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Arizona has Potash

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Potash ('pät-,ash) n: (1) Potassium carbonate (K_2CO_3) especially the crude impure form obtained from a solution of wood ashes in iron pots. (2) A term loosely used for any substance containing potassium whose potassium content is expressed in terms of K_2O. (3) Used in fertilizers, ceramics, glass, and soap. [Source: Webster's Dictionary; AGI Dictionary of Geological terms]. Most potash is now obtained by mining.

INTRODUCTION

Potash prices are skyrocketing and may soar to $1,000 or more per ton by the end of 2008 (Figure 1). Rapidly rising demand for fertilizer and limited expansion of production are leading causes of the increase (Sergeant, 2008). Good potash deposits are rare, there are few global producers, and growth in demand is great; generally bad news for consumers. The good news is that the dramatic increase in price has renewed interest in Arizona potash deposits. Yes, Arizona has potash!

This article is adapted from the recently released open-file report OFR-08-07, "Potash and related resources of the Holbrook basin, Arizona" (Rauzi, 2008).

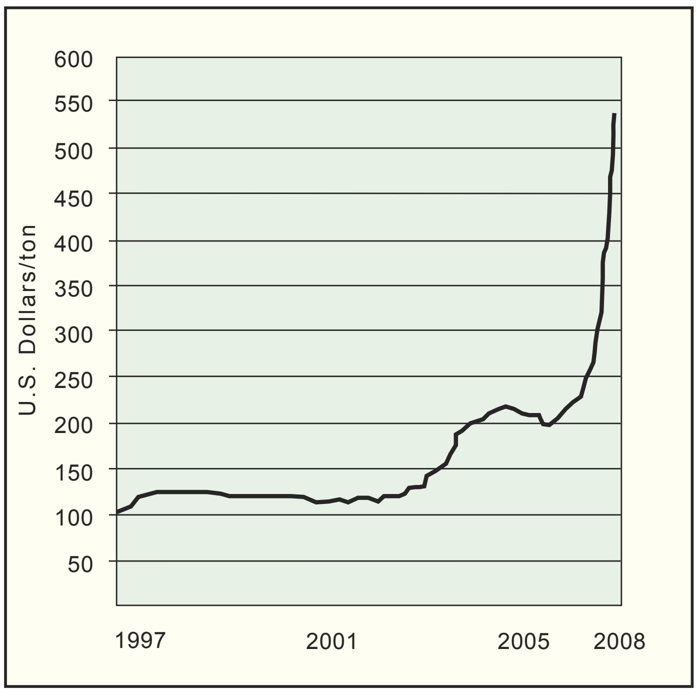

Figure 1. Muriate of potash (KCl) price in dollars per ton. Price is anticipated to reach $1000 per ton by the end of 2008. Source: Sergeant, www.Mineweb.com.

Arizona Potash

Potash in Arizona is present near the top of extensive salt (halite - NaCl) deposits in the Permian Supai formation (270-220 Ma) of east-central Arizona (Figures 2, 3, and 4), where bedded salt underlies about 3,500 square miles and attains a maximum aggregate thickness of 655 ft (Rauzi, 2000). The extent of the salt defines the Holbrook salt basin. Potash underlies about 600 square miles and ranges up to about 40 ft thick. The gross volume of potash as depicted on Figure 2 is 1.36 cubic miles (5.68 cubic kilometers) or 2.5 billion tons (2.27 billion metric tons) assuming a deposit wide average of 20% K_2O.

Potash is confined to the northern part of the basin where bedded salt reaches its maximum thickness (Rauzi, 2000). The salt appears to have formed by desiccation of saline mud flats and salt pans of an inner sabkha (supra-tidal environment in arid climates). The occurrence of potash near the top of the salt deposit may be due to the relative solubility of potash and salt during the evaporation of sea water across the sabkha. Repeated incursions of sea water appear to have preferentially dissolved and re-precipitated the potash thereby separating and concentrating the potassium from the halite.

In the 1960s and 1970s, Arkla Exploration Company and Duval Corporation drilled more than 100 holes to delineate the potash in the Holbrook salt basin. Only five

Mission

To inform and advise the public about the geologic character of Arizona in order to increase understanding and encourage prudent development of the State's land, water, mineral, and energy resources.

