December 14, 2016

THE MICHIGAN GEOLOGICAL SURVEY

THE 21ST CENTURY –
NATURAL RESOURCE GEOLOGICAL ASSESSMENTS
MICHIGAN BASIN GEOLOGICAL SOCIETY

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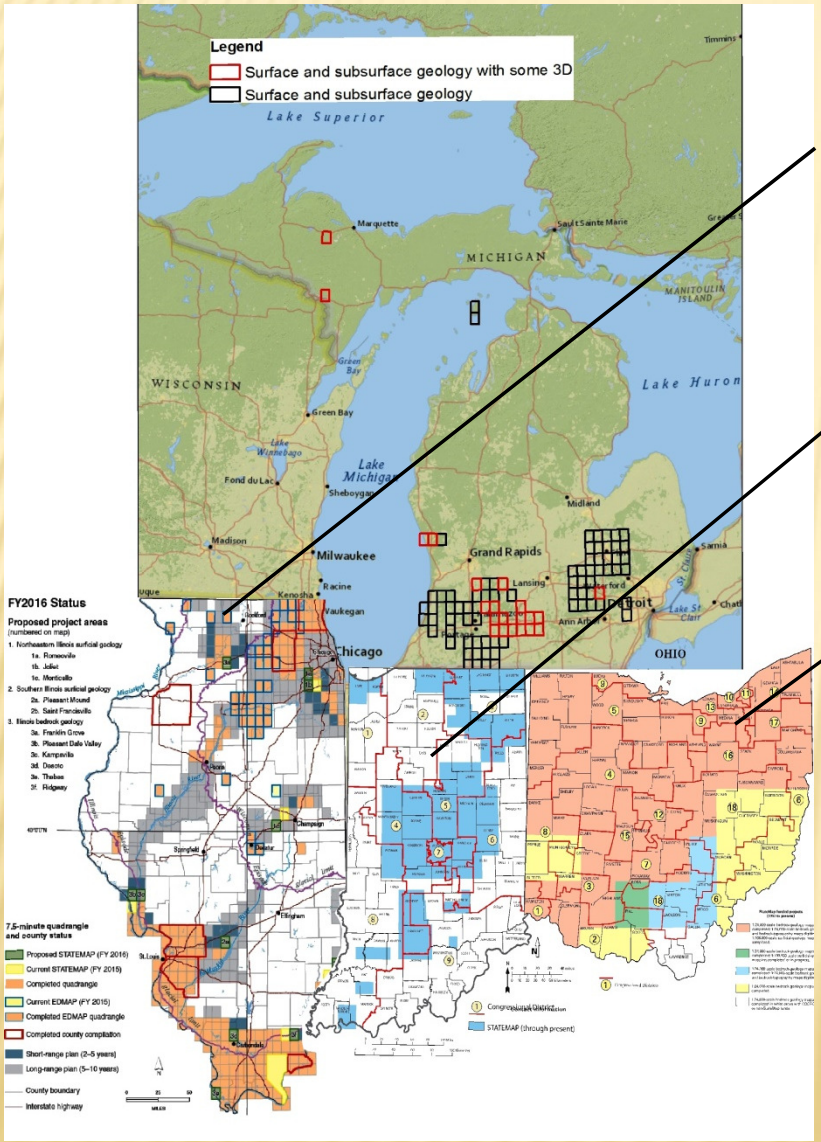
MICHIGAN GEOLOGICAL SURVEY

What is the role of a geological survey?

- Provide scientifically validated research and the data necessary for appropriate natural resource protection, discovery, assessment and management.
- Act as an independent, un-biased authority on geological matters underpinning Michigan's natural resource protection and management.
- Provide and preserve geologic records that can support the natural resource decision makers, public and private.

MAPPING-MICHIGAN VERSUS ADJOINING STATES!



Federal matching dollars in last 24 years

- ✖ Illinois, mapping in high impact and use areas, many priority areas for 3D mapping, ~ 30% mapped. ($4.716M=$196.5K/yr).
- ✖ Indiana, mapping in high impact areas, some priority 3D mapping, ~ 40% mapped. ($4.062 M=$169.2K/yr).
- ✖ Ohio funding from energy and minerals, geo-hazards for mapping in addition to Fed funds ~ 80% mapped ($2.942 M=$122.6 K/yr).
- ✖ Michigan, no dedicated funds in 24 years, not until 2014, $44,000 to support mapping in Cass County, < 10% mapped. ($1.602 M = $66 K/yr).

