

## **Strike at the Mississippian Carbonate Factory: Sequence Boundaries within the Mississippian Carbonates of Southeast Saskatchewan**

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The depositional cyclicity of Mississippian Carbonates in the Williston Basin is well documented. Major Sequence Boundaries attests to near complete drainage of the basin (ie. top of Alida Beds / Kisbey Sands interval). Sea level drops of shorter duration also record repeated devastating shutdowns of the Carbonate Factory with resulting exposure and erosion.

Sea level fluctuation patterns are repeated throughout the Alida, Frobisher and Midale Bed cycles. Repetitions include the Transgressive Surfaces of Erosion at the base of Alida (Handsworth Pool example) and base of Lower Midale (Weyburn Pool example). Peritidal muddy sediments were exposed and eroded and subsequently flooded and onlapped by higher energy sediments in both cycles.

A major Sequence Boundary separates the Lower and Upper Midale ( Midale Vuggy-Midale Marly) section. This boundary preserves erosional relief in the order of 10 meters at Weyburn Pool and the total loss of the Lower Midale section to the east at Benson Pool.

The Upper Midale section represents a Highstand Systems Tract with potential to preserve low energy shallow aeolian-derived clay-rich and organic-rich sediments (similar to modern Belize coastal deposits). These sediments were prone to dolomitization resulting from restricted circulation and fresh water mixing (Midale Marly reservoir).

Vuggy porosity distribution throughout the section further emphasizes repeated shutdowns of the Carbonate Factory through time. The Frobisher Beds example from Hastings Pool demonstrates that vuggy porosity developed contemporaneously with sedimentation. Ripup clasts with vuggy porosity are eroded and incorporated in the overlying sediments. The porosity is attributed to repeated exposure and weathering in a humid climate in order to account for the extensive porosity development. The lateral extent of vuggy porosity development is hence directly related to the extent of exposure of these beds. Major Frobisher Beds Sequence Boundaries may have more erosional topography than previously recognized (eg. Stoughton, Griffin, Halbrite and Huntoon informal members) and would be a logical stratigraphic exploration target. The State A Marker represents the Highstand Systems Tract of the Frobisher sequence (with potential for extensive dolomitization similar to the muds in the Upper Midale Highstand) .

Onlap of sediments over the Transgressive Surface of Erosion at the base of Alida and base of Midale is critical to understanding the reservoir characteristics of these beds (ie. their updip lateral extent). As well, the topographical relief on the erosional Sequence Boundaries (top of Alida, top of Lower Midale) is important for the influence it has on accommodation space (and hence energy available) for the overlying sediments.

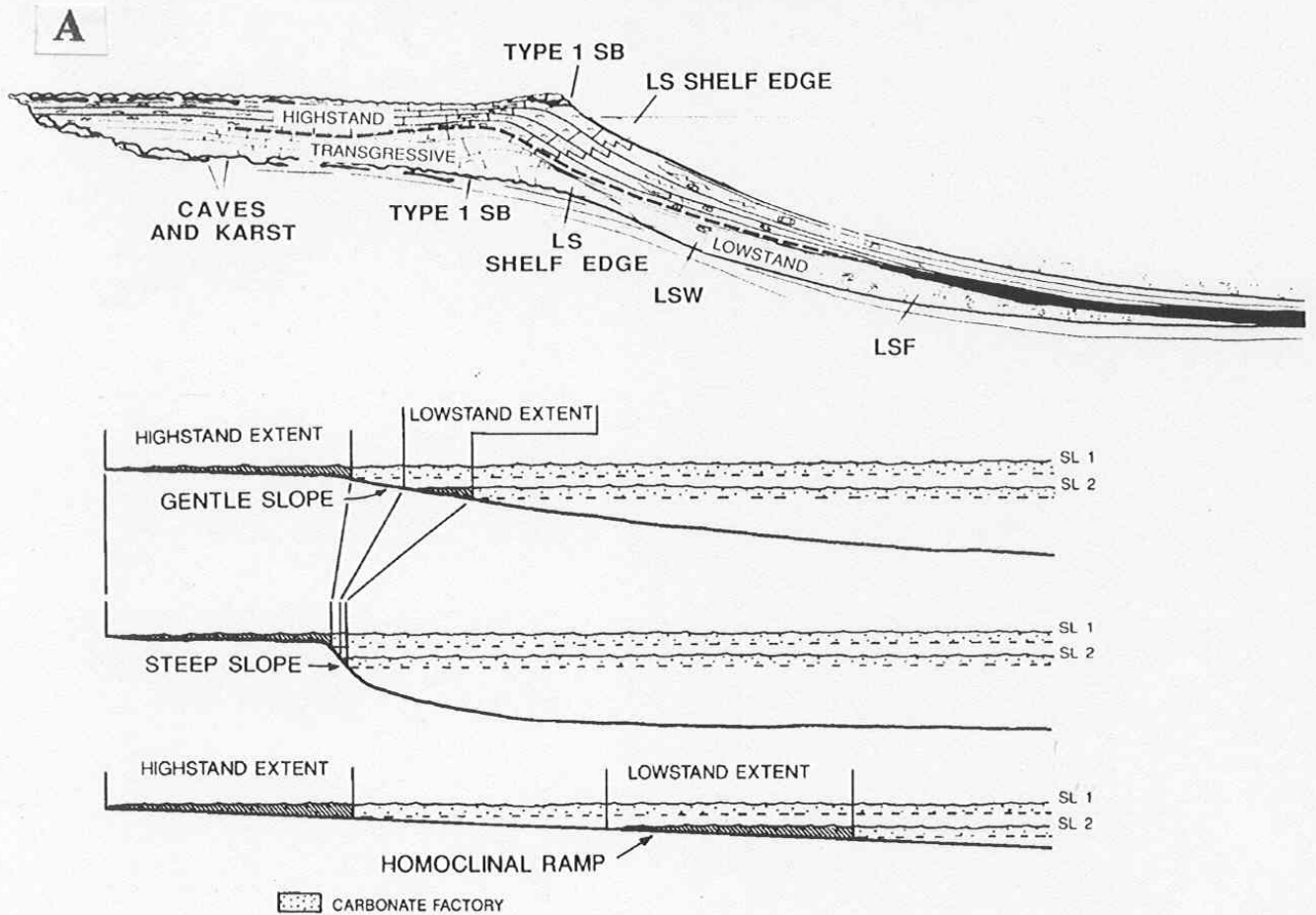
### **References:**

Handford, C.R., and Loucks, R.G., 1993, Carbonate Depositional Sequences and Systems Tracts-Responses of Carbonate Platforms to Relative Sea Level Changes in Carbonate Sequence Stratigraphy: Recent Developments and Applications: R.G. Loucks and J.F. Sarg (Eds) American Association of Petroleum Geologists Memoir 57, pp3-42.

