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New Mexico Geology, v. 2, n. 1 pp. 7-9, Print ISSN: 0196-948X, Online ISSN: 2837-6420.
https://doi.org/10.58799/NMG-v2n1.7

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New Mexico contains the nation's largest known concentration of potash reserves. In 1978, production in the state totaled 1.92 million metric tons of concentrate—about 85 percent of the domestic (United States) production—or 31 percent of the domestic demand (Singleton, 1978). Potash is the common term for compounds containing the element potassium. Natural potassium-bearing compounds of greatest importance are the soluble mineral salts, especially sylvite (KCl) and langbeinite ($K_2SO_4 \cdot 2MgSO_4$), the dominant potash ore minerals in the United States. The principal use (about 95 percent) of soluble potash minerals is in manufactured fertilizers. Potassium is essential to plant metabolism—no alternative exists. Nor can potash be recycled.

The potassium content of fertilizers is commonly reported in percent of K_2O, even though an oxide is not present. For example, the mineral sylvite contains about 52 percent potassium by weight; however, in converting to the K_2O equivalent percent, sylvite is rated at 63.17 percent. In other words, every 1,000 lbs of pure sylvite contains about 630 lbs of K_2O (or about 524 lbs of elemental potassium). Langbeinite, the other principal domestic ore mineral of potassium, is rated at 22.69 percent K_2O equivalent. Although containing less potassium, the langbeinite product is also low in chloride ion for which some plants have low tolerance. In addition, both the magnesium and sulfate ions in langbeinite aid in conditioning highly leached soil.

Potash from U.S. mines—chiefly in the Carlsbad mining district—supplied the nation's needs for many years until 1962, when imports, primarily from Canada, increased dramatically. Since then, domestic production has remained fairly constant while imports have continued to increase and now account for more than two-thirds of the potash used in the United States (fig. 1). Canadian imports come principally from the province of Saskatchewan; in 1970 the Saskatchewan government began setting minimum prices and cutting back production. These actions resulted in market prices high enough to continue mining the lower grade Carlsbad ores. Double-digit inflation of the 1970's, however, wiped out much of the profit. By mid-1970's New Mexico's deposits were near the low profit levels (in terms of constant dollars) of the early 1960's. To compound the problems of costs and profits, the ores mined today are lower grade and contain larger amounts of insoluble clays that tend to require additional chemical treatment in the mills, thereby increasing processing costs.

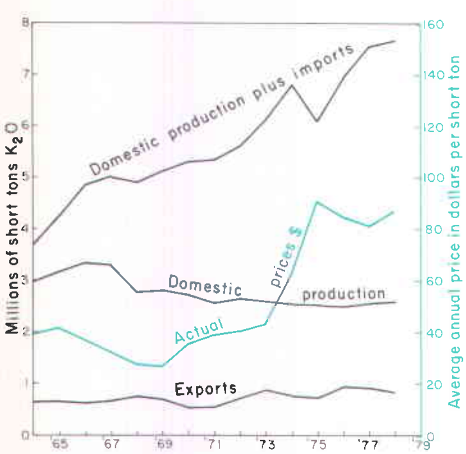

FIGURE 1—U.S. POTASH MARKET 1965 TO 1978.

Thick sections of salt and other evaporite minerals in the Permian Basin of west Texas and southeastern New Mexico (fig. 2) were deposited in a shallow but subsiding basin during Ochoan (Late Permian) time about 250–225 million years ago. During the Ochoan, marine waters within the basin were replenished, and dissolved solids in the water were being continually concentrated by evaporation. Continued evaporation/concentration led to the deposition of potassium salts, some of the most soluble (and nearly the last) minerals to be deposited from evaporating seawater.

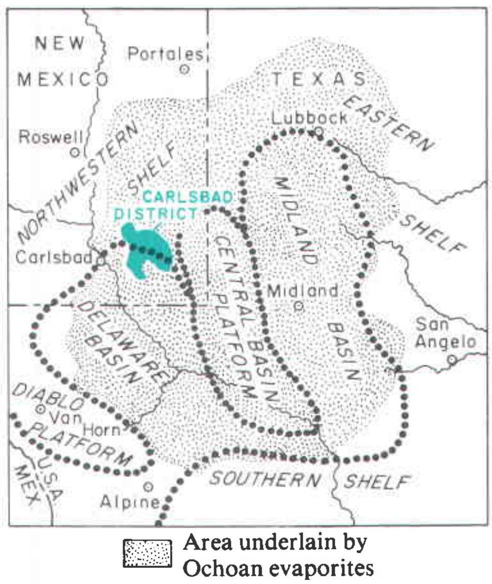

FIGURE 2—REGIONAL INDEX MAP.

