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ABSTRACT

The Kinderhookian-Osagean (Lower Mississippian) St. Joe and Boone Limestone represent an unconformity bounded transgressive-regressive sequence widely distributed throughout the southern midcontinent. An irregular erosional surface developed on the Chattanooga Shale (Upper Devonian) or older strata. As Mississippian Seas transgressed, they deposited a thin interval of sandstone, shale, or the two together derived from these old beds. Carbonate deposition was initiated as grain-dominated, crinozoan-bryozoan packstones and grainstones, with subordinate wackestones, and is essentially chert free. These carbonates, referred to as the St. Joe Limestone, reflect a ramp across northern Arkansas that experienced condensed sedimentation and red coloration along its conditions reflected by carbonate mudstones, very fine-grained packstones and grainstones, and penecontemperaneous chert of the overlying lower Boone Formation. The upper Boone (Burlington-Keokuk equivalents) represents a regressive sequence that returned St. Joe-type, grain-dominated, lithologies with diagenetic chert replacement to the shelf. The regression terminated in a pronounced regional unconformity overlain by Meramecian or younger strata.

INTRODUCTION

Kinderhookian and Osagean rocks crop out on the southwestern flank of the Ozark dome in southwestern Missouri, northern Arkansas, and northeastern Oklahoma. The St. Joe and Boone Formations (and equivalent strata) form this Lower Mississippian sequence and develop the Springfield Plateau across this area. The Lower Mississippian interval consists of an unconformity-bounded carbonate package with the St. Joe being predominantly chert-free and the Boone consisting of chert-bearing carbonates (Fig. 1).

The principal area of study include portions of northern Arkansas extending from the Oklahoma-Arkansas border eastward as far as Stone County, Arkansas (Fig. 2). A total of nine surface section localities were sampled and described from this area. Additionally, data from 159 subsurface well logs were used to construct an isopachous map of the Boone Formation to illustrate thickness trends throughout the region. This investigation involves a detailed petrologic study of the St. Joe-Boone interval, resulting in the delineation of various carbonate facies which ultimately gives an insight into the depositional history of the sequence.

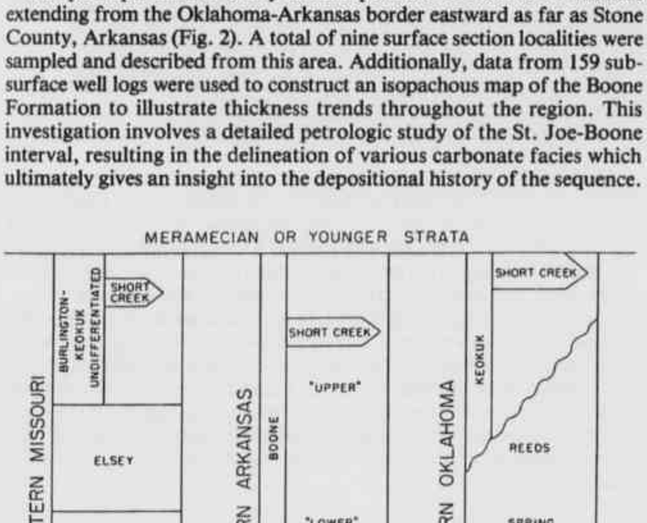

Figure 1. Stratigraphic nomenclature of Lower Mississippian rocks in Missouri, Oklahoma, and Arkansas.

DEPOSITIONAL HISTORY

The Kinderhookian-Osagean (Lower Mississippian) St. Joe and Boone Formations were deposited on a broad carbonate ramp designated as the Burlington Shelf by Lane (1978). In northern Arkansas, these formations represent deposition on a ramp at the southern edge of this shelf that extended southward into siliceous sediments of the Marathon-Ouachita Trough.

