Kansas Geological Survey Open-File Report 2026-29

Preliminary Top of the Graneros Shale Depth Structure Map in Central Kansas

Kate A. Andrzejewski, James L. Kalbas, and Kolbe D. Andrzejewski

The Kansas Geological Survey (KGS) is developing framework surfaces for geologic formations that comprise the Dakota Aquifer System in Kansas as part of a multi-year effort to model and evaluate this important groundwater resource. The first subsurface framework surfaces were mapped in 2025 across 13 counties in north-central Kansas (Phase I on inset map). Interpretations were based on outcrop, core, and wireline well log observations. In addition, newly interpreted stratigraphic surfaces incorporated historical observations (e.g., Macfarlane et al., 1993). Here we expand on that project, adding interpretations for wells across an additional 14 counties in central Kansas (Phase II area), integrating those observations into a reinterpretation of Phase-I relationships, and producing a new structure surface map spanning all 27 counties.

Methodology

The information used to generate these maps is public data from the database of Kansas hosted at the KGS (Graneros Well Tops Map, attached).

i. *Well tops associated with well logs*: Historical Graneros well tops from the oil and gas database were imported into Petrel as point data with X, Y, and Z coordinates. Newer well logs (post 2005) were added to the dataset to provide more extensive and thorough coverage of the study area. Independent research for this study produced a new sequence-stratigraphic framework based on high-resolution core and outcrop analysis, in combination with high-precision geochronology. By integrating historic well tops with new sequence-stratigraphic interpretations, we developed new, reproducible criteria to delineate stratigraphic surfaces that fit within a genetic framework. These criteria serve to predict subsurface properties away from well control. The top of the Graneros Shale is recognized as a regionally extensive bentonite marker bed, the “X-Bentonite” (CA-TIMS U-Pb radiometric age: 95.96 ± 0.11 Ma), which is interpreted to represent a maximum flooding surface. Recognition criteria in logs include a marked increase in total gamma ray (GR) and a sharp increase in the thorium spectral signature. An example well log is provided highlighting the pick criteria. Total well tops for the final surface include n = 348 wells.

ii. *Framework surfaces*: A top Graneros surface was generated in Petrel using a gridding increment of 1000 feet by 1000 feet and employing the convergent

interpolation algorithm. We used an iterative approach, integrating the structure surface and paired isochore map (Graneros Shale top to Dakota Fm. top) to refine interpretations. The top Graneros surface was then exported as a zmap, imported into Global Mapper Software, and converted into a GeoTIFF file. We then imported the GeoTIFF file into Esri ArcGIS Pro software and added layers including ancillary and reference information to the final map product which has a scale of 1:500,000. Associated metadata was recorded and submitted as a GeMS package.

iii. Results

The preliminary Graneros depth structure map shows a gradual shallowing trend to the southwest and indeed crops out in Pawnee and Barton counties (Latta, 1950; Johnson and Woodburn, 2015) of the Phase II area. More recent mapping in Lincoln County (Sawin and Layzell, 2024) and current STATEMAP work in Ellsworth County (Andrzejewski, 2025) further delineates the outcrop belt, but is out of scope to represent in this preliminary map. Minimum depth recorded in well log data is 2217 ft (above MSL) and maximum depth recorded in well log data is 1137 ft (above MSL) with an average depth of 1729 ft (above MSL).

The preliminary top Graneros depth structure map (PDF) is available as Open-File Report 2026-29 on the KGS website.

A Graneros Shale isochore map and a well correlation panel are also provided.

Coordinate Reference System

i. *Units*: **Field-UTM**. Units of distance in the X, Y, and Z (lateral and vertical) directions are in field units (feet).
ii. *Datum*: **NAD83** (North American Datum 1983) with **"**KS83-SF**"** as the coordinate reference system (CRS) and **"**SIS, 501270**"** as the authority code.
iii. *Depth*: **Mean Sea Level** (MSL) at 0 ft.

References

Andrzejewski, K.A., 2025, Preliminary surficial geology of the Ellsworth County portion of the Westfall SE quadrangle, Kansas: Kansas Geological Survey, Open-File Report 2025-27, scale 1:24,000.

Bayne, C.K, Franks, P.C., and Ives, W., 1971, Geology and Ground-water Resources of Ellsworth County, Central Kansas: Kansas Geological Survey, Bulletin 201, 84 p.

