

Michigan Geological Survey MGS Annual report (2012)

The Michigan Geological Survey is pleased to present this report summarizing its activities and accomplishments in 2012, its first full year of operation.

General Survey Activities

Staffing

Mr. Jeff Reicherts was hired as the MGS GIS specialist on Sept. 1, 2012. My Reicherts will have primary responsibility in final production of maps, construction and maintenance of the MGS web-based GIS system and administration of MGS computer networks.

Dr. Joyashish Thakurta joined the faculty of the Department of Geosciences. at WMU. Dr. Thakurta will also head the economic geology section of MGS. He plans to develop a research program focused on ore deposits of the Upper Peninsula of Michigan.

Meetings/visits/Presentations

- 1) January 10-12. Dr. Kehew attend annual meeting of Great Lakes Geologic Mapping Coalition in Indianapolis and presented the results of recent mapping projects in Barry County.
- 2) Feb., 20. Dr. Kehew joined several other state geologists and geological survey personnel in Washington D.C. to meet with Michigan legislative staffs in the House of Representatives and Senate to update congressional offices on the progress of the Great Lakes Geologic Mapping Coalition.
- 3) April, 18, 2012. Dr. Kehew made a presentation to Michigan Aggregates Association Annual Meeting in Kalamazoo. The presentation focused on geologic mapping by MGS and application to the aggregate industry.
- 4) May 10. Dr. Kehew made a presentation at Heritage Museum and Cultural Center in St. Joseph on Michigan's Ice Age Landscapes
- 5) June 10-14. Dr. Kehew attended AASG annual meeting in Austin Texas. Discussions following this meeting with AASG leadership resulted in the Director of MGS being designated as a member of AASG.
- 6) June 20. Meeting at MGRRE with Jeff Hawkins, Dept. and Survey advisory Council member, Jill Bland, VP of Southwest Michigan First, and Bob Miller, WMU VP.
- 7) July 20. Made presentations on survey to State Reps. Margaret O'Brien, Sean McCann, MDEQ Director Dan Wyant, and several other MDEQ staff members. This discussion related to the effects of geological survey activities on economic development.
- 8) August 15. Dr. Kehew visited Robert Marvinney, State Geologist of Maine, to discuss state geological surveys. Dr. Marvinney is the president of the AASG Foundation.
- 9) Oct. 2012. Visit by Tom Drean, State Geologist of Wyoming and alumnus of WMU Geosciences. Discussions about State Geological Surveys.

- 10) Nov. 4-7. Dr. Kehew attended the mid-year meeting of AASG, which took place at the GSA annual meeting in Charlotte, N.C.
- 11) Nov. 26. Met with Dr. Wayne Pennington, MTU regarding possible future joint management of Upper Peninsula Core Repository.
- 12) Nov. 29. First meeting of MGS advisory council at MGRRE. MGS staff made presentations describing the structure of MGS, geological surveys and economic development, and future survey activities. Membership of the advisory council is included in Appendix 1.
- 13) Participation in several meetings to establish a mining trade association in Michigan. MGS will play a major role in this effort.

Mapping activities

The following items refer to mapping projects including USGS STATEMAP, EDMAP, and Great Lakes Geologic Mapping Coalition (GLGMC). Grant amounts shown.

Completed STATEMAP, FY 2011 project: Augusta Quad. \$39,000

Completed field work on GLGMC, FY 2011; Marshall and NW Albion Quads

Received FY 2012 STATEMAP grant for Climax and NE Albion Quads: \$58,000

Received FY 2012 GLGMC grant for East Leroy, Lyons Lake and Ellis Corners quads: \$77,000.

Submitted proposal for EDMAP FY2013; Pictured rocks National Lakeshore

Submitted proposal for STATEMAP 2013; Proposal rejected due to late arrival at USGS.

Publications based on recent mapping and survey projects.