The St. Joe and Boone Limestones represent an unconformity bounded, transgressive-regressive sequence. As Mississippian seas transgressed, an irregular erosional surface developed on rocks of Ordovician, Silurian, and Devonian age (Thompson and Fellows, 1970). The Bachelor Member of the St. Joe Formation represents the initial transgression of these seas and is generally recognized as a thin interval of greenish shale, a light-colored sandstone, or the two together derived from older strata (Post, 1982). Carbonate deposition was initiated as grain-dominated, crinozoan-bryozoan packstones, with subordinate grainstones and wackestones, and is essentially chert-free (Shanks, 1976) (Fig. 3). These carbonates, referred to as the St. Joe Limestone, were deposited in relatively shallow waters initially with gradual deepening represented by strata of the lower Boone. In some areas, this change is marked by carbonate mudstones and wackestones (Fig. 3). In other areas, such as the Buffalo River section, it is marked by an abrupt decrease in grain-size which can be attributed to the lack of mud in the area during this time (Figs. 3, 4). Moving up through the Boone interval many surges of grain movement produce repeated cycles of carbonate strata. These cycles are reflected by repetition of grain sizes, allochemical content, and facies throughout the Boone interval (Fig. 4). However, upper Boone strata generally represent shallower water conditions than do those of the lower Boone, reflecting a regressive sequence ending with uppermost Boone deposition. This regression terminated in a pronounced regional unconformity overlain by Meramecian or younger strata.

Shallow Versus Deep Carbonates

Similar lithologies may be found in shallow and deep water settings due primarily to transportation of relatively shallow water sediments into deeper water settings. Wilson (1975) notes the documentation of several limestone turbidite facies deposited in relatively deep water settings. However, several characteristics may be used to differentiate between shallow and deep water carbonates.

Certain sedimentary structures are indicative of shallow marine settings, for example, the presence of current structures such as ripple marks and low angle trough cross stratification. Although some current structures are known from both deep and shallow environments, current activity would be much more pronounced in shallow settings, where tidal and storm activity commonly effect bottom sediments. Mudcracks are also common indicators of shallow water deposition. Character of

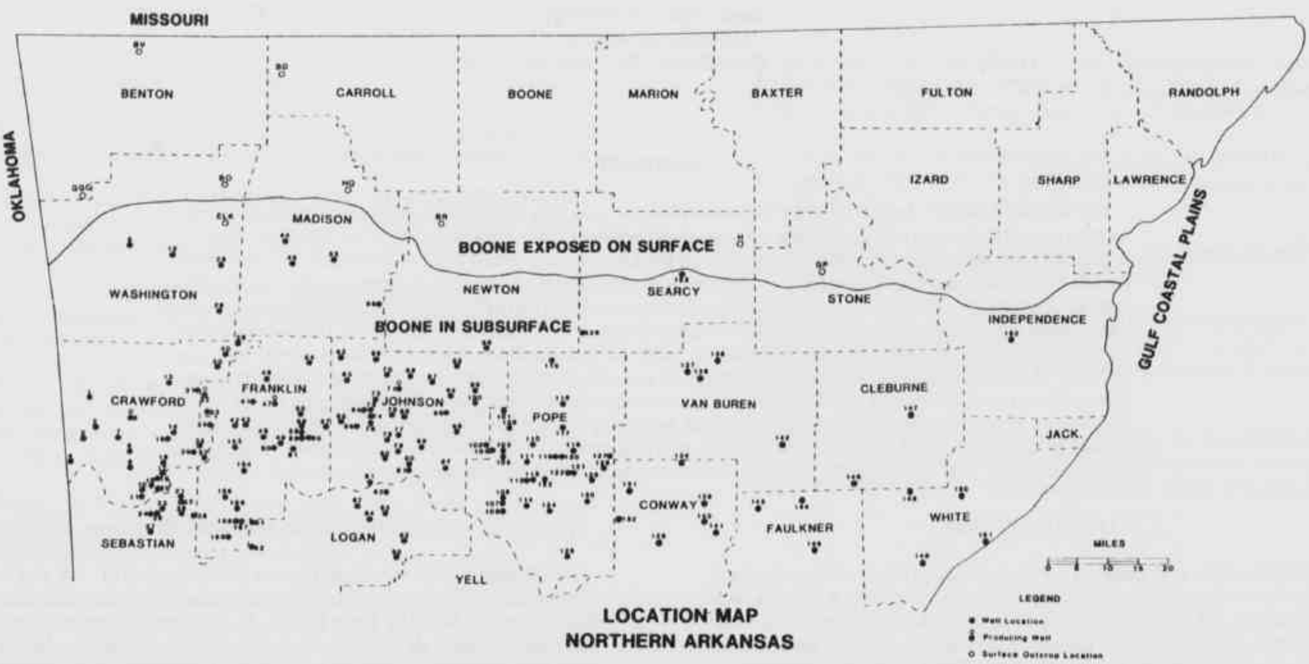

Figure 2. Location map of northern Arkansas showing section localities and subsurface well locations in study area.

