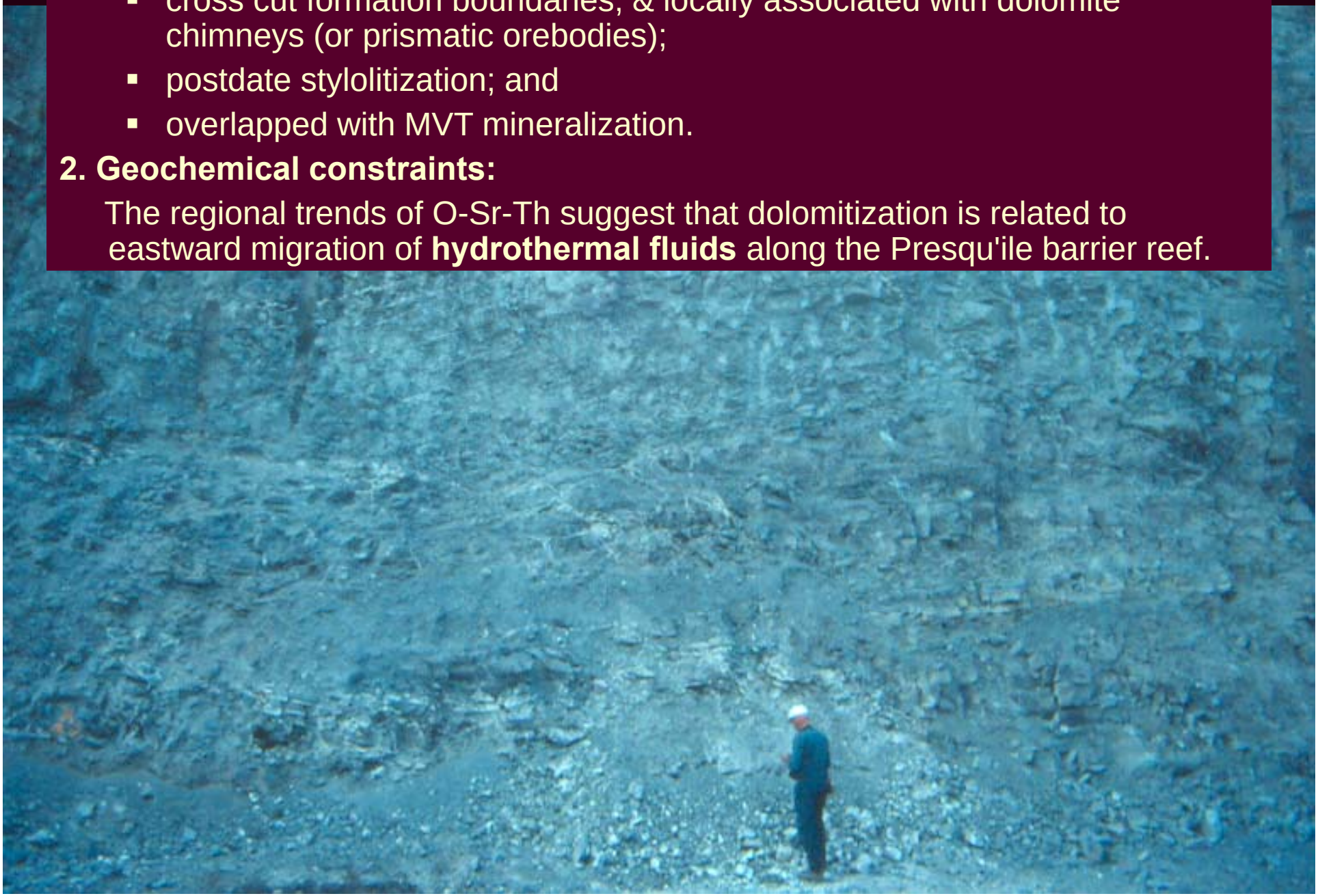

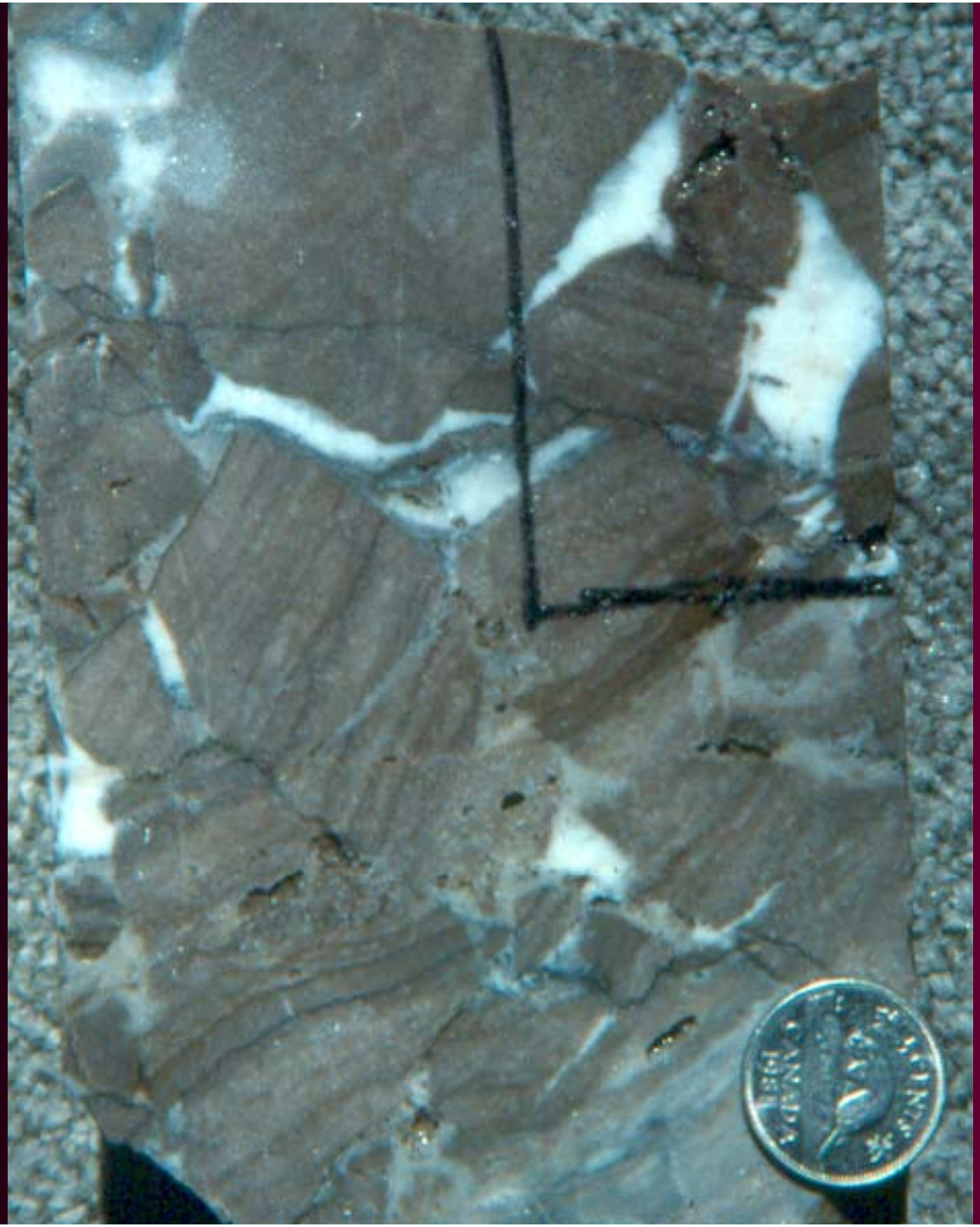

