Spatial Diagenetic Heterogeneity of Lenticular Sandbody in Shahejie Formation, Bohai Bay Basin, China, and Its Implications for Sandstone Diagenesis*

Haitao Sun[1] and Dakang Zhong[1]

Search and Discovery Article #50490 (2011)
Posted September 30, 2011

*Adapted from poster presentation at AAPG Annual Convention and Exhibition, Houston, Texas, USA, April 10-13, 2011.

[1]College of Geosciences, China University of Petroleum, Beijing, China. (sunhit@msn.com)

Abstract

The entity of diagenesis which refers to the physical and chemical processes that affected sedimentary materials after deposition and weathering was always an outstanding issue. We try to figure out its complicated process by studying a whole diagenetic system, which are composed of the deeply buried (3,100~3,300 m) lenticular sandbodies and the surrounded shales. The lenticular sandbodies of five diverse distribution patterns were lying at Shahejie Formation in the rift basin of eastern China. 141 core samples, including sandstones and shales, were acquired within sandbody and near the sand/shale contact (SSC) by densely sampling. Based on analysis of thin section, X-Ray Diffraction, Scanning Electron Microscopy and Cathodoluminescence Micrography, those samples' diagenesis and its differences between the exterior and the interior of lenticular sandbody were analyzed.

We found the lenticular sandstones got high porosity (20%) at the interior and low porosity (4%) at the SSC. The reason for low porosity was the present of carbonate cements. The quantity and sorts of carbonate cements formed during increasing burial depth is much more in the external (>15%) than in the interior of lenticular sandbody (<3%). Shale supplied the source for a portion of the diagenetic cements near the SSC in the whole diagenetic system. Thin sections showed that between 65°C and 140°C, sandstones and shales underwent massive chemical and textural reorganization. In this temperature interval, within sandstones and shales of late-stage illitization, unequal amounts of reactive components in the SSC created episodic chemical gradients, so the diffusive mass transport process was formed in the whole diagenetic system. Near the SSC, a cement band was formed rapidly on a geological scale and sufficient to take up over distances of 1 to 3 meters in lenticular sandbody. Sufficient burial depth could afford the temperature threshold to the formation of chemical gradient. The scale of lenticular sandbody and shales would influence the cement extent and cement distribution. Sorts and quantity of composition in both

sand and shale would dominate episodic diffusion gradients and the direction and velocity of the transfer mass. The whole diagenesis evolution result proved shales play an important role in the process and must be considered in to sandstone diagenesis.

Reference

Thyne, G., 2001, A model for diagenetic mass transfer between adjacent sandstone and shale: Marine and Petroleum Geology, v. 18/6, p. 743-755.

Spatial Diagenetic Heterogeneity of Lenticular Sandbody in Shahejie Formation, Bohai Bay Basin, China & Its Implications for Sandstone Diagenesis

Haitao SUN, Dakang ZHONG

College of Geosciences
China University of Petroleum-Beijing

12th,April,2011

OUTLINE

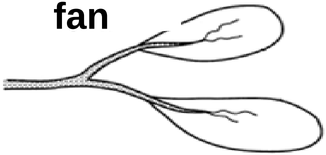
- INTRODUCTION & BACKGROUND
- SAMPLES AND METHODS
- DIAGENETIC HENTEROGENEITY
- ORIGIN DISSCUSSION
- CONCLUSIONS

Introduction & Background

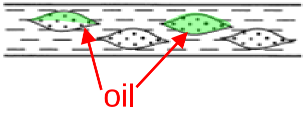
✓Why do we study the sandstone diagenesis

turbidite

fan



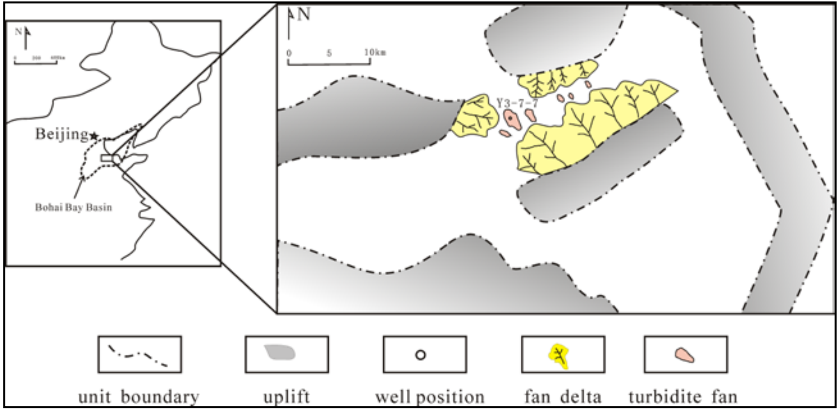
sandbody



?

