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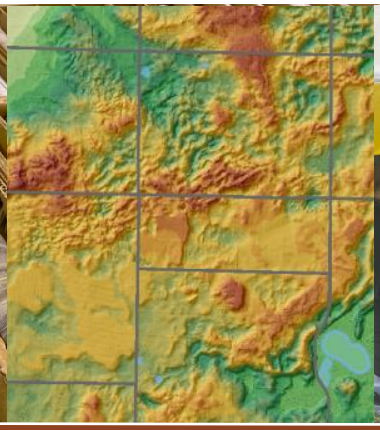
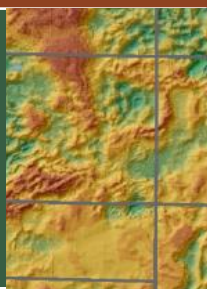


Issue 3
Summer '23

Quarterly Updates from the Michigan Geological Survey

MICHIGAN GEOLOGICAL SURVEY
EST. 1837

Core Quarterly



Highlights >>>

A Note from the Director

Since receiving annual funding in January 2023, the Michigan Geological Survey (MGS) is progressively expanding and producing more data to assess water, aggregates, carbon sequestration, natural hazards, and environmental issues. To meet priority objectives in Michigan and address our rapidly increasing data, the MGS is hiring several experienced professionals and support staff members. This quarter, MGS conducted drilling to support mapping in Ottawa and Allegan Counties and is now installing monitoring wells in critical groundwater areas to support the statewide groundwater monitoring program. The MGS has engaged with early career geologists in an effort to hire and train the next generation of geoscientists, and to support the compilation of Michigan's geologic data. The MGS thanks all those who have voiced and written support to fund the Michigan Geological Survey so that we can support all of Michigan's citizens.
Thank you again!

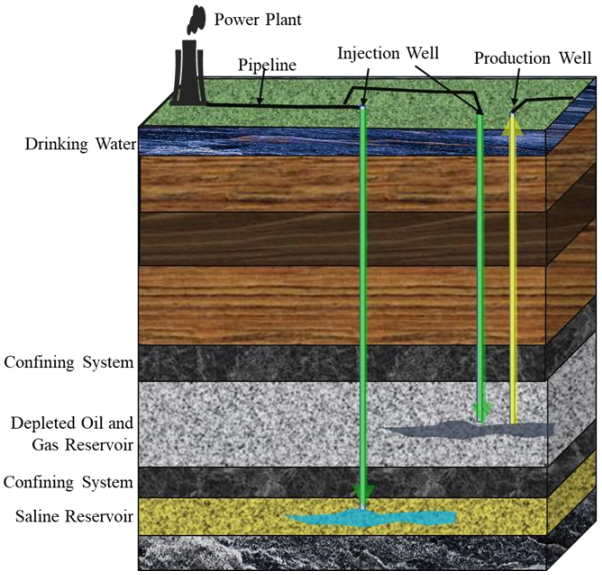
John Yellich

For more information go to
https://wmich.edu/geologysurvey

https://wmich.edu/michigangeologicalrepository

Big Win for New CCUS Research

MGS/MGRRE Wins new DOE grant to support CCUS research in Michigan



The Department of Energy (DOE) recently notified MGS/MGRRE that our proposal was selected for award under FOA2799, titled "***Advancing CCUS in the Michigan Basin.***" The project will likely begin in late 2023 or early 2024 and will span two years. Total funding includes ~$860K from DOE and $220K in cost share. The overall objectives of the project are to reduce the risks of commercial-scale storage, advance understanding of CCUS technology within communities, and ensure the long-term, safe, and equitable storage of CO_2 in the Michigan Basin. The project will conduct a thorough evaluation of major confining systems, expand characterization of reservoirs, evaluate leakage risks, and integrate findings with societal considerations. The team aims to produce an easy-to-use mapping tool, which will be publicly available, to provide critical data and information needed to make project decisions. The project team is composed of MGS/MGRRE, Western Michigan University, Central Michigan University, and Sallie Greenberg Consulting, LLC.

MICHIGAN GEOLOGICAL SURVEY
Western Michigan University
Department of Geological and Environmental Sciences
Established 1837

WESTERN MICHIGAN UNIVERSITY

Key Updates >>>

Introducing New Staff

Garrett Ringle – LP Field and Research Assistant

Garrett became part of the MGS team in early 2021, working part-time on the triage project. He has served in multiple roles along the way aiding in validating, updating, and mapping the water well database. He recently supported the project as an assistant project manager, overseeing location validation, mapping, and programming. Garrett plays a significant role in the education and outreach activities including in-person events and creating content for the YouTube channel. Now, Garrett joins the MGS full time as the Lower Peninsula field and research assistant. He will work on core logging, monitor well installation, geophysical surveying, mapping, and geologic interpretations. He will also assist with ongoing research projects.

Garrett graduated from Central Michigan University in 2020 with a B.S. in environmental science and a focus in math and geology.

Nolan Gamet – UP Field and Research Assistant

Nolan is an early career geologist with a background in general geology including experience with geochemistry and geologic field mapping. He went from analyzing trace element distributions in giant spodumene crystals formed in LCT pegmatites to mapping bedrock geology associated with the Midcontinent Rift System in Michigan's copper country. Nolan recently completed his Master's research project where he spent two field seasons mapping a segment of the Keweenaw fault and adjacent Proterozoic rocks along the Keweenaw Peninsula to better understand the fault system's kinematics, geometries, and related deformation history. He earned his MS in geology from Michigan Technological University and B.S. in geology from Central Michigan University. Nolan will be focused on supporting the MGS mapping efforts and natural resource assessments throughout Michigan's beautiful Upper Peninsula.

Data Highlight- Core Analyses

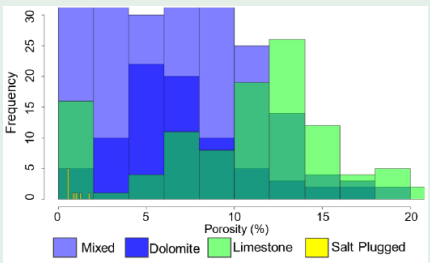
Did you know MGRRE has an entire database of core-measured properties? This often includes measurements of key reservoir properties such as porosity, permeability, fluid saturations, and grain density. Some of these include brief descriptions and notes. Digital analyses are available for approximately 2,300 wells and priced at $25 per well.

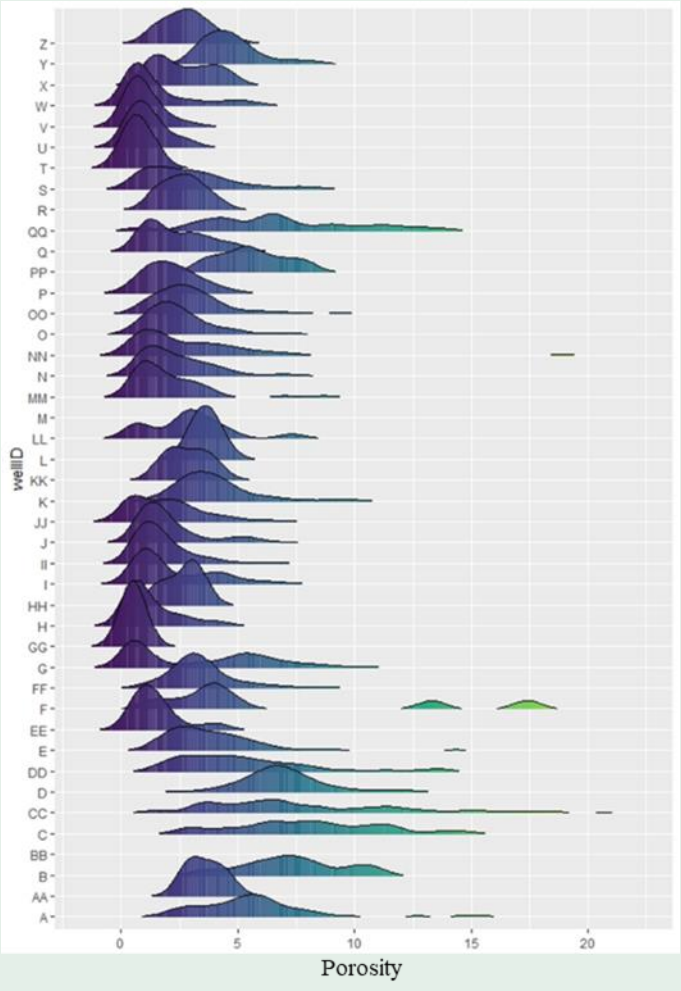
Map location of wells with core analyses

Core analyses are used for a variety of applications including oil and gas exploration, carbon sequestration, brine and waste disposal, salt and mineral production and exploration, and to improve understanding and interpretations of geology. Many cores span multiple formations from the near surface to the Precambrian basement.

