Arizona Geology

Vol. 32, No. 1
Spring 2002

Published by the Arizona Geological Survey

THE STATE AGENCY FOR GEOLOGIC INFORMATION

MISSION

To inform and advise the public about the geologic character of Arizona in order to foster understanding and 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, non-metallic, 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.

Arizona Has Salt

Steven L. Rauzi, Oil and Gas Administrator
Arizona Geological Survey

Two of the nine known salt deposits in Arizona are thicker than the Grand Canyon is deep. Total thickness of salt (comon table salt-sodium chloride) in the other seven deposits is unknown. Eighteen areas not yet explored are interpreted to have potential salt deposits in the subsurface.

Salt is the basis for two industries in Arizona – solution mining and subsurface storage. At the Morton Salt facility near Glendale subsurface salt is dissolved with fresh water and the brine is pumped into evaporating ponds. Salt harvested from the ponds is used for industrial and commercial purposes such as operating water treatment systems, de-icing highways, and making ice cream. Caverns dissolved in subsurface salt are used to store liquefied petroleum gas (LPG) at the Ferrellgas facility near Holbrook (Figures 1 and 2) and the AmeriGas facility near Glendale (Figures 2, 3, and 4). Both of the existing LPG-storage facilities are served by the Burlington Northern Santa Fe Railroad. Recent interest in building new gas-fired power plants in Arizona has focused attention on storing natural gas in the large subsurface salt deposits near Phoenix and Kingman.

The Arizona Geological Survey recently published Circular 30, *Arizona has salt!*, to summarize information about Arizona's salt deposits, including the literature, drilling, and gravity data that define the major deposits. Circular 30, announced on page 5 of this issue, also documents the relationship between gravity data and salt deposits, points to areas where additional deposits may be present, and shows the proximity of highways, railroads, and pipelines to the known and potential salt deposits.

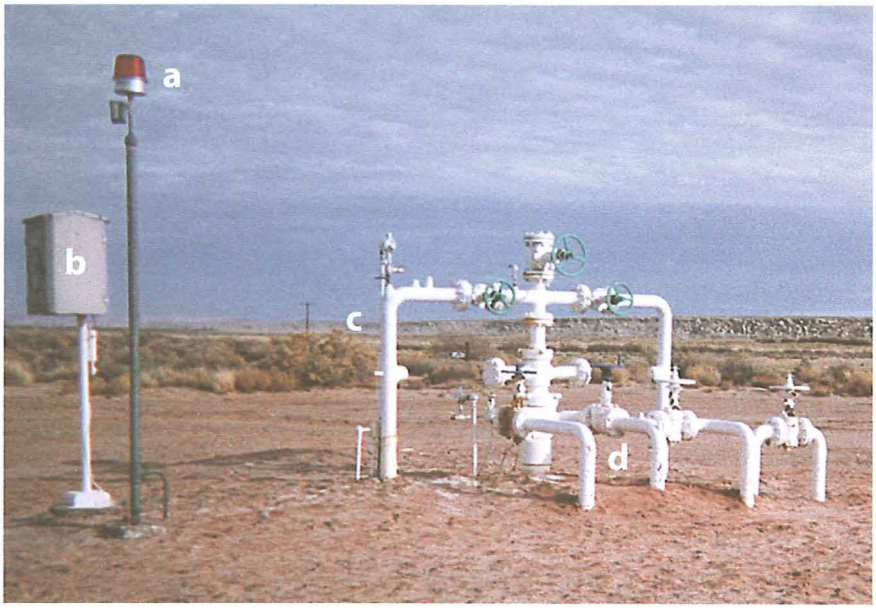

Figure 1. Wellhead at the Ferrellgas LPG-storage facility near Holbrook. (a) safety light, (b) pressure chart, (c) brine lines, (d) product lines. Eleven LPG-storage caverns are at this facility. Photograph by Richard Knudsen, Ferrellgas.

Distribution and thickness

Salt is present in all three physiographic regions in Arizona (Figure 2). Information about subsurface strata in the three regions comes primarily from gravity modeling, seismic surveys, and sparsely located drill holes.

The most extensive deposits are in the Colorado Plateau Province where salt underlies more than 3500 mi^2 in the Holbrook Basin. Salt there attains a maximum aggregate thickness of 655 ft and includes the potassium minerals sylvite, carnallite, and polyhalite near the top of the salt interval. The potassium-rich unit underlies about 600 mi^2, ranges up to 40 ft thick, and has an estimated potential of about 285 million tons of nearly 20 percent average grade K_2O.

The thickest known salt deposits are in the deep intermountain basins in the Basin and Range Province. Gravity data, seismic profiles, and a few deep drill holes indicate that the salt deposits in Mohave County north of Kingman and in Maricopa County west of Phoenix are at least 6,000 ft thick. They may be greater than 10,000 ft thick. As much as 100 mi^3 miles of salt may be present in the Hualapai Valley north of Kingman; more than 15 mi^3 may be in the Luke Basin west of Phoenix. These two salt deposits, and the anhydrite deposits in the Picacho Basin between Phoenix and Tucson, are among the thickest bedded evaporite deposits in the world.