NATURAL RESOURCES IN THE 21ST CENTURY

Assessing the Natural Resources of Michigan

MGS has received a one time allocation of $500K to establish process and programs to assess natural resources.

- Goal to present benefit(s) for annually funded Geological Survey
- Develop a stakeholder coalition of near and long term needs
  - Stakeholder Survey of eight (8) basic questions - Done
- Develop consensus of priority driven near term tasks or projects
- Develop long term strategy(s) to develop process and programs
- What data, not in a data base can industry provide?- Coalition
- Present completed demonstration projects to stakeholders and Legislators outlining the identification and protection of the natural resources – priority driven near and long term.

MICHIGAN GEOLOGICAL SURVEY

Priority Driven - Validated Research & Data

Proven methods

- Data output has changed and must meet new demands.
- "Boots on the ground" – always
  - Aerial photos, brunton compass, rock samples, paper maps, drawing on maps, chemical or thin section analysis, field check draft maps.
  - Subsurface information, drill core/cuttings, textures, geologic data summaries, possibly ground geophysics.
  - Publish ArcGIS (Drafted) based maps.
  - Data bases that many times do not communicate.
- The users of paper data files, reports? How many today?

MICHIGAN GEOLOGICAL SURVEY - 21ST

Priority Driven - Validated Research & Data

Now combine new and proven technologies and methods

- Maps and reports are needed with validated information, in real time.
- Data in formats (e.g. ArcGIS) accessed by phones, tablets, laptops, actively showing multi layers of data..... in seconds, in the field.
- Secondary mapping products of surface and subsurface data include: water bearing zones, surface drainage, aggregates, wetlands, recharge areas, deeper subsurface research and data, etc.
- Interactive electronic data bases.
- 21st Users: Citizen scientists, city and county planners & developers, geologists, earth scientists, consultants, industry representatives, regulators.