To the right is a ridge plot of 48 wells with core-measured porosity in the Trenton-Black River play. The variability and changes in distribution of the porosity demonstrate the complexity of the formation.

Factors such as lithology, facies, and diagenesis can greatly influence the quality of reservoirs and seals. The figure to the right illustrates differences in porosity by lithology in the Northern Niagaran Reefs.





Outreach and Education Activities

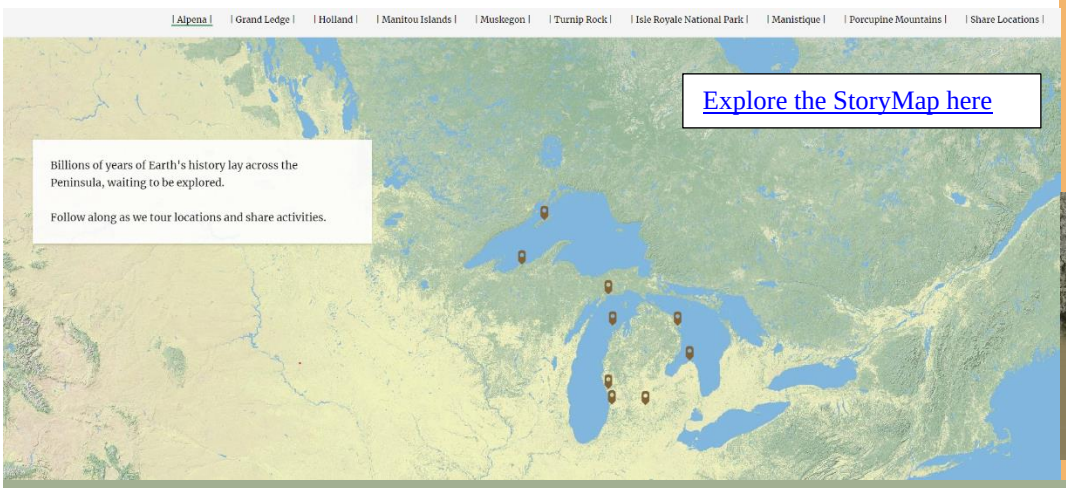
Exploring Michigan's Geologic Treasures – A StoryMap

We are excited to introduce our first StoryMap, a complement to our Michigan Geological Tourism series on YouTube. This map is constructed to take you on a virtual journey to nine geologic points of interest scattered throughout the upper and lower peninsulas. These destinations showcase the geological wonders that define Michigan's diverse landscape, providing bedrock and glacial geology maps by location, discussing formation and depositional system details, and providing information on access and preparedness. Some locations include exclusive content with insights and tips from geologist who have spent upward of decades studying these regions. Nine locations are currently covered in detail within the StoryMap: Alpena, Grand Ledge, Holland, Manitou, Muskegon, Turnip Rock, Isle Royale, Manistique, and the Porcupine Mountains.

Via the link below, you can discover the wide range of geologic topics studied in Michigan with primary examples for you to visit in person. Learn about the sinkholes and shipwrecks of Alpena, the sandstone cliffs and plant fossils of Grand Ledge, the shoreline and dune deposition of Holland and Muskegon, the copper ores of Isle Royale, and much more.

Our StoryMap is designed to be interactive, allowing users like you to make a contribution. If you know a fascinating geological site in Michigan, you have the option to add it to the map. After review by one of our staff members, your input may become part of our growing set of points of interests.

Attention educators—we've also prepared a comprehensive lesson plan to accompany the StoryMap. This resource guides students through each of the nine stops and includes thought-provoking questions that tie together the geological aspects of these locations in a self-guided fashion. Instructors interested in integrating our lesson plan into their teaching can reach out to Marie Solum, MGS Outreach Coordinator at marie.solum@wmich.edu. She can provide you with the lesson plan and associated key.



Free Geologic Maps for Educators

MGS is offering a limited supply of historic geologic and water resources maps and reports at no cost to educators. These maps are available for pick up only at MGRRE. If interested, please contact us with any questions.

Michigan Natural Resources YouTube Series Launches

Michigan hosts a diverse portfolio of resources across the state. This includes, but is not limited to, gold, copper, iron, gypsum, salt, sand, clay, gravel, and oil and gas. Our latest series will dive deeper into the importance of these resources and continued production of critical materials in Michigan.

November 2, 2023 Core Workshop will be held at MGRRE

On November 2, 2023, we will host a core workshop here at MGRRE. The topic is "A Review of Michigan Carbonate Reservoirs." Several industry members will share their knowledge and experiences in the Traverse, Trenton, and Niagaran formations. The home team of Autumn Haagsma and Bill Harrison will talk about some geological and data aspects of carbonate formations. Amber Conner from Battelle will talk about the geology of carbonates as that relates to CCUS. And our State Geologist, Adam Wygant, will bring us up to speed on developments in Michigan. The full program and registration material can be found by CLICKING HERE.

Outreach and Education Activities

STEAM Day at Kalamazoo Air Zoo

The Summer of 2023 was a busy time for Outreach at MGS. In July, Matthew Bell and Cristian Valle participated in STEAM Day at the Kalamazoo Air Zoo where they demonstrated groundwater models and well drilling at an event attended by 1000 people. Evangelia Murgia and Sophia White were on hand for the Naturalist Explorers' Camp teaching approximately 143 summer campers about fossils. Marie Solum attended the Michigan Earth Science Teachers Association (MESTA) Fall Meeting and Rock Party event where 80 members and their families participated in fun rock and fossil games. MGS provided teachers with educational materials and MGS literature.

In September, MGS hosted a space-themed day at Children's Nature Playscape in Kalamazoo where approximately 40 young children and their parents learned about impact craters, rocketry, the Artemis Moon missions, and about researchers who are studying how to grow food on the International Space Station and for future Mars missions with simulated Mars soil.

Sophia White helped children build a straw rocket and launch it at the moon

Children planted seeds in Earth soil and simulated Mars soil and could take them home to watch their experiments grow

Michigan Alliance for Environmental and Outdoor Education

Peter Voice identifying fossils found by MAEOE teachers in the Rockport Quarry

Petoskey stone found in the Rockport Quarry

Peter Voice and Marie Solum attended the Michigan Alliance for Environmental and Outdoor Education (MAEOE) conference in Alpena where they interacted with 150 Michigan teachers and provided educational materials and Michigan geological publications.

Peter Voice led a field trip to the Rockport State Recreation Area where 35 teachers learned about the Devonian geology and paleontology of the Alpena area and the former Rockport Quarry. The teachers thoroughly enjoyed collecting Petoskey stones, and other fossil corals, sponges, crinoids and brachiopods.

Outreach and Education Activities

MGS Presents to the United Tribes of Michigan

MGS made recent presentations to national and local organizations this past month. MGS was invited to present an overview of the MGS programs to the Annual meeting of the United Tribes of Michigan, held in L'Anse at the Keweenaw Bay Indian Community, Zeba Community Center, "*Annual funding for the Michigan Geological Survey, Justification and Benefits."* MGS now has funding and presented a slide show and posters of recent mapping products to show water resources and projects currently being done. MGS will continue to present our mapping and research successes to identify and protect our natural resources.

Below are new articles, theses, and maps produced by the Michigan Geological Survey and by WMU Students since early 2023. Michigan Geological Survey staff members' names are bolded.

Adeyilola, A., Zakharova, N., Liu, K., Gentzis, T., Carvajal-Ortiz, H., Fowler, H., & **Harrison, W. B**. (2023). Porosity distribution in the Devonian Antrim Shale: Controlling factors and implications for gas sorption. *International Journal of Coal Geology*, *272*, 104251. https://doi.org/10.1016/j.coal.2023.104251

Brandt, D., Higley, M., Marshall, M., Petcovic, H. L., Velbel, M., **Voice, P. J.,** Winkelstern, I., with contributions from Kodosky, L., LoDuca, S., Chapman, D., Williams, A., & Mazzola, M. (2023). *Mid-Michigan's Outdoor Classroom: Pennsylvanian Marginal-Marine Strata at Grand Ledge, Michigan*. Field Trip Guidebook for the North Central Section Annual Meeting, Geological Society of America.

