Diagenetic Events, Reservoir Compartmentalization and its Relationship with Lower Order Relative Sea-Level Fluctuation in Early-Middle Eocene Sylhet Formation, South Assam Shelf (SAS), Assam and Assam-Arakan Basin*

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Abstract

Our work focuses on diagenetic events, reservoir quality and its relationship with sea-level fluctuation for the reservoir sands restricted in upper part of Early-Middle Eocene Sylhet Formation within South Assam Shelf. Synergy between sequence stratigraphy and diagenesis, however, enables prediction of spatial and temporal distribution of diagenetic alterations and post-depositional evolution of reservoir quality. It also provides information on diagenetic baffles and barriers for fluid flow, thus potential diagenetic reservoir compartments and seals. Sylhet Formation consists of mixed siliciclastic-carbonate sequence deposited in tide affected marginal marine to inner shelf carbonate ramp environment with episodic siliciclastic supply during regressive pulses within an overall fining-up transgressive unit. Twenty-one cores along with electrologs have been investigated to infer lithofacies, mineralogy and diagenetic facies controlling reservoir quality using petrography, XRD and SEM analysis. The dominant microfacies are calcareous quartz arenite/quartz wacke and arenaceous foraminiferal wackestone with minor dolostone. Twelve diagenetic facies have been identified within Sylhet Formation. The salient diagenetic features responsible for reservoir deterioration are intense early calcite cementation, authigenic pore filling kaolinite and chlorite. However, during lower order sea-level fluctuations, diagenetic alterations owing to percolation of meteoric water below subaerially exposed sequence boundaries causes extensive dissolution of calcite cement enhancing secondary porosity (~30%). Based on textural relationship among different diagenetic facies, a paragenetic sequence depicting two major diagenetic events, has been identified and mapped to bring out the diagenetic history. Paragenetic sequence includes early calcite cementation and its immediate dissolution in eodiagenetic stage, subsequent dissolution of feldspar and precipitation of kaolinite and quartz cements, followed

by patchy calcite cementation in mesodiagenetic stage. Porosity distribution map depicts good porosity in NE-SW corridor with isolated poor porosity pods. However, in some areas, primary porosity is preserved where localized acidic environment inhibits precipitation of early calcite cement. Integration of diagenesis and sequence stratigraphy thus constitutes a powerful tool for prediction of the evolution of reservoir quality and of diagenetic baffles for fluid flow and seals.

Diagenetic events, reservoir compartmentalisation and its relationship with lower order relative sea-level fluctuation in Early-Middle Eocene Sylhet Formation, South Assam Shelf (SAS), Assam and Assam-Arakan Basin

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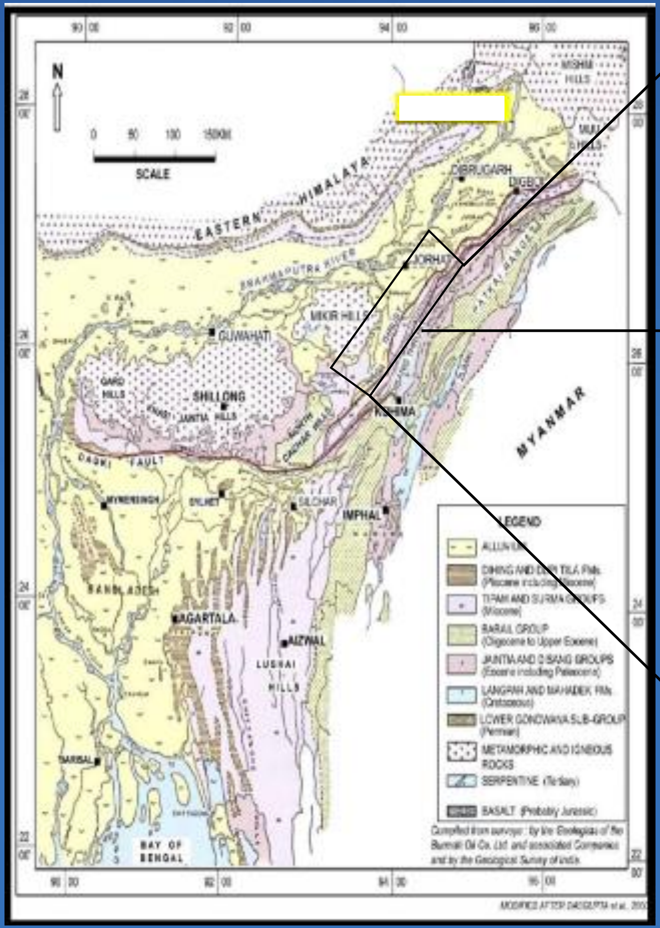
5th November, 2018

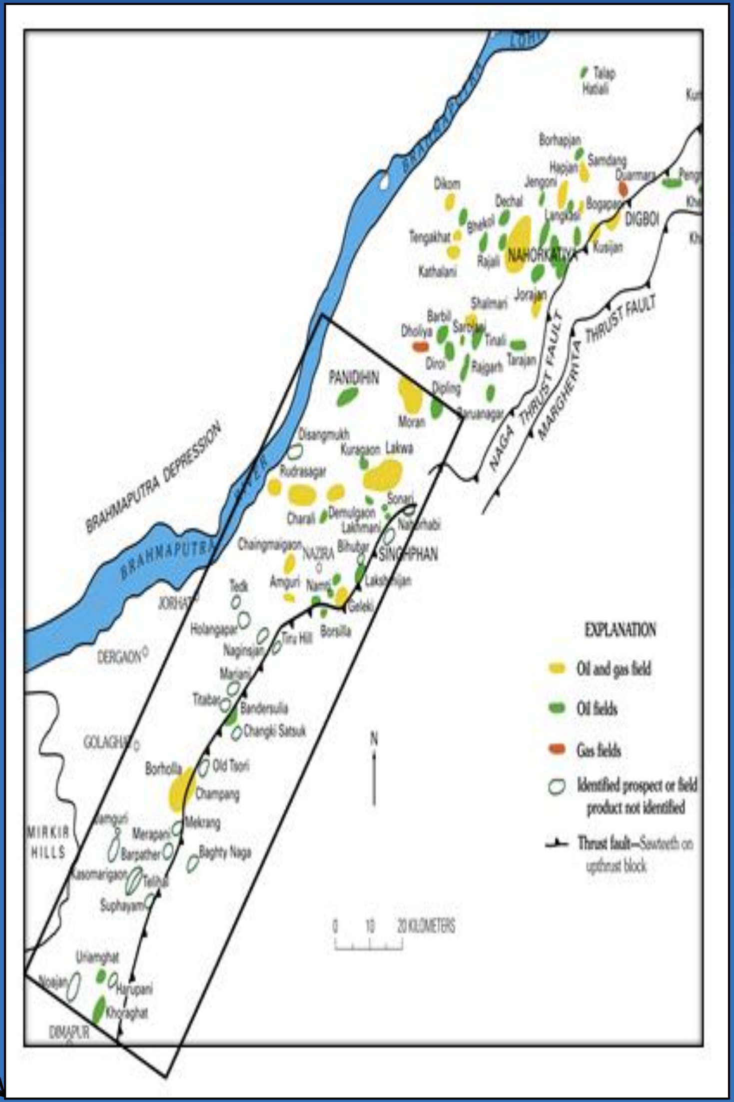
Presentation Outline

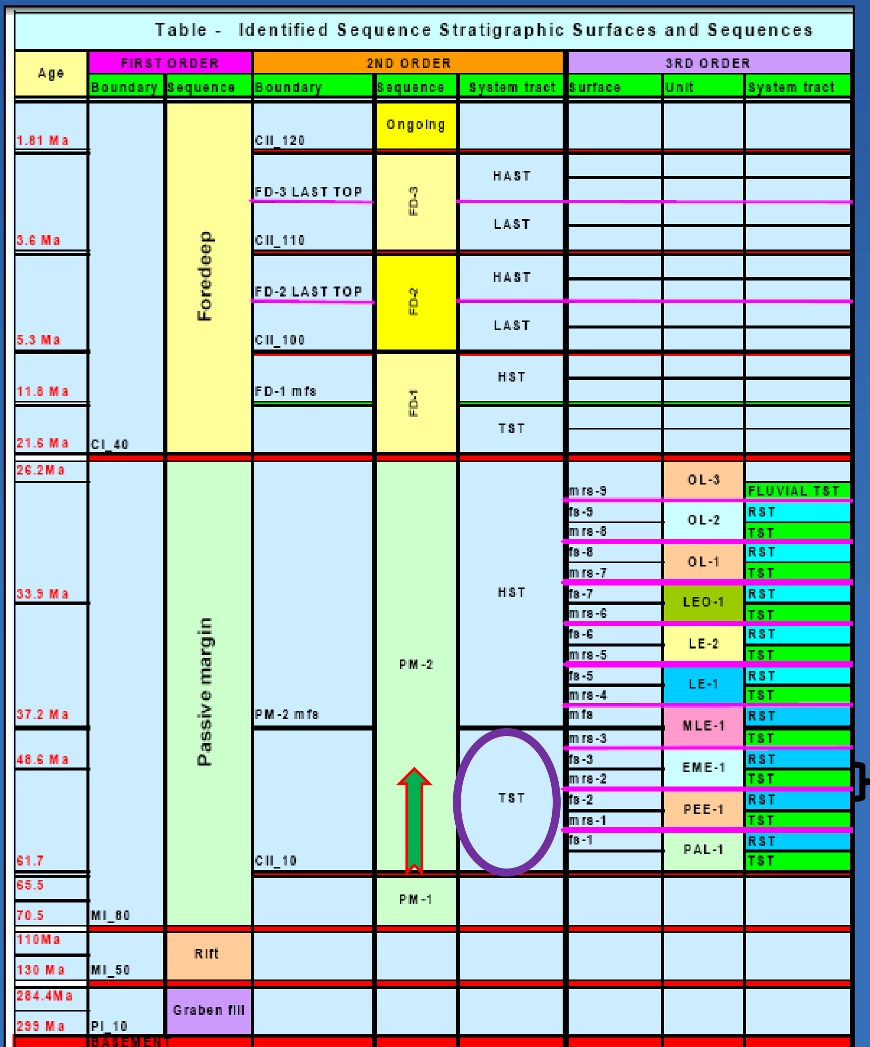
- ❑ Introduction
- ❑ Case Study Area
- ❑ Results
- ❑ Conclusion

Location Map of the Area

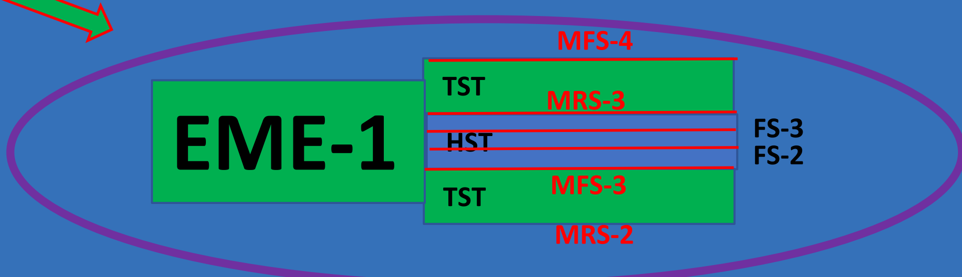


Study area

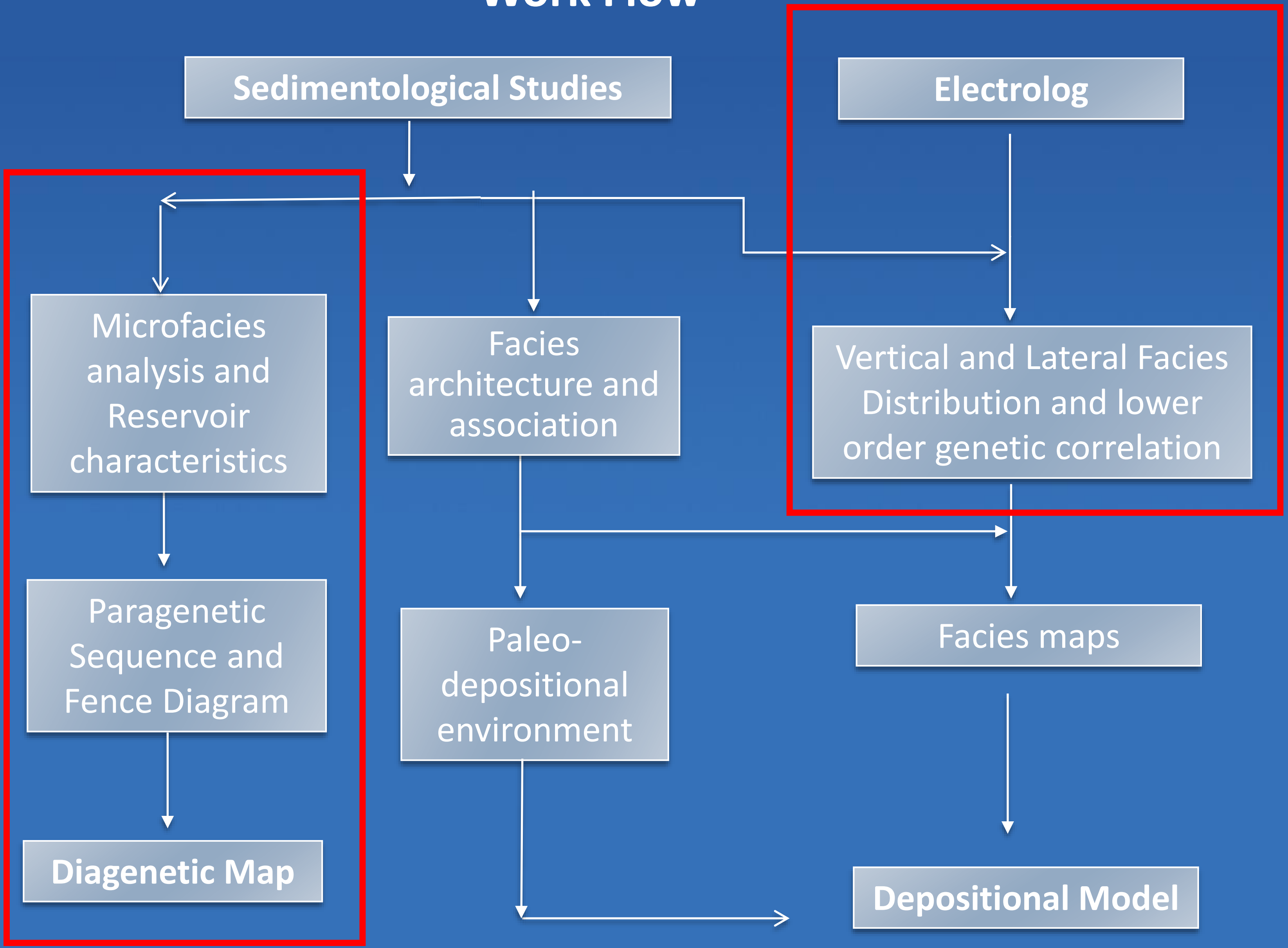




- In most parts of the Assam shelf, Passive margin sequence starts from Paleocene
- Sedimentary column of Paleocene to Oligocene age is demarcated as younger 2nd order passive margin sequence
- 2nd order TST is divided into three major lithostratigraphic units
  - Lower-Coaser Clastics (Tura Fm.)
  - Middle-Carbonate (Sylhet Fm.)
  - Upper-Finer Clastics (Kopili Fm.)