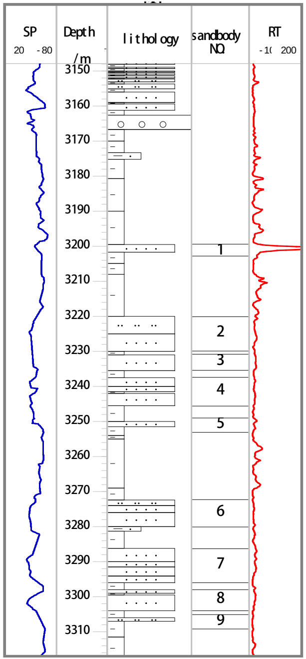
✓Background

- ☐Faulted basin
- ☐Faulted depression
- ☐Turbidite fan



Samples and Methods

➢Nine lenticular sandbodies and around mudstone



Column of well Y3-7-7

mudstone 3220.61m

3273.7m

3146.64m

sandstones 3147.44m

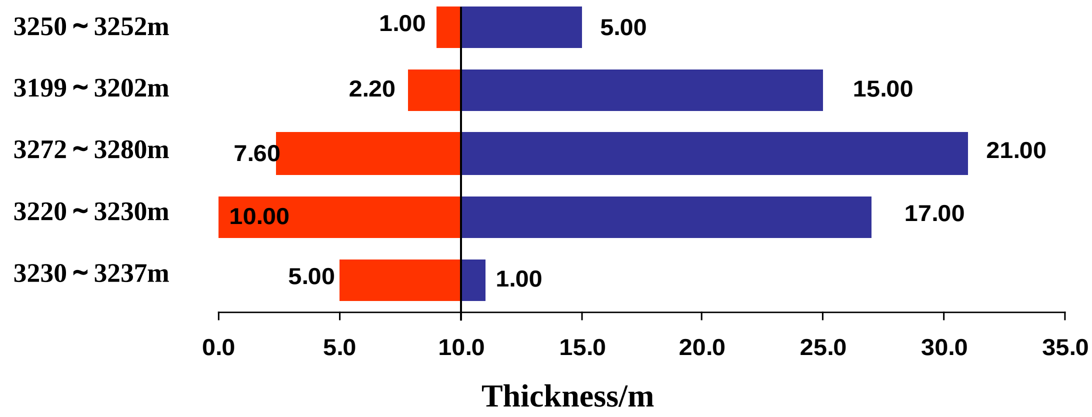
3150.44m

3147.94m

Samples and Methods

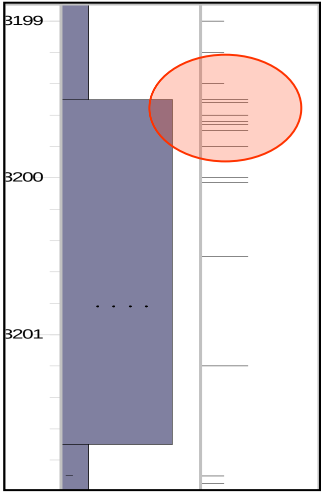
➢ Select five sandbodies and dense sampling

Burial depth **sandstone** VS **mudstone**



Burial depths and scale of sandbody and around mudstone

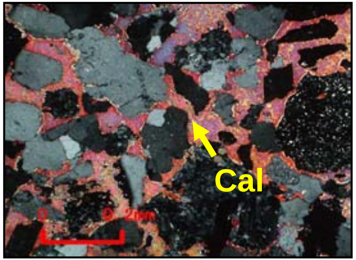
Dense sampling



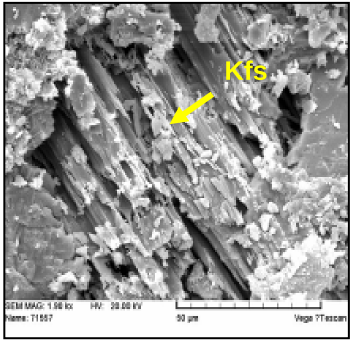
Samples and Methods

- Multi analysis methods

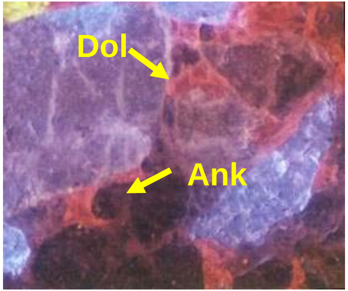
- Section
- CL
- SEM
- X-RD



3250.9m (+)



