Evaluation of the Effectiveness of Using Gravity and Magnetic Data to Define 3-D Seismic Survey Areas for Fault Related Hydrothermal Dolomite Reservoir Identification*

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Abstract

Basement faults are reactivated through geologic time and often influence the position of faulting in overlying strata. Basement faults reactivated in a strike-slip sense cause strike-slip and wrench faults in overlying strata. Strike-slip and wrench faults are excellent conduits for hydrothermal fluids, and the formation of dolomite, especially at dilatational bends, at the end of faults, and at fault intersections. It appears that fault related hydrothermal dolomite reservoirs (FRHDRs) can be found in many ancient carbonate margins and platforms, suggesting the extent of these reservoirs is broad.

3-D seismic is an effective method to locate FRHDRs. Magnetic data is often used to map basement faults and gravity data is often used to map basement, and shallower faults. Some geoscientists have suggested it makes sense to define the general location of basement and shallower faults with relatively inexpensive gravity and magnetic data in order to minimize the acquisition of expensive 3-D seismic data. While this approach appears to make sense, little evidence has been presented documenting the success of the method. This study utilizes gravity/magnetic modeling and public domain gravity and magnetic data subjected to various processing and enhancement techniques to determine whether discernible gravity and magnetic anomalies are associated with known FRHDRs.

The results of the study show that in a significant number of cases where data quality is adequate, gravity and/or magnetic data can be used to locate the general position of FRHDRs. The data requirements and methodology needed to assure best results is also discussed.

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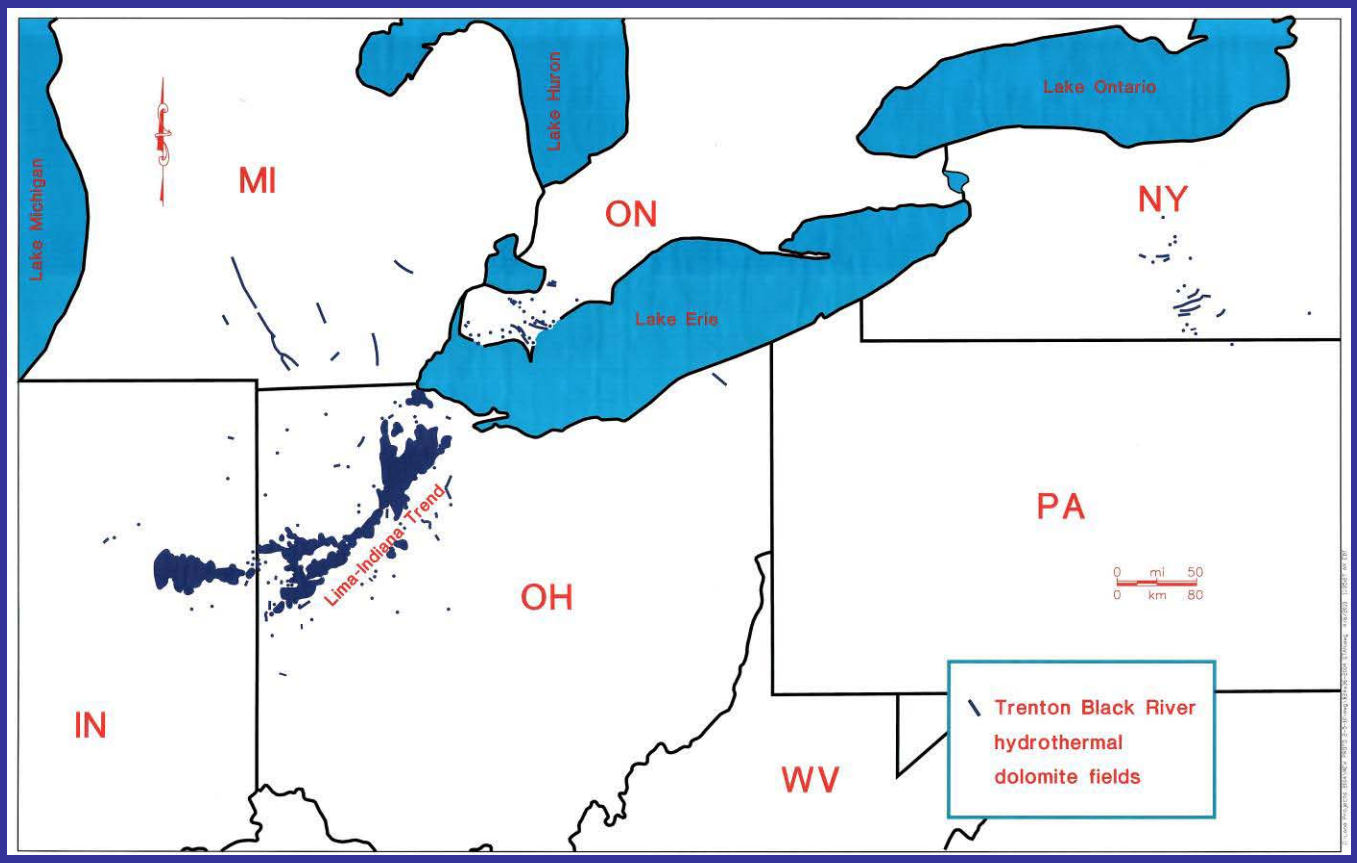
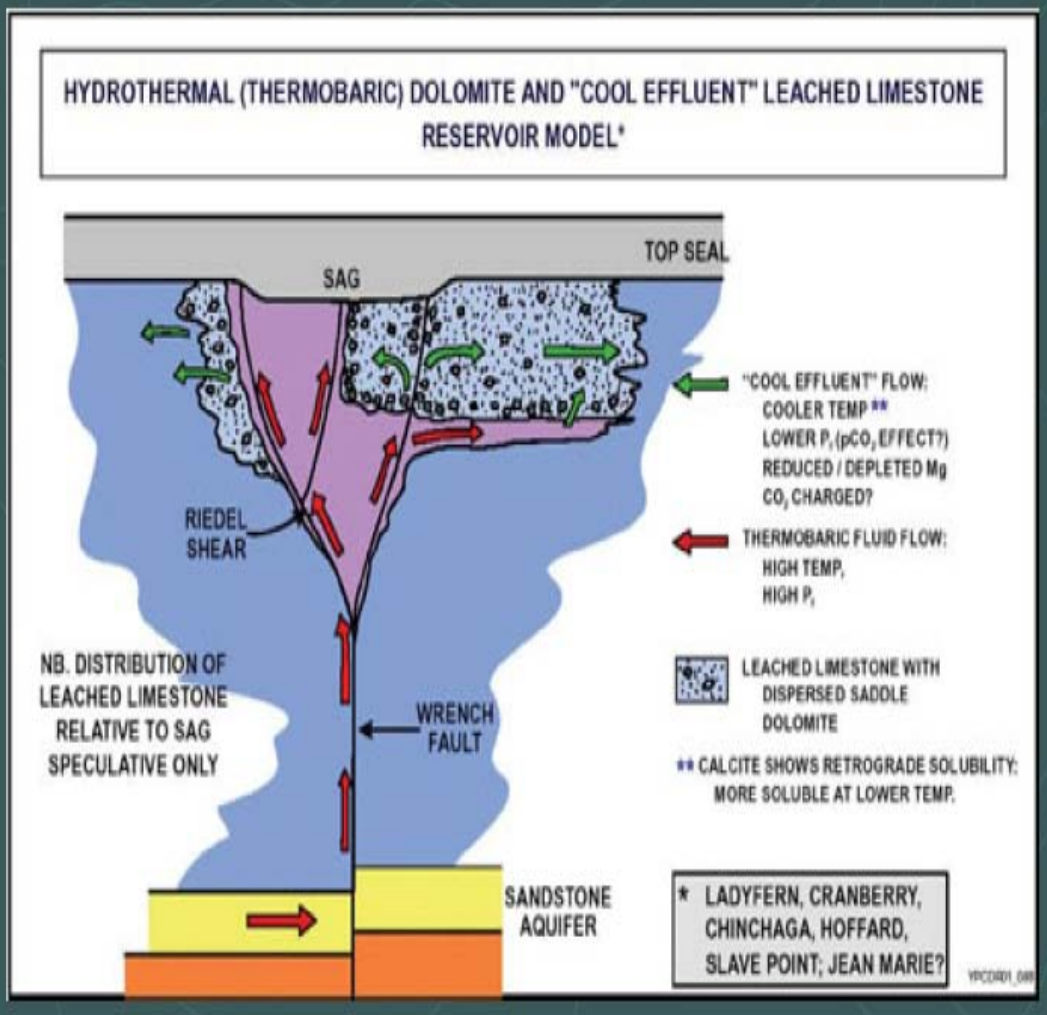