Franks, P.C., 1975, The transgressive-regressive sequence of the Cretaceous Cheyenne, Kiowa and Dakota Formations of Kansas: Geological Association of Canada Special Paper, No. 13, 469 p.

Johnson, W.C., and Woodburn, T.L. 2015, Surficial geology of Pawnee County, Kansas; text, geologic-unit descriptions, and cross section geology by C.M. Phillips-Lander: Kansas Geological Survey, Map M-114, scale 1:50,000.

Kansas Geological Survey. “Master List of Oil and Gas Wells.” Database. Accessed 2025. http://www.kgs.ku.edu/Magellan/Qualified.

Latta, B.F., 1950, Geology and ground-water resources of Barton and Stafford counties, Kansas: Kansas Geological Survey, Bulletin 88, 228 p.

Macfarlane, P.A., Combes, J., Turbek, C., and Kirshen, D., 1993, Shallow subsurface bedrock geology and hydrostratigraphy of southwestern Kansas: Kansas Geological Survey, Open-File Report 93-1a (plates updated in 2010 by J.J. Woods), 13 p.

Plummer, N.D. and Romary, F., 1942, Stratigraphy of the pre-Greenhorn Cretaceous beds of Kansas: Kansas Geological Survey, Bulletin 41, p. 315-348.

Sawin, R.S. and Layzell, A.L., 2024, Surficial geology of Lincoln County, Kansas: Kansas Geological Survey, Map M-127, scale 1:50,000

Whittemore, D.O., Macfarlane, P.A., and Wilson, B.B., 2014, Water resources of the Dakota aquifer in Kansas: Kansas Geological Survey, Bulletin 260, 68 p.

Funding

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KGS File Locations

i. KGS Open-File Report: Andrzejewski, K.A., Kalbas, J.L., Andrzejewski, K.D., 2026, Preliminary top of the Graneros Shale depth structure map in central Kansas: Kansas Geological Survey, Open-File Report 2026-29.

ii. K:\Ener_Strat\Cretaceous_Dakota_Aquifer_Research\Output\Deliverables\State map FY25 Subsurface Maps

Acknowledgments

The authors would like to acknowledge the following KGS staff: those who have contributed to, refined, and stewarded the KGS Oil and Gas Wells Database and online mapper; Katy Bream aiding in database searches, the Subsurface Dynamics Laboratory team at the KGS for technical support; Rhonda Houser for reviewing and providing editorial feedback; and Jon Smith for managing the projects and funding related to the STATEMAP Program. This map was produced using a Petrel subsurface software donation from SLB to the KGS, Global Mapper software, and ArcGIS Pro software developed by Esri.

