Mg-isotope & REE compositions of the St. George Group carbonates (WNL): Implications for the origin of dolomites & limestones

K. Azmy

Azmy et al., 2013. Chemical Geology 365, 64–75.

Post-doc fellows

Blamey, N.,	2012
Conliffe, J.,	2010

PhD Students

Olanipekum, B.J.	(in progress, 2015)
Bakhit, A.	(in progress, 2017)

MSc Students

Hou, Y.	in progress (2015)
Azomani, E.,	2012.
Greene, M.,	2008.
Schwartz, S.,	2008.

Publications

13 published (CG, AAPG, MPG, SG, CBPG, CJES, Geofluids)

2 reports

1 in progress

Publications (* = student or post-doc fellow)

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* Olanipekun, B.J., **Azmy, K.**, Brand, U., 2013. Dolomitization of the Boat Harbour Formation: implications for diagenetic history and porosity control. Bulletin of American Association of Petroleum Geologists (*in press*).

* Blamey, N., **Azmy, K.**, Brand, U., 2013. Provinance and burial history of cements in sandstones of the North Brook Formation (Carboniferous), western Newfoundland, Canada: a geochemical investigation. Sedimentary Geology (*in press*).

Azmy, K., Lavoie, D., Wang, Z., Brand, U., Al-Aasm, I., Jackson, S., Girard, I., 2013. Magnesium-isotope and REE compositions of Lower Ordovician carbonates from eastern Laurentia: implications for the origin of dolomites and limestones. Chemical Geology 356: 64-75.

Publications (cont.)

Azmy, K., Balmey, N., 2013. Azmy, K., Blamey, N., 2013. Source of diagenetic fluids from fluid-inclusion gas ratios. Chemical Geology 347: 246-254.

* Azomani, E., **Azmy, K**., Blemey, N., Brand, U., Al-Aasm, I., 2013. Origin of Lower Ordovician dolomites in eastern Laurentia: Controls on porosity and implications from geochemistry. Marine and Petroleum Geology 40: 99-114.

*Conliffe, J., **Azmy, K**., Greene, M., 2012. Hydrothermal Dolomites in the Lower Ordovician Catoche Formation. Marine and Petroleum geology 30: 161-173.

Publications (cont.)

Azmy, K., *Conliffe, J., 2010. Dolomitization of the lower St. George Group on the Northern Peninsula in western Newfoundland: implications for lateral distribution of porosity. Bulletin of Canadian Petroleum Geology 58(4):1-14.

*Conliffe, J., **Azmy, K.**, Gleeson, S.A., Lavoie, D., 2010. Fluids associated with hydrothermal dolomitization in St. George Group, western Newfoundland, Canada. Geofluids 9:1-16.

Azmy, K., Stouge, S., Christiansen, J.L., Harper, D.A.T., Knight, I., Boyce, D., 2010. Carbon-isotope stratigraphy of the Lower Ordovician succession in Northeast Greenland: implications for correlations with St. George Group in western Newfoundland (Canada) and beyond. Sedimentary Geology, 225: 67-81.

Publications (cont.)

Azmy, K., Lavoie, D. 2009. High-resolution isotope stratigraphy of the Lower Ordovician St. George Group of western Newfoundland, Canada: implications for global correlation. Canadian Journal of Earth Sciences, 46: 1-21.

Azmy, K., Knight, I., Lavoie, D., Chi, G., 2009. Origin of the Boat Harbour dolomites of St. George Group in western Newfoundland, Canada: implications for porosity controls. Bulletin of Canadian Petroleum Geology, 57: 1-24.

Conliffe, J., **Azmy, K.**, Knight, I., Lavoie, D., 2009. Dolomitization in the Lower Ordovician Watts Bight Formation of the St Georges Group, Western Newfoundland. Canadian Journal of Earth Sciences, 46: 247-261.

Publications (cont.)

Azmy, K., Lavoie, D., Knight, I., Chi, G., 2008. Dolomitization of the Aguathuna Carbonates in Western Newfoundland, Canada: Implications for a Potential Hydrocarbon Reservoir. Canadian Journal of Earth Sciences, 45 (7): 795-813.

Knight, I., **Azmy, K.**, Boyce, D., Lavoie, D., 2008. Tremadocian carbonates of the lower St. George Group, Port au Port Peninsula, western Newfoundland: Lithostratigraphic setting of diagenetic, isotopic, and geochemistry studies. Current Research Newfoundland and Labrador Department of Natural Resources Geological Survey. Report 08-1: 1-43.

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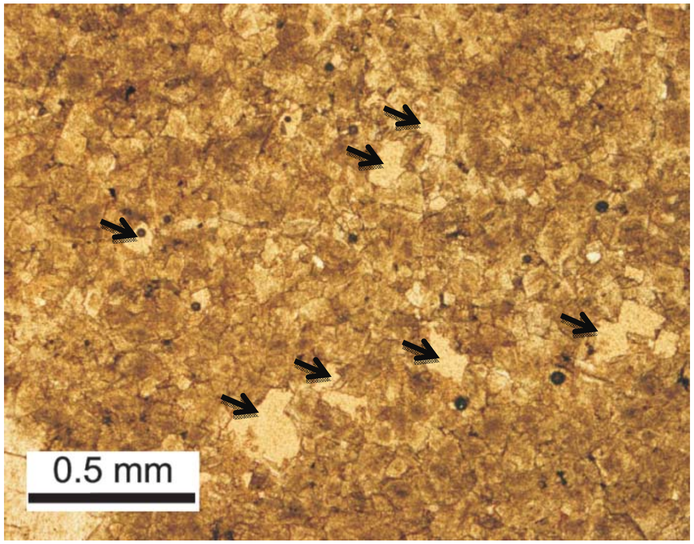
Publications (cont.)

Knight, I., **Azmy, K.**, ***Greene, M., and Lavoie, D. 2007. Lithostratigraphic setting of diagenetic, isotopic, and geochemistry studies of Ibexian and Whiterockian carbonates of the St. George and Table Head groups in western Newfoundland. Current Research Newfoundland and Labrador Department of Natural Resources Geological Survey. Report 07-1: 55-84.

Objectives:

•study (petrographically & geochemically) the dolomitization phases

•untilize the Mg-isotope signatures to better understand the genesis of dolomites.