Carlsbad mining district

The potash minerals were concentrated in a small area on the west side of the Permian Basin. Today, this area—known as the Carlsbad mining district—is astride the Capitan reef, a prominent geologic structure that separates the Delaware Basin from the northwestern shelf in the western part of the Permian Basin. The Capitan reef is exposed at the surface in the mountains southwest of Carlsbad. In the vicinity of the potash mines, this reef, shown in fig. 3 (the Capitan Limestone), is deeply buried beneath the Ochoan evaporites. Ochoan rocks include the Castile, Salado, and Rustler Formation, primarily a sequence of marine evaporites. The McNutt potash zone, the middle member of the Salado Formation, contains 11 potash ore zones (fig. 4). The 1st, 3rd, 4th, 5th, 7th, and 10th zones have proved concentrations of potash, the greatest tonnages being produced from the 1st and 10th.

The surface relief in the Carlsbad district averages a few hundred feet. The surface is characterized by dune fields as well as collapse features typical of karst or sinkhole topography. The soils have developed under mixed shrubs and grasses common to the semiarid continental climate of the southern High Plains province. Most of the soils have developed caliches and gypsum and have been worked by the wind. The Carlsbad mining district has no cities or towns; other than the structures relating to potash mining, only oil-well sites and a few ranches dot the landscape. The sparsely vegetated land is capable of supporting only a few head of cattle per section.

Identification of potash lands

The Conservation Division of the U.S. Geological Survey receives all drill-hole information for federal and state land in the Carlsbad mining district. The U.S. Geological Survey has defined the Carlsbad enclave (fig. 5) as the land within the district containing minable quantities of potash. Minable quantities are defined as beds at least 4 ft thick containing at least 10 percent K_2O as sylvite or at least 4 percent K_2O as langbeinite. All drill-hole information is confidential and can be released only by the companies involved. The informa-

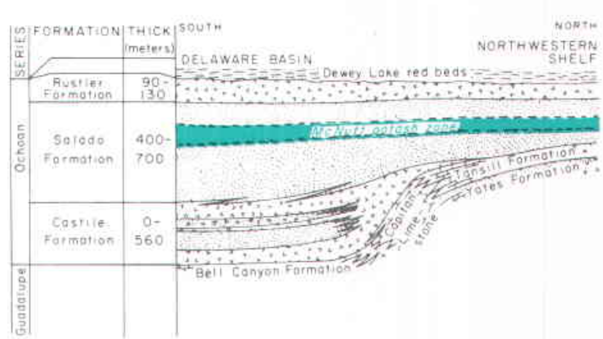

FIGURE 3—SCHEMATIC SOUTH-NORTH CROSS SECTION ACROSS CARLSBAD MINING DISTRICT.

tion, however, is used to prepare open-file maps showing the boundaries of the enclave, mined-out areas, and barren zones. These maps are updated annually with new drilling and mining data.

Although each of the 11 ore zones is fairly continuous within the enclave, minable concentrations of potash-bearing minerals are restricted to certain smaller areas. Jones and Madsen (1968) have shown the variability of the 5th ore zone in the district; apparently the other ore zones have equal variability in minable concentrations. Barren zones within the enclave have resulted either from nondeposition or removal of potash minerals within the Permian sea, later mobilization of the valuable minerals, or both. Thus, drilling programs are used extensively by companies searching for potash. Both chemical analyses of the cores and geophysical logging of the drill holes serve to identify areas of concentration of the valuable potash minerals.

Mining and milling

All mines in the Carlsbad district are underground with vertical shafts varying in depth from 650 to 1,750 ft. To the west of the district the soluble potash minerals have been removed by solution; on the east side of the district the beds dip about 1° to the east, are deeply buried, and are of lower grade. Shafts are either drilled with large-diameter drilling machines or drilled and blasted with conventional shaft-sinking equipment. Ground water is scarce, therefore not commonly a problem in sinking shafts.

