Structurally Related Migration of Hydrocarbons in the Central Appalachian Basin of Eastern Ohio*

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Abstract

The study of topography to determine geology and geologic events is one of the basic principles of geomorphology. A review of data from the National Elevation Dataset has allowed for an in depth study of the surface topography of Ohio on a macro scale. Surface features and interpreted lineaments are correlated with detailed subsurface maps. Topographic lows are interpreted to have developed along zones of preexisting weaknesses in the form of joints, faults, fractures, or some structural component. Topographic highs have sometimes been interpreted to develop as a result of actual structural uplift. Surface topography can, in many cases, be shown to correlate to actual basement structure.

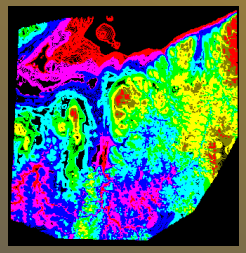
These zones of weakness, or fracture zones, can be correlated to known productive oil and gas fields in eastern Ohio and are interpreted to be major routes of migration for hydrocarbons. Migration occurs both vertically and horizontally along fracture zones which allows for updip migration. Vertical migration along fracture zones can account for downsection migration of hydrocarbons.

There are at least four major fracture zones that are interpreted to allow for migration from deeper in the Appalachian Basin in Pennsylvania and West Virginia. An additional fracture zone is interpreted to account for the migration of high nitrogen gas from the Kentucky portion of the Appalachian Basin. Migration patterns updip are believed to be controlled by an assortment of fracture zones, hinge lines, and structural arches, most of which are basement related.

Direct correlation of surface topography and migration routes to productive Ordovician/Cambrian oil and gas fields is demonstrated. Analysis of surface topography is shown to be a useful tool in exploration methodology.

Reference

Ryder, R.T., 2008, Assessment of Appalachian basin oil and gas resources: Utica-Lower Paleozoic Total Petroleum System: U.S. Geological Survey Open-File Report 2008–1287, 29 p.



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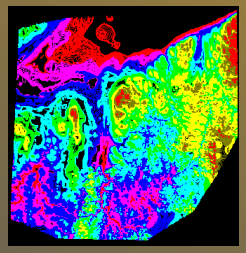
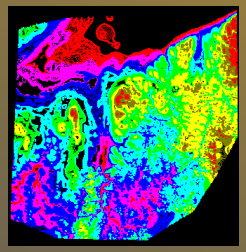


Structurally Related Migration

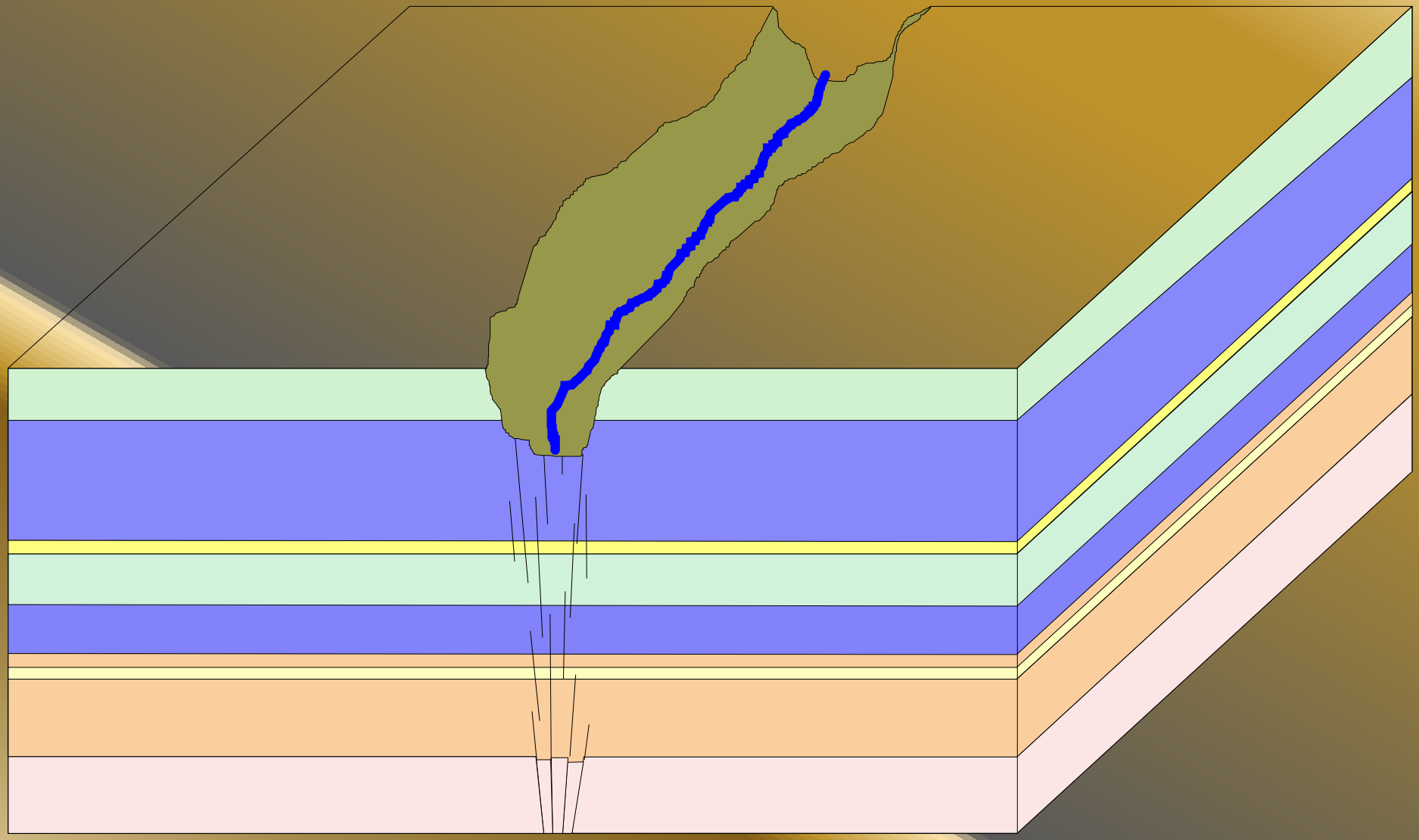
- Introduction and conceptual framework
- Methodology
- macro examples
- specific examples
- Conclusions



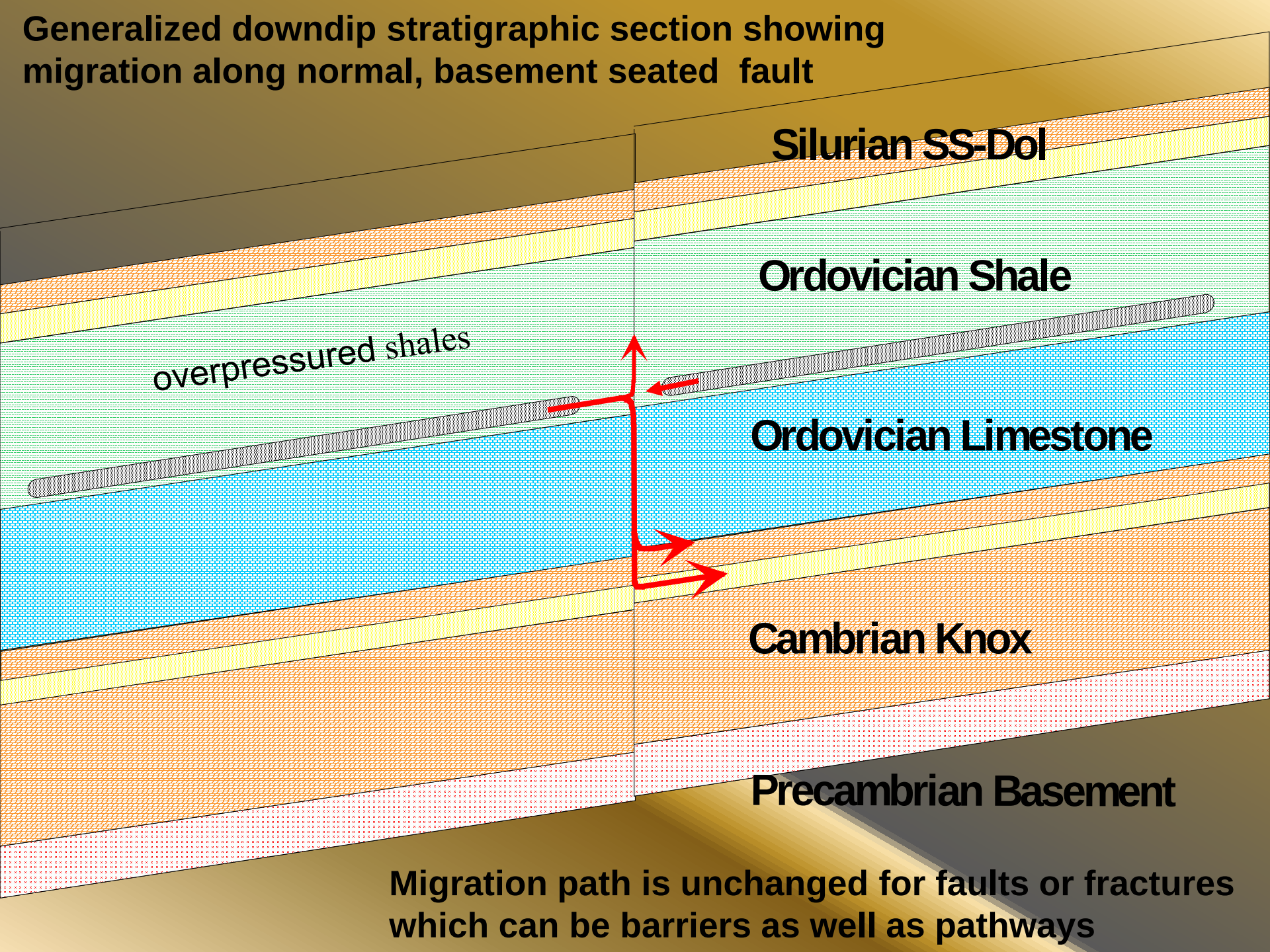
Introduction

- Fracture zones as geomorphic zones of weakness
- Topographic relief as surface expression of recurrent basement zones of weakness
- Hydrocarbon Sources and pathways of migration