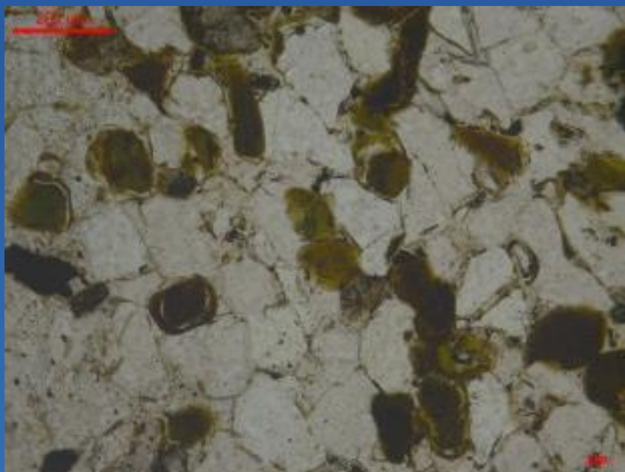


Work Flow

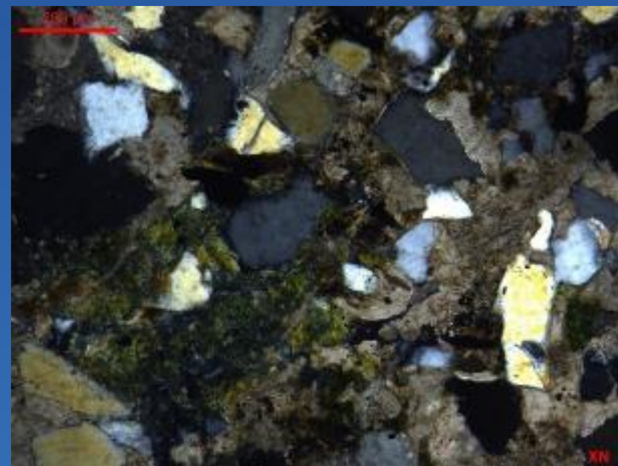

Sedimentological Studies
Electrolog
Microfacies analysis and Reservoir characteristics
Facies architecture and association
Vertical and Lateral Facies Distribution and lower order genetic correlation
Paragenetic Sequence and Fence Diagram
Paleo-depositional environment
Facies maps
Diagenetic Map
Depositional Model

Diagenetic Facies

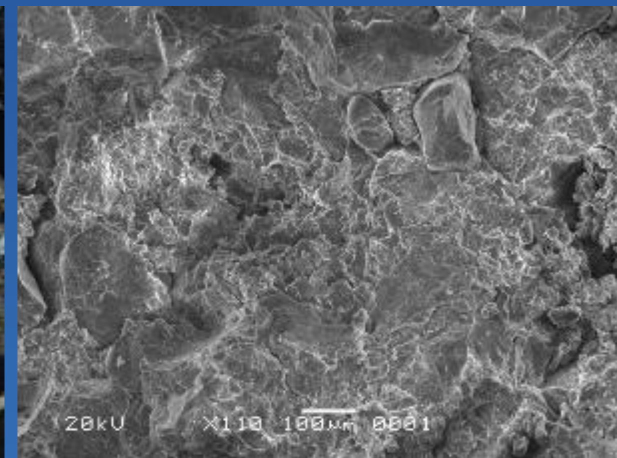
Glauconitisation



Well M-7, CC-1, 2836.8m glauconite pellets as framework grains



Well C-8, CC-2, 2700.60m



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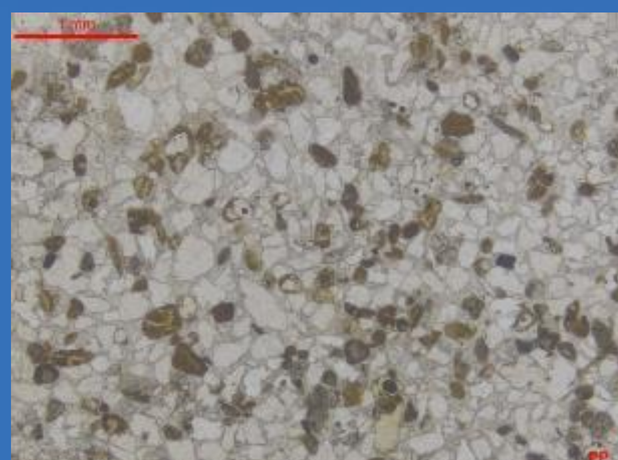
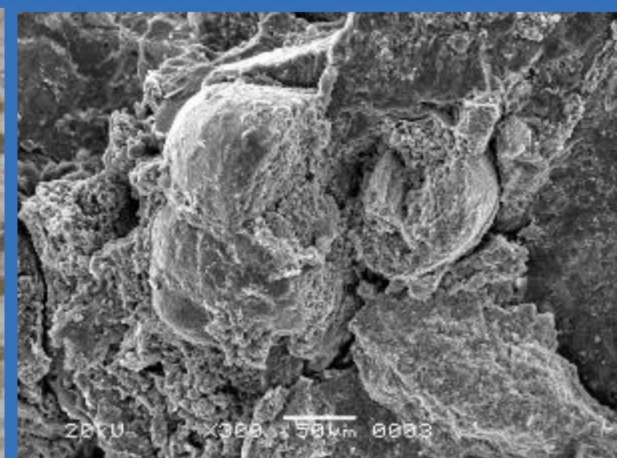
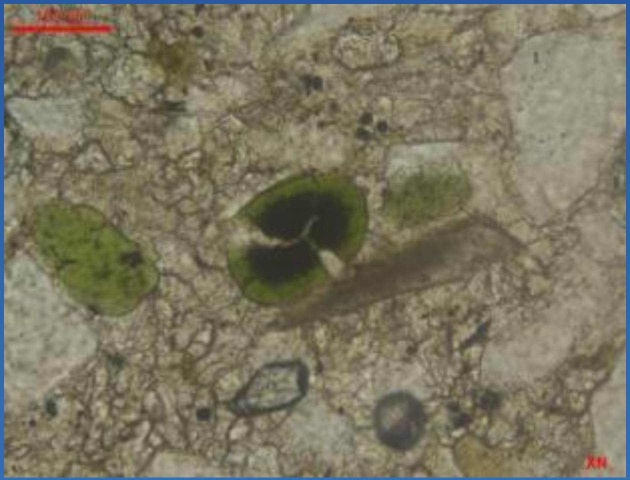


Well M-7,CC-1, 2836.8m



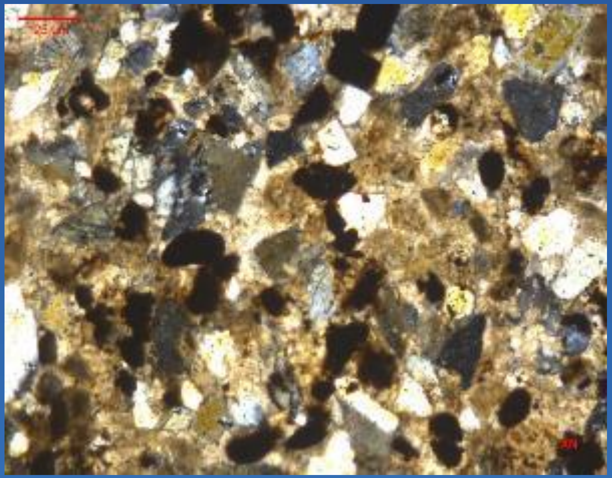
Well B-57, CC-3, 2479.6

Alteration of Glauconite

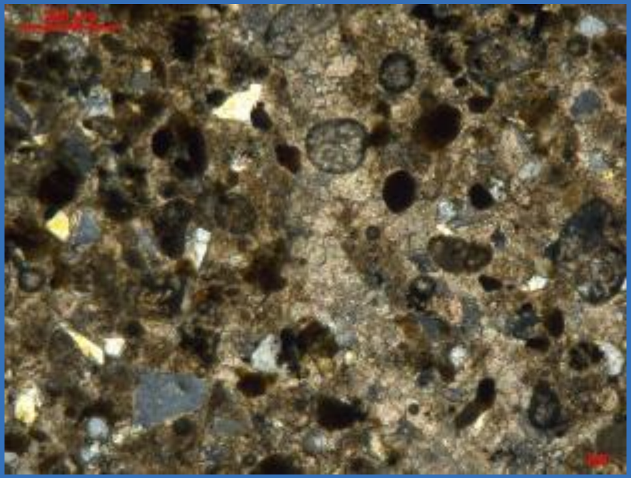


Well C-8, CC-1, 2702.5m

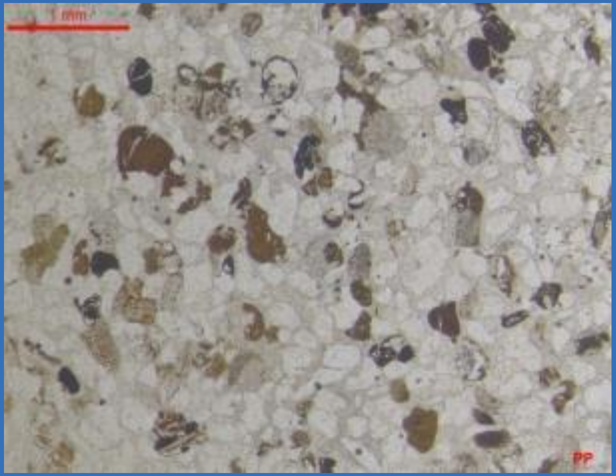
Well B-25, CC-1, 2734.4m



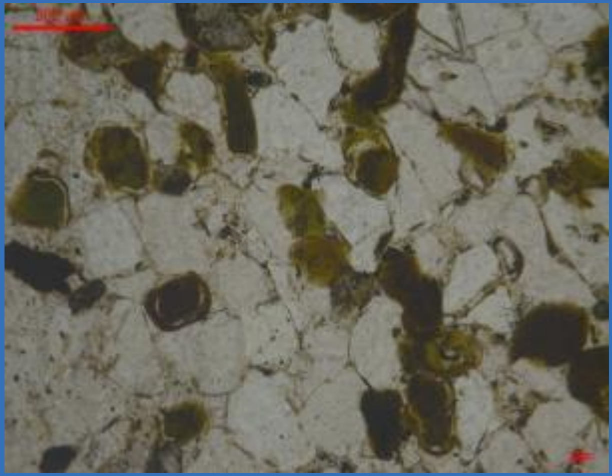
Well F-1, CC-1, 1587.8m



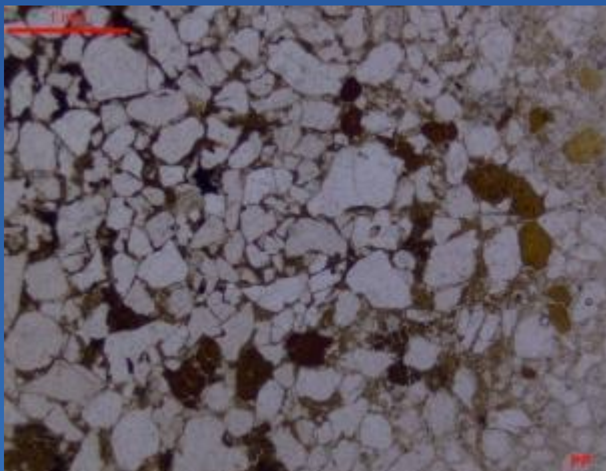
Well B-1, 1300-1305m



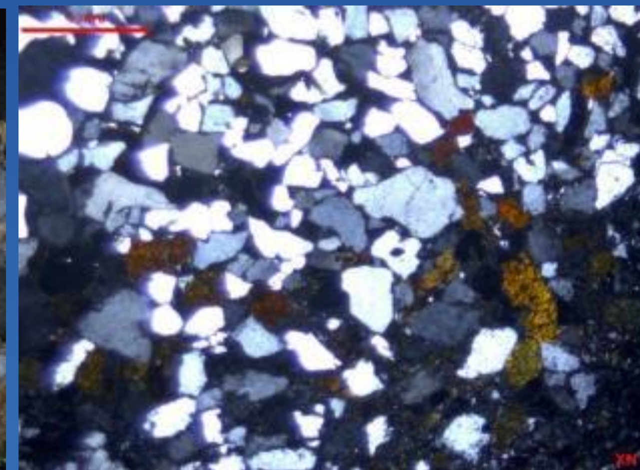
Well M-7, CC-1, 2840m

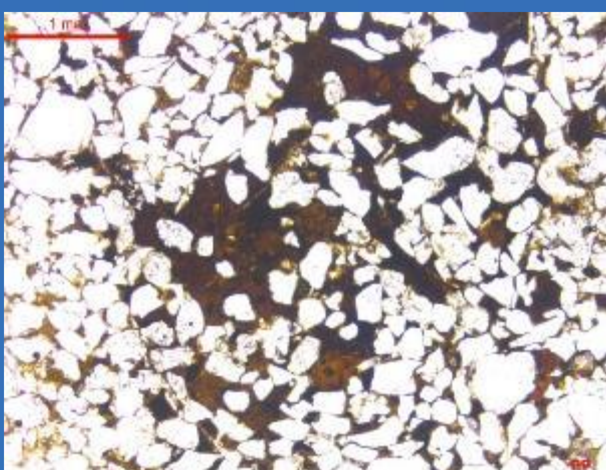


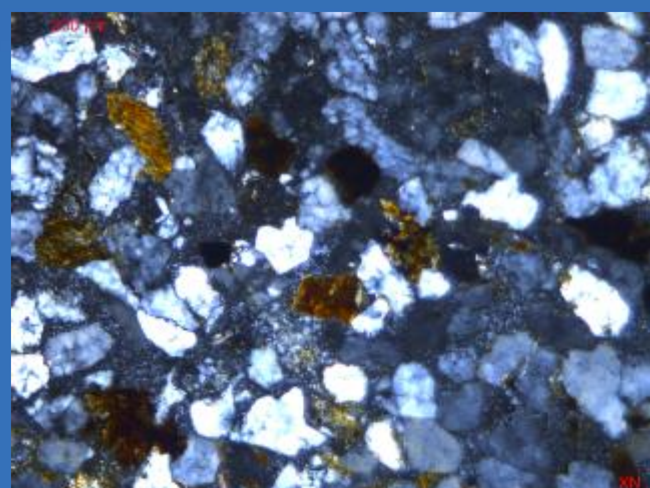
Well M-7, CC-1, 2836.8m

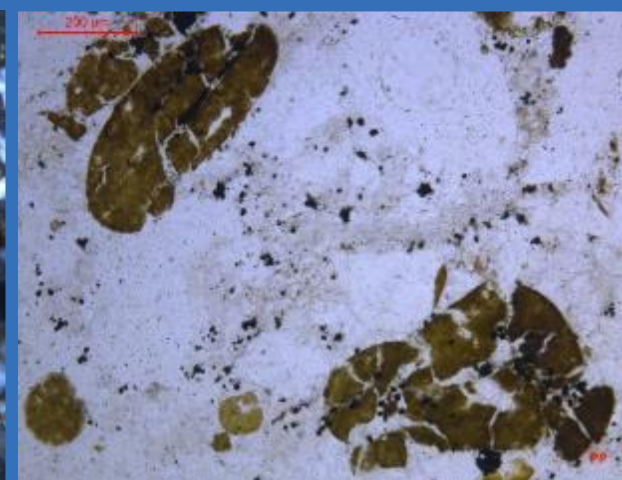

Well K-31, CC-3, 2333.30m


Well S-1, 2935-40m

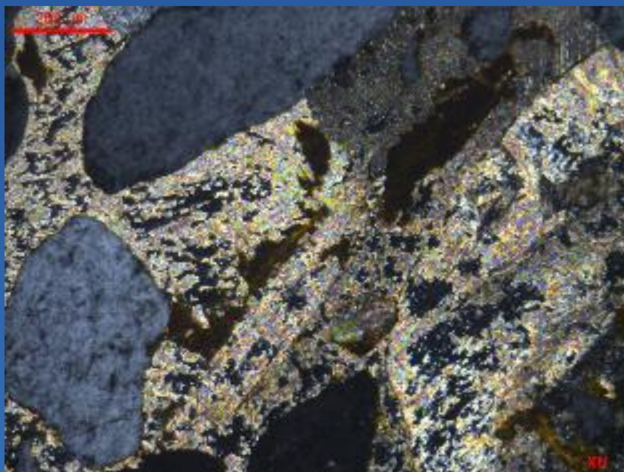

Well K-31, CC-3, 2333.30m


Well K-31, CC-3, 2333.6m

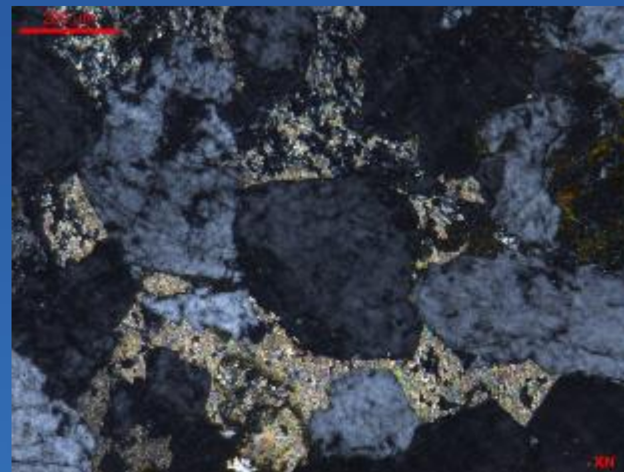

Well Y-1, 2155-60m


Well S-1, 2935-40m

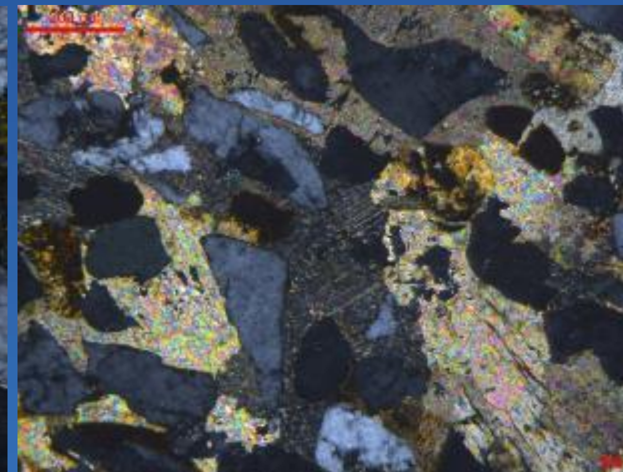
Anhydrite cementation (Early)