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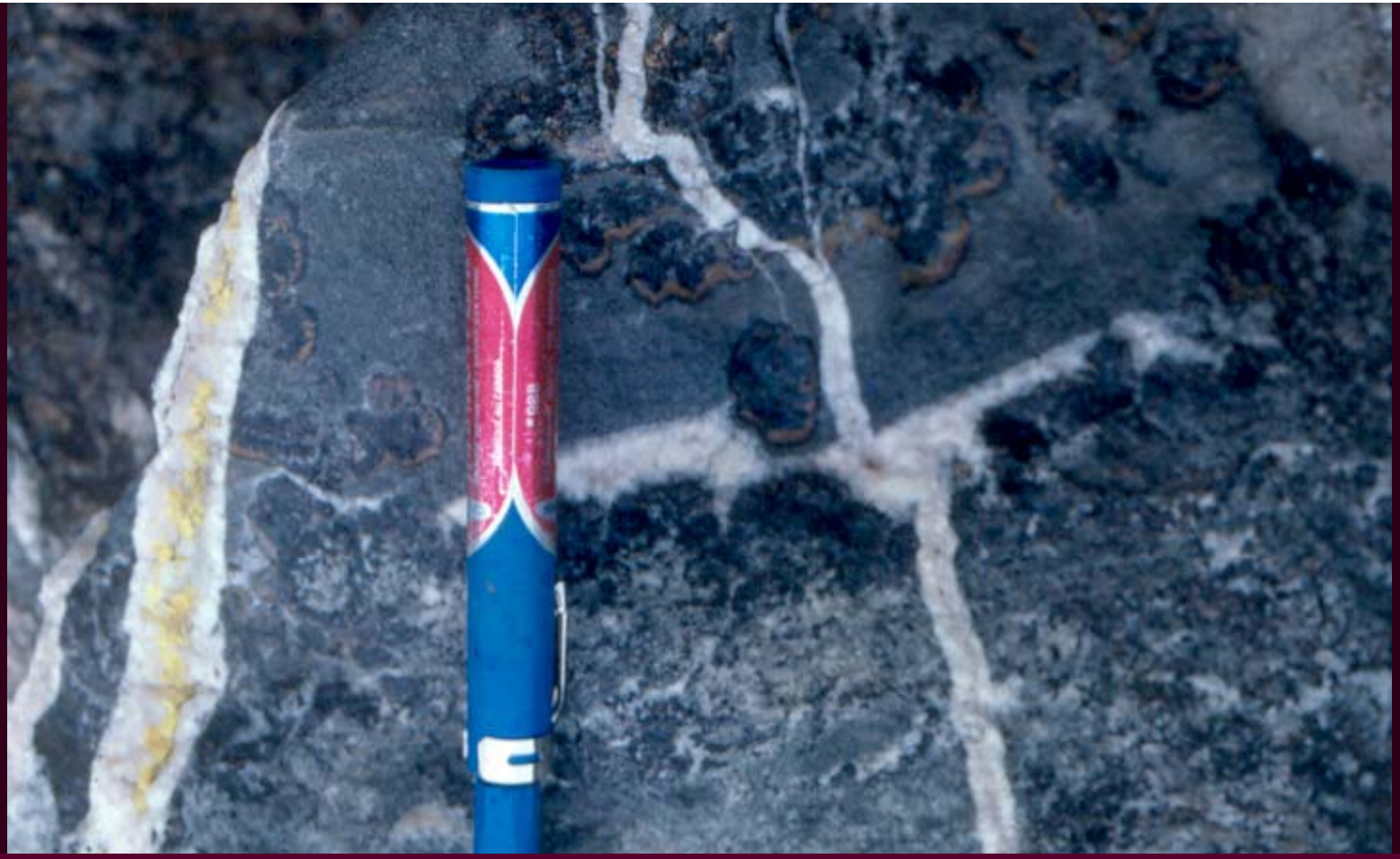