Colgan, P. M., **Erber, N. R., Esch, J. M., Yellich, J. A., & Anderson, G. P.** (2023). *Surficial Geology of Allegan County, Michigan*. Kalamazoo, Michigan Geological Survey. SGM-23-01, 1:62,500.

Erber, N. R., Kehew, A. E., Schaetzl, R. J., **Gillespie, R.,** Sultan, M. E., **Esch, J., Yellich, J.,** Brandon Curry, B., Huot, S., & Abotalib, A. Z. (2023). Revisiting the timing of Saginaw lobe ice retreat and implications for drainage adjustments across southern Michigan, USA. *Catena*, *233*, 107510. https://doi.org/10.1016/j.catena.2023.107510

Schaetzl, R. J., Arbogast, A. F., Baish, C., Curry, B. B., **Esch, J.,** Fulton, A. E., II, Kincare, A. K., Lepper, K., Lewis, M., Lowell, T., Lusch, D., & Yansa, C. (2023). *The Glacial and Postglacial History of the Houghton Lake Basin*. Midwest Friends of the Pleistocene. Guidebook.

Voice, P. J. (2023). *Geology and Paleontology of Rockport State Recreation Area*. Field Trip Guidebook for the Annual Meeting of the Michigan Alliance for Environmental and Outdoor Educators.

Voice, P. J., Harrison III, W. B., Harrison, L., Gillespie, R., & Trout, J. L. (2023). *Adventures with Cores: A Tour of the Michigan Geological Repository for Research and Education*. Field Trip Guidebook for the North Central Section Annual Meeting, Geological Society of America.

<u>WMU Student Research on Michigan topics</u>

Sanabria, N. R. (2023). *Concept Validation: Collecting composite samples to understand the presence of per- and polyfluoroalkyl substances (PFAS) in Michigan Forested Areas* Unpublished MS Thesis, Western Michigan University. Kalamazoo, MI.

Outreach and Education Activities

2023 Summer Research at MGRRE- A Keck Research Experience for Undergraduates

A Project to Study Middle and Upper Devonian Rocks of Michigan

By: Peter Voice and Jay Zambito (Beloit College)

This past summer MGRRE and the Michigan Geological Survey hosted 9 undergraduate students working on a Keck Research Experience for Undergraduates (REU) Project. Students from across the country were invited to spend a week in Kalamazoo to examine cores, collect samples, and make observations, followed by two weeks at Beloit College to analyze the samples. The students finished their summer work by attending the Subcommission on Devonian Stratigraphy meeting at SUNY Geneseo where they went on field trips to study the Devonian strata of Ohio, Pennsylvania, and New York, listened to talks from a wide variety of Devonian specialists, and even presented preliminary results from their projects.

At MGRRE, we had a series of cores laid out for the students that covered the interval from the upper Traverse Group through the Ellsworth Shale. The students explored the cores, and with consultation with Jay and Peter, developed individual projects.

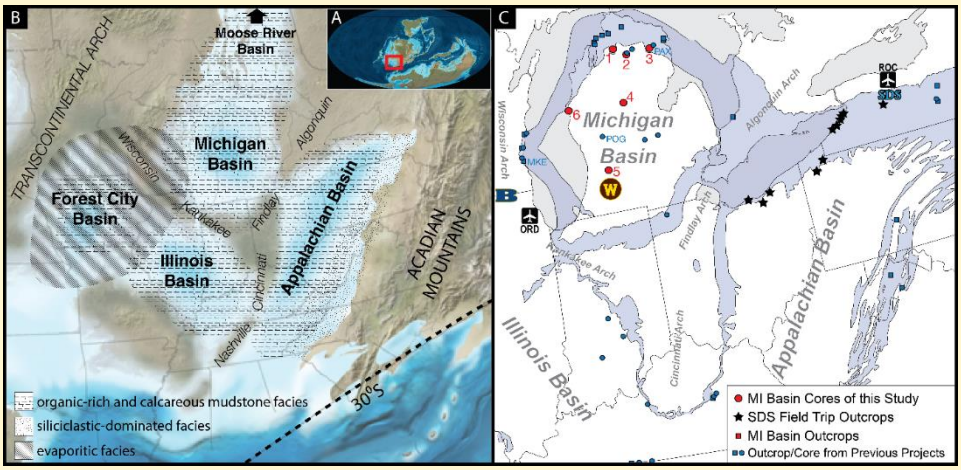


Figure 1 A) position of the Michigan Basin on a paleogeographic reconstruction of the Middle Devonian Earth, B) a subset of the Devonian Paleogeographic map showing that the Michigan Basin was an interior sea connected to the world ocean during this span, C) Map showing the distribution of Devonian rocks where they are the subcrop beneath the soil and glacial sediments. The map also shows most of the wells used in the study as well as important outcrops in Michigan. For the students, the map was also used to show several of the field trip spots that they were going to visit in New York.

The projects include:

1) A student examined the upper Traverse Group in the subsurface to attempt correlation to the outcrop belt of this unit. Historically much effort has been expended on mapping the discontinuous exposure along the outcrop belt which has led to a proliferation of geologic formation names. Unfortunately, correlating from the outcrop to the subsurface has been more difficult due to changes in rock type (the Traverse Group is shalier in eastern Michigan and more dominated by limestone to the west).
2) One student characterized the "Squaw Bay Formation." This formation is slated for a name change in the near future, but in order to formally change the name of a rock unit, we need to geologically define the revised unit. A second student looked at the contact between the Traverse Group and the "Squaw Bay Formation" in an attempt to understand the alteration of these sediments during lithification.
3) Several students collected high density sampling in the Antrim Shale to generate a robust dataset that includes organic carbon isotopes, elemental analyses from x-ray fluorescence, and magnetic susceptibility. These datasets will help with regional correlation and hopefully better constrain the age of the Antrim Shale.
4) Two students looked at the Ellsworth Shale – one doing detailed statistical analyses of the laminations and the other gathered elemental data from x-ray fluorescence and mineralogical data from x-ray diffraction of samples.

The last student is working on constructing a geologic map for Alpena County – the high density of wells, especially in the southern half of the county, provides a lot of information that can be used to construct a quality map for the region. Bedrock maps like this provide information on natural resources and even natural hazards – Alpena, for example, has areas of limestone bedrock that are susceptible to karsting and sinkhole development.

The students are not finished yet with their work on the Devonian of the Michigan Basin – they returned to their home institutions and will be working on writing theses and reports summarizing their work over the Fall 2023-Spring 2024 academic year. The students will also be preparing short contributions for a Keck Proceedings volume and will present their research at the Spring 2024 joint North Central-South Central Geological Society of America Meeting.

2023 Summer Keck Students

Outreach and Education Activities

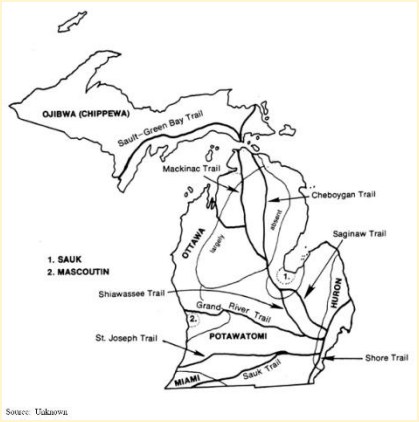
An Intersection of Art, Native American History, and Geology

Written By: Evangelia Murgia

In the spirit of connecting past and present, science and art, and nature and technology, MGS recently collaborated on an exciting project with a Western Michigan University fine arts student. This endeavor has led to the creation of a concept illustration for a new mural inside the Waldo Library, which acts as a testament to Michigan's rich geological heritage and the convergence of creativity and knowledge.

Audre Balanda, a talented fine arts student with a concentration in painting and portraiture, contacted MGS's outreach team to discuss an initial concept of converging geology with art, in order to portray Michigan's history and natural beauty. Her initial proposal was originally inspired by the true story of Angelique Mott, an Algonquin woman who in the mid-1800s faced a perilous journey, losing her husband to the elements in an effort to mine native copper deposits on Isle Royale. This mural, once realized, will not only adorn the walls of the Waldo Library but also serve as a powerful tribute to Michigan's copper heritage and its enduring impact on our state. At a scale of 336 square ft., the mural's size is intended to proportionally reflect the impact of copper on Michigan's economic history.