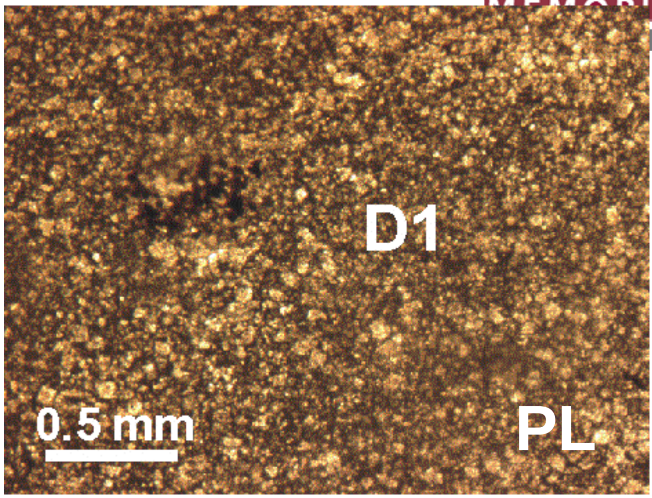


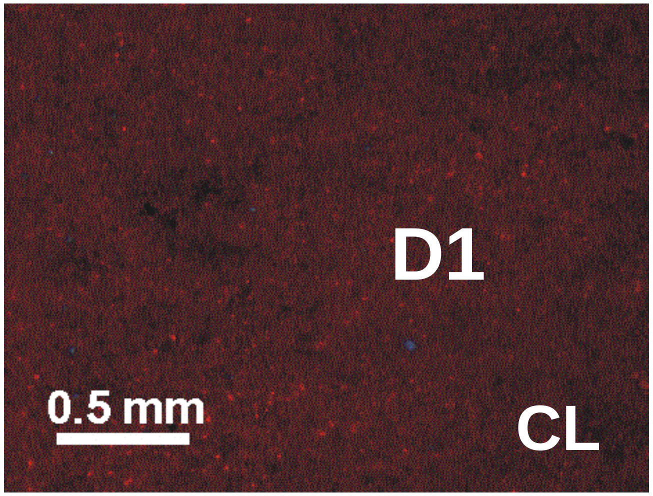

N
12P/1-12
Port au Choix
12i/6-121
St. John's
Island of Newfoundland
12B/11-44
RND1
Isthmus Bay
Saint Pierre and Miquelon
St Pierre
© 2010 Europa Technologies
Image © 2010 TerraMetrics
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2010 Tele Atlas
©2009 Google
48°38'54.88" N 55°18'37.39" W elev 438 ft
Eye alt 385.40 mi

Petrography

3 major dolomitization phases:

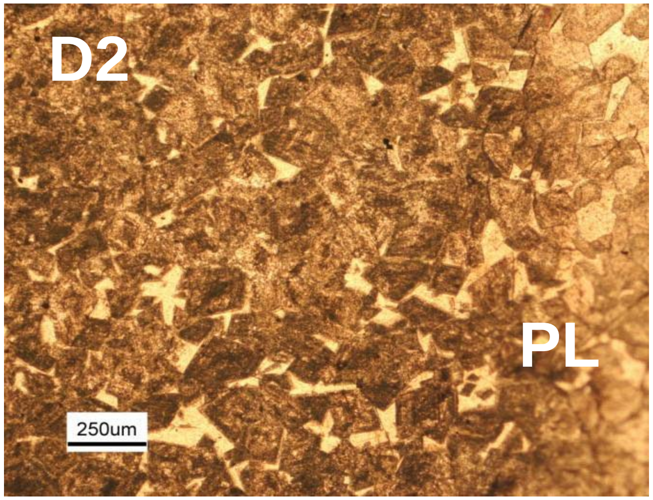
(D1) Pervasive fabric retentive dolomicrite (4 to 40 μm)

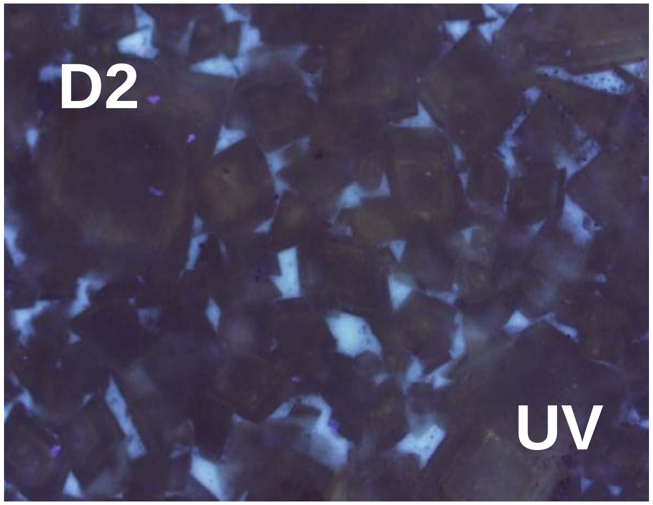


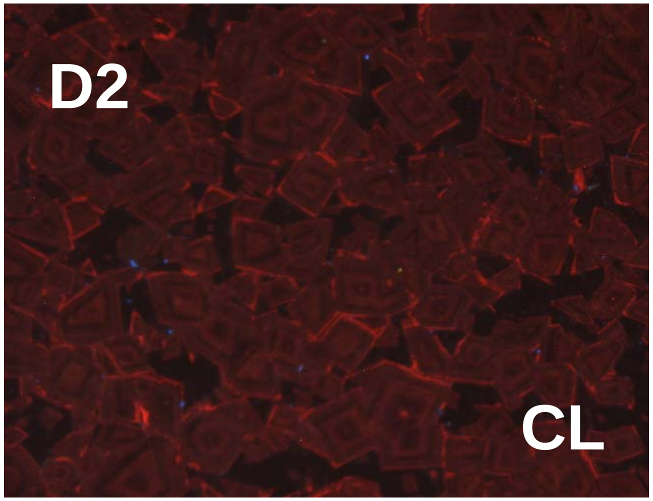


(D2) mid-burial hydrothermal

sub- to euhedral crystals (50–250 μm) with high intercrystalline porosity (up to 10% in some horizons).

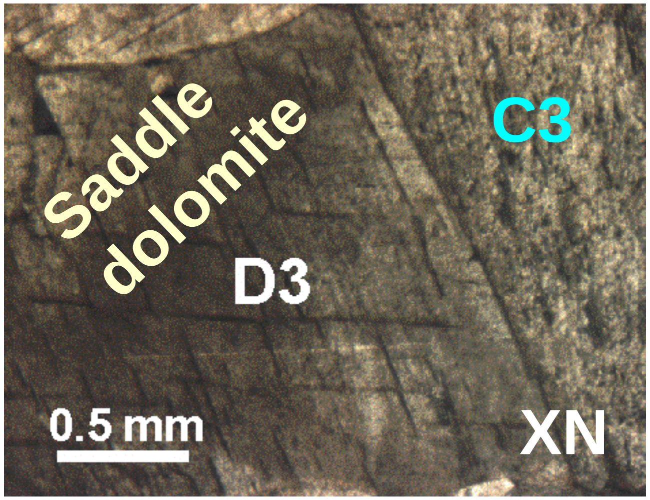


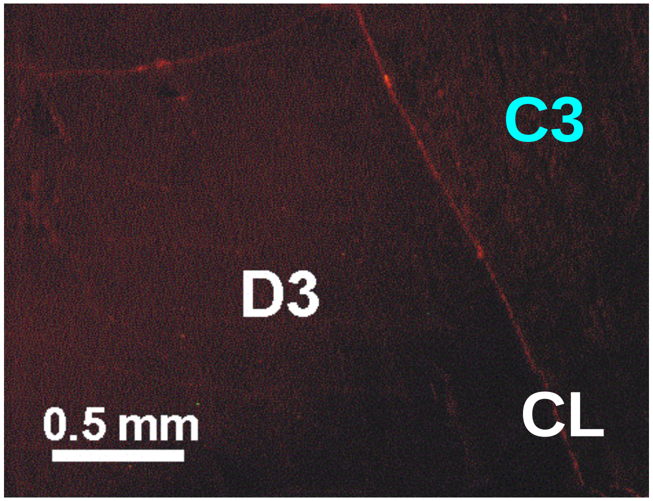




(D3) deep-burial hydrothermal fracture-filling
sub- to anhedral crystals (up to 0.5 cm)
milky appearance
undulose extinction