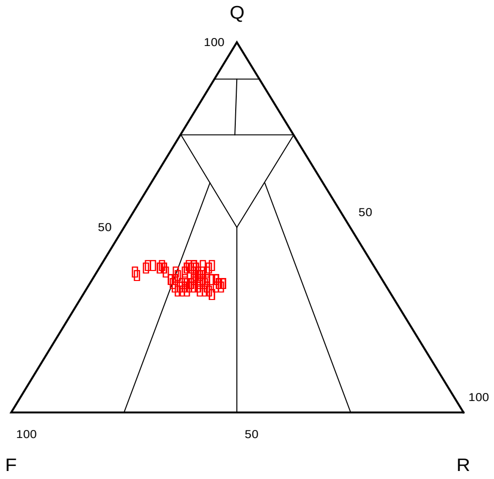
3250.54m (SEM)

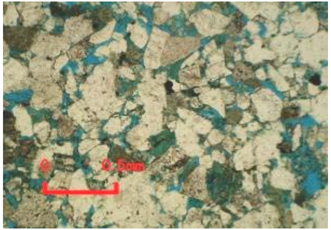


3280.5m(CL)

Diagenetic Henterogeneity

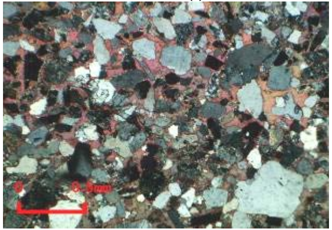
- Sandstone types according to Fork’s classification and porosity differences





Φ=8

3280.5m (-)



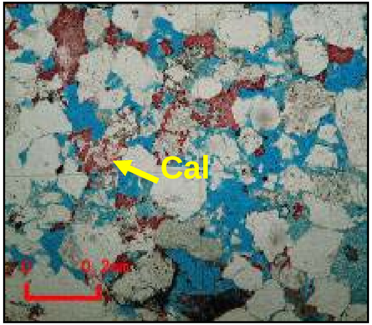
Φ=0.5

3298.35m (-)

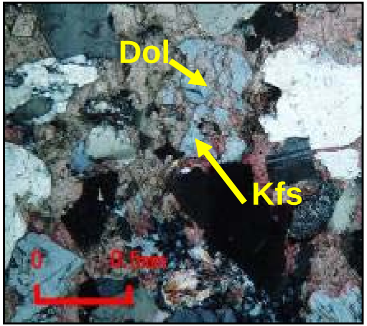
Diagenetic Henterogeneity

➢ Sandstone diagenetic stage

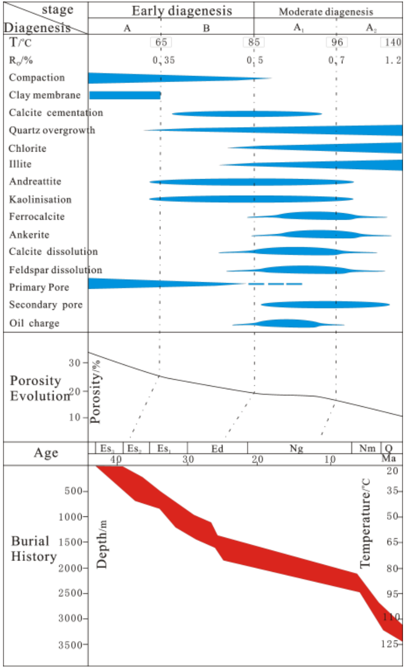
- I/S mixed layer ratio =20%
- Ro 0.8～1.3%
- T>105℃



3199.6m (-)