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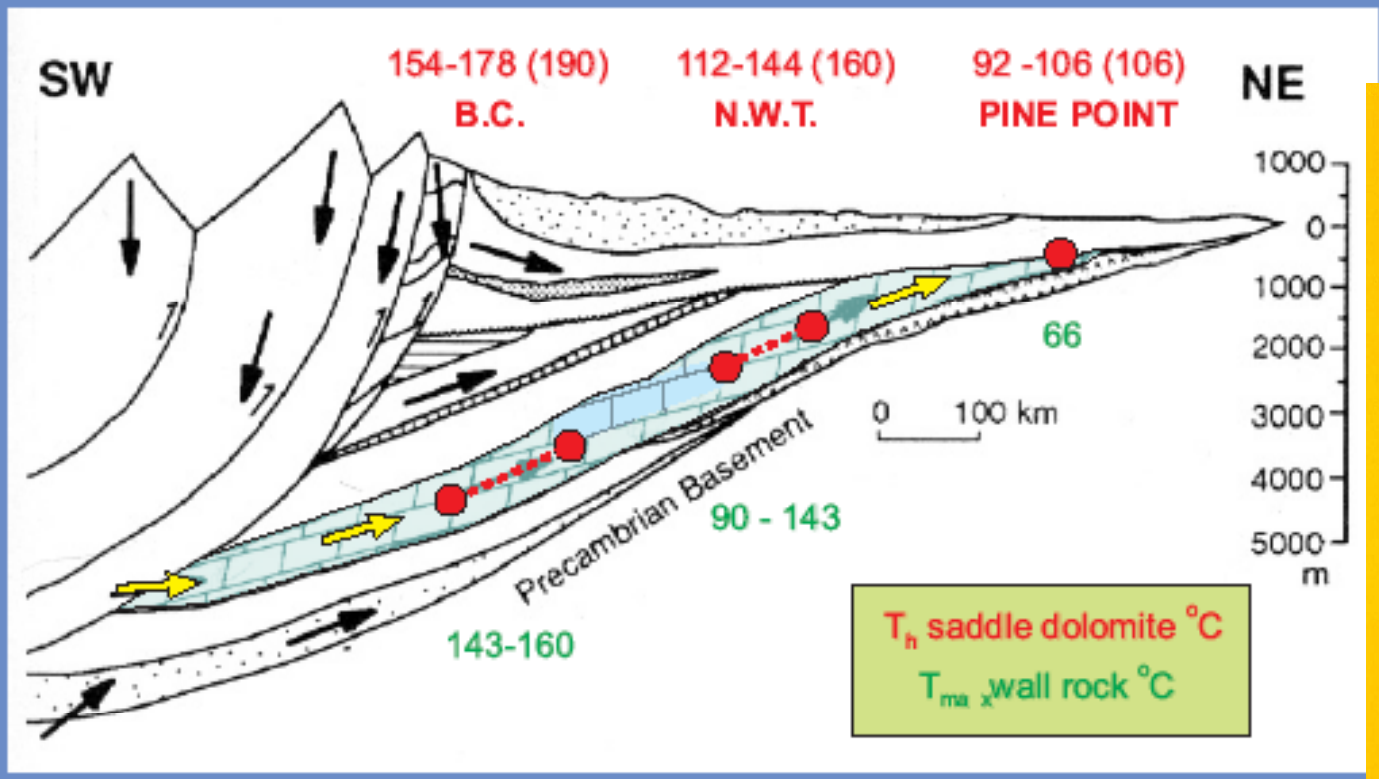
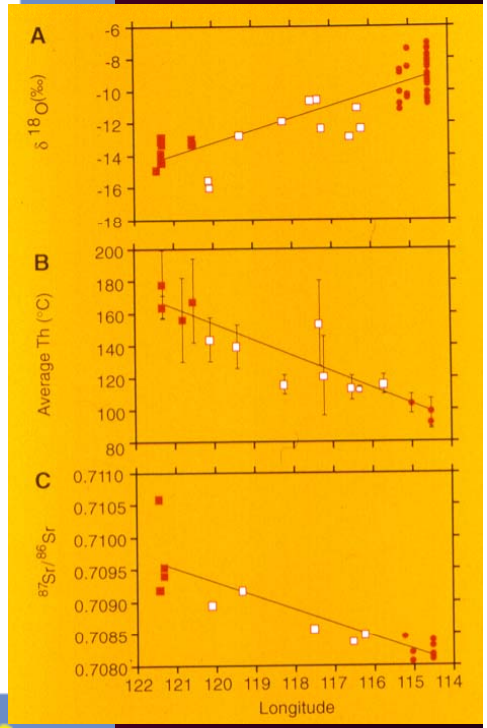
## PRESQU'ILE AQUIFER AND DOLOMITE




