Chert cycles on shelf margin in SE Kansas and SW Missouri

STRATIGRAPHIC CROSS SECTION

BASED ON COREHOLES AND MEASURED SURFACE SECTIONS
SOUTHEASERN KANSAS AND SOUTHWESTERN MISSOURI
– Please note: Cross Section index on previous panel

Key points from Cross Section

- Osagean and Warsaw tripolitic chert beds serve as hosts for Pb-Zn mineralization in the Tri-State Mining District in southeastern Kansas, southwestern Missouri, and northeastern Oklahoma in a manner closely resembling the oil and gas accumulations in Osage-Warsaw chat beds in western Kansas.

- Chert beds thicken, commonly locally, along the shelf margin in southern Kansas and southwestern Missouri.

- Local thickening of chert beds believed to closely correspond to contemporaneous deformation along basement structures analogous to western Kansas. Complex and contrasting thickening of the underlying Pierson suggest complex structural movement. This area, as in western Kansas, is associated with major basement structures influencing sedimentation and later migration of ore-bearing fluids.

- Chert cycles are capped by diagnostic indicators of subaerial exposure and classified as **high frequency, meter-scaled depositional sequences**. Brecciation, fracturing, and substantial microporosity development of chert (locally called "cotton rock" due to light weight, white color) occurred early, prior to deposition of the overlying high-frequency sequence.

Key for core description

Sedimentary Texures

Carbonate Rocks:		Siliciclastic Rocks:	
C	Crystalline - Depositional texture not recognizable	Gravel	Gravel - > 2mm
B	Roundstone - Original components were bound together at deposition	c	Sand Coarse - 1/2 to 2 mm
G	Grainstone - Lacks mud; grain supported	m	Sand Medium - 1/4 to 1/2 mm
P	Packstone - Contains mud; grain supported	f	Sand Fine - 1/16 to 1/4 mm
W	Wackestone - More than 12% grains; mud supported	Silt	Silt - 1/256 to 1/16 mm
M	Mudstone - Less than 10% grains; mud supported	Slate	Shale - < 1/256 mm