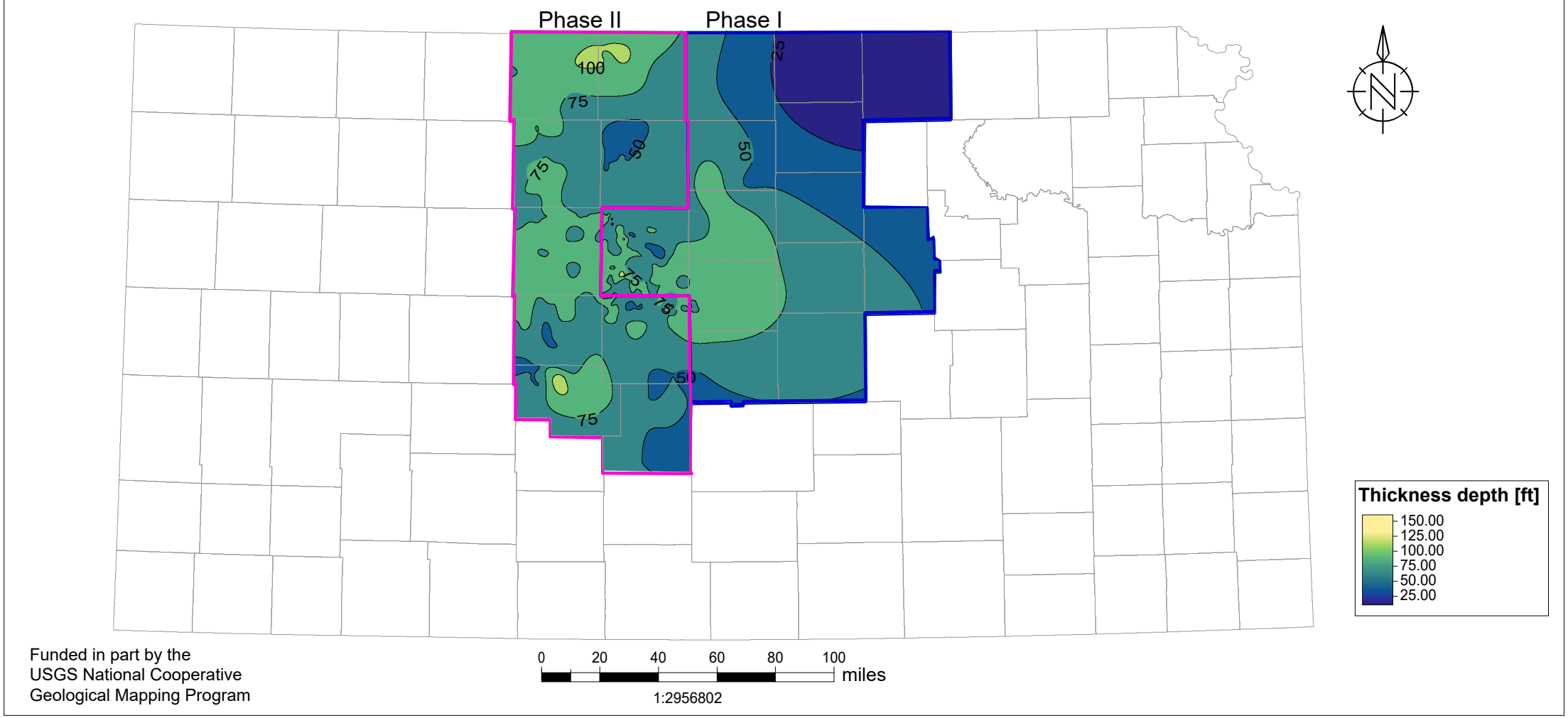
Credit Author Statement

Andrzejewski, Kate: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing; **Kalbas, Jay**: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing; **Andrzejewski, Kolbe**: Visualization, review & editing

Suggested Reference to this Report: Andrzejewski, K.A., Kalbas, J.L., Andrzejewski, K.D., 2026, Preliminary top of the Graneros Shale depth structure map in central Kansas: Kansas Geological Survey, Open-File Report 2026-29.

KANSAS GEOLOGICAL SURVEY
The University of Kansas

Graneros Shale Isochore Map for the Dakota Aquifer System in Kansas-Phase II Mapping



Funded in part by the
USGS National Cooperative
Geological Mapping Program

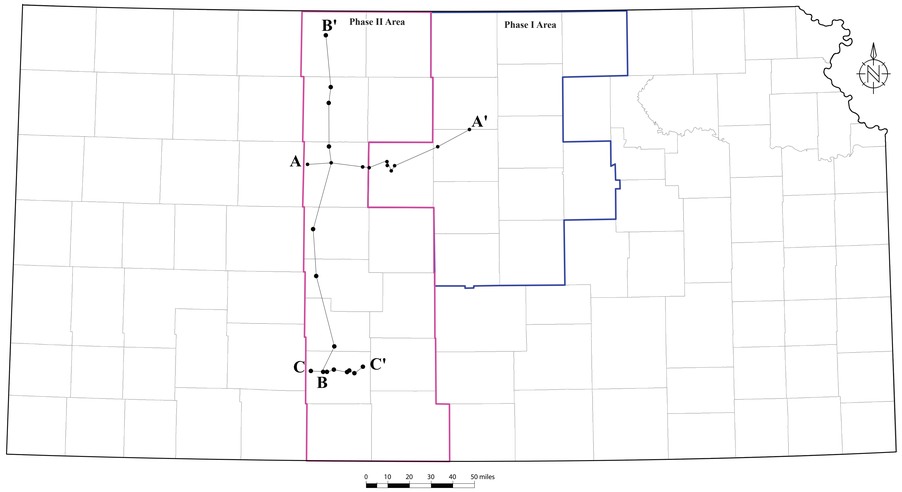
KANSAS GEOLOGICAL SURVEY
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Stratigraphic Cross Sections for the Dakota Aquifer System in Kansas – Phase II Mapping

