STRATIGRAPHIC ANALYSIS OF THE KGS #1 JONES CORE

By

P. Allen Macfarlane
Kansas Geological Survey
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Introduction

The KGS #1 Jones test hole was drilled in 10S-8W-2aaa, Lincoln County, during period from May 9-18, 1990 on land owned by Larry Jones. The purpose of drilling the test hole was twofold: (1) to link previously cored and logged test-holes to the northeast in Republic and Washington counties with test holes to the west in Russell and Ellis counties and with previous surface investigations to the east in central Kansas and (2) provide subsurface data for the design of a monitoring site to be installed later during calender year 1990. Two-inch diameter core samples of the strata penetrated were collected using wireline coring from 12-234 ft below land surface and 280-473 ft. Coring of poorly-consolidated sandstones in the lower Dakota Formation was not found to be practical given time and equipment limitations. The total depth of the test hole was 505 ft. The test hole was logged by Schlumberger using a diverse combination of tools to provide lithodensity, sonic, and fluid properties information. Logging runs were made to produce spectral gamma ray, conventional gamma ray, SP, shallow and deep spherically-focused induction, photoelectric absorption, neutron density and gamma-gamma density logs of the borehole. In the laboratory, core samples of the sandstones were selected and tested to determine the vertical variation of horizontal and vertical permeability.

The following narrative contains a description of the features and lithology of the core and an interpretation of the stratigraphy penetrated by the borehole.

Stratigraphic Description and Interpretation

0 to 14.5 ft

Tan sandy fossiliferous marl. According to Dunham's (1962) classification a wackestone. Fossils remains consist primarily of molluscan shell fragments and pelagic foraminifera (*Globigerina sp.*). An unevenly bedded fossiliferous limestone ranging in texture from grainstone to packstone is present from 14 to 14.5 ft. Fossilized remains in this limestone consist of fish bones and teeth and mollusc shell fragments.

The base of this unit is interpreted as the Greenhorn Ls. - Graneros Sh. contact from Hattin's (1975) description, even though the exact distance to the "X" bentonite below this bed is unknown from the core. From the gamma ray log the distance from the base of the limestone to the top of the "X" bentonite is estimated to be one ft which is approximately the same as Hattin's measurement at a nearby outcrop in Mitchell County (9S-8W-21 center). Therefore the top of the Graneros Shale is interpreted to be 14.5 ft below land surface.

The depositional environment for the Greenhorn Limestone part of the core is interpreted to be offshore marine open to ocean currents below normal wave base but shallower than storm wave base. This is due to the presence pelagic foraminifera and the storm deposits of the Lincoln Limestone member just above the Greenhorn-Graneros contact.

14.5 to 59 ft

Core was not recovered from 14.5 to 20 ft. except for pieces of bentonite (probably the "X" bentonite). Medium to dark gray finely laminated fossiliferous calcareous silty shale grading downwards to dark gray blocky fossiliferous calcareous silty shale (55-59 ft). A one-foot thick bentonite occurs at 35 ft. in the core. Interbeds of sandy fossiliferous siltstone containing wavy laminations and ?hummocky cross-stratification occur at 36 ft. Beds consisting of broken shell remains and fish teeth occur at 33 and lenticular interbeds of fossiliferous very-fine silty sandstone with hummocky cross-stratification and wavy laminations occur at 47-48 ft. Fossil fragments of mollusc shells and fish remains are common in these fine sands. Pyrite is common below 53 ft.

This section of the core is interpreted to be the Graneros Shale at this location. However, the thickness of the formation in core is significantly different from that recorded Hattin's (1965) outcrop surveys. The measured thickness in the core is 44.5 ft whereas the outcrop thicknesses measured by Hattin in southern Mitchell and Lincoln counties are on the order of 25 ft. The apparent discrepancy comes from how the formation boundaries are defined. The definition of the Greenhorn-Graneros contact in core and outcrop is the same. However, in outcrop Hattin defines the Graneros-Dakota contact using criteria that depend on the presence of thick flatbedded sandstones in the Dakota or interbedded sandstones and shales. In this core the contact is defined on the basis of: (1) the presence of plant debris and (2) lithology. Just below 59 ft sandstones that contain abundant carbonized plant debris become the major lithology. Plant remains do not occur above this boundary in the Graneros Shale and shale is the principal lithology.