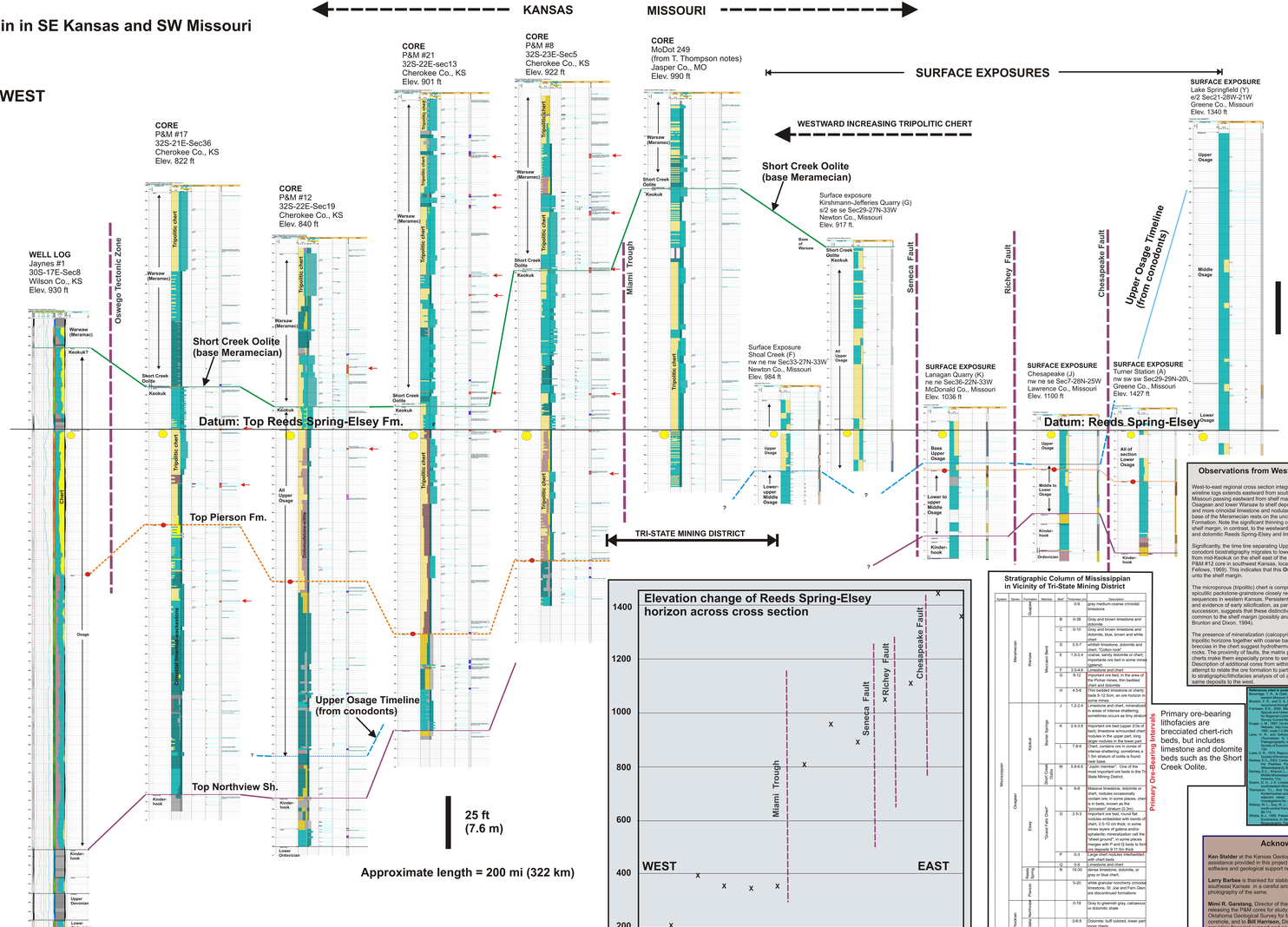
Lithologies

Sandstone	Shaly Sandstone	Shale
Limestone	Shaly Limestone	Shale - red
Dolomite	Shaly Dolomite	
Halite	Gypsum	Anhydrite
Other		
Silts	Siltstone	Obsidian
Fertiliser	Mines	Clays
Chert	Notables	Coal

Sedimentary Structures and Fossils (example from list selected to construct graphic)

Cross bedding - low angle; Flaser bedding; Lenticular bedding; Graded bedding-normal; Graded bedding-coarse; Imbrication; Slump structures; Convolute bedding; Nodules/Concretions; Stylolites; Bioturbation-slight; Bioturbation-intense; Bed Contacts-sharp,planar; Bed Contacts-sharp,irregular; Bed Contacts-gradational; Macrofossils; Inoceramidae; Ammonites; Arthropods; Arachnids; Crustaceans; Insects; Trilobites; Brachiopods; Bryozoans; Cnidarians; Corals; Stromatoporoids; Echinoderms; Crinoids

Reds Spring/Elsey (*Datum*)
Pierson
Subaerial Exposure Surface
Flooding and Condensed Section
Age correlation based on conodonts
Major Fault Zone
Chert
Limestone
Dolomite