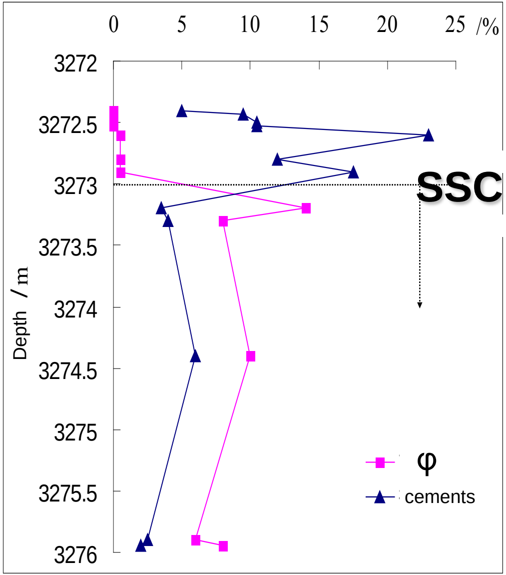


3272.9m (+)

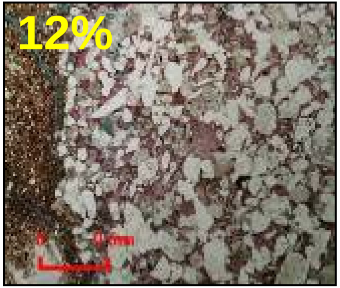


Diagenetic Henterogeneity

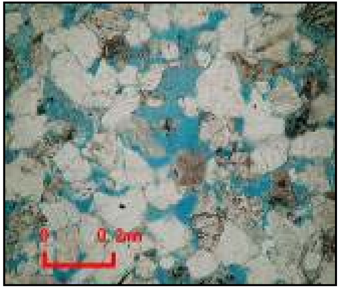
- Porosity differences



- Low poroisity near the SSC
- High porosity interior sandbody



3272.8m (-)

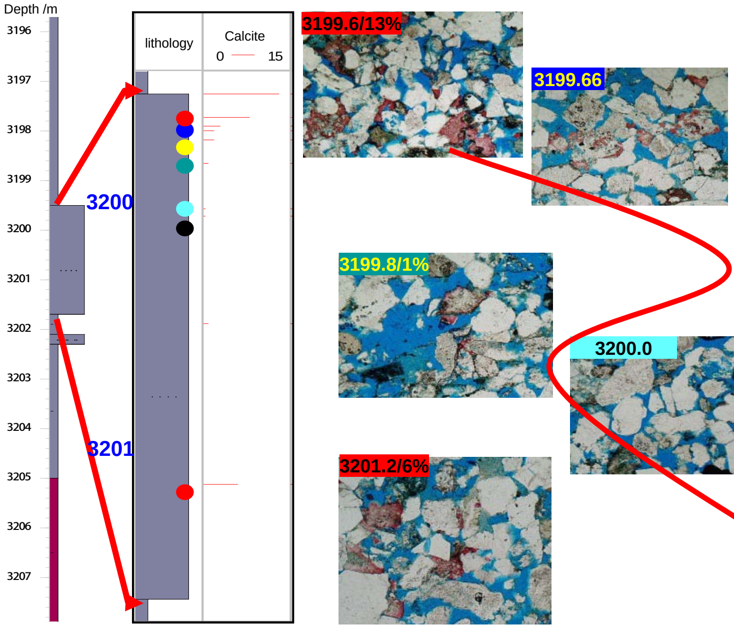


3273.3m (-)

SSC: sandstone / shales contact

Diagenetic Henterogeneity

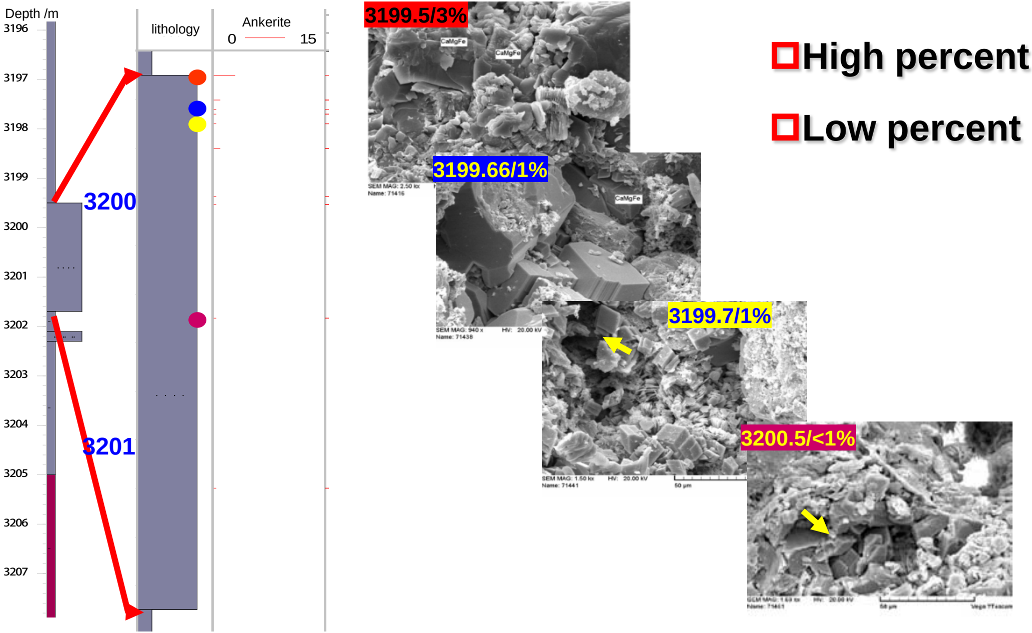
- Cementation henterogeneity was the main reason