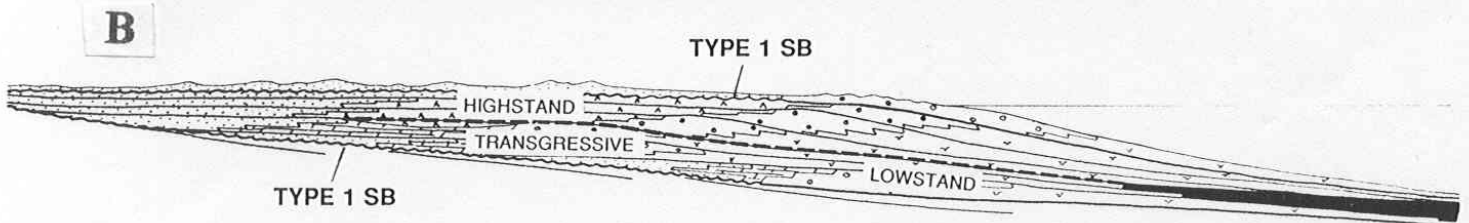
Lake, J.H., 2001, Onlap within the Mississippian Midale Beds of Southeastern Saskatchewan, in Summary of Investigations, 2001, Volume 1, Saskatchewan Geological Survey, Saskatchewan Energy and Mines Misc. Report 2001-4.1.

Lake, J.H. and Seifert, S., 2003, Horizontal Potential of the Lower Alida Beds at Handsworth Pool, southeast Saskatchewan, in 11<sup>th</sup> International Williston Basin Horizontal Well and Petroleum Conference Core Workshop Volume, Saskatchewan Geological Society Special Publication No. 16.

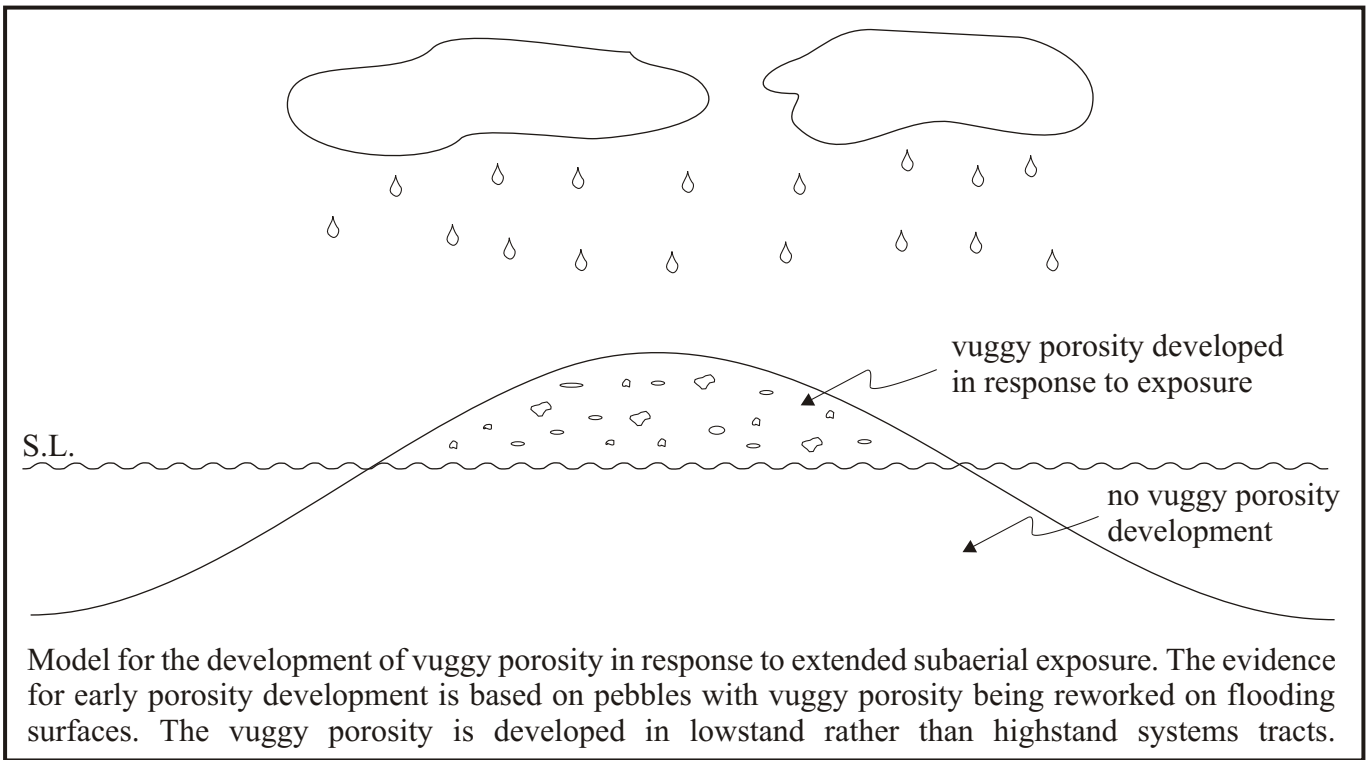
## DEPOSITIONAL SEQUENCE MODEL HUMID CARBONATE RIMMED SHELF



## DEPOSITIONAL SEQUENCE MODEL ARID CARBONATE-EVAPORITE-SILICICLASTIC RAMP



Comparison of Carbonate Rimmed Shelf (A) versus Ramp/Epeiric Sea (B) Depositional Sequence Models. The Ramp Highstand Systems Tract floods a very broad area because of the flatlying nature of the basin. (Modified after Handford and Loucks, 1993).