Stratigraphic Column of Mississippian in Vicinity of Tri-State Mining District

System	Series	Formation	Member	Bed*	Thickness (ft)	Description
Mississippian	Osagean	Warsaw	Boone	Quaternary	0-9	gray medium-coarse crinoidal limestone
				B	0-38	Gray and brown limestone and dolomite
				C	0-10	Gray and brown limestone and dolomite, blue, brown and white chert
				D	5.5-7	white limestone, dolomite and chert, "Cotton rock"
				E	1.5-2.4	coarse, sandy dolomite or chert; important ore bed in some mines (galena)
				F	3.3-4.6	limestone and chert
				G	9-12	important ore bed, in the area of the Pierson mines, thin bedded chert and dolomite
				H	4.5-6	Thin bedded limestone or cherty beds 5-12.5cm, are one horizon in some mines
				J	1.2-2.4	Limestone and chert, mineralized in areas of intense shattering; sometimes occurs as limy siltstone
				K	2.4-3.5	important ore bed (upper 2/3s of bed), limestone wmounded chert nodules in the upper part, lower 1/3 is massive crinoidal limestone
				L	7-9.0	Chert, contains ore in zones of intense shattering; sometimes a 1.5m stratum of oolite is found near base
				M	5.8-6.6	"Middle Member". One of the most important ore beds in the Tri-State Mining District.
				N	6-8	Massive limestone, dolomite or chert, nodules occasionally contain ore; in some places, chert is in beds; known as the "Cotton Rock" in Oklahoma
				O	2.5-3	important ore bed, round flat nodules embedded with bands of chert, 2.5-10 cm thick; in some mines layers of galena and/or sphalerite; mineralization call the "Oswego Lime" in Oklahoma; merges with P and Q beds to form ore deposits 9-11.5m thick	Primary Ore-Bearing Intervals
				P	0-3	Large chert nodules interbedded with chert beds	
				Q	0-3	Limestone and chert	
				R	15-30	dense limestone, dolomite, or gray or blue chert.	
		Reeds Spring	Pierson		5-20	White granular noncherty crinoidal limestone; Pierson, Elsey, and Glen are discussed formations	
		Elsey/Northview			0-19	Gray to greenish gray, calcareous or dolomitic shale	
					0-8.6	Dolomite; buff colored, lower part more cherty	

Primary ore-bearing lithofacies are brecciated chert-rich beds, but includes limestone and dolomite beds such as the Short Creek Oolite.

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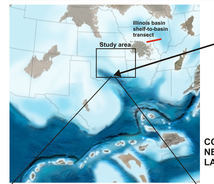
Future Work

1. Obtain and analyze basinal core during summer 2008 near Ada, Oklahoma, to sample sediment-starved Mississippian interval shales, chert, carbonate in basinal position.
2. Additional work in outcrop and subsurface to establish sequence stratigraphy.
3. Relate to global processes - relate refined geochronology of high-frequency depositional sequences to along shelf margin to onset of earliest glacio-eustacy.
4. Use resolved stratigraphy to better understand and predict natural resources including unconventional natural gas along shelf margin and basin.

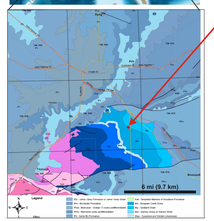


Paleogeographic reconstruction of early Mississippian for North America by Blakey (http://www2.nau.edu/rcb7/nam/M345.jpg)

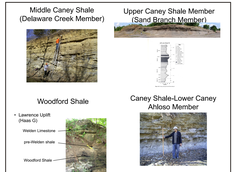
Location of core representative of the basinal conditions during the Mississippian Subsystem.

Photos of nearby surface exposures illustrate the nature of this strata to be sampled for isotope geochronology, gas geochemistry, and conodont biostratigraphy.

COREHOLE LOCATION NEAR ADA, OK WITHIN LAWRENCE UPLIFT



Surface exposures of basinal section near coresite outside of Ada,OK

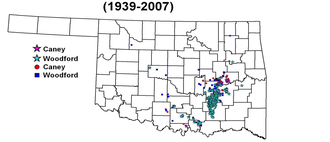


Potential for Unconventional Gas Accumulation

An estimated 1-10 TCF of natural gas may reside in the more dense fractured cherts associated with the Mississippian shelf margin in southern Kansas and northern Oklahoma. These cherty lithofacies have not been officially classified as an unconventional gas resource due to limited evaluation to date. Nevertheless, the tripolitic chert remains an important conventional reservoir across prominent structures in south-central Kansas and north-central Oklahoma. The tripolite is often called "chat" with Φ = 20-50%, k = 5-500 md, Sw 35-70%, BVW = 0.06-0.10) (Watney et al., 2001). Over 2.4 TCF gas and 278 million barrels have been produced from this interval in south-central Kansas.

