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## MICHIGAN GEOLOGICAL SURVEY

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### Michigan Geological Survey Annual Report for 2017

The Michigan Geological Survey is pleased to present the 2017 Annual Report summarizing the activities and achievements to the State Geologist, Harold R. Fitch, per Senate Bill No. 507.

#### MISSION STATEMENT:

- ***The mission of the Michigan Geological Survey is to facilitate basic and applied geological research to promote the best use of Michigan's geological resources for their social and economic benefits while protecting associated resource values and the environment.***
  - *The safety, health, welfare, social and economic benefits of completing these functions will enhance the education and employment opportunities for Michigan residents while preserving the environment.*

#### OVERVIEW:

The restructured Michigan Geological Survey (MGS) has been active at the Western Michigan University Geological and Environmental Sciences Department for just over six years. The primary functions mandated for the survey by the October 11, 2011 legislation include: investigation of the state's geological natural resources, the collection and archival of geological samples, cores, cuttings, and the preservation and publication of these geological investigations. The purpose of the Michigan Geological Survey is to serve the state's people, industry, and governmental agencies (the clients). The MGS activities continued to operate on grant awards received through December 31, 2017.

MGS continues to apply for and receive grants and awards for research and studies on Michigan geology, the mission of the MGS. In 2017, the MGS and our Resource Centers of WMU Geosciences staff and adjuncts (Appendix I) have been awarded approximately **\$379,204**. There is approximately \$800,496 remaining from previous grants, which includes a portion of the 2016 Special Appropriation Grant. New grant funding and remaining grants are summarized below and in Appendix I. MGS and the Resource Centers staff have continuing grant funds that apply to Michigan geology for a combined total of approximately **\$935,496**. MGS has pending proposals and grants for 2018 and beyond totaling \$318,712. *NOTE: None of this funding applies to pay for full time MGS staff, but represents incremental funding to support studies, staff and students as presented in the awards.*

The goal of the MGS is to be recognized as the "Go To" resource for geologic information in the state, both for the Lower Peninsula (LP) and the Upper Peninsula (UP). Michigan has not committed

# MICHIGAN GEOLOGICAL SURVEY

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sufficient funding for geological research and or scientific expertise on a continuing basis for many decades, over 30 years, to develop programs using proven and current scientific methods and technologies to assess and manage many of the valuable natural resources of this State, with exception of the Oil and Gas industry that has funded the regulatory management of this resource management through fees. The geological natural resources include but are not limited to subsurface water, minerals, soils, limestone and other building and construction materials, sand, salt, oil, gas, and metallic and non-metallic ores. Michigan Office of Oil Gas and Minerals maintains and updates factual data and compiles segments of geologic and other Michigan data bases on GeoWebFace, a good single data resource. However, there is not a continuing budgeted effort to properly identify, assess, collect and present new data to support the sustainable management and use of most of the natural resources. A fully functional Survey cannot occur until permanent, annually recurring appropriations and funding is provided to hire permanent professional staff that can integrate with the State departments and the Legislature to conduct needed and prioritized scientific geologic research and data collection.

The proper use, management and sustainability of the natural resources will or can provide economic and in many cases recreational benefits to Michigan, which cannot be done effectively without valid scientific data. The MGS is the most appropriate entity to provide unbiased documentation for the assessment to support the management and the potential economic development which is validated specific scientific geologic data to support the environmental and sustainable management of these natural resources by the State Quality of Life departments of Natural Resources (DNR), Environmental Quality (DEQ), Office of Great Lakes (OGL) Agriculture and Re-development (MDARD) and the Department of Transportation (DOT).

Michigan is now faced with a new threat to human health and the environment, polyfluoroalkyl substances (PFAS), groundwater contamination, which has been found in many areas of Michigan in various concentrations, some in hazardous concentrations. Michigan does not have a geological data base of the geologic stratigraphy (surface to bedrock) in most areas of these impacts. The surficial geological map was developed in 1915, updated in 1955 and again with limited surficial information in 1982 with only new colors. Less than 10% of Michigan Lower Peninsula has been mapped with any subsurface geologic data to support compilation of a stratigraphic interpretation of many of the potentially impacted area(s). The MGS mapping programs for the last 20 years have been compiling data, where budgets and priorities have allowed, and this form of geologic data compilation process is what is needed in critical PFAS impacted areas.

The Special Allocation funds (July 2016) have provided the opportunity to present documented evidence to support annual funding for the Michigan Geological Survey (MGS) and those demonstrations completed and proposals outlined below have identified programs, processes and results that have and can support geologic data voids. MGS has presented the capability to use practical geological methods and incorporate the current techniques and technology and integrate with Michigan geologic knowledge the data in format(s) useable by all the stakeholders. MGS has

# MICHIGAN GEOLOGICAL SURVEY

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presented those examples to justify the establishment of an annual legislative budget for the Geological Survey to manage the natural resources going forward with unbiased validated data.

## SUMMARY OF PROJECTS:

MGS met with stakeholders and identified and initiated select focused projects and presented those results to MDEQ, MDNR, MDARD and MDOT staff on November 29, 2017 and those results are summarized below, in addition, additional projects have been initiated at the request of local and county officials and those results are also summarized below.

1. **Portage, Michigan** – MGS contacted the City of Portage, proposed to compile a subsurface bedrock valley map utilizing a Tromino Passive Seismic instrument and integrate geologic data compilation for this Portage project. MGS conducted a review of factual geologic data which when combined with Tromino data has successfully shown the detailed locations of bedrock valleys, a potentially significant additional geologic groundwater resource. These results can now be used by the City to plan future development. This research provided partial support to Benjamin Seiderman for his Master's Thesis project. Attached is a link for the local public TV station that compiled a 3.5 minute summary of the benefits that the Portage City Manager noted is relevant to any future City growth. <http://www.publicmedianet.org/blog/portage-bedrock-valley-survey>
2. **GRACE Data review** - The Gravity Recovery and Climate Experiment (GRACE) database is a NASA satellite program that has demonstrated terrestrial water storage values in localized areas within Cass - St. Joseph and Ottawa - Kent Counties. The project utilized the last 14 years of GRACE data, 2002-2016. Calibrating the GRACE modeling data with factual water storage values has shown an estimate of Terrestrial Water Storage (TWS) over this period of time. This assessment provides incremental, validated data for Michigan to project possible water quantity changes when calibrated with current water use. This project did support a PhD candidate, Hossein Sahour. The initial results are favorable and this output is being compiled for a professional publication of how this GRACE assessment tracked two local areas and how refinements can track and support management of water storage for the entire state.
3. **Ottawa County subsurface geology and water quantity and quality assessment** - MGS has completed a detailed review of the Ottawa County subsurface geology with documented quantitative changes in water quantity and quality over time using real time factual data from the water well drilling community and geologic interpretation. This data summary of geology and groundwater resources has been combined with county projections for current and future growth. MGS and the drilling community also prepared an outline of strategic groundwater conservation objectives for Ottawa County to consider for meeting the growth of the second fastest growing county in Michigan, next to Kent County. This collaborative research will be presented to the County and township supervisors in the first Quarter of 2018, discussing the concepts of water use, groundwater recharge and what if any management or conservation goals may be needed to meet the long term goals. MGS will also be working with the Ottawa

# MICHIGAN GEOLOGICAL SURVEY

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Stormwater director on a demonstration program for the capture and infiltration of clean surface water into the shallow glacial groundwater system in the County.