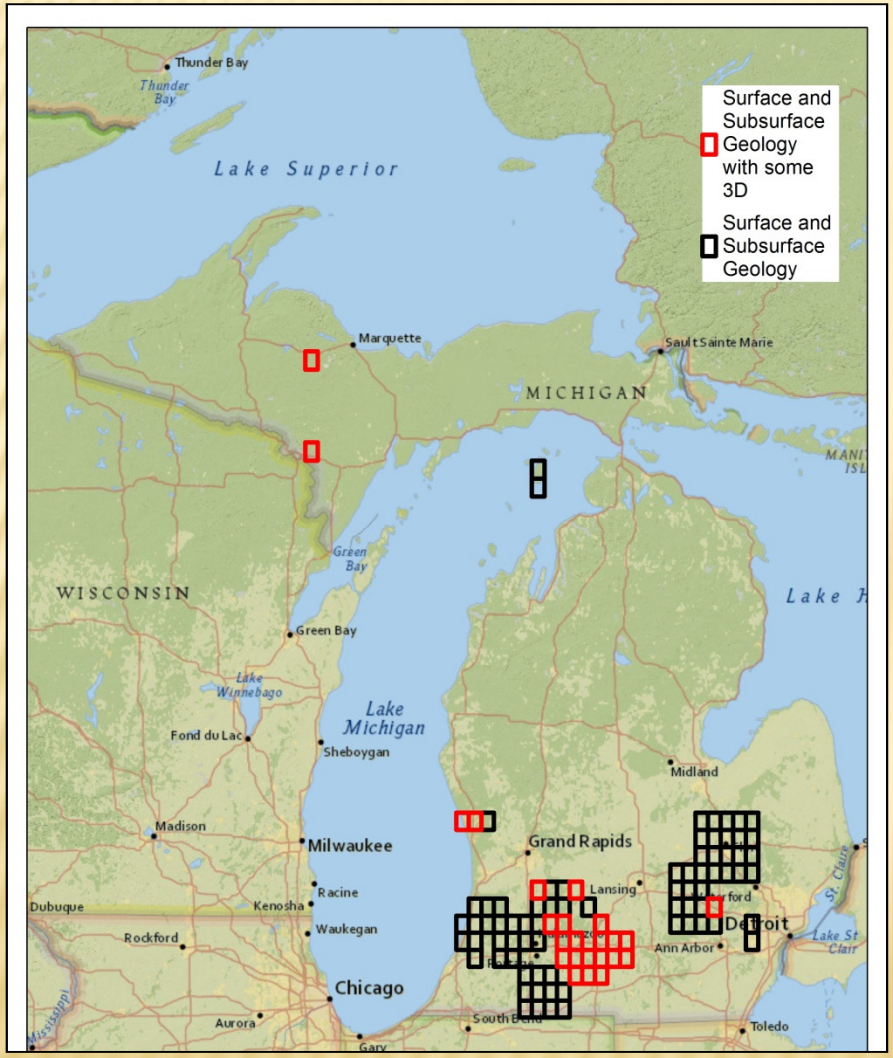
NATURAL RESOURCES IN THE 21ST CENTURY

Expand and combine data collection technologies

- Inclusive with all the standard field mapping methods.

- Airborne surveys - expedite and allow for projecting continuity and verifying surface interpretations, without walking the entire area.
  - These techniques include: LiDAR, remote sensing probes (infrared, spectral) and 3D photos from planes and drones, air and ground geophysical programs, satellite data, (Interferometry, radar, GRACE), etc.
  - What data and format is important today?
  - So where does Michigan have to go?
- We must utilize all available primary and new technologies to keep pace with the information demands of the users.

MICHIGAN CAN NOT GRASP RESOURCE ISSUES!



Where is scientific geologic mapping data needed? (MGS Survey results)

Priority mineral, aggregate need & availability?.

Mineral, aggregate & water data required.

Water quality and quantity data?

Define metallic and non-metallic mineral potential.

Energy -Development & Storage.

Stakeholder – Discussion – Michigan map

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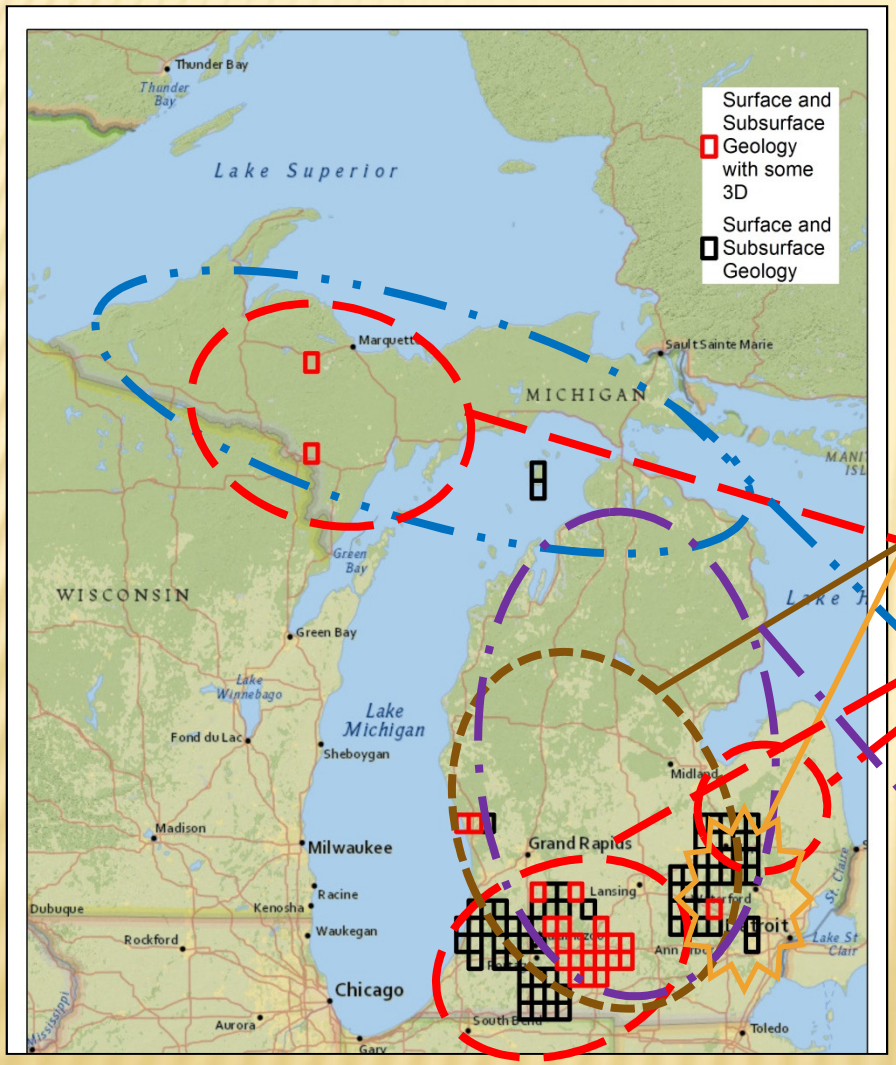