The Graneros Shale is the product of deposition in an offshore shallow marine setting below normal wave base but above storm wave base. Shale accumulates in marine environments below wave base in relatively quiet waters. However, the presence of hummocky cross-stratification and fossil debris in lenticular sandstones suggests that the sea bottom was periodically agitated by storm waves.

59 to 112 ft

Sandstones and interbedded bioturbated sandstones and siltstones comprise this part of the core.

Coarsening-upward fossiliferous medium to fine-grained moderately well-sorted quartzose sands containing clay clasts, glauconite, and pyrite and interbedded silty shales occur from 59-63 ft. Fossils include molds and casts of whole mollusc shells and some fragments, sharks teeth, and fish remains. The interbedded silty shales are dark gray and laminated and show evidence of bioturbation though no burrows were identified. An unconformity is evident at the base of this sequence. These deposits represent deposition in a distal bar seaward of a river-dominated delta and signal a rise in sea level resulting in inundation of the delta.

Coarsening-upward sequences of mostly fine-grained moderately well-sorted sandstone alternating with bioturbated interlaminated very fine-grained silty sandstones and siltstones are present below the distal bar deposits (63-112 ft). The sandstones are also wavy laminated to asymmetrically rippled with carbon flakes, plant debris, and mica flakes along bedding surfaces (70-77 ft) or horizontally bedded to cross-bedded with rip-up clasts and carbonized plant debris on bedding planes (84-106 ft). These sandstones are separated by interlaminated units with abundant *Skolithos* burrows and carbonized plant remains and layers of carbonaceous shale with roots in place extending down into underlying units. These strata were deposited as part of a sequence of events beginning with the formation of crevasse splays in an interdistributary bay and eventual filling with mud and colonization by land plants. The coarsening-upward sandstones are crevasse splay deposits; the interlaminated siltstones and sandstones are bay fill; and the lignites are from accumulations of plant material in swamps or boggy areas.

112 to 154 ft

This part of the core consists of a generally fining-upward sequence of sandstone, gray siltstone, and shale. The sandstones range from medium to very fine grained and are generally carbonaceous. Bedding in the sandstones is generally absent except for some cross-bedding at 150-154 ft. Otherwise, the strata appear to have been compacted and slumped. Clay clasts and carbonized plant fragments are abundant, especially near the bottom of the core. Scour surfaces are preserved at two locations in lower more sandy part of the core and there is an erosional surface preserved at the bottom of this sequence. Above the coarser grained sandstones, fine to very fine grained sandstone is interbedded with siltstones, silty shales, and carbonaceous shales. Leaf impressions are preserved on bedding plane surfaces within the silty and clay shales. Pyrite is a common accessary in the shales, whereas pyrite and siderite nodules are abundant in the gray siltstones.

This part of the core is interpreted as the fill of an abandoned distributary or river channel on a coastal plain. This is based on: (1) the generally poor sorting of the sediments filling the abandoned distributary, (2) evidence of slumping of the sediments due to compaction of the organic debris and clays, and (3) the erratic nature vertical changes in sedimentary texture within the sequence. The vertical succession of lithologies in the upper part of the sequence may have resulted from long-term filling and subsidence due to compaction of underlying water-saturated fine grained sediments.

154 to 183

This part of the core consists mostly of fine-grained clastics that exhibit vertical gradations from one lithology to another over several feet. Core was not recovered from 177-186 ft.