Kehew, A.E., Sultan, M., Harrison, W.B. III, Harrison, L., Gillespie, R., and Krishnamurthy, R.V. 2012. Restructuring and relocation of the Michigan Geological Survey: Geoscience for Economic Development. Geological Society of American, Abstracts with Programs, North-Central Meeting, Dayton, Ohio, May 2012.

Kehew, A.E., Ewald, S.K., Esch, J.M. and Kozlowski, A.L. 2012. On the origin of tunnel channels of the Saginaw Lobe, Laurentide Ice Sheet, Michigan USA. *Boreas*, in press

Kehew, A.E., Piotrowski, J.A. and Jørgensen, F. 2012. Tunnel Valleys: Concepts and controversies—A review: *Earth Science Reviews* 113, 33-58.

Kehew, A.E., Esch, J.M., Kozlowski, A.L. and Ewald, S.K. (2012) Glacial landsystems and dynamics of the Saginaw Lobe of the Laurentide Ice Sheet, Michigan, USA. *Quaternary International* 60, 21-31

Kehew, A.E. and Esch, J.M. 2012. Surficial Geologic Map of the Augusta 7.5 Minute Quadrangle. Michigan Geological Survey Map SGM-12-01. 1:24,000 scale.

MGRRE Repository and data management

Four truckloads of Michigan core, approximately 90 pallets, were acquired this summer. These had previously been archived at the Bureau of Economic Geology in Texas. They represent several rock types, largely from the Glenwood, St. Peter, and Prairie Du Chien formations. We are using them in research and education to produce reservoir property data relative to CO₂ sequestration.

Several newly acquired cores, as well as previously archived cores, represent the Utica Collingwood and Salina A1 Carbonate formations. Several industry visitors examined and sampled these cores this fall to evaluate prospective oil and gas production areas.

MGRRE also had visits by industry members who examined and extensively sampled Silurian Salina A1 Evaporite cores to evaluate their quality and distribution for potential potash production. Potash is highly sought after now as a major component in fertilizer.

These industry visits lay the foundation for future economic development for Michigan.

We also received a core collection from MDOT's highway and bridge work. These shallow bedrock cores add new data to our collections.

Research activities

1) Repository samples, data and metadata

Dr. William Harrison received a new grant from the US Geological Survey's National Geological and Geophysical Data Preservation Program (NGGDPP) to update inventories and continue adding metadata to our repository datasets. This is part of a national repository data program in which we have been active for several years. Working with staff members Lolita Krievs and Linda Harrison, Dr. Harrison has been working to

- Document and update the core inventory dataset and resolve historical discrepancies.
- Add direct links from our in-house core inventory to the MDEQ's new website "GeoWebFace" allowing direct comparison of driller's logs and scanned well files to core interval footage.
- Search historical documents for metadata and clues to help identify core which were acquired years ago and had been misidentified at their previous locations.
- Complete optical character recognition (OCR) of scanned mineral files received from the MDEQ, laying the groundwork for the creation of a searchable dataset. Although automation is proving possible for many of these files, problematic files cause software malfunctions.
- Manually review problematic mineral well files.
- Design procedures for OCR of scanned oil and gas well files.

These samples and data are essential to our research and education work. Our latest inventory of cores, cuttings and cuttings analyses can be found at <http://wsh060.westhills.wmich.edu/MGRRE/data/CoreInventory.shtml>; drill cuttings

databases are at <http://wsh060.westhills.wmich.edu/MGRRE/data/> and Drill cuttings analyses at http://wsh060.westhills.wmich.edu/MGRRE/data/files/Drill_Cuttings_Analyses.htm

2. Geothermal Energy

Dr. William Harrison is in the third and final year of his research, gathering data from Michigan wells relative to subsurface temperatures to evaluate Michigan's potential for geothermal energy. He has gathered data on shallower wells and will now focus data from deeper wells. These data from all over Michigan will be integrated into the National Geothermal Data System (NGDS) <http://www.geothermaldata.org/>. This project will help us understand the geothermal potential in Michigan to an extent never possible before.