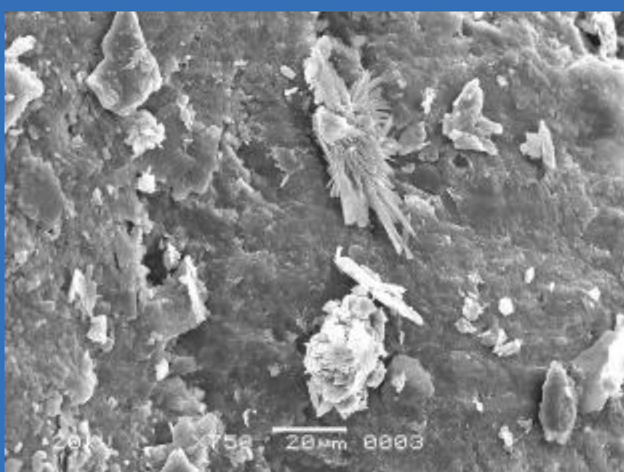
Well B-57, CC-3, 2479.6m



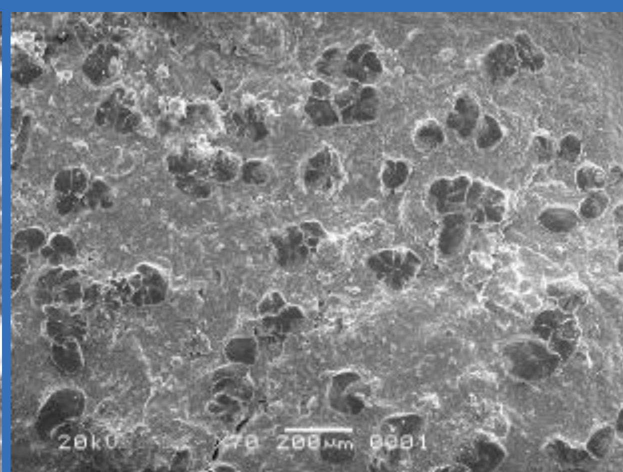
Well B-57, CC-3, 2479.9m



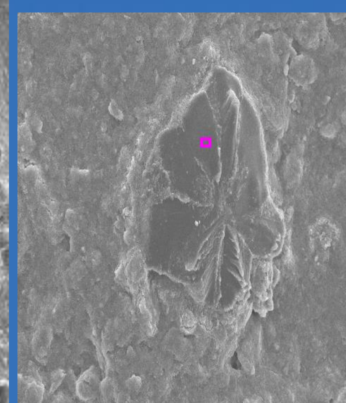
Well B-57, CC-3, 2480m

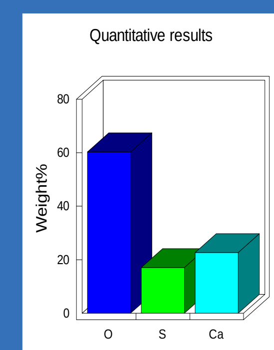


Well B-57, CC-3, 2475.2m



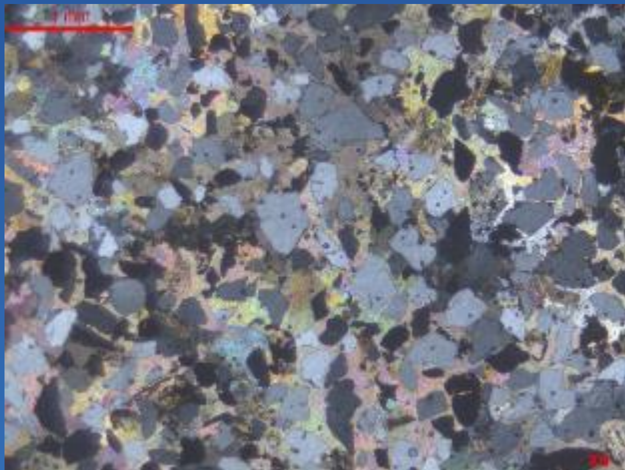
Well H-3, 1585-90m



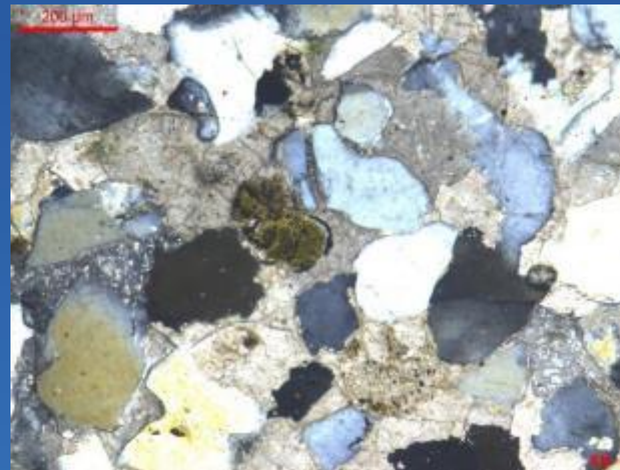


Well H-3, 1585-90m

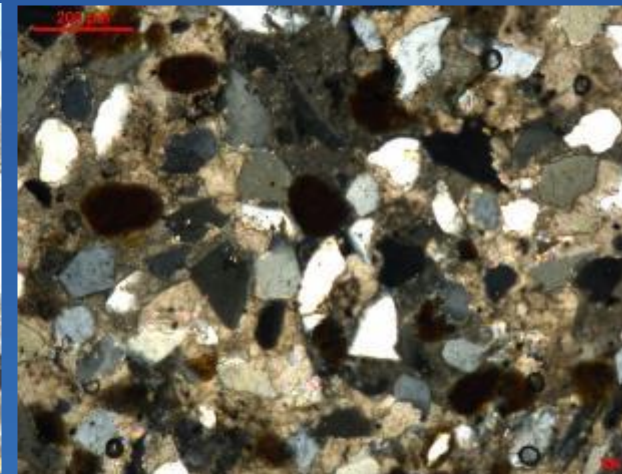
Calcite cementation (Early)