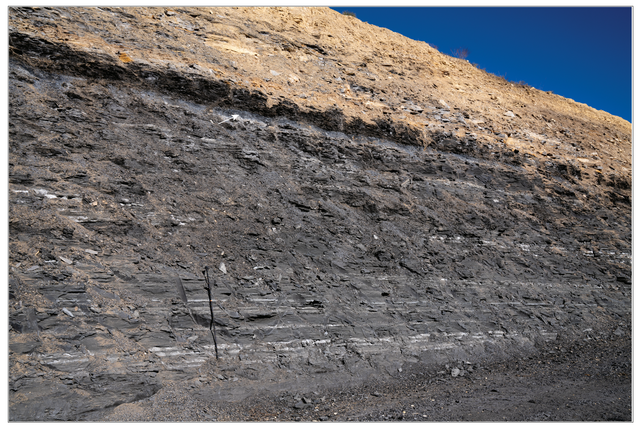
Kate A. Andrzejewski, James L. Kalbas, and Kolbe Andrzejewski

2026

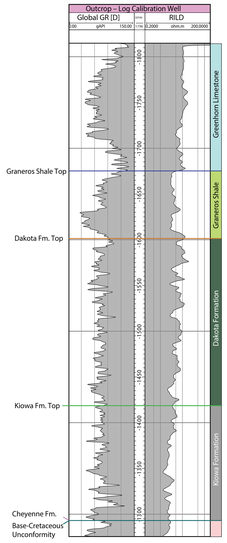
Funded in part by the USGS National Cooperative Geologic Mapping program



Map of Kansas counties showing the location of well-log cross sections A-A', B-B', and C-C'.



Outcrops of the Graneros shale demonstrate a distinctive stacking pattern resulting from transgression of the Western Interior Seaway following lowstand Dakota Formation deposition. This photograph of fresh outcrop near Russell, KS shows multiple mudstone parasequences in an overall retrogradational parasequence set. A postulated maximum flooding surface can be mapper regionally and coincides with the "X-bentonite", denoted in the photograph with a white arrow. A 1.5m jacobs staff demonstrates scale.



Calibration log from the Phase-I mapping area in Russell County.



Dakota Formation paleosols and interbedded fluvial and crevasse splay deposits are well exposed in outcrops near Russell, Kansas. In this photograph, gray and red coastal plain paleosols and thin fluvial strata are overlain by much thicker tidal deposits. Geologists are circled in the upper right hand of the photograph kneeling at the regionally extensive transgressive surface of erosion between terrestrial and nearshore marine strata.