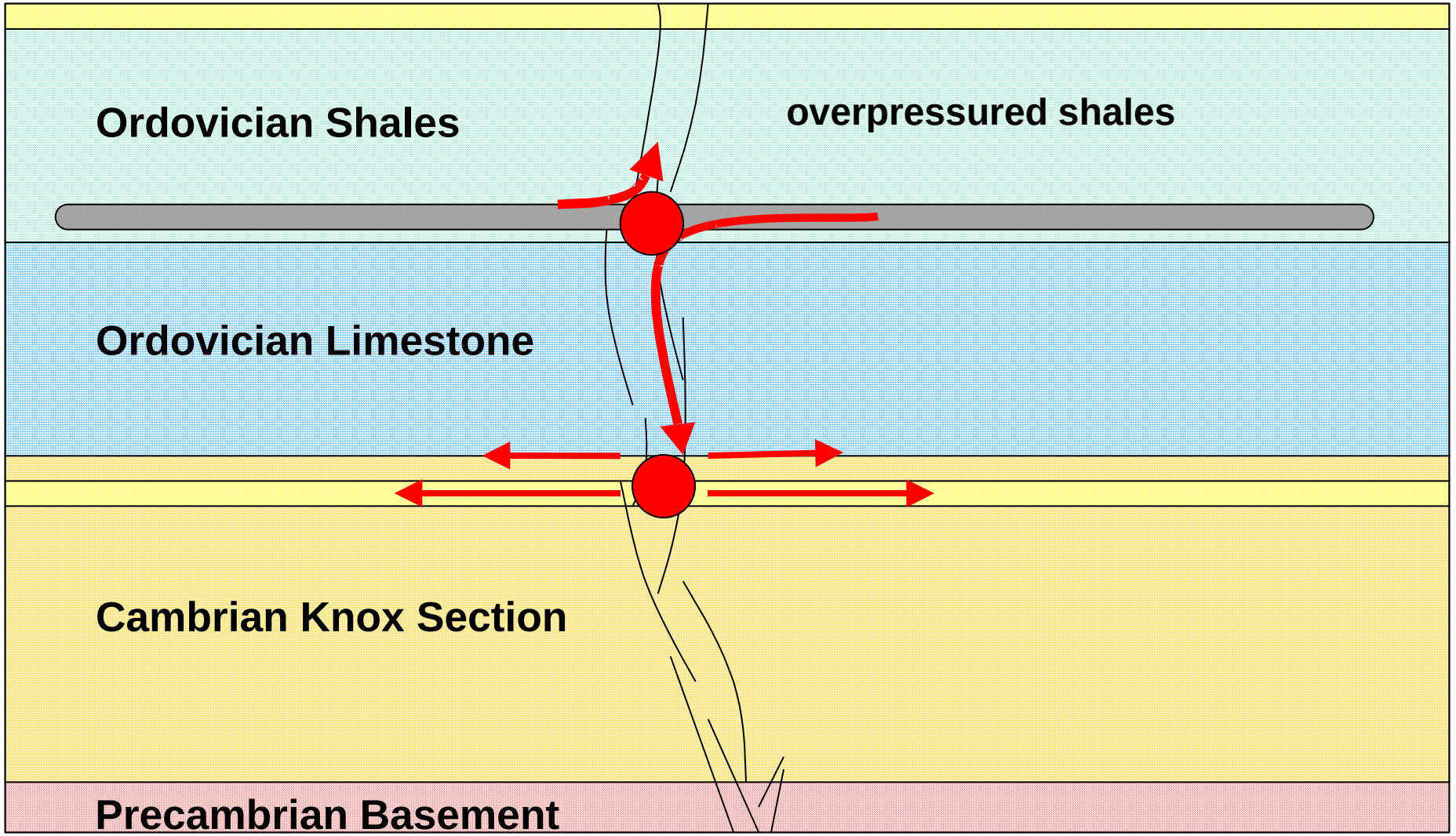
Valley created as a result of fracture weakened surface

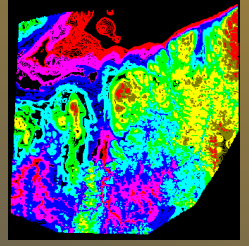


Recurrent basement movement generates fracture field


Generalized downdip stratigraphic section showing migration along normal, basement seated fault
Silurian SS-Dol
Ordovician Shale
overpressured shales
Ordovician Limestone
Cambrian Knox
Precambrian Basement
Migration path is unchanged for faults or fractures which can be barriers as well as pathways

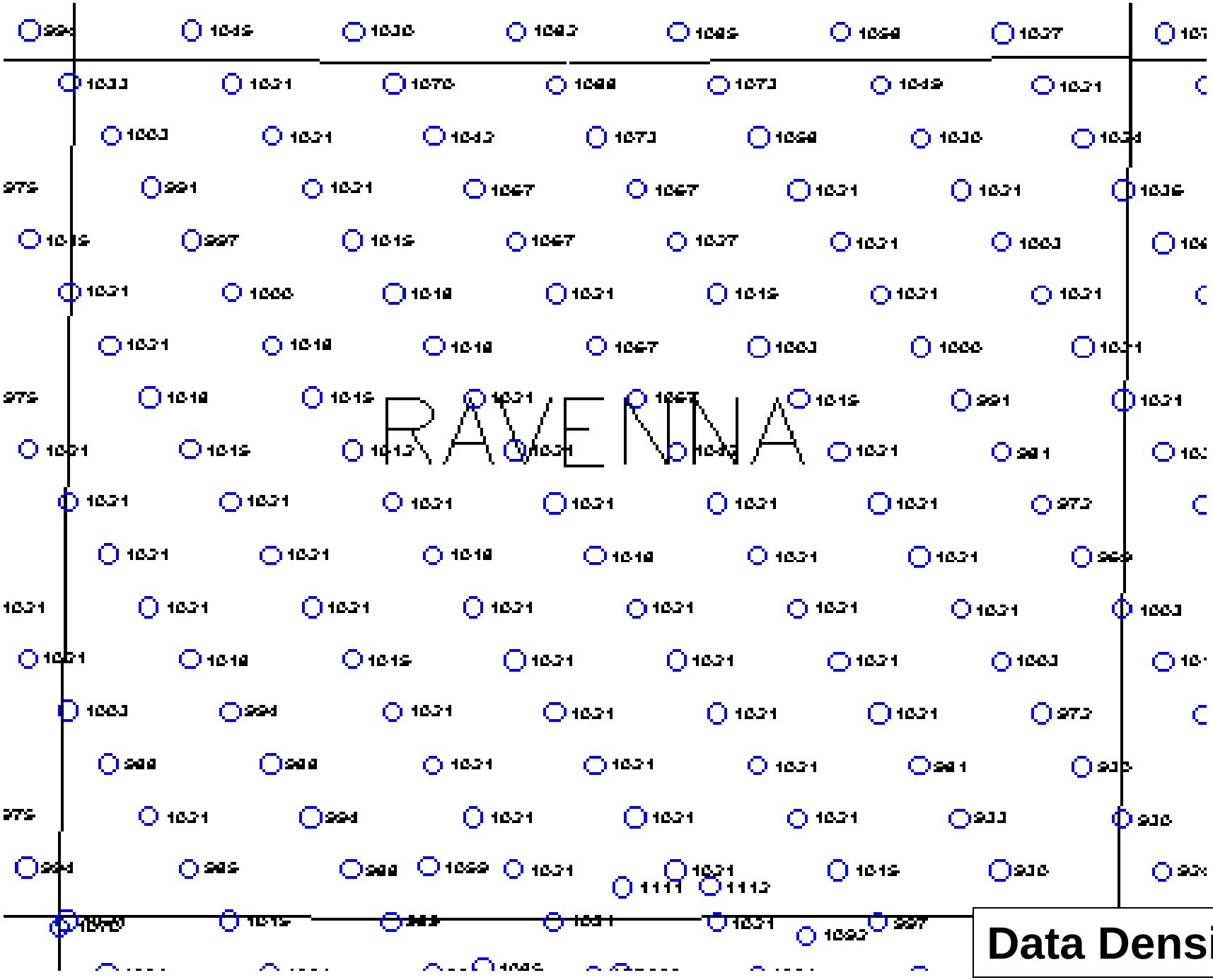
Generalized Stratigraphic section looking updip, showing migration paths along basement generated fracture field



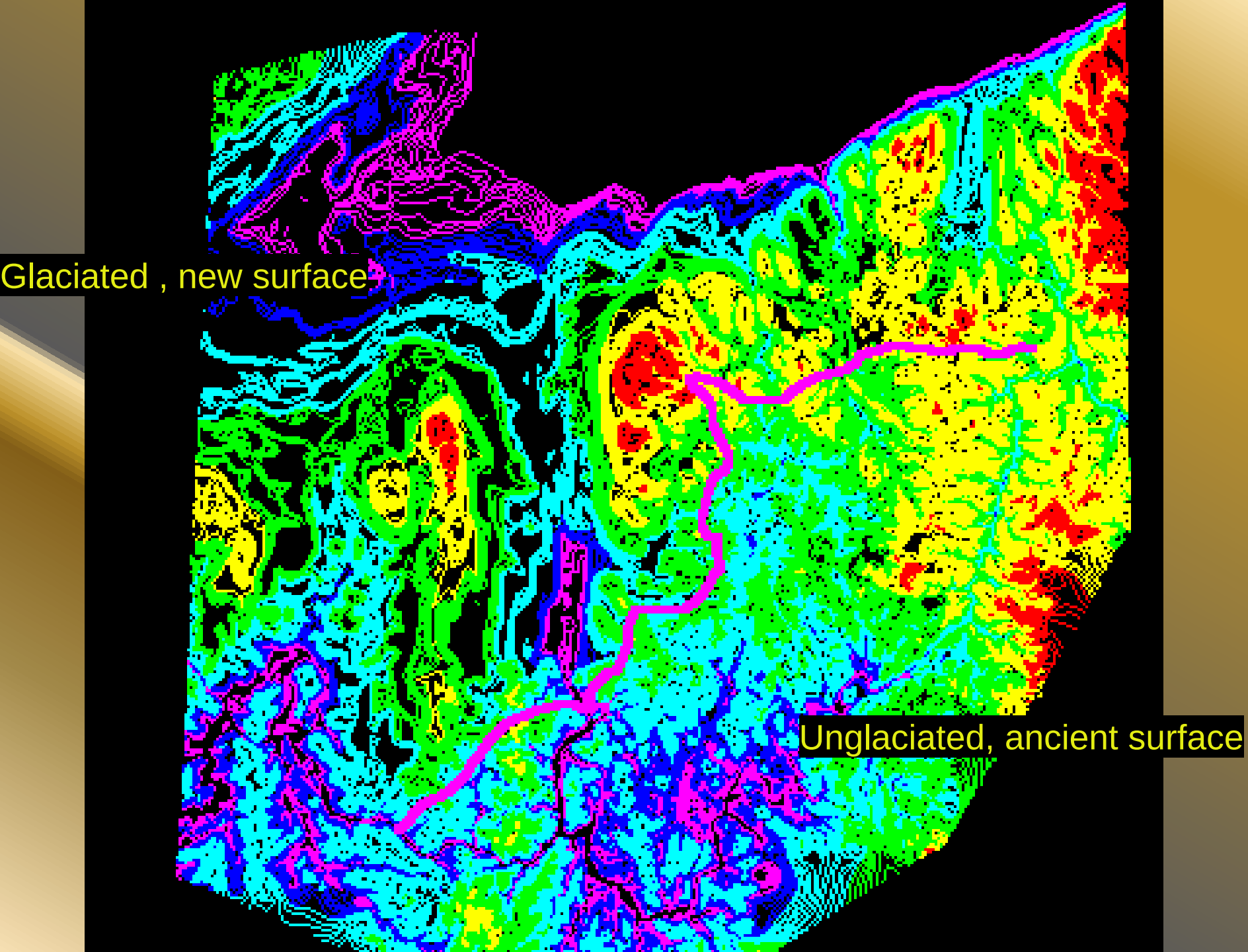


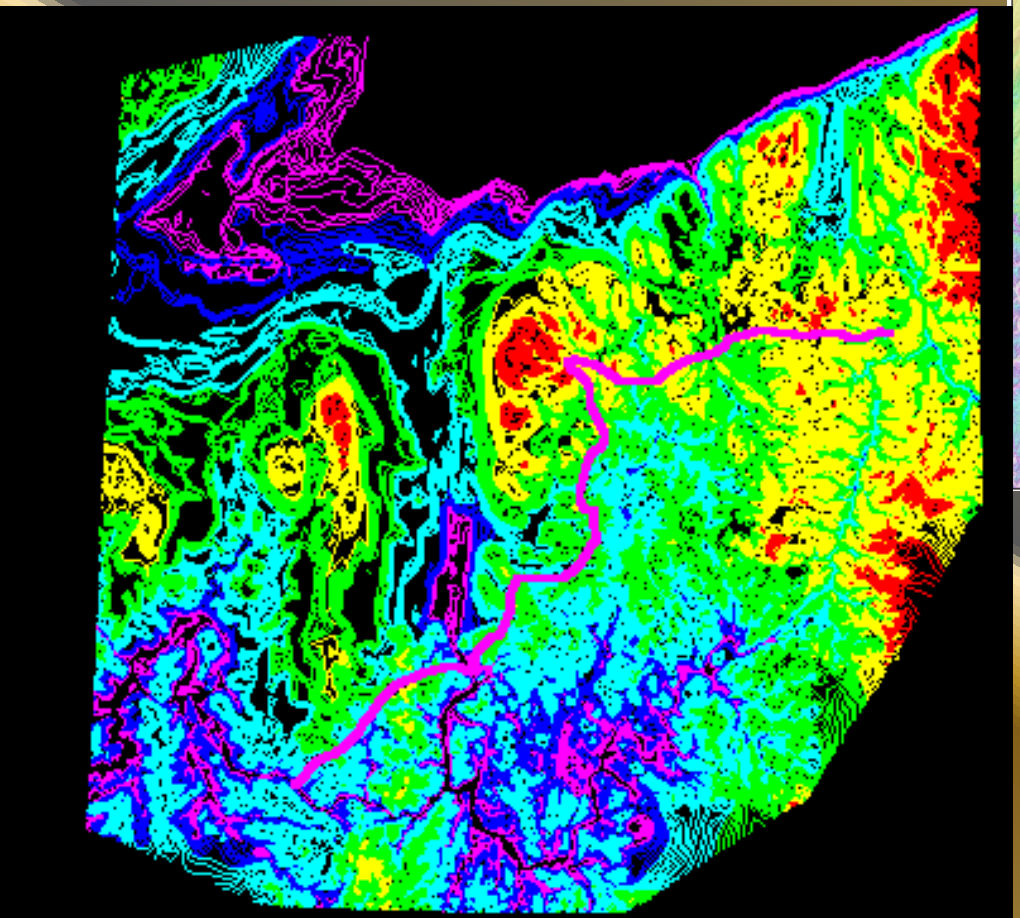
Methodology

- USGS Digital Elevation Models
- Creation of Geographix data set with 224,230 individual data points
- Lineament identification from mapped elevation
- Correlation with earthquake, structural surface, and production information

