

# LINEAMENT MAPPING AND ANALYSIS IN THE NORTHEASTERN WILLISTON BASIN OF NORTH DAKOTA

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## Introduction

Lineaments are lines on a map that follow linear trends. They can be defined as extended mappable linear or curvilinear features of a surface whose parts align in straight or nearly straight relationships that may be the expression of folds, fractures, or faults in the subsurface (Sabins, 2000). These features can be mapped at various scales from local to continental and can be utilized in mineral, oil and gas, and groundwater exploration studies. The NDGS recently completed a lineament mapping and analysis investigation of the area around Parshall in the northeastern portion of the Williston Basin. The aim was to potentially identify any surface features that future investigations may be able to link to deeper buried basinal and stratigraphic structures, such as faults, that may have an influence on the accumulation and production of oil and gas in the area.

## Description of the Study Area

The Parshall study area was predefined as a custom 1:250,000 scale (1° x 2°) quadrangle. The map covers an area of approximately 6,394 square miles centered on the Parshall and Sanish Oil Fields located between the towns of Stanley and Parshall (fig. 1).

## Previous Lineament Studies

Several lineament studies have been completed over the last four decades at regional to continental scales (e.g., Penner & Cosford, 2006). Lineament studies peaked in the 1980s coincident with the increased availability and wider use of LANDSAT imagery for geomorphologic analysis and oil exploration and development trends in the Williston Basin.

## Data and Imagery Sources

Lineaments in the Parshall area were derived from four sources: lineaments mapped from previous studies, lineaments mapped from digital shaded relief data, lineaments mapped from aerial imagery, and lineaments mapped from LANDSAT data and imagery.

Published lineaments within the Parshall area were digitally extracted from their original sources (Heinle, 2007), compiled, and merged into a single "historical" lineament coverage for the Parshall study area. Lineaments were also mapped from a digital shaded-relief image created from USGS National Elevation Dataset (NED) data, set to a vertical exaggeration of 9X (fig. 2). Lineaments were also mapped and digitized from a digital aerial image mosaic of the study area, compiled from 2003 USGS National

Agricultural Image Program (NAIP) imagery. In addition to the traditional mapping data sources, lineaments were also mapped from a digital image mosaic of the study area, compiled from 2002 LANDSAT-7 Enhanced Thematic Mapper Plus (ETM+) data mosaic. To facilitate visual lineament mapping and analysis, a digital image mosaic was created using a blue, green, red (BGR) false color combination of spectral bands 2, 4, and 7.

## Lineament Mapping and Analysis Methodology

Lineaments were mapped manually from their digital sources directly on screen, at various scales ranging from 1:24,000 to 1:1,000,000, and were transferred into a Geographic Information

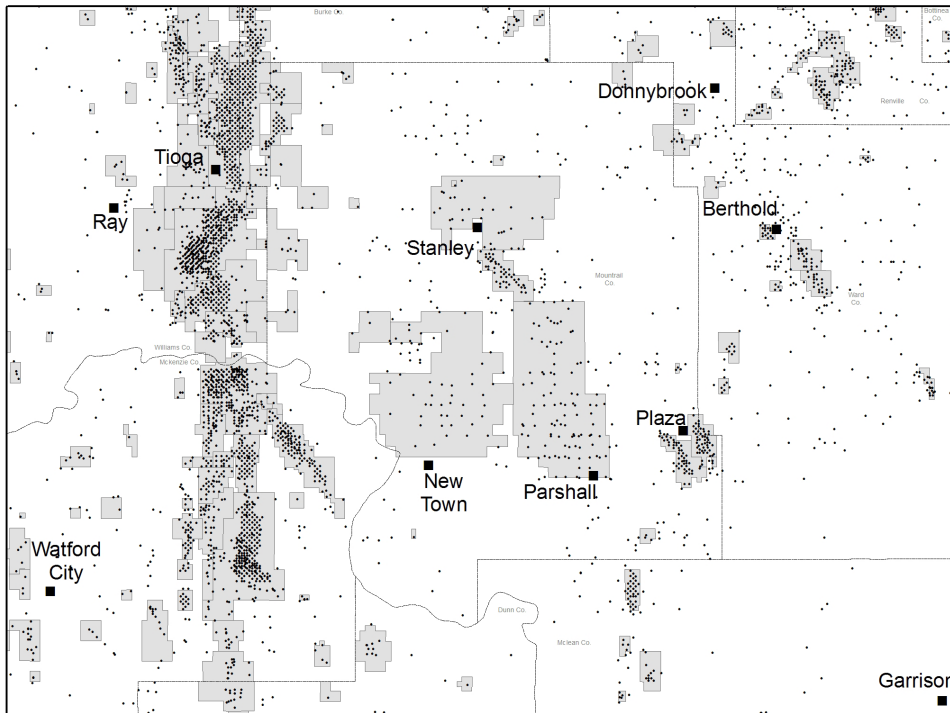


Figure 1. Parshall study area showing producing oil and gas fields (light gray) and the locations of all wells (black dots) drilled for oil and gas development in the area.