From 154-172 ft the lithology varies from gray to gray green sandy siltstone to gray silty shale. Thinly bedded to interlaminated light gray silty sandstones and dark gray clayey siltstones predominate in the upper part. From 154-156 ft these sediments are more thickly bedded, coarser grained, and they appear to have undergone slump. Below, the siltstones are increasingly fine grained and clayey, exhibiting slickensided surfaces (156-158 ft). Bedding ranges from finely laminated to indistinct. Carbon flakes, plant fragments, pyrite and siderite nodules are common. Below 158 ft gray and gray green siltstones with lenses of interlaminated very-fine grained sandstone and siltstone predominate. Bedding is generally indistinct except where the interlaminated lenses occur. At many locations the bedding dips at low angles (5-10 degrees). A scour feature was noted in the interlaminated sediments at 168 ft. Pyrite nodules, carbon flakes, and distinct zones of siderite nodules are common. In place roots were found at 164 ft.

Lower in the core, the grey siltstones grade downwards into fine to very fine grained sandstone that is ripple- to horizontally-laminated (172-177 ft). The sandstone near the top of the section is silty and interbedded with grey siltstone. This grades downward into well sorted, relatively clean sandstone interbedded with layers of gray siltstone. Still farther down, the well-sorted sandstone becomes silty and poorly sorted with both fine and very fine grained sand sizes present. Pyrite and carbon flakes are common accessaries.

This part of the core is interpreted to have resulted from deposition by fluvial processes in a flood plain environment away from the stream. This interpretation is supported by the abundance of fine-grained clastics and little evidence of scouring by moving water suggesting a low energy environment of deposition perhaps some distance from the stream; the spotty occurrence of interlaminated very fine grained sandstones and siltstones and ripple-laminated sandstones within a gray siltstone lithofacies suggesting periodic flooding under higher energy conditions; and the presence of in-place roots and the vertical gradation of siltstones into silty clays suggesting the development of soil horizons. The ripple- to horizontally-laminated sandstone may have resulted from the development of a crevasse near the site of deposition. The gray color of the whole sequence suggests that the soils were not well-drained and were probably near the water table.

183 to 273

From the borehole geophysical logs and the core the predominant lithology in this interval is sandstone. Core recovery was spotty due to the friable nature of the sandstones and mechanical problems that were encountered during coring.

The sandstone in this interval is generally clean except for occasional zones containing clay clasts (221-223 ft). The degree of sorting and grain size also vary from well-sorted, fine grained to poorly sorted medium to coarse grained. Bedding ranges from indistinct to horizontally bedded to cross-bedded. Mica flakes are abundant throughout the core and plant fragments and wood chips are only found in the more poorly sorted parts of the core. Mud drapes and fining-upward sequences are readily identified using the core and log data.

The variation in grain size and sorting of the sandstones in the core and the periodic fluctuations of gamma ray curve in this interval suggest that this is a multistoried channel sandstone body that was deposited in a fluvial environment. In general there is an increase in grain size and decrease in sorting downwards from the top of this multistoried body indicating that a change in depositional style from 183-228 ft. The bedding also changes from horizontally-bedded near the top to cross-bedded near the bottom of the interval. The poorly sorted coarser grained sandstones signify rapidly fluctuating higher energy flow regimes whereas the horizontally-bedded better sorted finer-grained sandstones signify either upper or lower flow regime but relatively constant stream power assuming a constant rate of sediment supply.

273 to 334

From the geophysical logs, the top of this interval is an unconformity marking the Dakota-Kiowa Formation contact.

Below the contact, the uppermost part of the Kiowa Formation consists of alternating gray and red and yellow mottled gray siltstone and bioturbated fine to very fine grained sandstone in the core. Within the primarily siltstone sequences, red and yellow mottled sections occur near the top and contain ?root holes lined with red-stained siltstone. Portions of the siltstone sequences are sandy or clayey. Siderite nodules are very abundant in the gray siltstone. During the coring operation, the behavior of the drilling rig suggested that these siltstones are harder and more consolidated than the typical red-mottled siltstones encountered in the the Dakota Formation. Each sandstone sequence generally coarsens upward from very fine to fine grained and even medium grained sand. The sandstone sequences are extensively bioturbated leaving, in many cases, no evidence of the original bedding. Broken laminae and *Skolithos* and *Arenicolites* burrows are common in these sections of the core. Fluid-expulsion structures caused by compaction of high water-content sediments are also common. At several levels the core contains clay clasts of varying size. Plant debris, though not very abundant occurs as carbon flakes deposited on bedding planes and as carbonized fragments and wood chips. Ripple- to wavy-laminated sandstones occur at 304-306 ft and 309-315 ft and show no evidence of bioturbation. In the latter case ripple- and wavy-laminated sandstones directly overlie a bioturbated sandstone. Other identifiable sedimentary structures are scours that occur sporadically, low-angle bedding (<5 degrees), and slump structures (310-315 ft and 306 ft).