QING AND MOUNTJOY 1992

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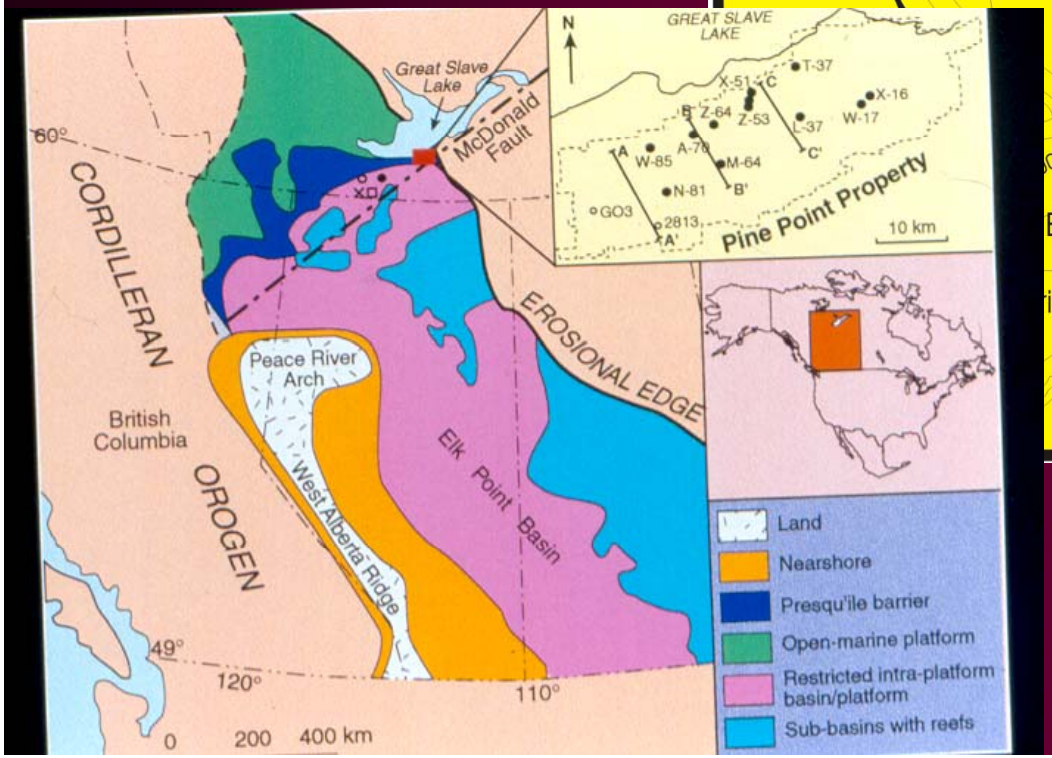
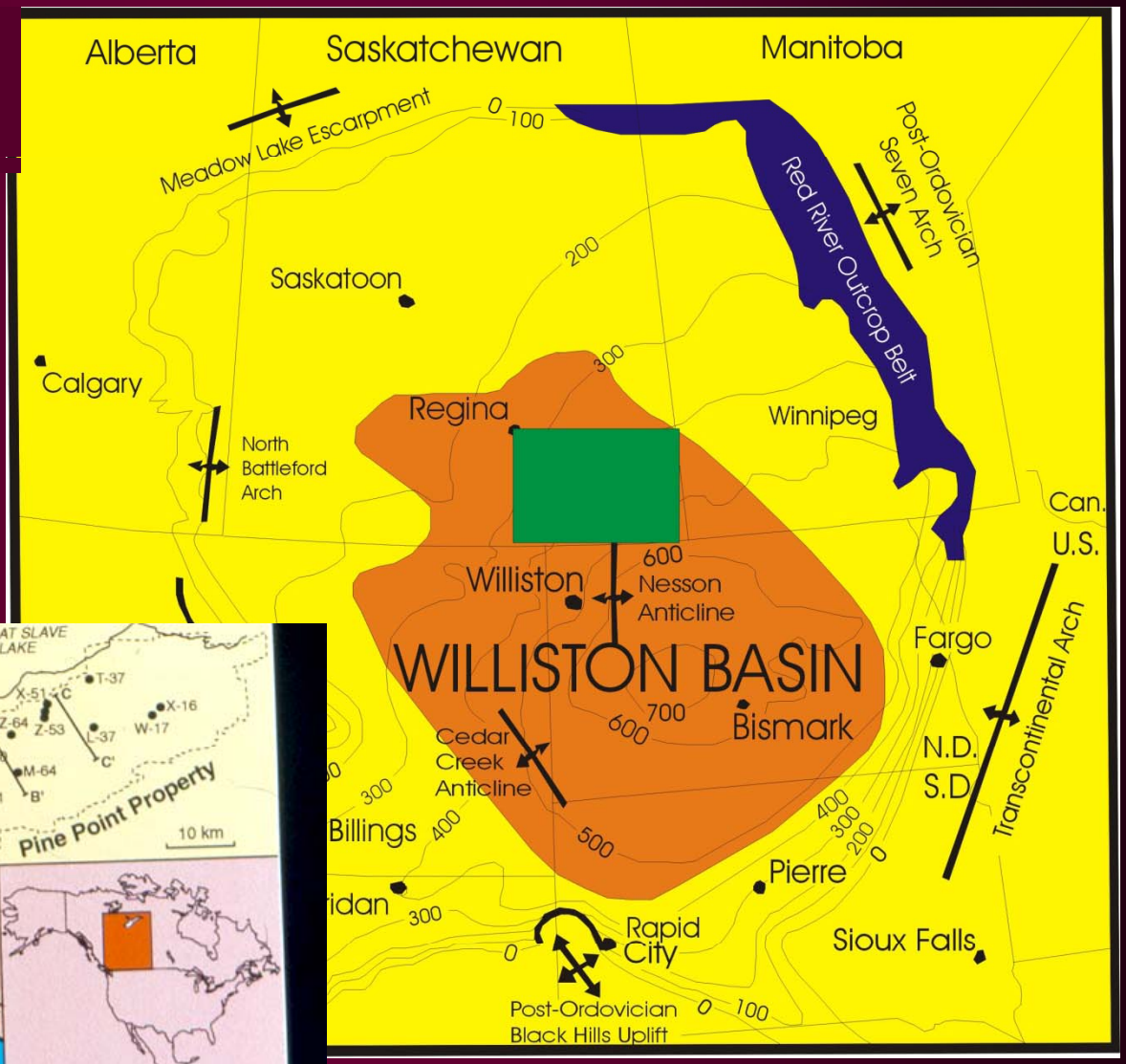
# Case-2: SD in M. Ord. Red River carbonates