Very little deep drilling has been done in Arizona. Statewide, the average drilling density is only about one well per 250 mi^2. In many of the basins in the Basin and Range Province the average drilling density is closer to one well per 400 mi^2. For this reason, the total extent and thickness of the massive salt deposits in the Basin and Range are not well defined. No drill holes have penetrated the entire thickness of the main mass of any of these salt deposits. Only a few holes have penetrated more than a few thousand feet of the salt. More drilling is needed to further define these salt bodies and shed light on the sedimentary units adjacent to and beneath the salt. These sedimentary units, like many others that are intimately associated with salt deposits around the world, may also have potential for oil and gas.

Age and origin

Marine and non-marine salt deposits are present in Arizona. Salt in the Holbrook Basin on the Colorado Plateau was deposited during the Permian period (285 to 245 million years ago). At that time east-central Arizona was an area of very low relief adjacent to open seas to the south. Salt was deposited in coastal areas that were inundated only occasionally and in which wave energy was low.

The thick deposits in the Basin and Range Province were deposited in a non-marine environment during Miocene time (15 to 12 million years ago). Prolonged periods of internal drainage, arid climate, and high evaporation rates resulted in the deposition of salts in closed basins.

Areas with potential salt deposits

The abundance of salt in Arizona, coupled with gravity anomalies that are associated with many of the salt deposits, suggest that salt may be present in less explored basins. Eighteen basins have gravity anomalies that are similar to the anomalies associated with the known salt deposits. Circular 30 includes descriptions of the available gravity data and seismic profiles, as well as information from sparsely located deep drill holes in the 18 basins. The abundance of salt in Arizona suggests that salt may also be present in basins other than the 18 described. As discussed in Circular 30, deeply buried salt deposits may be present in basins that do not have pronounced gravity anomalies.

Summary and conclusions

Salt is an abundant and valuable resource in Arizona. The potential to expand current facilities or develop new facilities in the nine known salt deposits is good. In addition, other salt deposits, currently untested, may be present beneath numerous areas of the state.

Recent interest in building new gas-fired power plants in Arizona has led two companies to investigate the feasibility of storing natural gas in Arizona salt. Copper Eagle Gas Storage, LLC (www.coppereaglegs.com) is evaluating the suitability of storing up to 5 billion ft^3 (Bcf) of natural gas in the Luke salt deposit west of Phoenix. Copper Eagle has drilled two stratigraphic holes to determine the characteristics of the salt for storage and the adjacent sedimentary units for disposal of brine. Core sampling of the salt has been completed. Test results of the core samples indicate that the physical qualities of the salt are similar to other salt formations in the country where natural gas is safely stored. Additional studies are in progress.

Desert Crossing Gas Storage and Transportation System, LLC (www.desert-crossing.com) is studying the feasibility of storing up to 10 Bcf of natural gas in the Red Lake salt deposit in the Hualapai Valley north of Kingman. The Desert Crossing facility would include multiple deep salt caverns and a pipeline upon completion. Initial studies are in progress.

Storing LPG and natural gas in Arizona's subsurface salt deposits has several benefits. Arizona is the only state in the Southwest with salt bodies large enough for storing large volumes of LPG and natural gas between the main sources of supply and regions of demand. Salt deposits in Arizona offer exceptional off-peak energy storage possibilities because of their proximity to interstate pipelines, railroads, and the several new natural