(C3) latest fracture-filling calcite



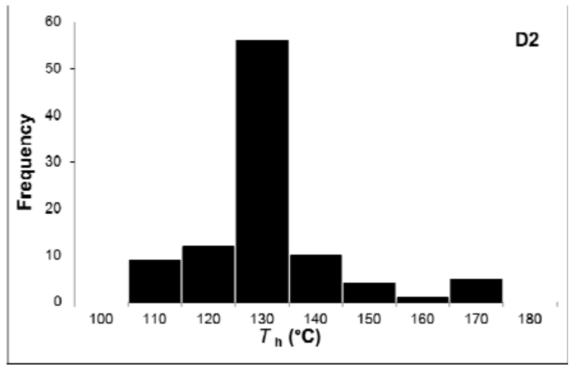


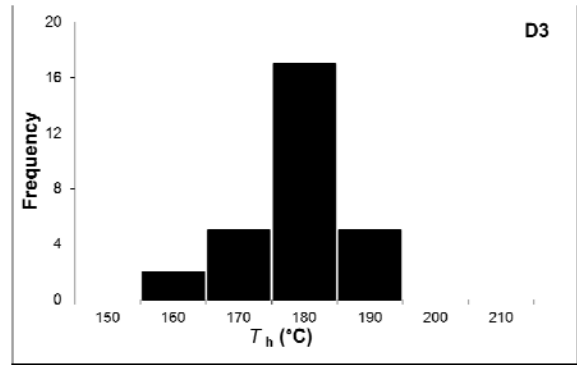
Microthermometry

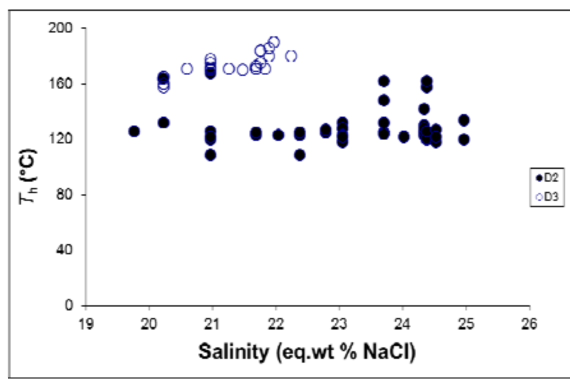
2 phases of hot dolomitizing fluids (D2 & D3)

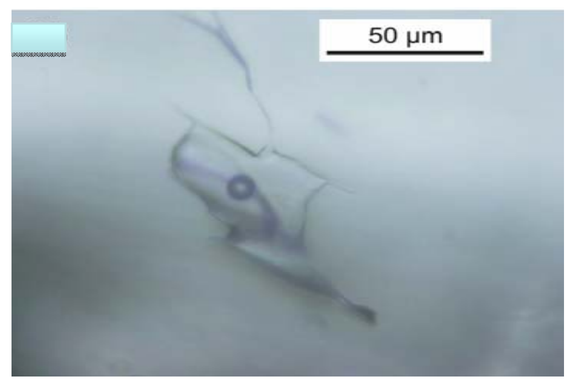
T_h up to 130ºC & 180ºC, respectively.