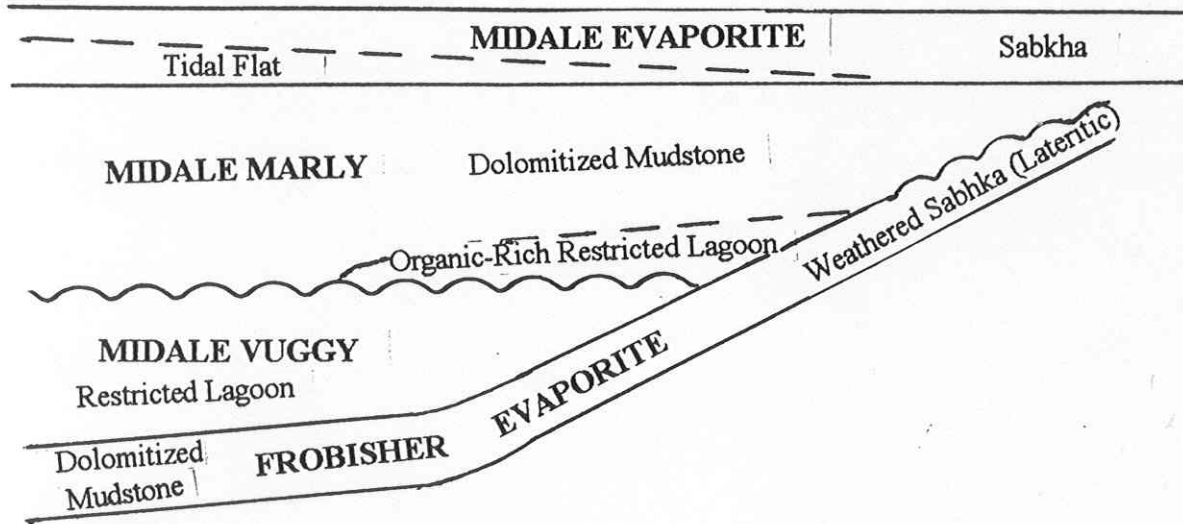


Model for the development of vuggy porosity in response to extended subaerial exposure. The evidence for early porosity development is based on pebbles with vuggy porosity being reworked on flooding surfaces. The vuggy porosity is developed in lowstand rather than highstand systems tracts.

WEYBURN

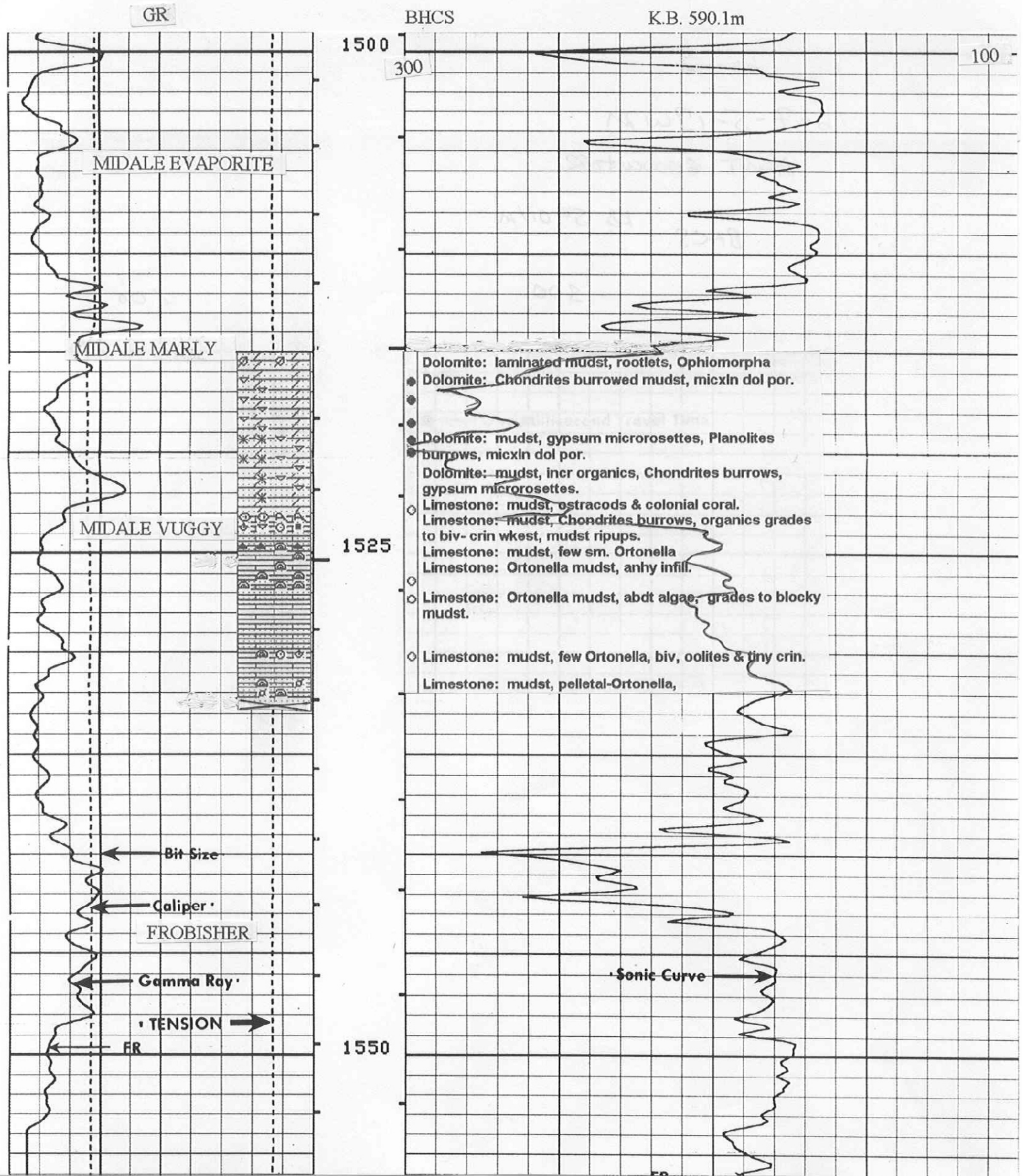
MIDALE

BENSON



Idealized east-west cross-section through the Midale Formation in southeast Saskatchewan. The Midale Vuggy unconformity onlaps the Frobisher Evaporite surface. The organic-rich restricted lagoonal sediments are part of the Midale Marly beds. The Midale Evaporite onlaps the Frobisher Evaporite at Benson Pool in the east. The Frobisher Evaporite is a weathered exposure surface with laterite development at Benson and pools to the east.