4. **Ottawa County Aggregate assessment** - MGS has initiated an assessment of the aggregate resources of Ottawa County to support population growth and development. This assessment will outline those aggregate locations, so County zoning can be appropriately assigned for potential approval of extractive functions going forward. This is to minimize the statements of not knowing there was an extraction potential for aggregates in my “backyard”. The second benefit of noting the aggregate locations is a potential for demonstrating groundwater recharge in those areas having geologic conditions favorable to near surface recharge.
5. **Geo-Hazards - USGS Research and bluff failure research project** – MGS, USGS and other Lake Michigan State geological surveys are discussing regional glacial geology and how a USGS FEDMAP program can support Michigan and the adjoining Great Lakes states. This would build a foundation for a 5-10year USGS research project in FEDMAP that can support near shore geological research in Michigan and the adjoining states. An initial discussion of geo-hazards along the Lake Michigan shoreline has been done and the data compiled with the documented bluff and shoreline movement has resulted in proposing changes and controls over some of the anthropogenic impacts to minimize mass shoreline failures. This program will use available historical WMU/US Army Corps of Engineers (USACE) data, recently and future acquired Federal, state and academic remote sensing research data. This will be a collaboration of USGS, USACE and State survey research programs. They will develop the initial studies for the proposed basic USGS FEDMAP geologic program in collaboration with MGS and USACE. For the bluff failure/shoreline program during this period, MGS will be conducting data collection utilizing selective funds from mapping and other budgets and utilizing available USGS matching funds. This study will provide a means to assess the bluff and shoreline impacts caused by population changes, and by monitoring anthropogenic and natural conditions with time, a multi-year project
6. **MGS** – Prepared and presented a proposal to MDEQ to establish a standardized geologic data compilation program/process to support understanding specific PFAS sites. Michigan does not have sufficient subsurface geologic data compiled in a structured format for all to use in assessing the pathways of PFAS in the glacial or bedrock system. The MGS proposed a program/protocol to compile this data for use by all in formal and public forums. There are ten’s to possibly hundreds of potential PFAS sites that will need this information available, which can then be used to establish and present a subsurface geological model for the area of each PFAS impact area. The proposal is pending approval.

Also of special note, MGS submitted an unsolicited “Proof of Concept” proposal to the Groundwater Research and Education Foundation (GWREF), a foundation of the Ground Water Protection Council (GWPC) and MGS was successful. The awarded grant project will present a proof of concept in Calhoun County, using existing surficial geologic mapping data with indirect geophysical techniques to map buried bedrock valleys for potential water resources. This grant will be one of the first MGS

# MICHIGAN GEOLOGICAL SURVEY

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collaborative programs in years, where the energy industry will provide 2D seismic data down to the estimated glacial/bedrock interface which will be integrated with MGS mapping results and the research staff will interpret the data to confirm data authenticity. In addition to the industry supplied 2D seismic data, there is funding for additional ground geophysics and confirmation drilling to support the proof of concept mapping process. Confirmation will provide a relatively low cost method of collaborative support from industry provided near surface 2D or 3D seismic data. The analysis will interpret the glacial thickness and the potential refined definition of the bedrock surface for the identification and protection of bedrock valleys, sources of new water resources using other shallow geophysical methods, including the Tromino Passive Seismic unit. This data package can then support the identification and protection of those newly found resources from any surface impact or proposed surface or subsurface activities that cannot be done in an environmentally safe manner. Success of the program can be extrapolated to many areas of Michigan and to other adjoining Great Lakes glacial sediment states.

A second demonstration example is associated with the rebuilding the Michigan infrastructure which has a major requirement for quality aggregates located in priority areas of infrastructure rebuilding and expansion. It has been postulated that known resources may not meet the quantity or quality of the projected need. This has been confirmed by MDOT, who completed an assessment (October 2016, Michigan Aggregates, Market Study, Phase 1 Report) of current and known future aggregate resources in Michigan. There are vast areas of the State that do not have sufficient quality or quantity of aggregates with stone to meet the current needs after 10 to 15 years. More specifically, this aggregate resource will be greatly diminished when the prescribed Michigan infrastructure rebuilding program begins and then the life span of many of these resources will be less than 10 years. There is a current geographical high demand for aggregates supplies having sufficient stone and rock in the glacial material. MGS continues to use established surface mapping techniques in addition to sophisticated airborne tools, LiDAR (Light detection and Ranging) and GIS data output, to assist in the mapping and data processing procedures to support the identification and presentation of the locations of favorable near surface geology that may contain aggregate resources previously not identified or extensions of the resource. Secondary geophysical tools such as Ground Penetrating Radar (GPR) have shown promise in some areas looking for the higher concentrations of the required stones reducing the need for backhoe trenches or excessive drilling.

Associated with this assessment of aggregate need, many Michigan residents may not be aware of the negative monetary impacts in each county in response to restricting aggregate operations in their respective county and then, what are the future county or local tax increases and all other associated cost impacts for any construction projects. Note, hauling of aggregates more than 30 miles can double the cost, the monetary impact of not having a nearby source of aggregates. Local aggregate resources can support the infrastructure installation and rebuilding required to maintain the counties current and future life style. Aggregates are a geological resource, located where they were deposited thousands to millions of years ago.

# MICHIGAN GEOLOGICAL SURVEY

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The MGS Director, John A. Yellich, has continued to both introduce and to update interested stakeholders to the progress the restructured survey has made across the state. The primary focus of many of these meetings was to present an overview of Michigan geology and the benefits that can accrue from a fully funded, functional geological survey supporting the evaluation of Michigan's mineral, energy, and water resources. The meetings not only present Michigan geology, natural and energy resources, but highlight the importance of the public access of the Michigan Geological Repository for Research and Education (MGRRE) core and data repository at WMU/MGS to the State. MGS has made approximately 140 presentations, meetings and discussions in the last four+ years to associations, committees and organizations that included: Michigan Manufacturers Association; Environmental and Mining Policy Committees; Michigan Association of Counties; Michigan Groundwater Association; representatives of the Michigan Chamber of Commerce; Michigan Oil and Gas Association; Michigan Environmental Health Association; MI CAMP professionals; American Institute of Professional Geologist (AIPG); Ottawa County Planning Department; Michigan Department of Natural Resources, Environmental Quality, Agriculture and Redevelopment, Office of Great Lakes, officers, chiefs, Directors and staff; members of the Michigan sovereign tribes; and private individuals. All these contacts are associated with some aspects of agriculture, industry, municipal and rural growth, water resources, regulatory issues, resource development, aggregate industry, and data management.

The MGS continues to underscore the benefit and the need for state funding if the MGS is to provide the science needed to address critical geological issues. MGS and Michigan Technological University (MTU) have a formal Memorandum of Understanding (MoU) and MGS has a second MoU with Wayne State in place and MGS is discussing a similar type of MoU agreement with Central Michigan University and Grand Valley State University. MGS has met with stakeholders in the UP and the priorities recommended were state funding for core storage and coordinated data management between the MGS/MGRRE and the UP facility to support sustainable environment, natural resources and economic development in the UP utilizing the scientists of MTU, Lake Superior State University, and MGS and the MGS-MGRRE repository data sharing systems.