Trenton Black River hydrothermal dolomite fields in northeast North America

(after Smith, L.B., 2006)

Alteration Models: Fractures, Faults and Fluid



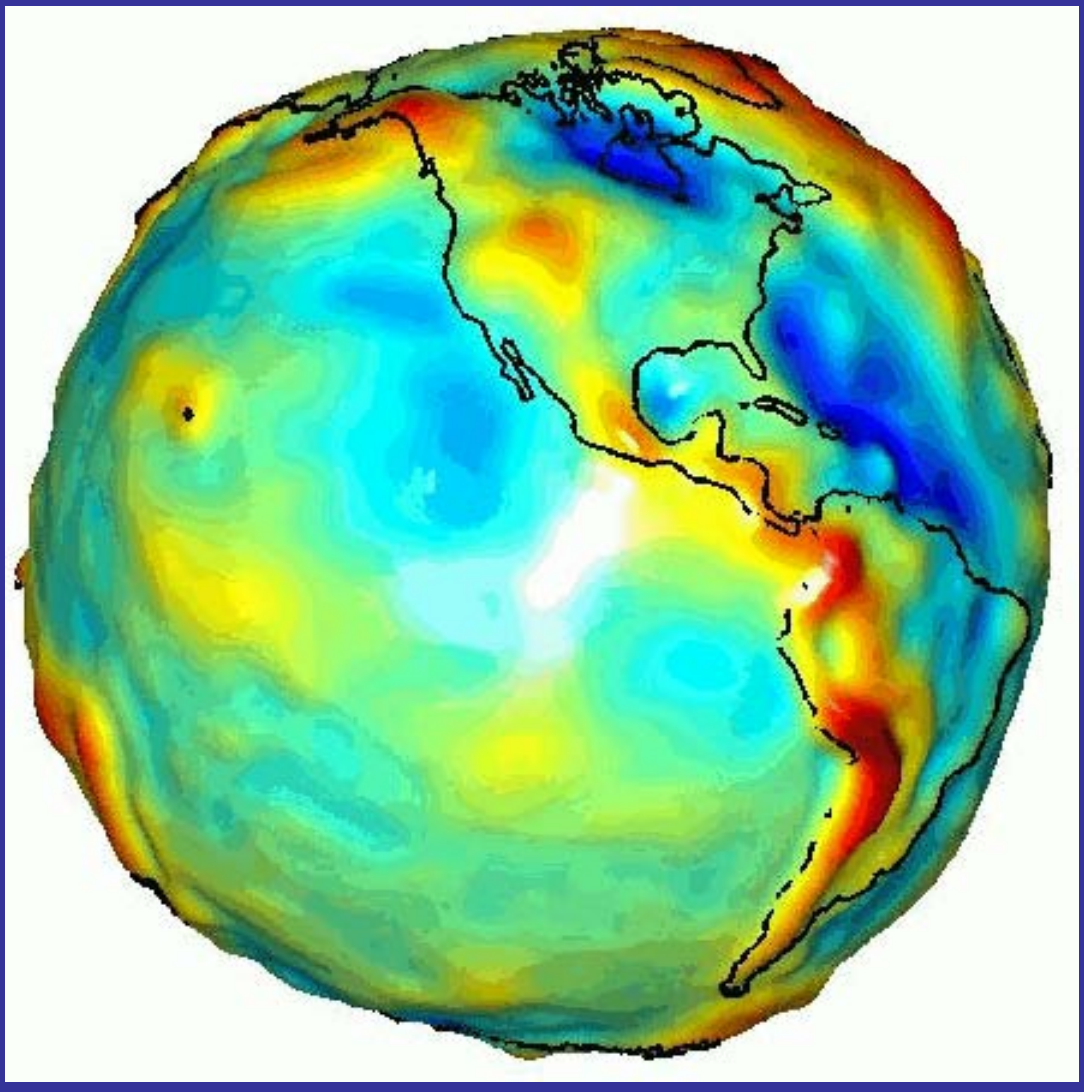
Hydrothermal dolomitization model (from Boreen & Davis, 2001) published in UWE STRECKER, MATTHEW CARR, STEVE KNAPP, MAGGIE SMITH, RICHARD UDEN and GARETH TAYLOR, *Matching to Model Can Cut Risk* , AAPG Explorer, July, 2005

Geologic model of a fault related hydrothermal dolomite reservoir (FRHTDR)

(from Martin, J.P., Development of the Ordovician Hydrothermal Dolomite Play in the Appalachian Basin, NYSERDA)

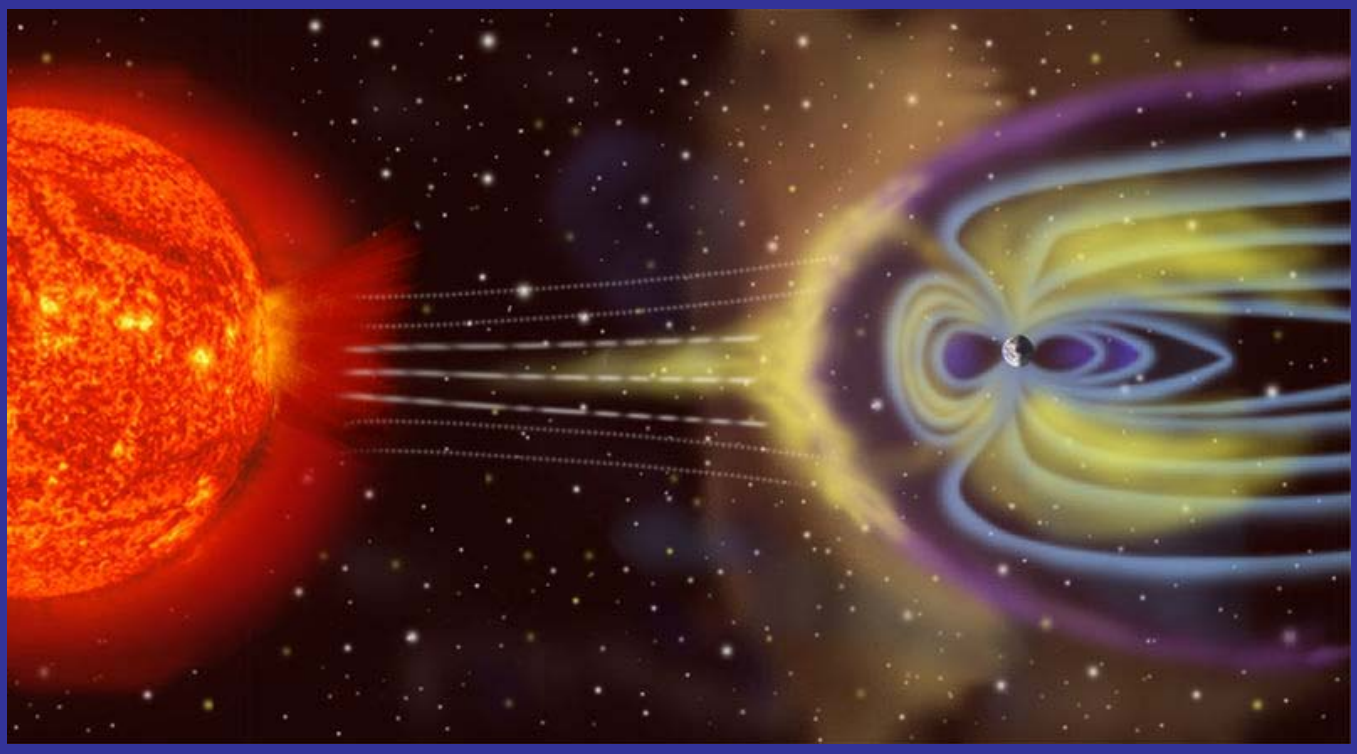
Presentation Order

- Background information on gravity and magnetics.
- Would we expect FRHTDRs to cause gravity and magnetic anomalies?
- What are effective repeatable processing steps to isolate anomalies?
- Do known FRHTDRs cause gravity and magnetic anomalies?
- Can gravity and magnetic data be used to target seismic survey areas?



