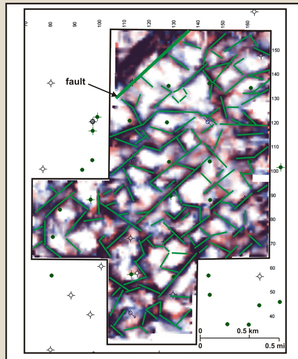
ORIENTATIONS OF SEISMIC LINEAMENTS COMPARED TO REGIONAL STRUCTURE

In order to search for seismic features related to fracturing in the Dickman Field Mississippian reservoir, maps of volumetric most negative curvature have been extracted from the top of Mississippian and Gilmore City seismic horizons. The Gilmore City is the base of the Mississippian aquifer, approximately 130-180 ft (20-30 milliseconds) below the reservoir in Dickman Field. The two maps are very similar, showing oriented sets of lineaments that appear to persist from the top of Mississippian to the base of the aquifer.

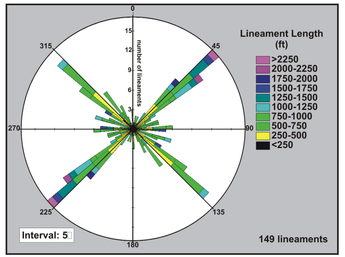
These lineaments were interpreted on the Gilmore City horizon, and their orientations were analyzed using rose diagrams. The Gilmore City horizon was used because it is more continuous than the top of Mississippian, and curvature of the Mississippian surface is somewhat affected by topographic irregularities due to erosion at the pre-Pennsylvanian unconformity surface.

Rose diagrams of the interpreted lineaments show two main orientations, N45E and N45W, similar to the orientations of lineaments interpreted from a dip map of the regional top of Mississippian surface and also similar to regional gravity and magnetic lineament trends for Ness County, KS.

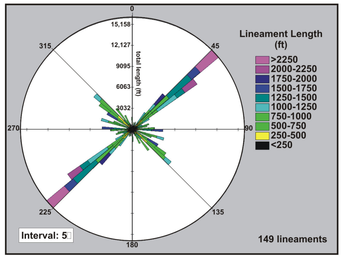
Although the number of lineaments interpreted with NE and NW trends is approximately equal in the Dickman seismic survey, NE-trending lineaments have greater length and continuity than the NW-trending lineaments. The NE lineament trend parallels the fault at the northwest corner of the seismic survey.



Superimposed volumetric most negative curvature maps extracted at the top of Mississippian (red) and Gilmore City (blue) horizons. Saturated colors indicate tightest curvature. Purplish colors indicate features that are coincident on the two maps. Lineaments interpreted from the Gilmore City curvature map are superimposed in green.

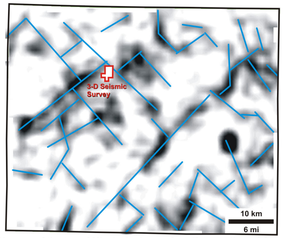


Rose diagram showing the number of interpreted lineaments within a given azimuth sector. Lineament length is indicated by color.

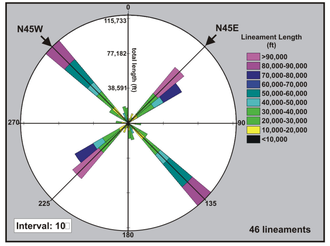


Rose diagram showing the sum of lineament lengths within a given azimuth sector. Lengths of individual lineaments are indicated by color.

REGIONAL MISSISSIPPIAN STRUCTURAL TRENDS

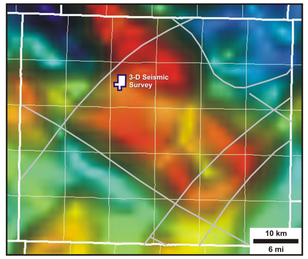


Dip map of the top of Mississippian surface (from well tops) for Ness County. Black indicates high dip. Interpreted lineaments are shown in blue. High dip lineaments are likely to represent faults.

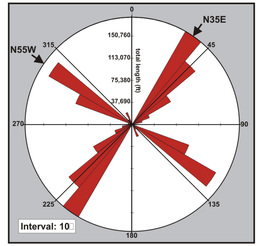


Length-azimuth rose diagram of lineaments interpreted from the top of Mississippian dip map.

REGIONAL MAGNETICS

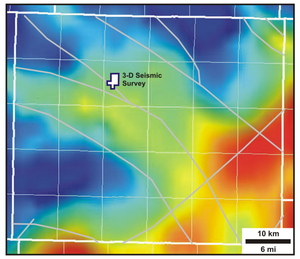


Magnetic map of Ness County with regional lineaments superimposed in gray (After Kruger, 1997). Blues represent lowest values, reds represent highest values.

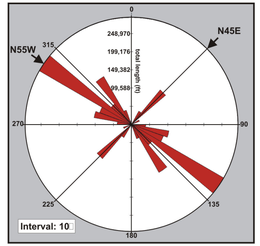


Length-azimuth rose diagram of Ness County regional magnetic lineaments.

REGIONAL GRAVITY

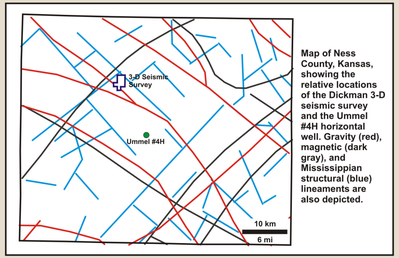


Bouguer gravity map of Ness County with regional lineaments superimposed in gray (After Kruger, 1997). Blues represent lowest values, reds represent highest values.