Michigan is the only Great Lakes state that has not committed to any recurring annual funding for either statewide or specific, local geologic mapping. Capturing geological information would support future continued geologic, natural resource and environmental management and potential economic development in the state. *NOTE: MGS cannot maximize the application for Federal USGS National Cooperative Geologic Mapping Program (NCGMP) matching funds, until there are direct monies or full time staff to use for increasing the matching dollars.*

MGS has presented significant documentation in support of completing high quality LiDAR (Light Detection and Ranging) mapping programs in most areas of the State. Completion of this program in selective areas has shown high quality expedited geologic mapping products in recently published areas of the Lower Peninsula. LiDAR also supports all facets of Michigan's economic and business entities including agriculture, municipal development, drain commissioners, forestry, flood issues, aggregates and water resources. The LiDAR program, has finally garnered additional interest by many parties for implementation and completion using federal, state and local funding.

Quality airborne data collection associated with natural resources using airborne geophysics, the indirect measuring of earth's physical properties, has not been done in most areas of Michigan. A USGS demonstration program was morally supported by MGS and many Michigan geoscientists and it

# MICHIGAN GEOLOGICAL SURVEY

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was initiated in late spring, 2016. This was located in areas of the Upper Peninsula that have complex Precambrian geologic terranes buried under Paleozoic and glacial rock cover and the area is from Menominee to Gwinn and Iron Mountain to Escanaba. This study was temporarily halted and is projected to restart in 2018. When completed, this program can potentially lead to the mapping and definition of geologic units and structure that is conducive to identifying water, minerals or other buried resources.

The MGRRE core and data repository is the cornerstone of available Michigan Basin scientific geologic data and it represents an estimated \$20 billion in savings to replace this data or the samples in over 560,000' of core, 20,000 well cuttings, >2,000 water well cuttings and electronic versions of all the electric logs and analytical data compiled and stored on the MGRRE/MGS data systems. Over 30% of the MGRRE samples are from State Land and there is a documented Return on Investment (ROI) of hundreds of Millions of dollars to Michigan in the last 20 years, yet there is no continuing support for the operation and maintenance of this facility. WMU/MGRRE receive a nominal amount of funds to store the State water well cuttings that were going to be discarded, had MGRRE not offered to hold them. MGS is seeking annual state legislative funding for survey staffing, and for core and data repositories that will combine the geologic data resources of MGRRE and would support data compilation programs that can be used at a repository in the UP as a collaborative data facility.

This past year the USGS and the National Geology and Geophysical Data Preservation Program (NGGDPP) recognized the MGRRE facility as the example of data preservation and presented the potential return on investment of hundreds of Millions of dollars to Michigan that would support the agricultural community of Michigan and the nation. This recognition was associated with the resurgence of the potash resource in Mecosta County having a potential in place value of \$65 Billion. The USGS and the NGGDPP program summarized the benefits of data and core storage having a high social and economic value to Michigan and the agricultural community in this attached USGS link. <https://www.usgs.gov/news/mineral-discovery-could-mean-billions-michigan> Yet, the State of Michigan is not providing annual funding for the operation of this state data repository.

Attached, Appendix IV, to this annual report is a summary of all 2017 Michigan geologic research, for all submitted proposals and awards, publications, map products, presentation abstracts, and reports completed by MGS, WMU, and high caliber student researchers, an incremental testament of having ongoing research and the economic benefits of a functional geological survey, a Return on Investment (ROI).

The MGS has an Advisory Council (Appendix V) established at the time of the transfer of MGS to WMU in 2011. The members of the Council represent a cross section of interests for Michigan geology and they have been kept apprised of the initiatives and programs during this period. The members have provided guidance and input to these programs to garner State annual funding for MGS, MGRRE and our overall collaborative programs and MGS appreciates their volunteer efforts to support these initiatives and programs.

# MICHIGAN GEOLOGICAL SURVEY

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## GENERAL - MICHIGAN GEOLOGICAL SURVEY ACTIVITIES AND ACHIEVEMENTS:

### RESOURCE CENTERS – Appendix II

#### MGRRE:

The Michigan Geological Repository for Research and Education (MGRRE) has served Michigan for over 30 years under the direction of Dr. William Harrison III. MGRRE remains to be the primary asset of the MGS and continues to request funding from the State for this economic asset to assess and manage Michigan's Natural Resources. For over 20 years, MGRRE has conducted collaborative student and industry research workshops that have supported not just natural gas storage and the energy industry, but glacial geologic research on water and aggregate resources.

#### Oil and Gas:

March - MGRRE held a Petroleum Technology Transfer Council (PTTC) workshop with 90 attendees from all over Michigan and the US. This was a Dundee core workshop focusing on facies distribution, lithology and reservoir types and production history. Registrants viewed core from 25 wells, most of which were selected by Michigan companies. Speakers included Bill Harrison, Peter Voice, Steve Kaczmarek and several industry members.

June - MGRRE received a new DOE grant (CarbonSafe) to review where a national CO<sub>2</sub> sequestration project site could be located in the Midwest. A core workshop and research startup meeting was held at MGRRE for this new grant with the Midwest Regional Carbon Sequestration Partnership (MRCSP). The MRCSP group discussed project goals, scope, timeline, and major tasks. Dr. William Harrison leads the geological research team at MGRRE on these CO<sub>2</sub> & EOR research projects.

September - MGRRE welcomed a new program for about 30 professionals, the Brock Gas Storage Workshop where industry experts from active and new gas storage states of Oklahoma, Ohio, Texas and Michigan reviewed the current equipment and the proposed new rules and regulations being promulgated for gas storage facilities. MGRRE offered the repository venue to allow presenting equipment and then core samples of the formations where these applications are applied within gas storage formations.

MGRRE also held a core workshop and update for Battelle National Laboratories, Core Energy, and the DOE, member partners of the Midwest Regional Carbon Sequestration Partnership (MRCSP) that has been active for the last 4 years. This collaborative scientific program for carbon sequestration research in oil and gas reservoirs continues with funding by the Department of Energy (DOE). As a result of this program, Dr. William Harrison, Dr. Stephen Kaczmarek, Dr. Andrew Caruthers are conducting research with a number of students on the development of new Niagaran reef reservoir models. The additional benefits are a greater understanding of formations and areas and those formations having potential for gas storage, continuing to make Michigan number one in the US for gas storage operations at more than a billion cubic feet, which has supported a number of student/industry research projects.

As part of the MGS on-going data preservation program, MGRRE received 150 pallets of cores and cuttings from another Michigan university. Many of the cores are one of a kind from gas storage fields and will be used in our research here and will be available for industry. Before coming here,



# MICHIGAN GEOLOGICAL SURVEY

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that collection had suffered extensive damage from water and poor storage conditions. The MGRRE group of nine students, Jenny Trout and Linda Harrison worked at that University for several days to rebox 1500 core boxes that were in danger of coming apart during the move. Much of the cataloging and repairing the sample storage and data compilation was supported by funding from a grant from the National Geological and Geophysical Data Preservation Program (NGGDPP).

The MGS and MGRRE has annually requested and received incremental but not sufficient funding from operating service costs and donations from industry sources to support the core, data storage, and other functions.

Ongoing Studies, publications, Outreach and Grants: Listed below are some of the ongoing and most recent achievements that have emerged from the numerous requests and onsite researcher visits and Outreach for data review at MGRRE. A summary of the value of the new 2017 grants, ongoing grants and submittals can be found in Appendix I.