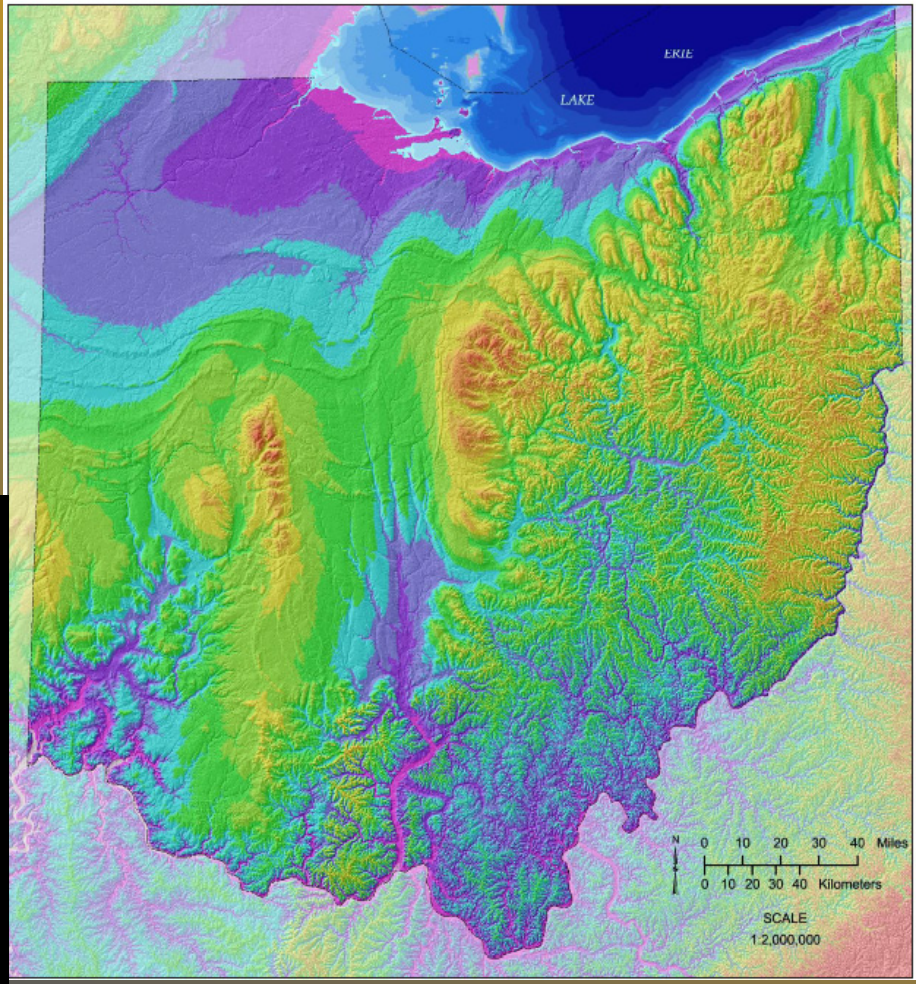


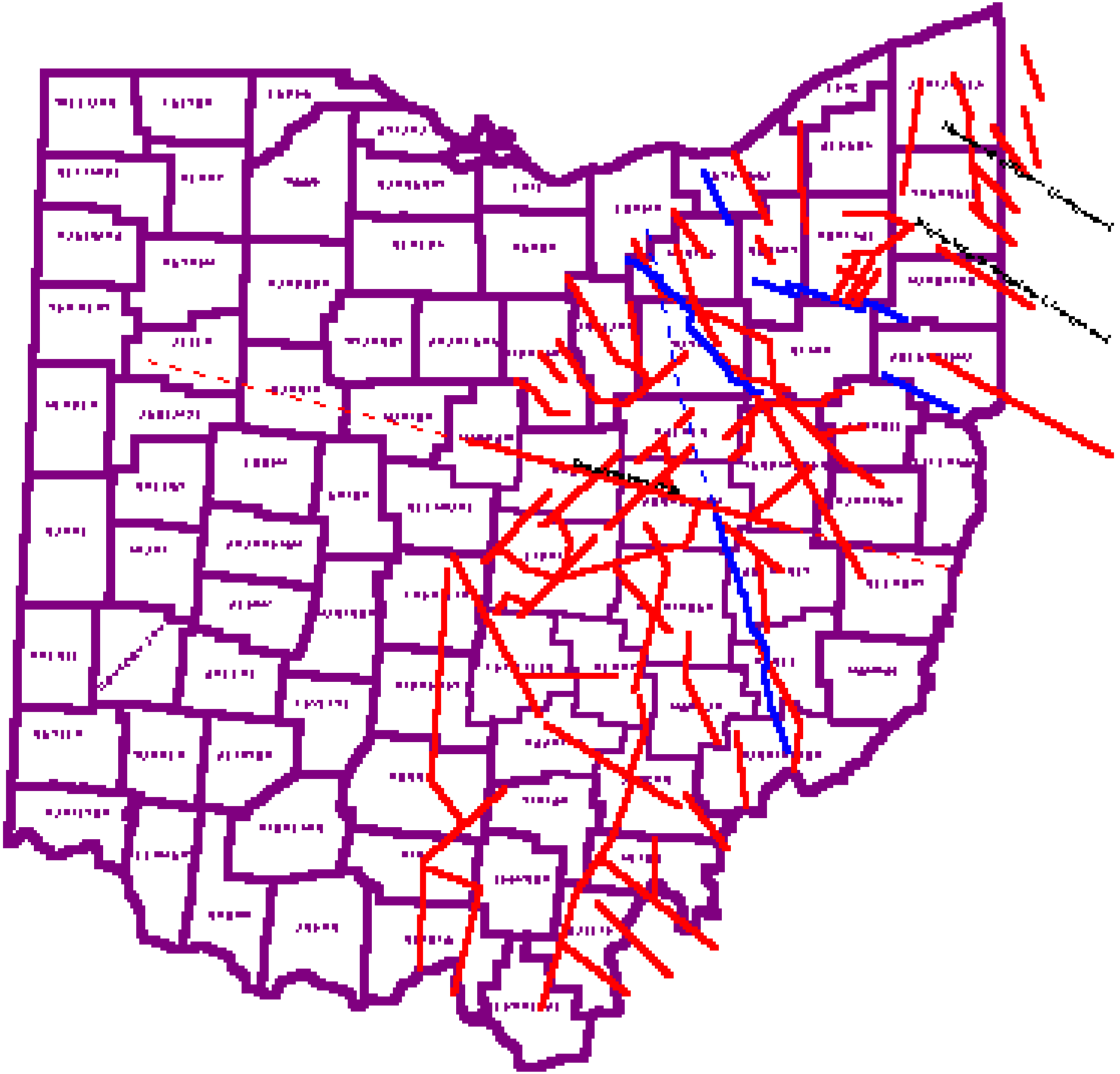
Data Density

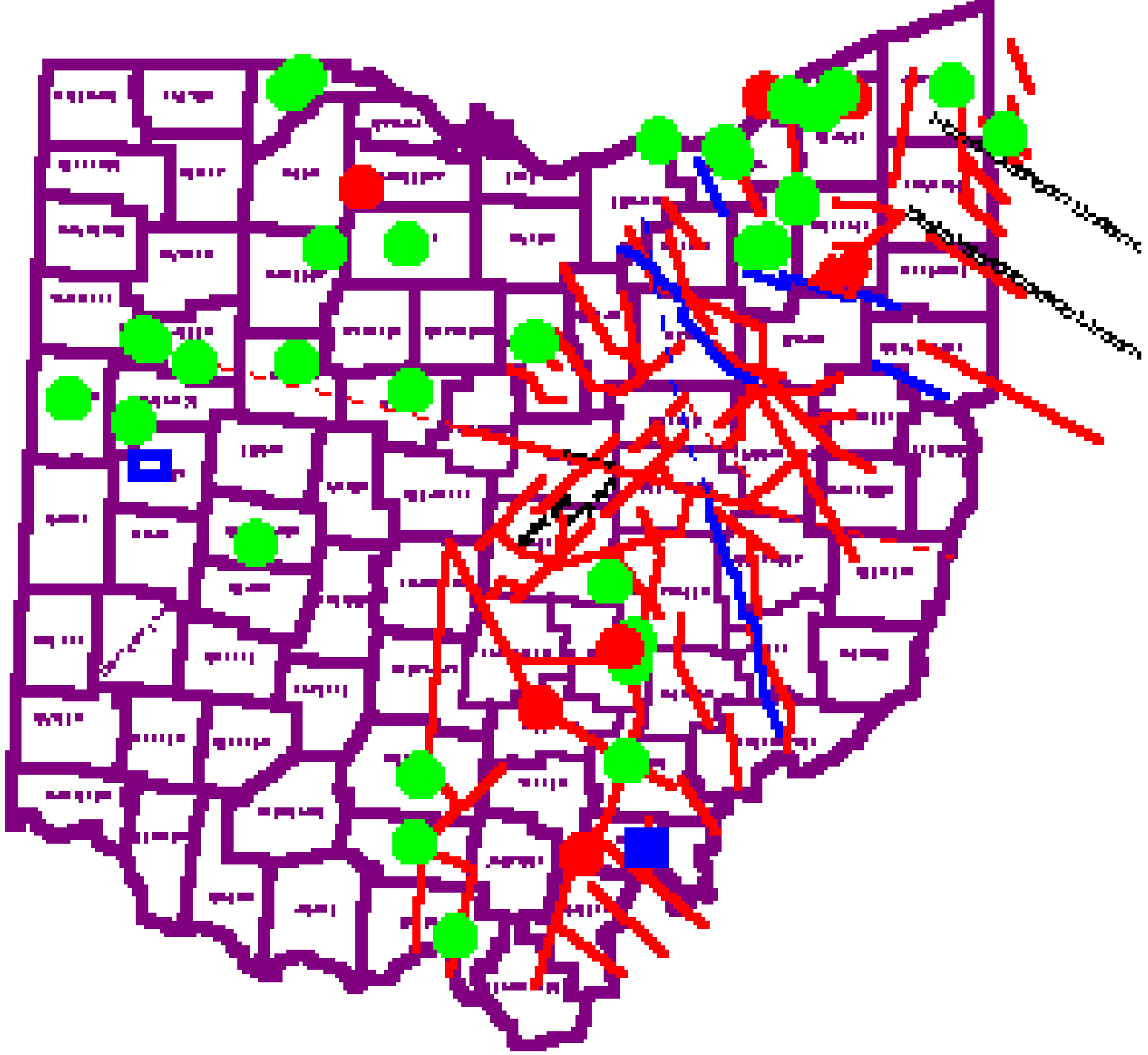

Glaciated , new surface
Unglaciated, ancient surface

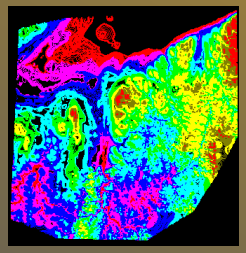


SHADED ELEVATION MAP OF OHIO