Lake, 2001.





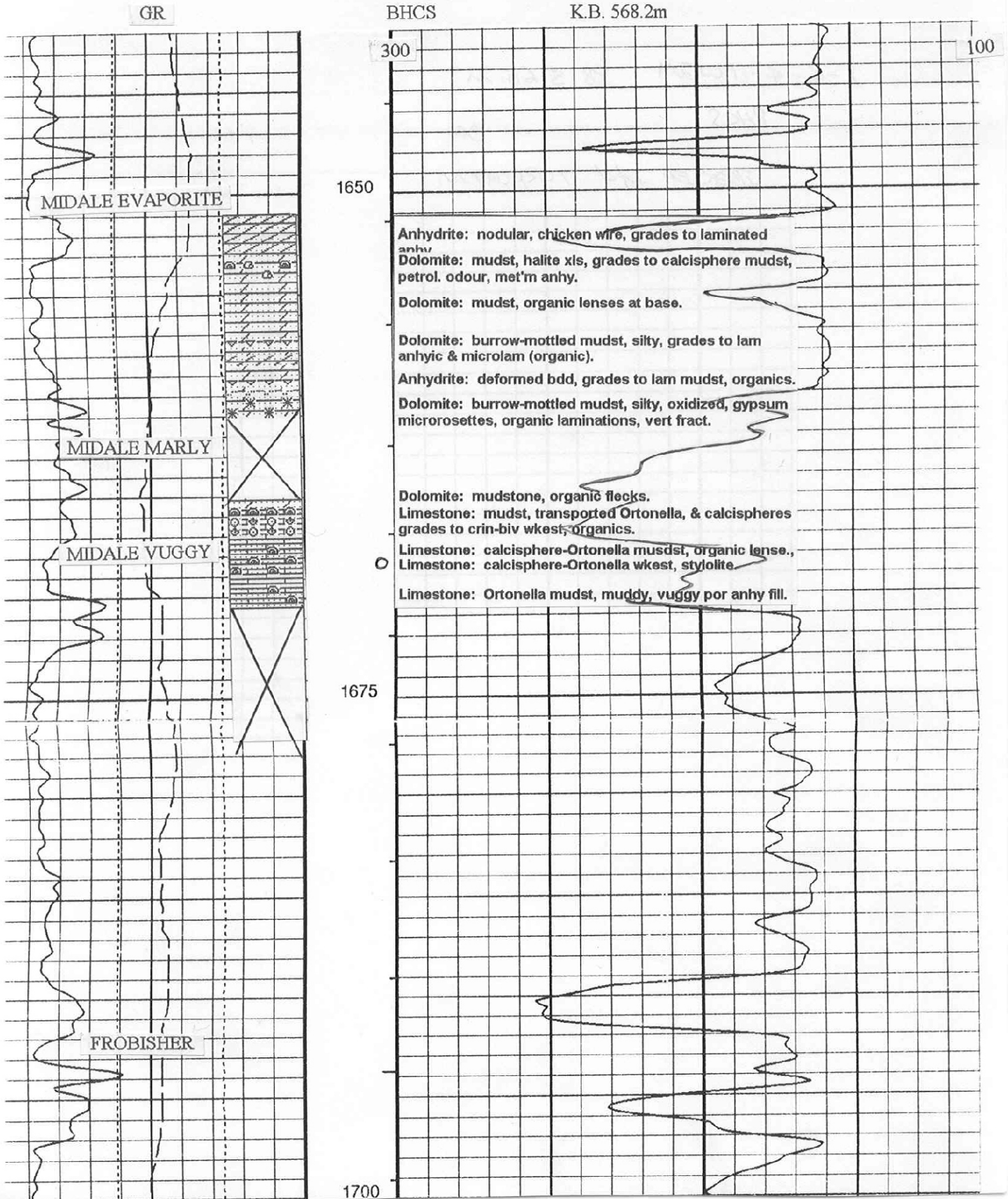
A



B

Sequence Boundary between Lower and Upper Midale Beds (Marly and Vuggy). The upper Midale (Marly) contains organic material, burrowing and a basal lag. It represents a Highstand Systems Tract. The Lower Midale (Vuggy) contains *Ortonella* mudstones. (A) Overview of contact (top of core to left). (B) Detailed view of contact showing basal lag. (16-7-5-13W2M).

1-4-4-11W2M Berkley et al Torquay N.



Midale Evaporite

Upper Midale (Marly)



C

Contact between Midale Evaporite and Upper Midale (Marly) beds (k-k). A Marine Regression occurred above the Upper Midale (Marly) Highstand Systems Tract. The Midale Evaporite consists of stacked deepening-up cycles. Individual cycles contain basal dolomitized tidal flat mudstones (often organic-rich) which grade into burrow-mottled mudstones. The Upper Midale (Marly) was deposited in restricted ponds adjacent to the shoreline and underwent dolomitization via fresh water mixing. (1-4-4-11W2M, 1653m at k-k contact).



