Potash Deposits in the Michigan Basin

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Abstract

Potash occurs in the center of the Michigan basin in the Salina A-1 Evaporite formation. It occurs as sylvite in beds up to 30 feet thick or as sylvite (KCl) intermixed with halite (NaCl) as sylvinite. The potash zones are between 7000 and 9000 feet deep in the northern half of Michigan's Lower Peninsula. Large-scale commercial potash mining in Michigan began at a solution mining facility near Hersey, Michigan in 1997, however a pilot production program began in 1989 and grew to commercial scale throughout the 1990's. The grade of this potash deposit is the highest in the world at nearly 70% KCl by volume. Potash production at the Hersey mine ceased in 2013.

In 2007, a significant collection of cores from the A-1 Evaporite in the commercial mining area, as well as throughout the northern half of Michigan was donated to the Michigan Geological Repository for Research and Education (MGRRE) at Western Michigan University. The company that had initially drilled those cores had used the data and no longer needed the cores. The collection consists of more than 11,300 linear feet of conventional, 4-inch core sealed in plastic sleeves, from 77 different wells in 9 counties.

Using geophysical logs, it can be estimated that Michigan's potash deposits occur in 17 counties in the north-central part of the Michigan basin. Based on thickness of sylvite intervals and grade values from core analyses, commercial production could likely be developed in 9 counties, representing 2.9 million acres.

Michigan potash core at MGRRE

Introduction

A potash-bearing salt formation was discovered in the Michigan Basin when Dow Chemical Company drilled the Dow # 8SM well in 1951 in Midland County, section 21 of township 14N and range 2E. The well was cored in the Salina A-1 Salt from a depth of 8145 feet to 8570 feet. Results from chemical assay testing of core samples were reported by Anderson and Egleson in 1970. Comparison of analytical results from the Dow #8SM core to nearby wireline well logs documented a measurable radioactive anomaly on the gamma ray logs through the potash-bearing intervals. Regional mapping using gamma ray logs enabled Anderson, et al., (1972) to estimate the lateral distribution throughout the north-central Michigan basin.

The large collection of potash rock core samples currently preserved at MGRRE, part of the Michigan Geological Survey (MGS), provides an exceptional sample and data resource to study and

analyze this geologically unusual and economically valuable rock formation. Research by MGRRE staff and students has identified the geologic and stratigraphic distribution of this deposit and analytical testing by industry has confirmed it to be the highest grade potash known throughout the world.

Research activity

Staff and students at MGRRE and MGS received a 2021-2022 research grant from the U.S. Geological Survey National Geological and Geophysical Data Preservation Program (NGGDPP) to digitize and evaluate wireline logs from wells throughout the Michigan Basin that penetrated the Silurian-aged evaporite-bearing geologic interval. The Salina A-1 Salt unit in this sequence is known to contain potash-bearing layers that can be identified by detailed examination of the gamma ray track on these logs. Creating digitized versions of the log tracks allows for quantitative assessment of the concentration of potash-bearing strata. We analyzed and digitized 523 wireline logs from wells in northern and central Michigan where the state's deposits of potash, a critical mineral, occur. By analyzing the wireline logs we defined the distribution of potash, an essential fertilizer ingredient that helps plants take up retain water. There is no substitute for potash. More than 93% of potash consumed in this country is imported. We examined well records to identify formation top and bottom depths in each of the 523 wells. Potash occurs only in the A-1 Salt formation, stratigraphically between the A-1 Carbonate and the Brown Niagaran formations. By recognizing distinct patterns in the log curves, particularly the gamma ray and bulk density curves, we could distinguish the potash beds from other evaporite deposits. Recording the depth and thickness of these beds in each well, we then produced cross-sections defining the lateral and vertical extent of these deposits. That data along with assay data describing the concentration of potash in 22 core samples was entered in the NGGDPP's ReSciColl public database. Both the Borgen Bed deposits and the Basin-Centered Beds showed a very high concentration of K_20, compared to other world potash sources. Both the distribution and grade data compiled in this work may support further investigation into economically developing these domestic potash deposits in several counties, that may help increase food security through reducing the country's reliance on foreign sources.

Through a current NGGDPP-funded research project (2023-2025), the MGRRE team is compiling analytical geochemical data from 200 samples throughout the cored areas. Through another NGGDPP-funded project (2024-2027), we are creating 3-D digital model images of selected potash core samples. These images will provide quantitative data that will allow us to visually estimate the percentage of potash (KCl) versus salt (NaCl) in selected cored intervals. These estimates can be compared to quantitative geochemical analyses to verify the accuracy of these visual estimates.

A recent publication examining the evaporites in the Michigan Basin (Harrison and Voice, 2017) briefly reevaluates and describes the Salina A-1 Evaporite Formation that contains the potash-bearing interval. The following is a direct quote from Harrison and Voice (2017).

> "The Salina A-1 Evaporite is the basal evaporitic unit in the Salina Group. In basinal and shelf-margin settings, it has a gradational lower contact with the underlying A-0 Carbonate (Cain Formation), which is a restricted, laminated micritic carbonate that grades upward over several feet into millimeter-scale laminae of carbonate and anhydrite that then grade further upward into millimeter-scale laminae of anhydrite and carbonate