These strata have been grouped together because they represent the preserved upper part of an overall progradation of deposits into the developing interior seaway that at times was sufficient to keep up with rising sea level but at other times was not. Consequently, the resultant sequence of strata shows alternating marine and nonmarine influences. The gray siltstones were deposited during periods of nonmarine deposition on a natural levee or coastal plain. Since they become red mottled near the top of each siltstone unit, this implies that initially deposition occurred in wet areas which gradually became drier with time. The gradual change from sandstone to siltstone at the base of each siltstone sequence in the core suggests increasing distance away from a fluvial source with time and the onset of soil development. The siltstone units alternate with sandstones were deposited in crevasse splays in a shallow subaqueous brackish-water interdistributary bays. At times the influx of sediment must have been great enough in the lower sandstones that a burrowing fauna could not remain established. Rapid deposition is also indicated by the occurrence of water-expulsion and slump structures in the sandstones.

334 to 430

Above 381 ft the core consists of mostly fine grained sandstone interbedded silty shale and sandy siltstone near the bottom grading upward to sandy siltstone and silty fine to very fine grained sandstone. Medium-grained sandstone occurs only sporadically. The sandstone is cross-bedded (10-19 degrees dip) near the bottom of this section but changes to ripple, wavy, and horizontally-laminated for the rest of the section. Throughout this section of the core the sandstone is well-sorted. Carbon and mica flakes are commonly concentrated along bedding planes. However, carbonized plant remains are relatively rare. Clay clasts were noted at 352 and 376 ft; a scour surface was found at 376 ft. Bioturbation is sporadic in the sandstones but specific traces could not be identified. The interbeds contain lenses of sandy siltstone (linsen) near the bottom and grade upward to bioturbated interlaminated siltstone and fine to very fine grained well-sorted sandstone.

From 381-412 feet the core consists of muddy poorly sorted medium to coarse grained sandstone that grades upward to well-sorted to moderately well-sorted medium to fine grained sandstone. High-angle cross-bedding (approximately 20 degree dip) is common throughout this section except near the bottom where occasionally the dip is less, approximately 10-15 degrees. Ripple-laminated bedding occurs throughout this section but is more common in the interval 381-394. The one occurrence of horizontal bedding in the upper part is in a well-sorted, medium-grained sandstone. Mud drapes are present in the lower part near a scour at 412 ft. In general, scours are poorly preserved except where mud drapes appear to be eroded. Clay clasts occur at 410-412 ft above the unconformity and at levels where there is a change in overall grain size. Carbon flakes are ubiquitous in the upper part of this section whereas carbon fragments and carbonized wood chips are more common in the lower part. Pyrite occurs sporadically in this interval. Above the unconformity, a conglomeratic sandstone that is largely sandy-mud supported consists of sandstone and siltstone clasts that range from granule to ?cobble size. The mud matrix of the conglomerate appears to be chaotically bedded.

Below 412 feet the core consists of fine grained sandstone interbedded with layers of mostly silt containing lenses of very fine grained sand and silt. The sandstones display a wide variety of bedforms in core ranging from horizontally- and wavy-bedded to asymmetrical ripple laminated to cross-bedded (10-22 degree dips). The siltstone beds show a progressive upward change from silty clay shale with rare lenses of silt near the bottom to sandy siltstone with lenses of fine to very fine grained sandstone. Occasional clay clasts are common throughout this section ranging up to pebble size. Carbonized plant fragments are common near the upper-bounding unconformity but are absent below. However, carbon flakes are common throughout. At the base of this interval is an unconformity which underlies a clay pebble conglomeratic sandstone.