Out-Reach at MGRRE supports a number of academic, professional associations and institutions. MGRRE hosted visiting geology classes from Central Michigan University, Michigan State University, Grand Valley State University and Calvin College, where students spend the entire day examining and describing cores that were selected by their Professors to meet their course requirement. Dr. William Harrison also taught a course for the Osher Lifelong Learning Institute in October, focusing on Michigan's geology and its economic deposits. He also made three presentations about the geologic history and petroleum systems of the Michigan Basin at the May meeting of the Ontario Petroleum Institute in Toronto.

Drrs. William Harrison, Dave Barnes and Peter Voice with support from Jenny Trout and several students have submitted their final papers to be included in a Geological Society of America (GSA) Special Paper 551 scheduled for 2018. This special publication focuses on the geology and economic resources of the Michigan Basin and highlights much of the research of students, faculty and industry conducted during the past ten years.

MGRRE applied for and received a grant from the USGS-National Geological and Geophysical Data Preservation Program (NGGDPP) in support of their data capture and preservation functions. As MGS has noted in previous presentations and annual reports there has been both an indirect and direct State economic benefit from the functioning MGRRE facility. MGRRE, a functioning core repository and data source has provided Michigan with major economic benefits in the last 12-15 years to include: State tax revenue, huge contributions to the Natural Resources Trust Fund and State royalties. Specifically, there has been no State funding provided to MGRRE and MGS to cover the annual costs for providing these services. This research facility has resulted in hundreds of millions of dollars to Michigan through these documented natural resource benefits and the collaborative scientific work conducted by industry and other researchers at the MGRRE facility with the staff and students.

In addition, tens of successful collaborative student theses, industry and Federal agency research studies, and other geological programs conducted over the last 30 years are also documented and industry has graciously donated to show their appreciation. Yet as of this date, there has been no direct annual State funding for MGRRE or MGS Michigan to support this ongoing data resource, which has shown continuous scientific and economic benefits.

# MICHIGAN GEOLOGICAL SURVEY

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Surficial mapping cores and data: The MGRRE repository is also the location for all of the drilling and coring samples from the surficial geologic mapping programs done in Michigan. There are MGS/USGS, MDOT and other engineering company cores and these samples and the supporting data are cataloged and available for research on glacial and shallow bedrock geology, critical to understanding the water resources of Michigan.

MGS and MGRRE Websites: The number of contacts (hits) on a website is a measure of the importance of that information resource. The MGRRE and MGS website contacts indicate greater visibility with an increased public exposure and an increased number of data sets. The number of unique requests continue to increase at lower rates, depending on the energy industry pricing. In 2017 MGRRE had 1122 new users, indicating continued interest in Michigan geology. The MGS website has been fully functional for the last four years and the number of unique IP requests for 2017 was at 2,743, approximately 228 per month, a continued increase at the same rate and numbers.

**Geologic Mapping:** Dr. Alan Kehew and John Yellich, direct the MGS submittals to participate in, and submit projects in both of the USGS Federal National Cooperative Geologic Mapping Programs (NCGMP), STATEMAP, and Great Lakes Geologic Mapping Coalition (GLGMC) programs, which provide matching Federal dollars for geologic mapping. This past year, the USGS mapping program awarded funding to map areas in both the Lower Peninsula, (Cass County – Edwardsburg, Adamsville, Dowagiac, Sumnerville and Sister Lakes Quadrangles) under the direction of Dr. Alan Kehew and John Yellich, and in the Upper Peninsula (Dickinson County – Iron Mountain Quadrangle), under the direction of Dr. Alan Kehew and John Esch.

The emphasis in the two USGS mapping programs is surficial geology concentrated in the areas of favorable geology for water and mineral resources for the Upper Peninsula, and for state-wide (UP and LP) aggregate and water resources. The need for accurate geologic data and aquifer characterization in the LP cannot be underestimated. The LP studies are being conducted with an introduction to a refined 3-D approach that includes a combination of surface geologic mapping with hand augering, trenching and confirmation of lithologies integrating with available LiDAR imagery to prepare a documentation of the surface and subsurface geology, then combined within a limited wireline or geoprobe drill coring program. Sampling of core and outcroppings for age dating assists in the refinement of the glacial geologic history using Carbon 14 or optically stimulated luminescence (OSL). Finally, combining a refined subsurface geologic mapping approach that includes core samples and sieve analyses, down-hole geophysical logs and validated geologic logs from water well drillers completes the data set for a mapping product.

LiDAR increases the quality of the surficial data used in assessing the potential areas for aggregate resources combined with the data from underlying water-bearing strata, which can support locating potential water for high production users such as the agricultural community. Quality LiDAR also allows for a more rapid assessment of the geology of areas where physical access maybe limited, and where field validation can then be focused on mapping the continuity of the surface geology.

Groundwater, Data Bases, Resource Assessments: MGS is compelled to restate issues of relevance that have not be clarified. For review, the governor's Water Use Advisory Council (WUAC), under the

# MICHIGAN GEOLOGICAL SURVEY

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direction of the director of the DEQ, completed a two-year review of the water resource issues in the state in 2015. The WUAC supports the adoption of the Great Lakes Compact that requires permitting of large capacity water wells, and quantifies their impact on local stream flows. Local requests have been made to the MGS for information on the quality and quantity of the groundwater in certain areas of the state, but many of the requests cannot be supported by MGS, because the local or personal request does not have funding to allow MGS to conduct a geological assessment associated with the specific permitting request.

One of the issues revealed by the WUAC was that available geologic data is not available to be used. The MGS recognizes that because of the paucity of mapping (<10%) in Michigan there is an abundance of geologic information that is not known or available for use in assessing and protecting our resources, which includes groundwater as well as aggregates. This situation was presented and is described below.

The State of Michigan has numerous data sets and documents that are either in paper or microfiche format, along with various electronic databases. None of these data sets communicate with each other, nor are they retrievable in a uniform electronic format. There could be up to a million data sets that represent geologic information having an estimated minimum value of over \$10 million (\$10.00/file) up to 1.0 billion.

Michigan risks the loss of a substantial portion of these data resources due to physical deterioration, mishandling, and to the expense of physical storage. This is called “orphan data”. The inefficiency that is inherent in the use of non-communicating databases is substantial. The result is that state employees, and the public, spend unproductive time in both retrieving and sorting data before it can be effectively used.

It is obvious that there is a demand for a set of central electronic databases that could be used to archive standard geologic information into formats that are easily searchable and appropriate for the type of information requested. A centralized set of databases would make Michigan’s agencies more functional and time responsive. Properly prepared electronically formatted files would also provide the public with an expedited mechanism to fill FOIA requests, or to allow electronic inquiry rather than personally handling paper files. The files would be made available through three electronic steps: request, receive, and review. A searchable electronically formatted document program would encourage greater use of available data, and would save manpower and time for both state employees and public users. For example, many of the databases could be supported by a multi-tiered fee structure, and users would have existing documents almost instantly available. Fees would cover the cost of continuing input and maintenance of electronic data.

Drillers Workshop and a DEQ Geologists Outreach Roscommon Stakeholder review: In 2015, 2016 and 2017, the MGS proposed a format for drill hole data entry to the Michigan Groundwater Association (MGWA) representing all the water well drillers to support more consistent, verifiable data for water resource studies. MGS has conducted training session for the drillers, a formal training workshop again in 2017. A collaborative effort is continually being proposed by MGS to have the professional geologic community and the MGWA drillers input “standard” formatted data to the same data base. Per discussions and feedback, MGS has confirmed that drillers and public users of water well data would appreciate a standardized approach to data notation and entry of drill cuttings information to a standard format.