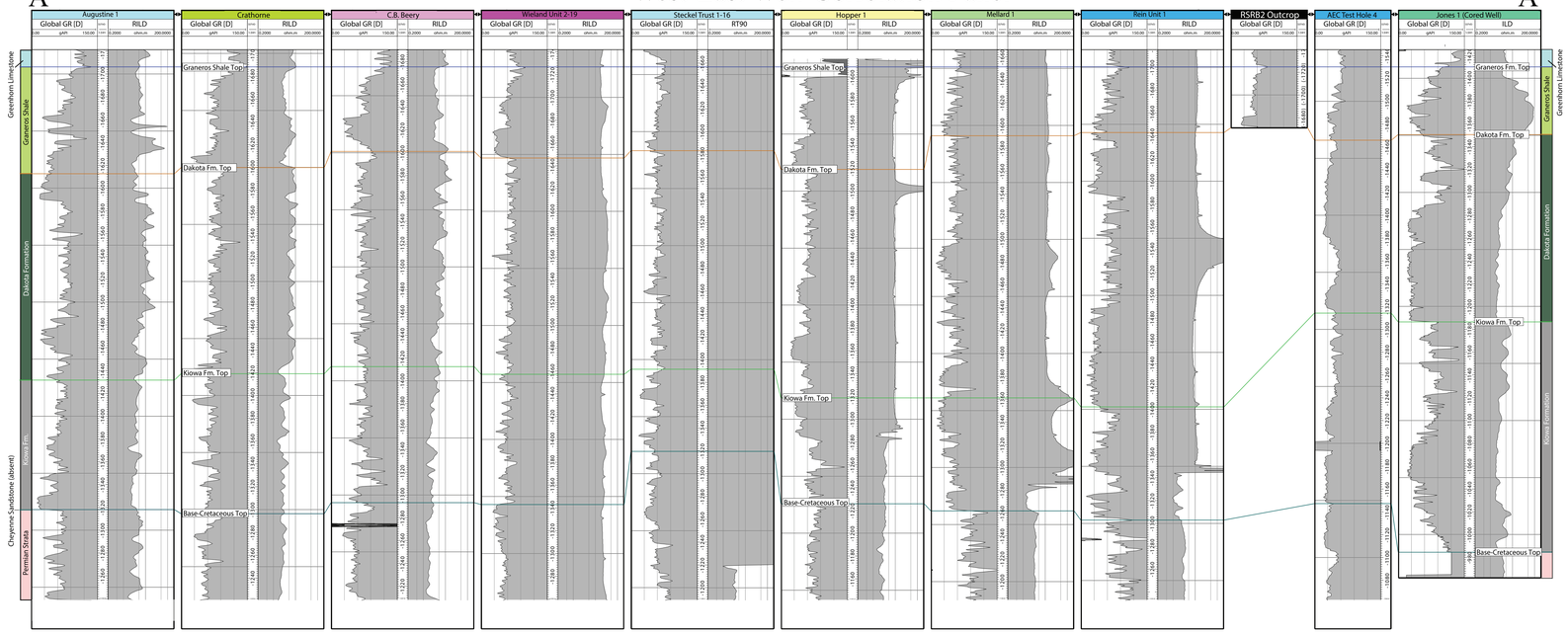


Well formed Dakota Formation paleosols were recovered in the KGS Kenyon-1 well and examined for this study. This photograph shows a well-developed paleosol with blocky ped structures and minor root traces at ~350 ft in the cored section. Color = 7.5YR 7/1.