Salinity estimates 22 to 25 eq wt% NaCl

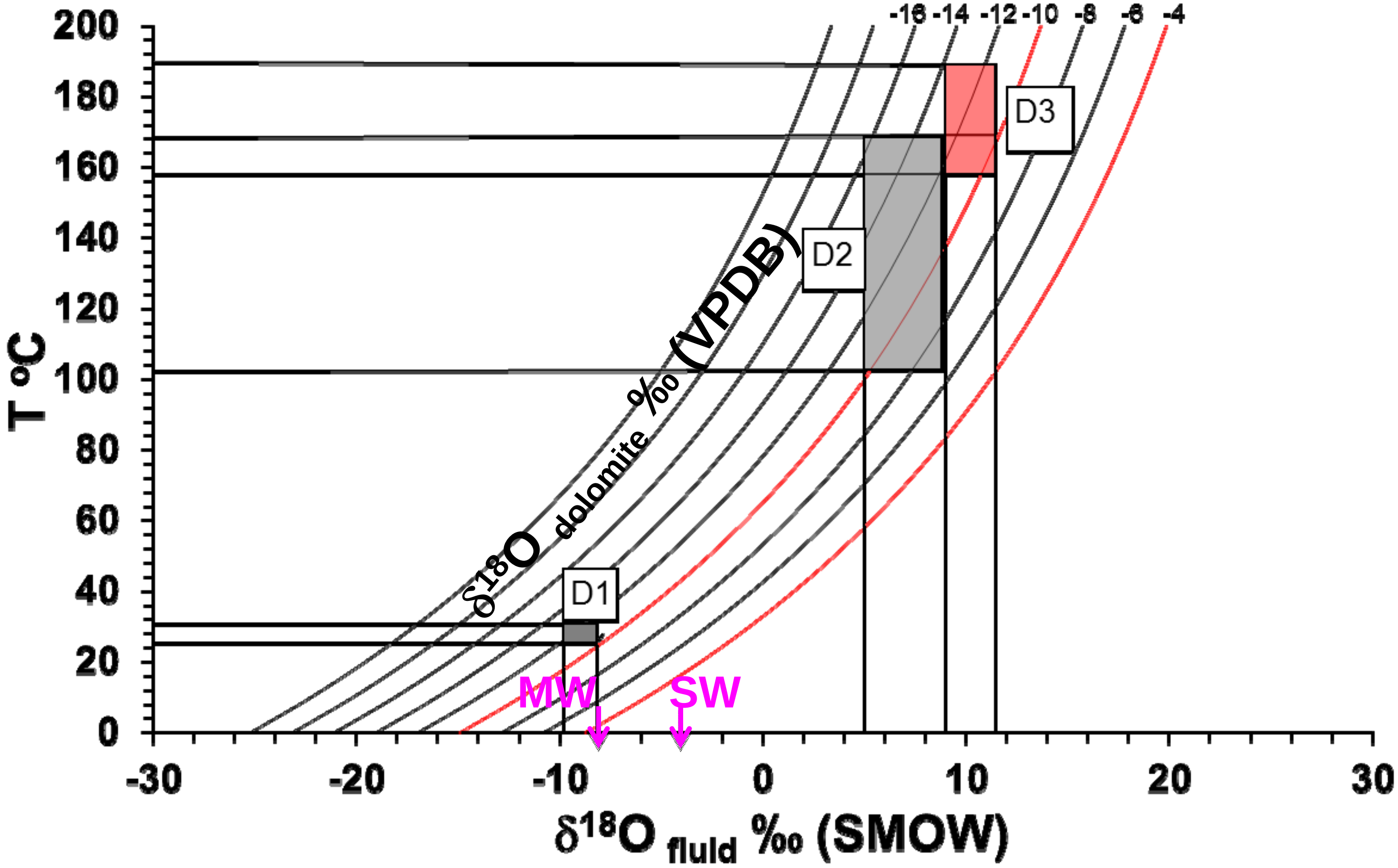


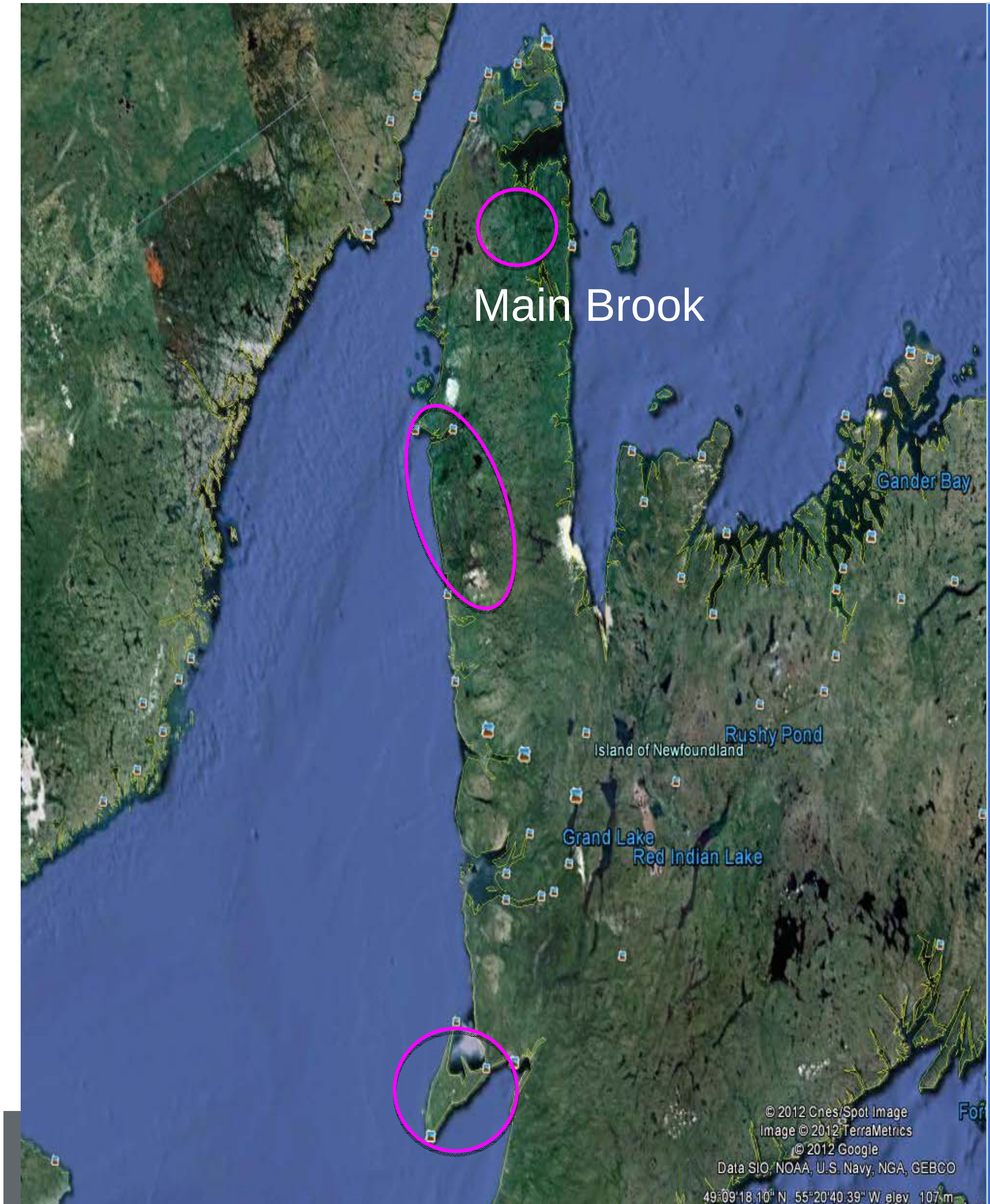


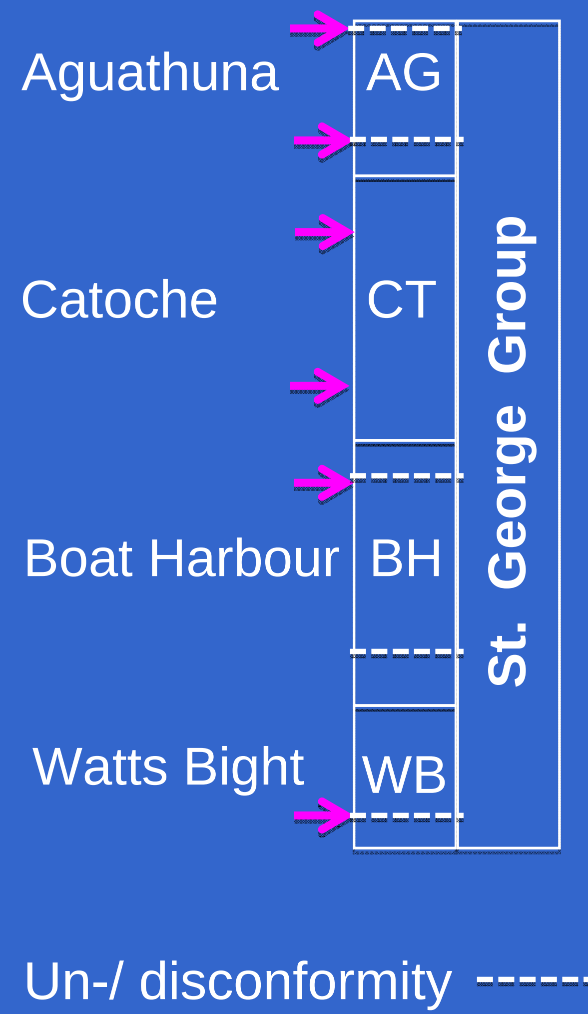




Stable isotopes




Main Brook
Gander Bay
Rushy Pond
Island of Newfoundland
Grand Lake
Red Indian Lake
© 2012 Cnes/Spot Image
Image © 2012 TerraMetrics
© 2012 Google
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
49°09'18.10" N 55°20'40.39" W elev 107 m


Aguathuna
AG
Catoche
CT
Boat Harbour
BH
Watts Bight
WB
St. George Group
Un-/ disconformity ------

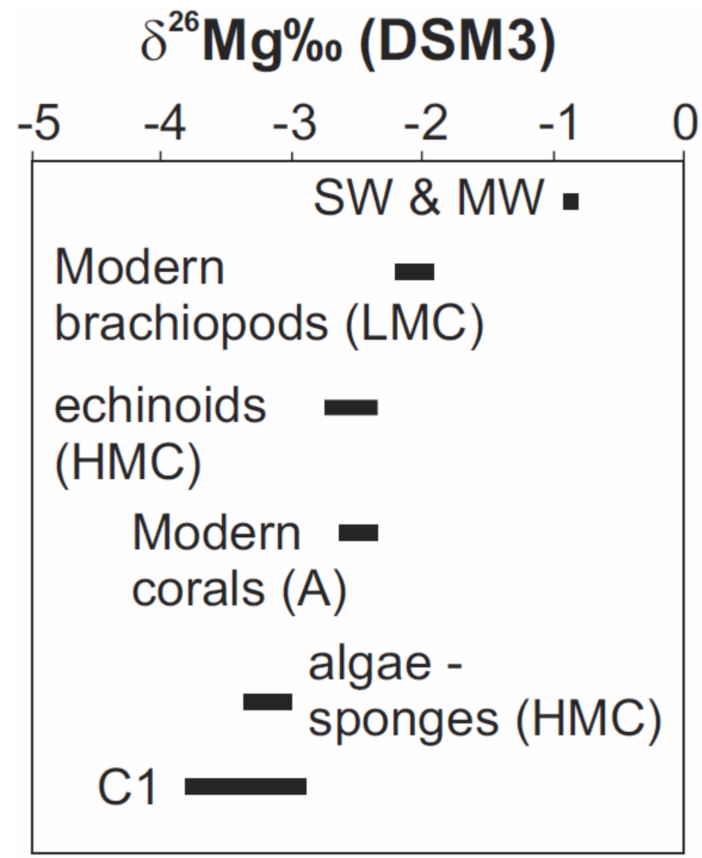
Mg has 3 stable isotopes $^{24}Mg_{12}$, $^{25}Mg_{12}$, $^{26}Mg_{12}$