# MICHIGAN GEOLOGICAL SURVEY

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A standard approach to the logging of drill cuttings is also a way for MGWA members to add value to the non-standard datasets that exists today. This is an ongoing discussion.

**Economic Geology:** Dr. Joyashish Thakurta, the Geosciences Department economic geologist / petrologist, has focused his research on the igneous and metamorphic rock suites of the Upper Peninsula of Michigan. His current UP research efforts are integrated into an overall program of sample collection, and geochemical analysis of little known geologic environments. He has received a grant that will allow a student to sample and analyze data for their respective theses.

As previously noted, MGS has been spearheading the endorsement of a USGS funded aeromagnetic demonstration project to be located in an area of buried Precambrian rock types that may contain favorable geology having social and economic importance.

**MGS GIS Data Management and MGS Store:** MGS continues to format new and historic maps and other documents to comply with ArcGIS standards. The MGS believes that there are many older Michigan publications and paper resources that need to be acquired and archived, in order that they can be made available to the scientific community and to the general public.

**Outreach and CoreKids K-12 program:** Dr. Peter Voice has coordinated and directed the CoreKids K-12 program at MGS-MGRRE for over five years which has had increasing interest by the Michigan education community with another successful year of contacts with fewer events. In 2017, CoreKids had contact with more than 14,000 students, teachers and parents. During the five years under Dr. Voice a total of more than 64,000 person contacts have been documented. Due to limited funding this year there was a reduction of in-school events that focused on reaching as many people as we could by providing educational content at mineral shows and science/STEM career days. CoreKids began a new partnership with MiCareerquest Southwest, which hosts an annual experiential career investigation event. A booth was provided at the event that focused on careers in the Earth sciences with a variety of hands-on activities exploring rocks, minerals, fossils, and groundwater. Over 5,000 high school students attended the three-day event and we have already registered to participate in their next event in the fall. The Michigan Earth Science Teachers Association (MESTA) also hosted a STEM Career day for students in southeastern Michigan at which WMU Geosciences hosted a CoreKids booth and a groundwater booth where Dr. Duane Hampton graciously helped us with the event, by presenting the functioning groundwater model. Over 400 students attended the MESTA STEM Career Day. Dr. Voice continued to generate educational resources for teachers—this year focused on Michigan's natural resources where he presented summaries at both the annual MESTA meeting and Grand Valley State's Fall Science Update meetings where MGS/CoreKids provided the teachers with workbooks showing graphs of mineral production from Michigan and discussed which everyday products are made from Michigan resources. Also, Dr. Voice had the opportunity to run a field trip for the annual meeting of the Michigan Alliance for Environmental and Outdoor Educators in the fall, plus an Out-Reach for a group of 10 local teachers who visited MGRRE and toured the premiere core facility. The CoreKids program received a generous gift of \$2,000 from the American Institute of Professional Geologists (AIPG), the Michigan Chapter.

**Geohazards:** MGS has initiated discussions with the USGS through the National Cooperative Geologic Mapping Program Director, John Brock; the Illinois State Geological Survey; and the Indiana

# MICHIGAN GEOLOGICAL SURVEY

<http://wmich.edu/geologysurvey>

Geological Survey to present a collaborative program for assessing the shoreline systems of Lake Michigan. The area of interest is the bluffs and dune sands and their associated impacts on housing and the developing beach features and structures. These discussions evolved to have a joint Great Lakes states, Federal and Canadian geological surveys meeting in April 2017. The USGS, NOAA and other Federal agencies joined the state and Canadian geological surveys, with representatives of State Departments and university professional having an interest, to discuss how to establish research programs on active shorelines of the Great Lakes States. In addition, MGS proposed to support emphasis on baseline data on the active shorelines of Michigan, Indiana and Illinois, particularly along Lake Michigan. USGS is currently drafting a five to 10 year FEDMAP project to incorporate the USGS geological resources to support research along the shorelines of the Lake Michigan states.

Particular interest is being discussed to map these areas with airborne surveys, perhaps using current or research technology in radar, LiDAR or other remote sensing methods in aircraft or drones and using existing data, i.e. Interferometry to assess and track movements in centimeters per year of slope stability.

**Remote Sensing:** The MGS and the Earth Sciences Remote Sensing (ESRS) laboratory under the direction of Dr. Mohamed Sultan prepared, submitted and was awarded a project using satellite Interferometry imaging for measuring responses to surface movements associated with faults, karst features, water and energy injection and withdrawals. This project is in Qatar and the analysis is projected to provide evidence of the locations of instability to support infrastructure during industrial expansion. Knowledge of these areas is critical to long range planning and engineering specifications to minimize the impact from subsurface movements. The capabilities of the ESRS lab will also be used to assess the history of water resources in SW Michigan, using the NASA Gravity Recovery and Climate Experiment (GRACE) satellite data from 2002 to 2016. WMU research has demonstrated the ability to document Michigan Lower Peninsula water storage in regional settings on an annual basis. This data set has been calibrated from a pixel of 100 Km, reduced to 25 Km (~15 miles sq.) to more accurately reflect the water storage in the glacial system. The primary emphasis has been proven in desert areas of the US and outside of the U.S., however, these recent studies indicate GRACE may be useable in the near surface glacial terrains of Michigan and the Great Lakes States using tested, and proven, remote sensing techniques.

Respectably submitted,



Attachments:

Appendix I- MGS/WMU/MGRRE Awarded and continuing Grants and Contracts

Appendix II – Resource Centers

Appendix III – Funded Professional Publications

Appendix IV - MGS/WMU, Faculty, Staff and Student 2017 Publications and presentations

Appendix V – MGS Advisory Council members

# MICHIGAN GEOLOGICAL SURVEY

<http://wmich.edu/geologysurvey>

## Appendix I

### Michigan Geological Survey, MGRRE, WMU Geosciences Michigan Professional Activities Report for 2017

#### Michigan Related Research Awarded Grants, Contracts

**MGS generated \$379,204 in NEW research grant funding in 2017. A total of ~\$556,292 of continuing awards for a combined total of \$935,496 for 2018 budgets.**

#### **New Grants and Awards \$379,204:**

Sultan, M.; Yellich, J. A.; Assessment of the Spatial and Temporal Subsidence (Sinkholes) Patterns and Controlling Factors in Qatar: A Radar Interferometric approach, Qatar, \$135,000

Harrison, William B., III, Contract with Battelle Memorial Institute funded by USDOE (2017), CarbonSAFE team will address implementation of a real-world CO<sub>2</sub> storage complex in the Northern Michigan Basin \$52,957

Harrison, William B., III 2017-2018 National Geological and Geophysical Data Preservation Program Funded by United States Geological Survey \$37,289.

Yellich, J. A.; Kehew, A. E.; Great Lakes Geologic Mapping Coalition (GLGMC) Surficial Geologic Mapping Cass County, Michigan; Sister Lakes and Sumnerville 7.5 minute \$75,462

Yellich, J.A.; Kehew, A. E.; Harrison, W.; Surficial Geologic Mapping: Dowagiac 7.5 Minute Quadrangle, Cass County, Michigan and Bedrock Geologic Mapping, SE Michigan: Bedrock Geologic Map, Wayne County, Michigan. \$74,412

#### **Existing or continuing Grants and Awards: (~\$524,562)**

Michigan Geological Survey, a 2016 Michigan Legislative Special Appropriation funding (\$500,000): "Identifying the programs to assess the Natural Resources of Michigan" managed through the MDEQ-Office of Oil Gas and Minerals for the period 2016 to 2018. There is approximately \$210,000 remaining.