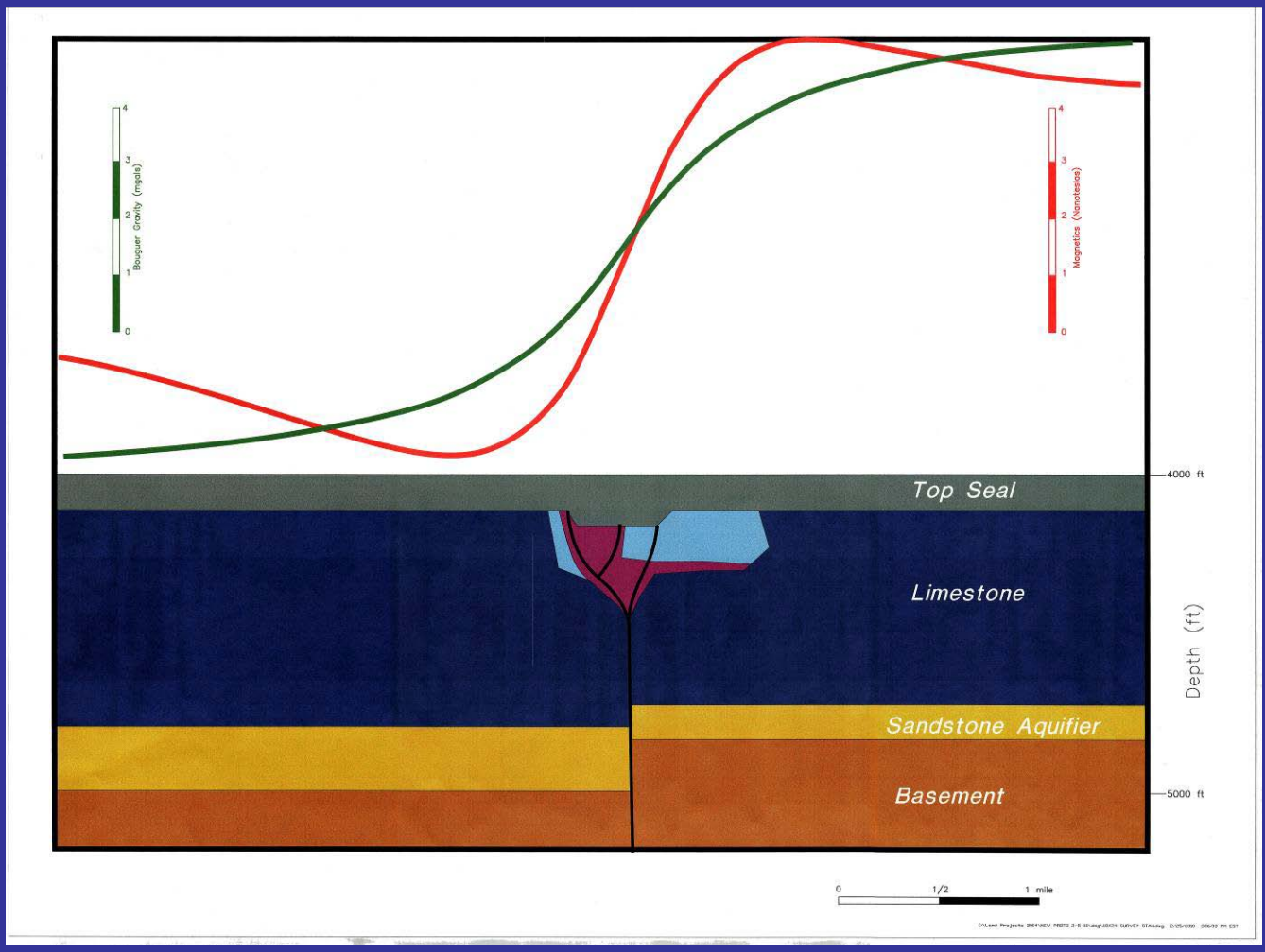
Gravity basics

(picture from GRACE gravity recovery and climate experiment)



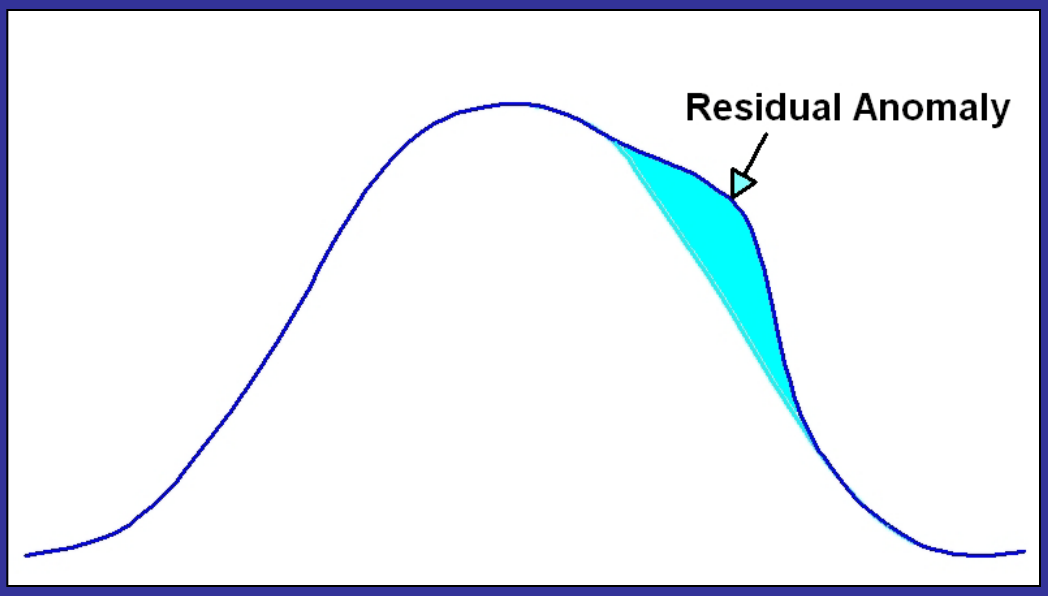
Magnetic basics

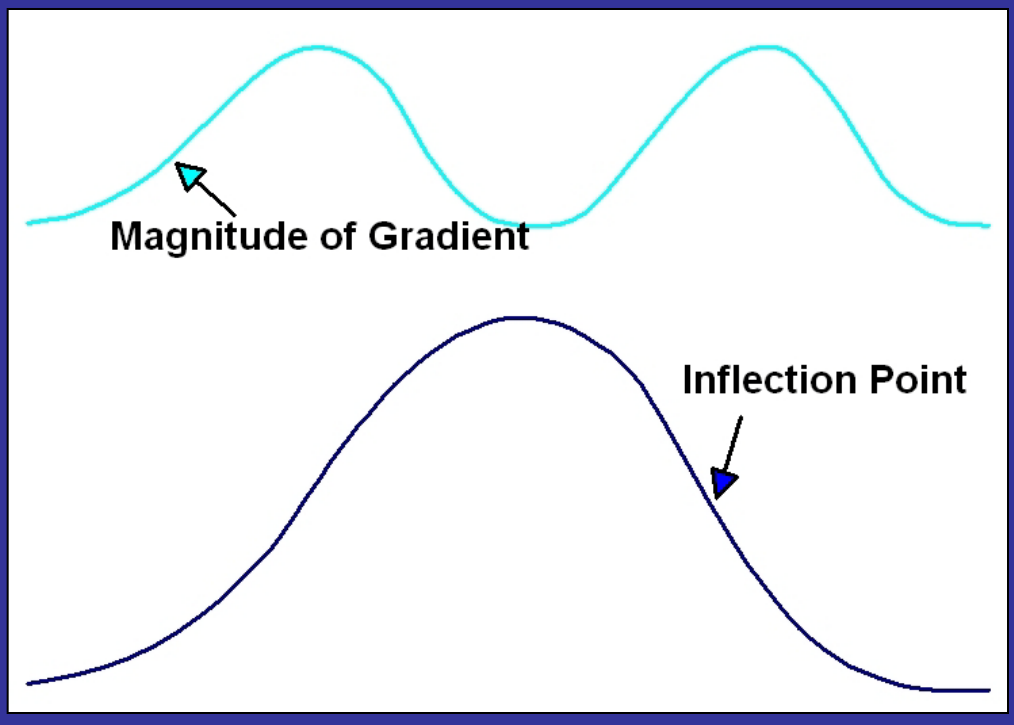
(picture from Wikipedia)