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Does Michigan have the data to assess the Resources?

MGS DEMONSTRATION PROJECTS -21ST CENTURY

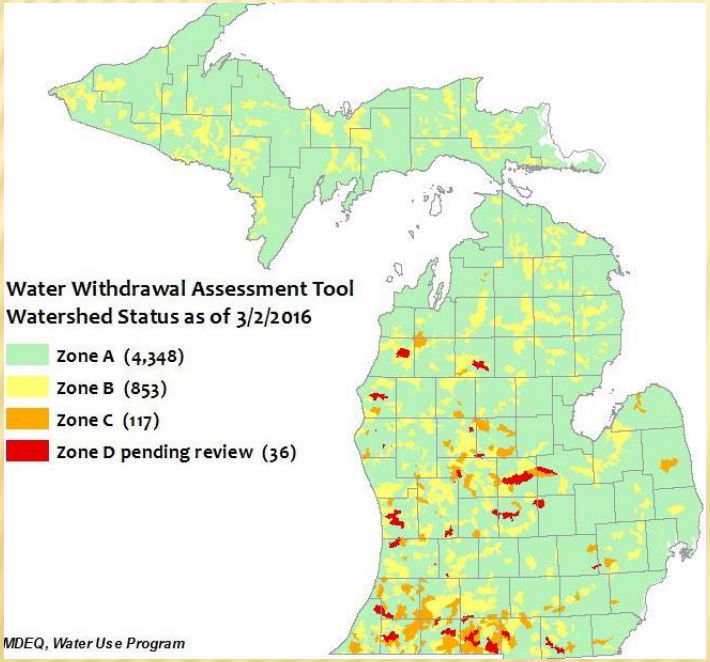
21st Century approach - Combine proven and new technologies to project potential resources

- Buried bedrock valleys for potential water resources
  - Tromino (HVSR) passive seismic and 2D seismic profiles (City of Portage)
- Surficial data to support identification of aggregate resources
  - Mapping & LiDAR, with geophysics- ground penetrating radar, resistivity
- Groundwater SW MI storage -GRACE analysis - 2002 to present
  - Satellite and aerial probes i.e. radar, infrared, spectral.
- Completed demonstration projects
  - Natural Resources of Michigan: A Summary of Production Statistics from 1845 to 2011.
  - County Geological Atlas (Kalamazoo County) of geologic and physical data for planning.

STRESSED WATERSHEDS VS DETAILED SCIENTIFIC DATA

<10% OF MICHIGAN (QUADS) IN THE LP AND MINIMAL AREAS OF THE UP HAS HAD THE SURFACE AND SUBSURFACE SCIENTIFIC DATA PUBLISHED BY THE SURVEY OR ANYONE ELSE IN THE LAST 18 +YEARS.

Location of stressed aquifers in Michigan, per Mi WATT.



This is the real summary of mapping of the surface and subsurface by MGS, USGS or others.

Less than 10 % Detailed MGS mapping.