Barnes, David A. and William B. Harrison, III, 2014 to 2018, Reservoir Characterization and Petrophysical Studies in Niagaran-Silurian Northern Lower Michigan, Midwest Regional Carbon Sequestration Partnership, Phase III, Budget Period 5, Funded by Battelle Memorial Corp. (approximately) \$150,000 per year, the last year to support student and faculty research.

Yellich, J.A., MDEQ-WRD, Groundwater Quality Monitoring Strategy, 24 month, August 1, 2015 extended to May 30, 2018, \$45,000 remaining.

Yellich, J. A.; Sauck, W.; and Kehew, A. K.; Ground Water Research and Education Foundation of the Ground Water Protection Council of the National Ground Water Association awarded an unsolicited

# MICHIGAN GEOLOGICAL SURVEY

<http://wmich.edu/geologysurvey>

grant for a “Proof of concept/demonstration using geophysical methods to map water resources” 2016-2018 in the amount of \$74,521. NOTE: The contract was signed in early 2018.

National Science Foundation: EAR-Instrumentation & Facilities, PI: S. Kaczmarek & A. Caruthers  
“Acquisition of a handheld XRF spectrometer to enhance sedimentary and paleoenvironmental research,  
Award #1636441 (\$76,771) 2016-2018

**Proposals submitted in 2017 and still pending, funding would be January 1, 2018-2019 and are estimated at \$318,712.**

Yellich, J.A.; DEQ\_RRD proposal, Data capture “Triage” for newly identified PFAS locations, through September 30, 2018, newly identified PFAS contaminated locations in Michigan. Pending final approval, \$125,401.

Yellich, J. A.; Kehew, A. E. USGS-GLGMC - Surficial Geologic Mapping Cass County, Michigan; Twin Lakes and continuation of county map compilations with adjoining Van Buren, St. Joseph and Berrien counties \$68,800

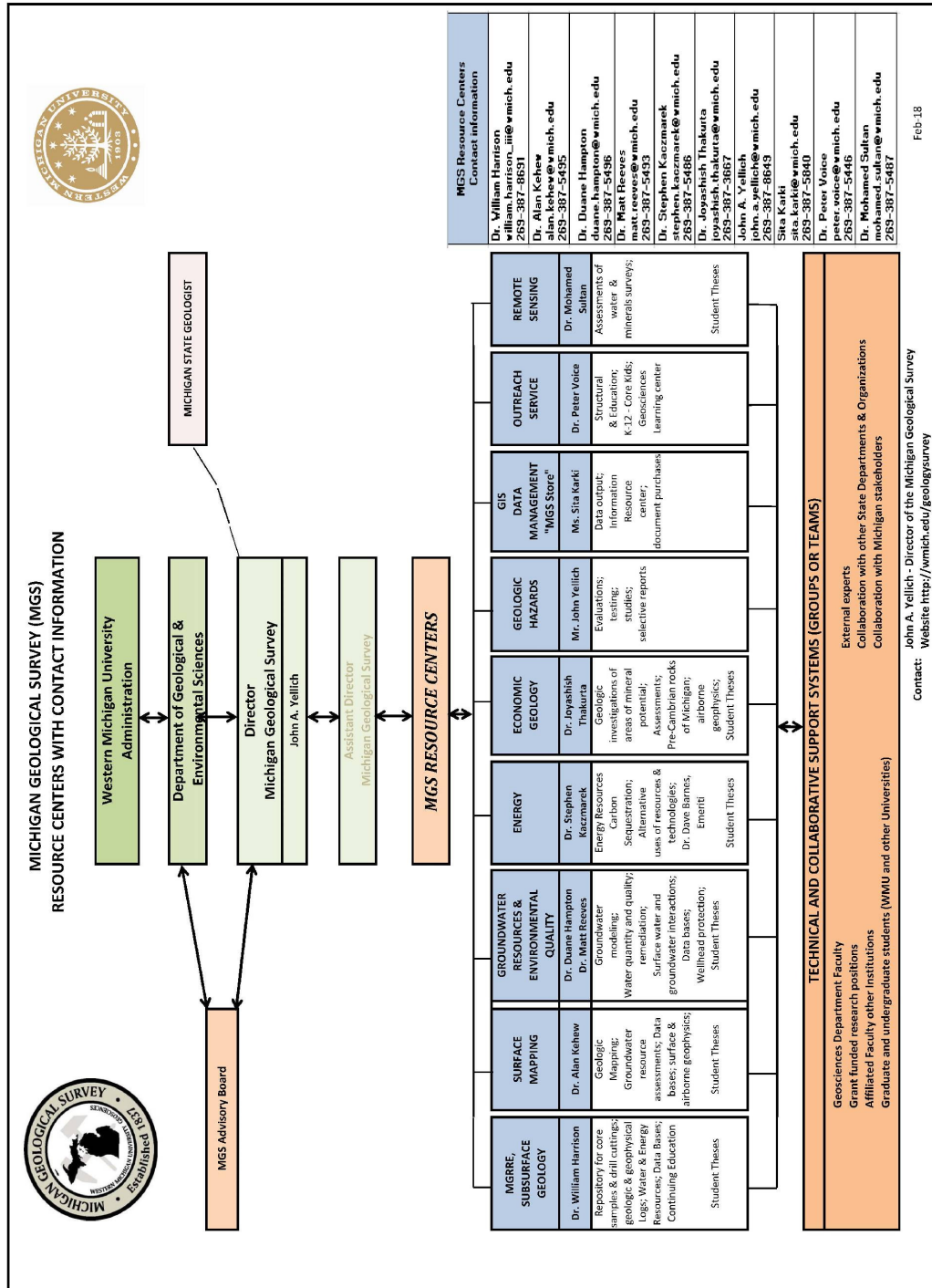
Yellich, J. A.; Kehew, A.E.; USGS STATEMAP Surficial Geologic Mapping: Twin Lakes, Edwardsburg and Adamsville 7.5 Minute Quadrangles, Cass County, Michigan and Project 2, Bedrock Geological Mapping in segments of Parma, Jackson North, Spring Arbor, and Jackson South 7.5 Minute Quadrangles in Jackson County, Michigan. \$75,117

Harrison, William B., III, 2017, National Geological and Geophysical Data Preservation Program Funded by United States Geological Survey, \$49,394

# MICHIGAN GEOLOGICAL SURVEY

<http://wmich.edu/geologysurvey>

## Appendix II





# MICHIGAN GEOLOGICAL SURVEY

<http://wmich.edu/geologysurvey>

## Appendix III

### Michigan Geological Survey, MGRRE, WMU Geosciences Michigan Funded Professional Publications Summary Report for 2017

#### USGS Quadrangle Maps produced and published with matching Federal funds in 2017:

Esch, J.M., **Yellich, J.A., Kehew, A.E.** and **Karki, S.**, 2017, Surficial Geology of the Vandalia 7.5 Minute Quadrangle, Cass County, Michigan, Surficial Geologic Map Series SGM-16-03 Scale 1:24,000.

**Kehew, A.E.**, Esch, J.E. and **Karki, S.**, 2017. Surficial Geology of the Jones 7.5 Minute Quadrangle, Cass County, Michigan, Surficial Geologic Map Series SGM-16-04, Scale 1:24,000.