The trace of the gamma ray curve from 380 ft down to the top of the Permian shows the classic coarsening upward of sediments which is suggestive of sandstones deposited in deltaic or offshore barrrier bar environments. The sequence of lithologies, sedimentary structures from the core, and the occurrence of plant remains, body and trace fossils provide evidence that support a deltaic interpretation. From 380-412 ft, high and low angle cross-bedding is gradually superseded by current-ripples, zones of clay-clast conglomeratic sandstone at the bottom of this section, and the fining-upward sandstones all indicate a more fluvial-dominated environment near the shoreline, probably a distributary channel sandstone or distributary mouth bar. On the basis of a single core it is difficult to determine whether the delta is wave, current, or tide dominated. However, the interbedded siltstones with linsen bedding in sections of the core from 334-381 ft and 412-430 ft suggest that a flow regime with intermittent slack periods may have been responsible for the deposition of these sediments. This conclusion favors a tidally-influenced delta depositional environment. The sections of the core containing the interbedded siltstones may represent deposition in a submerged river-mouth bar or tidal sand ridge. Then, the fining-upward poorly to well-sorted sandstone between 381-412 ft was probably deposited in an estuarine distributary nearer a channel axis.

430 to 444

This section of the core from consists of (1) fine grained carbonaceous and glauconitic well-sorted sandstone with thin interbeds and laminations of siltstone that grades downward to very fine grained sandstone from 430-440 ft and (2) chaotically-bedded carbonaceous very fine grained silty sandstone and siltstone from 440-444 ft. In the uppermost part of this section, the sandstones are current-ripple laminated to wavy bedded, contain abundant plant fragments and granules of glauconite, and show some evidence of disturbance either from slumping or bioturbation. The lower part of the core in this section is heavily bioturbated and burrowed. The larger carbonized plant fragments and wood chips are abundant in the upper part but not in the lower. However, the darker color of the core in the lower part and abundance of carbon flakes suggests abundant organic matter content. Scour and and fill surfaces are abundant in the upper part and some clay clasts were observed in the upper and lower portions. Pyrite is abundant throughout this section.

This part of the core is interpreted to have been deposited in a brackish river mouth bar environment or marine offshore bar near the mouth of a river. The presence of glauconite, wavy laminations, scours, and clean well-sorted nature of the sandstones suggests deposition in an environment slow sediment accumulation and frequent winnowing by currents and waves. Proximity of this part of the core to the overlying distributary sands, the abundance of plant fragments and wood chips, and the degree of bioturbation implies that the site of deposition was proximal to river discharge.

444 to 463

From the top down this part the core consists of: (1) wavy interbedded fine grained sandstone and siltstone grading downward to interlaminated very fine grained sandstone and siltstone, (2) a fine grained silty sandstone with in-place roots that grades downward to a bioturbated very fine grained silty sandstone, and (3) wavy to ripple-laminated interbedded very fine grained silty sandstone and siltstone.

In the upper unit the sandstone interbeds range in thickness from 2 in to 2 ft and are only slightly bioturbated. High-angle cross-bedding occurs at the bottom of this sequence. Carbon flakes occur primarily on bedding planes in the sandstones. The contact with adjacent siltstone units is wavy and conformable. The interbeds of siltstone consist of very fine grained silty sandstone interlaminated with gray siltstone. These interlaminated units do not appear to have been disturbed by burrowing organisms.

The middle unit shows extensive evidence of disturbance by organisms, including burrows and broken laminations. In-place roots extend at least two feet below the top of this unit. The only primary sedimentary structure found in this section of the core was horizontal bedding in finely laminated sandy siltstone that are scattered infrequently through this part. Structures that appear to be related to loading on soft sediment were also observed. Near the bottom of this section a scoured surface was noted. Scattered carbonized plant fragments were also found.