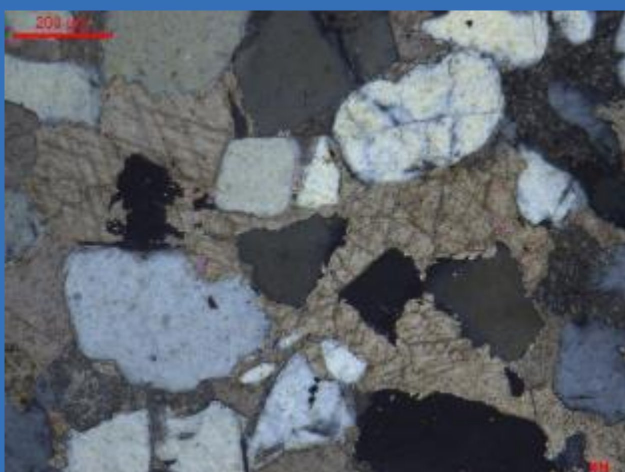
Well M-7, CC-1, 2840m



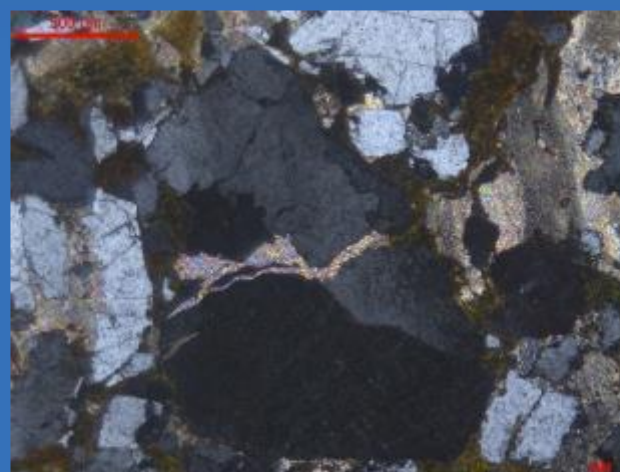
Well C-8, CC-2, 2700.60m



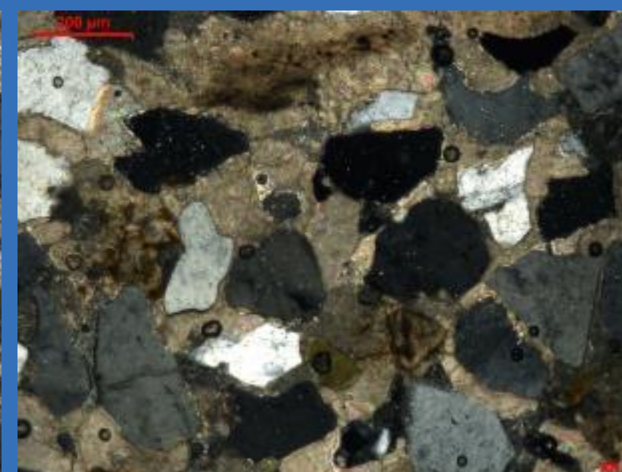
Well E-4, 2055-60m



Well C-8, CC-2, 2700.60m

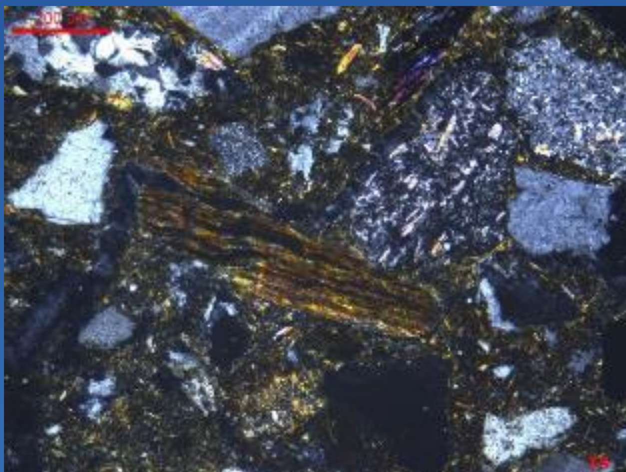


Well B-57, CC-3, 2479.9m

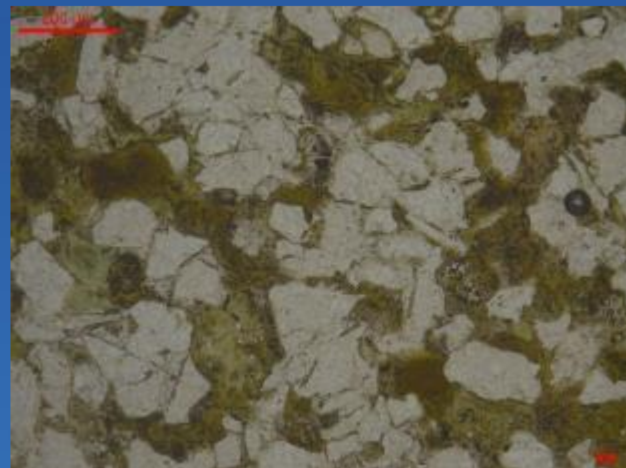


Well S-1, 2945-50m

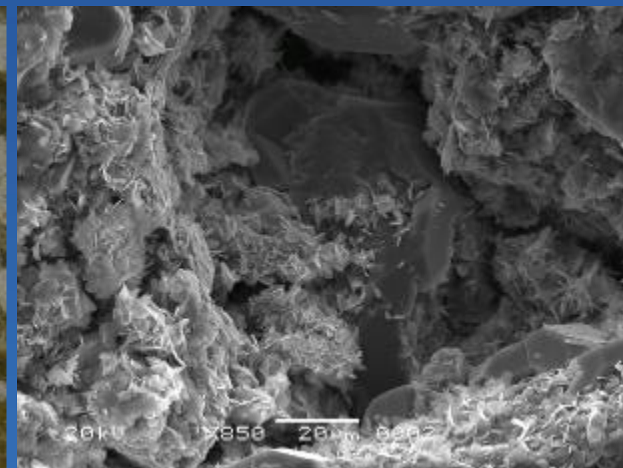
Chloritisation



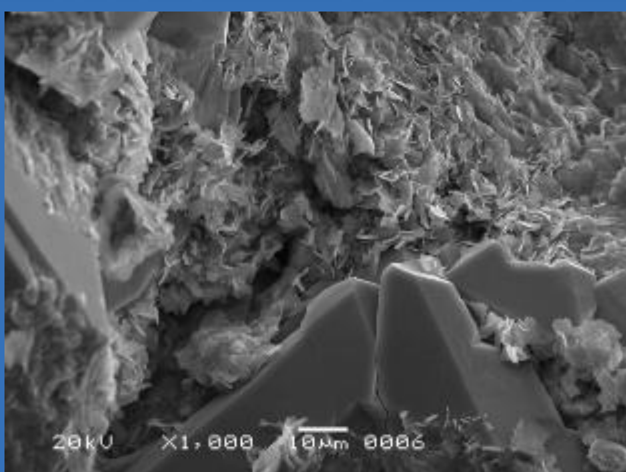
Well C-8, CC-2, 2703.8m



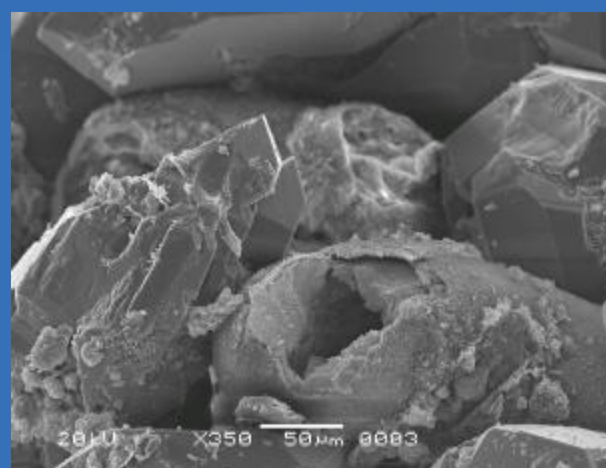
Well B-57, CC-3, 2475.2m



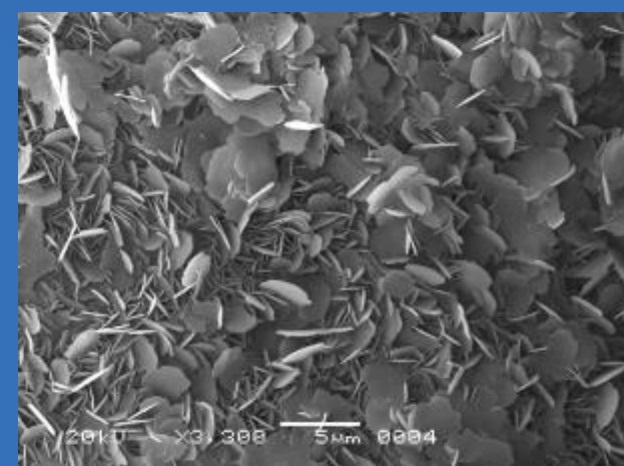
Well C-8, CC-2, 2705.6m



Well C-8, CC-2, 2705.6m

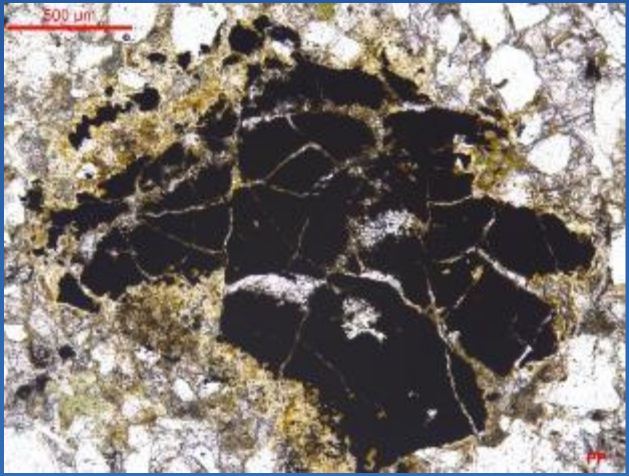


Well B-25, 2734.9m

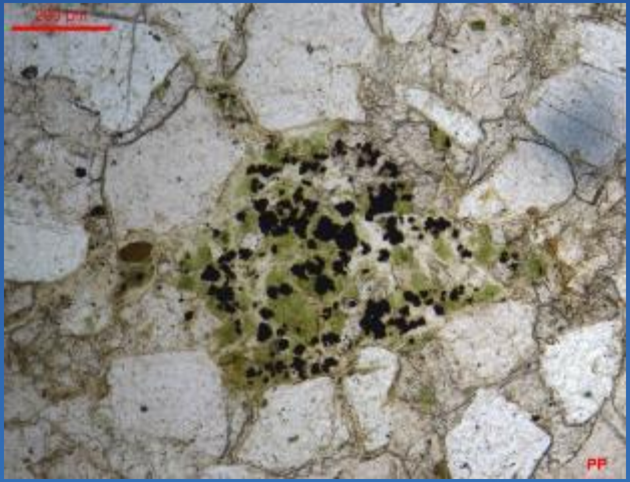


Well B-25, 2734.9m

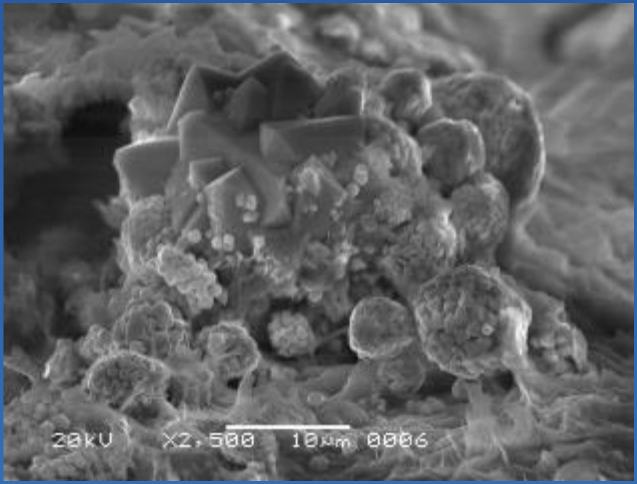
Pyritisation and Iron-oxide cement



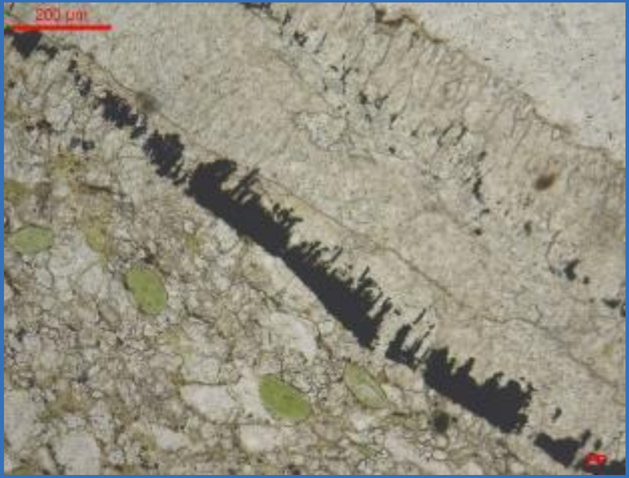
Well C-8, CC-2, 2700.60m



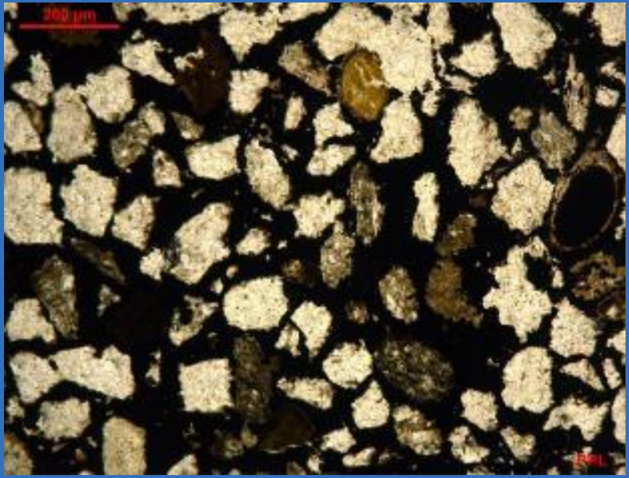
Well C-8, CC-2, 2700.60m



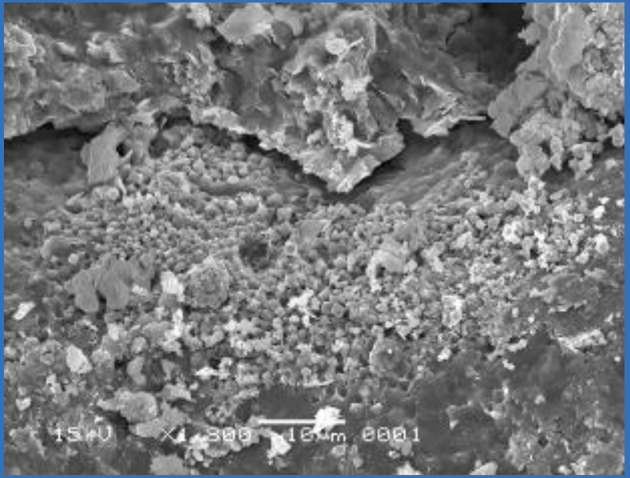
Well N-1, 1406.3m



Well C-8, CC-2, 2702.50m

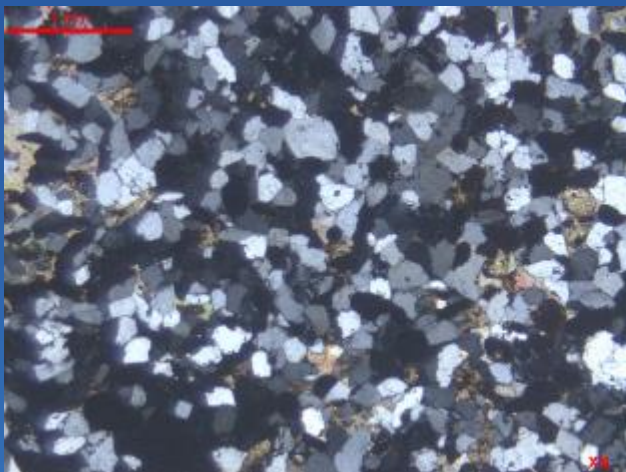


Well E-4, 2030-35m

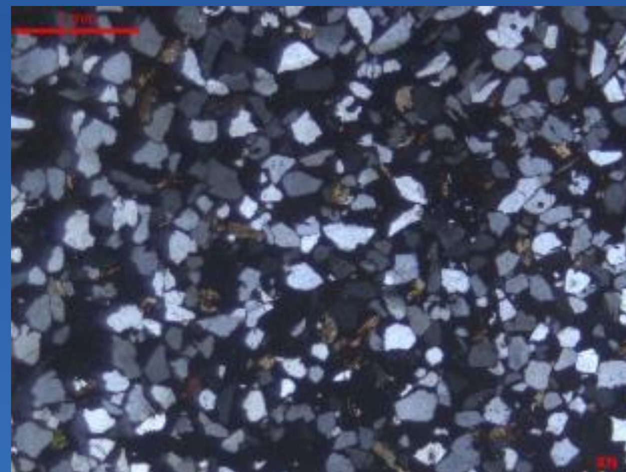


Well B-25, 2729.2m

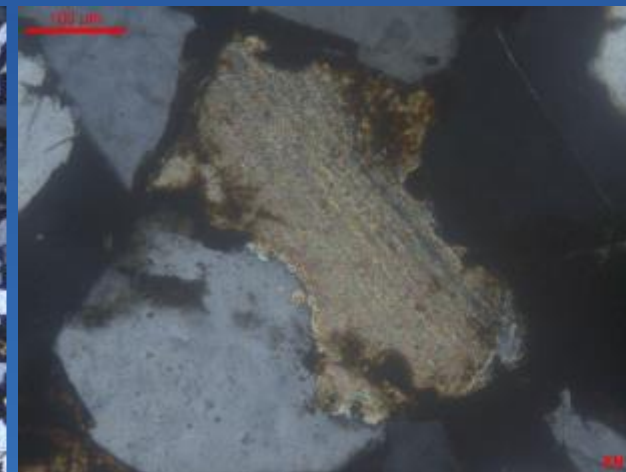
Calcite cementation (Late)