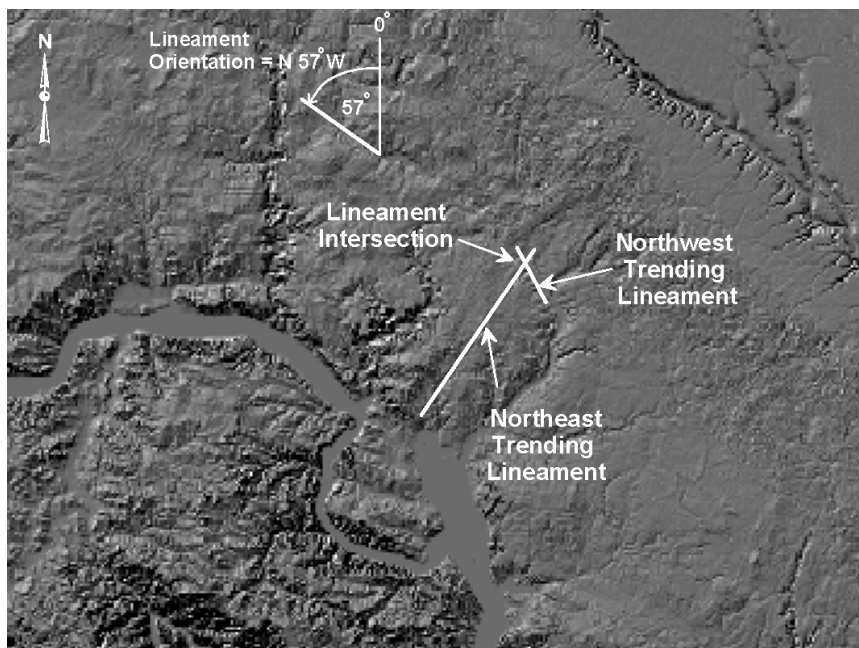


Figure 2. Shaded relief map used for lineament mapping in the Parshall study area. Three of the 5,759 lineament traces that were mapped in this area are shown as examples.

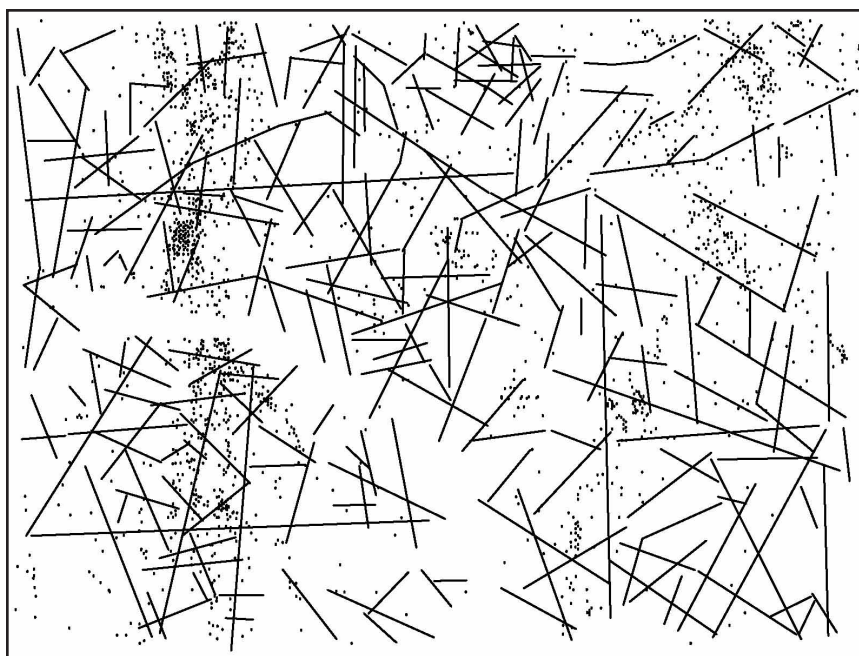


Figure 3. Relationships of lineaments mapped from 2003 NAIP aerial imagery and the locations of producing and non-producing oil and gas wells (black dots) in the Parshall area.

System (GIS) for final mapping and analysis. Use of the GIS system allowed the comparison of mapped lineaments to existing features such as roads, fence lines, transmission lines, etc., so that these artificial features could be omitted. The relationships between mapped lineaments and current oil and gas production in the Parshall area was explored by comparing the spatial relationships of mapped lineaments, lineament intersections, degree of lineament interconnectivity, and overall lineament density with the locations of currently producing and non-producing oil and gas wells.

## Discussion

Lineament orientations are dominantly found in NE to SW and NW to SE orientations consistent with previous lineament studies in the region and the current understanding of regional tectonic stress regimes and fracture development in the Williston Basin of North Dakota (fig. 3). This is why horizontal legs completed in the Bakken Formation in this area are generally oriented towards the NW and SE. This investigation supports the orientations of those wells. Generally, producing wells appear to be located in areas of greater lineament density, lineament intersection, and degree of lineament connectivity. Non-producing wells were commonly found to be located in areas that contained fewer lineaments (fig. 3). A detailed technical description of this investigation can be found in the recently completed NDGS Geologic Investigations No. 70 (Anderson, 2008).

## Selected References

- Anderson, F.J., 2008, Lineament Mapping and Analysis in the Northeastern Williston Basin of North Dakota: North Dakota Geological Survey, Geological Investigations No. 70, 21 p.
- Heinle, S., 2007, Compilation of Lineaments Mapped in the Williston Basin Region: North Dakota Geological Survey Data Compilation.
- Penner, L.H., and Cosford, J., 2006, Evidence Linking Surface Lineaments and Deep-Seated Structural Features in the Williston Basin: Saskatchewan and Northern Plains Oil & Gas Symposium, Saskatchewan Geological Society, p. 19-39.
- Sabins, F.F., 2000, Remote Sensing - Principles and Interpretation: New York, W.H. Freeman and Company, 494 p.