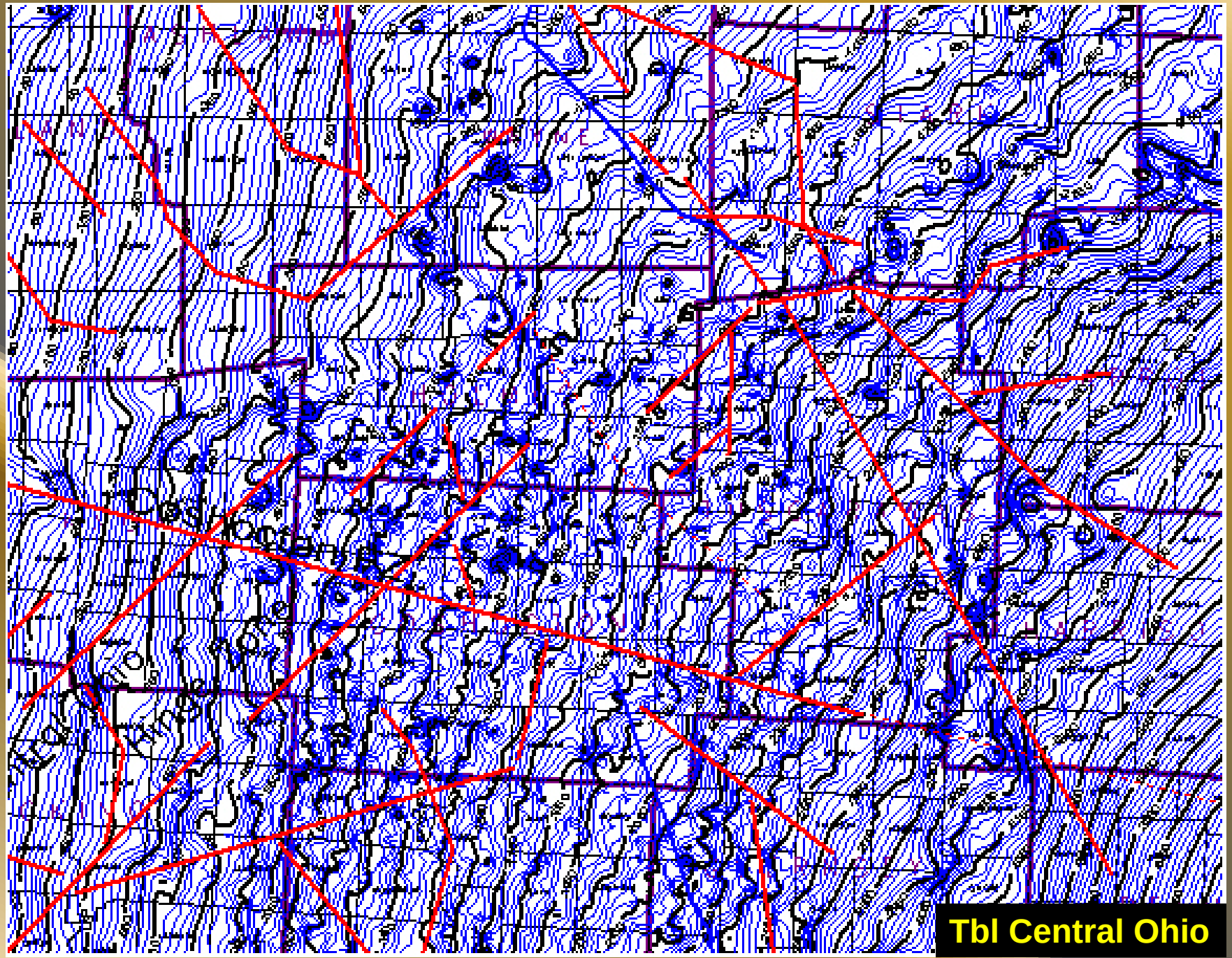


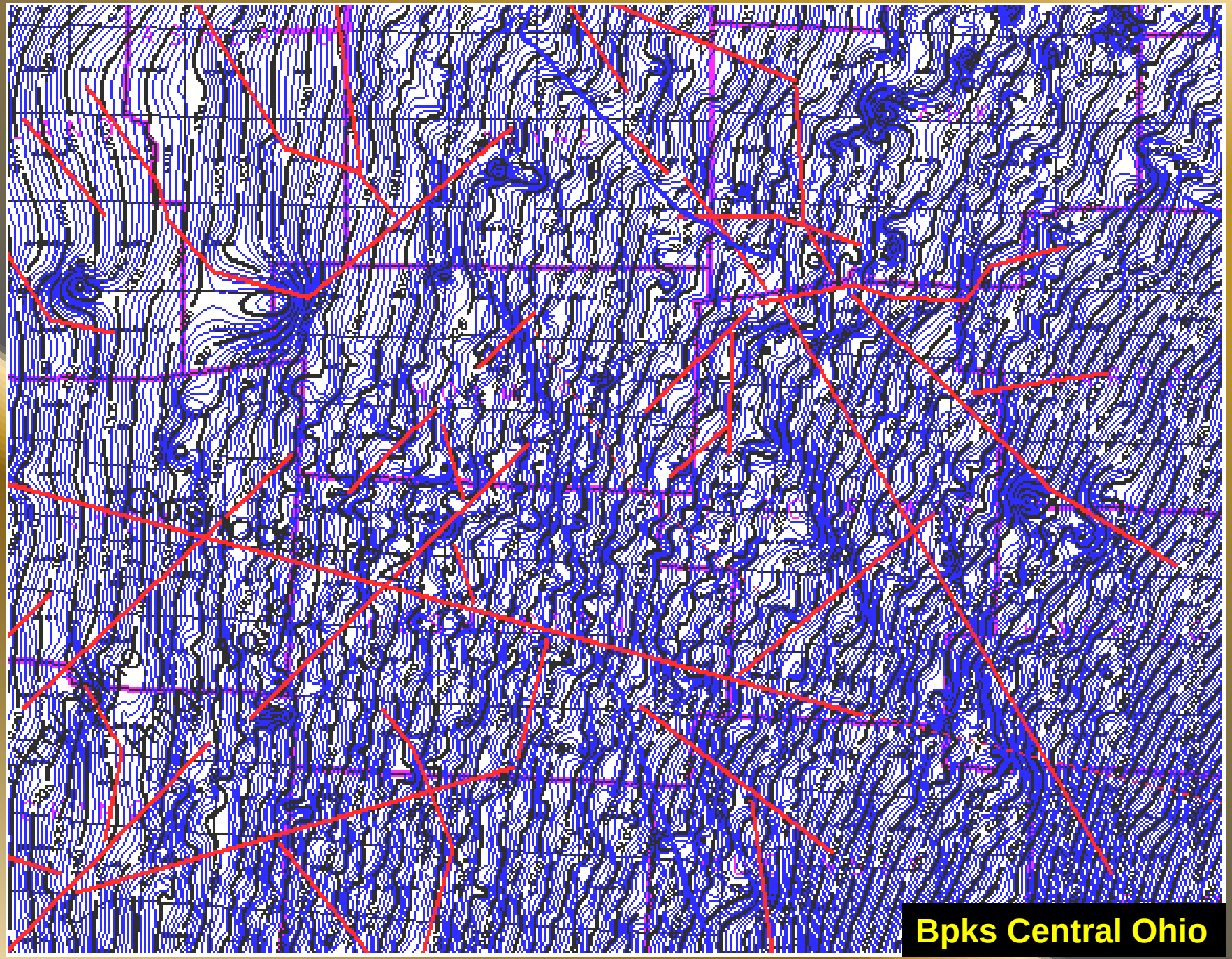


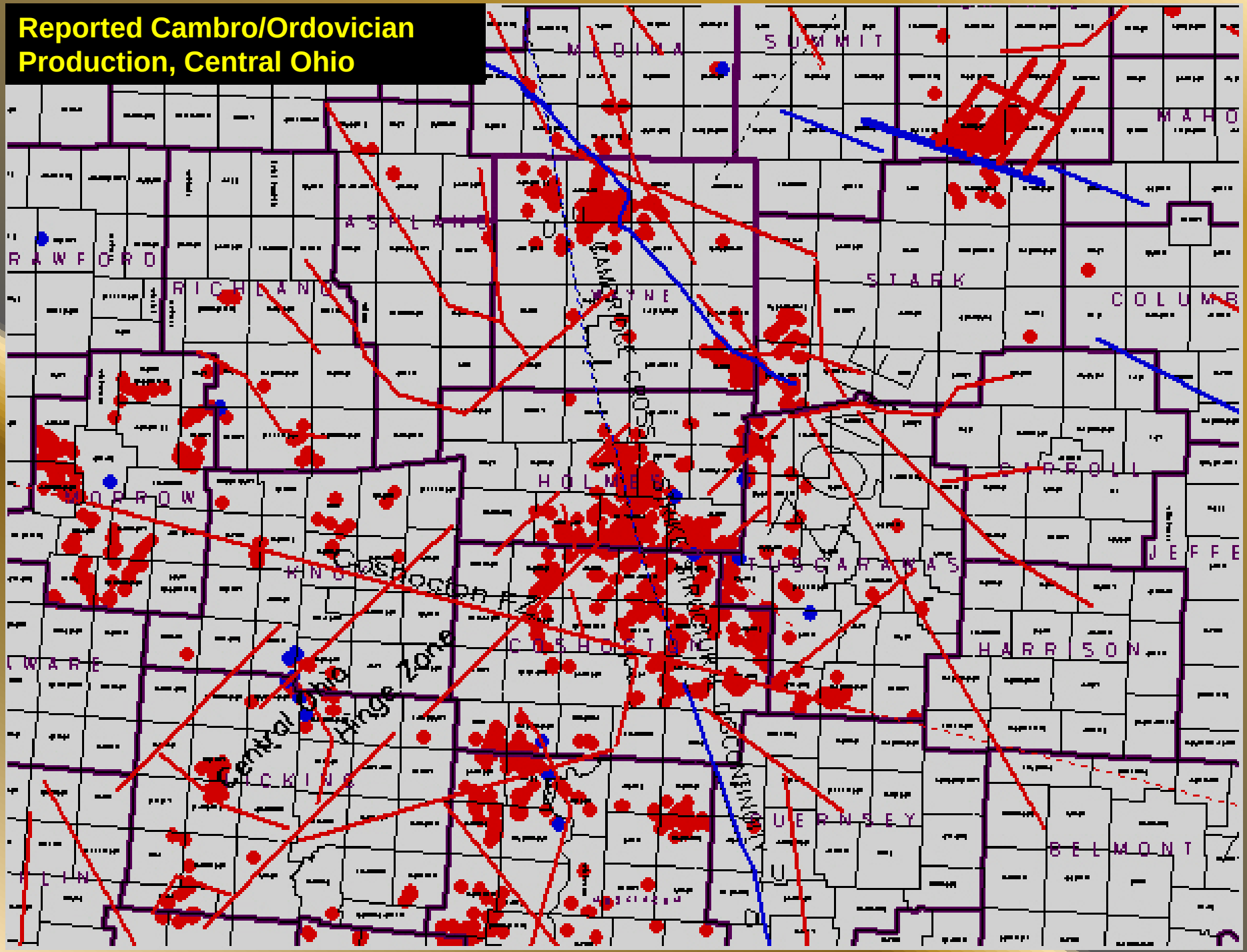


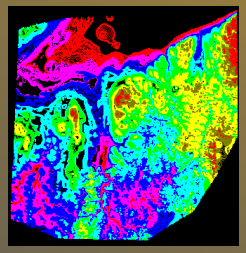
Macro examples

- North central/eastern Ohio look at structural and production data correlated to interpreted linear fracture zones