Upper Midale (Marly)

Lower Midale (Vuggy)



D



E

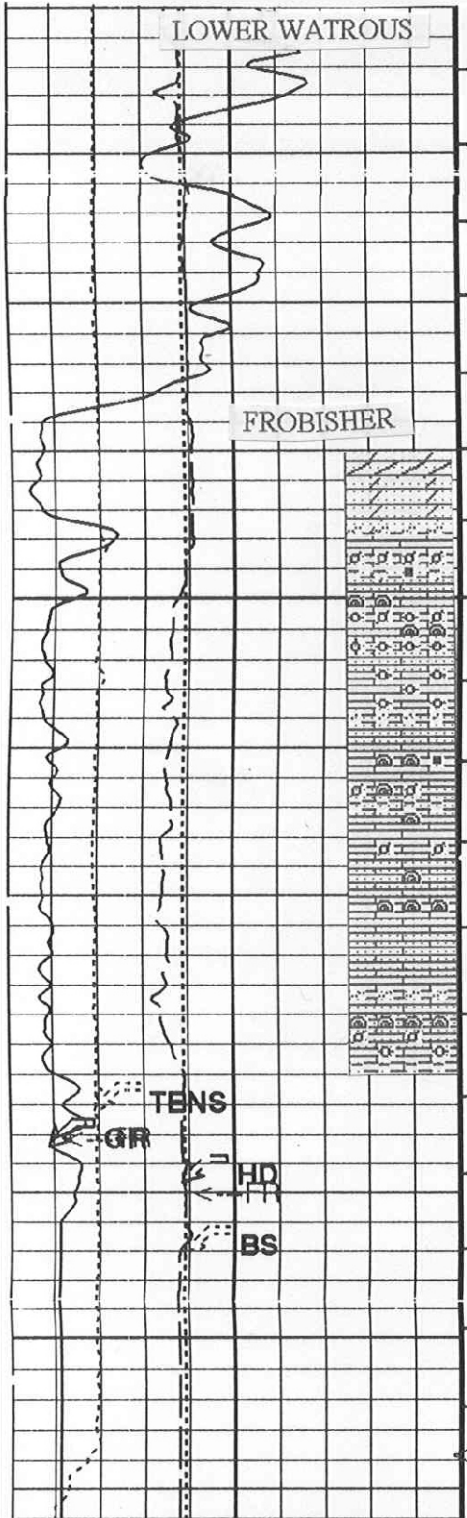
Upper Midale (Marly) Highstand Systems Tract / Lower Midale (Vuggy) Lowstand Systems Tract contact (D; 1667.5m). Note the high organic content of basal beds of Upper Midale (Marly) and the presence of transported crinoids and bivalves (E; 1666.0m). (1-4-4-11W2M).

# 2D14-34-3-1W2M CIMARRON HASTINGS

GR

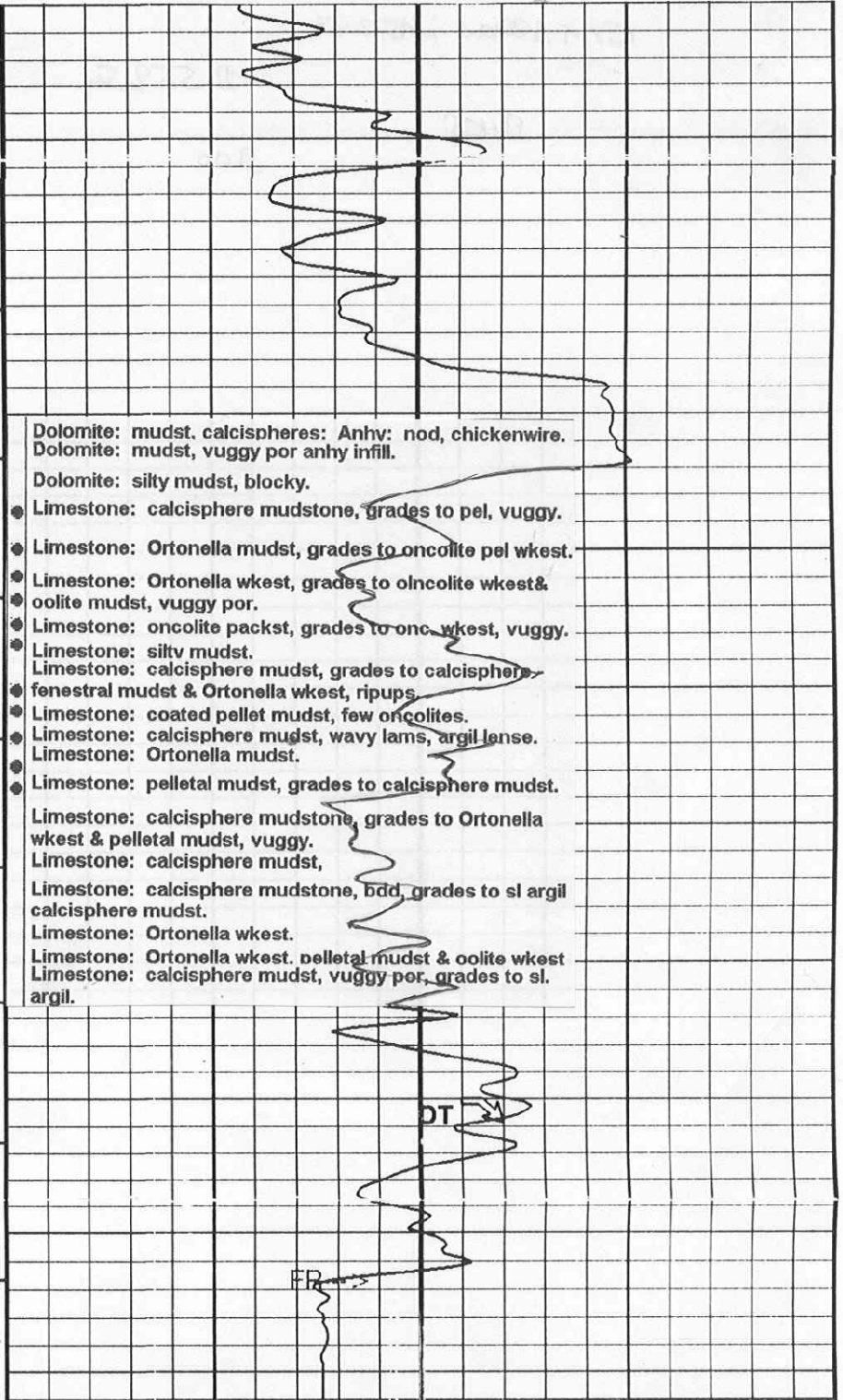
BHCS

K.B. 559.5m



1250

1275



Dolomite: mudst. calcispheres: Anhy: nod, chickenwire.  
Dolomite: mudst, vuggy por anhy infill.