Well B-25, CC-1, 2734.9m

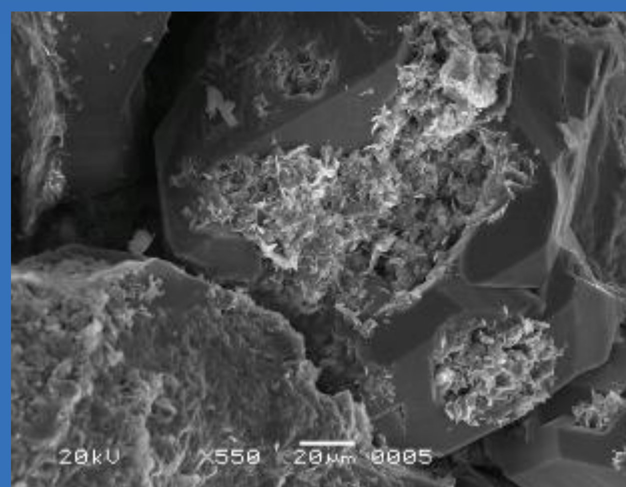


Well C-2, CC-2, 2705.6m

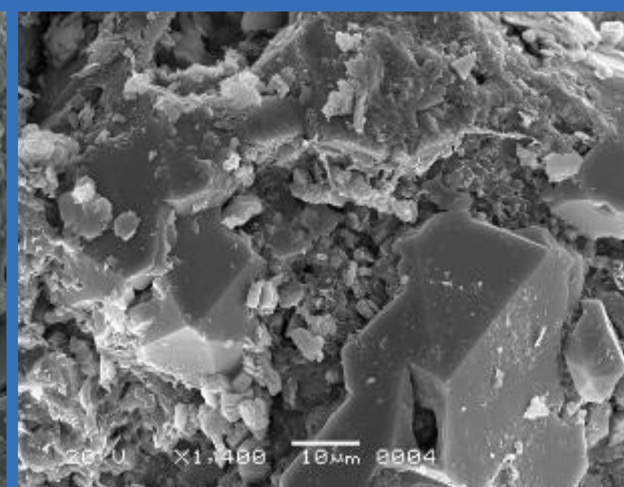


Well C-2, CC-2, 2705.6m

Well B-25, CC-1, 2734.9m

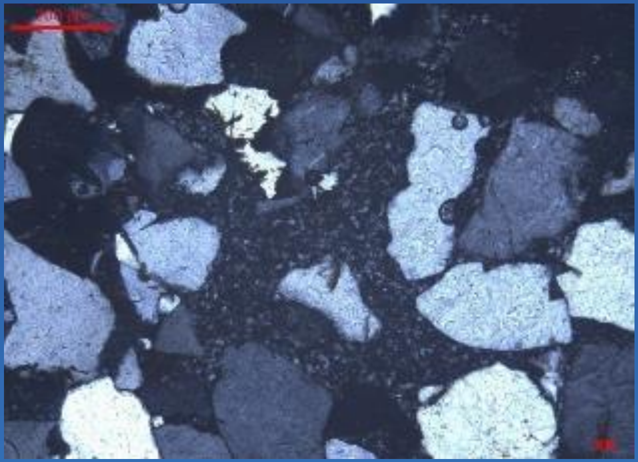


Well C-2, CC-2, 2705.6m

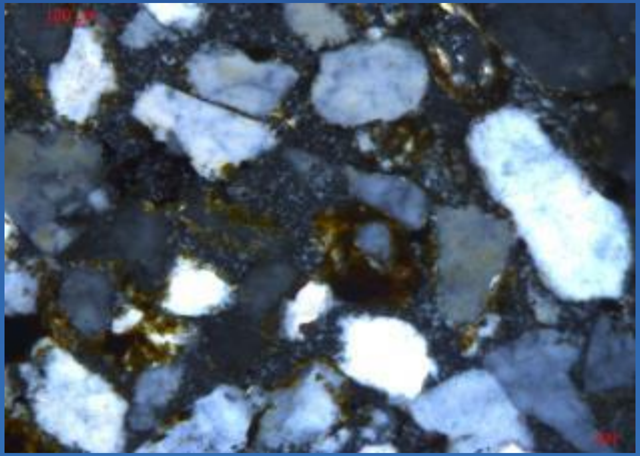


Well K-2, 3305-10m

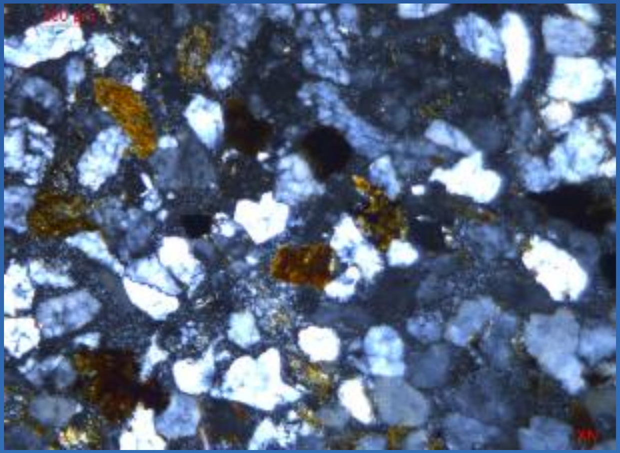
Kaolinitisation



Well K-31, CC-3, 2333.30m

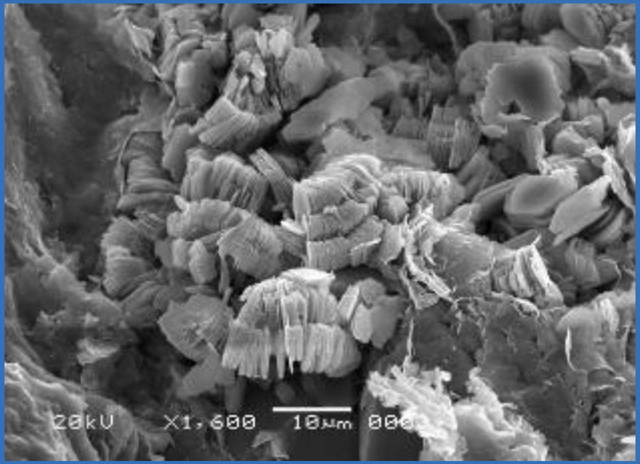


Well Y-1, 2155-60m

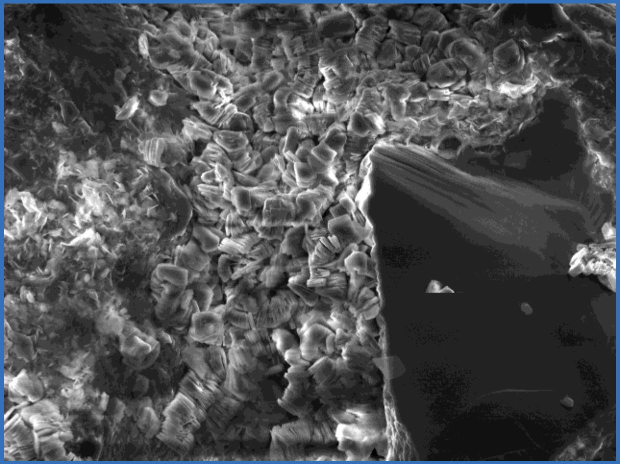


Well Y-1, 2155-60m

Well K-31, CC-3, 2333.30m

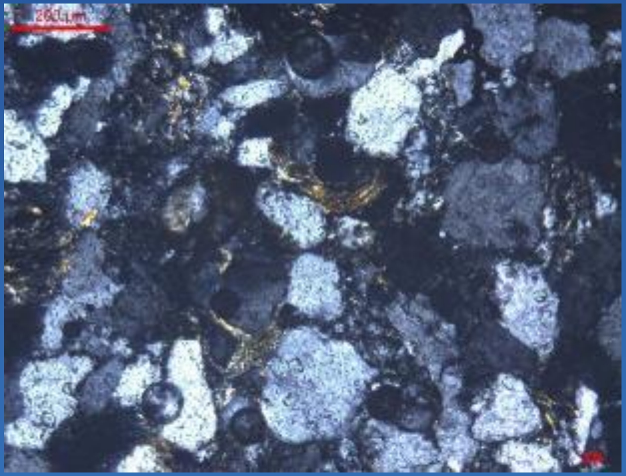


Well K-31, CC-3, 2334.4m

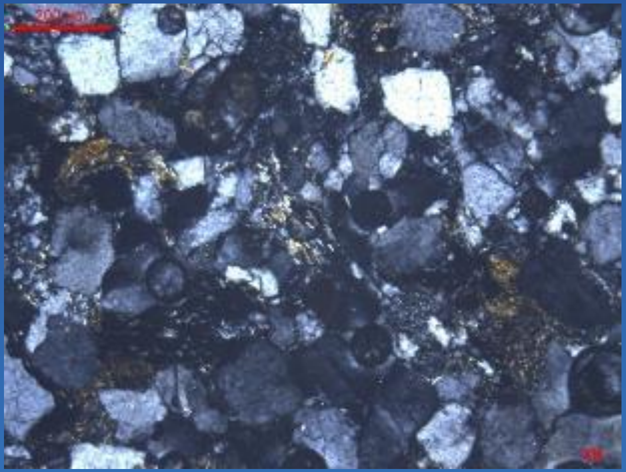


Well K-31, CC-3, 2333.30m

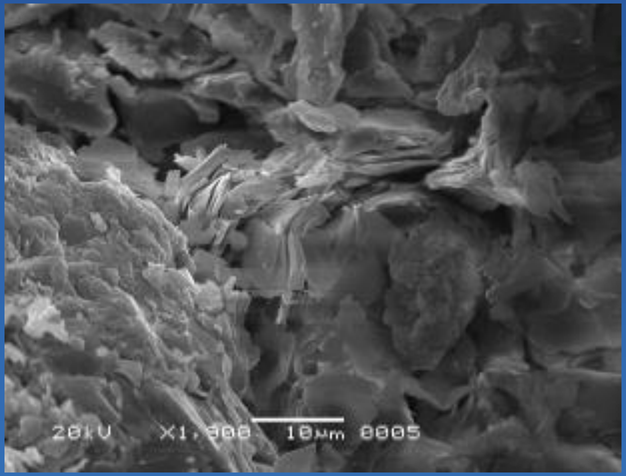
Mechanical compaction



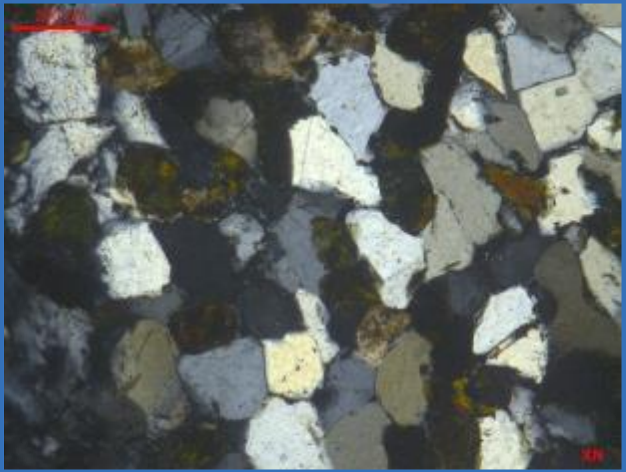
Well N-1, CC-3, 1405.35m



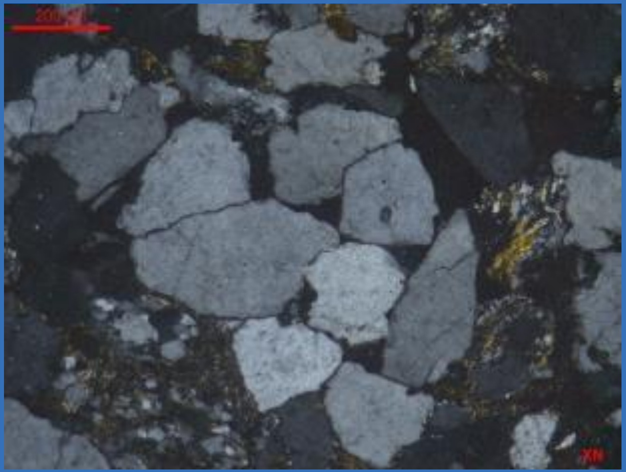
Well N-1, CC-3, 1405.35m



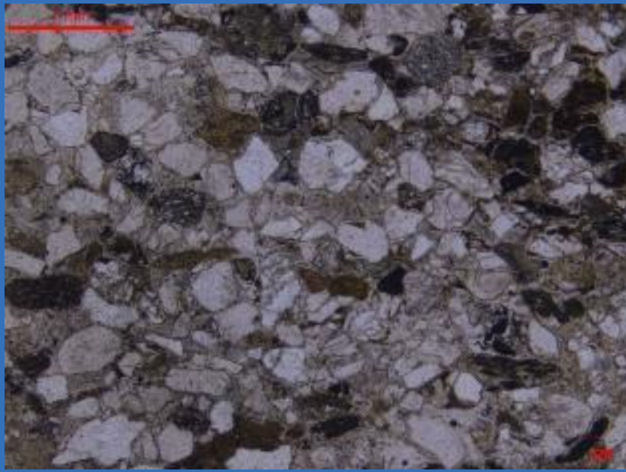
Well N-1, CC-3, 1405.35m



Well M-7, CC-1, 2836.8m

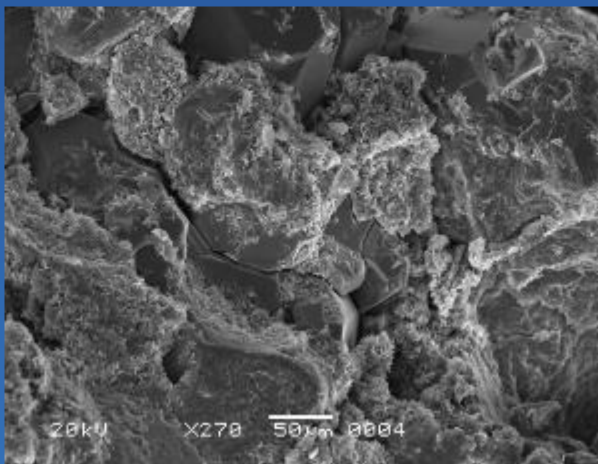


Well B-57, CC-3, 2474.9m

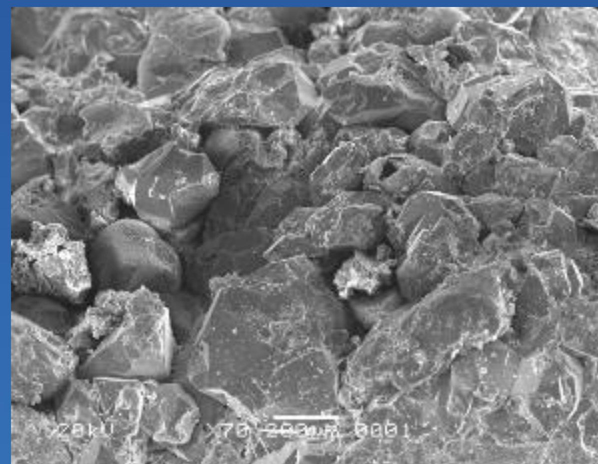


Well N-1, CC-3, 1406.8m

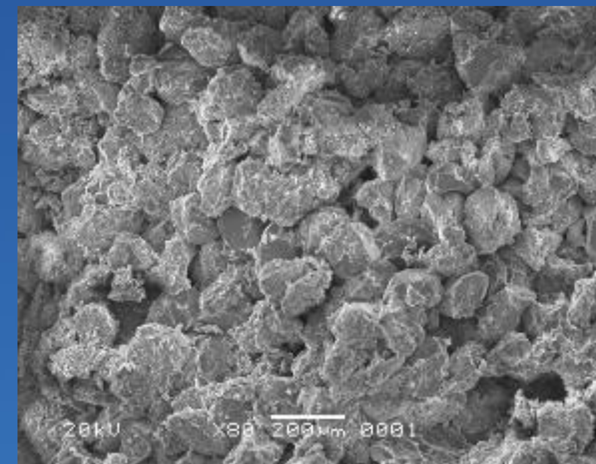
Constructive Porosity



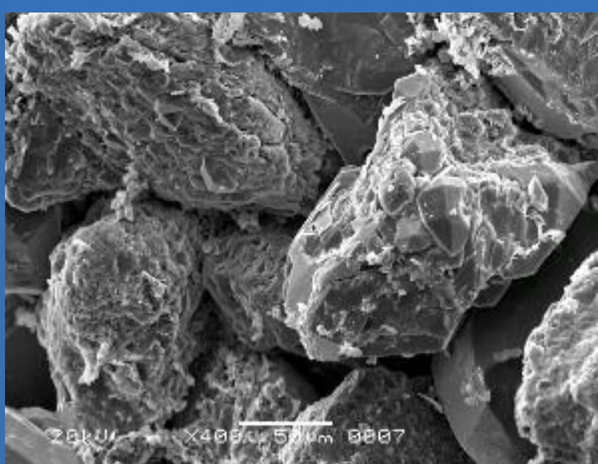
Well C-8, CC-2, 2705.6m



Well B-25,2734.9m



Well K-2,3305-10m

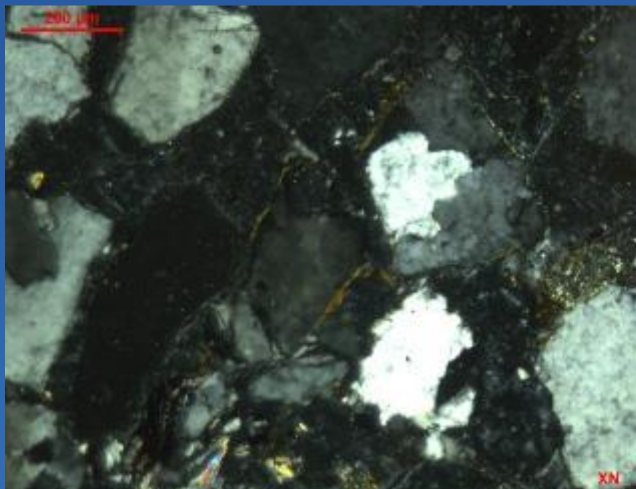


Well K-2,3305-10m

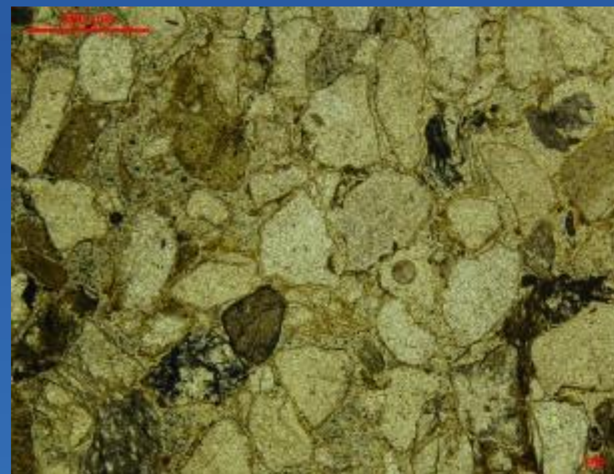

Well C-8, CC-2, 2703.8m


Well C-8, CC-2, 2700.6m

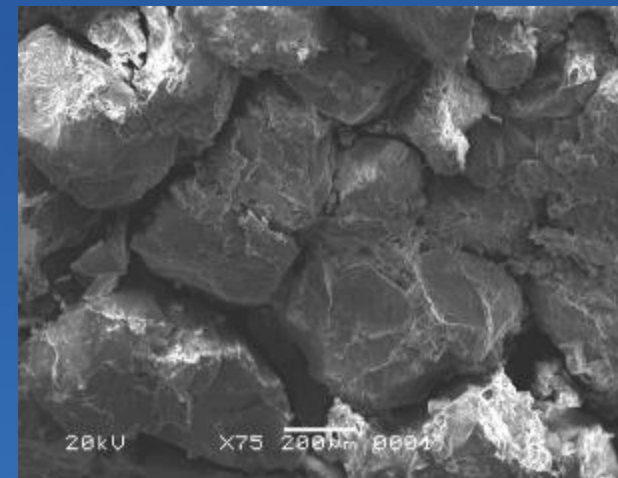
Constructive Porosity



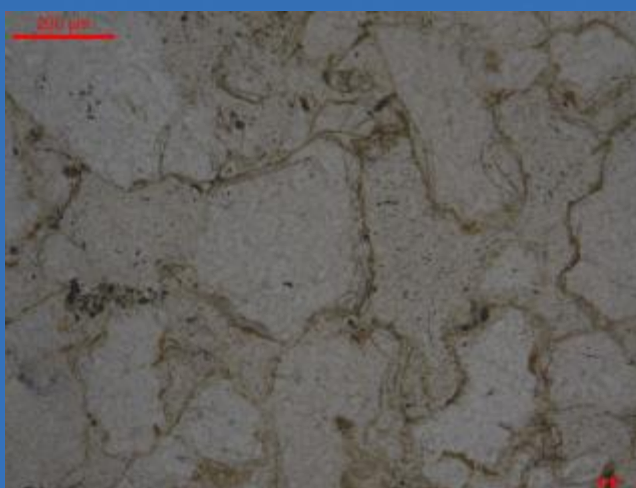
Well N-1, 1406.8m



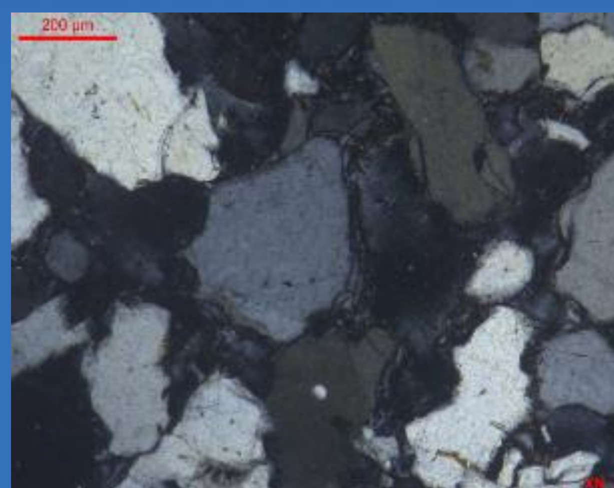
Well N-1, 1406.8m



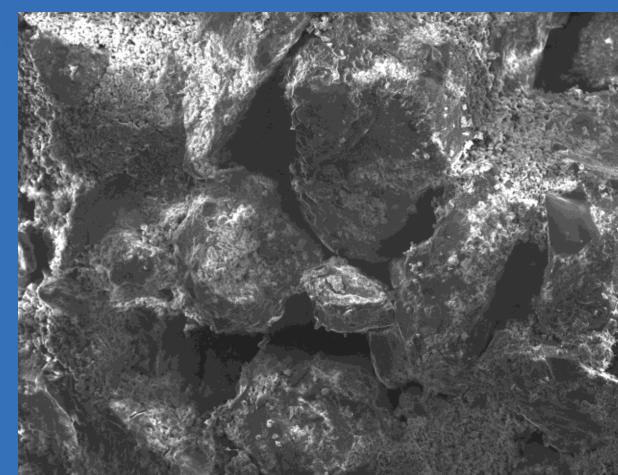