The Keweenaw Peninsula in Michigan's Upper Peninsula is home to some of the world's most extensive copper deposits. Native American tribes, particularly the Ojibwa, Ottawa, and Potawatomi, were the first to recognize the value of this abundant resource. Copper was extracted, shaped, and traded across the state and continent, making it a vital part of precolonial North American trade networks.



Historic Native American Tribes and Trails

The concept illustration shown above for the Waldo Library mural contains an homage to a unique piece of Michigan's native copper—a mitten-shaped artifact displayed outside Rood Hall, the Department of Geological and Environmental Sciences' building (pictured to the right). This distinctive copper piece serves as a tangible link to Michigan's copper mining past and its cultural significance. Furthermore, the traces of major Native American copper trade routes dating back to approximately 1760 are superimposed over the mitten, showing the spread of copper trades from their northwestern Michigan source. These routes evoke the historical significance of copper as a traded commodity. Many of these trade routes followed rivers and streams, facilitating transportation and trade. Birch trees, featured prominently on the right side of the mural, represent the use of birch bark in the crafting of canoes, an essential part of transportation and trade networks. The circular motif in the top left corner symbolizes the sun, casting a spotlight on the areas of Michigan with some of the world's most significant copper deposits along the Keweenaw Peninsula and Isle Royale. Adding another layer of depth, the mural features water waves along the bottom, alluding to the Great Lakes. The waves themselves are constructed of monochromatic recreations of bedrock geology maps reiterated upon one another, seamlessly intertwining Michigan's geological history with our state's freshwater abundance and its role in the spread of copper throughout the Midwest.

Copper Mitten Display Outside Rood Hall

The joint concept of this project alongside Balanda's execution, contemporarily merges nature, history, and science, all while paying homage to Native American legacy. As we anticipate the realization of this mural project, we are reminded of Michigan's deep connection to copper, a legacy that has significantly impacted our state's history and culture.

Sources:
Davis, C.M. Readings in the Geography of Michigan. Michigan State University Press, 1954.
Halsey, John R., Ed. Retrieving Michigan's Buried Past: Archaeology of the Great Lakes State. Bloomfield Hills, MI: Cranbrook Institute of Science, 1999.
Martin, Susan R. Wonderful Power: The Story of Ancient Copper Working in the Lake Superior Basin. Detroit: Wayne State University Press, 1999.
Morton, Ron and Carl Gawboy. Talking Rocks: Geology and 10,000 Years of Native American Tradition in the Lake Superior Region. Minneapolis: University of Minnesota Press, 2000.

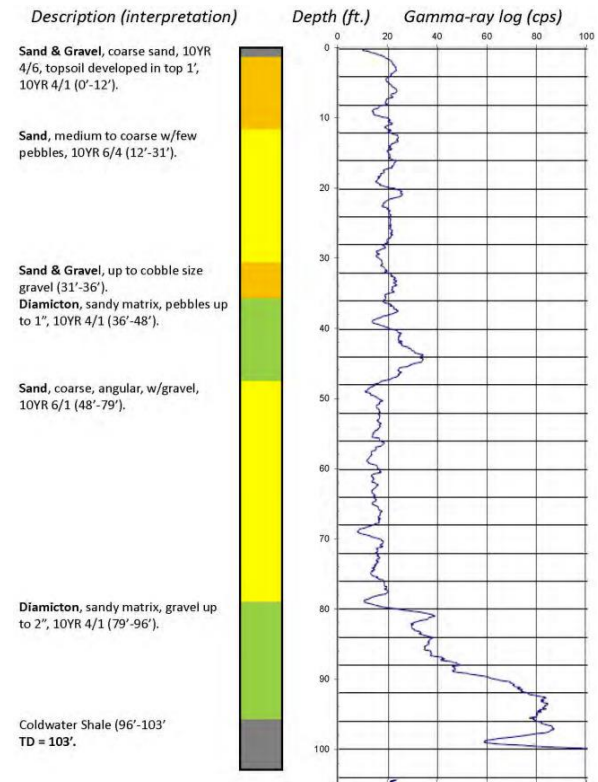
Research Findings

Surficial Geologic Map of Allegan County
Mapping Project Update

Surficial geologic mapping of Allegan County was completed by the Michigan Geological Survey because the county is a high priority area for mapping within the State of Michigan due to its high population growth rate and existing transportation corridors of I-96 and US-131. Allegan County contains complex glacial landforms and sediments that formed during advance and retreat of the Lake Michigan Lobe of the Laurentide Ice Sheet during the last glaciation (~32,000 to ~11,700 years ago). Since the ice sheet retreated out of Allegan County ~16-17,000 years ago, wind, water, and weathering have eroded and modified glacial sediments and formed eolian dunes (e.g., coastal and inland), stream sediments (e.g., alluvium), lake sediments, and productive soils for agriculture.

MGS staff collecting samples in the field

Uses of Surficial Geologic Maps:
A surficial geology map shows the geological materials such as diamicton, sand and gravel, or clay found within ~5 feet of the ground surface. In some cases, these surface units extend to much greater depths, and in other cases a different sediment may lie just below the surface sediment. The map shows the areal distribution of the different types of sediment and landforms as described in the map explanation. Surficial geology maps can assist anyone wanting to know what lies at or beneath the land surface.



Example core description and gamma-log from a borehole in Allegan County

For example, these maps may aid in the search for water supplies, or economically important deposits such as sand and gravel for aggregate or clay for bricks or clay tile. The maps, along with water-well logs, can provide an indication as to whether an aquifer at depth is connected to a surface stream. This information is critically important in assessing whether or not a water well near a stream could cause an excessive depletion of surface water. Foundation conditions determined by the surficial geological materials are critical inputs to any type of development. Environmental issues such as the location of a suitable landfill site or the possible spread of contaminants are directly related to surficial geology. Construction projects such as locating new roads, excavating foundations, or building homes may be better planned with a knowledge of the surficial geology of the site. Once a surficial geologic map is constructed, it can be used for a variety of derivative maps, such as aquifer thickness and extent, range of transmissivity values, sensitivity to surface and near surface derived contaminants, and reserves of sand and gravel.

Methods:
Field mapping of Allegan County was completed by Prof. Patrick Colgan (MGS contract mapper and professor at Grand Valley State University) and Nathan Erber (MGS senior research associate) with support from John Esch (MGS contract mapper). Their mapping was informed by existing county maps constructed by Gephart and Larson (1989), and quadrangle maps by Alan Kehew and his students. Light Detection and Ranging (LiDAR)-derived 1-m DEMs, which include high-resolution elevations of the land surface (<4 in), are available for Allegan County. The LiDAR data was a critical tool to interpreting the subtle features like sand dunes, terraces, and beach ridges. Without the LiDAR data many of these features would not have been recognized.
Test borings using the rotary wireline, mud rotary, and roto-sonic coring methods were drilled as part of this mapping project and are plotted on the maps. Cores are archived at the Michigan Geological Repository for Research and Education (MGRRE) facility at the Michigan Geological Survey. These borings are essential to an understanding of the subsurface geology of the glacial deposits. Gamma-ray logs are made of the borehole at the time of drilling.