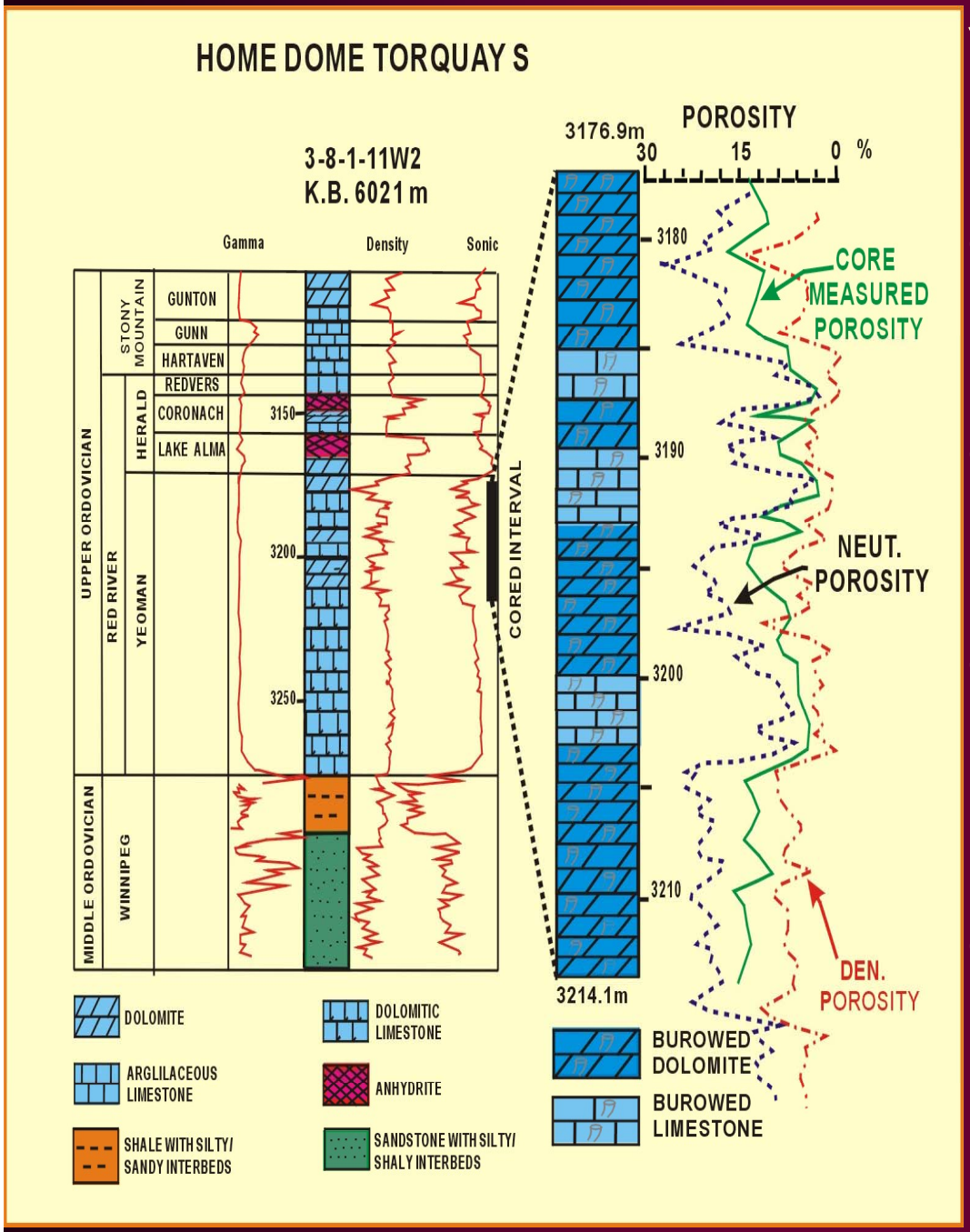

(Modified from Longman and Haidl, 1996)

**Notes by Presenter**

**This slide shows regional distribution and isopach of Ordovician Red River strata. In SK, the RR strata gradually increase in thickness SE towards the center of the Williston Basin, shown in orange. However, the spatial distribution of Red River strata extends far beyond the basin margins.**

**The Red River oil production in SK is limited in the SE corner of the province, within this green area, and the details of it is shown in next slide**
**(The petrography of my presentation is based on the study of outcrops north of Winnipeg and examination of core samples from SE SK.)**

Saddle dolomite restricted to the host replacement dolomites and occurs in trace amount of cement in vugs.


Spatial distribution of saddle dolomite in the Ord Red River carbonate SE Saskatchewan

1) restricted to the upper 30 m of Yeomen Fm where the host carbonate is dolomitized;

1) absent in the thick limestone (up 100 m) below and dolomite above (1,000 m);

1) occurs as trace amount of cement in vugs.

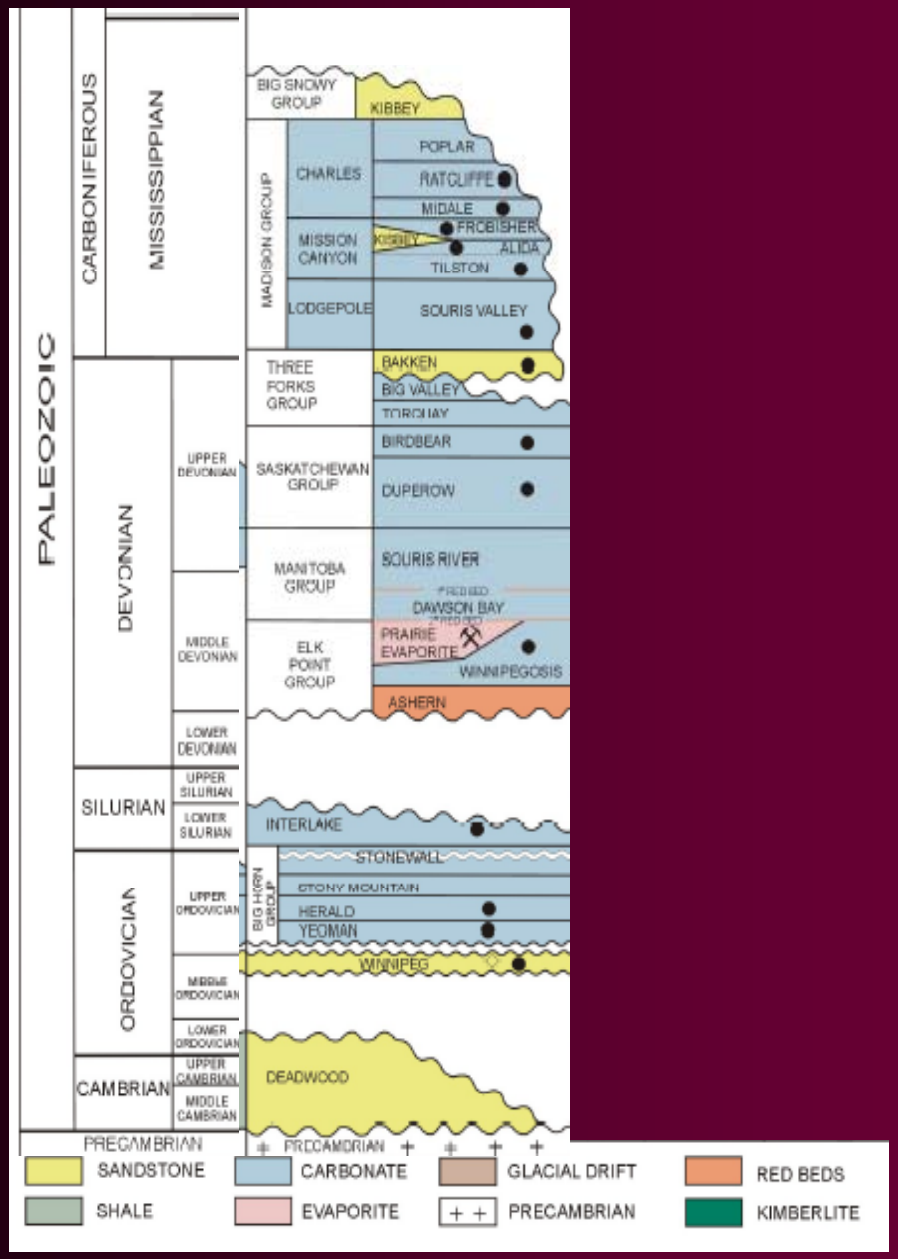
Implication:

1) SD precipitated relatively closed system;