Dolomite: silty mudst, blocky.

● Limestone: calcisphere mudstone, grades to pel, vuggy.

● Limestone: Ortonella mudst, grades to oncolite pel wkest.

● Limestone: Ortonella wkest, grades to oncolite wkest & oolite mudst, vuggy por.

● Limestone: oncolite packst, grades to onc. wkest, vuggy.

● Limestone: silty mudst.

● Limestone: calcisphere mudst, grades to calcisphere fenestral mudst & Ortonella wkest, ripups

● Limestone: coated pellet mudst, few oncolites.

● Limestone: calcisphere mudst, wavy lams, argil lense.

● Limestone: Ortonella mudst.

● Limestone: pelletal mudst, grades to calcisphere mudst.

Limestone: calcisphere mudstone, grades to Ortonella wkest & pelletal mudst, vuggy.

Limestone: calcisphere mudst,

Limestone: calcisphere mudstone, bdd, grades to sl argil calcisphere mudst.

Limestone: Ortonella wkest.

Limestone: Ortonella wkest. pelletal mudst & oolite wkest

Limestone: calcisphere mudst, vuggy por, grades to sl. argil.

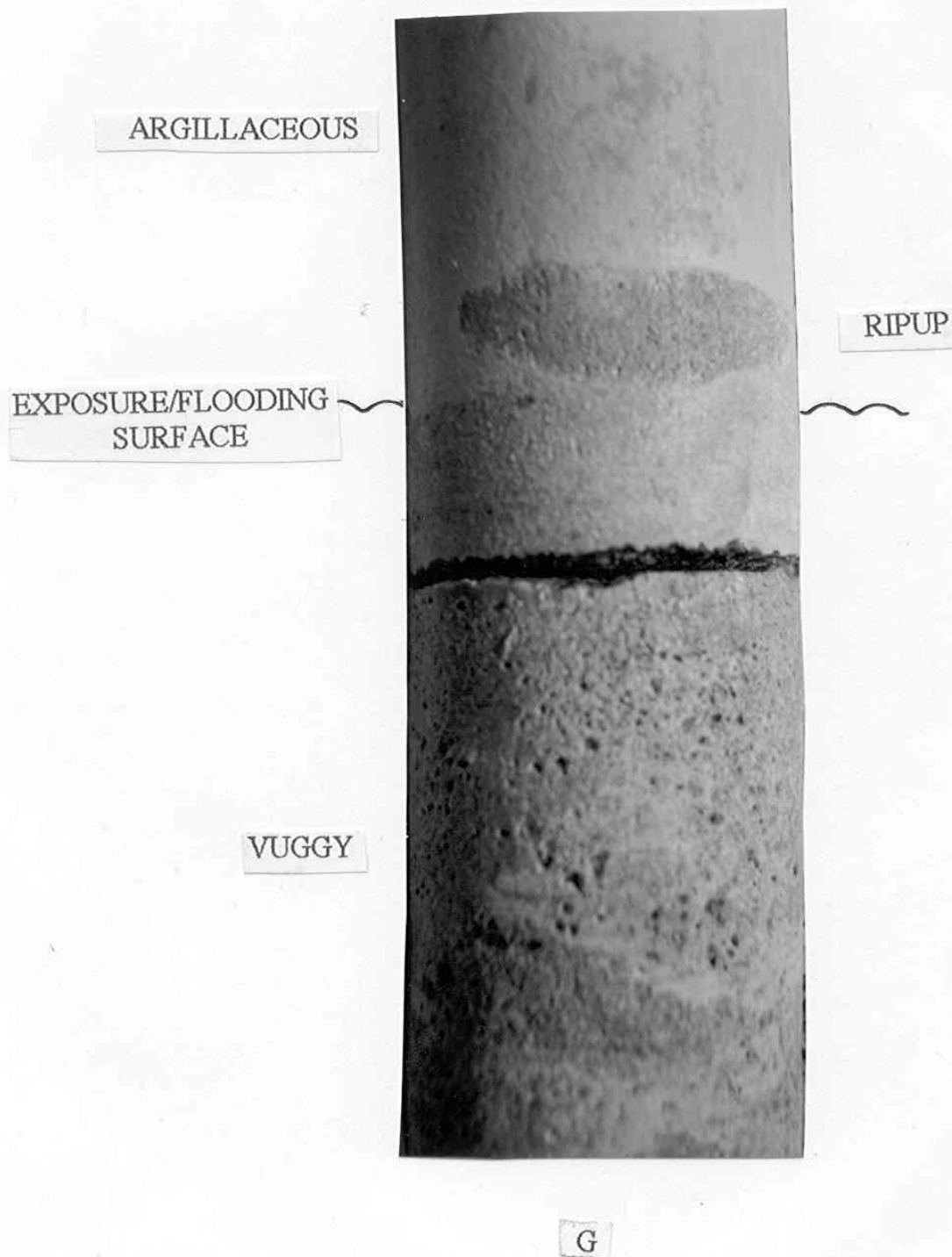
Hole Diameter (HD) (MM) 125 375

Delta-T (DT) (US/M) 300 100

Gamma Ray (GR) (GAPI) 0 150



Cycles within the Frobisher Lowstand Systems Tract. Individual cycles consist of highly argillaceous mudstones (erosional bases –Arg) which grade into vuggy porosity limestones (Vug). Note ripup clast (with vuggy porosity development) incorporated into the argillaceous base of the cycle. (Details of this feature in the following core photo). (2D14-34-3-1W2M, 1245-1253m).



Detail of erosional contact / flooding surface at the top of a typical cycle within the Frobisher Beds Lowstand Systems Tract. Individual cycles grade up from argillaceous mudstone into vuggy porosity limestones. Incorporation of a ripup with vuggy porosity development suggests the vuggy porosity developed by exposure and dissolution prior to the next flooding event. (2D14-34-3-1W2M, 1244.4m, (G)).