* Quads (~56 Sq Mi)

- Black Surface only with validation of borings
- Red – Surface + some subsurface drilling / geology

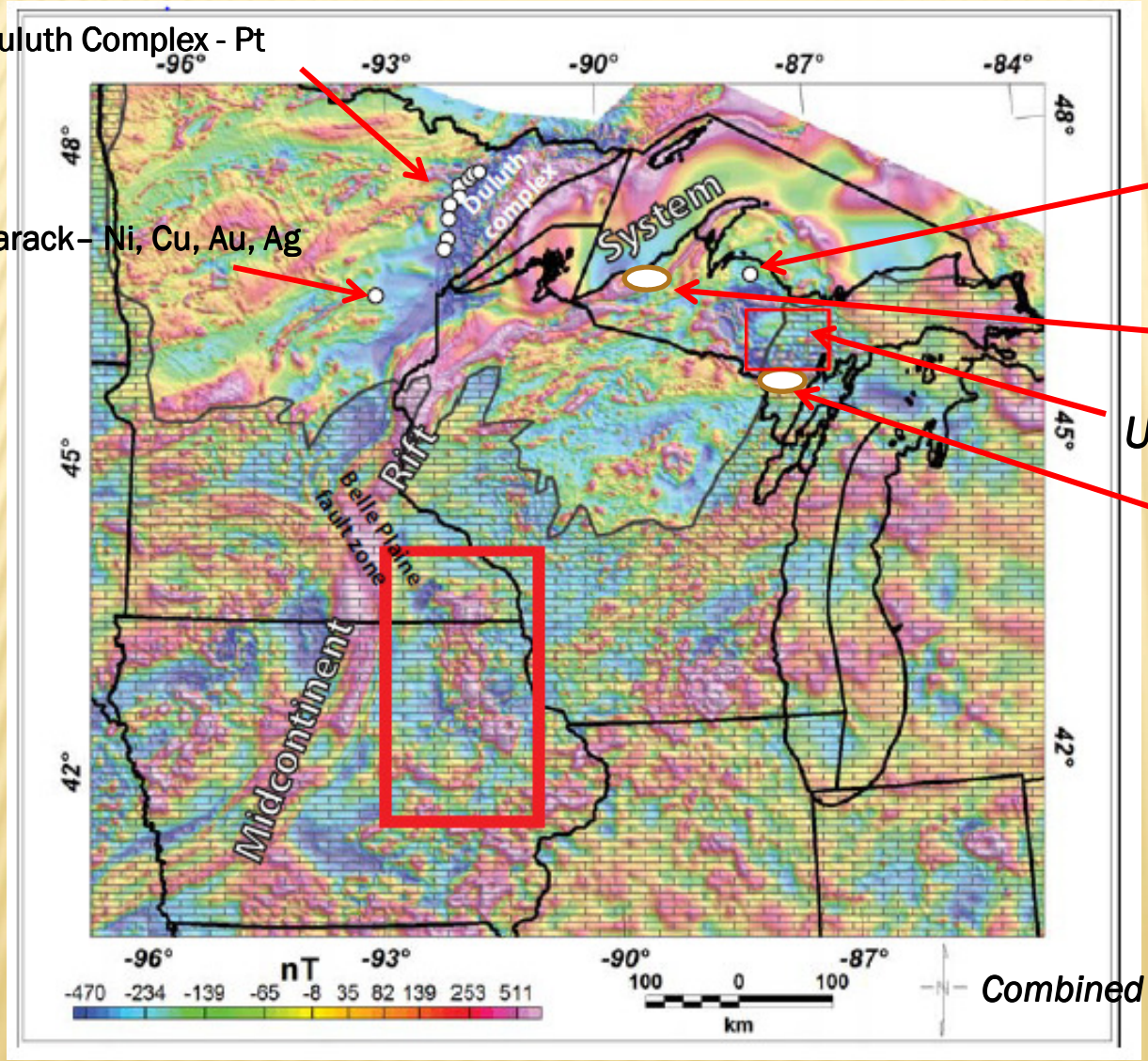
What should MI do? Stakeholder comments

AIRBORNE GEOPHYSICAL SURVEYS – ROI

OVERVIEW:

- Minnesota invested $4.5M in 1979 to 1983 for airborne magnetics and re-evaluated and published all the data.
  - Resulted in multiple mineral discoveries of nickel, gold, silver and platinum group metals in rock types similar to Michigan.
- Rio Tinto discovery, Tamarack, 45 miles SW of Duluth, 5 years
  - Tamarack is similar to the Eagle Deposit in Marquette County, MI
  - $1.6 million in leases
  - $4.0 million in spending in the local communities
- Michigan airborne magnetic data is not useful geologic data.
- USGS is proposing a demonstration aeromagnetic project for an area of the UP spending $380,000, which was initiated but halted.
- Anticipating MGS, MTU and industry will provide some moral and “in kind” support.
- State economic development support is needed now?