In the lower unit interbedded siltstone and very fine grained wavy laminated and hummocky cross-stratified sandstones and siltstones grade downward into bioturbated sandy siltstone. Broken laminations and a "patchiness" to the sedimentary texture suggest extensive disturbance by burrowing organisms. Within the interbedded portion, scoured surfaces are a common occurrence leaving behind what appear to be "erosional ripples". A ?slump feature was noted at the 460 ft level in the core. The contact between this section of the core and the underlying section is an erosional unconformity. Carbon flakes and pyrite are abundant throughout this part.

On the basis of these observations, these units were probably deposited in a tide-influenced upper shoreface and beach environment in the vicinity of a prograding sequence of delta deposits. In the middle unit, the presence of roots in a bioturbated sandstone suggests subaerial exposure of highly bioturbated marine or brackish-water deposits and suggests that sediment deposition had temporarily overtaken rising sea level at least locally. Above the zone containing roots, interlaminated silty sandstones signal inundation of the beach environment by the Kiowa sea and a return to the shoreface environment. In the upper and lower units, the interbedded siltstone and sandstone and the occurrence of ripple marks and wavy bedding in well-sorted fine grained sediments suggests low current velocities with slack periods of relative quiescence, such as in a tidally-influenced environment. The slight upward increase in overall grain size suggests increasing proximity to a sediment source.

463 to 474

This part of the core consists entirely of finely-laminated black clay shale and gray silty shale. The shale is black in the upper part and grades downward to medium gray in the middle where the shale is interbedded with siltstone and very fine grained silty sandstone containing glauconite and carbonized plant fragments. The sandy siltstone layers are laminated and wavy bedded. Below, the shale grades to black and then greenish brown clay shale containing carbonized plant fragments near the bottom. Just beneath the interbedded section, fragments and whole remains of bivalve shells were found in shale along with abundant carbon flakes. Slickensides and pyrite nodules are common throughout this section. The contact between this section and the underlying green siltstone is sharp and just above the contact the shale becomes silty with some sand grains.

The black shale in this section belongs to the marine shale facies of the Kiowa Formation. Its marine character is indicated by the fossil content,the finely laminated shales that accumulated under relatively quiet-water conditions and the wavy-laminated glauconitic sandy siltstones that may be storm deposits and slow rates of deposition. The base of this section is interpreted to be the Cretaceous-Permian boundary.

474 to 476

This section consists of gray-green siltstone which, in the upper part, shows evidence of disturbance from burrowing organisms or slump. Broken laminations occur sporadically through the sediment as well as very indistinct chaotic bedding. In some instances it appears that the laminations have undergone *en echelon* faulting. Contact with the underlying Permian is abrupt. However, the green siltstone is similar to the underlying siltstone except for its variegated color. This suggests that the green siltstone is weathered Permian Wellington Formation or Ninescah Shale, the former of which is described by Franks (1966) as being yellow gray, yellowish green, or pale red where it has been affected by weathering.

476 to 479

Fractured variegated mudstones of the Permian Wellington Formation or Ninescah Shale that may have been unaffected by pre-Cretaceous weathering.

Discussion

Kiowa Sedimentation at the Jones Core-Hole Site

The sequence of strata in the Kiowa Formation described above belongs to the unnamed marine shale facies and the Longford Member. The Longford consists of shallow marine and transitional clastic rocks that Franks (1979, 1980) interpreted to be part of a transgressive sequence deposited as the Kiowa sea invaded central Kansas. The marine shale facies (463-474 ft) consists of black shales containing marine fossils and is laterally equivalent to Longford Member strata. In the type area of central Kansas, Franks defined the Longford in outcrop, underlying the marine shales of the Kiowa Formation. However, in the KGS #1 Jones core similar shallow marine and transitional strata (273-463 ft) are above the marine black shale and are interpreted to be progradational equivalents to the Longford. Sedimentation at the Jones core site was able to keep up with and at times exceed the rate of sea level rise, which is clear from the alternation of subaerial and subaqueous delta plain sediments from 273-334 ft and the thick accumulation of distributary and delta front sediments below (334-412 ft). No strata resembling the Longford Member were found beneath the marine black shale, which indicates that these sediments did not accumulate prior to inundation by the Kiowa sea. This site may have been topographically higher in the landscape, perhaps on an upland away from the principal areas of deposition in adjacent stream valleys. As the Kiowa sea invaded only fine-grained clastic sediments would have been available for deposition in the higher areas of the landscape after the stream valleys had been filled in with sediments.