Research Findings

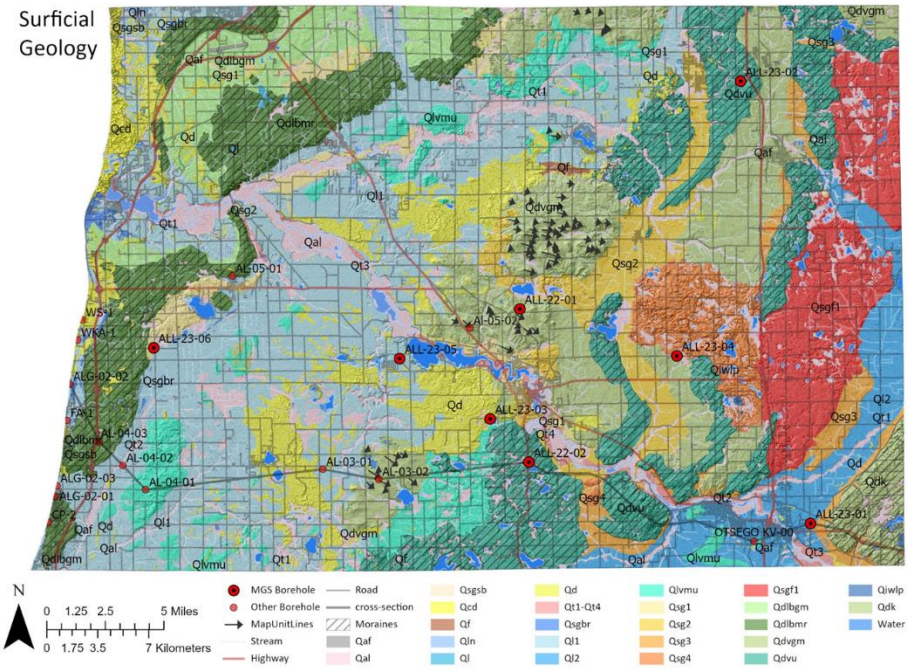
Surficial Geologic Map of Allegan County

Mapping Project Update

Updates to the map:

Recent fieldwork, elevation data, and subsurface information were critical to updating the surficial geology of Allegan County. These updates are evident when comparing the delineation of geologic units such as dunes, terraces, and moraines shown on previous maps with those on the revised map. The map cross-section highlights a selection of the subsurface data collected from test borings during this project (and from previous work). A second map sheet of Allegan County also includes derivative maps of bedrock topography, drift thickness, water table, hydric soils, aggregate resources, water well locations, and field observations.

Major glacial geological features and sediments in the county include prominent uplands of the northeast-southwest trending Lake Border, Valparaiso, and Kalamazoo moraine systems (composed of diamicton, sand, and gravel), and widespread glaciolacustrine (sand, silt, clay), and glaciofluvial sediments (sand and gravel) in plains and lowlands between moraines. Nonglacial features include eolian dunes (sand), alluvial fans and floodplains (sand, silt and clay).

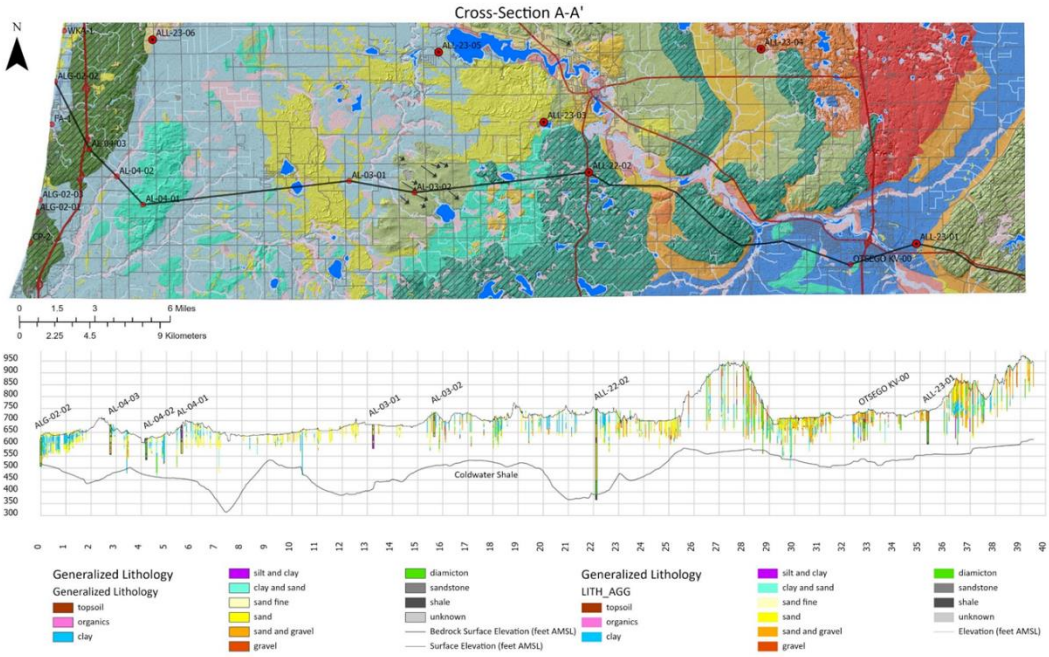


Updated surficial geology map of Allegan County

Water Resources:

Bedrock aquifers are not commonly used in Allegan County to supply drinking water. However, wells that do target bedrock aquifers are predominately located in the northeast corner of the county and target the Michigan and Marshall Formations (sandstone). Outside the northeast corner of the county, the predominate bedrock unit is the Coldwater Formation (shale), which is not a productive aquifer, but instead an aquitard that is a barrier to the movement of groundwater or contains saline water.

Unconsolidated sediments deposited by glacial processes host aquifers that are typically used for drinking water supplies throughout Allegan County. Glacial aquifers are typically located in subsurface glaciofluvial sand and gravel, subsurface glaciolacustrine sand, and near surface glaciofluvial sand and gravel units. Nonglacial aquifers in the county include dune sand and alluvial sediments at the surface.



Geologic cross section through Allegan County showing well locations and lithologies

Aggregate Resources:

Significant sand and gravel mining operations occur across Allegan County. Most of the sand and gravel pits are associated with fan, outwash, and lacustrine deposits. Other areas of numerous sand and gravel pits occur in the incised Kalamazoo River terraces and floodplain, and the apparent former shoreline deposits at the boundary between the lacustrine and morainal uplands. In the central part of the county there are some inland dune fields which are a source for sand.

For more details:

MAP:
https://wmugeography.maps.arcgis.com/sharing/rest/content/items/6e4633c660464f878be5c373dd3a2892/data

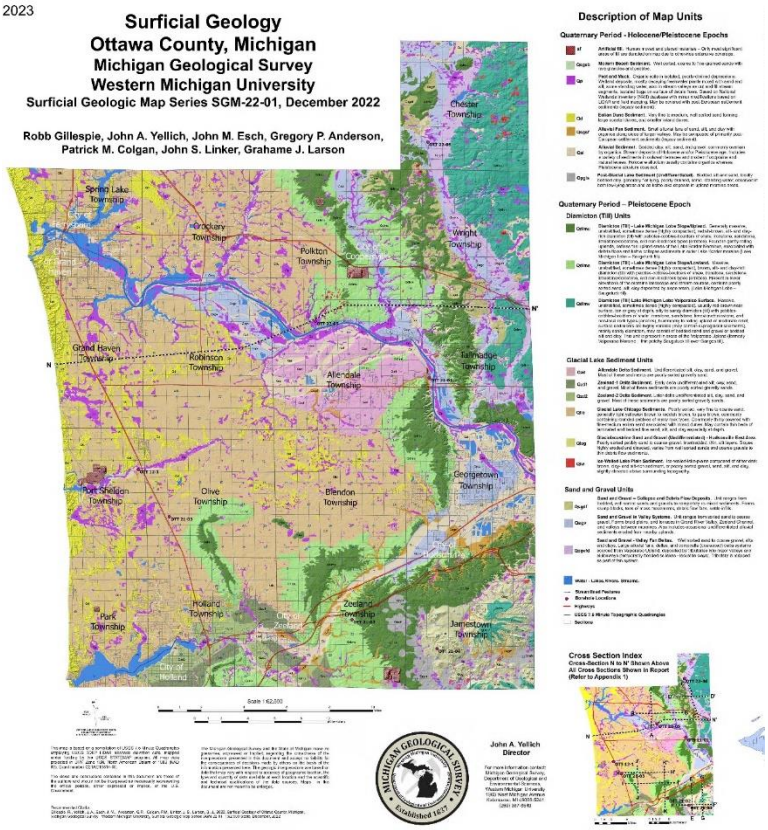
REPORT:
https://wmugeography.maps.arcgis.com/sharing/rest/content/items/7a5714922a6c4fa69e3cc7556d3f2f38/data