Gravity and magnetic model of hypothetical FRHTDR

Residual Separation

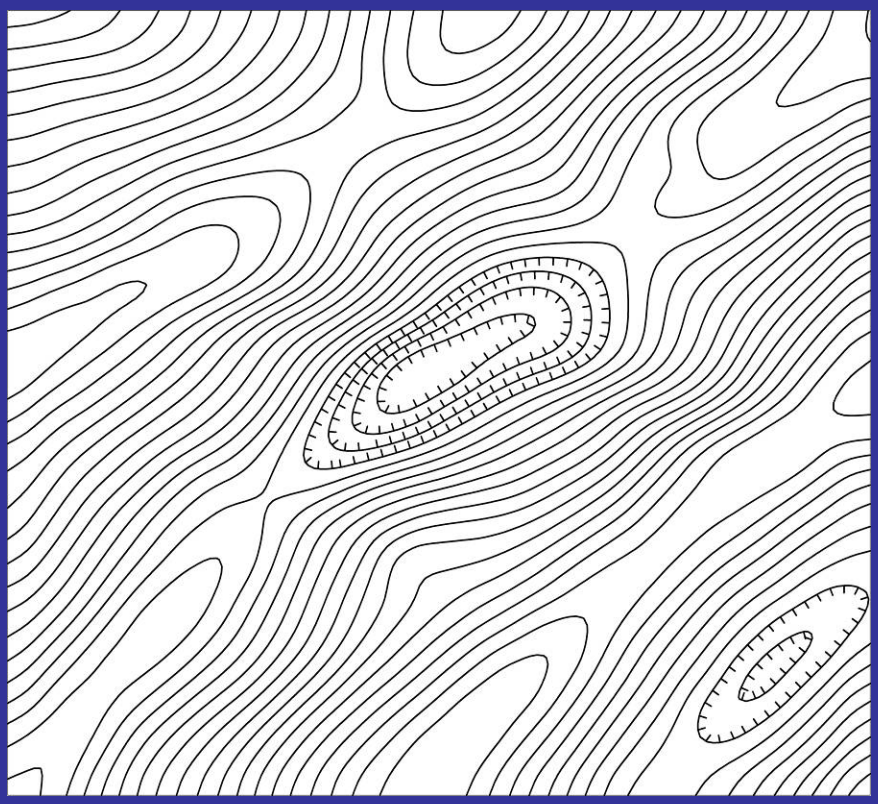




Magnitude of Gradient

Effective repeatable processing/enhancement techniques used in this study #1

Contoured potential field data

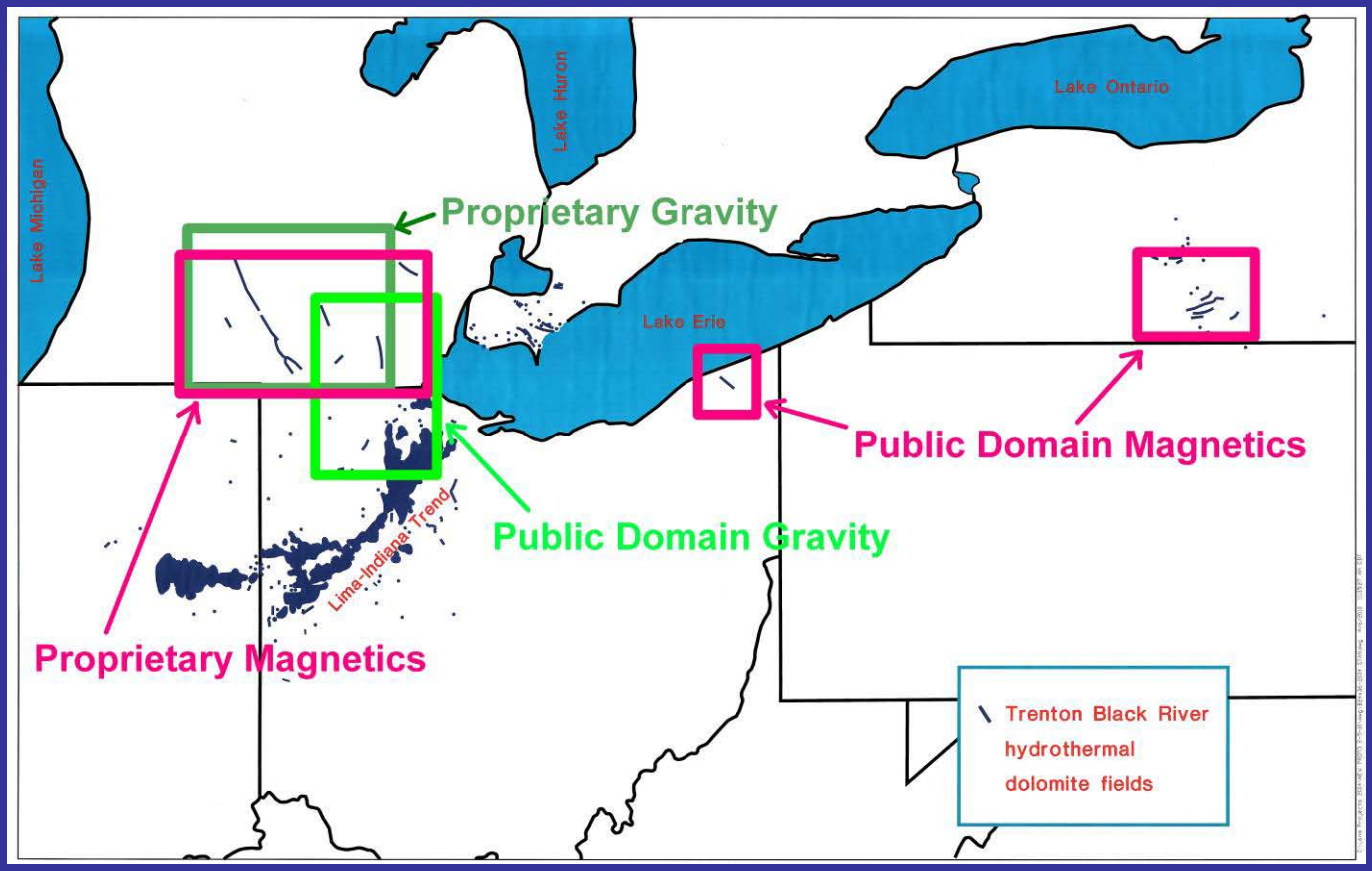


Same data enhanced using a shaded relief operator

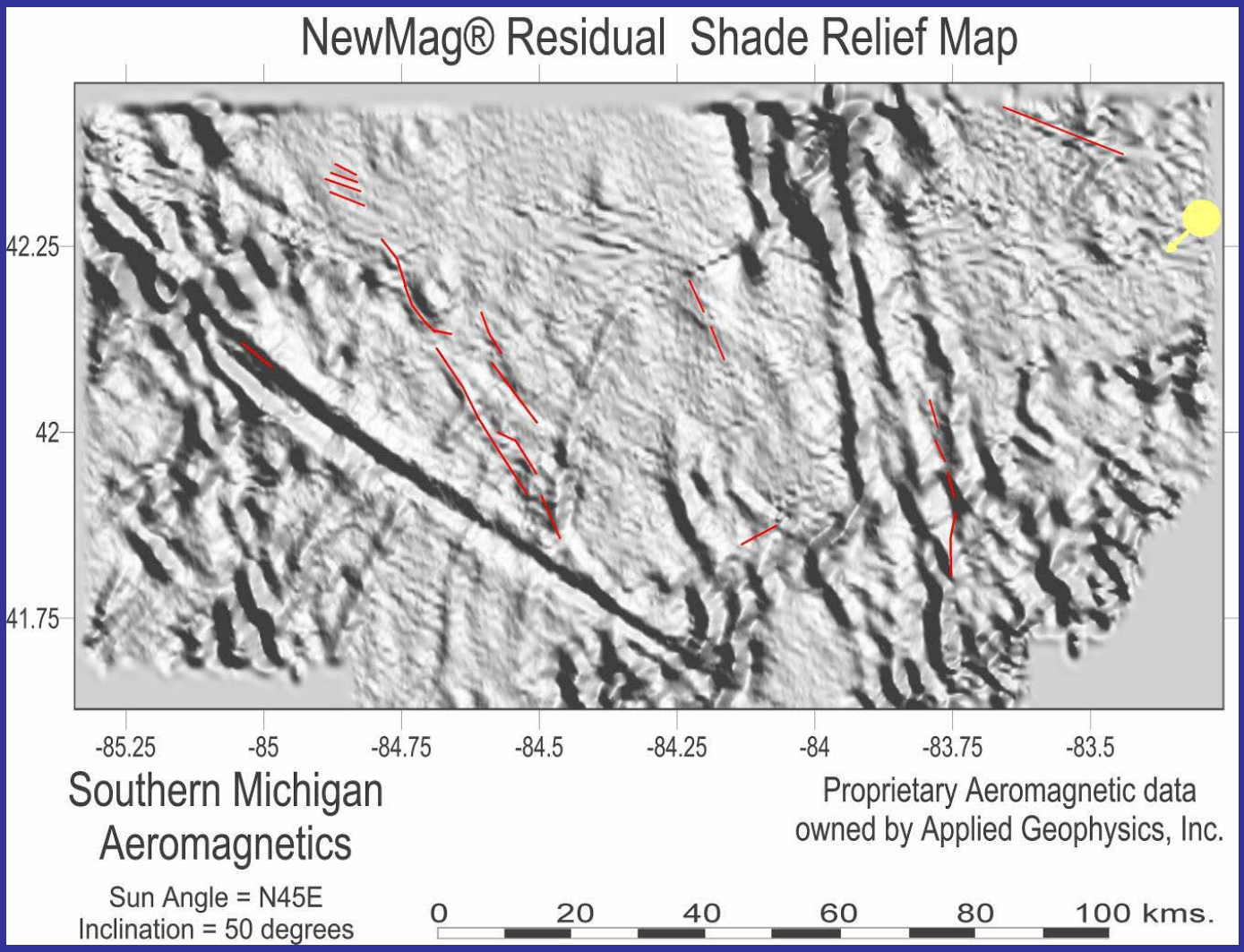
Effective repeatable processing/enhancement techniques and in this study #2