individual grains is also an important indicator. Micritic envelopes surrounding grains and presence of moderate abrasion are indicative of high energy shallow water deposition. Presence or absence of certain allochemical constituents are significant. For instance, abundance of pellets, algal material, and/or shallow-water forams are all indicators of shallow water environments. Other indicators of shallow water deposition include abundance of burrowing and presence of trace fossils. Both of which are prevalent in quiet, shallow water settings. Another characteristic of quiet shallow water deposition is presence of primary dolomite, frequently associated with mudflats and stromatolites. Biohermal or mound-type buildups are also usually indicative of shallow water settings. However, the Waulsortian Mounds in lower Mississippian strata of Arkansas, Missouri, and Oklahoma are thought to be deep water (Manger and Thompson, 1982).

The mud-dominated facies of the lower Boone contains none of the characteristics of quiet, shallow-water environments. Mud cracks, algal stromatolites, bird's eye structures, and penecontemporaneous dolomite are all absent. Although some burrowing is present, it is not developed to the degree that would be expected in a lagoonal type setting. Mooreover, there is a marked absence of distinctive shallow water fauna in all facies of the lower Boone. There are no foraminifers, algae or pellets. Micritic envelopes are not present, and there is an absence of current structures. Another important characteristic missing in the lower Boone is the development of mound-type or biohermal buildups. Manger and Thompson (1982) note the development of more than 40 Waulsortian mounds within the St. Joe interval in northeastern Oklahoma and southwestern Missouri. Harbaugh (1957) found apparent Waulsortian mound development in northeastern Oklahoma within the Keokuk interval (upper Boone equivalent).

In contrast, the upper Boone interval represents the return of relatively shallow-water conditions towards the top of the interval. At the Elkins and Huntsville Quarry sections, foraminifers and quartz sand grains are found scattered in samples taken near the top of the Boone interval. Also, apparent mud cracks are developed in one sample at the Elkins Section. Low angle cross-stratification is present within a ten foot bed near the top of the Buffalo River section. Oolitic grainstones (Short Creek Oolite) are developed sporadically in the upper Boone interval across northern Arkansas. Liner (1979) and Van den Heuval (1979) noted the present of ooliths in three separate sections (Buffalo River, Hemmed-In-Hollow, and War Eagle).

Carbonate Depositional Cycles

The Boone Formation appears to be cyclic in some areas throughout much of its lower interval. Graded bedding is present, consisting of tightly packed bryozoan-crinozoan packstones and grainstones exhibiting fining-upwards sequences.

At the Buffalo River section, these cycles are represented by the alternation of coarse-grained crinoidal grainstones and subordinate packstones with fine-grained bryozoan grainstones and packstones (Fig. 4). At another locality (Beav-O-Rama), a single crinoid bed exhibits this graded-bedding. This bed grades from a coarse crinoidal grainstone at the base to a very fine-grained bryozoan packstone at its top.

These cycles may be attributed to a combination of two possible origins. They may represent turbidity flows in which shallower water sediment is periodically brought into the deeper water setting (Fig. 5). In between these periods of active transport not much deposition occurs with only very fine-grained material setting out from the water column. These cycles may also be related to fluctuations in the early Mississippian shoreline where the orientation changed frequently in localized areas.

Condensed Sedimentation

Thompson and Fellows (1970) noted that St. Joe thickness in northeastern Oklahoma and southwestern Missouri was inversely proportional to the rate of sedimentation. Post (1982) reported that sections of St. Joe strata in northcentral Arkansas showed evidence of condensed sedimentation. Condensed sections produced a relatively high number of conodonts suggesting a slow rate of deposition. An isopachous map prepared by Gandl (1983) illustrates the thinning trend of St. Joe Strata across northern Arkansas and southwestern Missouri (Fig. 6).