**Notes by Presenter**

**This slides show lithology based on core examination of 45 m of core samples from the upperYeoman or C burrow member. The deep blue represents sections where matrix is dolomitized, and the light blue is sections where matrix is preserved as limestones. These lines are neutron porosity, density porosity, and measured core porosity. They all show that porosity in dolomitized matrix is much higher than that in the limestone matrix.**



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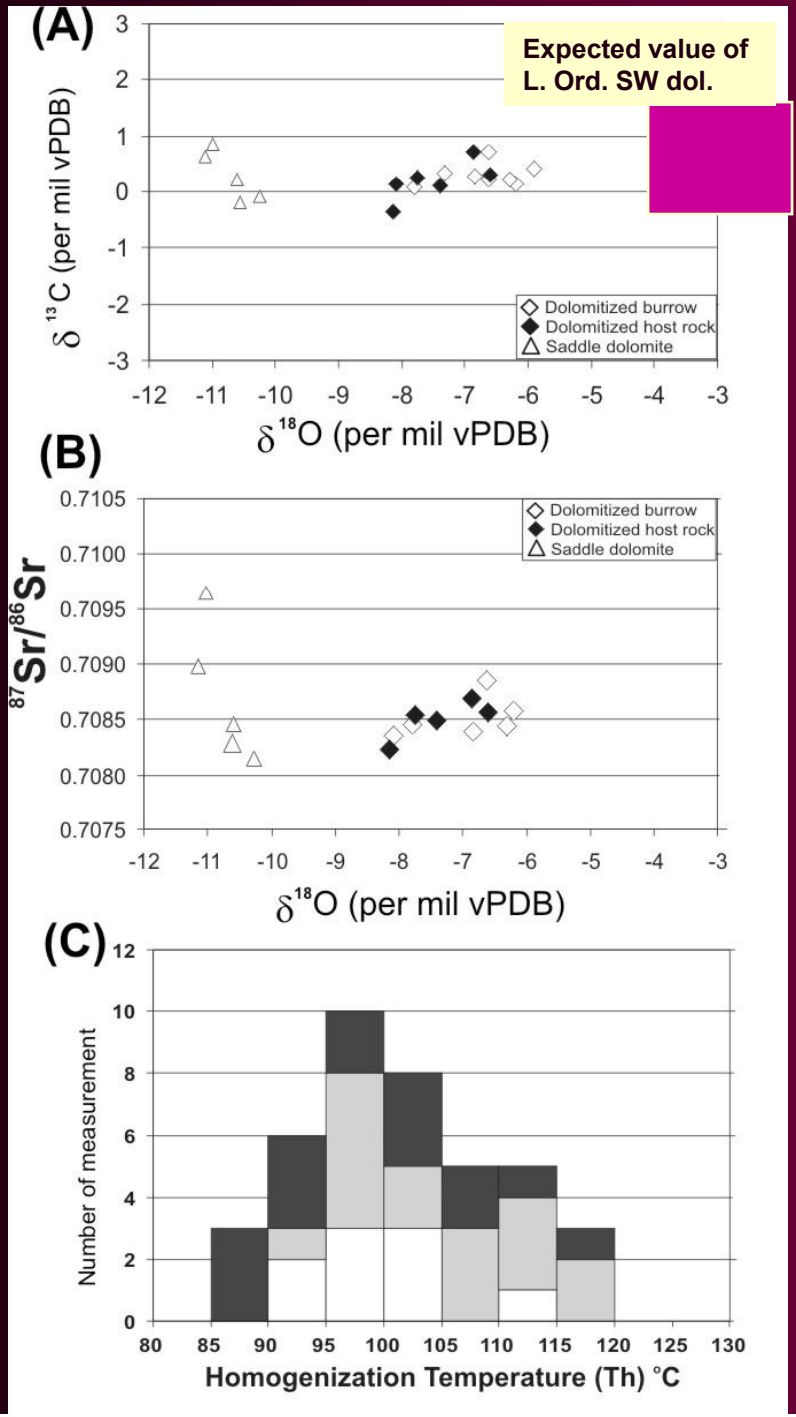



Geochemical characteristic of saddle dolomite in the Ord Red River carbonate SE Saskatchewan

1) has d13C values overlapping with those of their host dolomite, all of which fall within the range of the expected value of Ordovician seawater;

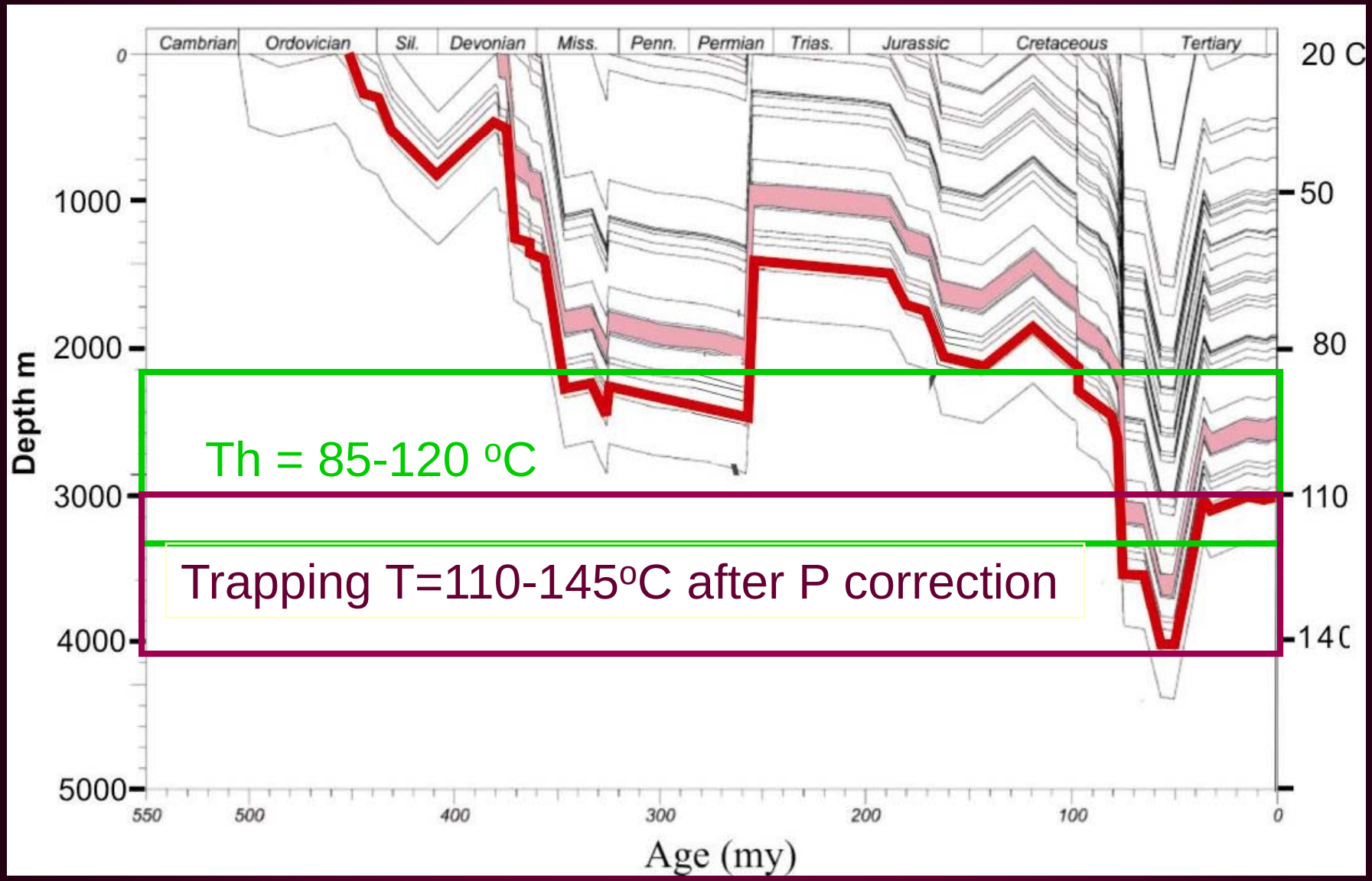
1) with Sr isotopic ratios similar to those of its host replacement dolomites;