The ore zones are nearly flat lying; the potash ore is mined with slightly modified conventional coal-mining equipment. Room and pillar workings are commonly 5-6½ ft high; as much as 70 percent of the ore is removed during the first stage of mining. Some operations also use a second stage—robbing the pillars during withdrawal from a section of mine, allowing overlying rock to settle slowly. In this manner, as much as 92 percent of the ore may be removed. Subsidence fractures have been observed in the land surface above workings that have collapsed at depths of 1,000 ft or more. With few exceptions only a single ore zone is worked in a given mine. Even in multilevel mines, however, overlying ore zones are seldom worked if underlying ore zones have been mined.

Other occurrences

In a well drilled in Lincoln County, 10-15 mi northwest of Carrizozo, nearly 2,000 ft of halite has been reported in the Yeso Formation (Lower Permian). Although the well log also indicates limestone, sandstone, shale, and anhydrite are present in the interval, potash-bearing salts are not mentioned.

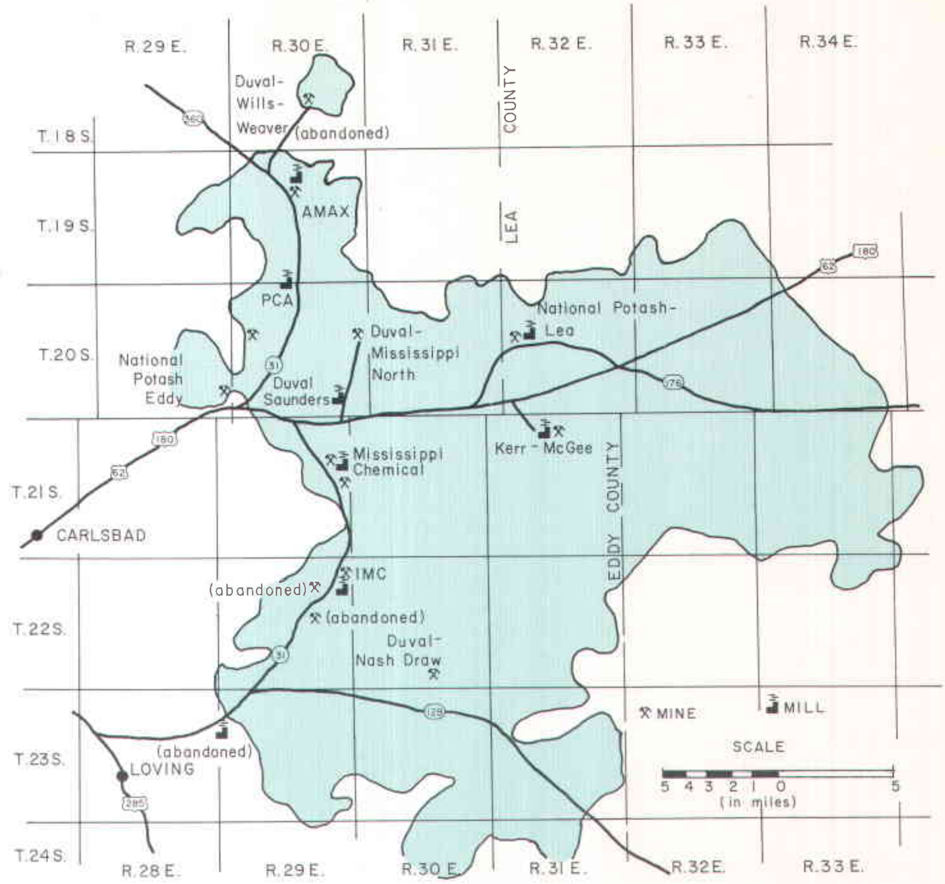

FIGURE 5—CARLSBAD ENCLAVE INCLUDING MINES AND MILLS.