- High percent near the SSC
- Low percent interior sandbody

Diagenetic Henterogeneity

➢ Same characteristics of ankerite



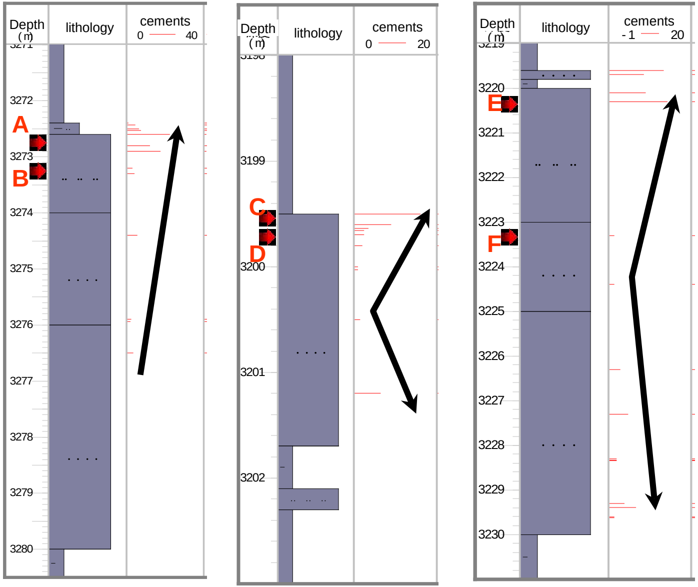
□High percent near the SSC

□Low percent interior sandbody

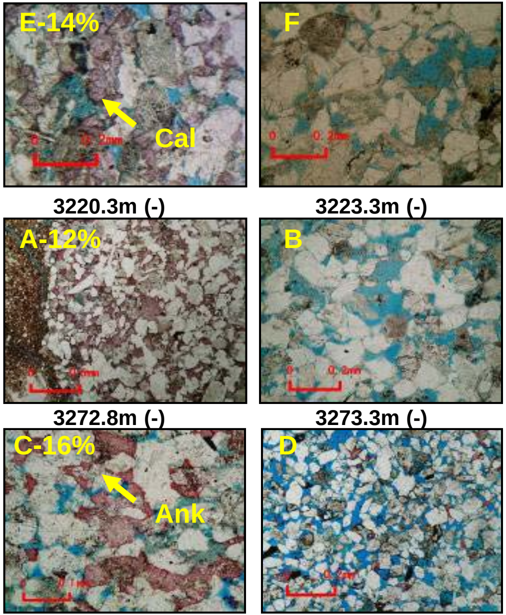
Diagenetic Henterogeneity

why?

- Three sandbodies have the same characteristics



3272～3280m　　3199～3202m　　3220～3230m

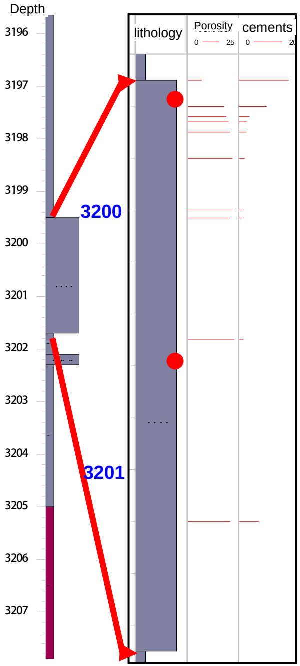


3220.3m (-)　3223.3m (-)