Activities

Public Information

Inform the public by answering inquiries, preparing and selling maps and reports, maintaining a library, databases, and a website, giving talks, and leading fieldtrips.

Geologic Mapping

Map and describe the origin and character of rock units and their weathering products.

Hazards and Limitations

Investigate geologic hazards and limitations such as earthquakes, land subsidence, flooding, and rock solution that may affect the health and welfare of the public or impact land and resource management.

Energy and Mineral Resources

Describe the origin, distribution, and character of metallic, nonmetallic, and energy resources and identify areas that have potential for future discoveries.

Oil and Gas Conservation Commission

Assist in carrying out the rules, orders, and policies established by the Commission, which regulates the drilling for and production of oil, gas, helium, carbon dioxide, and geothermal resources.

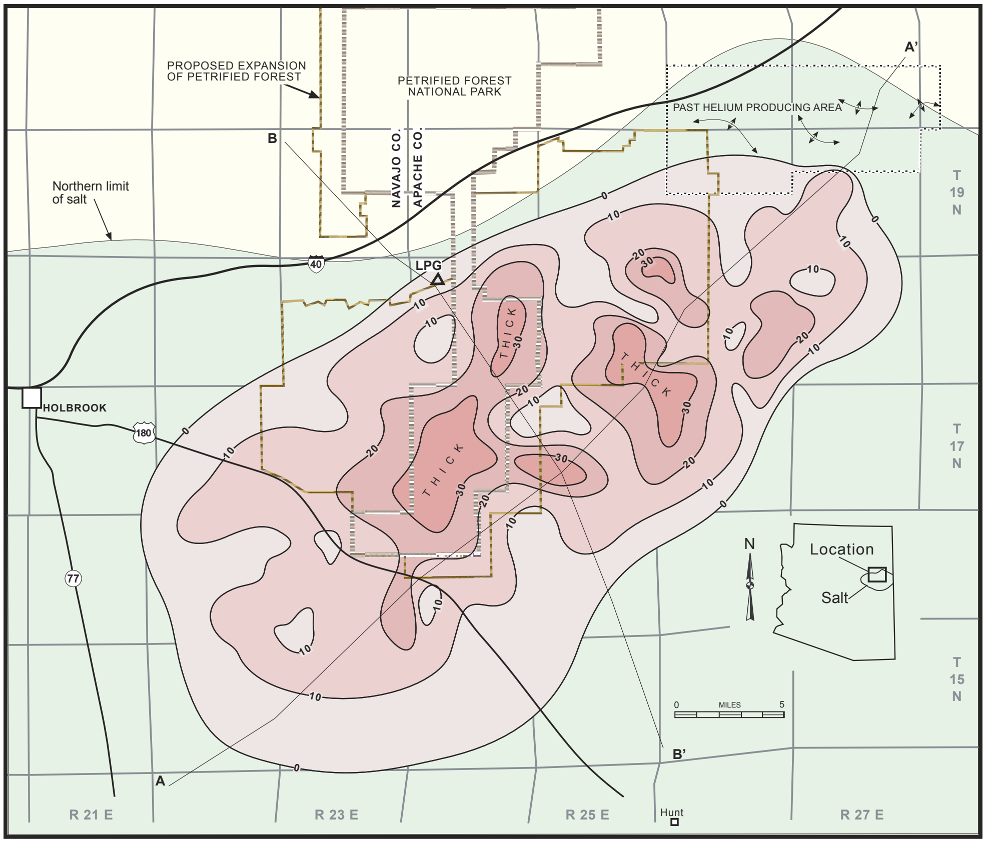

Figure 2. Map showing thickness of potash in the Holbrook salt basin, Apache and Navajo Counties, Arizona. Contour interval is 10 ft. Note former helium producing area near northeastern extent of potash deposits and LPG-storage facility near the northwestern extent.

holes were drilled through the entire thickness of salt but 127 holes were drilled into the upper 100 to 300 ft of salt where potash is present. Most holes were cored through the upper 100 ft of salt to get direct information about the nature of the potash deposits. Arkla and Duval reported the presence of potassium minerals sylvite (KCl), carnallite ($KMgCl_3$), and polyhalite ($K_2Ca_2Mg(SO_4)_4{\cdot}2H_2O$) in the main potash "pay zone." Scattered blebs and traces of potash persist to about 30 ft below the main potash "pay zone." Well logs, samples, and core descriptions from the potash drilling are available in the well files of the Arizona Oil and Gas Conservation Commission at the Arizona Geological Survey in Tucson.

