

## Explanatory Notes for Preliminary Lineament Map of Kansas

Gerhard, Lee, 2003, Preliminary Lineament Map of Kansas: Kansas Geol. Survey Open File Rpt. #2003-7

### Introduction

In order to understand the role of basement structures on later tectonic and sedimentologic history, it is imperative that major structures are identified and their geometry mapped. In particular, identification of planes of potential recurrent motion is crucial to prediction of good reservoir quality and likely oil and gas traps. Many basement fractures are evident only by analysis of subtle indicators of their existence, such as drainage anomalies, potential field linears, linears in topography or linears on structure maps.

Although earlier studies of Kansas have identified major structures, they have been regarded as folds, basins and anticlines, a view that this paper in part challenges (Merriam, 1963, for instance). I postulate that most of the major basement structural elements of Kansas result from block faulting and recurrent movement along pre-Phanerozoic planes of failure, modified by pre-Phanerozoic and pre-Pennsylvanian erosion, and post-Precambrian tectonic distortion.

### Methodology

Identification of structural "grain" and linear structures in the deep subsurface often requires integration of several data sources. One of the most powerful of these data sources is drainage pattern analysis, particularly when coupled with other tools.

Drainage in homogeneous rocks with uniform slope is dendritic. Non-dendritic patterns reflect slope change, inhomogeneities in surficial sediments or rocks, or structural anisotropy. Subtle structural control of drainage creates patterns that have linear segments, concentricity, or radial symmetry, for example. Other, even more subtle, indicators of structural control of drainage are changes in frequency and amplitude of meander bends, ponding, and segment geometry variations. Yet these variations can mask major subsurface features. The giant oil fields of the Indonesian reef trend were discovered by a small American company after global majors had used seismic and other standard tools without success. The key was simply recognizing that drainage varied from tight meanders to straighter segments, reflecting superposition of drainage on the reef and inter-reef rocks. Drainage “piled up” against reef cores and then straightened out in the softer inter-reef deposits, because of damming by the reefs and increased gradients off reef, albeit hardly measurable by normal surveying methods (pers. com., 1986, Norman Foster, former Trend Corp. executive).

In this study, I had available to me Cole’s (1976) basement structure (pre-Phanerozoic topography) map, based on over 1000 Precambrian drill penetrations and numerous interpreted points based on drilling to Sauk and Tippecanoe Sequence rocks, and on which he had identified several faults. In addition, gravity and magnetic potential field maps are available (Lam and Yarger, 1989; Yarger, 1989). Although these maps are not precision instruments, they are useful to locate major features and to corroborate interpretations of other data. They are especially useful where thick soft sediments and rocks cover more brittle materials and mask underlying structural evidence, such as in western Kansas where thick Cretaceous shale and Cenozoic detrital deposits accommodate subtle structural distortion. Inden and Frush (2002) and Silverman (2002) have recent documented examples of use of potential field information for interpretation of structural “grain.”

The Cole (1976) map is printed at a 1:500,000 scale. This map was digitized by the Automated Cartography group, and the Kansas state-wide drainage layer was added at the same scale. The very minor mismatches were minimized, with the match problems being accommodated in the northeast corner, where they were assumed least likely to create interpretation problems. Larger-scale published maps of small areas showing basement fractures or linears were consulted and their directional attributes correlated into the new project (Baars, D. L., 1995; Berendsen, 1997; Berendsen and Blair, 1986, Burchett, et al, 1983).

It is important for the reader to understand that the purpose of this exercise is to develop new hypotheses for oil and gas accumulations, but not to identify specific prospects. Consequently, the mapping presented is purposefully generalized, and no attempt was made to map every possible basement fracture or drainage linear, but rather to map in sufficient detail to establish structural grain, major structures, and indicate provinces where potential new accumulations of petroleum might occur. The resulting map (Plate 1; Gerhard, 2003) is color-coded (as noted on the map) to reflect the data sources from which the linears were derived. This permits the viewer to interpret a confidence level for each feature.

### Structural Description

The underlying Precambrian framework of Kansas is a highly fractured complex of crystalline rocks and younger, still Precambrian, detrital sediments that have been faulted and eroded prior to the Sauk transgression (latest Precambrian through Lower Ordovician). The fractures are in two major sets, north-northeast trending and northwest trending. The NNE trending fractures are the major controls of the Midcontinent Rift System, and include the present day Nemaha Ridge and parallel faults such as the Abilene Anticline (Plate 1). West of the

Nemaha Ridge and the Rift System the trend is more NE than NNE, and the fracture sets appear to be normal conjugate shears.