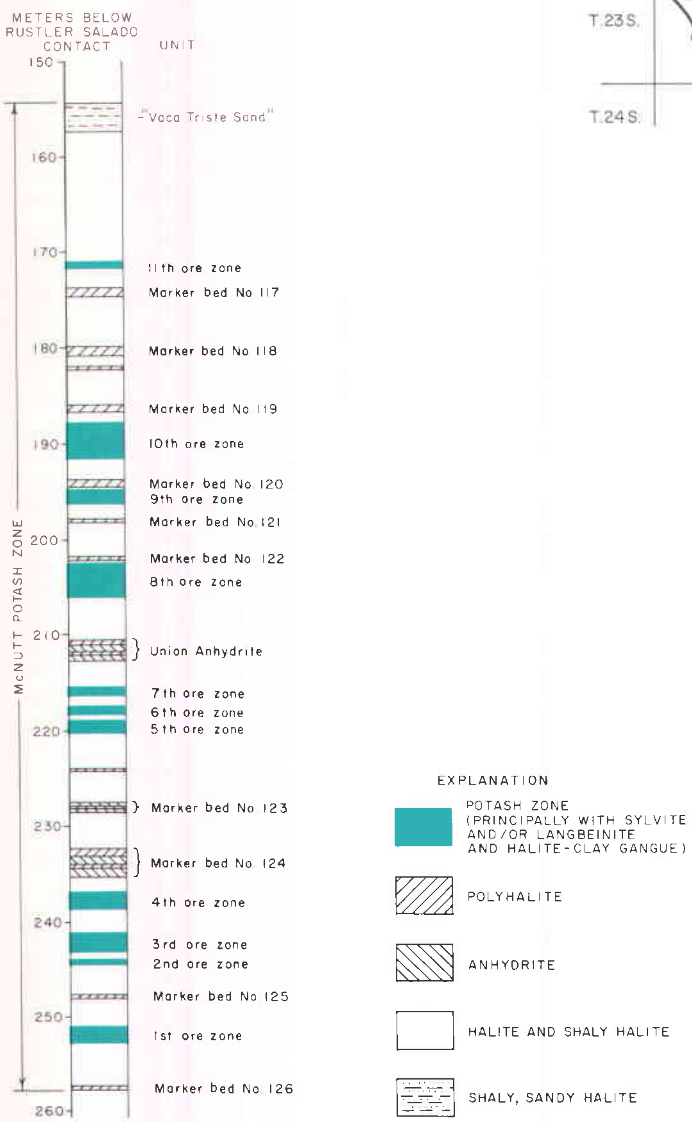

FIGURE 4—COLUMNAR SECTION THROUGH McNUTT POTASH ZONE (after Jones, Bowles, and Bell, 1960).

The Paradox Member of the Hermosa Formation (Pennsylvanian) is recognized in the subsurface of extreme northwest New Mexico. Information on the mineralogy of the salts, their quality, or thickness is not available, although potash salts are produced from this interval in the Paradox Basin of southeastern Utah.

Summary

The demand for fertilizers and potassium will increase in accordance with projected increases in world food needs. Although the United States has only about 4 percent of the world's known potash resources, the deposits near Carlsbad occur at minable depths in a sparsely populated area, and in a concentration that can be mined profitably even though lower in grade than Canadian deposits. Other concentrations of potash salts in the United States occur in Arizona, California, Utah, Michigan, and North Dakota, but none match the New Mexico deposits in volume and grade. The potash industry of southeastern New Mexico is assured of continued production in the foreseeable future.

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Zeller Peak named in Big Hatchet Mountains

In September, 1979, the U.S. Board of Geographic Names approved the name *Zeller Peak* for the prominent peak 2 mi north of Big Hatchet Peak in the Big Hatchet Mountains of Hidalgo County, New Mexico (fig. 1) in honor of Robert A. Zeller, Jr., who compiled a detailed geologic map of these rugged mountains and established the basic stratigraphic framework for the region. Zeller, whose work on the Big Hatchet area has been published in Memoir 16 and Circular 146 of the New Mexico Bureau of Mines and Mineral Resources, was killed in March 1970 when the aircraft he was piloting crashed in southeastern Arizona. Sherman A. Wengard later prepared a memorial tribute to Dr. Zeller for the 21st field conference guidebook of the New Mexico Geological Society (1970).