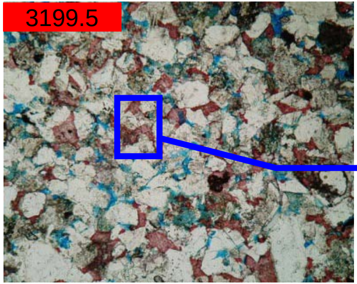
3272.8m (-)　3273.3m (-)

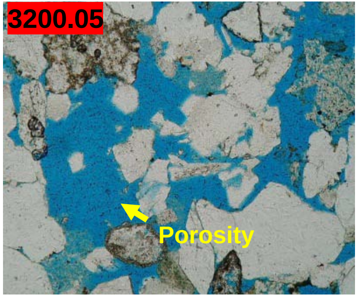
3199.5m (-)　3199.66m (-)

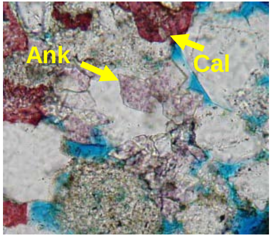
Origin Discussion



➢ Carbonate cements formation







- **Ferrocalcite**
- **Ankerite**

How?

$[Mg,Fe,Ca]\cdot nCO_3$

$[Fe,Ca]\cdot nCO_3$

Origin Discussion

- Diagenesis material come from around mudstone

☐ Illitization ⟶ Cations

☐ Organic material maturation ⟶ Acid root

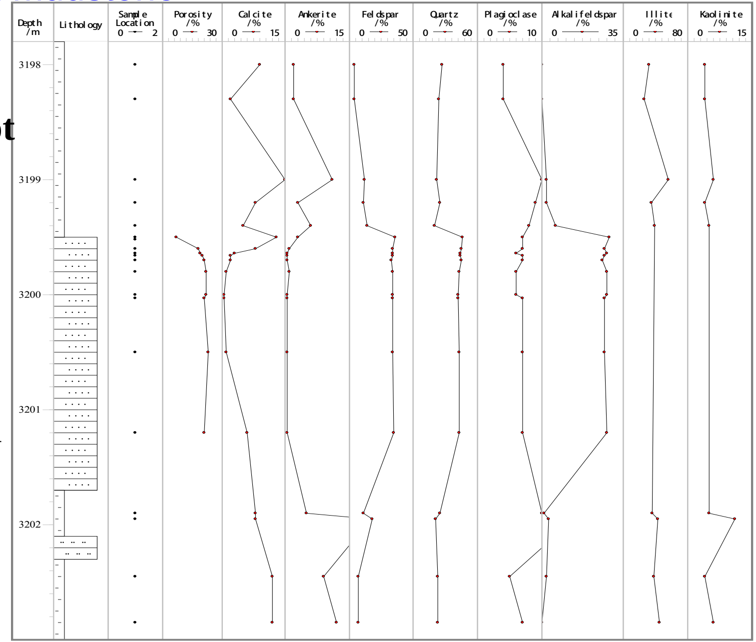
$$CaCO_3 + 2H^+ = Ca^{2+} + H_2O + CO_2$$

$$(Na_{0.7}Ca_{0.3})Al_{1.3}Si_{2.7}O_8 + 5.2H^+ + 2.8H_2O =$$
$$0.7Na^+ 0.3Ca^{2+} + 1.3Al^{3+} + 2.7H_4SiO_4$$

$$K_{0.12}Na_{0.25}(Al_{1.41}Fe_{0.22}Mg_{0.41})(Si_{3.88}Al_{0.12})O_{10}(OH)_2 + 9.96H_2O =$$
$$0.12K^+ + 0.25Na^+ + 0.22Fe^{3+} + 0.41Mg^{2+} + 1.53Al^{3+} + 3.88H_4SiO_4 + 6.44OH^-$$