In Michigan, Dr. Harrison is looking for geothermal energy found in naturally occurring hot brines in deep rock formations. For the first two years of the project, he amassed data from all subsurface rocks in Michigan, but especially those deeper than 10,000 feet deep. Data was found in two types of well tests originally conducted by oil and gas companies when they drilled deep wells: Drill Stem Tests (DST's) and Wireline Logs ("logs"). In this final year, Dr. Harrison will be searching for data from shallower wells.

3. CO₂ Sequestration and Enhanced Oil Recovery

For several years, MGS faculty and staff members have been collecting data and samples on a statewide basis about Michigan's geological formations relevant to CO₂ storage, containment and potential for enhanced oil recovery. Much of this work was conducted as a member of a research consortium, the Midwest Regional Carbon Sequestration Partnership (MRCSP). The MRCSP is one of seven regional partnerships established by the U.S. Department of Energy's National Energy Technology Laboratory (DOE/NETL).

Dr. Barnes leads the research team and works with Drs. Harrison and Hampton and several graduate students. Goals for this research include:

- Accumulating data with which to construct maps and tables of physical properties
- Implementing internal data shares (intranet) to facilitate compilation of information into a digital atlas
- Conducting basic and applied research to characterize Michigan saline reservoirs for CO₂ storage potential volume, injectivity and containment
- Integrating any new data from wells drilled primarily by the oil and gas industry.
- Compiling data for geological and fluid flow models
- Formulating models, integrating data, and running the models
- Applying models to specific predictive uses of CO₂ storage and enhanced oil recovery

This year significant work was accomplished on study of geological controls on reservoir properties in the Sylvania Sandstone-Bois Blanc (Middle Devonian) interval in the Michigan Basin:

- The team compiled field data from several states for screening potential oil and gas fields as candidates for enhanced recovery using CO₂. The first

criterion for selection of fields to be evaluated was depth to the top of the reservoir. A depth of 2,600 feet or greater was selected so that CO₂ would be kept in the supercritical phase and likely be miscible in most reservoir oils. Additionally, only oil fields that have already produced at least 250,000 barrels of oil were considered for this evaluation

1. Data was acquired from Michigan sources and from the Geological Surveys of Kentucky, Ohio, Pennsylvania and West Virginia. Michigan data was derived from records at MGRRE and the Michigan Office of Oil Gas and Minerals (formerly the MDEQ [Michigan Geological Survey]). Data for all other states was taken from the TORIS database for the Appalachian Basin.
2. The number of fields evaluated in this project include: 3 from Kentucky, 95 from Michigan, 19 from Ohio, 2 from Pennsylvania and 17 from West Virginia.
3. In addition to the 95 Michigan fields that have undergone some secondary or enhanced recovery, we have selected approximately 400 additional fields that have produced over 250,000 barrels of oil and may be candidates for enhanced recovery.
4. Data collected includes: *Field name, Field location, Discovery date, Number of producing wells, Number of dry holes within field area, Active wells, Abandoned wells, Producing formation(s), Lithology, Producing area, Pay thickness, Secondary or enhanced recovery efforts, Cumulative Total oil production, Cumulative primary oil production, Cumulative Total gas production, Cumulative primary gas production, Cumulative water production, Cumulative secondary or enhanced oil production, Cumulative secondary or enhanced gas production, Original oil in place, Original gas in place, Oil recovery factor, Formation volume factor, Initial reservoir pressure, Current reservoir pressure, Reservoir temperature, Initial water saturation, Oil viscosity, Oil API gravity, Average reservoir porosity, Average reservoir permeability.*
5. Average recoveries from fields that have undergone some secondary recovery treatment can be evaluated from the data provided for Michigan, Ohio and West Virginia. Because there is very limited available field data in Kentucky and Pennsylvania, no interpretations about average performance of secondary recovery in reservoirs was made.
6. Average primary recovery from oil reservoirs is: Michigan – 36.2%, Ohio – 17.0% and West Virginia – 17.9%.
7. Average secondary recovery from the same reservoirs is: Michigan – 13.8%, Ohio – 5.25% and West Virginia – 14.9%

Drs. Harrison and Barnes continued to compile data about production and reservoir performance of CO₂-enhanced oil recovery (EOR) projects in the Niagaran Reefs of the Michigan Basin. They also continued to compile reservoir properties data that can be used to evaluate candidate fields for CO₂ EOR development. The performance of this field may be a useful analog for CO₂ enhanced oil recovery, which might be similar to the gas storage-enhanced oil recovery process.