Tbl Central Ohio

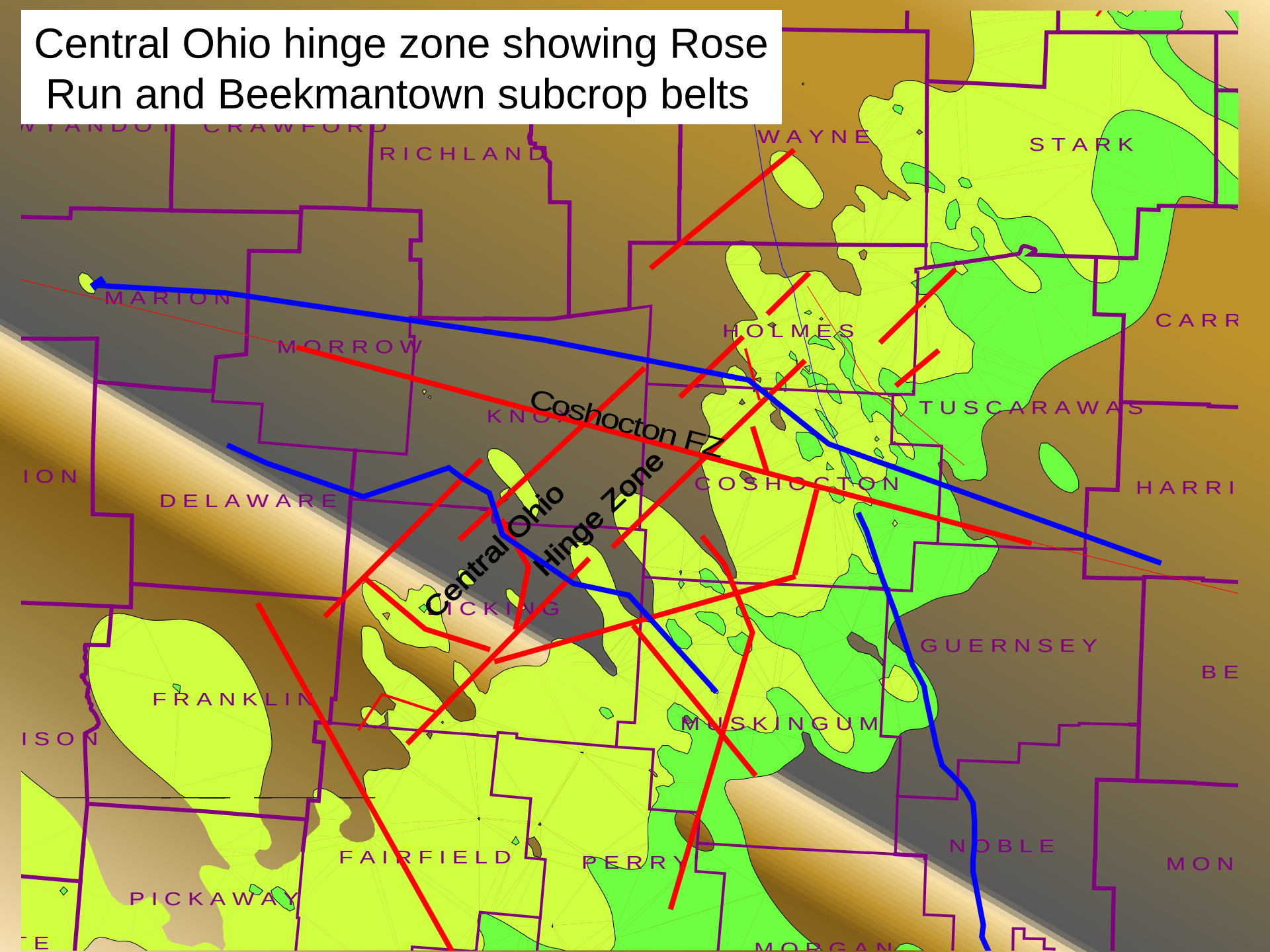

Bpks Central Ohio

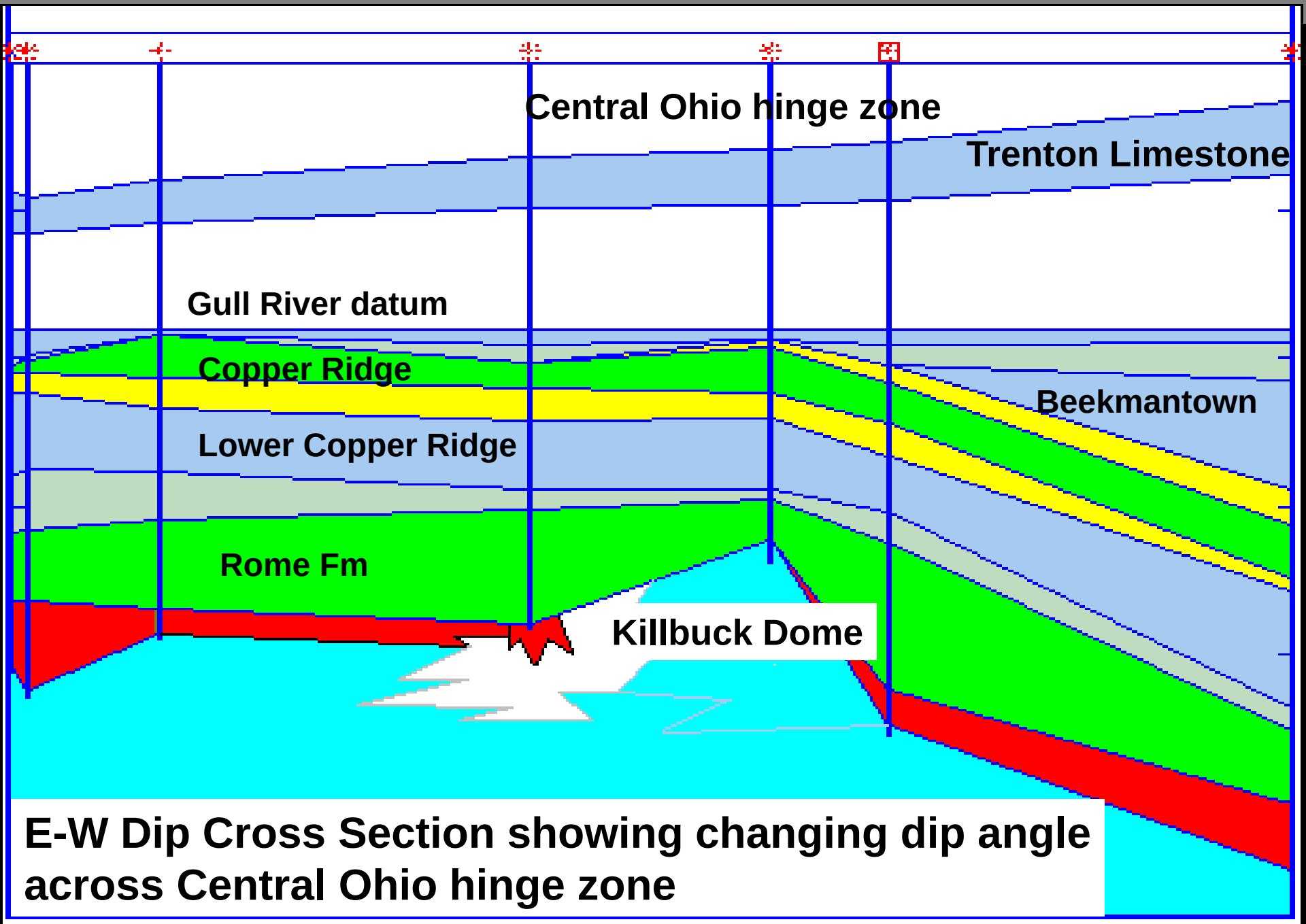

Reported Cambro/Ordovician
Production, Central Ohio
SUMMIT
MAHO
STARK
COLUMB
RICHLAND
HOLMES
CARROLL
JEFFE
TUSCARAWAS
HARRISON
MORROW
KNO
COSHOCTON
LAWARE
LICKING
GUERNSEY
BELMONT
Cambridge Arch
Central Ohio Knox Zone



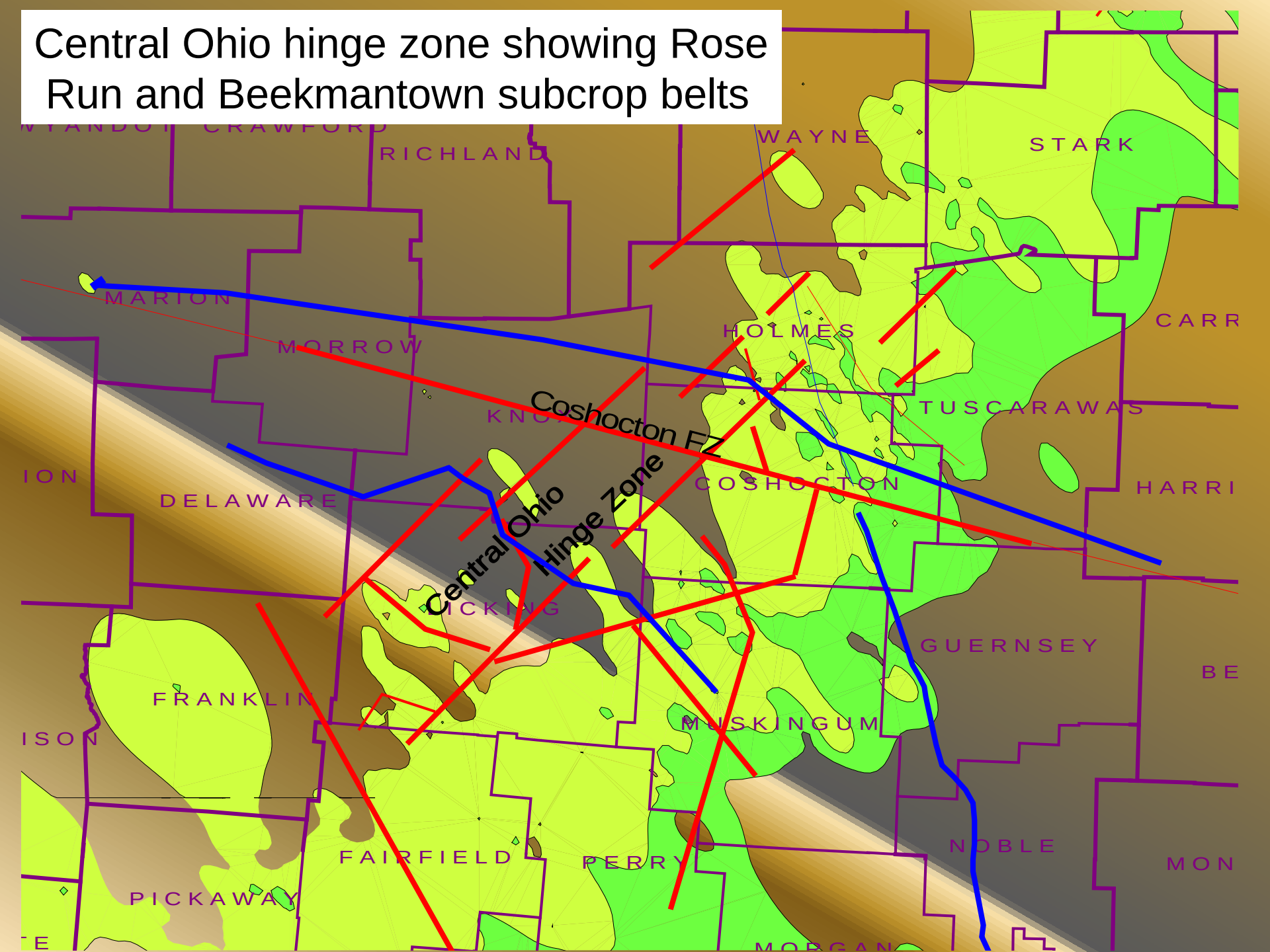
Specific Examples

- Central Ohio hinge zone
- Portage County
- PRIMARY MIGRATION ROUTES


Central Ohio hinge zone showing Rose Run and Beekmantown subcrop belts
RICHLAND
WAYNE
STARK
MARION
MORROW
HOLMES
CARR
TUSCARAWAS
Coshocton FZ
Central Ohio Hinge Zone
COSHOCTON
HARRI
DELAWARE
LICKING
GUERNSEY
FRANKLIN
MUSKINGUM
FAIRFIELD
PERRY
NOBLE
PICKAWAY
MON