In contrast, Boone strata in the same area is quite thick and yet contain less conodont zones than does the St. Joe, suggesting that the rate of sedimentation was higher. This could be attributed to a higher frequency of turbidite type transport to the area resulting in thicker sediment in less duration of time. Condensed sections may be present in the Boone farther to the south and east, where it dips into the subsur-

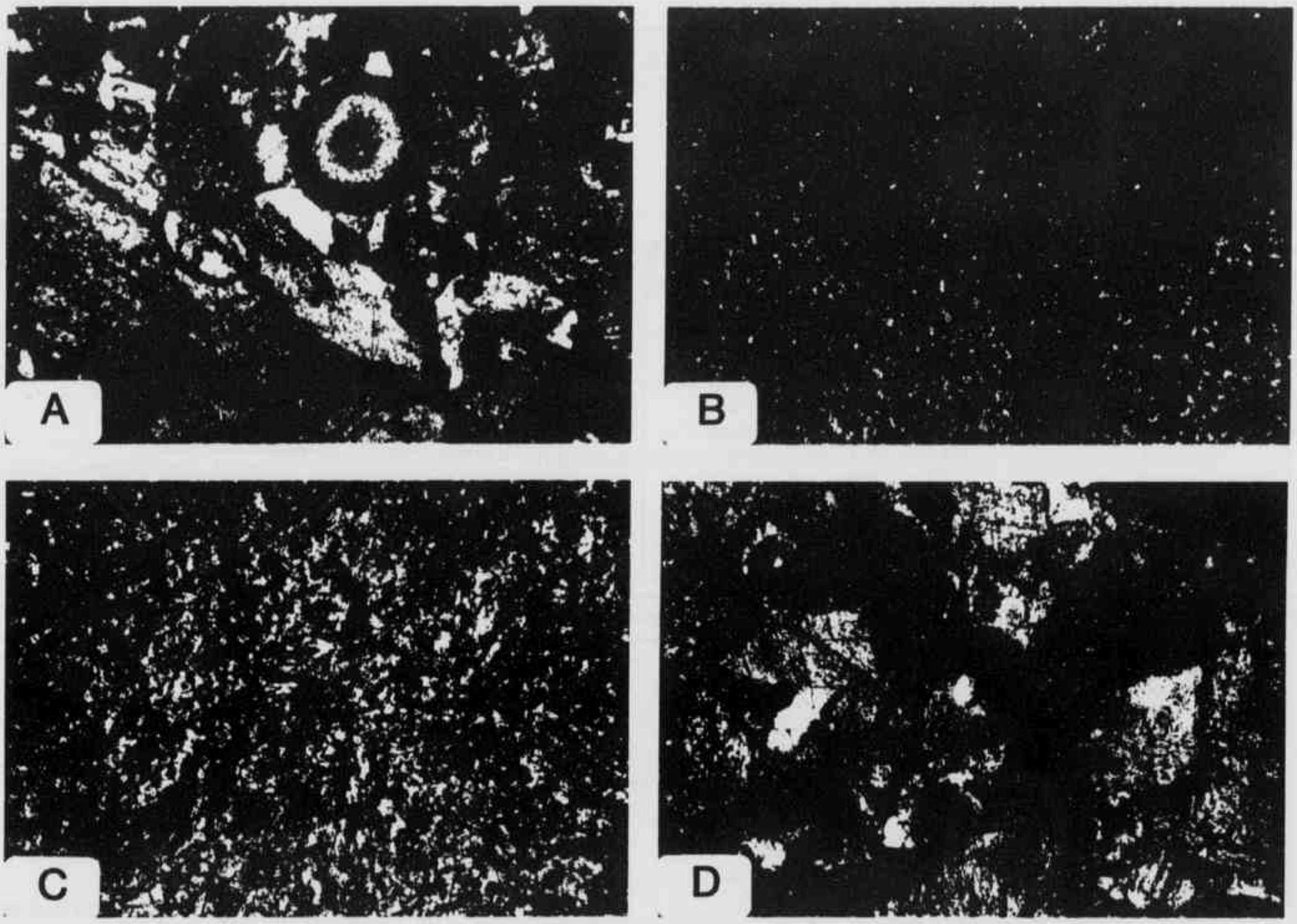

Figure 3. Photographic plate: A) photomicrograph of typical St. Joe lithology, crinoidal lime grainstone; B) photomicrograph of typical lower Boone lithology, lime mudstone; C) photomicrograph of typical lower Boone lithology, fine-grained bryozoan lime grainstone; D) photomicrograph of typical upper Boone lithology, crinozoan lime grainstone; all photographs 25X.