Well N-1, 1406.3m



Well K-31, CC-3, 2333.30m



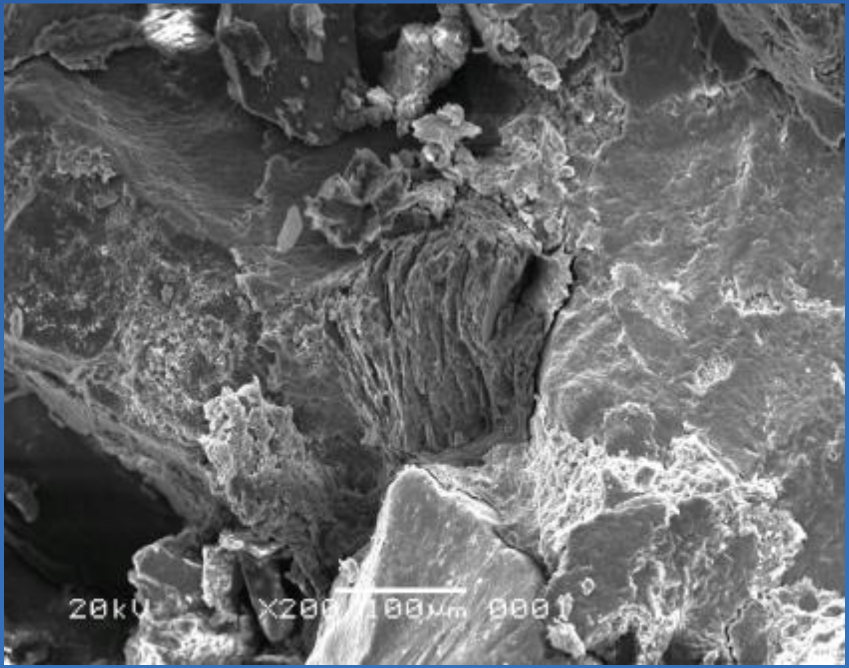
Well K-31, CC-3, 2333.30m



Well K-31, CC-3, 2333.30m

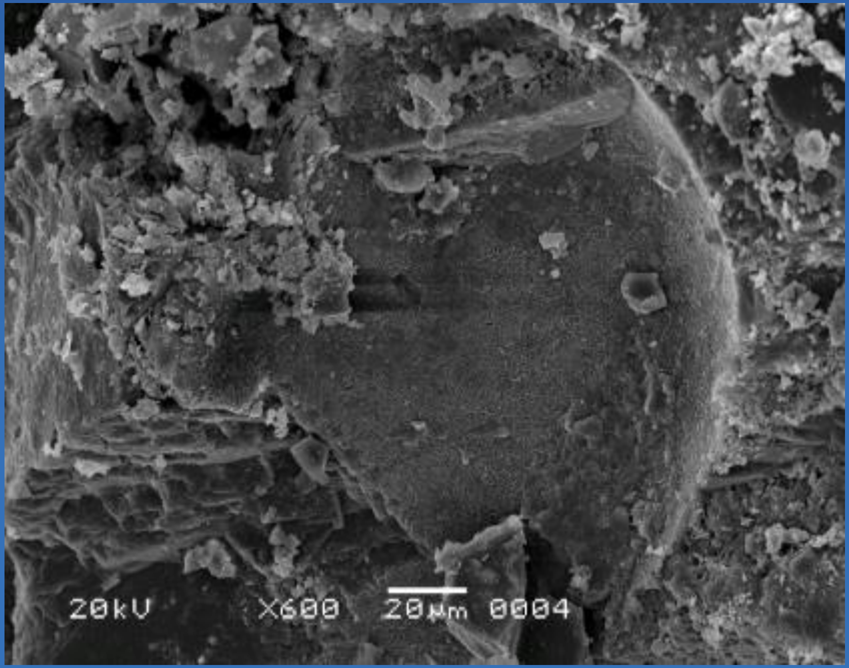
Constructive Porosity

Dissolution of feldspar



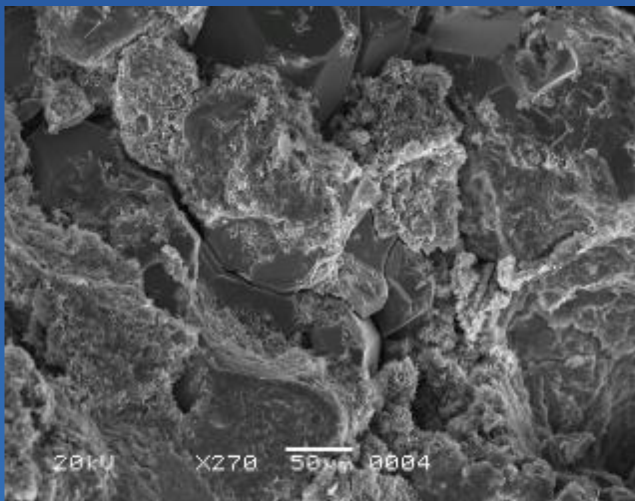
Well C-8, 2703.8m

Clay coating

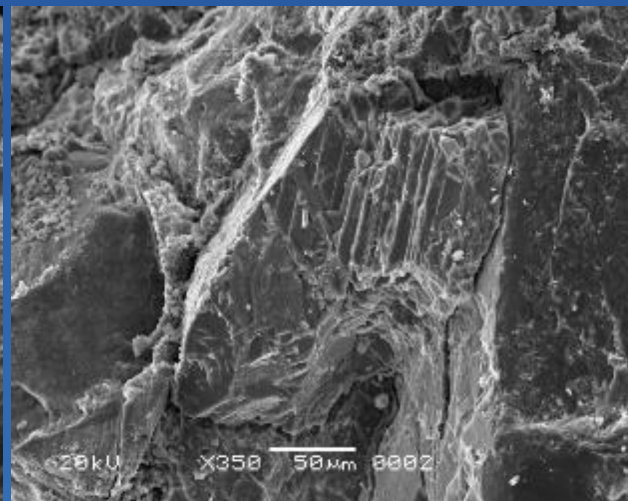


Well M-7, 2836.3m

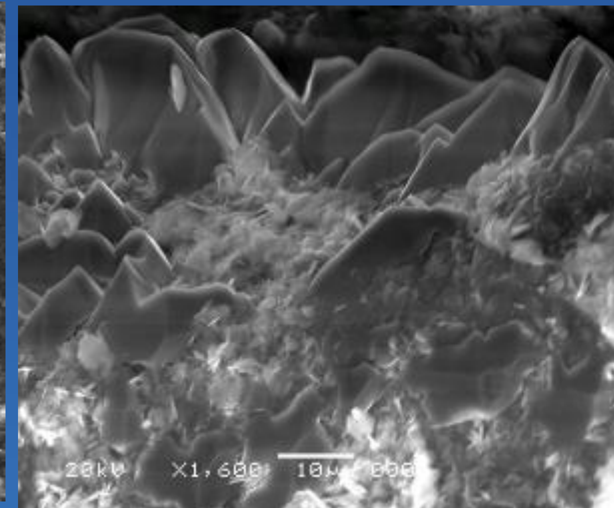
Destructive Porosity



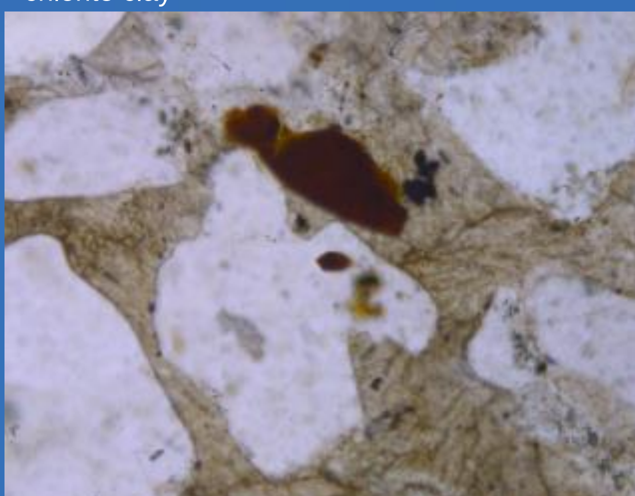
Well C-8, 2705.6M: Quartz overgrowth and chlorite clay



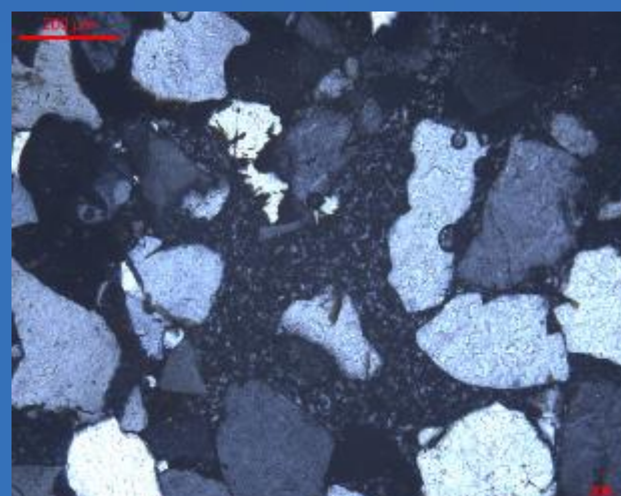
Well B-57, 2479.6m



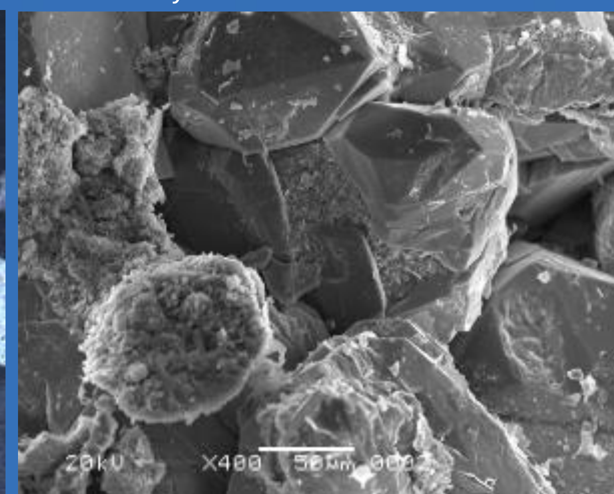
Well K-31, 2333.3m: quartz overgrowth and chlorite clay



Well G-1,2155-60m



Well K-31, CC-3, 233.3m



Well M-7, 2836.8m: quartz overgrowth and chlorite clay

Sedimentological Attributes

S.No	Parameter/ Observation	Diagenetic Process	Inference	Diagenetic stage
1	Floating contact with calcite cement	Precipitation	Early diagenetic cementation	Eogenesis
2	Corroded quartz	Dissolution	Etching of quartz grains	
3	Good porosity along with etched quartz	Dissolution	Dissolution of early calcite cement	
4	Bent mica/deformed glauconitic pellets	Compaction	Mechanical compaction due to overburden pressure	Mesogenesis
5	Suture contacts	Compaction and recrystallization	Pressure solution due to mechanical compaction	
6	Feldspar dissolution/kaolinite precipitation	Dissolution	Burial diagenesis	
7	Silica cemenattion	Precipitation	Late diagenetic cementation	

Paragenetic sequence and diagenetic stages

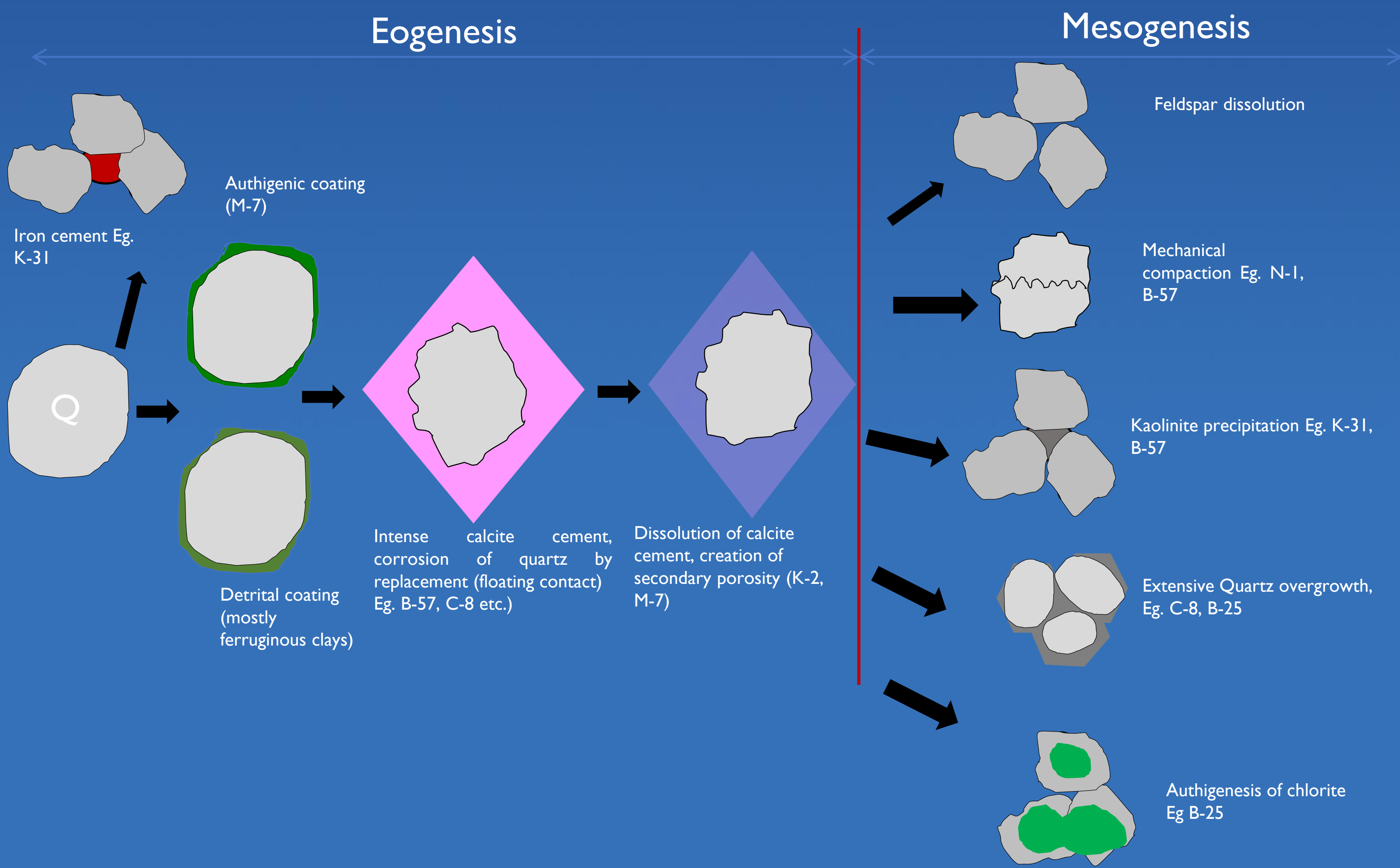
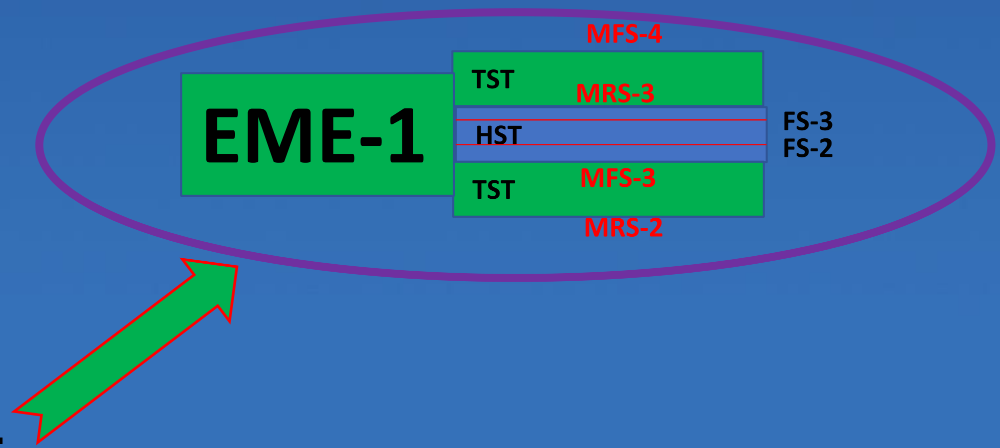
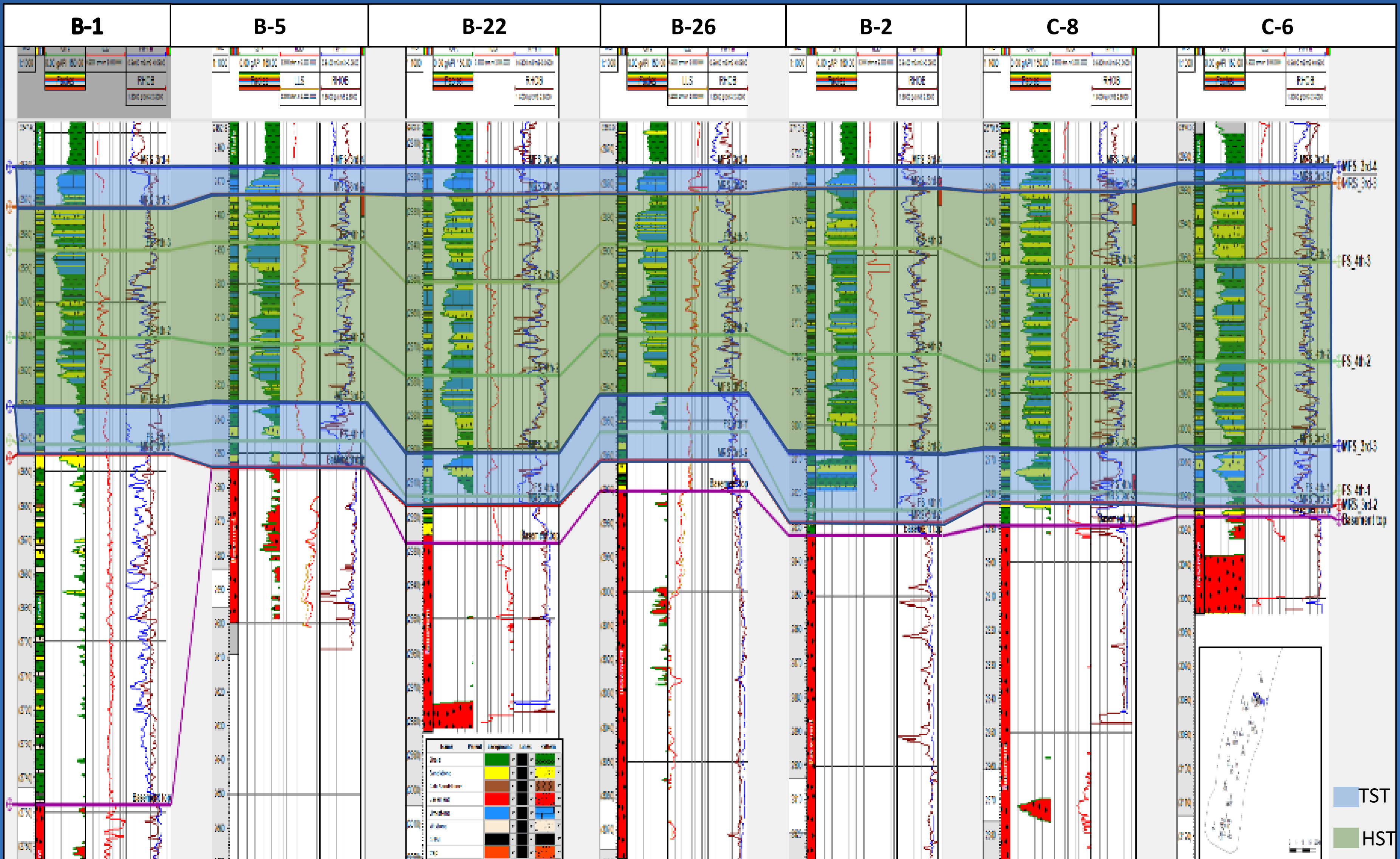