Research Findings

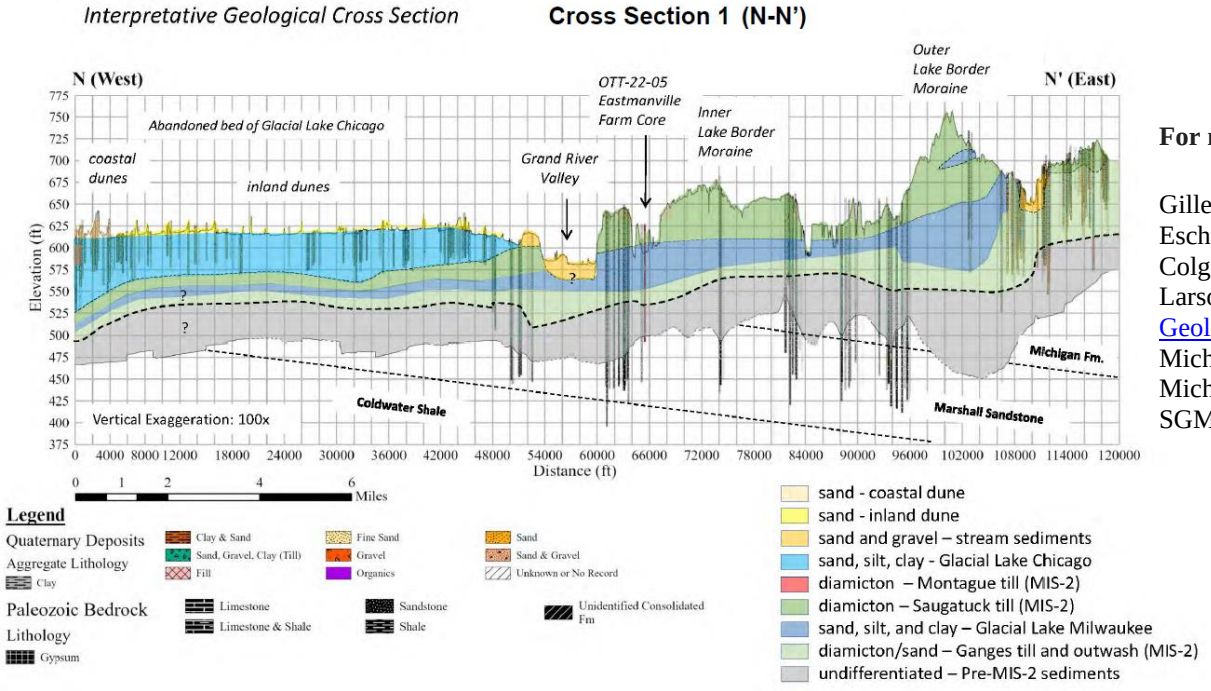
Surficial Geologic Map of Ottawa County

Mapping Project Update

Ottawa County was proposed for surficial geologic mapping because of the high priority issues related to groundwater resources and geology as indicated by the Michigan PFAS Action Response Team (MPART), EGLE Water Resource Division- High Capacity (WRD-HC), and Ottawa County Department of Strategic Impact. Because of these local and statewide high priority needs, the MGS applied for USGS STATEMAP matching funds for surficial geologic mapping in Ottawa County in 2020. Due to COVID-related issues, mapping of the county took longer than the anticipated 2 years to complete. The map was completed by MGS staff Robb Gillespie, John Yellich, and Greg Anderson, with contracted support from John Esch (EGLE), Dr. Patrick Colgan (GVSU), John Linker (Kellogsville Public Schools), and Grahame Larson (MSU – Emeritus). MGS conducted surficial mapping in multiple areas and subsequent drilling in priority geologic and water resource areas. MGS confirmed the limited glacial aquifer resources in the central portion of the county and the shallow and deeper aquifers in the West and Eastern segments of the county. Shallow water resources are critical for understanding the groundwater recharge and aggregate resources of the county. The detailed mapping confirmed areas of sand and gravel, but also confirmed areas of productive soils in the central part of the county that have limited available water resources, hence needing deeper wells. MGS mapping team compiled data from water wells together with data from appropriate MGS and other drill holes to prepare detailed cross sections adjacent to the MGS core holes. That compilation better reflected a 3D picture of the area. This is included in the supporting Technical Report.



With annual funding in 2023, MGS drilled more holes this year, after the draft map was submitted. MGS will be updating our Ottawa map with this new information for all to use. MGS produced a Technical Report that presents the glacial and bedrock water wells, oil and gas wells, bedrock contour map, and aggregate resources databases, noting test pits or production areas. All this information is open-file data.



Geologic cross section through Ottawa County showing well locations and lithologies

For more details:

Gillespie, R., Yellich, J. A., Esch, J. M., Anderson, G.P., Colgan, P.M., Linker, J. S., and Larson, G. J., 2022, Surficial Geology of Ottawa County: Michigan Geological Survey, Michigan Geological Map SGM-22-01, scale 1:62,500.

Core Stories

Salina Group, C-Shale Formation

Consumers Power- Brine Disposal #1-7
St. Clair County, Sec. 7-T5N-R17E
API# 211476116080000

Written and Interpreted by: Dr. William B. Harrison, III

The Salina Group in Michigan reaches a maximum thickness of nearly 3000' (Figure 1), mostly because of the thick intervals of evaporitic strata. Bedded salt up to 450' thick occurs in each of the Salina A-1, Salina A-2 and Salina B formations. A much thinner Salina D formation is less than 70' thick; and the massive, multi-member, Salina F reaches a maximum thickness of 1000' in the depocenter of the basin just northwest of Saginaw Bay (Harrison and Voice, 2017).

Although dominated by salt (throughout the basin center) and anhydrite (around the basin margins), the Salina Group does contain other lithologies. Limestone and dolostone occur in the Salina A-1 and A-2 carbonates and the calcareous and evaporitic Salina E-Unit. Unusual calcareous shales are present in the Salina C and Salina G units.

Many of the Salina Group units have had current or historical economic value: the hydrocarbons in the A-1 and A-2 carbonates; solution-mined salt in the A-1, A-2 and B salts; and underground salt mining in the F salt. However, the C-Shale has never been recognized as having much commercial value.

The shale units of the Salina Group, including the C-Shale, have garnered relatively limited interest from geoscientists, other than for their use as stratigraphic marker beds, especially, from gamma ray tracks on wireline well logs. Due to this limited interest, very few core samples were drilled in this formation throughout the basin. So, we were surprised to find a 35-foot section of core from the C-Shale, as we were working of a project here at the Michigan Geological Repository for Research and Education (MGRRE). It's from the Consumers Power Brine Disposal well #1-7 (API 21147611608000) in St. Clair County. Most of the core shows the typical C-Shale

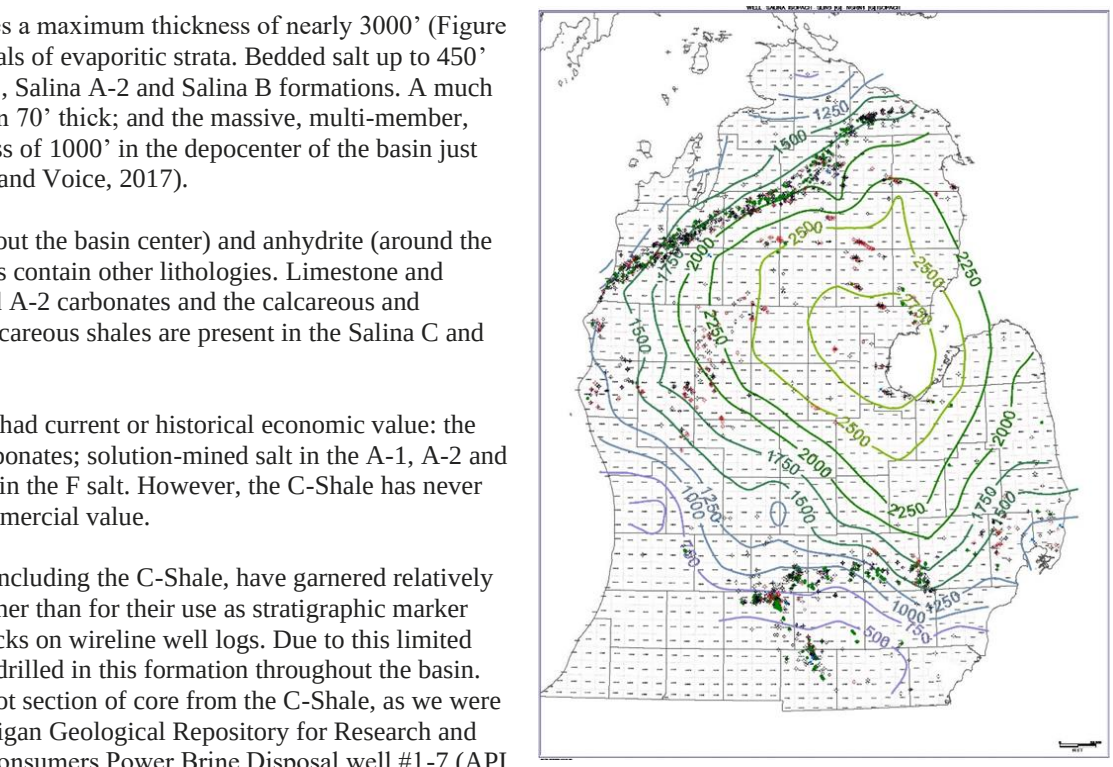


Figure 1 Thickness Map of Salina Group in Michigan Basin. Contour intervals in feet (from Harrison and Voice, 2017)

Figure 2: Middle C-Shale slabbed core from Consumers Power Brine Disposal #1-7 (depth in feet). From online collection of Michigan Cored well photos (https://scholarworks.wmich.edu/core_photos/5836/)

lithology: a fine-grained, gray to tan to grayish-green calcareous shale with patches of bluish anhydrite dispersed throughout. Figure 2 is a section of this core as shown in one of the high-resolution core photographs we are creating as part of our National Geological and Geophysical Data Preservation Program (NGGDPP) project.