To date, there has been no commercial production of potash in Arizona by conventional or solution mining even though drilling by late 1965 indicated about 450 million tons of ore-grade K_2O covering an area of 80 square miles (Cox, 1965). Cox estimated that 100 million tons of at least 60% product were economically recoverable. By early 1966, Arkla estimated a potential of more than 285 million tons of nearly 20% average grade K_2O underlying its lease block (Carr, 1966). Carr reported that the amount under Arkla's prospective area exceeded the minimum economic requirement to justify mine and process installation by 540%. Overproduction of potash in Saskatchewan during a period of government subsidies and a global glut of potash in the late 1960s may have been the biggest factors in preventing development of Arizona potash at the time.

Another factor in the lack of exploitation of Arizona potash may be that the area underlain by potash in east-central Arizona is approximately centered under Petrified Forest National Park (PFNP; Figure 2). The Petrified Forest Expansion Act of 2004 substantially increases the area of potash underlying the park. The location of the potash under the PFNP will require a creative approach to full access and future development of Arizona's strategic potash deposits. A combination of State Trust and public

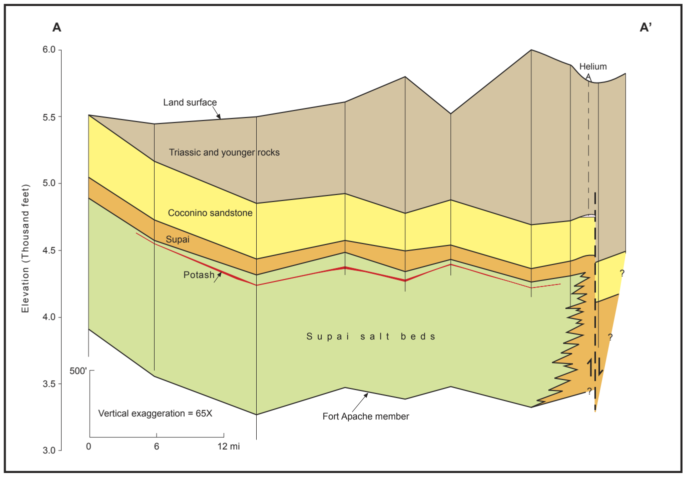

Figure 3. Diagrammatic structure section A-A' trending northeast-southwest showing northern edge of Supai salt, extent of potash deposits, and former helium producing area near the northeastern limit of the salt and potash deposits. Vertical scale exaggerated 65 times.

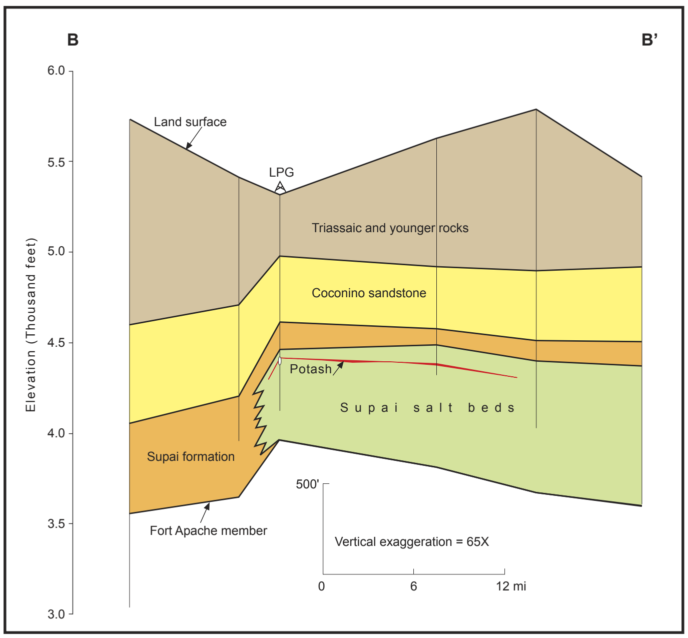

Figure 4. Diagrammatic structure section B-B' trending northwest-southeast showing northern edge of Supai salt, extent of potash deposits, and storage well for liquefied petroleum gas (LPG) with cavern leached near the top of the salt deposits. Vertical scale exaggerated 65 times.

and private land is available for potential development east and southwest of the PFNP.