Table - Identified Sequence Stratigraphic Surfaces and Sequences								
Age	FIRST ORDER		2ND ORDER			3RD ORDER		
	Boundary	Sequence	Boundary	Sequence	System tract	Surface	Unit	System tract
1.81 Ma		Foredeep	CII_120	Ongoing				
			FD-3 LAST TOP	FD-3	HAST			
3.6 Ma			CII_110		LAST			
			FD-2 LAST TOP	FD-2	HAST			
5.3 Ma			CII_100		LAST			
11.8 Ma			FD-1 mfs	FD-1	HST			
21.6 Ma	CI_40				TST			
26.2Ma		Passive margin		PM-2	HST		OL-3	
						mrs-9		FLUVIAL TST
						fs-9	OL-2	RST
						mrs-8		TST
						fs-8	OL-1	RST
						mrs-7		TST
33.9 Ma						fs-7	LEO-1	RST
						mrs-6		TST
						fs-6	LE-2	RST
						mrs-5		TST
						fs-5	LE-1	RST
						mrs-4		TST
37.2 Ma			PM-2 mfs			mfs	MLE-1	RST
					TST	mrs-3		TST
48.6 Ma						fs-3	EME-1	RST
						mrs-2		TST
						fs-2	PEE-1	RST
						mrs-1		TST
						fs-1	PAL-1	RST
61.7			CII_10					TST
65.5				PM-1				
70.5	MI_80							
110Ma		Rift						
130 Ma	MI_50							
284.4Ma		Graben fill						
299 Ma	PI_10							
	BASEMENT							



Dip Profile

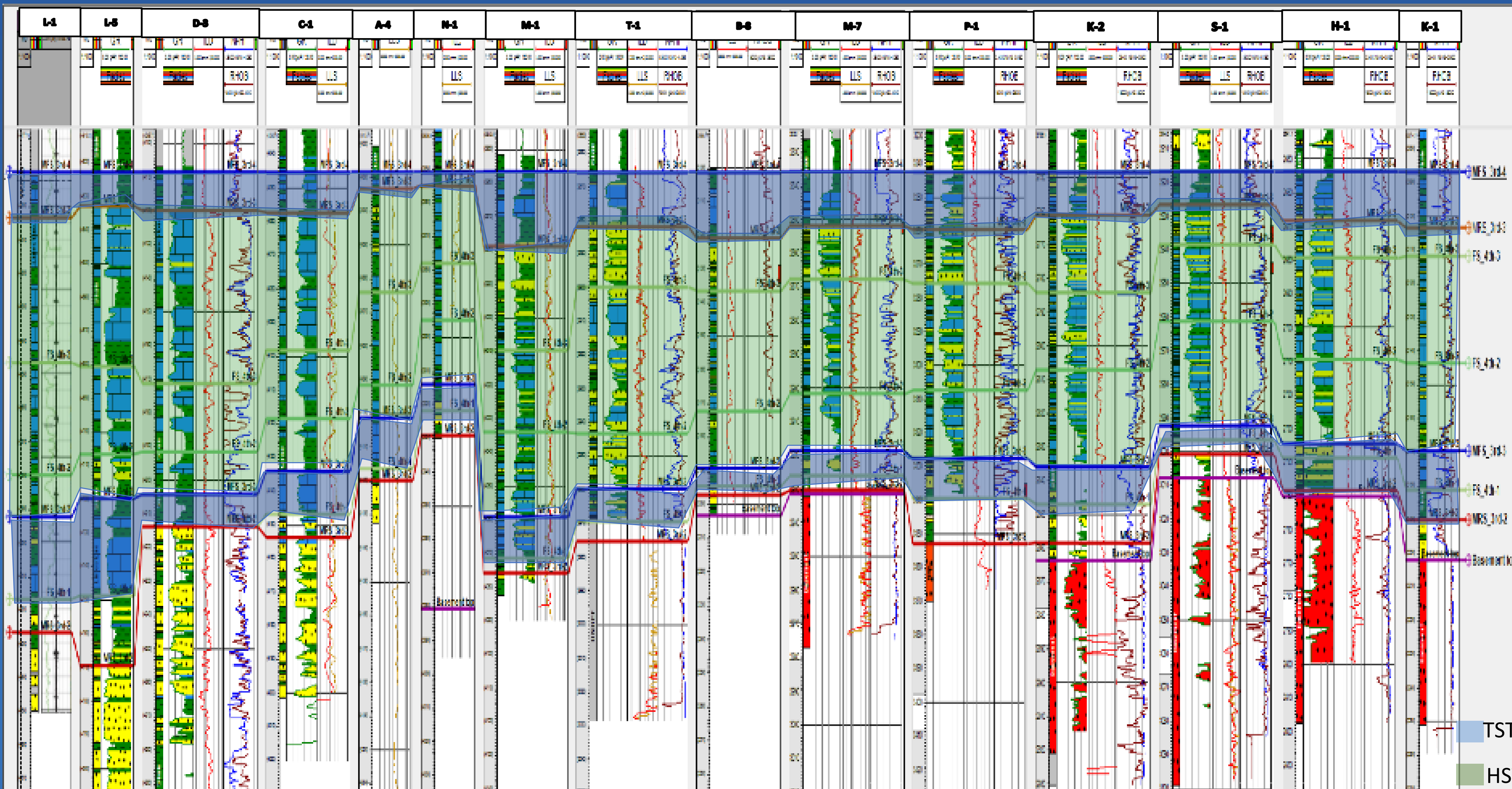


NW-SE profile showing the distribution of different systems tracts in dip direction

Strike Profile

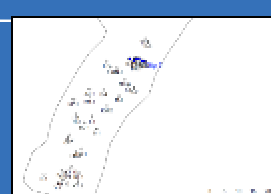
NE

SW



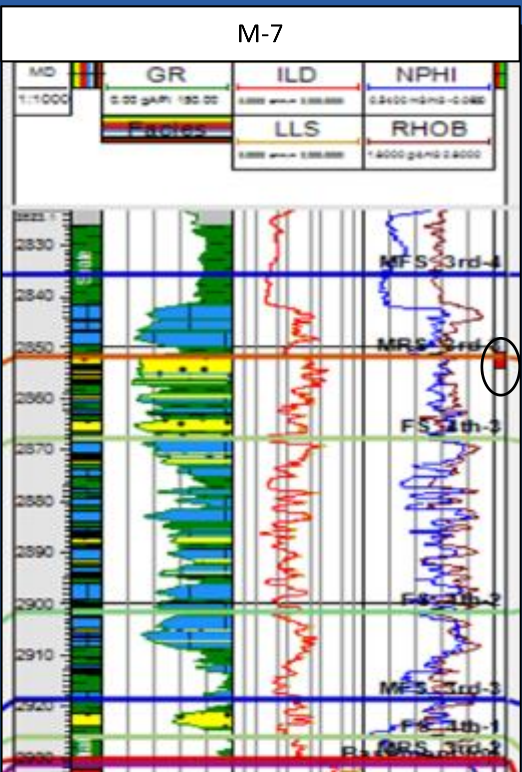
NAS

SAS



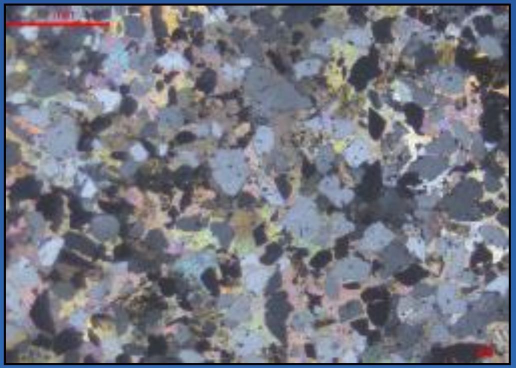
Name	Parent	Background	Lines	Pattern
Shale				
Sandstone				
Calc Sandstone				
Basement				
Limestone				
siltstone				
COAL				
trap				

M-7 CC#1 (2846-2856m) Recovery 33%

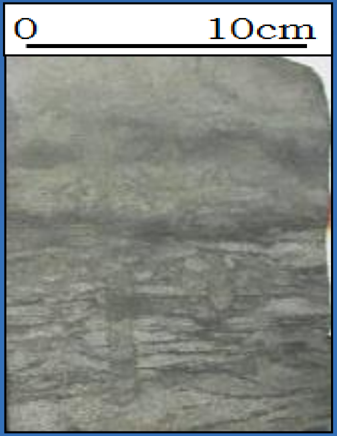


Whole core

Sandstone with rip-up mud clast at base

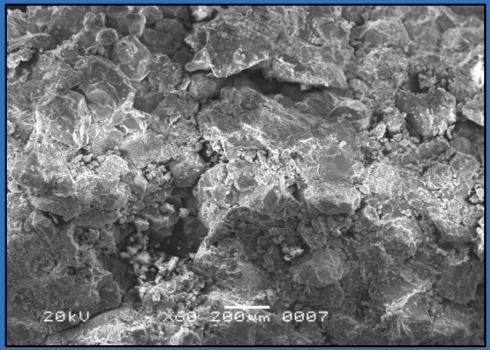


Depth 2854m: Photomicrograph depicting calcareous quartz arenite microfacies



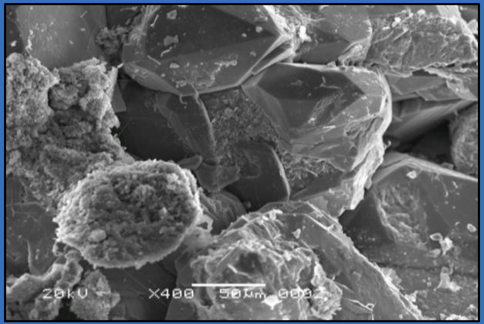
Intermixed sandstone shale as a result of burrowing activity

Depth 2850.8m**:** Photomicrograph depicting flood-Ebb cyclicity

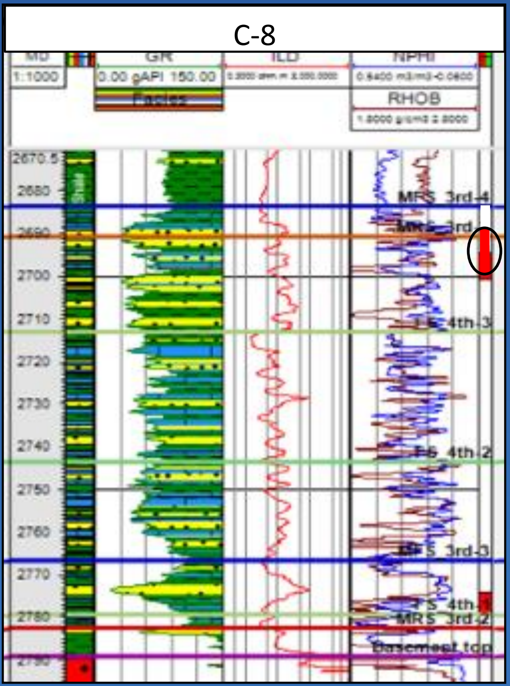


Depth 2850.8m: General view showing moderate intergranular porosity

Depth 2850.8m: SEM image showing good intergranular porosity



C-8 CC#2 (2700-2708m) Recovery 96.25%

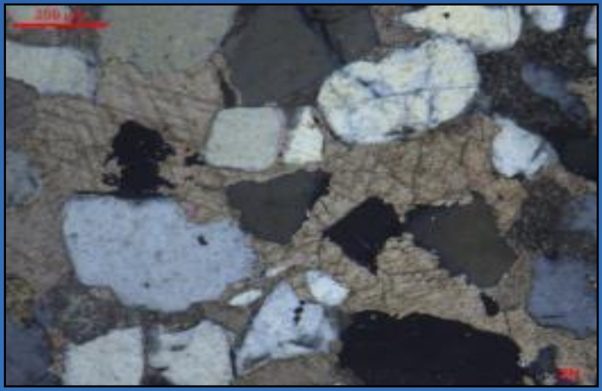


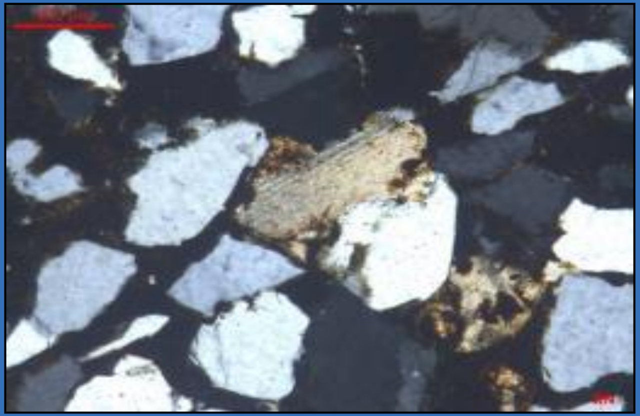
Whole core image

Argillaceous Sandstone

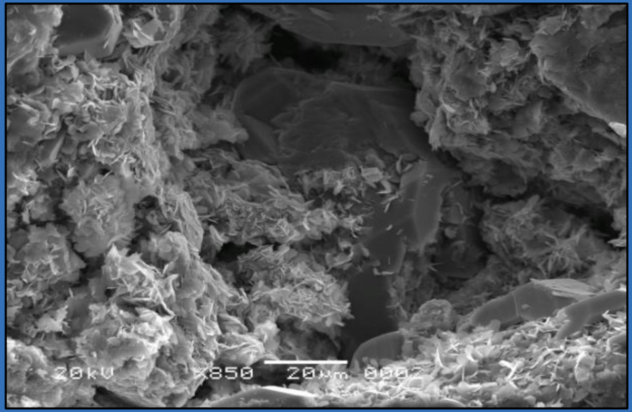
Massive Sandstone

Depth 2700.6m: Etched quartz grains floating in calcite cement.