AERO-MAGNETICS – SCIENTIFIC INVESTMENT IN THE FUTURE



Michigan and some of the Wisconsin geologic environments are similar to Minnesota

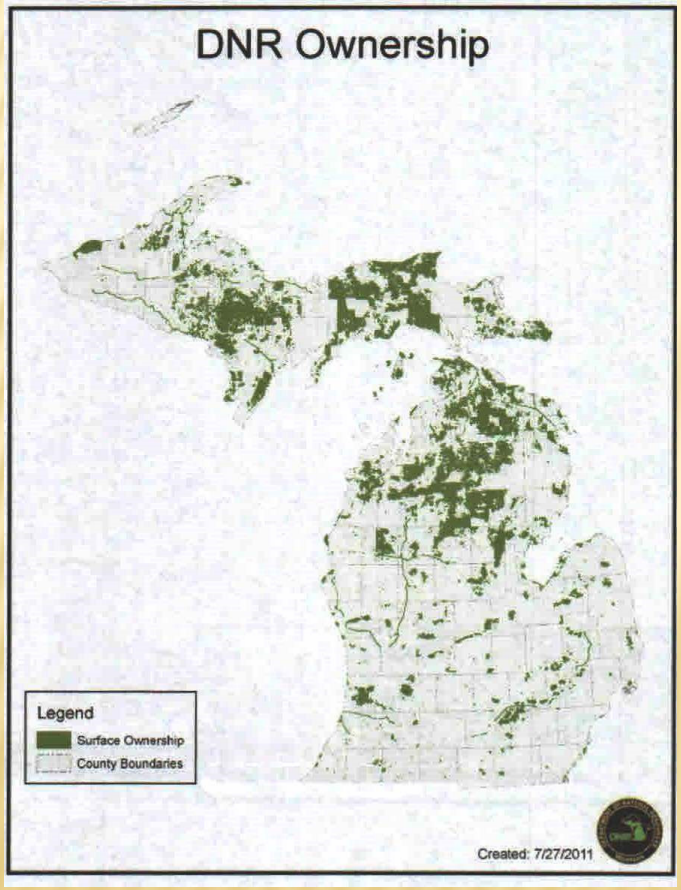
Combined summary of aero-magnetic data

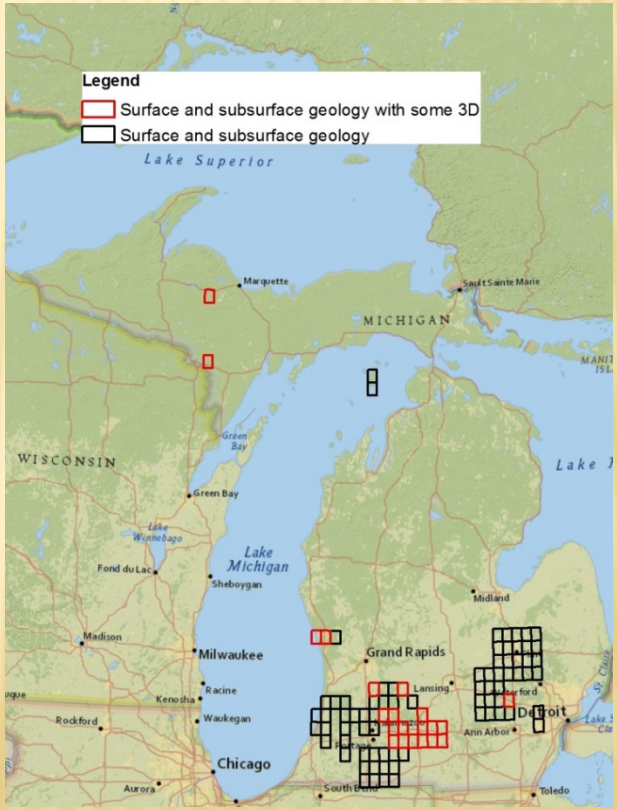
MICHIGAN MUST INVEST IN SCIENCE

Summary of State land vs Open file validated mapping products

STATE LAND MANAGEMENT -Minimal open file geologic data

~4.6 MILLION ACRES





DOCUMENTED ROI FROM MAPPING PRODUCTS

ROI – Validated from survey mapping in Michigan, Kentucky and Ohio

- 1979 – The Survey with USGS mapped an area in Marquette County,
  - The result - the Eagle Deposit was identified,
- This was the last formal Survey mapping project in Michigan, over 30 years ago.
  - 500/300 jobs, >$100 million in tax revenue over 8 year life (Now expanded).
- Kentucky Survey completed geologic mapping of the entire State, Illinois survey conducted an economic study (1999).
  - The ROI was $25 to $39 for every mapping dollar spent = $2.2B to 3.5B.
- An economic study for Ohio Survey showed data acquisition and research results has an ANNUAL benefit of over $575 million.

MGRRE ➡ ECONOMIC DEVELOPMENT

ROI - Industry & Academic Milestones

- MTU-WMU partnership – DOE grant for the application testing of horizontal drilling technology to develop Michigan oil in **1995.**
- PTTC Research & conferences over 20 years, industry, WMU, DOE/Government
- USGS data compilation of oil basins, MGRRE core led to Trenton Black River – + 3D, rediscovery in **2006** of 5 + fields + 5 M bbls oil (**+$21M tax rev**).
- Collingwood, Utica and A-1 Carbonate studies - $178 M lease sale, the largest in Michigan history, + 3D, which led to new exploration success in **2010.**
- DOE - CO2 Sequestration program for 9+ years – **2005 - present.**