Review of Gravity and Magnetic Basics

- Magnetic data responds to structure and composition in basement.
- HRAM sometimes responds to the sedimentary section.
- Magnetics works best where basement is relatively shallow.
- Bouguer gravity responds to density contrasts at all depths.
- Large gravity and magnetic anomalies are related to basement/crustal lithology and large structures.
- Very high frequency anomalies are noise.
- Interested in anomalies in between.
- Use simple processing. Test “robustness” of anomaly by using several methods.
- To define anomaly character and avoid aliasing, use densely sampled accurate data.

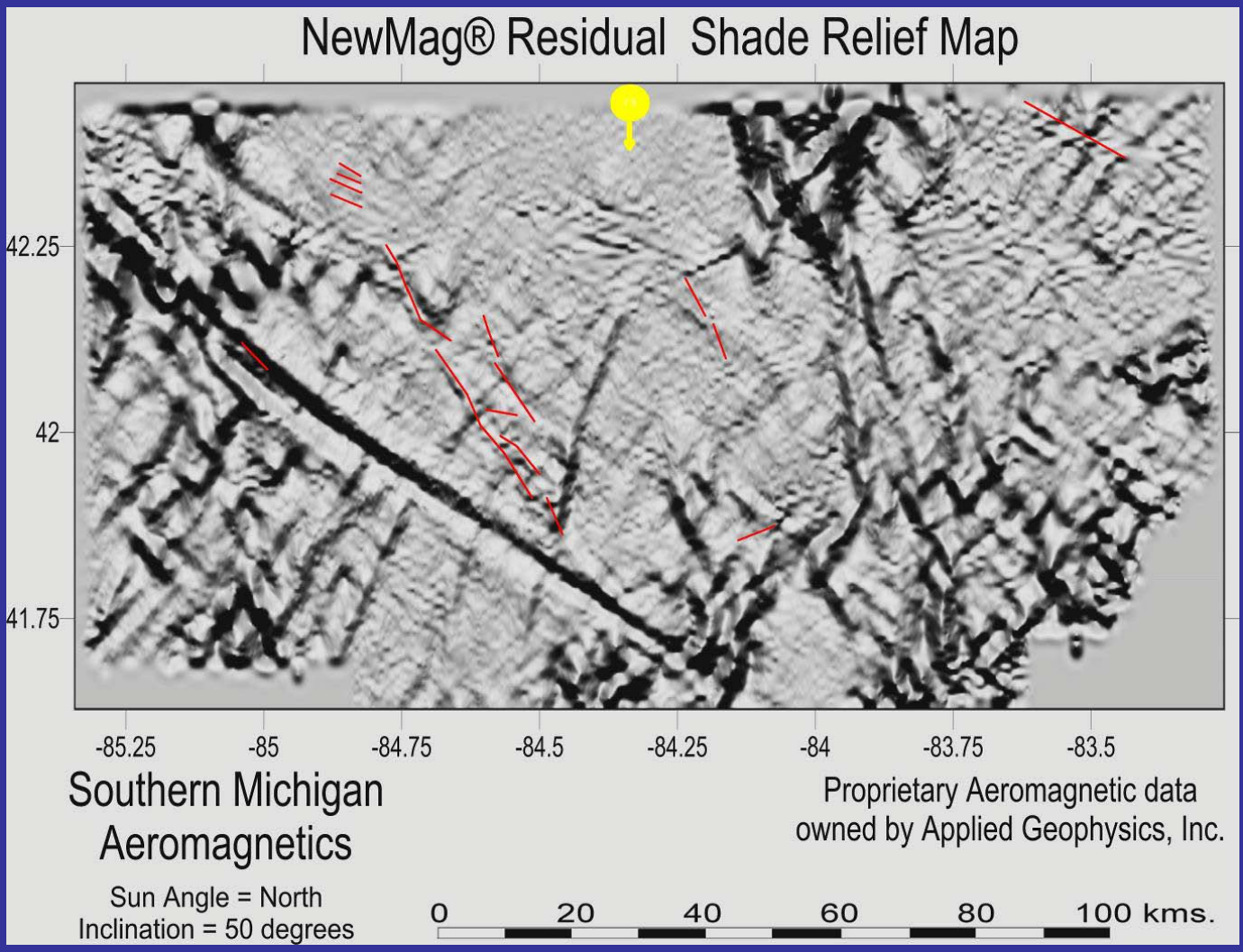


Magnetic and gravity data sets reviewed in this study



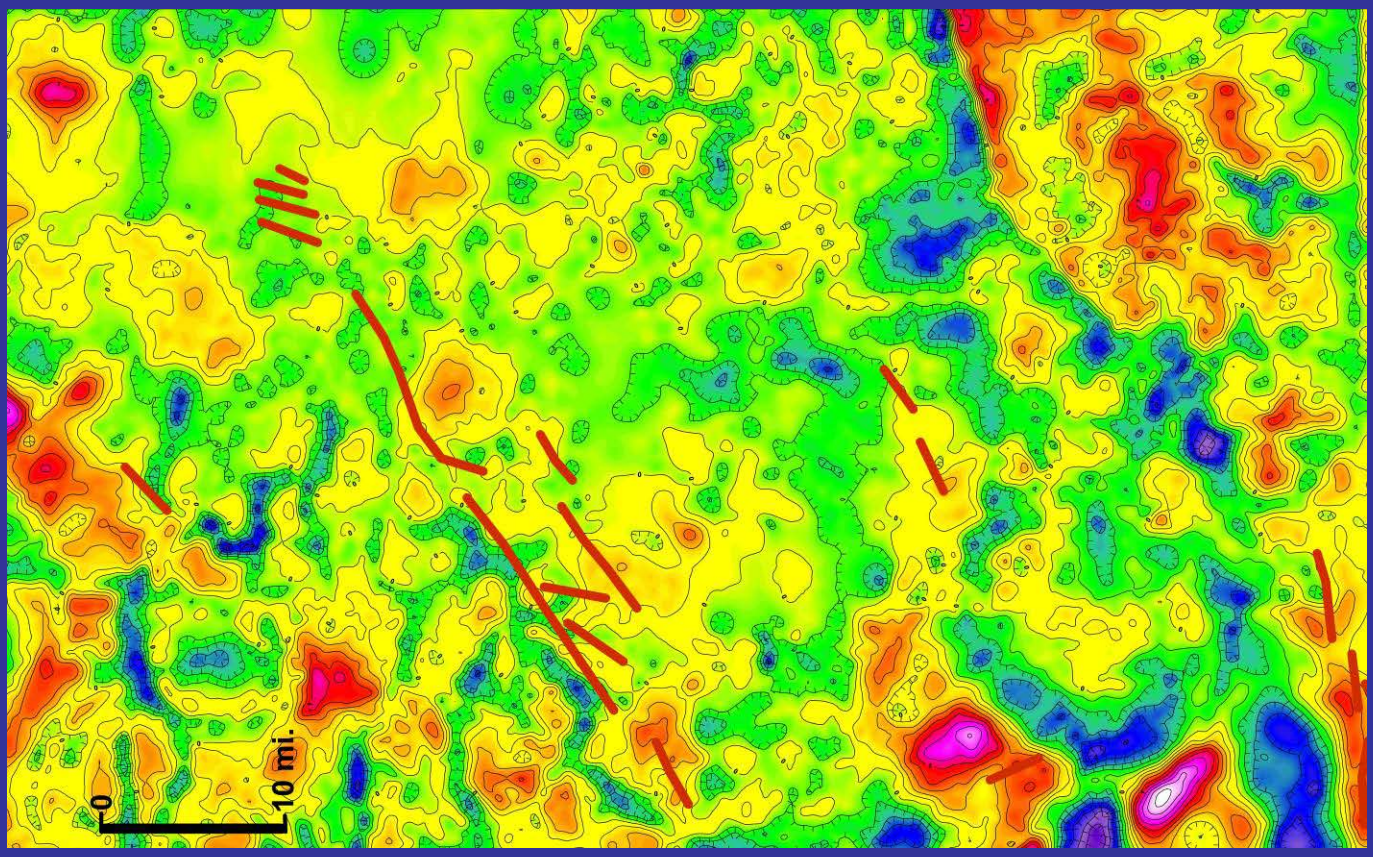
Northeast shaded relief of residual magnetics (proprietary) in southeast Michigan