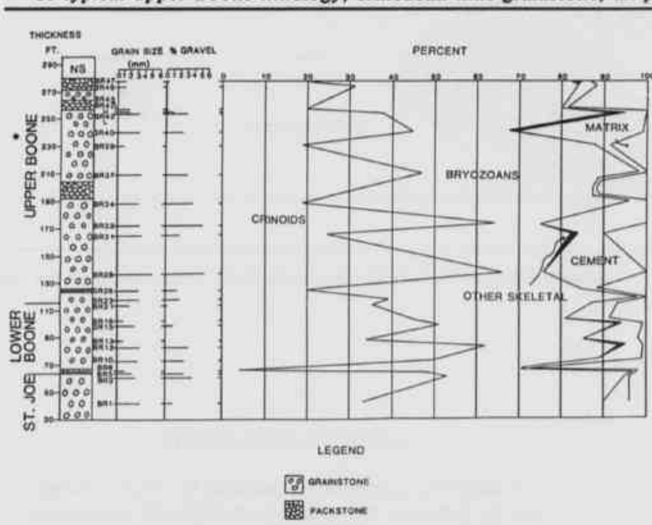

Figure 4. Grain size and modal analysis data of St. Joe-Boone samples at Buffalo River section.

face. A newly constructed isopach map of the Boone interval shows trends of thinning to the south and east (Fig. 7).

CONCLUSION

The Kinderhookian-Osagean (Lower Mississippian) St. Joe and Boone Limestone represent an unconformity bounded, transgressive-regressive sequence deposited on the southern edge of a broad carbonate platform known as the Burlington Shelf. In northern Arkansas, none of the St. Joe-Boone Strata was deposited in place. The sediment was transported down slope and deposited in deeper water conditions.

The Bachelor Member of the St. Joe Formation represents the initial transgression of the Mississippian seas and is everywhere approximately the same age suggesting rapid initial movement of these seas. Carbonate deposition was initiated as shallow-water grain-dominated lithologies and is represented by the St. Joe Limestone. These carbonates reflect a ramp across northern Arkansas that experienced condensed sedimentation eastward.

As the seas continued to transgress and greater water depths were achieved, different carbonate facies were deposited. These changing conditions are reflected by mud-supported carbonate, turbidite-type transported packstones and grainstones, and penecontemporaneous chert of the lower Boone. The upper Boone represents a general regressive sequence that returned St. Joe-type, grain-dominated shallow-