- EOR with CO2 – Core samples lead to program testing + 3D, and successful tax reduction legislation – **2005 to 2014** with est. 1.6 m bbls produced (**$7.3M tax rev**).
- Re-discovery of a potash resource, Mecosta – Osceola Counties (**~$65B**) - **2013.**
- Many WMU Geoscience graduates ➡ professional positions

No Research funding from the State has been received by MGRRE/WMU as a result of these milestone State economic & employment events.

SUPPORT FOR MAPPING LEGISLATION

Summary of stakeholder support - industries, contractors, consultants, professionals and citizens !

Michigan requires priority driven input on preparing unbiased scientific information to assess the nature and content of it's natural resources and this is the responsibility of Michigan Geological Survey . This is a summary of the current supporters:

- Michigan Aggregate Association; Michigan Manufacturers Association-Environmental and Mining Committees; MOGA; Michigan Association of Petroleum Landmen; Michigan Groundwater Association,
- University Professors, consultants, AIPG, MBGS, Citizens with a scientific interest. Who else?
- More support is needed to document funding for science!

MICHIGAN GEOLOGICAL SURVEY

Summary as of May 1, 2015

MICHIGAN GEOLOGICAL SURVEY (MGS) - STATE DATA SUMMARY

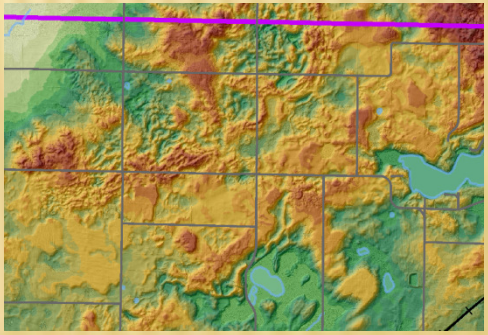
WITH DATA LOCATION NOTED

County	Number of RRD site entries in Environmental Mapper	RRD Files	Oil and Gas (OOGM) permitted boreholes	Wellogic water wells	Number of O&G Wireline log files -MGRRE	Shallow bedrock cored wells at MGRRE-WMU	Drill cuttings sets MGRRE
Alcona	108		934	3,300	755	0	73
Alger	56		0	2,286	4	0	1
Allegan	1,642		3,473	11,927	654	0	892
Alpena	321		1,469	2,877	1,367	2	116
Antrim	208		2,750	4,356	2,291	0	181
Arenac	362		1,076	2,498	457	0	731

Your comments and thoughts?

Thank you

Questions?



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