Subsequent Phanerozoic tectonic activity has undoubtedly modified Precambrian structures. Berendsen (1997) cites tectonic events that terminate the Sauk Sequence, Tippecanoe Sequence, Lower Kaskaskia Sequence (Gerhard et al, 1982), and Upper Kaskaskia Sequence, all of which can be related to craton margin events whose stress is reflected in strain within the craton (Gerhard et al, 1991).

The relative frequency of these events obfuscate dating the origins of the two major tectonic "grain" trends. Some Midcontinent Rift faults are offset by northwest-trending faults, but this may reflect only the most recent relative motion along these faults. As Berendsen (1997) has pointed out, there is a lateral component to some of the stress fields, so that it is not possible to date the origin of the fractures.

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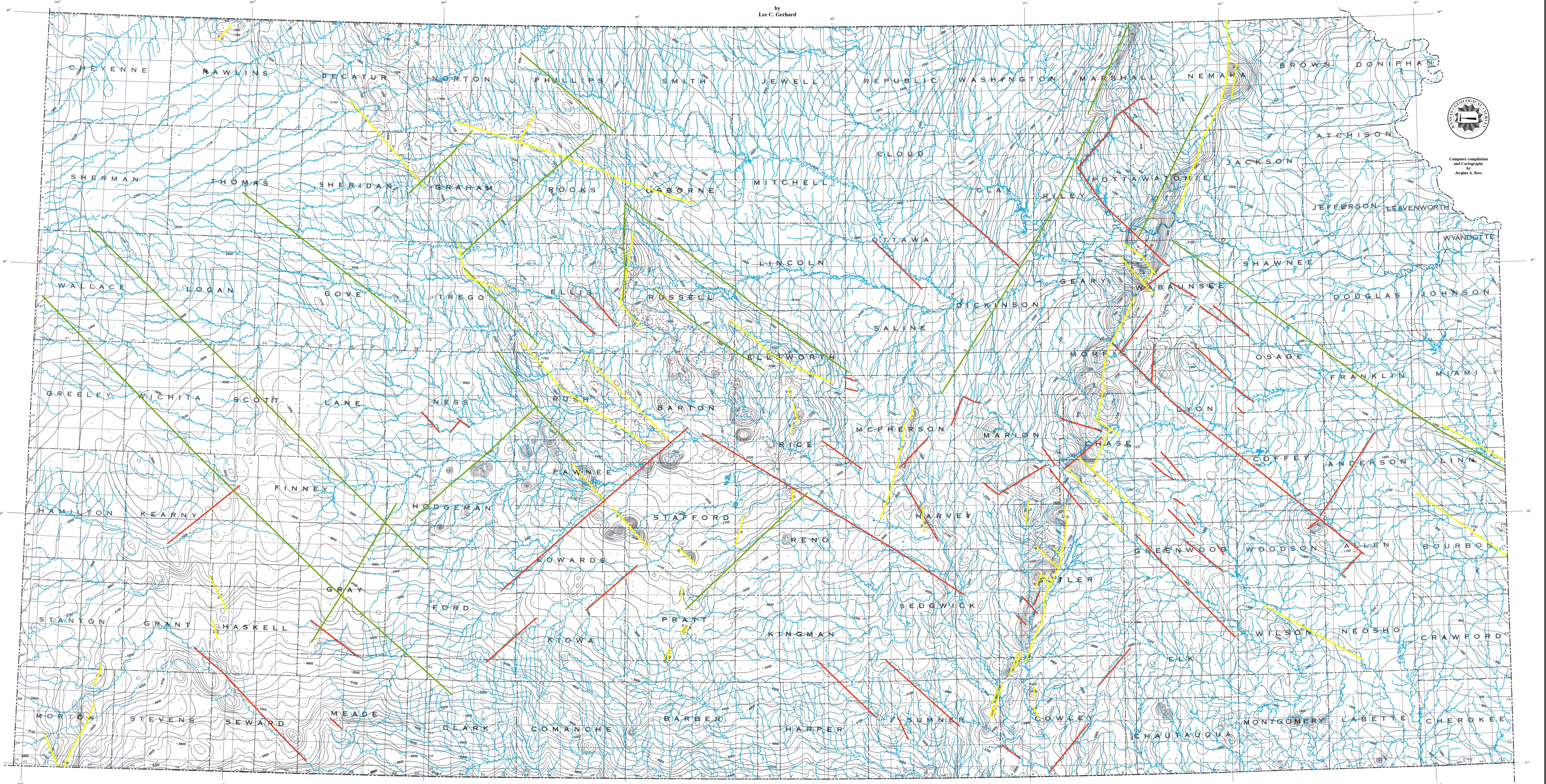
# PRELIMINARY LINEAMENT MAP OF KANSAS

2003

by  
Lee C. Gerhard



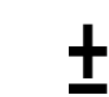
Computer compilation  
and Cartography  
by  
Jorgina A. Ross



- Drainage controlled linears
- Potential fields controlled linears
- Faults
- Wells to the Precambrian
- Estimated depth to Precambrian

Prepared on a base of Cole, Virgil B., 1976, Configuration of the Top of the Precambrian Rocks in Kansas; Kansas Geological Survey, Map M-7, 1:500,000, and drainage from the digital Kansas Cartographic Database.