Esch, J.M., and **Kehew, A.E.**, 2017, Surficial Geology of the Iron Mountain 7.5 Minute Quadrangle, Dickinson County, Michigan, Florence & Marinette Counties, Wisconsin, Surficial Geologic Map Series SGM-17-04, scale 1:24000.

**Kehew, A.E.**, Esch, J.M., **Yellich, J.A.** and **Karki, S.**, 2017, Surficial Geology of the Mottville 7.5 Minute Quadrangle, Cass County, Michigan, Surficial Geologic Map Series SGM-17-03 Scale 1:24,000.

Esch, J.M., **Kehew, A. E., Yellich, J.A., and Karki, S.**, 2017, Surficial Geology of the Marcellus and Decatur 7.5 minute Quadrangles, Cass County, Michigan, Surficial Geologic Map Series SGM – 17-05

# MICHIGAN GEOLOGICAL SURVEY

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## Appendix IV

### Michigan Publications, Published Abstracts or Professional Presentations - (Student Authors are highlighted in Bold)

#### January 1, 2017 to December 31, 2017- Students with Faculty Staff

**Al-Musawi, A. Mohammed**, Stephen E. Kaczmarek, William B. Harrison, III, and Peter J. Voice, 2017, Sequence Stratigraphy and Depositional Facies Model of the Burnt Bluff Group, Michigan Basin, USA, Abstract of Poster, AAPG Student Expo, Laramie, WY.

**Hurst, Shelby**, and R.V. Krishnamurthy, 2017, Unusual Isotopic Effects Produced in Precipitation as a Byproduct of Unusual Atmospheric Processes, Abstract of Presentation, MASAL Annual Meeting, Kalamazoo, MI

**Hurst, Shelby**, Thomas Brubaker, and R.V. Krishnamurthy, 2017, Lake Effect winter precipitation and regional ground water hydrology: perspectives from stable isotopes, Abstract of Presentation, Goldschmidt Annual Conference, Paris, France

**Hemenway, Matthew A.**, Stephen E. Kaczmarek, and **Katharine G. Rose**, September 2017, Chemostratigraphic Analysis of the Silurian-aged, Salina A-1 Carbonate using Handheld ED-XRF, Abstract of Presentation, Rocky Mountain Rendezvous AAPG Student Expo, Laramie, WY

**Hemenway, Matthew A.** and Stephen E. Kaczmarek, June 2016, The Henrietta Structure: Exploring a Potential Impact Structure in the Trenton-Black River Formation of the Michigan Basin, Abstract of Presentation, SEPM Carbonates Meeting at AAPG ACE, Calgary, AB

**Hemenway, Matthew A., Mohammed Al-Musawi, Clayton D. Joupperi, Jack H. Hybza, and Zaid Naseer Nadhim**, March 2017, Hydrocarbon Potential of Penobscot, Nova Scotia, 2<sup>nd</sup> Place at AAPG Imperial Barrel Award Competition, Pittsburgh, PA (National Graduate student competition).

**Hybza, Jack**, and Michelle Kominz, 2017, Thermal Maturation Modeling of the Michigan Basin, Abstract of Presentation, Rocky Mountain Rendezvous Annual Meeting, Laramie, WY

**Manche, Cameron J.** and Stephen E. Kaczmarek, 2017, High-Frequency Cyclicity in Dolomite Stoichiometry in the Upper Glen Rose Formation: Implications for Penecontemporaneous Dolomitization, 2017 Mountjoy Carbonate Research Conference, Austin, Texas, June 25-27, 2017

**Joupperi, Clayton D.**, Donald M. Reeves, and Jonathan D. Garret. 2017, Reservoir Characterization and Fracture Analysis of Silurian-Aged Gas Storage Reservoirs in the Michigan Basin, Rocky Mountain Rendezvous AAPG Student Expo, Laramie, WY

# MICHIGAN GEOLOGICAL SURVEY

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**Rine, M.**, Garrett, J., and Kaczmarek, S.E. (2017) A new facies architecture model for the Silurian Niagara-Lower Salina "Pinnacle" Reef Complexes of the Michigan Basin, in: Characterization and Modeling of Carbonates - Mountjoy Symposium 1 (Eds. A. MacNeil, J. Lonnee, and R. Wood) SEPM Special Publication 109, DOI: <http://dx.doi.org/10.2110/sepm.sp.109.02>, 17 p.

**VanderMeer, S.M.**, Sauck, W.A., and Esch, J. (2017), Discovering buried bedrock valleys using the HVSR passive seismic method in the Pictured Rocks National Lakeshore area, Michigan, Technical Program Abstracts, 30<sup>th</sup> Annual Symposium on the Application of Geophysics to Engineering and Environmental Problems, the Environmental and Engineering Geophysical Society, Denver, CO

**VanderMeer, S.M.**, and Sauck, W.A. (2017), Subsurface Exploration of Glacial Landforms using Ground Penetrating Radar in Pictured Rocks National Lakeshore, Michigan, Program with Abstracts, Association of Environmental & Engineering Geologists 60<sup>th</sup> Annual Meeting, Colorado Springs, CO

**VanderMeer, S.M.** (2017), Surficial Geology of Pictured Rocks National Lakeshore, Michigan – Indian Town, Melstrand, Wood Island SE, Grand Portal Point, Trappers Lake, Au Sable Point SW, Au Sable Point SE, Au Sable Point, Grand Sable Lake, and Grand Marais 7.5 Minute Quadrangles, Geological Society of America Annual Meeting, Seattle, WA, Abstracts with Programs, v. 49, no. 6

**Ziqian Li**, Chanse Ford, Duane Hampton, Paul Doss and Diane Walker, 2017, Groundwater-surface water interaction in the Headwaters of the White River, Manistee National Forest, Michigan. Abstract of Presentation, Michigan Academy of Science Arts & Letters, Kalamazoo, MI.

**Pankratz, H, Karki, S.**, Geophysical investigations in Kalamazoo County using ground penetrating radar, Michigan Academy of Science, Arts and letter Annual Meeting, Western Michigan University, March, 2017.

## **FACULTY AND STAFF (in Bold) PUBLICATIONS:**

Esch, J.M., **Yellich, J.A.**, **Kehew, A.E.** and **Karki, S.**, 2017, Surficial Geology of the Vandalia 7.5 Minute Quadrangle, Cass County, Michigan, Surficial Geologic Map Series SGM-16-03 Scale 1:24,000.

**Kehew, A.E.**, Esch, J.E. and **Karki, S.**, 2017. Surficial Geology of the Jones 7.5 Minute Quadrangle, Cass County, Michigan, Surficial Geologic Map Series SGM-16-04, Scale 1:24,000.

Esch, J.M., and **Kehew, A.E.**, 2017, Surficial Geology of the Iron Mountain 7.5 Minute Quadrangle, Dickinson County, Michigan, Florence & Marinette Counties, Wisconsin, Surficial Geologic Map Series SGM-17-04, scale 1:24000.

**Kehew, A.E.**, Esch, J.M., **Yellich, J.A.** and **Karki, S.**, 2017, Surficial Geology of the Mottville 7.5 Minute Quadrangle, Cass County, Michigan, Surficial Geologic Map Series SGM-17-03 Scale 1:24,000.