Other Geologic Resource in the Holbrook salt basin

Helium: Helium was produced near the northeastern limit of the potash deposits from 1961 to 1976 (Figures 2 and 3). Wells in the Pinta Dome and Navajo Springs fields (Conley, 1974) produced nearly 700 million cubic feet of grade-A helium from the Permian Coconino Sandstone. Helium concentrations ranged up to 10% and averaged 8%, which is some of the richest helium-bearing gas ever produced. Spencer (1983) and Rauzi (2003) reviewed the geologic setting, production, and future potential of helium in Arizona.

Helium is vital in obtaining the extremely cold temperatures essential in cryogenic and superconducting technologies. Helium is also used for pressurizing and purging, welding cover gas, controlled atmospheres, leak detection, breathing mixtures, and filling blimps, weather balloons, and party balloons.

Hydrocarbon Storage: The bedded salt (halite) associated with the potash is used to form caverns to store liquefied petroleum gas (LPG). A cavern is formed by drilling a hole into the salt and pumping fresh water through steel pipe. The fresh water dissolves the salt and the resulting brine is pumped out of the hole. Some brine is stored at the surface for later use and some is pumped back into deep underground rock formations. The shape and size of the cavern is determined by controlling the amount and direction of fresh water pumped into the hole.

Enterprise Products operates the LPG-storage facility, which is about 20 miles east of Holbrook at Adamana (Figures 2 and 4). Propane and butane are the most common types of LPG. Most propane is used as fuel to heat homes in the winter whereas butane is commonly used to blend gasoline at refineries. The Adamana facility was first constructed in the early 1970s.

There are 11 storage wells at Adamana with a total capacity of about 90 million gallons. The top of the salt is about 900 ft below the ground surface. The caverns are leached about 75 ft below the top of the salt, have an average radius of 60 ft and height of 95 ft. Individual cavern volumes range from about 7 to 11 million gallons. The Adamana facility is served by the BNSF railroad (Rauzi 2000 and 2002).

Future

The time is right for potash development in Arizona. A creative approach will be necessary for exploitation, however, because of proximity to the PFNP. There also remains good potential for additional storage of LPG along the BNSF railroad, and for future helium discovery in the region. Many of the small structures in the area have yet to be drilled.

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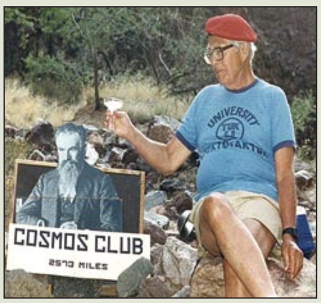
In the Wake of Powell and Péwé: Science in the Grand Canyon

By Brian F. Gootee

Since John Wesley Powell's inaugural exploration of the Unknown Territory in 1869 and 1872, geologists have been exploring the Grand Canyon. From 1967 to 1999, Troy L. Péwé (1918-1999), ASU geology professor emeritus, AZGS contributor, and internationally renowned geologist, led geology students into the Grand Canyon to study its origins and to appreciate the discoveries made by Powell.

On August 17th, 2008, Péwé's son Rick Péwé, ASU geology professor Ramon Arrowsmith and I continued the 1869 and 1967 tradition leading 28 participants on a memorial river trip that honored John W. Powell and Troy L. Péwé and see "the book … open and read as [we] run" (Powell, 1869).