Dr. Barnes and graduate students conducted high-resolution sedimentologic and petrologic investigations to prepare a detailed sedimentary facies model for the Sylvania Sandstone in Midland County. Data were acquired from studying conventional cores from 4 brine extraction wells. This work was the subject of an abstract presented in April to the Geological Society of America, entitled: Geological Controls on Reservoir Properties and CO₂ Potential in the Lower-Middle Devonian Sylvania-Bois Blanc interval, Michigan Basin, USA; POLLARD, Katherine A., Geosciences, Western Michigan University, and BARNES, David A., Geosciences, Western Michigan University.

Additional research using subsurface well log data for the construction of regional sequence stratigraphic cross sections was done to address regional stratigraphic relationships in the Sylvania-Bois Blanc interval. This work more confidently established the regional facies relationships of these units and the spatial distribution of reservoir facies in the Michigan basin.

The results indicate significant prospectively for CO₂ sequestration in dolomitic facies of the Sylvania sandstone. Sandstone portions of the formation were found to be somewhat less prospective, but are now recognized to be a less volumetrically significant component of the Sylvania "Sandstone" in areas of the Michigan basin most suitable for geological sequestration activities.

Dr. Hampton continued to focus on conceptual geologic model formulation, deployment of modeling software, and general guidance and coordination.

- Dr. Hampton worked extensively with graduate students in simulating supercritical CO₂ injection and the geomechanical effects of injection. The main programs used were GEM from CMGL. Many different modeling scenarios were carried out. Results were reported to Battelle Columbus in Ohio on June 26, 2012.
- One task of the Arches Province Simulation Project is to simulate a specific site and determine what limits are necessary to be observed on injection pressures to avoid breaching the confining Eau Claire formation or otherwise inducing failure. For this geomechanical simulation a location near Holland, Ottawa County, Michigan, was chosen. In the analysis, multiple model scenarios were created and studied. All of our recent models assume dual permeability of the formation. This allows the models to have permeability values for the formation and for any fractures rather than the formation alone. Each simulation covered 15 years, with CO₂ injected during the first ten.
- Various supercritical CO₂ injection rates, ranging from 10,000 ft³/day to 2,000,000 ft³/day, were modeled. Injection well perforation depths and lengths were varied. Perforations were located just below the cap rock layer, just below the upper Mount Simon and also at the bottom of the middle Mount Simon layer. Several rock strength parameters were tested for sensitivity as well. Variable cap rock thicknesses were simulated. The default boundary conditions which were applied to all models constrained both the bottom and sides of the grid leaving only the top to move freely in space.

- The first model is a 3D model created using Schlumberger's Petrel using permeability and porosity values obtained from the wells in Ottawa County. A second model was created in 2D also using permeability and porosity values obtained from the wells in Ottawa County. The third and fourth models were homogenous (or "layer cake") models with single permeability and porosity values for each of three layers: Eau Claire, Upper Mount Simon and Lower Mount Simon. These models were 2D and 3D. These latter model studies included sensitivity analysis of permeability values in the Eau Claire.