# MICHIGAN GEOLOGICAL SURVEY

<http://wmich.edu/geologysurvey>

Esch, J.M., **Kehew, A. E., Yellich, J.A., and Karki, S.**, 2017, Surficial Geology of the Marcellus and Decatur 7.5 minute Quadrangles, Cass County, Michigan, Surficial Geologic Map Series SGM – 17-05

**Kehew, A.E.**, Esch, J.M., and **Karki, S.**, 2017, Sediment-landform assemblages in southern Michigan: Implications for basal processes of the Saginaw Lobe of the Laurentide ice sheet, GSA Special Paper 530, pp 115-137



# MICHIGAN GEOLOGICAL SURVEY

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## Appendix V

Michigan Geological Survey, Advisory Council						
NAME	AFFILIATION, PROFESSIONAL INTEREST AND (OTHER)	PRIMARY PHONE CONTACT	EMAIL	ADDRESS		
1 John A. Vellich	Director Michigan Geological Survey, Western Michigan University, Dept. of Geosciences	305-901-2886 (M) 269-387-8649	<a href="mailto:john.a.vellich@wmich.edu">john.a.vellich@wmich.edu</a>	1187 Road Hall 1903 West Michigan Ave Kalamazoo, MI 49008-5241		
2 Al Kehew	Western Michigan University, Dept. of Geosciences Faculty, Quaternary, hydrogeology, glacial geology	269-387-5495	<a href="mailto:alan.kehew@wmich.edu">alan.kehew@wmich.edu</a>	1187 Road Hall 1903 West Michigan Ave Kalamazoo, MI 49008-5241		
3 Mohamed Sultan	Department Chair, Geosciences Department, Western Michigan University Environmental Sciences & Remote Sensing	269-387-5451	<a href="mailto:mohamed.sultan@wmich.edu">mohamed.sultan@wmich.edu</a>	1187 Road Hall 1903 West Michigan Ave Kalamazoo, MI 49008-5241		
4 William Harrison	MGRE, Director of the MGS - MGRE core repository at WMU, Emeritus Professor, WMU Geosciences Department	269-387-8691	<a href="mailto:william.harrison@wmich.edu">william.harrison@wmich.edu</a>	1187 Road Hall 1903 West Michigan Ave Kalamazoo, MI 49008-5241		
5 Hal Fitch	Director, Office of Oil, Gas, and Minerals, Michigan Department of Environmental Quality (MDEQ), State Geologist (WMU Advisory Council)	517-341-1548	<a href="mailto:fitchh@michigan.gov">fitchh@michigan.gov</a>	Office of Oil, Gas, and Minerals P.O. Box 30256 Lansing, MI 48909-7756		
6 Wayne Pennington	Dean - College of Engineering and Geology Michigan Technological University	906-487-2005	<a href="mailto:wayne@mtu.edu">wayne@mtu.edu</a>	712 Minerals and Materials Engineering Building 1409 Townsend Drive Houghton, MI 49931-1295		
7 Tom Quigley	Vice President - Exploration, Aquila Resources, Menominee, MI Back Forty Deposit - Menominee, long time Michigan Explor Develop Geologist	906-452-4024	<a href="mailto:tquigley@aquilaresources.com">tquigley@aquilaresources.com</a>	414 10th Avenue Menominee MI 49855-3028		
8 Paul Daniels	Earth Resources International, Principal/Registered Professional Geologist, Oil, gas, potash, minerals, environmental, Michigan, US, So America, Europe, Russia	269-343-1181	<a href="mailto:paul.daniels@earth-resources.com">paul.daniels@earth-resources.com</a>	P.O. Box 20245 Kalamazoo MI 49019		
9 David Preston	Varnum Law, Grand Rapids, Retired Senior Partner Environmental and property liability, mining projects, mine and powerplant development	616-336-6520 (Direct) 616 / 336-6000 (Office)	<a href="mailto:depreston@varnumlaw.com">depreston@varnumlaw.com</a>	333 Bridge Street, NW Grand Rapids, MI 49504		
10 Jeff Hawkins	President, Envirolgic Technologies, (Past Pres. - Kalamazoo Chamber, Member of Southwest Mich First) Brownfields development expertise, politically connected in Michigan	269-342-1100 269-345-5289	<a href="mailto:jhawkins@envirolgic.com">jhawkins@envirolgic.com</a>	2960 Interstate Parkway Kalamazoo, MI 49048		
11 Dan Balkema	Balkema Excavating - Michigan aggregates industry	517-381-1732 Ag Assoc	<a href="mailto:dan@balkemaexc.com">dan@balkemaexc.com</a>	1500 River St, Kalamazoo, MI 49048		
12 Bill Stetler	Consultant Oil, gas, geophysics, production Michigan primary area	(517) 209-3385	<a href="mailto:stetlerb@aol.com">stetlerb@aol.com</a>	1500 Kendale Blvd, Suite 301 East Lansing, MI 48823		
13 Robert G. Mannes	President, Core Energy Inc.	231-346-2419	<a href="mailto:rgmannes@coreenergyllc.com">rgmannes@coreenergyllc.com</a>	1011 Nodeware Drive Traverse City, Michigan 49646		
14 Jill Bland	Executive VP, Southwest Michigan First	(269) 492-5375	<a href="mailto:jbland@southwestmichiganfirst.com">jbland@southwestmichiganfirst.com</a>	241 East Michigan Ave, Kalamazoo, MI 49007		
15 Ralph Haefner	Director - USGS - Michigan and Ohio Water Science Center Van Wagnen Engineering	(517) 599-4954 (517) 887-8927 (W)	<a href="mailto:rhaefner@usgs.gov">rhaefner@usgs.gov</a>	6520 Mercantile Way, Suite 5 Lansing, MI 48911-5991		
16 Joe Van Wagnen	Propane storage, Und Inject wells, permitting	(517) 331-1694	<a href="mailto:vwagn@vwewway.com">vwagn@vwewway.com</a>	849 W Dansville Road Mason, MI 48854		
17 Jerry L. Allen	Consultant- Rare Earths, precious metals potash, Michigan, US, So America, Europe, Asia, Russia	520-293-9832 520-460-3572 (M)	<a href="mailto:j.l.allen@att.net">j.l.allen@att.net</a>	6845 N Maple Lane Tucson, AZ 85704		
18 Dan Willala	North Jackson Company, Environmental Science and Engineering, Partner Environmental, Groundwater, permitting mining and development (Brownfields) UP - Eagle Mine Brock Engineering	906-225-6787	<a href="mailto:dwillala@northjacksonco.com">dwillala@northjacksonco.com</a>	307 South Front Street, Suite 105 ~ Marquette, Michigan 49855 ~ (906)225-6787		
19 Tim Brock	Geological Engineer - Oil, Gas, aggregates in Michigan	(231) 421-3001	<a href="mailto:brock.engineering@yahoo.com">brock.engineering@yahoo.com</a>	170 Southeast Silver Lake Road Traverse City, MI 49685		
Ex-Officio Members						
20 Greg Rosine	WMU VP Government Affairs (State and Federal)	269-207-4434 (M) 269-387-2072 (W)	<a href="mailto:greg.rosine@wmich.edu">greg.rosine@wmich.edu</a>	1903 West Michigan Ave Kalamazoo, MI 49008		
21 Katie M. John	WMU Director of Government Affairs (State and Federal)	269-387-3606	<a href="mailto:katie.john@wmich.edu">katie.john@wmich.edu</a>	1903 West Michigan Ave Kalamazoo, MI 49008		