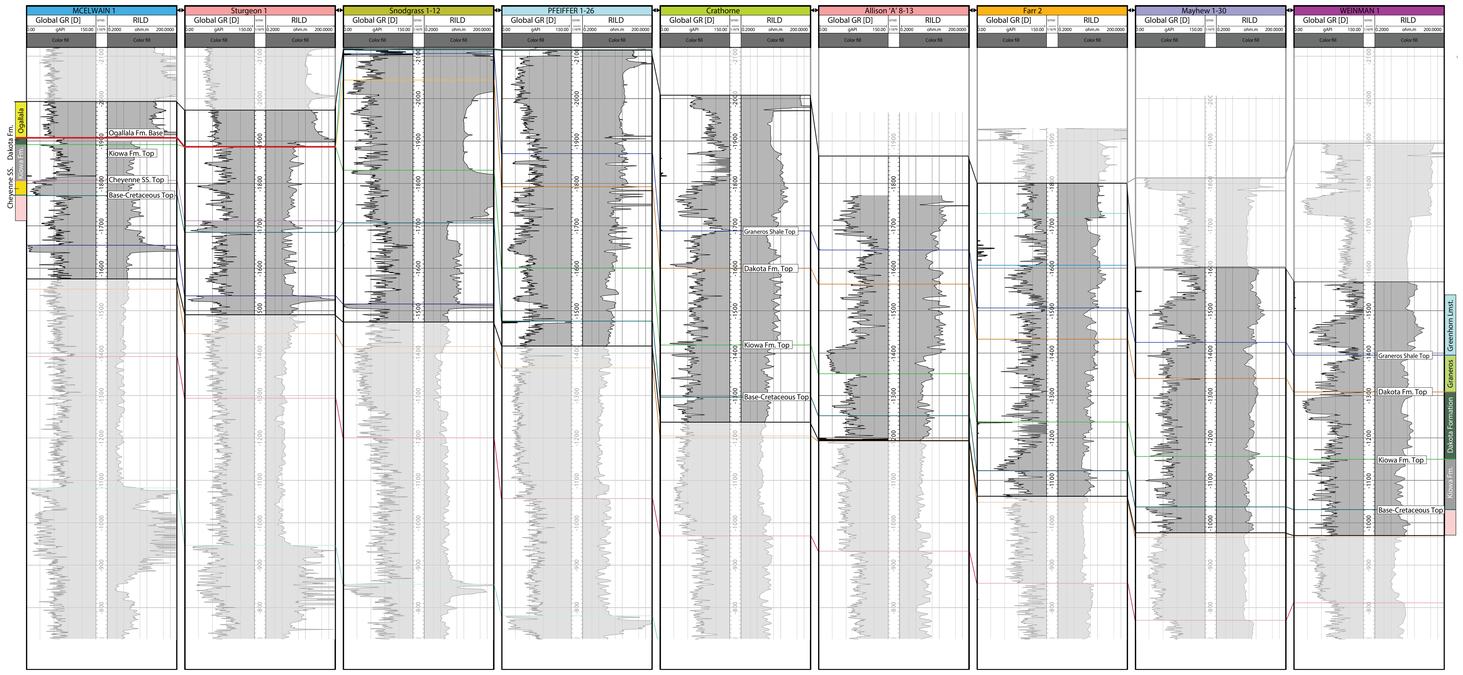


The Kiowa Formation crops out at Kanopolis State Park in Ellsworth County, Kansas. The amalgamated trough cross-stratified sandstones shown here are part of a 30 ft thick delta front succession that extends for some tens of miles throughout central Kansas and helps calibrate the variable log signature of the unit throughout this part of the state.

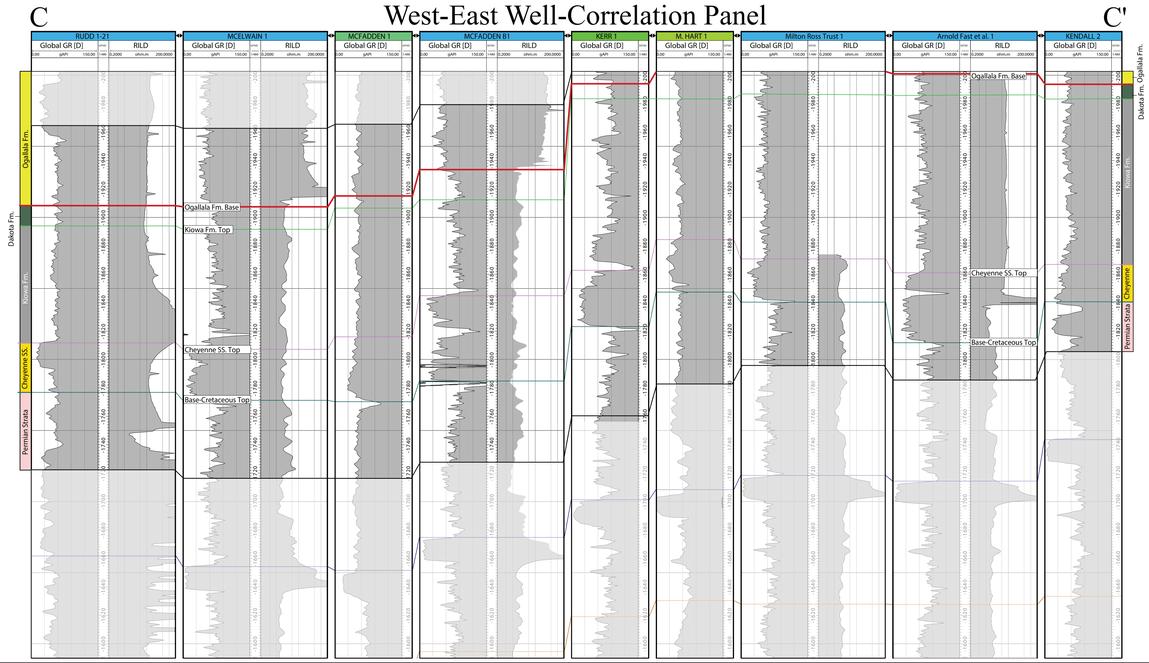
West-East Well-Correlation Panel



South-North Well-Correlation Panel



West-East Well-Correlation Panel



KANSAS GEOLOGICAL SURVEY
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Open-File Report 2026-29

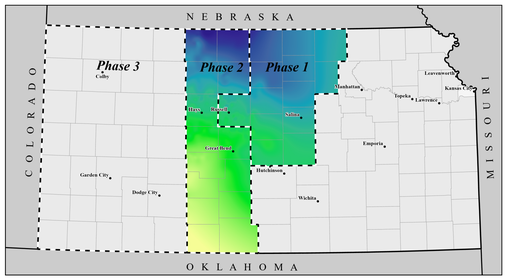
Funded in part by the
USGS National Cooperative
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PRELIMINARY TOP OF THE GRANEROS SHALE DEPTH STRUCTURE MAP IN CENTRAL KANSAS

Kate A. Andrzejewski, James L. Kalbas, and Kolbe D. Andrzejewski

2026

MAP LOCATION



Phase 1 and 2 are combined and shown on the main map.