Although direct correlation of Jones core strata with the outcropping Longford Member strata to the east (approximately 50-75 miles to the east and southeast from KGS #1 Jones) is problematic some insight into the movement of the Kiowa shoreline through central Kansas can be gained from the overall sequence of sediments in outcrop and in the core hole. On the basis of cross-bed orientation and the observed overlap of progressively younger pre-Dakota Formation strata onto the Permian in the central Kansas outcrop belt, Franks (1966) argued that the Kiowa sea invaded Kansas from the southwest approximately parallel to the central Kansas outcrop. However, later work by Macfarlane *et al.* (1990) argued that from the statewide distribution of deposits associated with the Kiowa transgression the sea invaded Kansas from the west. Additionally, they concluded that the progressive replacement of marine shale facies in western Kansas laterally with Longford Member deposits indicates that central Kansas was near the maximum eastern extent of transgression by the Kiowa sea. The strata in the Jones core largely support this interpretation. Early in the Kiowa transgression, the core site was inundated as sea level rose and the marine black shale facies was deposited. However, sediment supply from nearby river systems was able to keep pace with the transgression and as a result the advance of the shoreline was halted or in part reversed by progradation of a tidally-influenced delta system outward from the shore. The total thickness of the Kiowa Formation preserved at this location is more than 200 ft which is untypical for central Kansas. However, farther east in the vicinity of the type Longford stratigraphic sections, there is no evidence of progradation preserved in Longford strata (Franks; 1979, 1980). Instead, the succession of deposits suggests a normal vertical progression above the Cretaceous-Permian unconformity from fluvial to transitional marine to shallow marine. This implies that the area around the Jones core site may have been a "hinge point" around which the direction of Kiowa shoreline movement apparently shifted from eastward to northeastward. This apparent shift in direction may have resulted from the building out of deltaic sediments at the Jones core site into the Kiowa sea. As the delta prograded into the sea creating new land area, the orientation and shape of the coastline would change and thus the direction of onlap would appear to shift to the northeast. Additionally, the imprint of tidal and fluvial processes in the sediments suggests that these were more important factors than wave action in the depositional environment. This may due to sheltering by an embayed coastline, possibly.

Dakota Sedimentation at the Jones Core-Site

Sedimentary strata belonging to the Dakota formation the Jones core are similar to Dakota strata in the KGS #1 Haberer core hole in Russell Co. and other test holes that have been drilled in Republic and Washington counties. The lower part of the Dakota Formation in the KGS #1 Jones consists of a stacked sequence of fluvially-deposited channel sandstones, very much like the lower part of the Dakota Formation in the Haberer test hole. Preservation of a greater than average thickness of Kiowa Formation suggests either considerable relief on the Kiowa-Dakota unconformity or subsidence contemporaneous with Kiowa deposition. Evidence for the latter is lacking at the Jones core site. Upward from this sequence the strata were deposited in floodplain and abandoned distributary environments, apparently closer to the shoreline of the advancing Dakota sea. Sediments associated with the "D" unconformity were not observed in the Jones core. Above this sequence, the strata were deposited in a river-dominated deltaic environment which is similar to the upper Dakota strata described in the Washington and Republic Co. test holes. Evidence that fluvial processes dominated the deltaic environment comes from juxtaposed sequences of interdistributary bay-fill and crevasse-splay deposits suggestive of lobe switching and the lack of sedimentary structures and bedding associated with wave or tide action. Lobe switching occurs commonly in river-dominated deltas. Above these deltaic deposits are shallow marine shales and siltstones of the Graneros Shale.

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