(Aeromagnetic image courtesy of Applied Geophysics, Inc.)



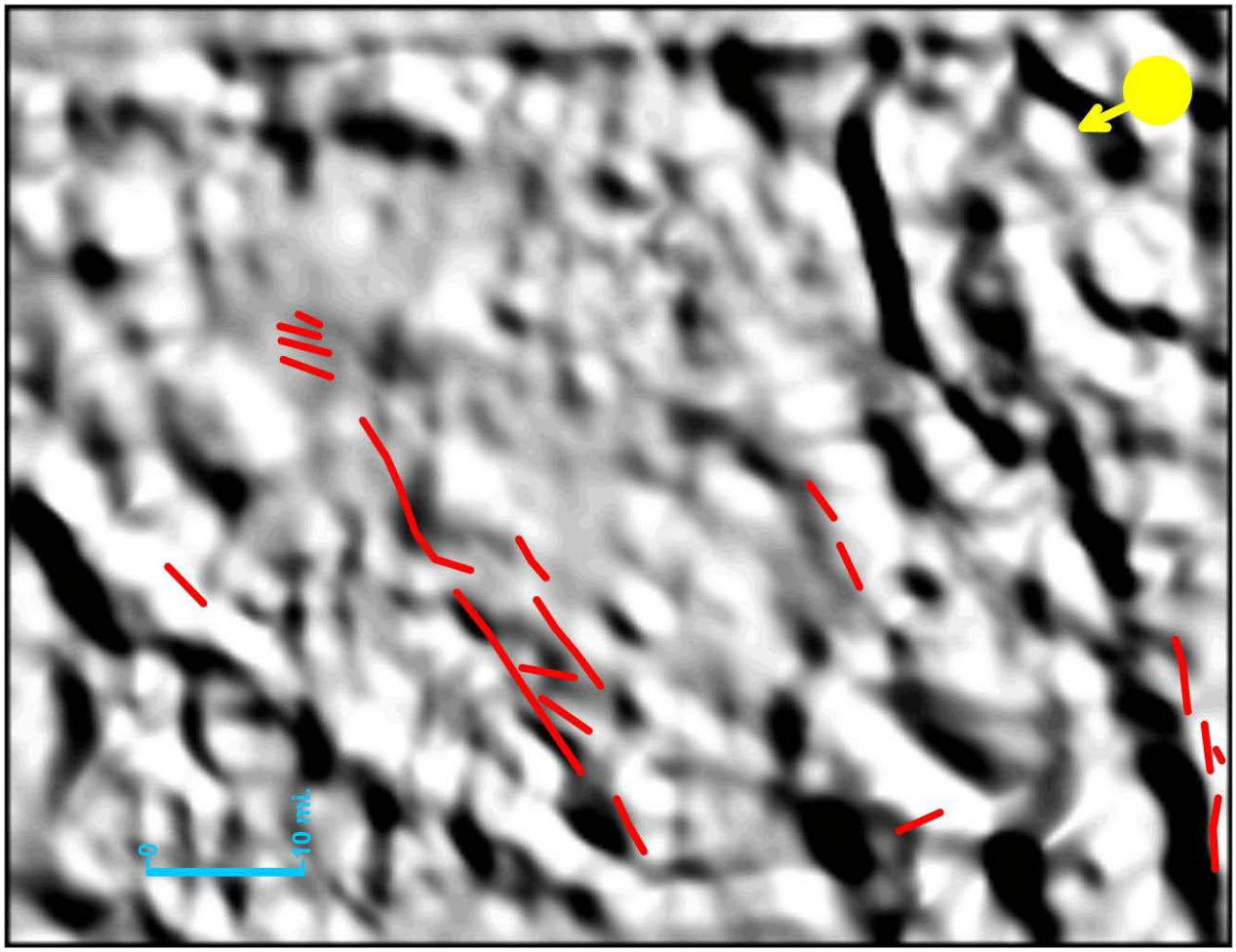
North shaded relief of residual magnetics (proprietary) in southeast Michigan

(Aeromagnetic image courtesy of Applied Geophysics, Inc.)



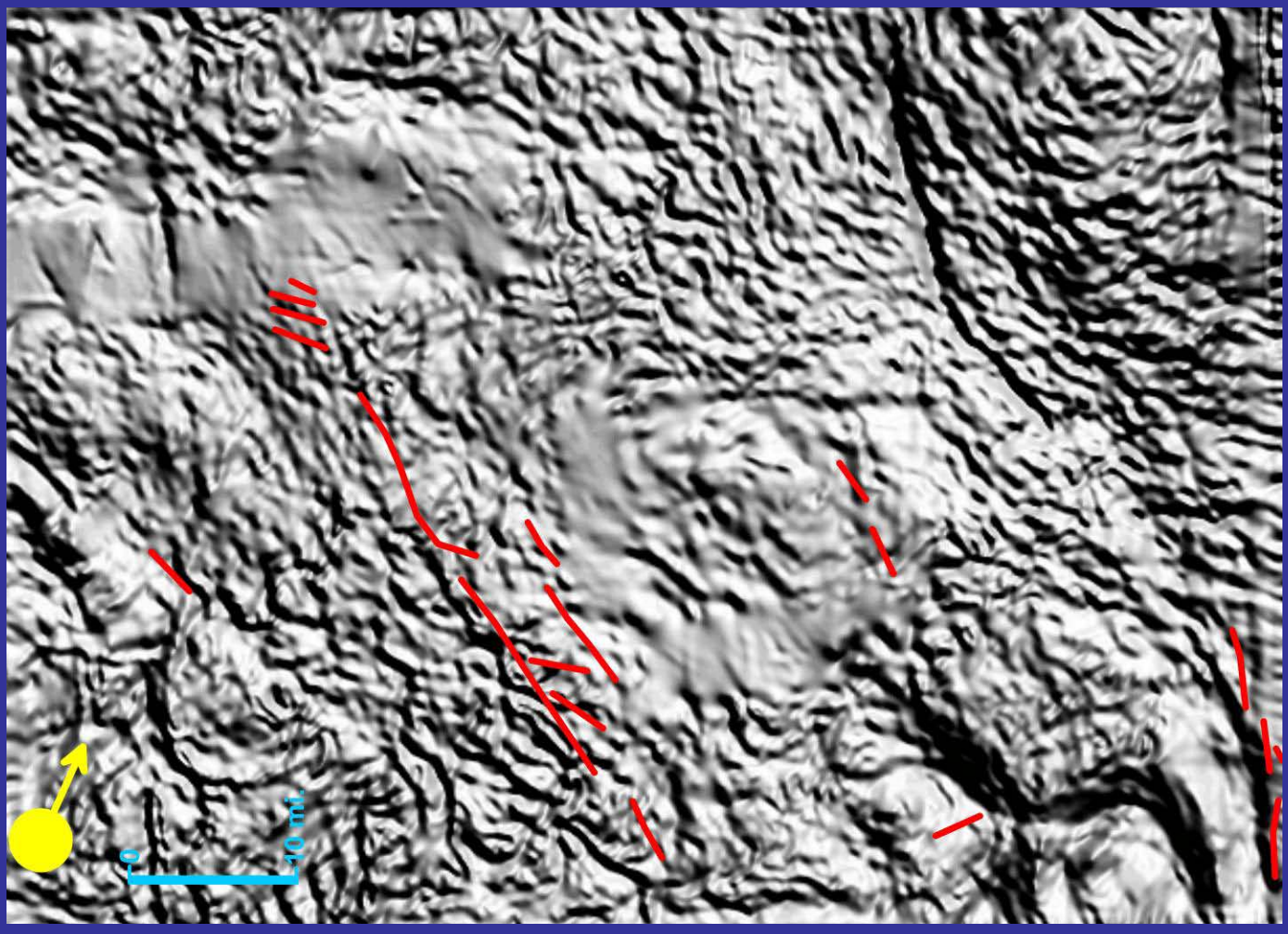
Residual gravity (proprietary) in southeast Michigan