Shale gas potential in the Osage Caney Shale will be evaluated in the core taken near Ada, Oklahoma. The Caney Shale (2-5% TOC) is not currently a significant gas play, but further evaluation is needed. A detailed petrophysical interpretation including extensive wireline log suite of this shale-dominated section, including measurements of chert, silt, and organic matter richness and thermal maturation, may provide relationships between gas content, fracturing and potential productivity. The shelf margin lithofacies contains less amounts of highly organic-rich shale, but considerably more chert and dolomite than the basinal facies. The brittle behavior of these lithologies would tend to encourage natural and induced fracturing that may be important in establishing gas production. Off-structure and downdip locations where thick chert-rich sequences are developed may offer potential for unconventional gas production. Downdip interbedded shelf margin lithofacies and basinal shales and cherts may also harbor gas adsorbed in matrix and in fracture pore space.

Oklahoma Gas-Shale Completions (1939-2007)



Major Questions Remaining to Be Addressed

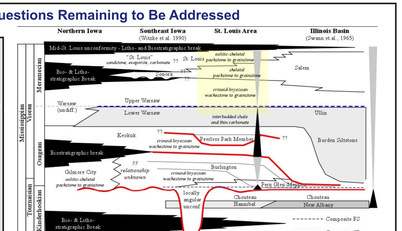
1. Sequence Stratigraphic Model

Preliminary regional sequence stratigraphic framework, Lower and Middle Mississippian (Tournaisian and Visean), Midcontinent U.S.A.

Insight can be gained by comparing the preliminary stratigraphic framework shown in this poster with that of an age-equivalent carbonate shelf-to-basin transition on the east side of the Ozark Uplift in the St. Louis area extending into the Illinois Basin.

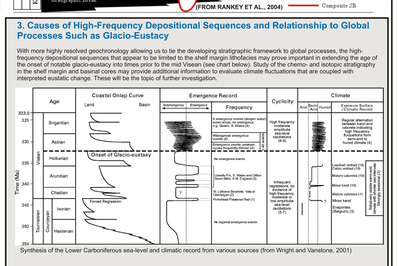
Of note is a typical epsilon-shaped accretionary wedge of the Osagean carbonate shelf developed east of the Ozark Uplift, composed of crinoid-bryozoan wackestones to grainstones. Noticeably lacking in the area east of the Ozark Uplift are chert-rich depositional sequences along the shelf margin (Rankey, personal com., 2008).

The preliminary stratigraphic analysis in the current study suggests a succession of high frequency, unconformity-bounded depositional sequences within a similar stratigraphic framework resembling that developed along the Illinois Basin margin - the throughgoing and widespread Kinderhook carbonates overlain by the time-transgressive lithofacies of the Pierson, Reeds Spring-Elsey, and the Keokuk (younger toward the basin based on conodont biostratigraphy). Geometries along the shelf margin suggest outbuilding of the cherty carbonate shelf toward a sediment-starved basin.



2. Source of Chert

The abundance of thick, microporous massive brecciated (tripolitic) chert beds and nodular bedded cherts in lime and dolomitic mudstones along the shelf margin west of the Ozark Uplift is in stark contrast to the crinoidal-rich carbonate deposits that dominate the area east of the Ozark Uplift. The paleogeographic setting of the western shelf margin may have been conducive to upwelling of cool, basin waters (Lowe, 1975). Such upwelling may be tied to the presence of volcanic arc volcanoes located downwind from the shelf. Migration of basinal fluids is evident in conjunction with the development of the Tri-State Mining District and abundance of baroque dolomite in the southeastern Kansas cores. However, while some of the silica may be derived from late fluid migration, the silicification appears to be early. The penecontemporaneous activity of basement faults and sedimentation is believed to have influenced the location of tripolite chert buildups and also their later preservation based on the current study. Basinal fluids could also have contributed to the silica budget along the developing shelf margin.

3. Causes of High-Frequency Depositional Sequences and Relationship to Global Processes Such as Glacio-Eustacy

With more highly resolved geochronology allowing us to tie the developing stratigraphic framework to global processes, the high-frequency depositional sequences that appear to be limited to the shelf margin lithofacies may prove important in extending the age of the onset of notable glacio-eustacy into times prior to the mid Visean (see chart below). Study of the chemo- and isotopic stratigraphy in the shelf margin and basinal cores may provide additional information to evaluate climate fluctuations that are coupled with interpreted eustatic change. These will be the topic of further investigation.