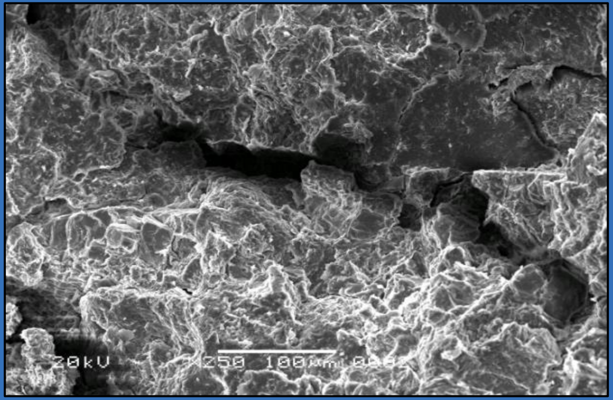




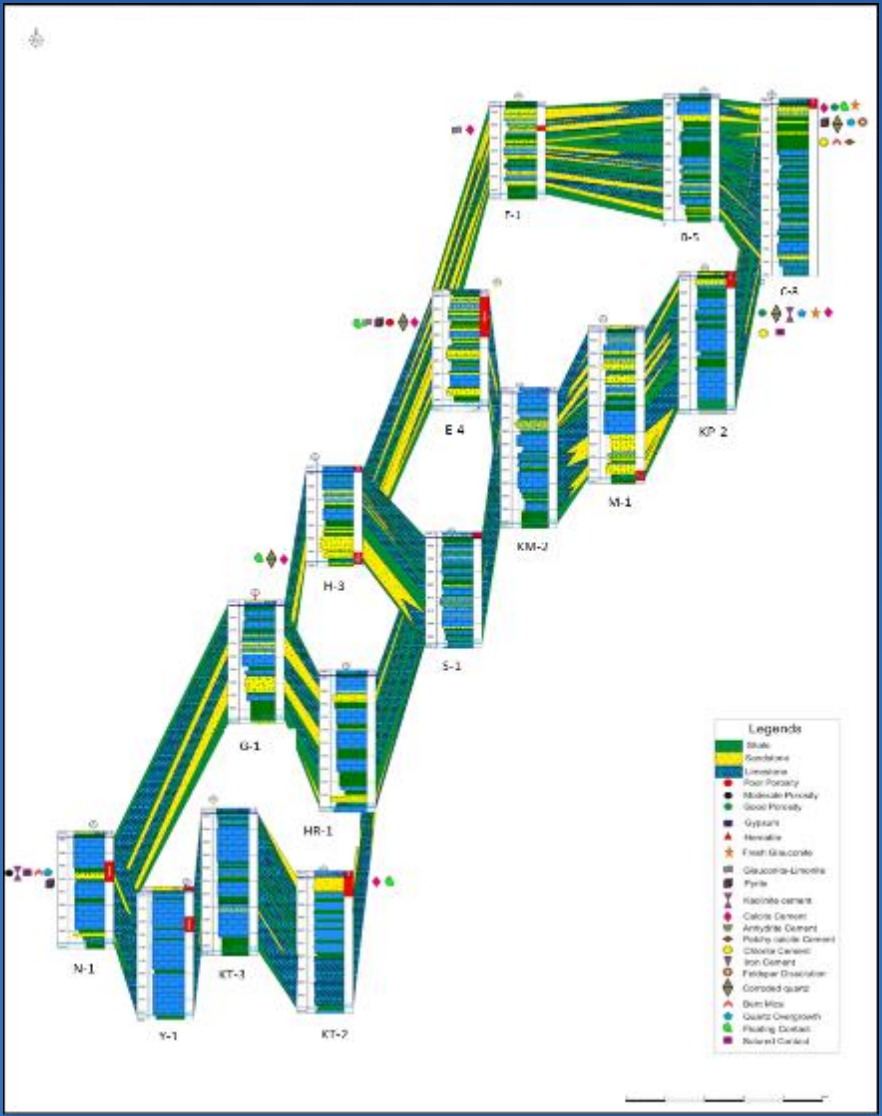
Depth 2705.6m: Enlarged view depicting etching of quartz grains by patchy calcite cement



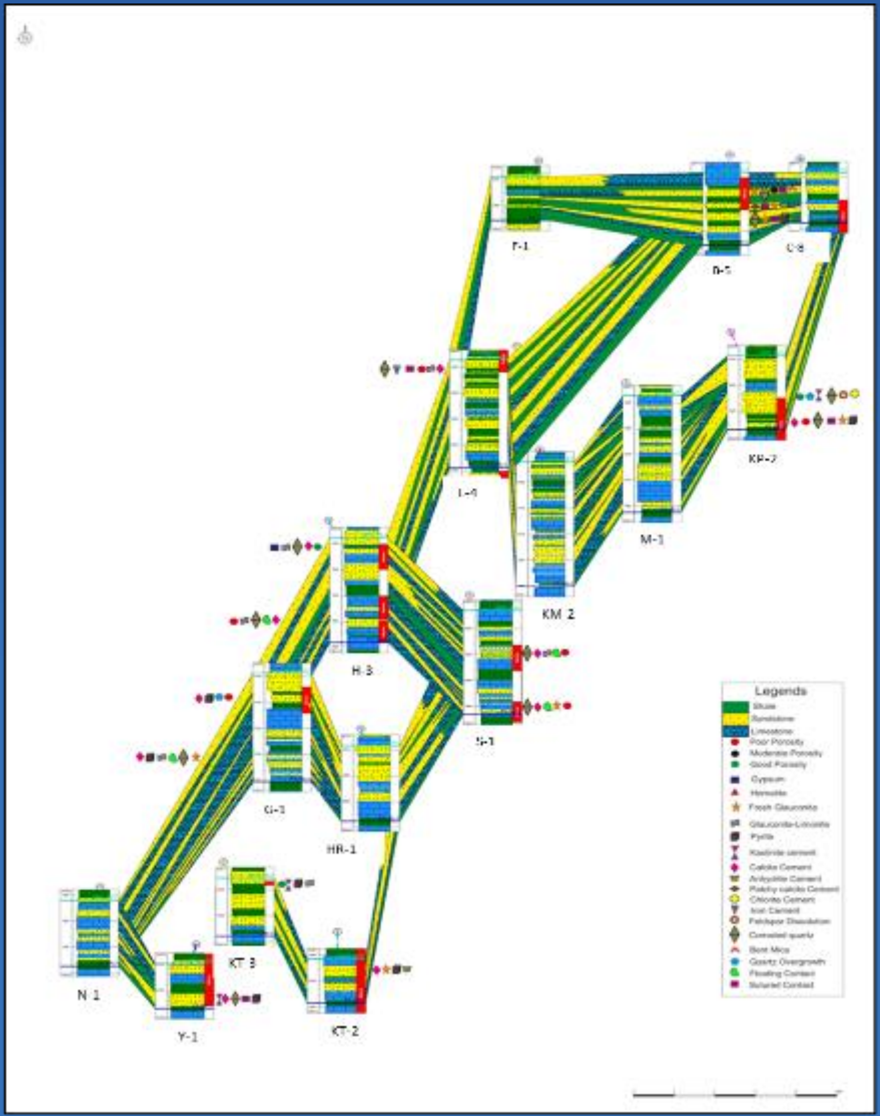
Depth 2705.6m: Enlarged view showing pore spaces



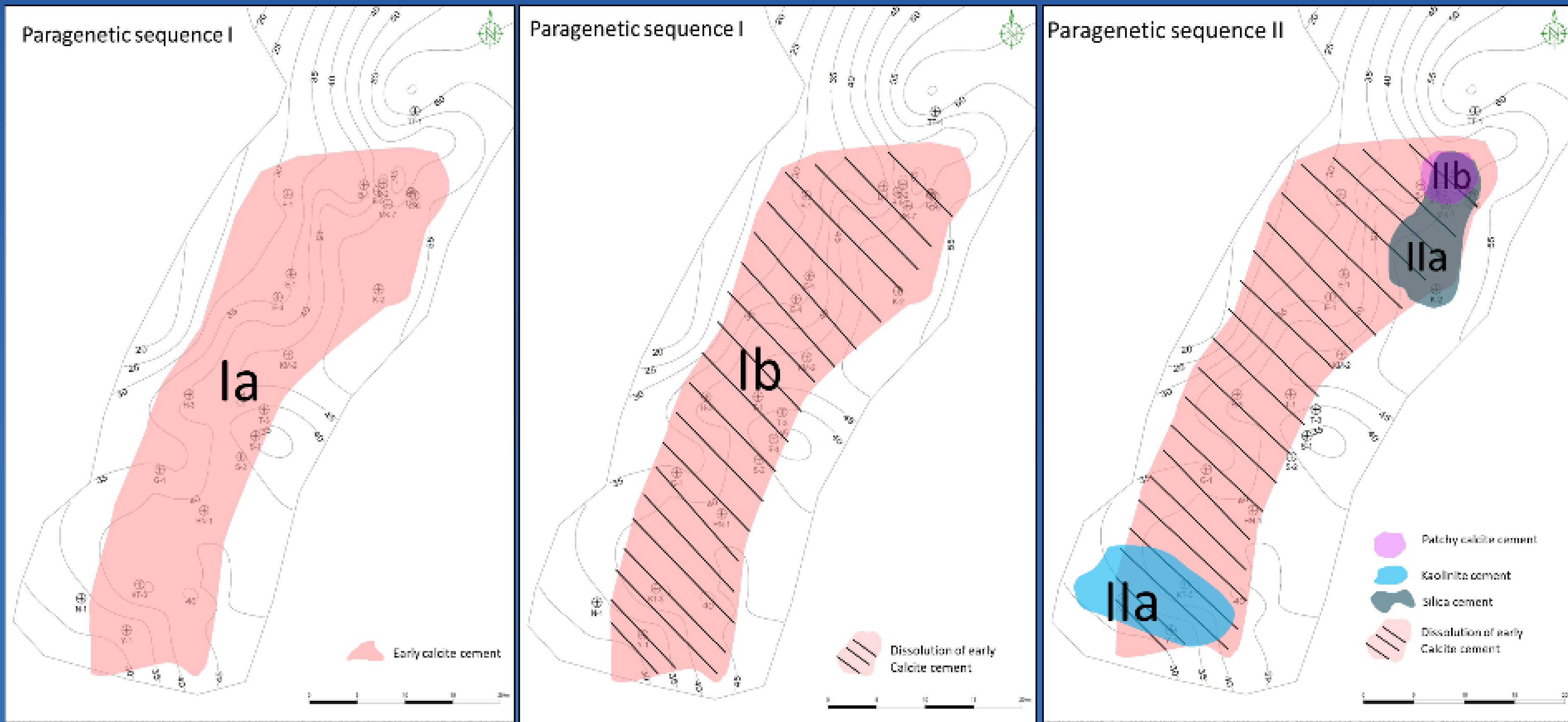
Depth 2700.6m: SEM image showing secondary porosity created by dissolution



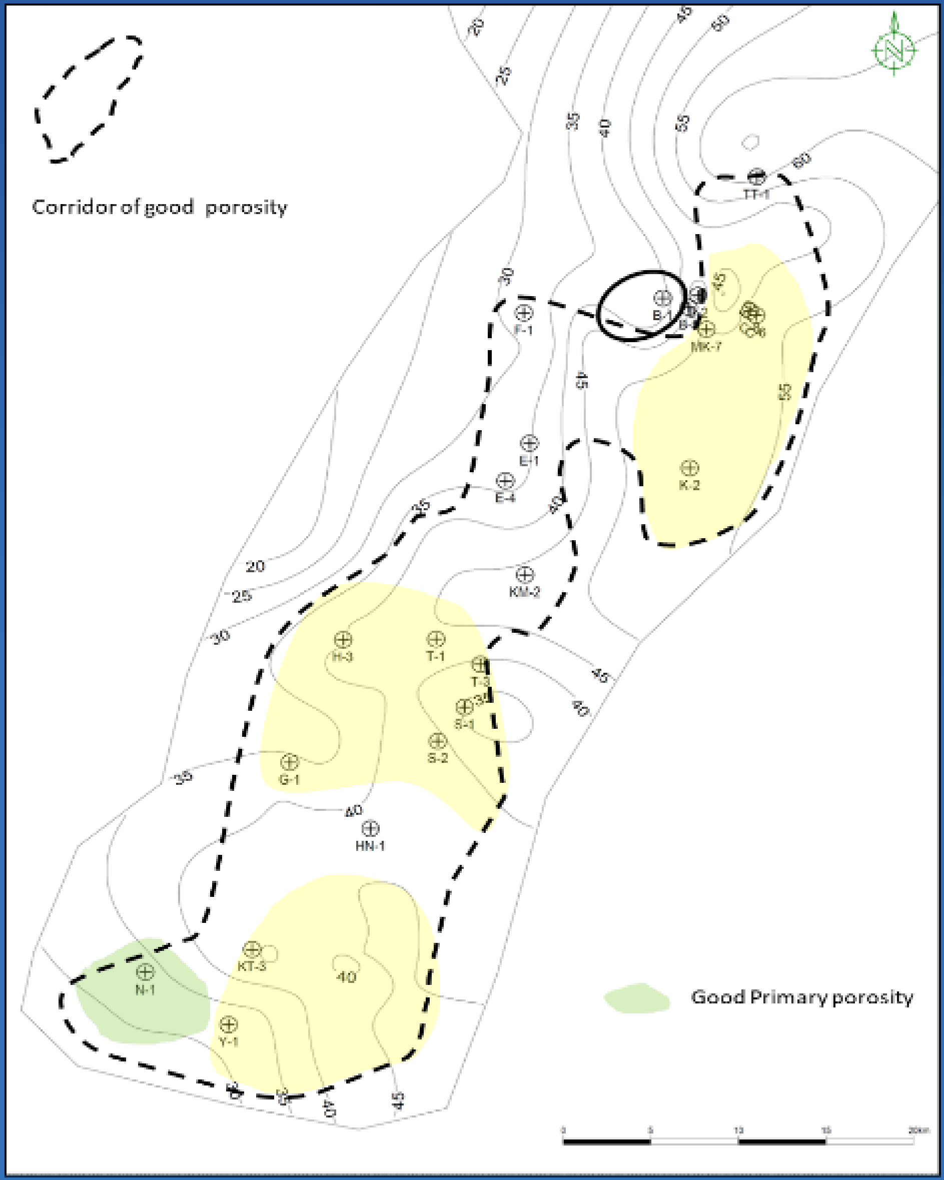
Fence diagram depicting sedimentological attributes and porosity distribution in between MFS_3rd -3 (bottom) and FS_4th-3 (top) within South Assam Shelf



Fence diagram depicting sedimentological attributes and porosity distribution in between FS_4th-3 (bottom) and MRS_3rd-3 (top) within South Assam Shelf



Paragenetic sequence 1) Eogenesis a) Early calcite cement b) Dissolution of early calcite cement,
II) Mesogenesis a) Kaolinite cement (southern part) and silica cement (northern part) b) Patchy calcite cement;



Porosity distribution map showing zones of good primary and secondary porosities and poor porosity

Conclusion

- Carbonate cementation is more extensive in TST sandstones that creates reservoir compartments between amalgamated sandstone

- A fall in relative sea-level and exposure of the sand in Sylhet Formation is accompanied by infiltration of meteoric waters, which results in dissolution of pre-existing calcite cement, leads to creation of secondary porosity.

- Two paragenetic sequences identified viz. early diagenetic stage (eogenesis) and late diagenetic stage (mesogenesis). In Eogenesis, intense calcite cementation has created a mappable corridor and during regressive phase, dissolution of early calcite cement has created good secondary porosity zones. In Mesogenesis, kaolinitisation is the salient diagenetic event which has reduced the porosity.

- The porosity distribution map shows an overall good porosity corridor along NE-SW direction with patchy zones of poor porosity. The map also depicts better porosity zones in eastern and western part. In the eastern part (basinal), good porosity zones may be interesting from the hydrocarbon point of view because of its close proximity to kitchen area. In contrast, in the western margin part, is more prone to sub-aerial exposure resulting in development of secondary porosity and consequent structurally favourable entrapment condition.

Thank You