E-W Dip Cross Section showing changing dip angle across Central Ohio hinge zone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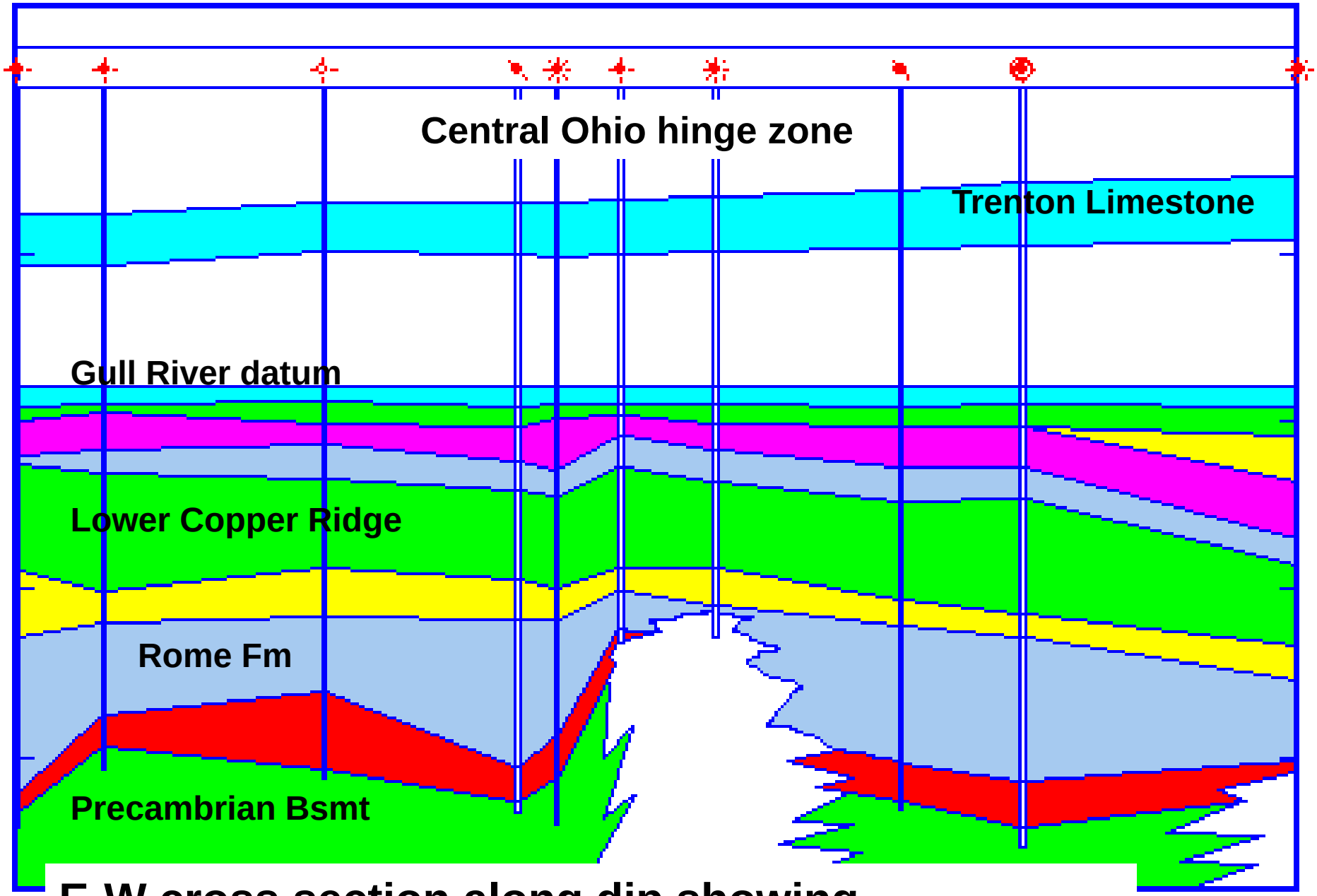
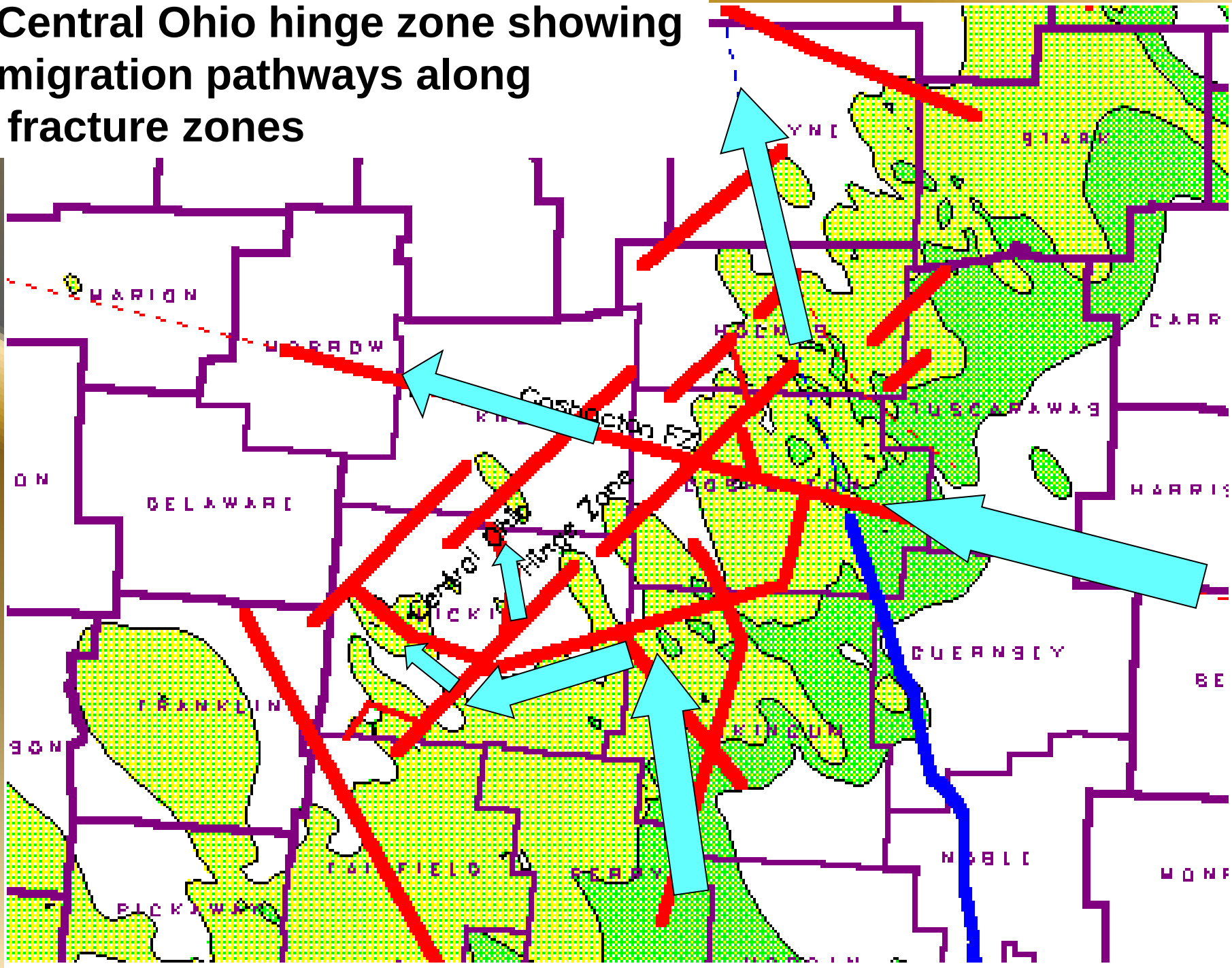
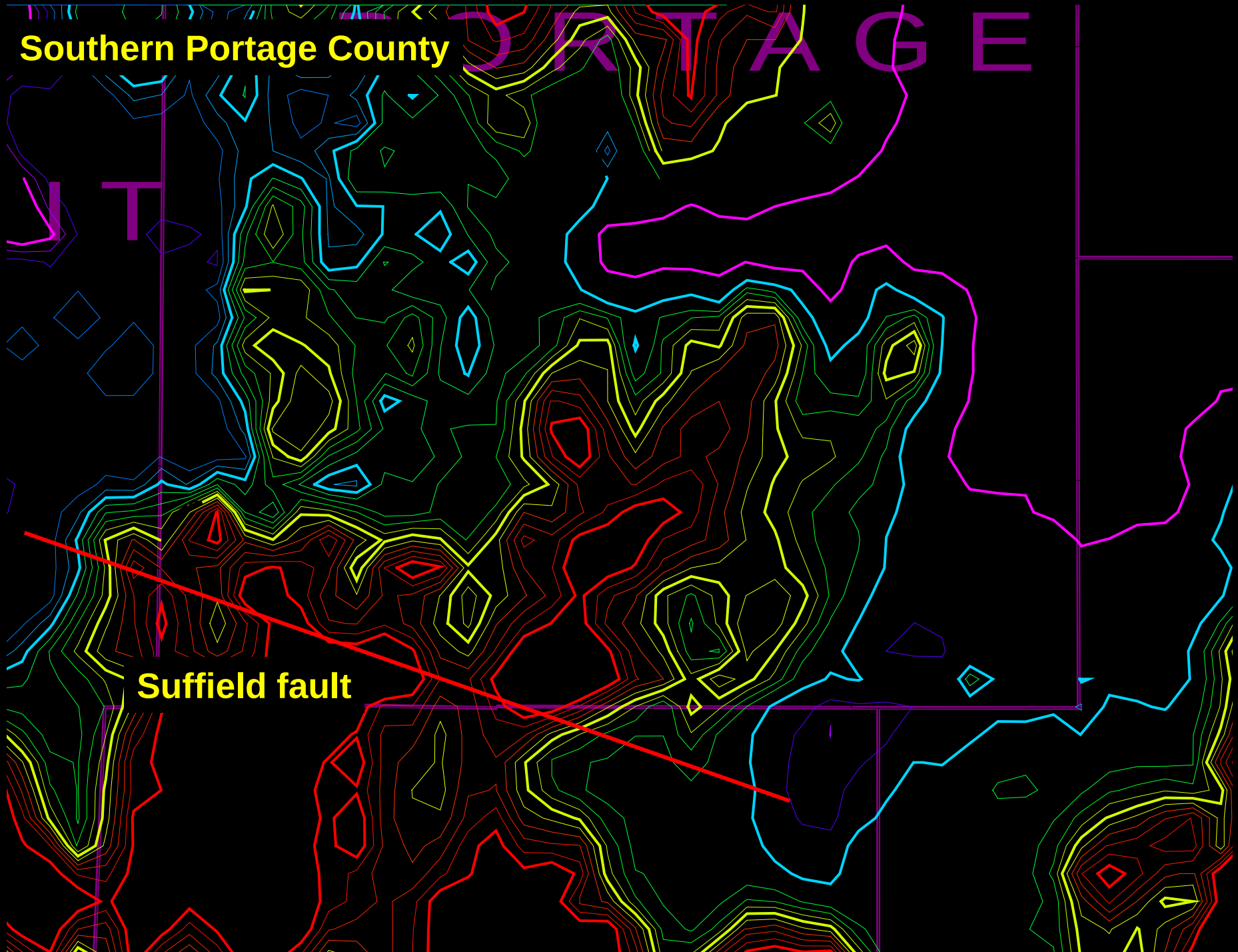
Central Ohio Hinge Zone
COSHOCTON
HARRI
DELAWARE
LICKING
GUERNSEY
FRANKLIN
MUSKINGUM
FAIRFIELD
PERRY
NOBLE
PICKAWAY
MON