interbedded with decimeter-scale beds of halite (Fig. 4A). The halite often shows chevron crystal growth forms (Fig. 4B), suggesting shallow subaqueous deposition (Schreiber and El Tabakh, 2000). Sylvite is interbedded with halite (Fig. 5) throughout the upper half of the A-1 Evaporite in the north-central part of the basin. Chemical assays of cores from the producing area show these deposits to be one of the highest-grade potash deposits in the world, at an average of nearly 45% KCl by volume (30% K2O). Elowski (1980) mapped "fingers" of thin sylvite beds along the basinward edge of the northern "pinnacle reef" trend, suggesting that the sylvite-producing brines extended a short distance into the reef trend. Matthews (1970) suggested that potash occurred in parts of 22 counties covering over 13,000 mi^2 (over 33,700 km^2). Recent mapping for this study showed commercial volumes of potash occur in only about eight counties in north-central Michigan (~11,700 km^2). There are two main target horizons that have been evaluated for commercial development of Potash in Michigan. The western area of the Sylvite occurrence is limited to a single unit, informally named the "Borgen Bed," near the top of the Salina A-1 Evaporite interval. It is generally one continuous bed 3–10 m (10–30 ft) thick. Average estimated sylvite content in the "Borgen" interval from core observation is 55% KCl or 35% K2O. The other potassic zone is an interval informally termed the "Basin-Centered Beds" that occur several hundred feet stratigraphically below the top of the Salina A-1 Evaporite. This interval has numerous thin beds (centimeters to meters thick) in a gross interval 21.3–45.7 m (70–150 ft) thick with net log measured sylvite bed thickness of 12–21 m (40–70 ft). The average estimated sylvite content calculated from core observation is 43.8% KCl or 27.7% K2O. The A-1 Evaporite attains a thickness of over 136 m (450 ft; Fig. 6A) in the basin center, where it is predominately halite or halite interbedded with sylvite in the central and northwestern portions. The evaporite interval gradually thins toward the basin margin, where it reaches a zero edge at the Niagaran platform shelf edge. The Niagaran "pinnacle reefs" that lie on the Niagaran slope, basinward of the shelf edge, have A-1 Evaporite between them, but the A-1 Evaporite does not overtop these reefs. In the southern portion of the reef trend, the A-1 Evaporite is exclusively anhydrite, but in the northern trend, the A-1 Evaporite is anhydrite near the reefs but grades into halite a short distance away from the reefs. Nurmi and Friedman (1977) also mapped the extent of the sylvite facies in the center of the basin, as well as the limits of the Salina A-1 Evaporite, Salina A-2 Evaporite, and B Evaporite deposits."

Production History

Early history of potash production in the Michigan basin was recorded as secondary mineral production from producing natural brines for other commodities such as salt, bromine, magnesium, calcium chloride and iodine. Dow Chemical Company was the primary brine producer in Michigan and they produced potash from brine in wells in Midland County, Michigan. State records indicate that there was reported potash production from natural brines from at least 1951 through 1970. Production averaged about 3500 tons annually during that 20-year period.

Renewed potash production began with development of a solution mining operation in the Salina A-1 Evaporite formation near Hersey, Michigan in Osceola County in the late 1980's. That production continued until 2013 when the plant was closed for potash processing. Annual potash production averaged only about 22,000 tons per year in the early 1990's, however it rose to over 100,000 tons per year by the late 1990's and continued near that level until closing in 2013.

References

Anderson, R.J., Egleson, G.C., Matthews, R.D. & Majeske, E.C., 1972, The Recent Discovery and Probable Distribution of Extensive Deposits of Potash in the Silurian of Michigan. in Gill, J.E., ed. *24th International Geological Congress*, Montreal, Canada, Section 4, p. 445-452.

Anderson, R.J. and Egleson, G.C., 1970, Discovery of Potash in the A-1 Salina salt in Michigan, in Kellner, W.A., ed., *Proceedings of the Sixth Annual Forum on The Geology of Industrial Minerals*, Miscellany 1, Geological Survey Division, Michigan Department of Natural Resources, Lansing, MI, p. 15-19.

Anderson, R.J. and Majeske, E.C., 1970, Detection of Potash zones by drilling fluid analysis, in Kellner, W.A., ed., *Proceedings of the Sixth Annual Forum on The Geology of Industrial Minerals*, Miscellany 1, Geological Survey Division, Michigan Department of Natural Resources, Lansing, MI, p. 34-36.

Elowski, Ronald, 1980, Potassium Salts (Potash) of the Salina A-1 Evaporite in the Michigan Basin, Michigan Geological Survey Report of Investigation 25, Michigan Department of Natural Resources, Geological Survey Division , 15p., 9 plates.

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).

Matthews, R.D., 1970, The distribution of Silurian potash in the Michigan basin, in Kellner, W.A., ed., *Proceedings of the Sixth Annual Forum on The Geology of Industrial Minerals*, Miscellany 1, Geological Survey Division, Michigan Department of Natural Resources, Lansing, MI, p. 20-33.

Matthews, R.D. & Egleson, G.C. (1973) The Origin and Implications of a Mid-Basin Potash Facies in the Salina Salt of Michigan. Coogan, A.H., ed., 4th *International Symposium on Salt [Proceedings]*, p. 15-34.

Nurmi, R.D., and Friedman, G.M., 1977, Sedimentology and depositional environments of basin-center evaporites, Lower Salina Group (Upper Silurian), Michigan Basin, *in* Fisher, J.H., ed., Reefs and Evaporites—Concepts and Depositional Models: American Association of Petroleum Geologists Studies in Geology 5, p. 23–53.

Sonnenfeld, P., and Al-Aasm, I., 1991, The Salina evaporites in the Michigan Basin, *in* Catacosinos, P.A., and Daniels, P.A., Jr., eds., Early Sedimentary Evolution of the Michigan Basin: Geological Society of America Special Paper 256, p. 139–153, doi:10.1130/SPE256-p139.

U.S. Geological Survey, 2013, Website about U.S. potash resources, http://minerals.usgs.gov/minerals/pubs/commodity/potash/mcs-2013-potas.pdf, Accessed, September 12, 2013.

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