Figure 1. KGS drilling operations collecting new Cretaceous core samples in Ellsworth County to aid in well log calibration. The recovered KGS HOT-DAM #1 core was collected during PHASE I of the Kansas Cretaceous STATEMAP Project FY24. Photo credit: Kate Andrzejewski, University of Kansas.

Abstract

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About

This map was funded in part by the USGS National Cooperative Geologic Mapping Program, STATEMAP award number G25AC00518 (FY2025).

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This map is a preliminary product and has had less scientific and cartographic review than the Kansas Geological Survey's M-series geologic maps. The KGS does not guarantee this map to be free from errors or inaccuracies and disclaims any responsibility or liability for interpretations made from the map or decisions based thereon.

Sources

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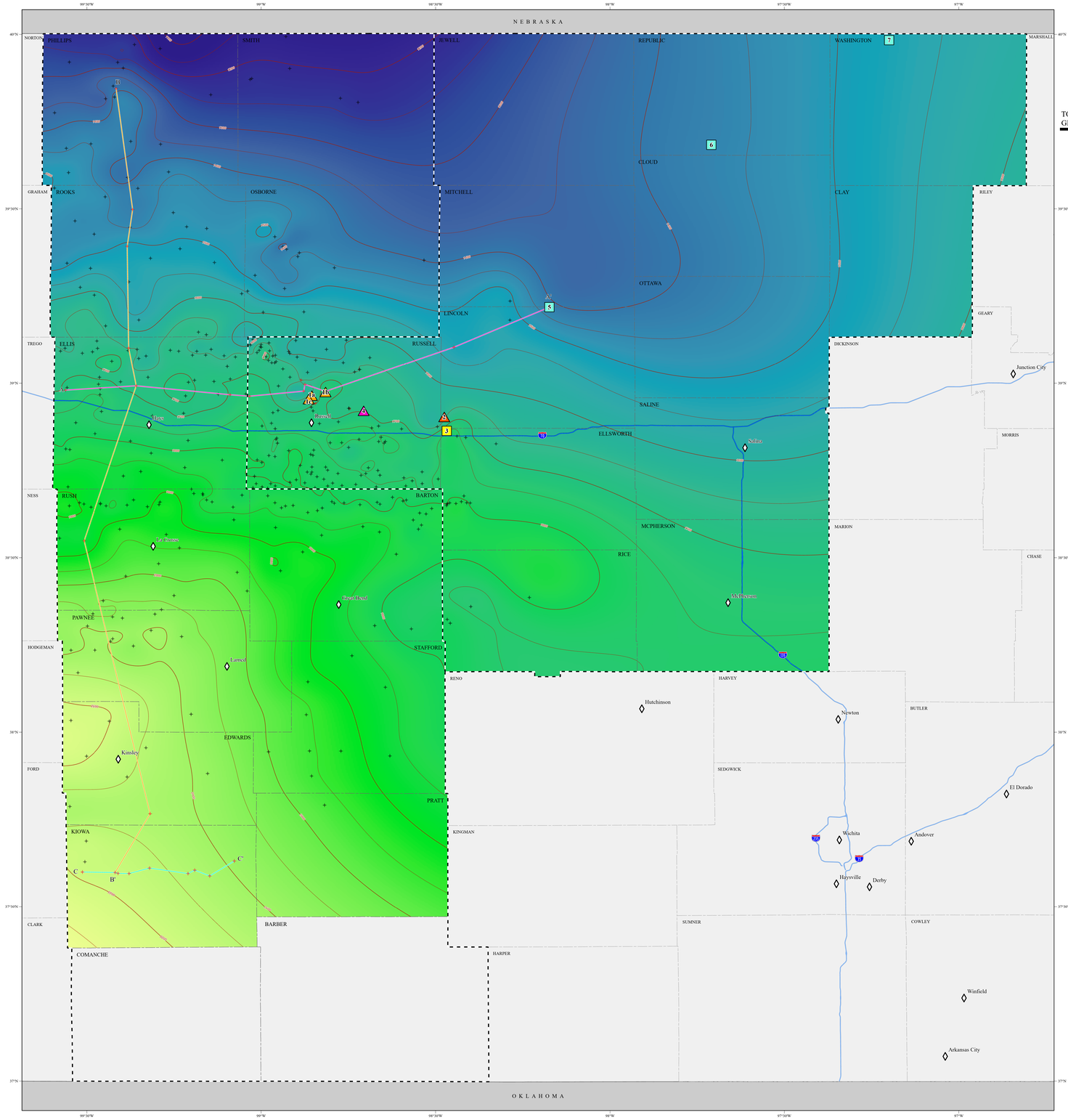
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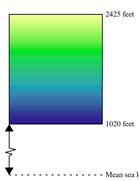
SUGGESTED REFERENCE TO THE MAP