1) has Th: 85-120 $^{o}$C (Tt: 110-145 $^{o}$C) that can be related to the normal burial T in the region.

Implication:

1) SD precipitated relatively closed system.

1) probably related to cannibalization of early replacement dolomite during burial.




The Th (~ 85-120 °C, with Tt ~110 – 145 °C) of Ord. Red River SD can be related to the normal burial temperatures in the region.

(Modified from Osadetz *et al*., 2002)

**Characteristics of saddle dolomite in the Ord Red River carbonate SE Saskatchewan**

**Spatial distribution:**

- restricted to the upper 30 m of Yeomen Fm where the host carbonate is dolomitized; but absent in the thick limestone below and dolomite above;

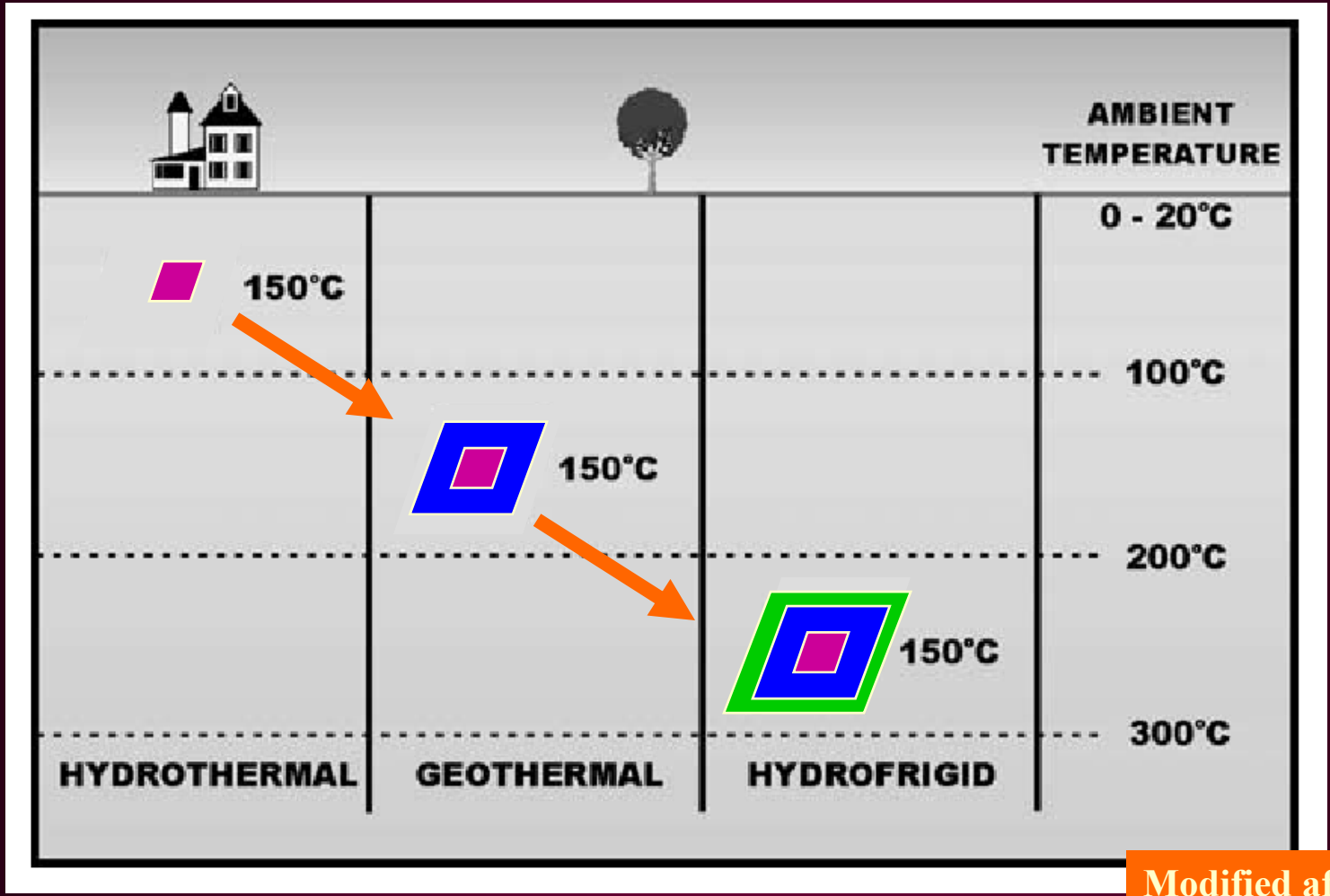
**Geochemical attributes:**

- has Sr and C isotopic values overlapping with those of their host dolomite; has relatively low Th (85-120 $^{o}$C) that can be related to the normal burial T in the region.