79% 11% 10%

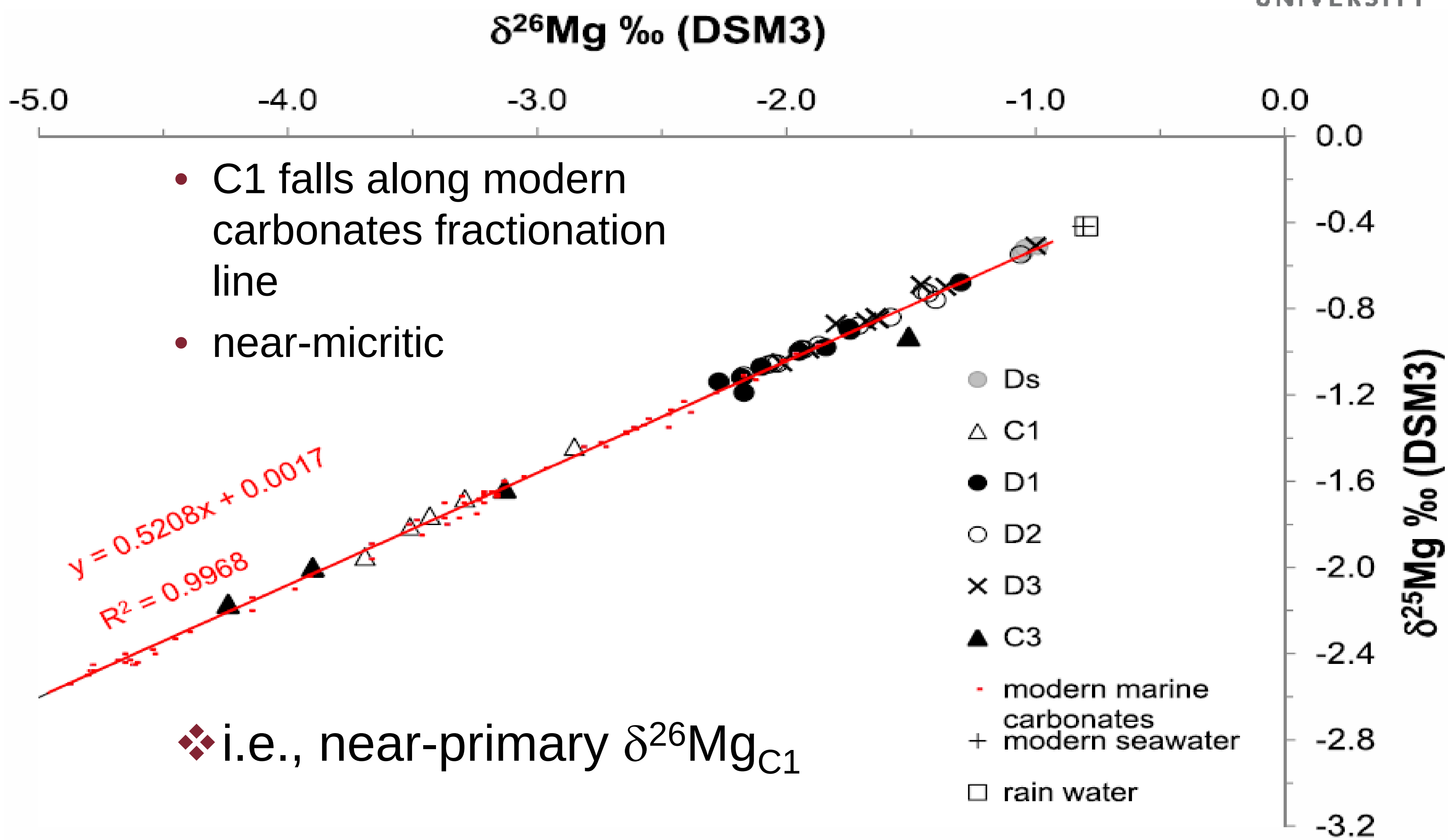
$\delta^{2X}\mathbf{Mg}_{\mathbf{DSM3}}$ =

$(^{2X}Mg/^{24}Mg_{sample} - ^{2X}Mg/^{24}Mg_{DSM3})/(^{2X}Mg/^{24}Mg_{DSM3}) \times 1000$

- **δ^{26}Mg of precursor lime mudstone (C1)**
  - ❖ different from modern
    - brachs (LMC)
    - chrinoids (HMC)
    - corals (A)
  - ❖ similar to modern
    - algae (HMC)
    - sponges
  - ❖ C1 had an algal origin (HMC) & diagenesis likely did not reset the $\delta^{26}Mg_{C1}$ since MW & SW have similar δ^{26}Mg