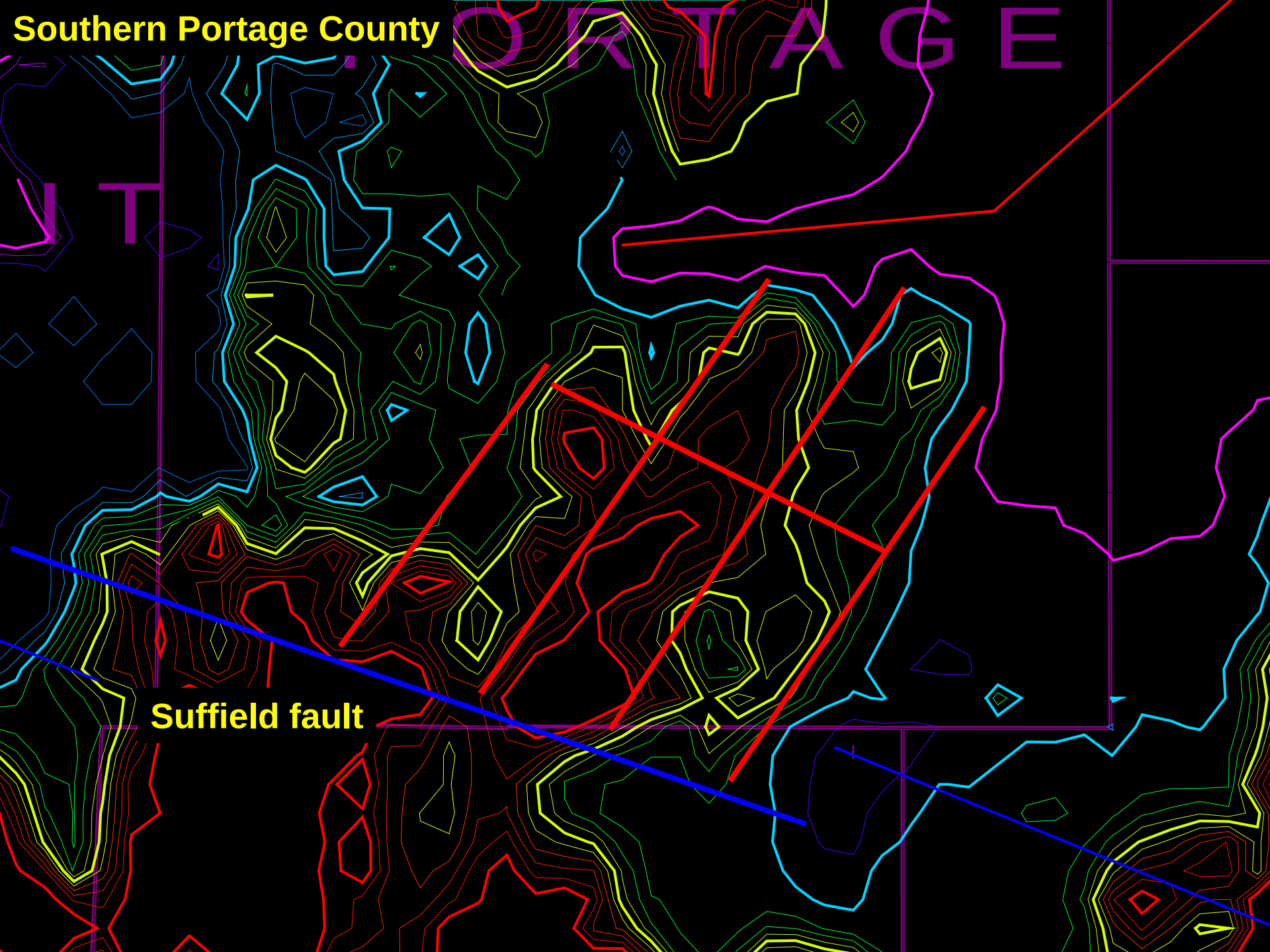


E-W cross section along dip showing difference in slope along Central Ohio hinge zone

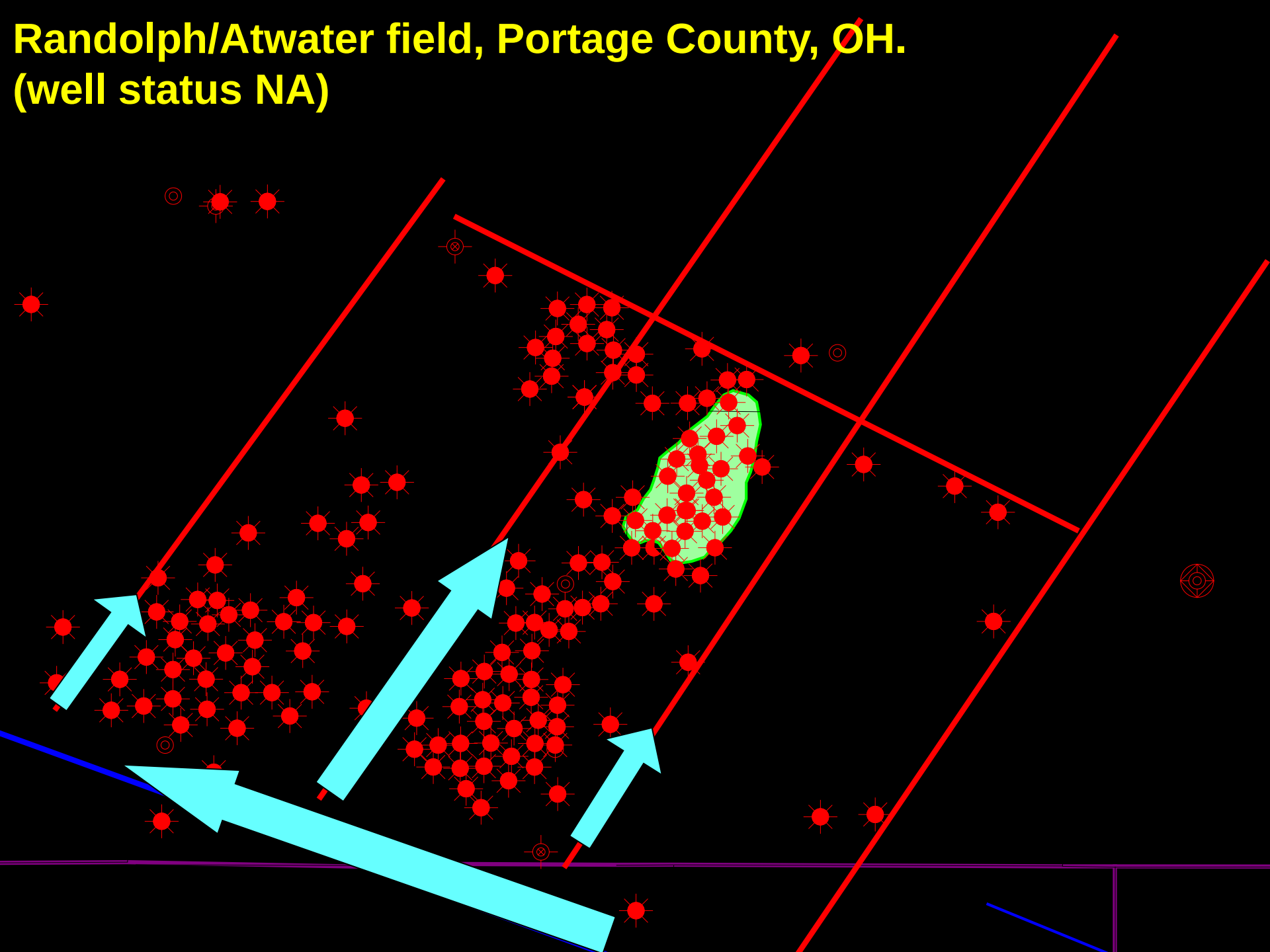
Central Ohio hinge zone showing migration pathways along fracture zones