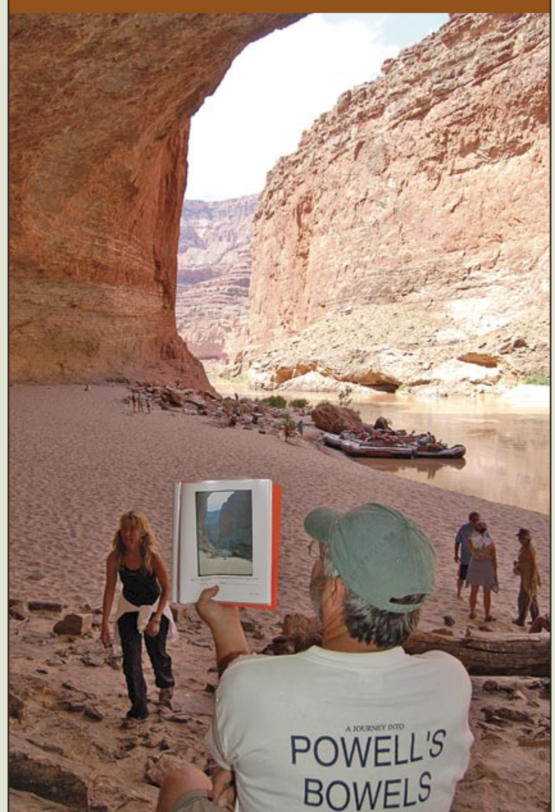
Troy L. Péwé toasts to John W. Powell during a Cosmos Club West meeting. Photo from Péwé archive.

Besides the thrill of riding 15,000 cfs (cubic ft per second) of the brown, rapid-rich Colorado River through "Powell's Bowels", we had other business to attend to. We drafted a proposal to formally name a large cave at mile marker 26.2 after Troy L. Péwé in consideration of his years of work in the Canyon. And Troy Péwé's 41 year-old Grand Canyon photographic archive came to life again in 2008 as photo stations were rephotographed to record changes in debris flows, beach and slope morphology. With copies of his original photographs in hand, we revisited more than 60 photographic sites. Our goal is to publish the results of that study as an AZGS open-file report.

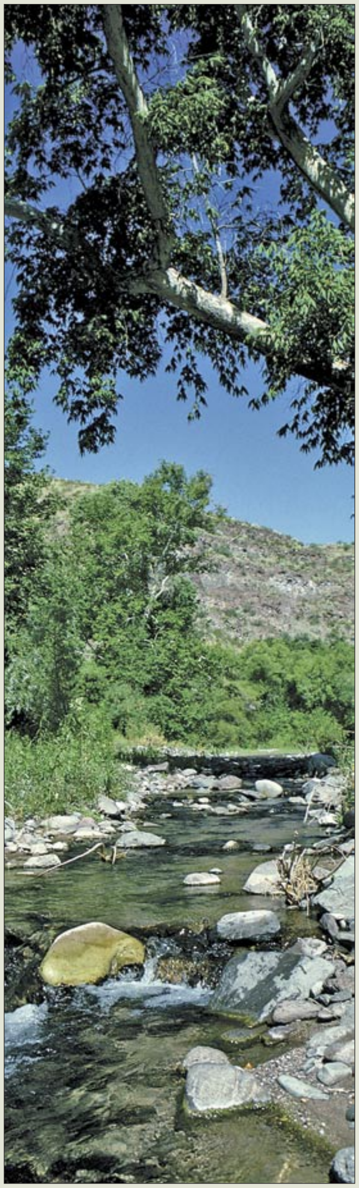
This trip also marked the 23rd anniversary meeting of Cosmos Club West. John Wesley Powell founded the original Cosmos Club in Washington DC in 1878; where meetings still continue. Troy Péwé founded the Cosmos Club West in 1985, patterned after the original Cosmos Club. Every several years, former colleagues and students organize a Cosmos Club West raft trip to foster discussion and insight into the geologic processes operating in the Grand Canyon.

Brian F. Gootee, a research geologist for AZGS, also teaches backcountry courses with the Grand Canyon Field Institute and the Maricopa Community Colleges. To view more photos from this expedition, visit www.pbase.com/bgootee/colorado_river.

On the morning of August 17th a flash flood from Cataract Canyon flooded the Havasu Creek floodplain, sending residents of Supai Village and hundreds of campers scrambling for high ground.. We learned of the flood as we put in the Colorado River at mile 0, Lees Ferry. Five days and 157 miles later we approached Cataract Canyon, looking for telltale signs of the recent flood. At the confluence of the Colorado River and Havasu Creek, we could see a high-water mark of mud, debris and stripped vegetation (dotted white line) nine feet above the stream floor. Person visible for scale (arrow). Photograph by Kevin Hoover.



Rick Péwé holds up a photo taken by his dad Troy L. Péwé on May 30th, 1967 from this exact location. Photograph by Brian F. Gootee taken August 18, 2008 during a stop in the Mississippian-age Redwall Cavern at mile 33.1.



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