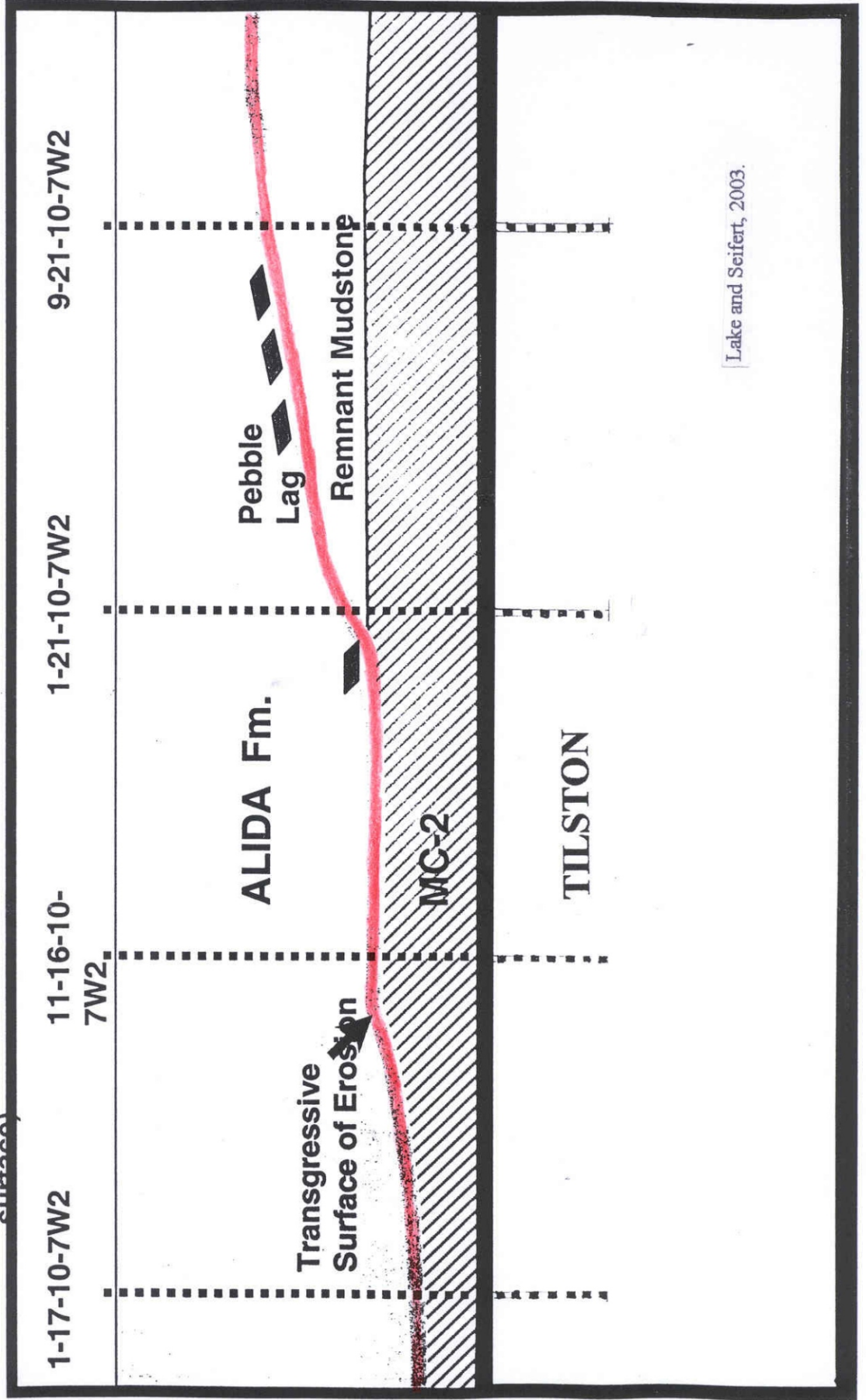
# Handsworth Schematic Cross

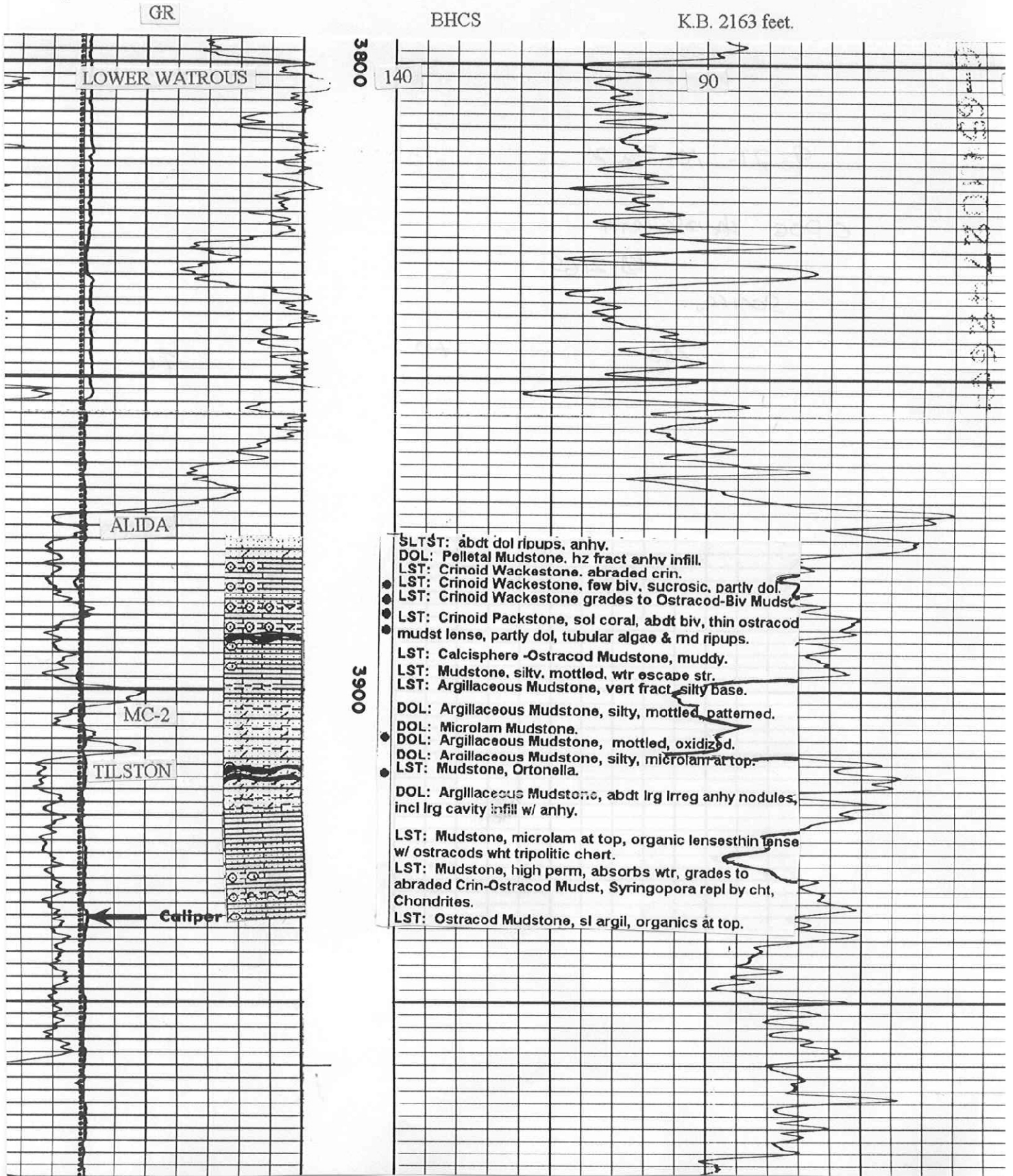
## Section

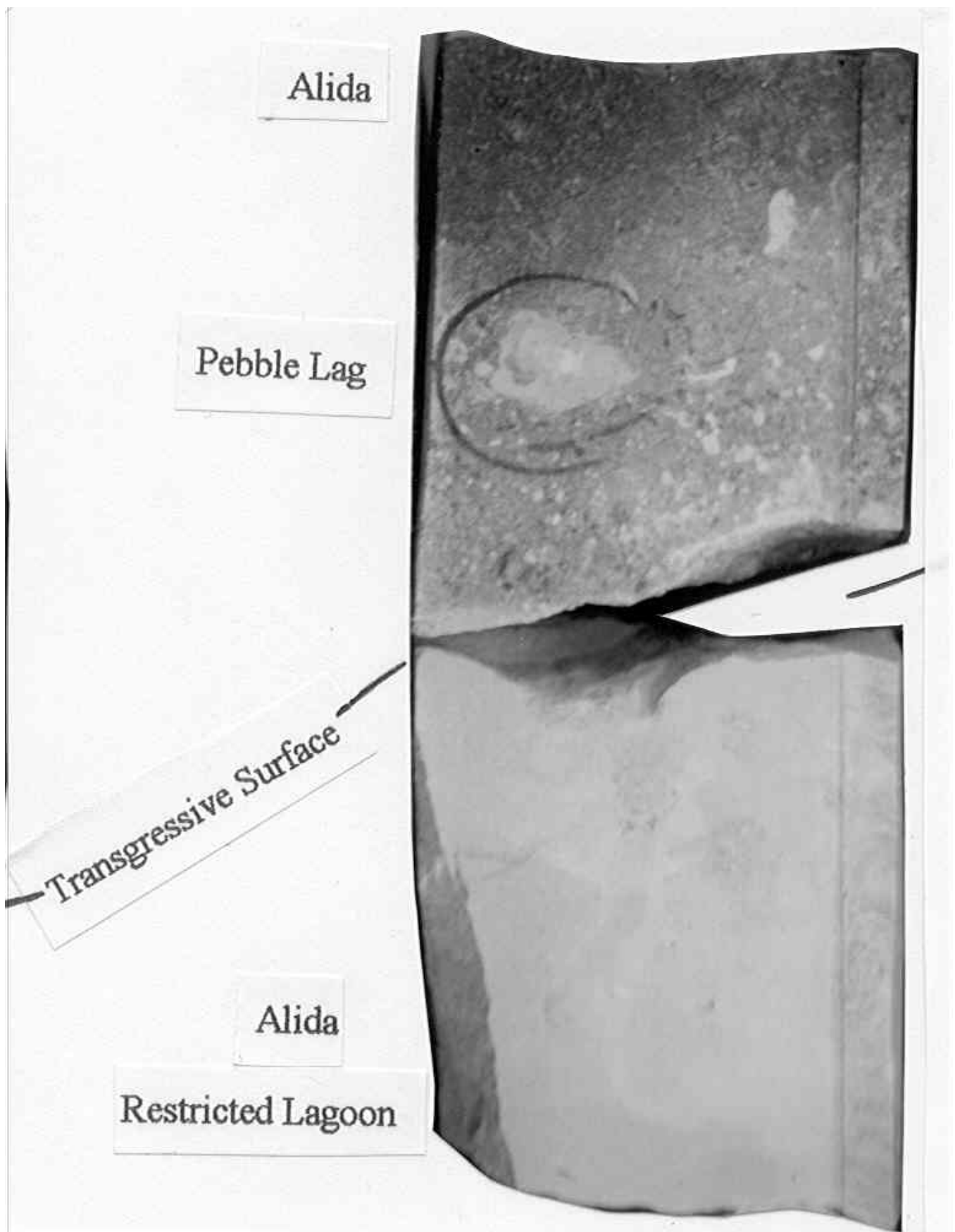
N

S

(Showing removal of more section to South by transgressive erosional surface)







Transgressive Surface of Erosion pebble lag/exposure surface at the Alida crinoidal/Alida restricted lagoonal contact. The surface acts as a bottomseal for trapping oil in the Handsworth Pool (9-21-10-7W2M, 3891 feet).

Lake and Seifort, 2003