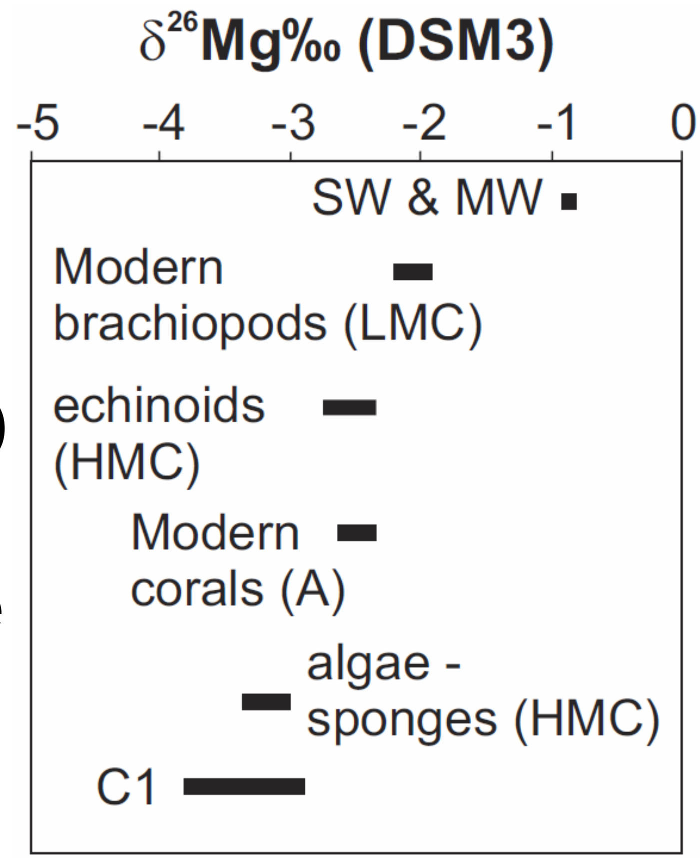


- C1 falls along modern carbonates fractionation line
- near-micritic

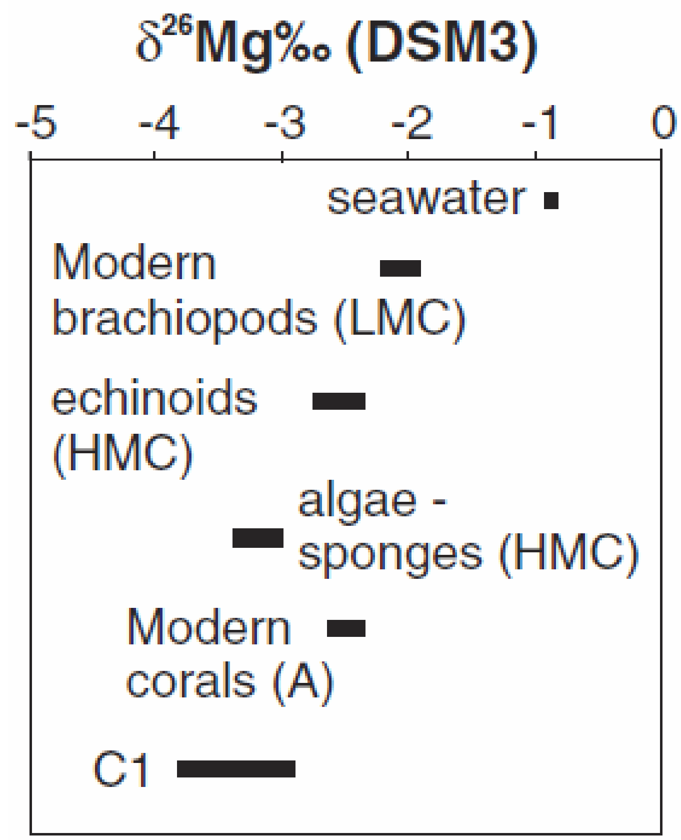


❖ i.e., near-primary $\delta^{26}Mg_{C1}$

- **δ^{26}Mg of dolomites**
  - δ^{26}Mg of modern SW (-0.80‰ DSM3) & MW (-0.81‰ DSM3) are almost identical
    - i.e., no fractionation by evaporation
  - This is consistent with the modern sabkhas δ^{26}Mg (–1.03‰)
  - The slight depletion could be due to associated bacterial activity and/or possibly mineralogical control

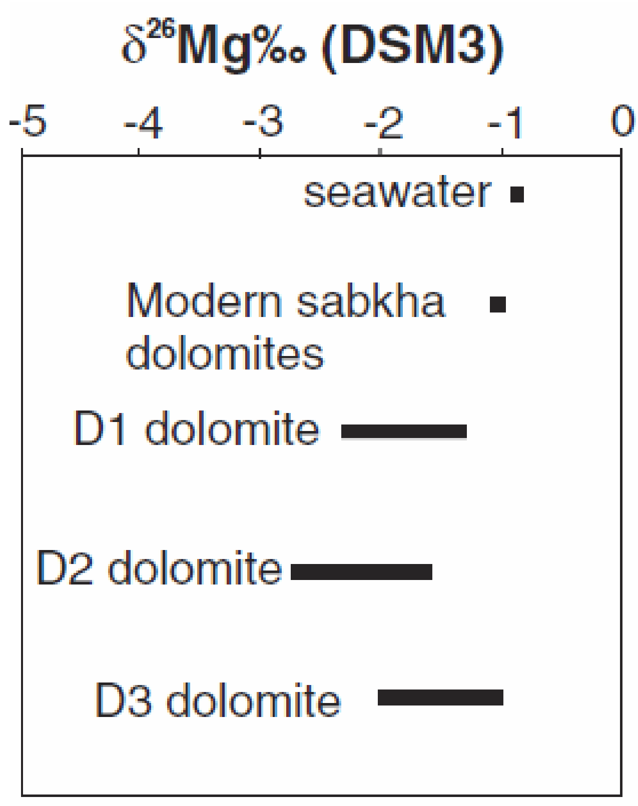


- This may explain the wide range of δ^{26}Mg of the Phanerozoic lime mudstone that was formed by disintegration of biogenic carbonates or by microbial mediation.



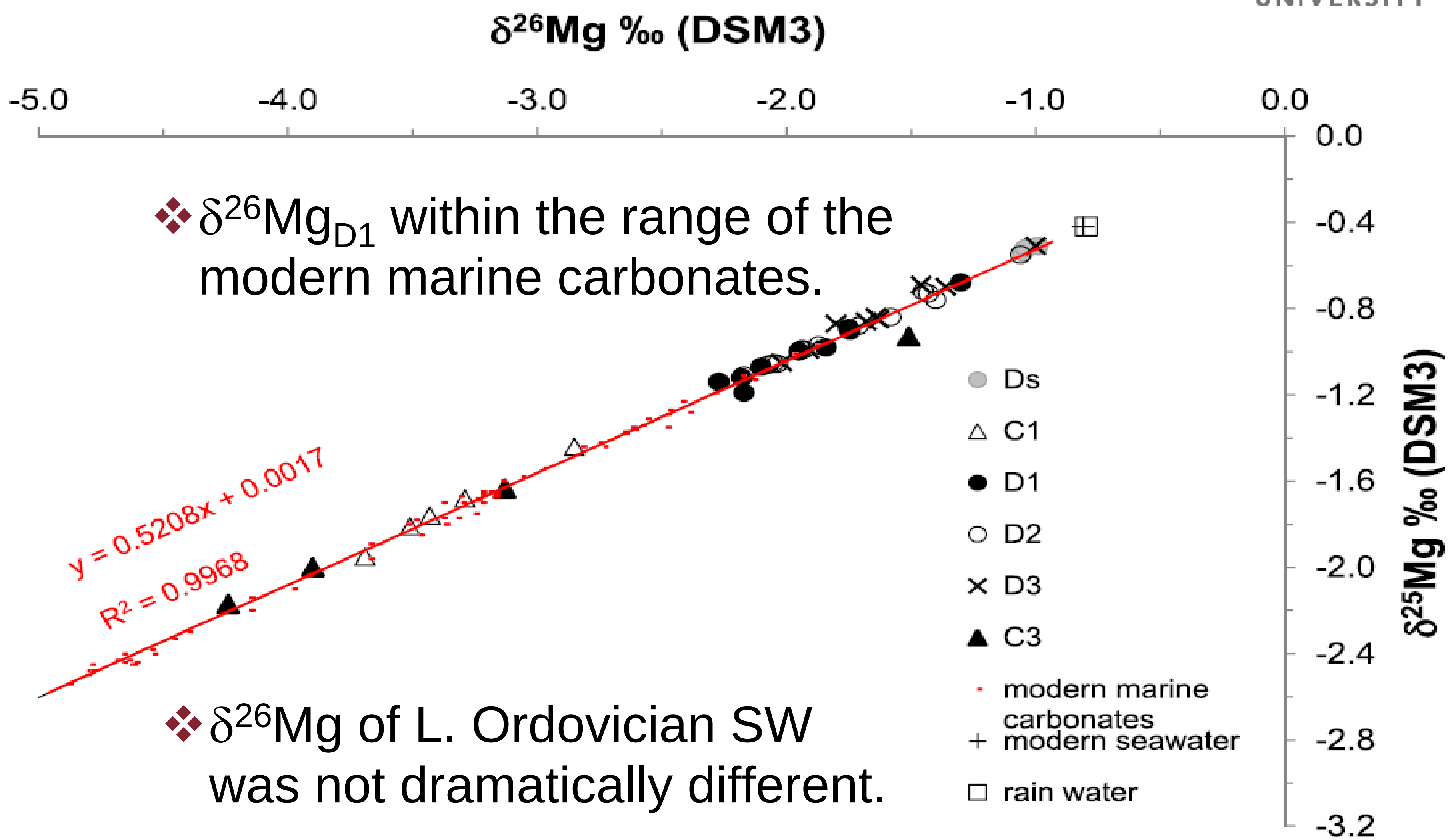
- Temperature seems to unlikely control fractionation in Mg-isotopes during formation of D1

- Instead D1 (dolomicrite) inherited its δ^{26}Mg from the precursor carbonate & diagenetic fluid.