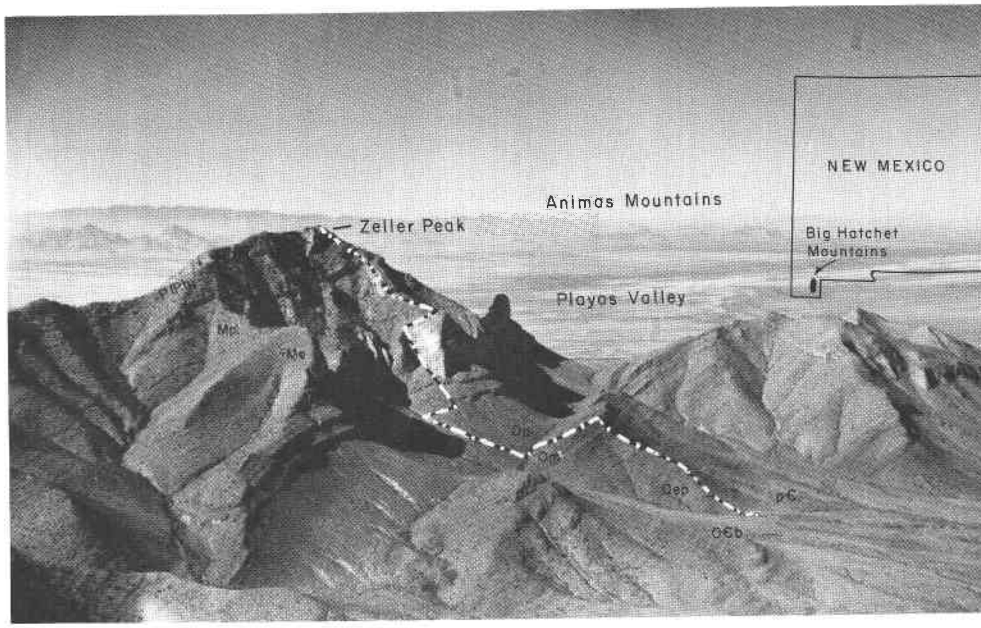

FIGURE 1—AERIAL VIEW NORTHWEST OF ZELLER PEAK (ELEV. 7,313 FT) IN NORTHERN PART OF BIG HATCHET MOUNTAINS (photo by Robert A. Zeller, Jr., published in Bureau Memoir 16). Zeller's line of measured section for the Mescal Canyon section includes Precambrian granite (p€; elev. approximately 5,100 ft), Bliss Formation (O€b), El Paso Formation (Oep) and Montoya Dolomite (Om), Percha Shale (Dp), Escabrosa Limestone and Paradise Formation (Mp), and the lower Horquilla Limestone (PPh) at top of peak. This stratigraphic section, discovered and described in detail by Zeller, composes the most complete and best exposed succession of lower Paleozoic rocks in southwestern New Mexico. □

Search organized for thousands of abandoned New Mexico mines

A search has been launched for New Mexico's 'orphan,' or abandoned mines, estimated at more than 500 sites for coal alone and perhaps another 3,000 sites where other minerals were once extracted. The project, started by the State Energy and Minerals Department with a contract to the New Mexico Bureau of Mines and Mineral Resources, is a result of federal legislation. A section of the Surface Mining Act of 1977 passed by Congress provides the means for obtaining funding to support this work. This money, according to Don Baker, project coordinator for New Mexico Energy Secretary Larry Kehoe and Emery Arnold, director of the Division of Mining and Minerals with the Department of Energy and Minerals, is derived from a tax on extracted coal based on a formula calling for 35 cents a ton on surface-mined coal, 15 cents for underground coal, and 10 cents a ton for lower grades of coal such as lignite and peat. Thus, Baker states, "the act provided a means to solve old problems and take care of the orphan mines through taxing current coal production."

These mines, found throughout the state and once a source of wealth and jobs as well as a focus for local community pride, no longer enjoy the status of those bygone years. Concentrated for the most part in the northern half of the state, the coal mines can be found in the San Juan Basin, Raton, Madrid, Gallup, White Oaks and Carthage areas. "We have had coal mines," says Baker, "that have been burning continuously since around the turn of century. These must, in time, be carefully studied."

Other aspects of the study, begun in June and scheduled to run through February with total funding of $226,970, embrace assessing the potential for remining and for evaluating esthetic impacts such as 'gob piles' (waste materials) alongside picturesque mountain streams or highways.

Other goals include collection of historic data. Madrid, for example, is listed on the Federal Register of Historic Sites. Baker and his crew are concerned that the historic value of such places remains intact—while safety of the public is insured. Such sites will require careful study and research to produce a practical plan that achieves both aims.

Investigators will examine the impact on fish and wildlife. Mine openings, for instance, are sometimes used as nesting sites for certain endangered species of wildlife and birds.

Current work, prefaced by a 45-day bibliographic inventory of New Mexico's abandoned mines carried out this summer, provided the basis for the present phase that involves eleven full-time workers and six to eight student assistants from New Mexico Tech.

—condensed from the *Albuquerque Journal*

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