The map documents linears interpreted from Cole (1975) (yellow), drainage anomalies (red), and potential fields information (green). The linears outline basement trends, reflecting interpreted basement structural elements.



Distance: See legend

Contour interval: 100 feet  
(except as indicated otherwise by contour values)

Scale: 1:200,000  
Lambert conic projection  
with standard parallels at  
37° north and 47° north

The Kansas Geological Survey does not guarantee this map is free from errors or inaccuracies and declines any responsibility or liability for interpretations made from the map or decisions based thereon.

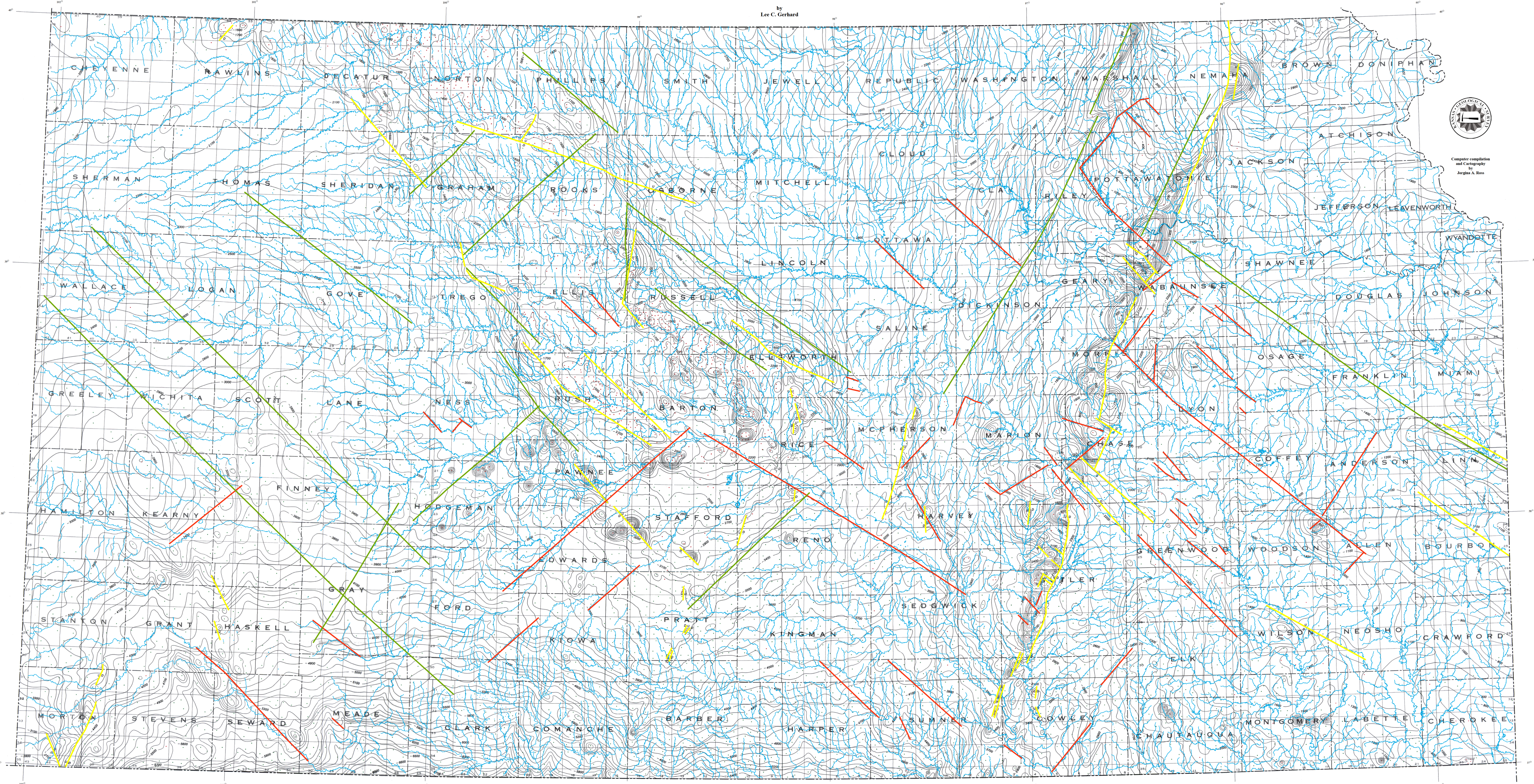
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