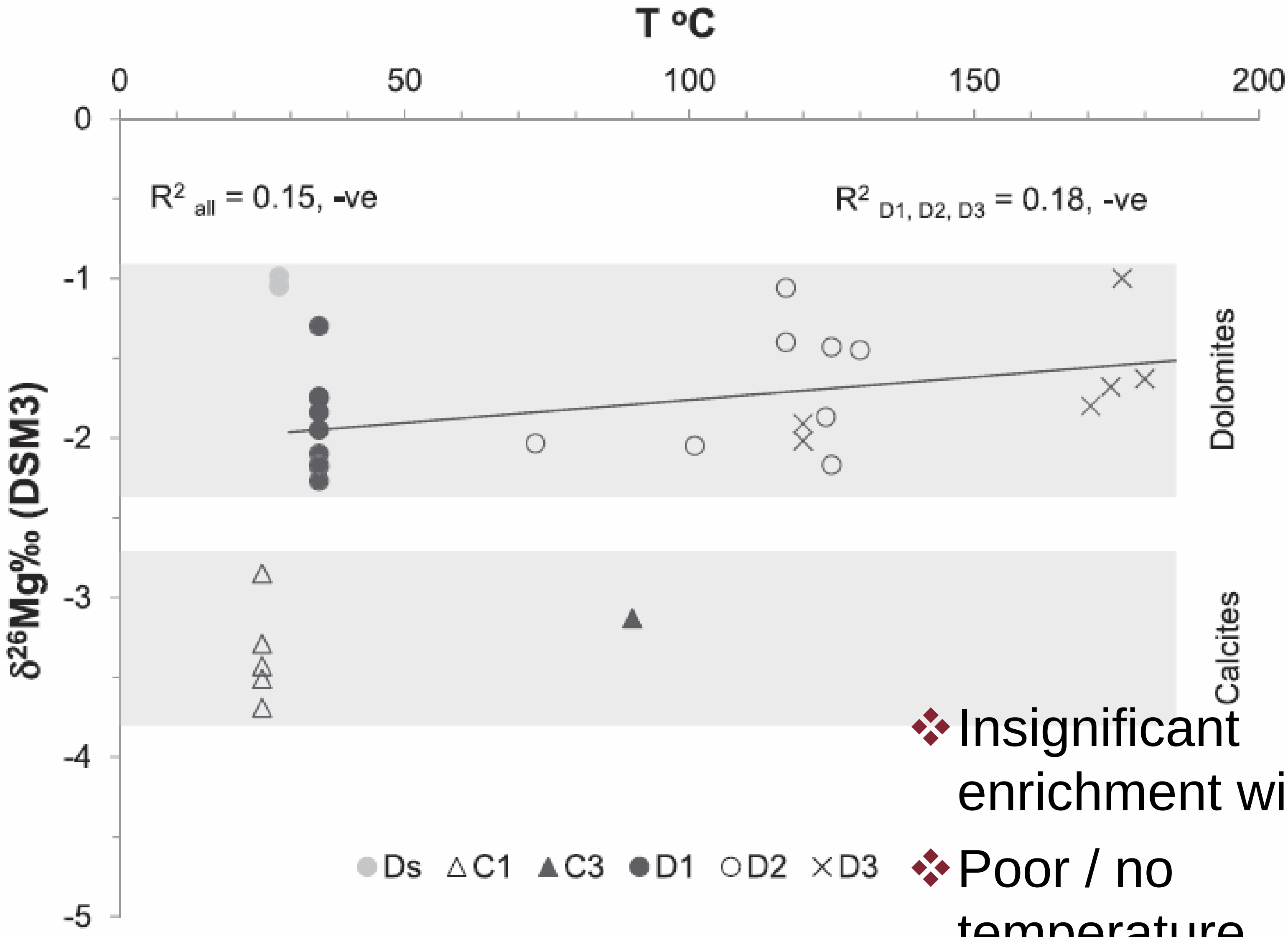
❖ $\delta^{26}Mg_{D1}$ within the range of the modern marine carbonates.

❖ $\delta^{26}Mg$ of L. Ordovician SW was not dramatically different.