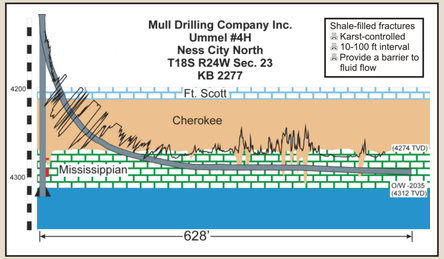


Length-azimuth rose diagram of Ness County regional gravity lineaments.

RELATIONSHIP BETWEEN LINEAMENTS AND SHALE-FILLED FRACTURES

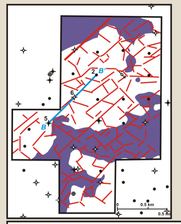


Map of Ness County, Kansas, showing the relative locations of the Dickman 3-D seismic survey and the Ummel #4H horizontal well. Gravity (red), magnetic (dark gray), and Mississippian structural (blue) lineaments are also depicted.

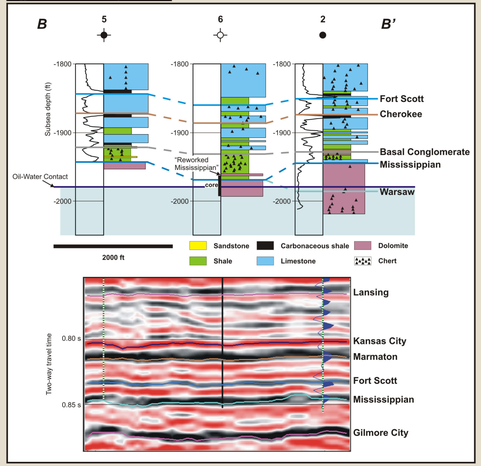


Shale-filled fractures have been interpreted at the top of the Mississippian in a horizontal well from central Ness County, Kansas, approximately 8 miles from the Dickman Field study area (Carr et al., 2000). In this well, numerous near-vertical shales were identified at intervals of 10-100 ft along the lateral length of the well. These intervals were interpreted as solution-enhanced fractures extending down from the karst surface at the top of Mississippian that have been filled by Pennsylvanian shale of the Cherokee Formation (Carr et al., 2000). The shale-filled fractures provide a barrier to fluid flow in the reservoir.

Evidence for shale-filled fractures in Dickman Field

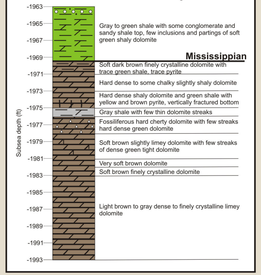


Cores from several wells in Dickman Field contain fractures and green shale in the Mississippian subjacent to the pre-Pennsylvanian unconformity surface, and Well 6 (located directly on a volumetric curvature lineament) shows a zone of reworked Mississippian dolomite above the unconformity surface. In general, fractures that were solution-enhanced by post-Mississippian karst and remained open during the Pennsylvanian are likely to have been filled by both Pennsylvanian shale and weathered Mississippian debris. Therefore, it is assumed that locations with evidence of a thicker section of weathered Mississippian material at the base of the Pennsylvanian (subsequently referred to as the "karst zone") will have a higher incidence of shale-filled fractures. For the purposes of this study, the karst zone in a well was defined as the interval between the highest occurrence of the basal chert conglomerate in the Pennsylvanian section (chert weathered from the Mississippian) and the top of the un-weathered Mississippian, as identified from cuttings and core.

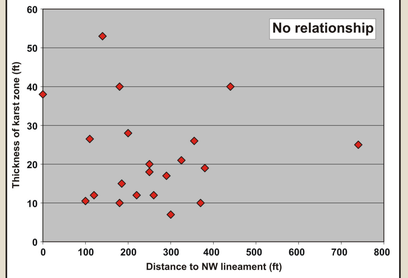


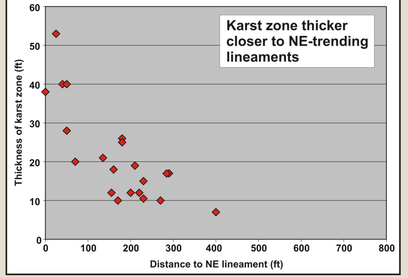
Lithologic (top) and seismic (bottom) cross section through Well 6, which is located directly on a volumetric curvature lineament. The synthetic seismogram for Well 2 is displayed in blue on the seismic section.

Well 6 Core Description



THICKNESS OF KARST ZONE VS. DISTANCE TO LINEAMENTS





In order to determine whether either of the two dominant lineament trends seen in the volumetric curvature data relate to filled solution-enhanced fractures, crossplots were created of the thickness of the karst zone versus the distance to the nearest NE- and NW-trending lineaments. These crossplots show that there is no apparent relationship between the thickness of the karst zone and the NW-trending lineaments; however, there is an increase in the thickness of the karst zone closer to the NE-trending lineaments. The relationship between the thickness of the karst zone and distance to the NE-trending lineaments suggests that these lineaments are likely to represent fractures preferentially solution-enhanced during karst formation and subsequently filled with shale and debris. Since some of the NE-trending lineaments have interpreted lengths in excess of 0.5 mile, they may provide significant barriers to fluid flow in the northwest-southeast direction.