Salt Deposits in Arizona

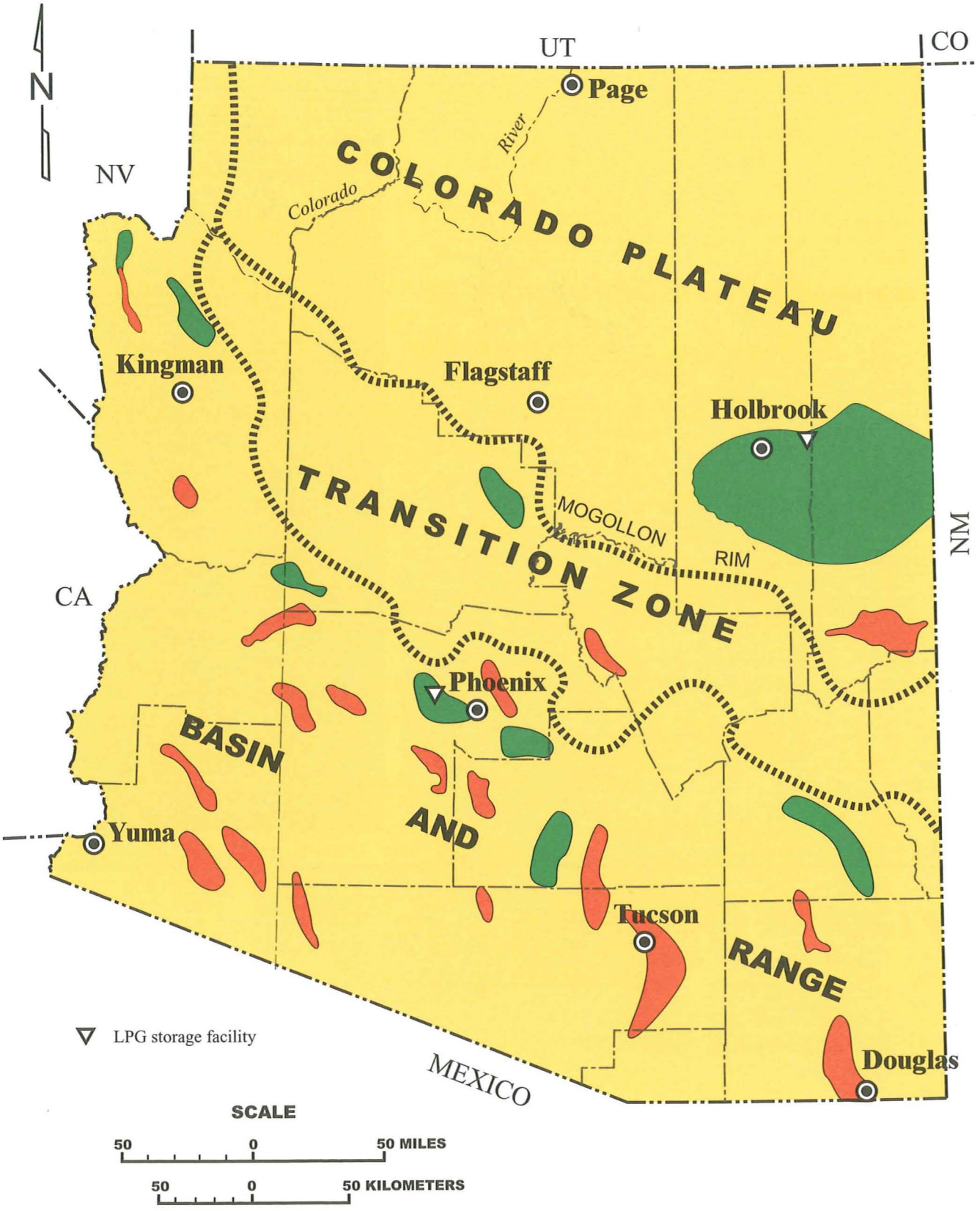

Figure 2. Known (shown in green) and potential (shown in orange) salt basins superimposed on physiographic regions in Arizona. Each basin is described in detail in Circular 30, *Arizona has salt!*

Figure 3. (Left) Rail walks at the AmeriGas LPG-storage facility near Glendale, where LPG is pumped from tank cars into storage caverns in salt. Railroad tank cars are used to transport butane and propane from refineries to the storage facility. Butane goes back to the refineries by rail, whereas most of the propane is distributed regionally by trucks. It takes about 1,500 rail cars to fill a 50-million-gallon storage cavern. The AmeriGas facility has three LPG-storage caverns about that size. Photograph by Steven L. Rauzi.

Figure 4. (Right) Truck racks at the AmeriGas facility near Glendale. Trucks are used to distribute propane to outlets in Arizona, California, Nevada, and Utah. A 50-million-gallon storage cavern has the capacity to fill about 5,000 trucks. Holding pond for brine is in background. Photograph by Steven L. Rauzi.

gas-fired power plants being built in Arizona. Salt-solution caverns provide an economic alternative to surface storage in steel tanks. The high deliverability of natural gas stored in salt caverns is a distinct advantage over storage in depleted oil and gas fields and aquifer reservoirs. Subsurface salt is ideal for gas storage because it is impermeable, making it impossible for gas to escape. Finally, special technology and expertise makes solution mining and cavern development in subsurface salt safe, efficient, and environmentally friendly.

Suggested References

Lysonski, J.C., Aiken, C.L.V., and Sumner, J.S., 1981, Complete residual Bouguer gravity anomaly maps: Arizona Geological Survey Open-file Report 81-24, 2 p., 23 sheets, scale 1:250,000.

Oppenheimer, J.M., and Sumner, J.S., 1980, Depth-to-bedrock map, Basin and Range Province, Arizona: Tucson, University of Arizona, Department of Geosciences, Laboratory of Geophysics, scale 1:1,000,000.

Neal, James T., and Rauzi, S.L., 1996, Storage opportunities in Arizona bedded evaporites: Arizona Geological Survey Open-File Report 96-27, 16 p.

Rauzi, S.L., 2000, Permian salt in the Holbrook Basin, Arizona: Arizona Geological Survey Open File Report 00-03, 21 p., 6 sheets, scale 1:250,000.

Rauzi, S.L., 2001, Arizona has oil and gas potential!: Arizona Geological Survey Circular 29, 40 p.

Rauzi, S.L., 2002, Arizona has salt!: Arizona Geological Survey Circular 30, 36 p.

Richard, S.M., Reynolds, S.J., Spencer, J.E., and Pearthree, P.A., compilers, 2000, Geologic map of Arizona: Arizona Geological Survey Map M-35, scale 1:1,000,000.