Faculty and students attended numerous professional meetings and made presentations. Notable among these were:

- Dr. Barnes and graduate student Katherine Pollard presented an abstract in April to the Geological Society of America, entitled: Geological Controls on Reservoir Properties and CO₂ Potential in the Lower-Middle Devonian Sylvania-Bois Blanc interval, Michigan Basin, USA.
- In September, Dr. Harrison gave two presentations at the Eastern Section of AAPG Annual Meeting in Cleveland. One presentation was to a PTTC Workshop on Enhanced Oil Recovery, titled "Secondary and Enhanced Oil Recovery in Niagaran Reefs" The second was at the general meeting in a session on Enhancing Hydrocarbon Production, titled "Secondary and Tertiary Oil Recovery in the Michigan Basin."
- Dr. Barnes submitted an abstract for Poster presentation at the DOE-NETL, Carbon Storage R&D Project Review Meeting (July, 5, 2012); *A Comparison of Geological CO₂ Storage Resource Calculation Methodologies to Evaluate Parameter Sensitivity and Reduce Uncertainty: Case study of the St. Peter Sandstone (Ordovician) in the Illinois and Michigan Basins*, Dave Barnes¹, Kevin Ellett², John Sosulski¹, John Rupp² and Hannes Leetaru³, ¹Western Michigan University, Kalamazoo, MI, ²Indiana Geological Survey, Bloomington, IN, ³Illinois State Geological Survey, Champaign, IL

New Faculty member

Dr. Peter Voice joined MGRRE and the Michigan Geological Survey as a research associate. He recently completed his dissertation at Virginia Tech. Dr. Voice has a strong background in carbonate sedimentology, numerical and statistical sedimentology, and provenance analysis. He is currently involved with our CO₂ sequestration research, generating facies analyses and core profiles of Niagaran reef material.

MGS Web pages work

Staff member Lolita Krievs has updated the Survey's website and many of our datasets now link to the MDEQ's datasets. The "CoreKids" links are useful for parents, teachers and students. Learning modules focus on geology, natural resources, rocks, minerals, water, coastlines, and climate change.

The "Links" go to information from the State and US Geological Survey, mineral guides, directories and dictionaries. Imagery and photos are at "Multimedia". Research is accessed at "Data" and "Publications" and "MGRRE's online data" has lists of cores, core analyses, drill cuttings, mudlogs, thin sections, and oil and gas data.

These Websites are at <http://wsh060.westhills.wmich.edu/MGRRE/index.shtml> and <http://mgs.geology.wmich.edu/>

Industry and Government Outreach

Dr. William Harrison and staff member Linda Harrison organized a Petroleum Technology Transfer Council (PTTC) workshop presented in March at Mt. Pleasant, Michigan. More than 200 people attended the meeting, focused on renewed activity in the Trenton/Black River formations. Dr. Harrison was one of eleven speakers. They addressed reservoir analysis, stratigraphic controls, facies distribution, depositional models, engineering considerations, seismic exploration, and exploration techniques.

In June, MGRRE welcomed U. S. Department of Energy assistant secretary Charles McConnell. He spoke at a press conference about the "un-mined gold" in abandoned oil fields in Michigan and how that oil is now being produced as a result of the research done here at MGRRE, and the technologies developed by industry leader Core Energy of Traverse City. Core's President, Robert Mannes, discussed its leading role in producing previously inaccessible domestic energy. Drs. David Barnes and William Harrison answered questions about their research in carbon dioxide sequestration and utilization to produce a win-win: greenhouse gases being stored underground AND producing more energy.

K-12 Outreach

The CoreKids K-12 Earth Science outreach program is updating presentations and scheduling school visits to classrooms around SW Michigan, including Kalamazoo, Vicksburg, St. Joseph, Benton Harbor, Hastings, Middleville, Battle Creek and Coldwater. We are also expanding our geographical coverage to include schools in the metropolitan Detroit and Grand Rapids area.

CoreKids program director Jeffrey Barney, faculty advisor Dr. Heather Petcovic, and CoreKids educator Steve Barone, are also developing new presentations on natural gas, hydraulic fracturing and the geology of Michigan state parks and recreational areas. We are also expanding each presentation to allow grade-level appropriate lessons for elementary, middle school and high school classrooms. Ultimately, we plan to be able to respond to teacher requests to integrate existing lesson modules to meet the needs of their students.