(Gravity data courtesy of GETECH)



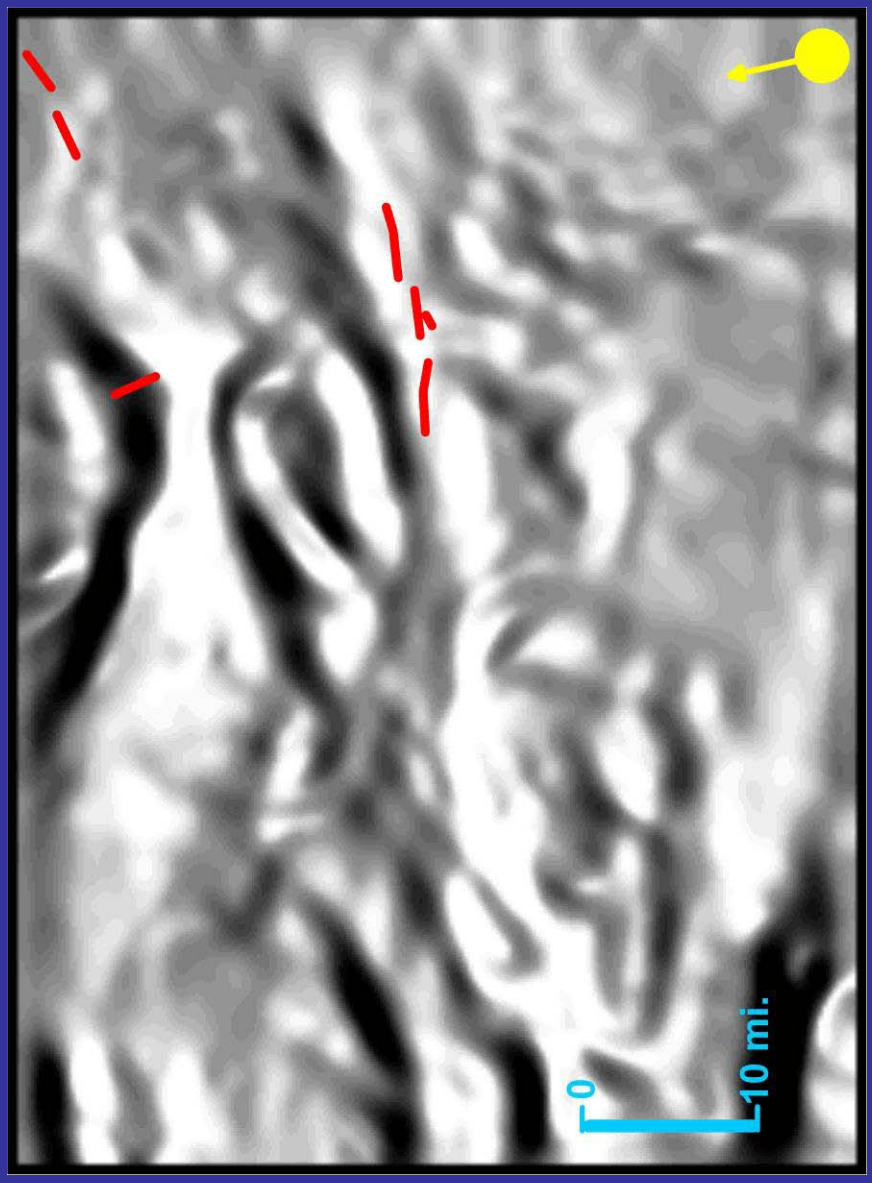
East northeast shaded relief of residual gravity (proprietary) in southeast Michigan

(Gravity data courtesy of GETECH)

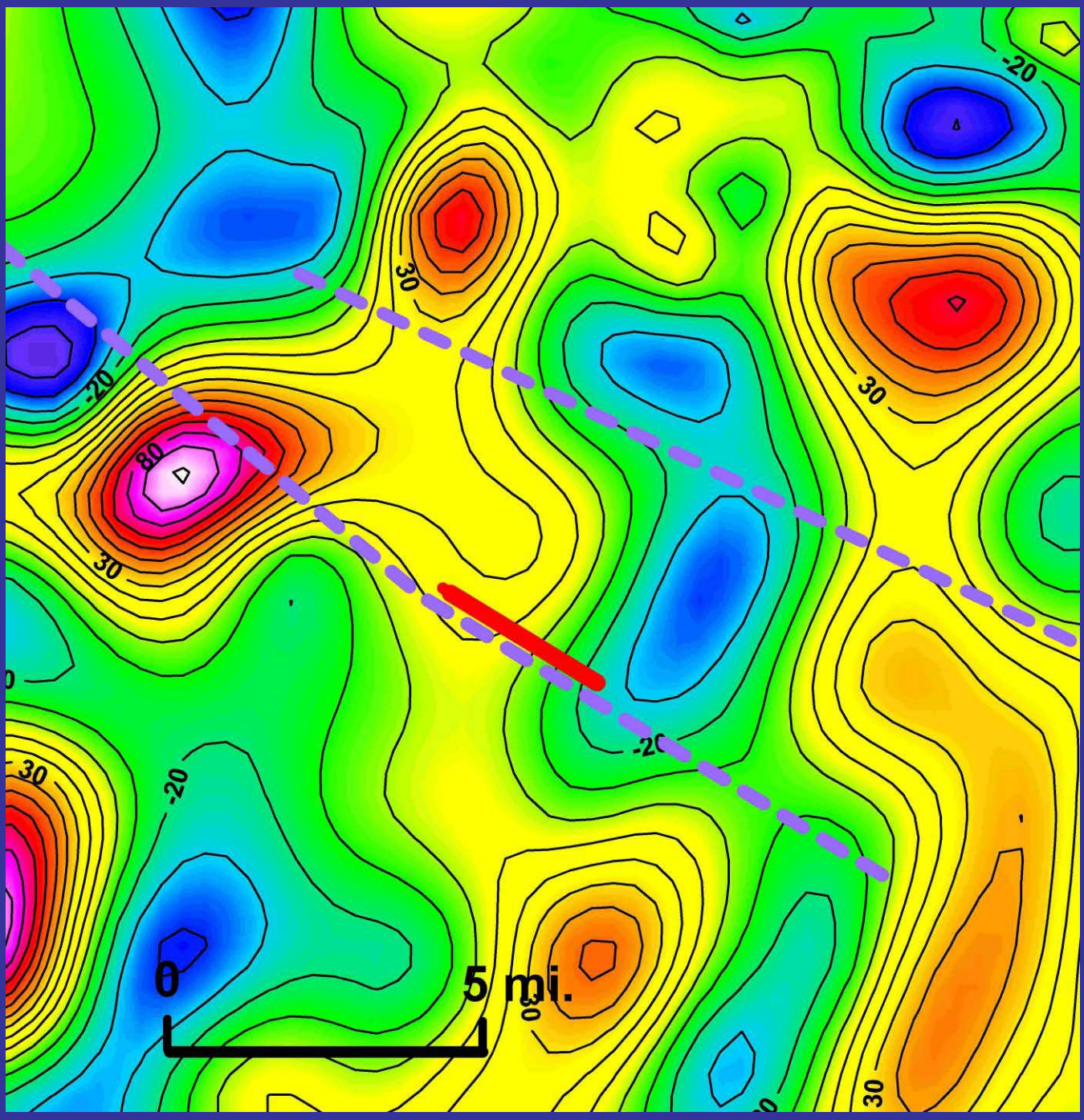


South southwest shaded relief of gradient of gravity (proprietary) in southeast Michigan