$$CH_2O + H_2O \rightarrow CO_2 + 4H^+$$

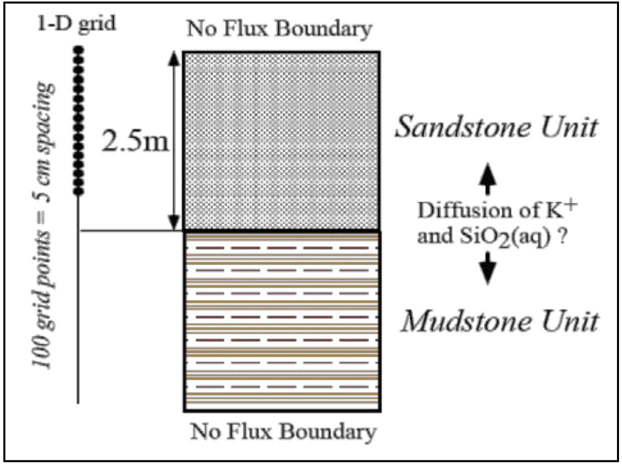
$$Ca(Sr)CO_3 + HAC \rightarrow Ca(Sr)^{2+} + HCO_3^- + AC^-$$



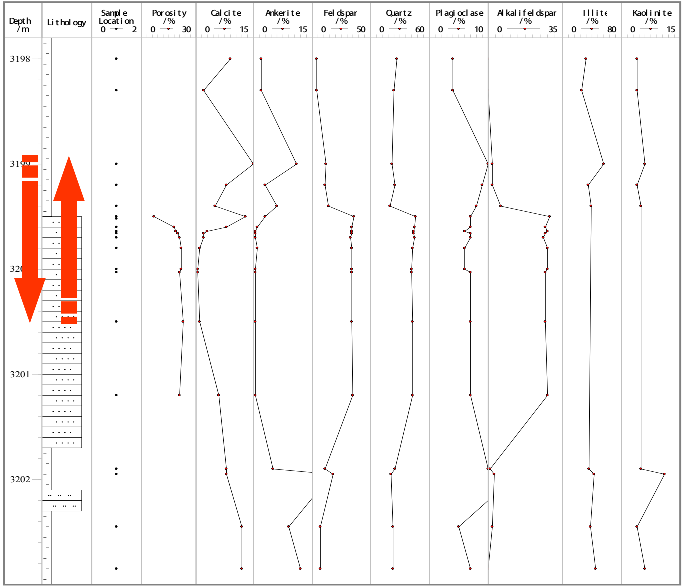
Origin Discussion

- Material can be transported to sandstones

The transportation experiment



(Thyne 2001)

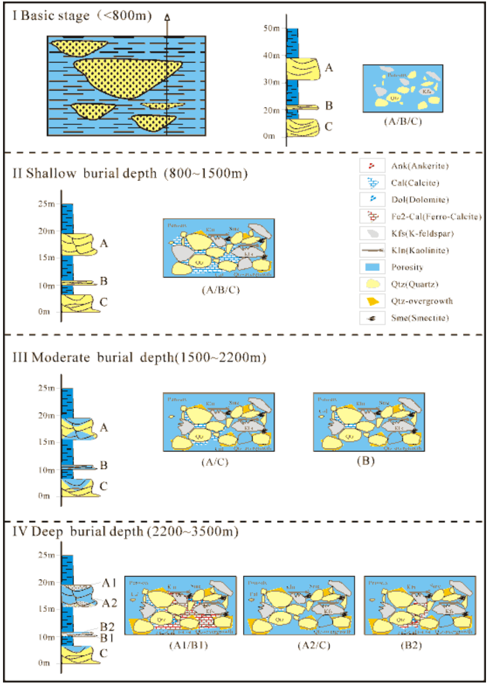


Origin Discussion

➤Sandstone evolution model according to the lenticular sandbody diagenetic heterogeneities

different stage, different diagenesis ,different porosity

- **Primary stage**
- **Shallow burial depth**
- **Moderate burial depth**
- **Deep burial depth**



Conclusions

- Lenticular sandstones got high porosity (20%) at the interior and low porosity (4%) at the sandstones/shales contact (SSC)
- The reason for low porosity was the present of carbonate cements
- Shale supplied the source for a portion of the diagenetic cements near the SSC in the whole diagenetic system, the diffusive mass transport process was formed in the whole diagenetic system
- Sufficient burial depth could afford the temperature threshold to the formation of chemical gradient. The scale of lenticular sandbody and shales would influence the cement extent and cement distribution. Sorts and quantity of composition in both sand and shale would dominate episodic diffusion gradients and the direction and velocity of the transfer mass

Acknowledgements

Giving Thanks To

National Natural Science Foundation of China (NSFC, 41072104)

National Key Fundamental Research Project (973, 2011CB201104)

Sinopec for its supply of the well data and core samples

THANK YOU