We were even more surprised to see some dramatic orange-colored salt filling fractures. Unlike the typical salt found in the Salina Group, this was bright orange and made up of long, thin fibrous crystals that are oriented perpendicular to the fracture walls. (Figure 3).

This unusual occurrence of salt-filled fractures in the C-Shale was featured in a recent core workshop held at MGRRE, in conjunction with the North-Central Geological Society of America Annual Meeting in Grand Rapids, Michigan (Figure 4).

coming soon >>>

New Core/Data

A core was received from Consumers Power from the Cranberry Lake storage field in Clare County.

Core Stories

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Figure 3: C-Shale slabbed core showing fractures filled by fibrous orange salt. Core from Consumers Power Brine Disposal #1-7. Photograph from online photos of Michigan cored wells: https://scholarworks.wmich.edu/core_photos/5845/

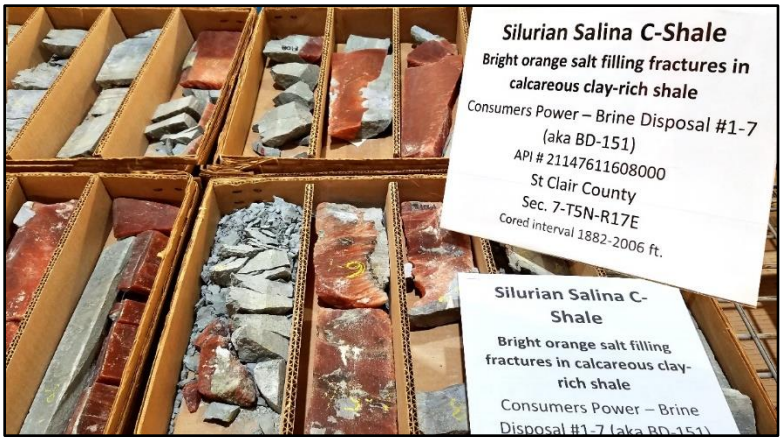


Figure 4: C-Shale slabbed cores with fractures filled by fibrous orange salt (photo courtesy of Linda Harrison)

We were curious about this orange salt's composition and thought the color might have been due to some iron. So, we asked WMU's Carbonate Petrology and Characterization Laboratory (CPCL) (https://www.researchdolomite.com) to carry out sample analyses. After their analyses by X-ray diffraction, SEM imagery, and elemental mapping, the mystery was solved: the orange crystals are largely composed of NaCl—Halite. Trace amounts of CaSO4, Anhydrite, are found disseminated within the fibrous salt crystals. At the base of those fibrous salt crystals, near the contact with the fracture wall of the C-Shale matrix, is a zone of blocky anhydrite crystals (Fig. 5). One last surprise—there was less iron in these samples than is found in the clear halite from other Salina units in the basin, based on X-ray fluorescence testing by Mohammed Al-Musawi, another graduate student in the CPCL.

We speculate that the large fibrous crystals might have "flash-crystalized," as hot saline fluids from deeper in the basin were injected into fractures. We have seen these orange salt crystals only in two other cores, also in the C-Shale, drilled by MDOT into the bedrock in Wayne County of Southeast Michigan. We are now keeping our eyes open for more of these unusual fracture-filling orange salt crystals.

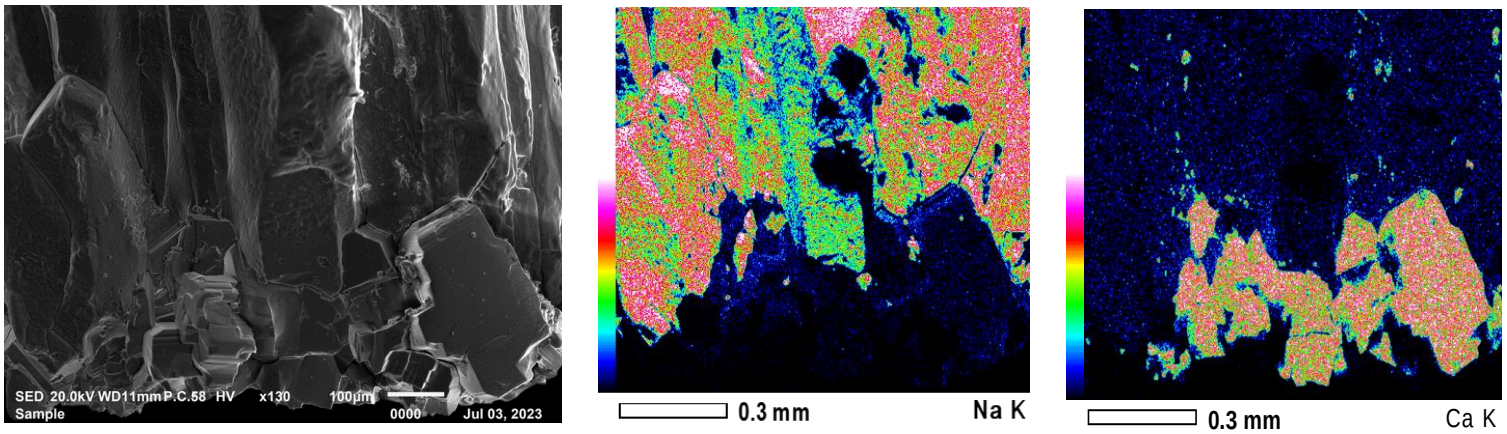


Figure 5. Left - SEM Image -Orange Salt sample from fracture filling in C-Shale in Consumers Power Brine Disposal well #1-7. Middle – colors show elemental mapping for Sodium atoms (Na) implying NaCl (Halite). Right – colors show elemental mapping of calcium atoms (Ca) implying CaSO4 (Anhydrite). SEM analyses, courtesy Ashley Scott, WMU graduate student.

Reference:
Harrison, W.B., III, and Voice, P.J., 2017, Evaporite facies of the Michigan Basin, *in* Grammer, G.M., Harrison, W.B., III, and Barnes, D.A., eds., Paleozoic Stratigraphy and Resources of the Michigan Basin: Geological Society of America Special Paper 531, p. 197–216, doi:10.1130/2017.2531(10).

The Michigan Copper Industry

One of Michigan's First Experiences with Critical Minerals

Written and Interpreted by: Dr. Peter Voice

During the early days of the first Michigan Geological Survey, Douglass Houghton was tasked with mapping the mineral resources of the Upper Peninsula. Rumors of high-purity copper drove interest in these mapping efforts (Eustis, 1818; Schoolcraft, 1821). By the 1850s copper was being mined at several locations along the Keweenaw Peninsula. Copper production was continuous through 1995 when the White Pine Mine closed. Since 2014, the Eagle Mine of Marquette County has been producing copper, nickel, and platinum group elements. An excellent review of the copper deposits and industry of Michigan is provided by Bornhorst and Lankton (2009).

Copper In the Keweenaw area is hosted in (Figure 1):

1) Amygdule and fracture fills in the Portage Lake Volcanics. Amygdules are vesicles filled with minerals. The vesicles formed from cooling of the basaltic magmas around exsolved gas bubbles. Copper is present as native copper, copper oxides, and copper carbonates.
2) Cements in pores and fractures in the interflow conglomerates interbedded with the basalt lava flows of the Portage Lake Volcanics and in the Copper Harbor Conglomerate – some cements formed thick rinds around cobbles that are called "Skull Copper." Copper is present primarily as native copper.
3) Cements and fracture fills in the Nonesuch Shale. Copper is present as Copper sulfides.