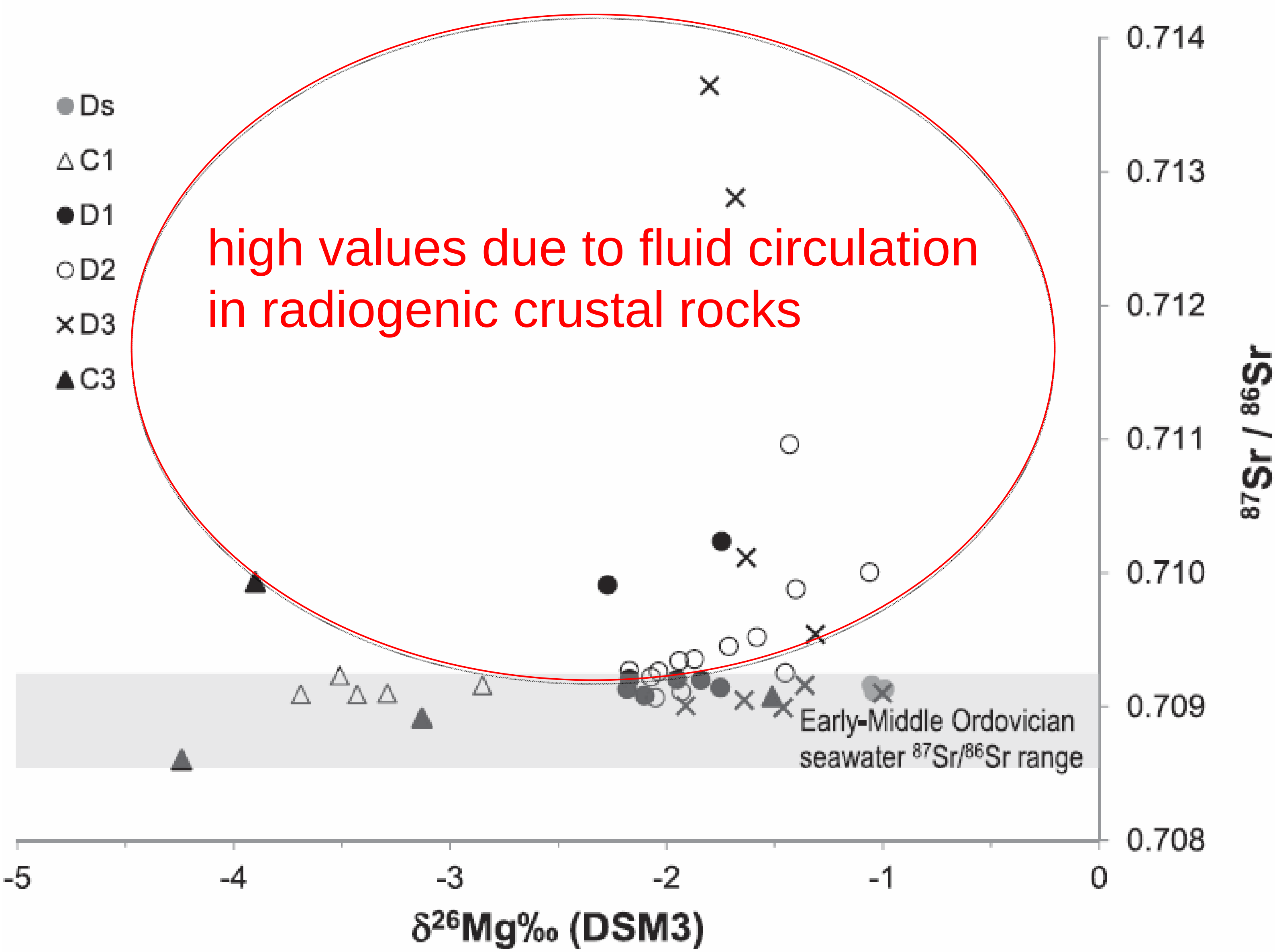


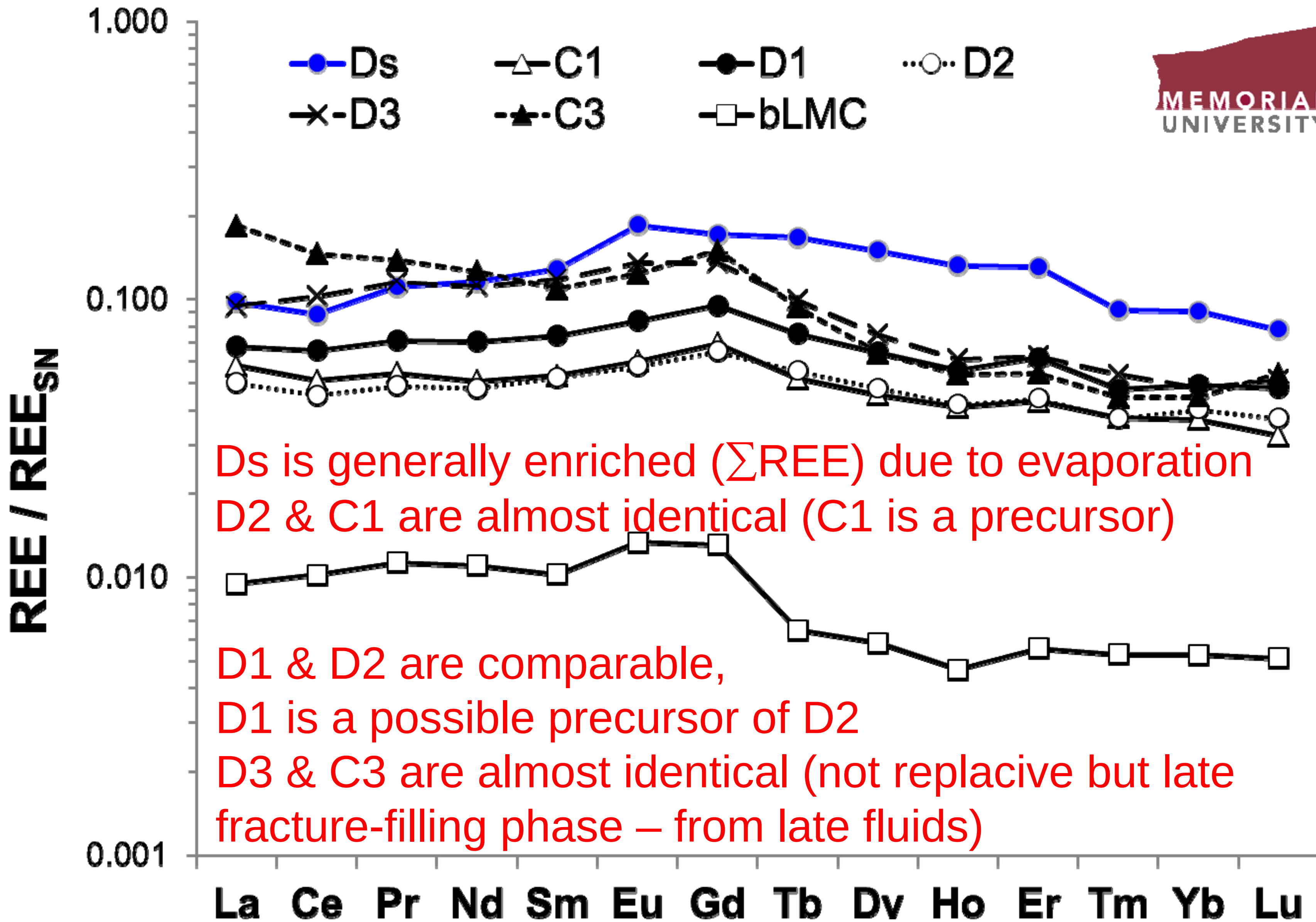
- Modern sabkha (UAE)
  - high Sr (4000 ppm) – ∑REE = 19±1 ppm
- D1 (St. George)
  - dolomicrite (fabric retention)
  - low Sr (<100 ppm) – ∑REE = 12±6 ppm
  - no associated evaporites
  - most enriched $\delta^{18}O$ (-3‰ VPDB)
  - precursor was ~ -7‰ within the best preserved E. Ordovician carbonates (-6 to -10‰ , $\Delta_{\text{dolomite-calcite}}$ = up to 4 ‰).

- Unlikely D1 had a sabkha origin but mixed meteoric & marine waters



- Insignificant enrichment with T
- Poor / no temperature control


Ds
C1
D1
D2
D3
C3
high values due to fluid circulation in radiogenic crustal rocks
Early-Middle Ordovician seawater ⁸⁷Sr/⁸⁶Sr range
0.714
0.713
0.712
0.711
0.710
0.709
0.708
87Sr / 86Sr
-5
-4
-3
-2
-1
0
δ26Mg‰ (DSM3)



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Conclusions

- The $\delta^{26}Mg$ values of the lime mudstones C1 from the St. George Gp. are comparable to those of modern HMC algae.

- Thus, in conjunction with petrographic and other geochemical evidences, it is proposed that C1 was sourced from Ordovician algae with precursor HMC mineralogy.

Conclusions (cont.)

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- The δ^{26}Mg values of D1 (dolomicrite), are bracketed by those of modern meteoric & SW and other Phanerozoic carbonates, suggesting that D1 likely formed from dolomitizing fluids consisting of a mixture of marine & meteoric waters in a near-surface setting.

- The similarity in δ^{26}Mg between D1 & D2 suggests that D1 was at times a precursor of D2.

Conclusions (cont.)

- Ranges of δ^{26}Mg values of the late hydrothermal D2 & D3 and of early D1 dolomite overlap considerably.
- This suggests that the hydrothermal fluids possibly originated from solutions of Mg-isotopic compositions similar to those sourcing the D1 or probably from fluids where their Mg-isotope composition evolved through circulation in the crust during progressive burial of the sediments.

Conclusions (cont.)

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- The mean δ^{26}Mg values of the investigated dolomites show only a slightest enrichment with temperature (T), suggesting that "T" is not the controlling factor.

- Instead, the Mg-isotopic composition of the diagenetic fluids circulating through ^{26}Mg-rich siliciclastic crustal rocks, under closed to semi-closed system conditions, imparted Mg-isotope characteristics on these later formed dolomites & calcites.

Thank you