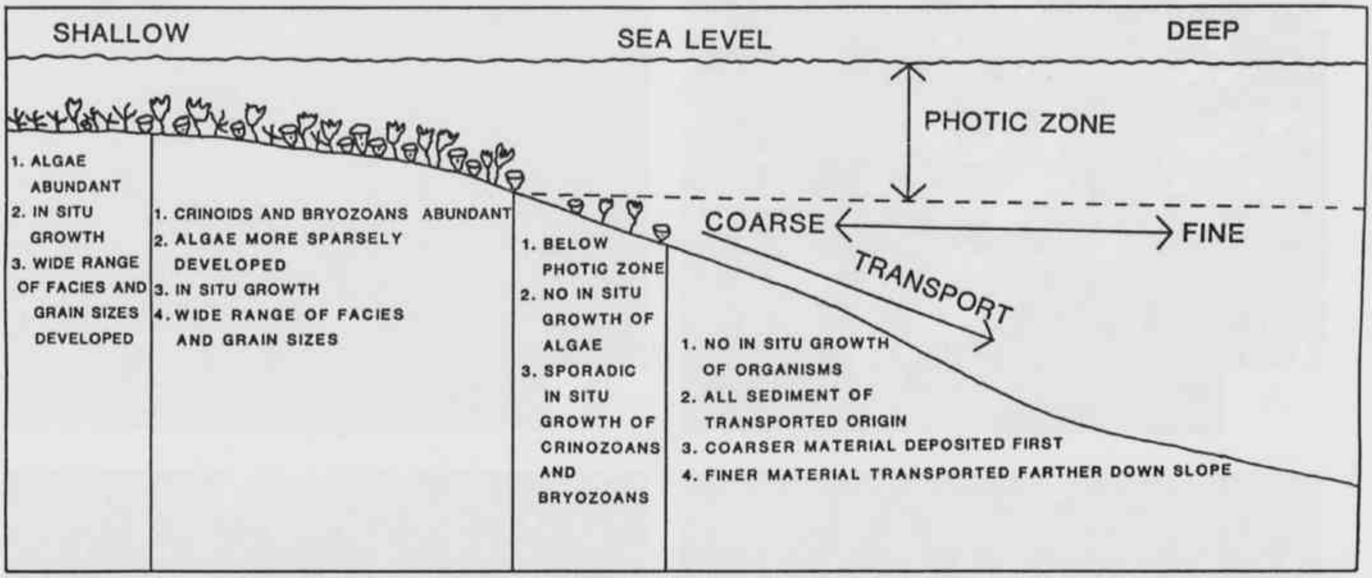

Figure 5. Generalized regional depositional setting of St. Joe-Boone interval.

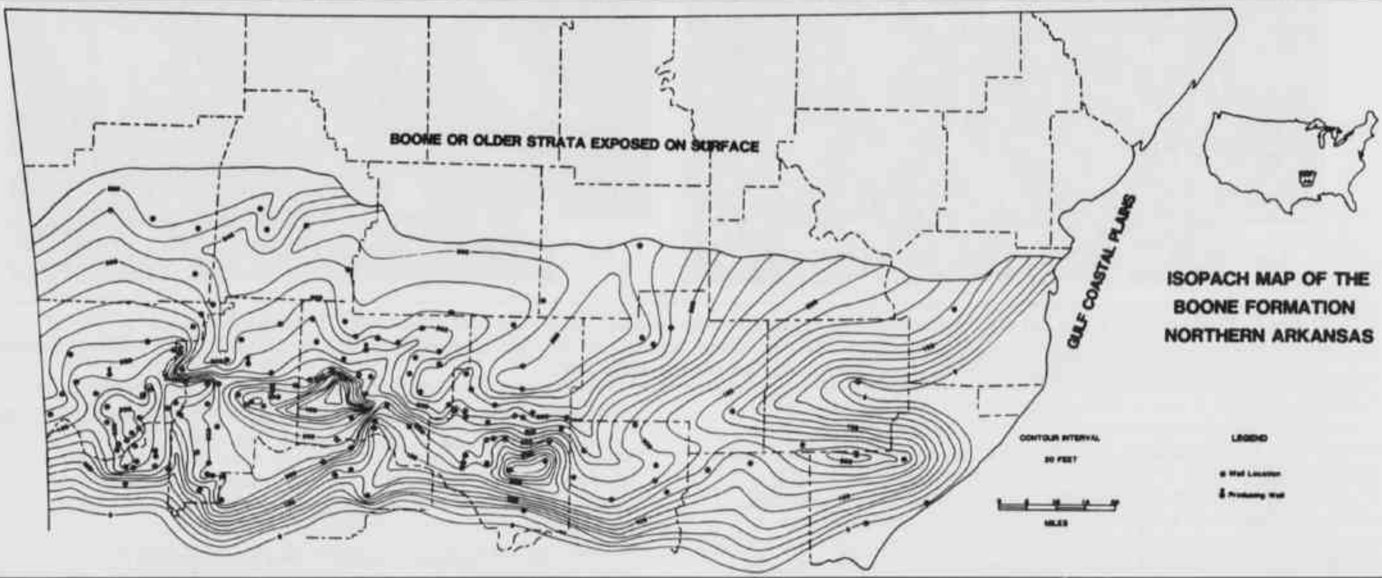

Figure 7. Isopachous Map of the Boone Formation.

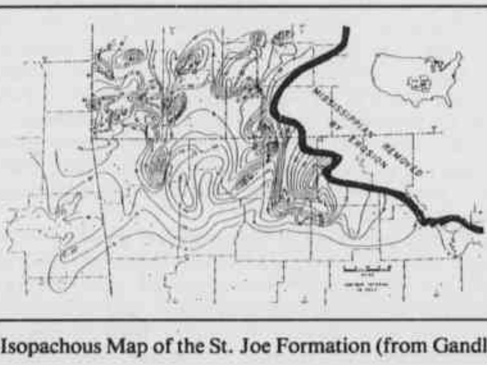

Figure 6. Isopachous Map of the St. Joe Formation (from Gandl, 1983).

water lithologies with later diagenetic chert replacement to the shelf.

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