Andrzejewski, K. A., Kalbas, J. L., and Andrzejewski, K. D., 2026, Preliminary top of the Graneros Shale depth structure map in central Kansas Kansas Geological Survey, Open-File Report 2026-29, scale 1:500,000, unpublished.



SCALE 1:500,000
LAMBERT CONFORMAL CONIC PROJECTION
WITH STANDARD PARALLELS AT 33 AND 45 N
CENTRAL MERIDIAN 100 30' W
NORTH AMERICAN DATUM OF 1983

DEPTH RELATIVE TO MEAN SEA LEVEL



E X P L A N A T I O N

Transportation
- Interstate

Locations
- City

Topography
- Index elevation contour (100 feet)
- Elevation contour (50 feet)

Geology
- Well (n = 348)
- Cross section well
- Cross section A - A'
- Cross section B - B'
- Cross section C - C'
- Graneros shale absent

CALIBRATION SECTION

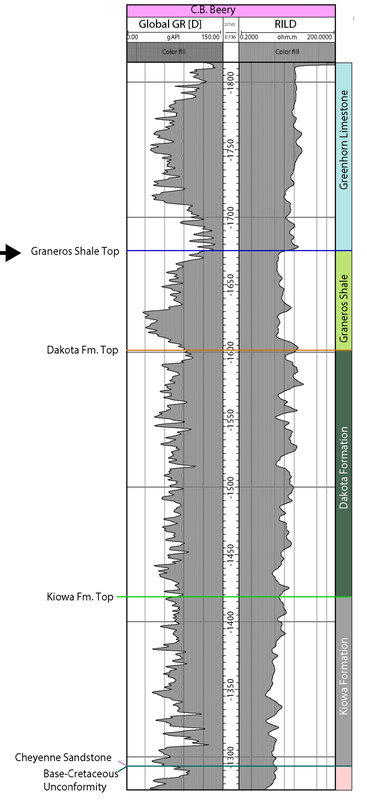
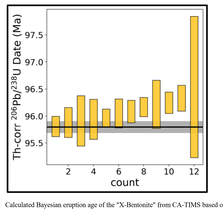




Figure 2. Field photograph of an outcrop exposure near Russell, KS showing the "X-bentonite," interpreted in this study as a major Cenomanian flooding surface marking the top of the Graneros Shale Formation. U-Pb radiometric ages of ash zircons for this program yield an age of 95.80±0.11 Ma. A 35 cm tape measure is shown for scale. Photo credit: Jay Kalbas, University of Kansas.



Bayesian Eruption Age:
95.80 ± 0.11/0.12/0.16 Ma

Calculated Bayesian eruption age of the "X-Bentonite" from CA-TIMS based on the youngest grain population (n=12 zircon grains).

CALIBRATION DATASETS

Russell-Saline River Bridge Outcrops

STATEMAP FUNDED
- RSRB-1 exposure: 63 meters of measured section
- RSRB-2 exposure: 32 meters of measured section
- RSRB-3 exposure: 16 meters of measured section
- Hell Creek Outcrop Exposure: 20 meters of measured section
- 3 KGS HOT DAM #1 Cored Well: 85 meters of measured core

KGS FUNDED ANALYSIS
- Bunker Hill Outcrop Exposure: 14 meters of measured section
- 5 KGS Jones 1 Cored Well: 142 meters of measured core
- 6 KGS Kenyon 1 Cored Well: 151 meters of measured core
- 7 KGS Gaydusek 1 Cored Well:135 meters of measured core

Last updated: 9/23/2026