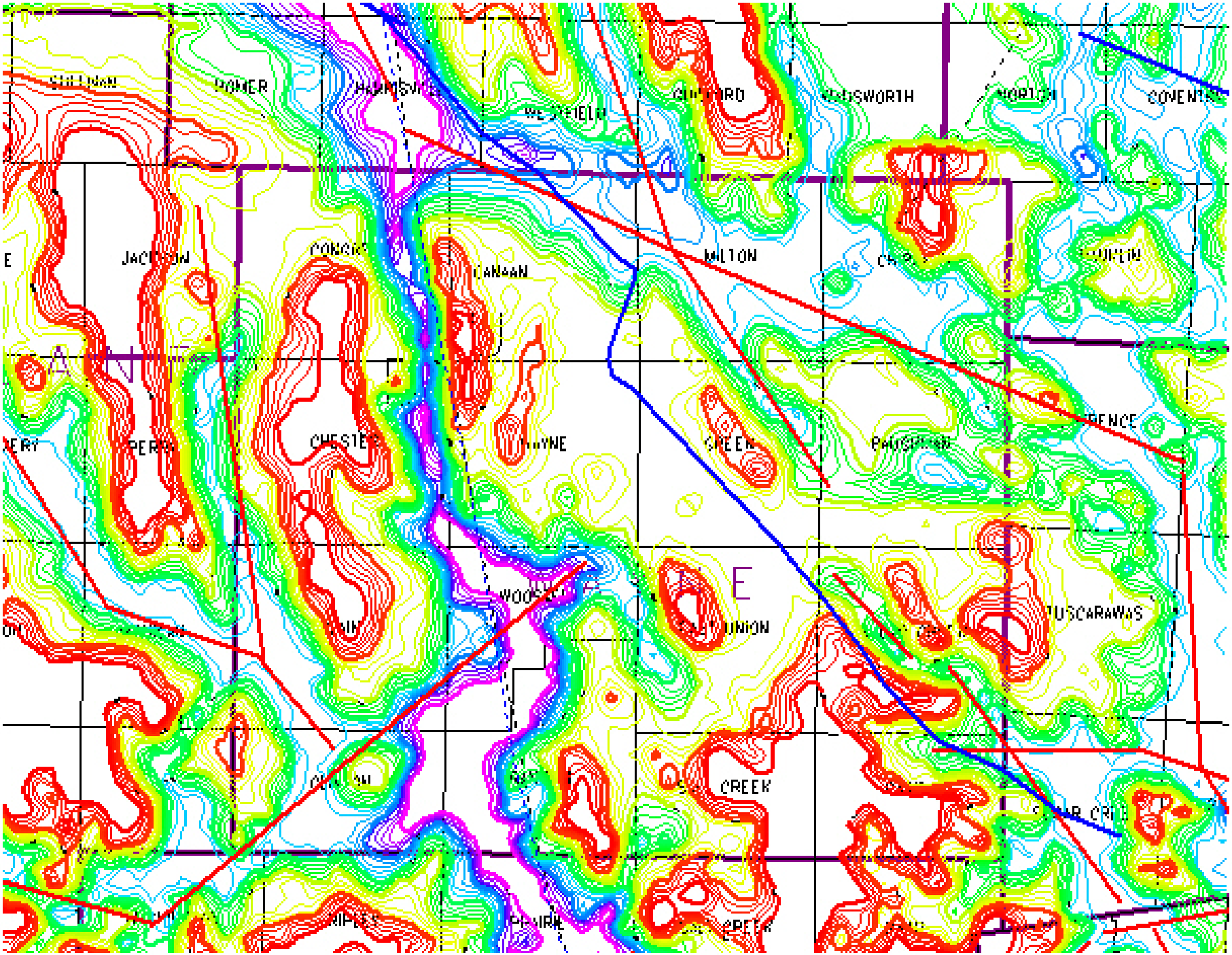


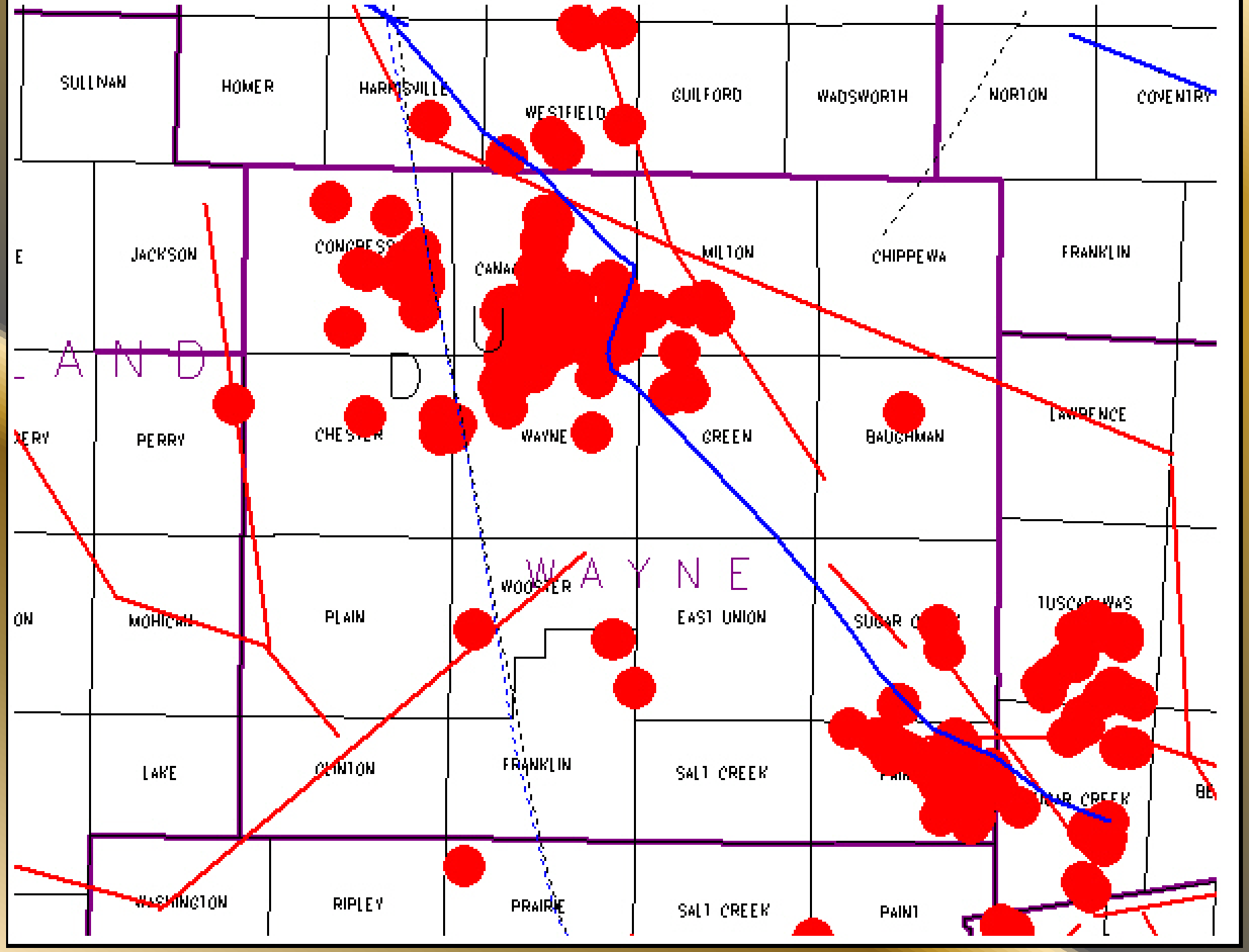

Southern Portage County
Suffield fault


Southern Portage County
Suffield fault

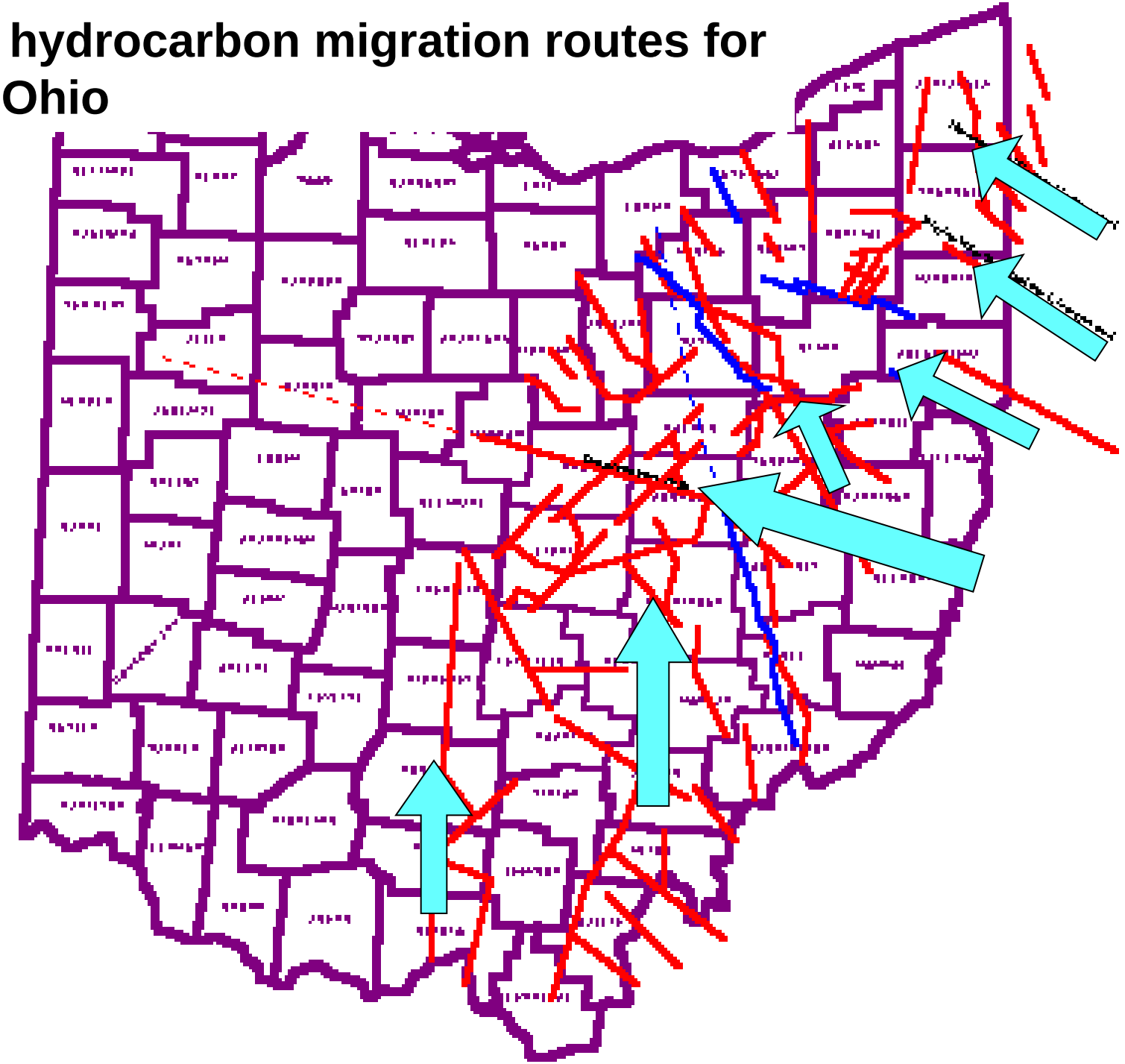
Randolph/Atwater field, Portage County, OH. (well status NA)




JACKSON
CANAAN
MILTON
CHESTER
WAYNE
CREEK
PERRY
FRANKLIN
UNION
TUSCARAWAS
CREEK
CREEK


SULLIVAN
HOMER
HARRISVILLE
WESTFIELD
GUILFORD
WADSWORTH
NORTON
COVENTRY
JACKSON
MILTON
CHIPPEWA
FRANKLIN
PERRY
CHESTER
WAYNE
GREEN
BAUGHMAN
LAWRENCE
WAYNE
WOOSTER
PLAIN
EAST UNION
LAKE
CLINTON
FRANKLIN
SALT CREEK
WASHINGTON
RIPLEY
PRAIRIE
SALT CREEK

Primary hydrocarbon migration routes for eastern Ohio



Ryder, R.T., 2008, Assessment of Appalachian basin oil and gas resources: Utica-Lower Paleozoic Total Petroleum System: U.S. Geological Survey Open-File Report 2008–1287, 29 p

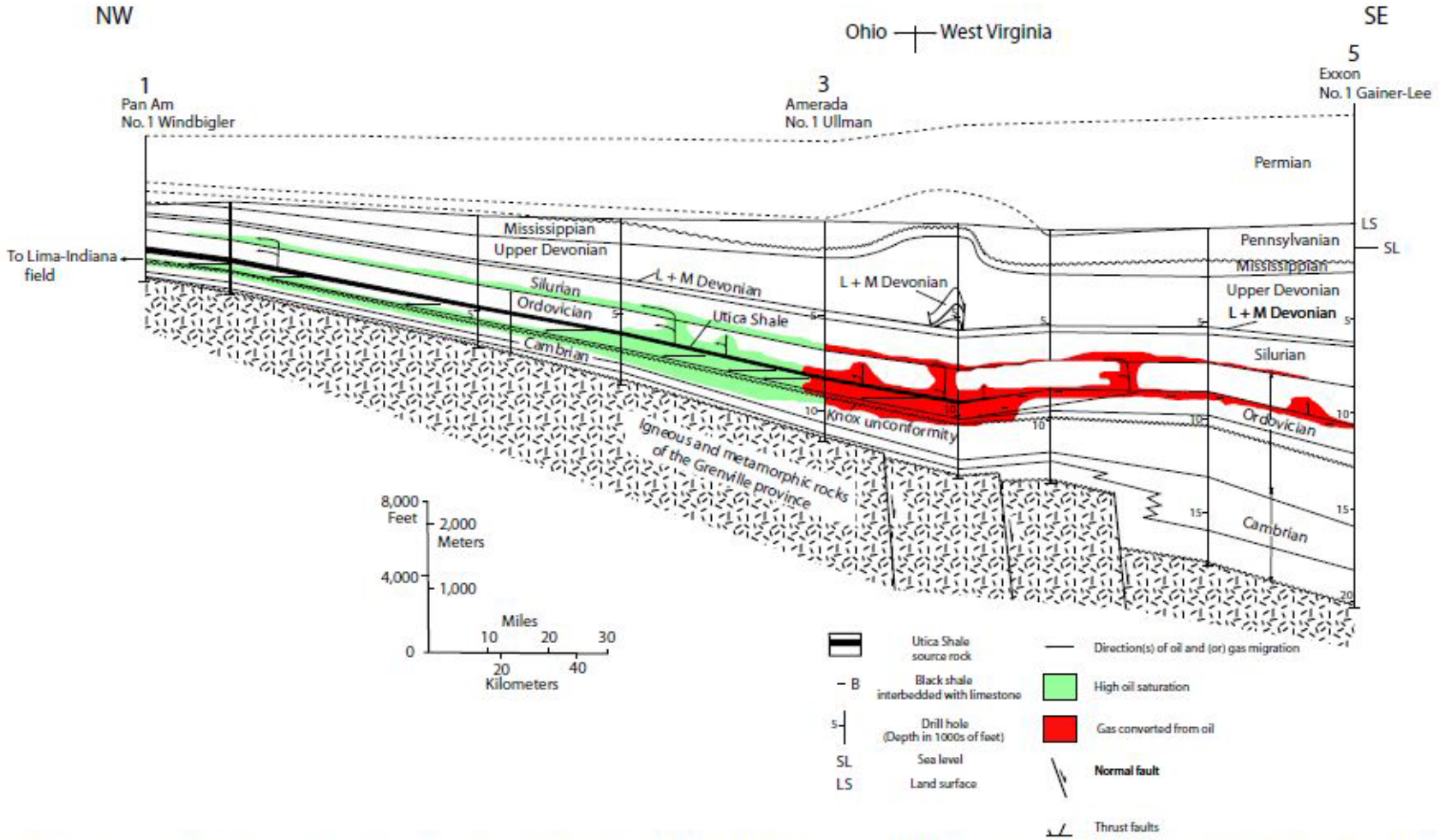
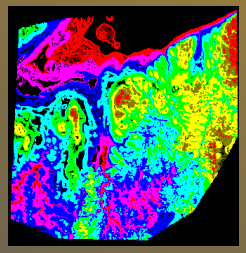


Figure 12. Generalized geologic cross section through the Appalachian basin from central Ohio to western West Virginia showing suggested locations of oil and gas generated from the Ordovician Utica Shale (modified from Ryder and others, 1998). This geologic cross section follows the middle part of the restored stratigraphic cross section through Upper Cambrian, Ordovician, and Lower Silurian rocks shown on figure 3.



Conclusions

- Basement related fracture zones can be demonstrated to translate to the surface in the form of topographic relief
- fracture zones are the primary routes of hydrocarbon migration in eastern Ohio
- BASEMENT RELATED FRACTURE ZONES EXCERCISED SOME CONTOL ON DEPOSITIONAL PATTERNS