This year we have taken our presentations to community events such as the Kalamazoo Gem and Mineral Show and the Water festival at Cranbrook Institute for Science in Bloomfield Hills, and we hope to install permanent displays at the Cranbrook Institute Museum, as well as other local museums.

Other outreach activities include assistance with Science Olympiad, helping local Scouting groups earn geology badges, and presentations on geology careers at Niles Middle School and Mattawan Elementary.

Appendix 1. MGS Advisory Council

Michigan Geological Survey, Advisory Council

NAME	AFFILIATION, PROFESSIONAL INTEREST AND (OTHER)	PRIMARY PHONE CONTACT	EMAIL	ADDRESS
Al Kehew	Director Michigan Geological Survey, Faculty Member, Western Michigan University, Dept. of Geosciences	269-387-5495	alan.kehew@wmich.edu	1187 Rood Hall 1903 West Michigan Ave Kalamazoo, MI 49008
Mohamed Sultan	Department Chair, Geosciences Department, Western Michigan University Environmental Sciences & Remote Sensing	269-387-5451	mohamed.sultan@wmich.edu	1187 Rood Hall 1903 West Michigan Ave Kalamazoo, MI 49008
William Harrison	MGRRE, Director of the MGSMGRRE core repository at WMU, Emeritus Professor, WMU Geosciences Department	269-387-8691	william.harrisonIII@wmich.edu	1187 Rood Hall 1903 West Michigan Ave Kalamazoo, MI 49008
Hal Fitch	Director, Office of Oil, Gas, and Minerals, Michigan Department of Environmental Quality (MDEQ), (WMU Advisory Council)	517-241-1548	fitchh@michigan.gov	Office of Oil, Gas, and Minerals P.O. Box 30256 Lansing, MI 48909-7756
Tom Quigley	President, Aquila Resources, Menominee, MI	906-352-4024	tquigley@aquilaresources.com	414 10th Avenue Menominee MI 49585-3028
Paul Daniels	Earth Resources International, Principal/Registered Professional Geologist, (WMU Advisory Council)	269-343-1181	paul.daniels@earth-resources.com	P.O. Box 20245 Kalamazoo MI 49019
David Preston	Varnum Law, Grand Rapids	616-336-6520 (Direct) 616 / 336-6000 (Office)	depreston@varnumlaw.com	333 Bridge Street, NW Grand Rapids, MI 49504
Jeff Hawkins	President, Envirologic Technologies, (Pres.- Kalamazoo Chamber, West Mich First, WMU Advisory Council)	269-342-1100	jhawkins@envirologic.com	2960 Interstate Parkway Kalamazoo, MI 49048
Mike Newmann	Michigan Aggregate Association - Executive Director	517-381-1732	mnewman@miagg.org	215 N. Walnut Street Lansing, MI 48933
Bill Stelzer	Consultant	(517) 694-4770	stelzrb@aol.com	6500 Mercantile Way, Suite 6A Lansing, MI
Craig Johnson	Director, Storage Deliverability & Planning	(517) 788 1916	craig.johnson@cmsenergy.com	1945 West Parnall Road Jackson, MI 49201
Jill Bland	Executive VP; Southwest Michigan First	(269) 492-6375	jbland@southwestmichiganfirst.com	241 East Michigan Ave. Kalamazoo, MI 49007
Jim Morris	Director - Michigan and Ohio Water Science Centers, USGS	(614) 551-7572 (517) 887- 8906	jmorris@usgs.gov	6520 Mercantile Way, Suite 5 Lansing, MI 48911-5991
Joe Van Wagnen	Van Wagnen Engineering	(517) 676-1987	JoeVan@cablespeed.com	849 W. Dansville Road Mason, MI 48854
Tim Brock	Brock Engineering	(231) 421-3001	brock.engineering@yahoo.com	771 N. West Silver Lake Road Traverse City, MI 49684