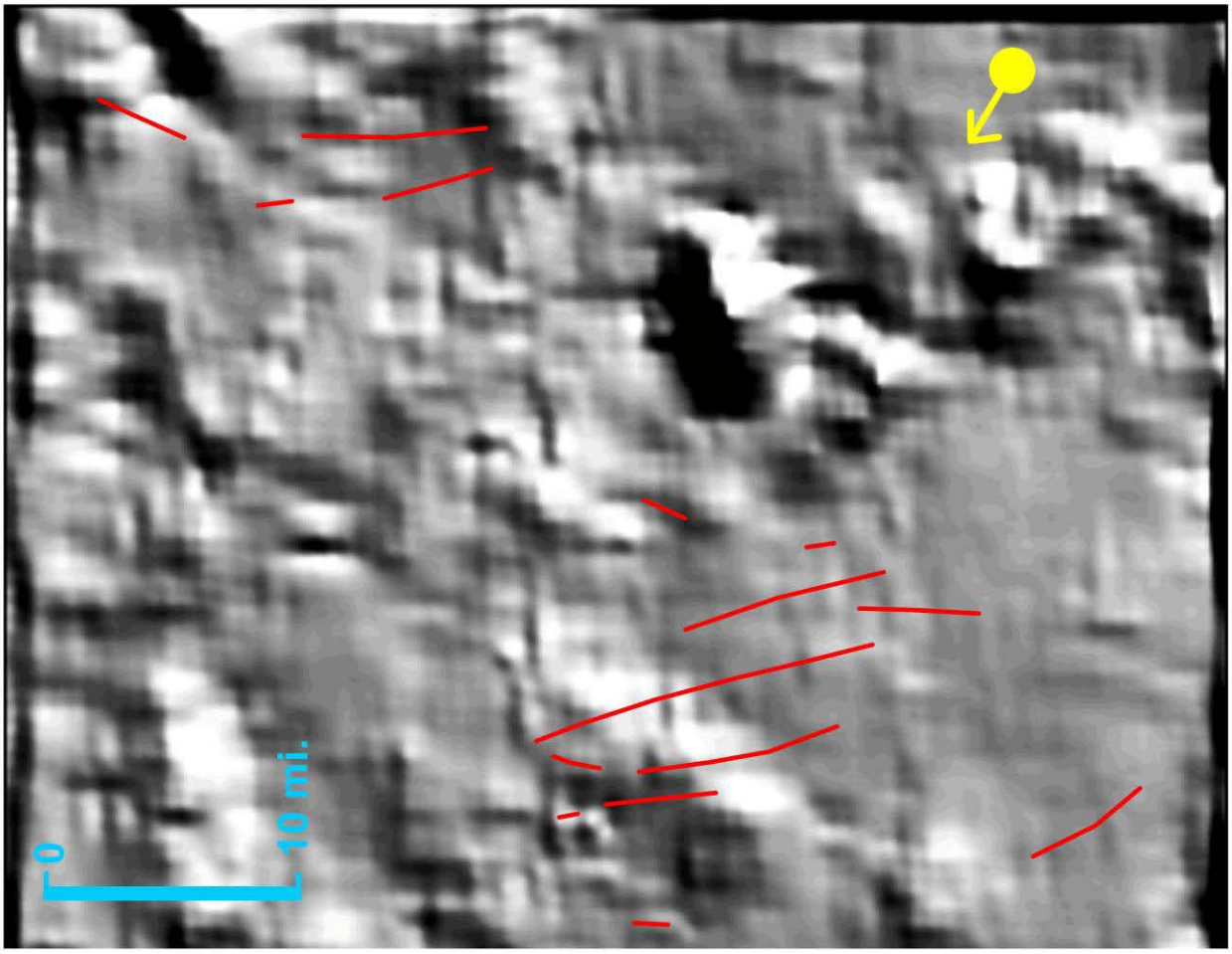
(Gravity data courtesy of GETECH)



East northeast shaded relief of residual gravity (public domain) in southeast Michigan and northeast Ohio

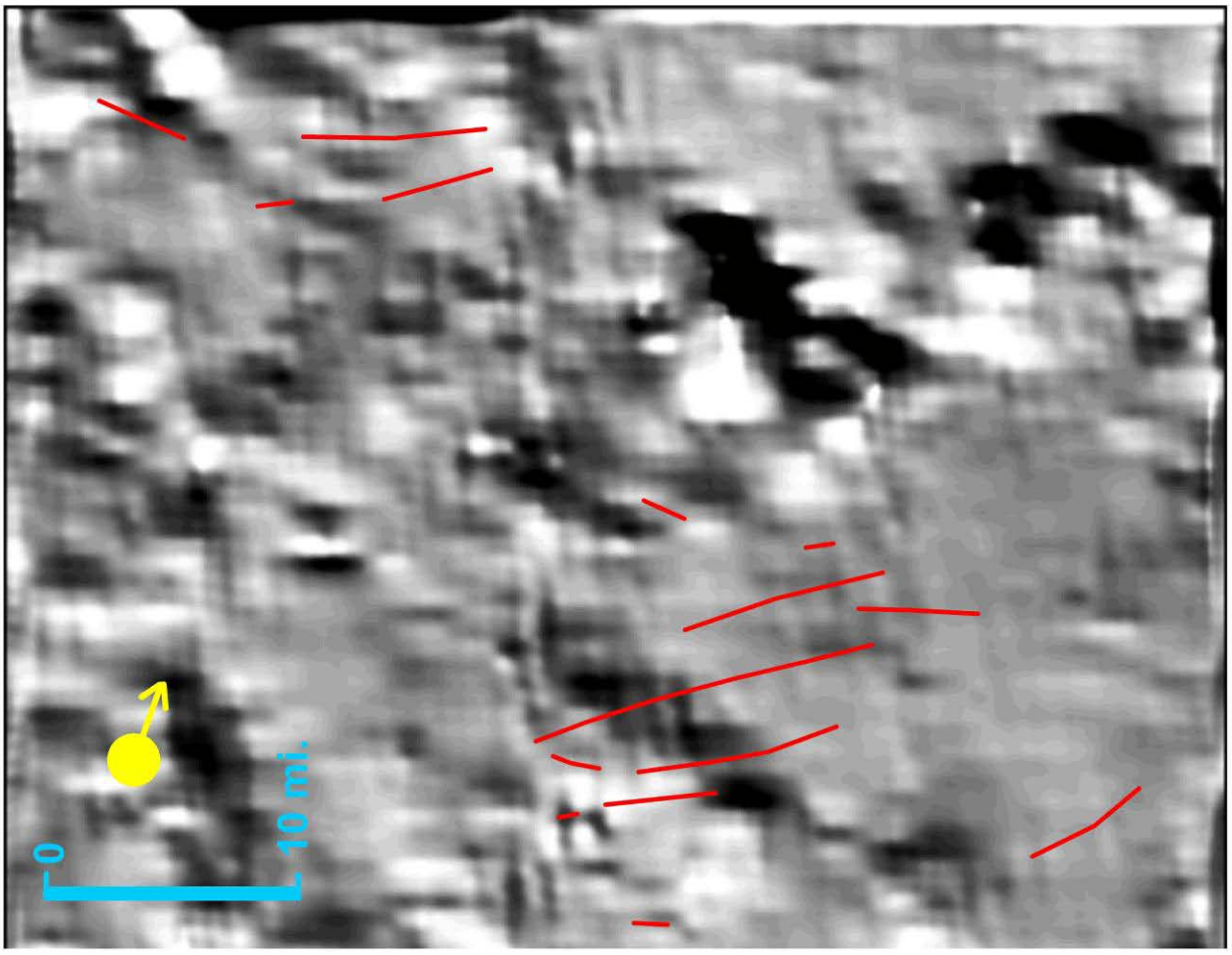


Residual magnetics (public domain) in northeast Ohio



North northeast shaded relief of residual magnetics (public domain) in central New York state

(Gravity data courtesy of GETECH)



South southwest shaded relief of residual magnetics (public domain) in central New York state

(Gravity data courtesy of GETECH)

Observations and Summary

- Proprietary magnetic and gravity data successfully imaged known Michigan FRHTDRs.

- Public domain gravity and magnetic data successfully imaged known FRHTDRs in SE Michigan/NW Ohio and NE Ohio

- Public domain magnetic data was less successful in New York.
    - It is likely the decrease in success relates to data quality.
- **Conclusion** – Can use gravity and magnetic data to target 3-D seismic surveys.
    - Use available data where adequate. Attain higher quality data where necessary.

Acknowledgements

- Westshore Consulting for giving me the time to do this and their support.
- Gary Thompson from GETECH for letting me use their data.
- Parker Gay from Applied Geophysics, Inc., for letting me use their data.