Figure 2 shows a summary of copper production from Michigan. This figure was compiled from production statistics archived at the Michigan Geological Survey. Copper production initially went toward kitchenware (pots, pans, kettles, etc.) and fixtures and pipes used in early plumbing. By the 1890s, Michigan copper was being used to electrify America's cities – an effort that would last into the early 20th century. In 1910, the Michigan copper industry faced its first major challenge in the form of competition from the newly opened copper mines of Arizona, which is reflected in the first large drop in copper production. Declines continued as the Great Depression intensified in the 1930s. Rural electrification was one of the experiments fostered by the Roosevelt administration as part of its jobs programs in the 1930s – of course it also had the side benefit of promoting safer storage of farm products, such as refrigeration for milk, that benefited farmers and consumers.

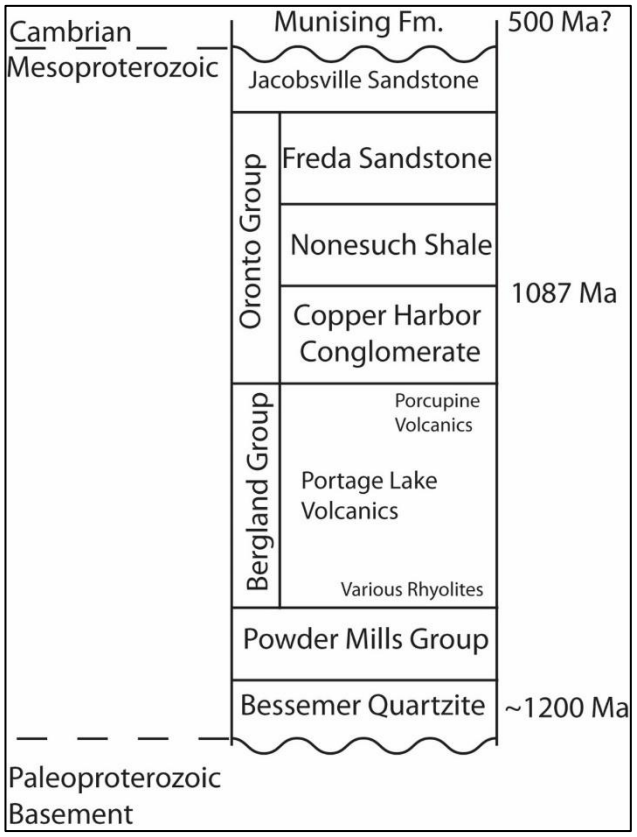


Figure 1: Stratigraphy of the Keweenaw Area. Copper is hosted in the Portage Lake Volcanics, the Copper Harbor Conglomerate, and the Nonesuch Shale.

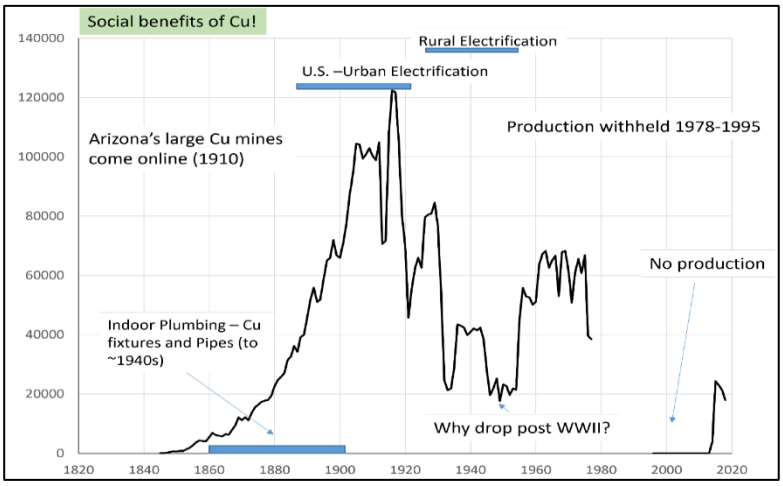


Figure 2: Copper production history of Michigan.

Military uses of copper (electrical wiring for planes, ships, trucks, etc., as well as copper casings for ammunition) also promoted the surge of production in the later 1930s and early 1940s. Another severe challenge to the Michigan copper industry came right after World War II when copper scrap became widely available from recycling of expended military equipment. Michigan copper mining continued in the Keweenaw area through 1978 but the number of mines decreased steadily from 1950 to 1978. In 1978, only one copper mine was left in the area at White Pine. The White Pine Mine would persist until 1996 when it finally closed. On Figure 2 you will see a gap in the production statistics. Although production occurred at White Pine during this span, the annual production numbers are considered proprietary by the U.S. Geological Survey because the production was by a sole company. From 1995 to 2018, commercial production of copper ore occurred in Michigan. The Eagle Mine started producing copper in 2014 and is still producing today.

The cumulative production of copper in Michigan from 1845 to 2018 (the last year for which we currently have production numbers) was just over 6.6 million metric tons! In 2021, copper was valued at $9317.00 per metric ton. The total value of the copper mined in Michigan in 2021 dollars would be over 61.5 million dollars!

Field Stories

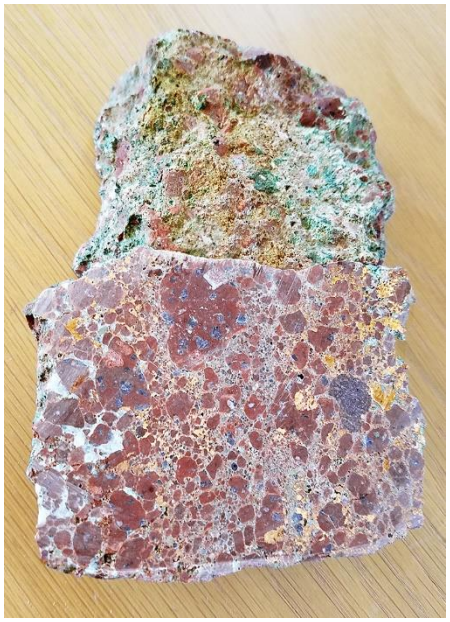
Rock Hounding Copper in the Keweenaw

Written and Interpreted by: Autumn Haagsma

This summer, several members of the MGS/MGRRE team vacationed in the Upper Peninsula of Michigan. A vacation for a geologist cannot be complete without some rock hounding and collecting! Of particular interest were the copper-filled conglomerates in the Keweenaw Peninsula. These beauties can be highly deceiving on the outside, but filled with coppery-goodness on the inside. Many abandoned hoists and their tailings make excellent locations for rock collecting. Always check with local laws and do not trespass if marked as private property. A favorite spot for our team was located near an abandoned hoist. In the tailings we found samples of the Calumet and Hecla (C&H) conglomerates. Not all samples like these will contain copper, but a good way to find copper includes:

1) Using a metal detector – every metal detector is different. A great method is to keep a small piece of copper with you to compare to the chirps of the detector
2) Looking for the classic green/blue weathered discoloration (image below)

Photograph taken by Linda Harrison of an abandoned hoist



Photograph (above) taken by Linda Harrison of inside and outside of C&H conglomerate

C&H conglomerates were interpreted to be deposited in an alluvial fan environment within the ancient rift valley. They are composed of silt to cobble-sized grains composed of clasts of rhyolite and other volcanic rocks. C&H conglomerates can have different shades of red and green matrix with clasts of various sizes, colors, and composition. Copper can be found coating grains or filling in spaces between grains.

Photographs (above and right) taken by Autumn Haagsma showing variability of C&H conglomerates

References:

Bornhorst, T. J. and Lankton, L. D. 2009, Copper Mining: A Billion Years of Geologic and Human History, in Schaetzl, R. Darden, J., and Brandt, D. (Eds.), Michigan Geography and Geology, Pearson Custom Publishing, p. 150-173.

Eustis, W. 1818, Experiments made by the Assay-Master of the King of the Netherlands, at the Mint of Utrecht on the Native Copper Existing in Huge Blocks on the South Side of Lake Superior, American Monthly Magazine and Critical Review, 2, 366-367.

Schoolcraft, H. R. 1821, Account of the native copper on the southern shore of Lake Superior with historical citations and miscellaneous remarks in a report to the Department of War, American Journal of Science, 3, 201-216.

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