**Implication:**

- SD precipitated in relatively closed system; probably related to cannibalization of early replacement dolomite during burial.

**The occurrence of saddle dolomite, in this case, is not necessarily indicative for hydrothermal activities or fluid flow.**




Modified after Machel & Lonnee (2002)

1. High T is NOT equal to hydrothermal!!!
2. Formation of SD is NOT necessarily restricted to one geological condition!

**Notes by Presenter**

**It is all relative: like income index, you (from oil patch) might be poor if you are a guest of Bill Gates; but rich if you are my guest (professor).**

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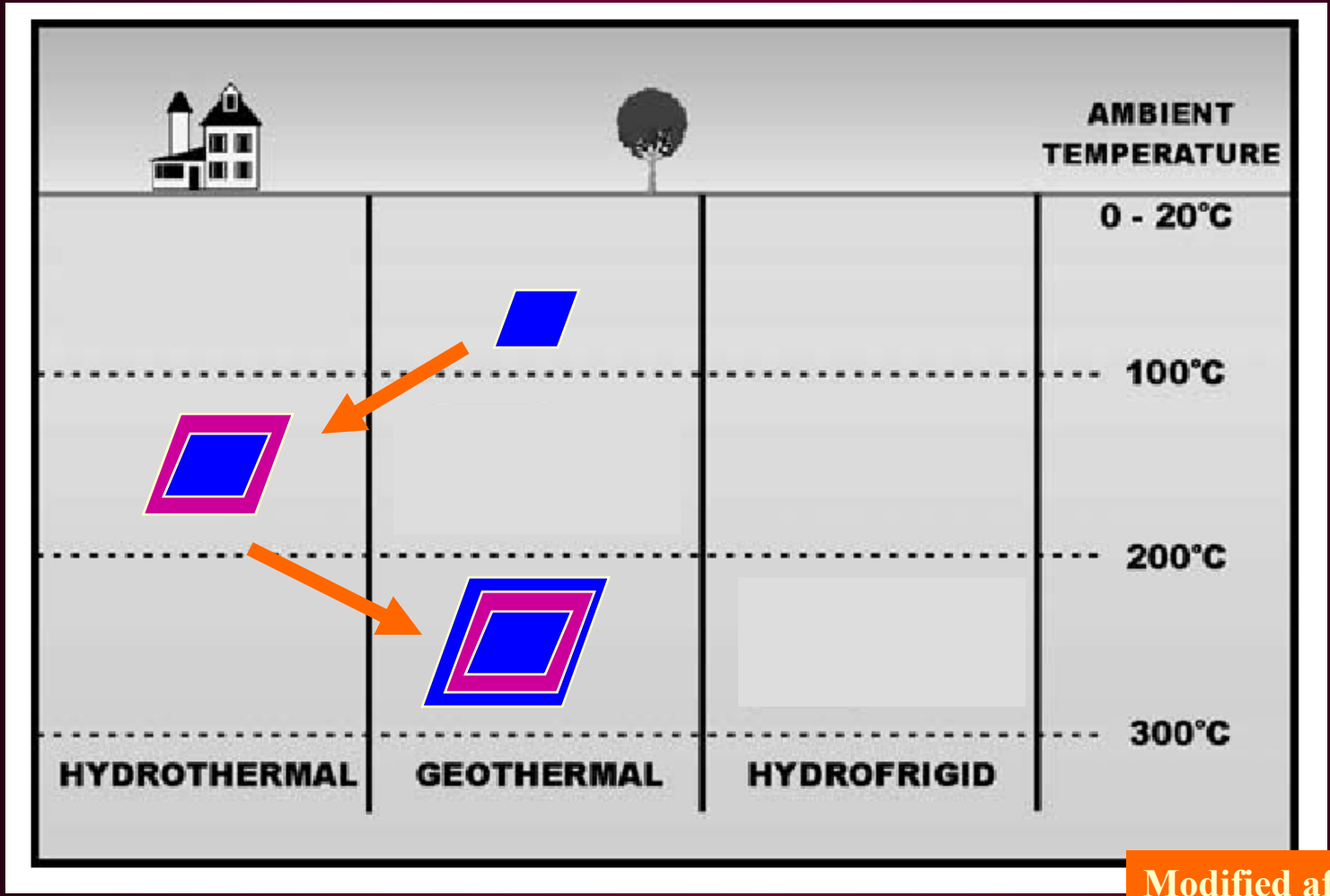


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# Conclusions

$$Ca^{2+}_{(aq)} + Mg^{2+}_{(aq)} + 2CO_3^{2-}{}_{(aq)} \longrightarrow CaMg(CO_3)_{2\ (s)}$$

$$2CaCO_3 + Mg^{2+} \longrightarrow CaMg(CO_3)_2 + Ca^{2+}$$

1. When a solution is supersaturated with dolomite, high T certainly helps to overcome kinetic barrier of dolomite precipitation.
2. If above conditions are satisfied, saddle dolomite can be formed either in hydrothermal or non-hydrothermal environments.

**Notes by Presenter**

**With a fluid that is supersaturated with dolomite, the high T certainly helps to overcome kinetic barrier of dolomite precipitation; SD can be formed either in hydrothermal or non-hydrothermal conditions.**

## References

Longman, M.W., and F.M. Haidl, 1996, Cyclic deposition and development of porous dolomites in the Upper Ordovician Red River Formation, Williston Basin: *in* Paleozoic Systems of the Rocky Mountain Region, p. 29-46.

Machel, H.G., and J. Lonnee, 2002, Hydrothermal dolomite; a product of poor definition and imagination: Sedimentary Geology, v. 152/3-4, p. 163-171.

Osadetz, K.G., B.P. Kohn, S. Feinstein, and P.B. O'Sullivan, 2002, Thermal history of Canadian Williston basin from apatite fission-track thermochronology implications for petroleum systems and geodynamic history: Tectonophysics, v. 349/1-4, p. 221-249.

Qing, H., and E. Mountjoy, 1992, Large-scale fluid flow in the Middle Devonian Presqu'ile Barrier, Western Canada sedimentary basin: Geology, v. 20/10, p. 903-906.

# Every dog has its days!!!

Thank you!

Hydrothermal?

or non-hydrothermal?