The nearest railroad point is Jackson Siding, 4 miles east of the deposit, on the St. Thomas branch of the Union Pacific R.R. About 20 years ago the Rex Plaster Co. shipped a small amount of gypsum from this deposit to a plant in Los Angeles.

Volcanic Ash Deposit

A deposit of volcanic ash owned by the Dotson Bros., Mart and Henry, of Logandale, Nev., occurs 13.6 miles northwest of Moapa. The deposit is covered by four unpatented lode claims.

The volcanic ash occurs as a horizontal bed about 30 inches thick, exposed on a side of a bluff for a distance of about 1 mile. The material is uncemented, fine-grained, and gray in color. No effort has been made to work the deposit.

Tin Deposit

In 1936 tin was reported to have been found about 13 miles southeast of Moapa, Nev. The Cosmo Mining Co. acquired a large group of claims and some stock was sold. Pieces of sandstone stained with manganese, said to contain tin, were taken by the writer. A composite sample of the material was analysed by the Mackay School of Mines laboratory at Reno, Nev., but no tin was found.

MUDDY MOUNTAINS DISTRICT

(Borates, Gypsum, Silica Sand, Bentonite, Sodium Sulphate)

Deposits of borates, gypsum, silica sand, bentonite, and sodium sulphate occur in the southern part of the Muddy Mountains in eastern Clark County north of Lake Mead. The only production of any consequence has been from the borate deposits. The non-metallic deposits that occur in the northern part of the Muddy Mountains are described in this paper under the Moapa and St. Thomas districts.

The borate deposits, which occur chiefly as colemanite ($Ca_2B_6O_{11}.13H_2O$), are of interest in that they constitute the only commercial occurrences of this mineral in the United States outside of California. These deposits were discovered in 1920 and 1921 and were exploited from 1922 to 1928. In the latter year operations ceased, due to the discovery of a new boron mineral, kernite ($Na_2B_4O_7.4H_2O$), near Kramer, San Bernardino County, Calif. Because of the different types of borate deposits that have been worked successively in the United States, the borax industry has been very unstable, and at every stage of development different processes of exploitation were devised.

In the United States the industry began with the discovery of borax ($Na_2B_4O_7.10H_2O$) by John A. Veatch in the waters of Tuscan Springs, Tahama County, Calif. Doctor Veatch extended his search, and other deposits were found in the same year on the east side of Clear Lake, Calif. The borax

from hot springs and Clear Lake constituted the chief source of supply in the United States for many years. In the early seventies, when the lake deposits of California were virtually exhausted, borax and ulexite ($NaCaB_5O_9.H_2O$) were discovered in the desert playas in Nevada and California. These playa deposits were worked up to 1887, when the industry was revolutionized by the discovery of colemanite beds near Death Valley, San Bernardino County, and later in Inyo and Los Angeles Counties, Calif. The latest development in the domestic borax industry was the discovery of extensive deposits of kernite, which supplanted colemanite in much the same manner as colemanite supplanted the playa deposits of borax and ulexite. Kernite has a smaller content of water of crystallization than the borax of commerce, so that when it is recrystallized to borax the original weight is increased.

Borate Deposits

Borates occur in two localities 13 miles apart in the southern end of the Muddy Mountains. One deposit is in the White Basin, 20 miles by automobile road southeast of Crystal, Nev., and the other is near Callville Wash, 26 miles by road east of Lovell Siding on the Union Pacific R.R.

The White Basin colemanite deposit was discovered by John F. Perkins of Overton, Nev., in 1920. Shortly after, the Perkins group of 12 claims was sold to the Pacific Coast Borax Co. Subsequently other locations were made in the vicinity, which were acquired by the American Borax Co. This company operated from 1922 to 1924, when operations ceased because of litigation with the Pacific Coast Borax Co. Since 1924 there has been no borax activity in this area.

Development work done by the American Borax Co. includes an inclined shaft and several hundred feet of lateral workings. The calcining plant erected by this company near the mine has been dismantled.

According to Noble[24/], colemanite occurs in bunchy lenticular layers interbedded with white shale containing gypsum, beds of volcanic ash, or thin layers of limestone. Some of the limestone shows a peculiar concretionary structure called "goose eggs," and these concretions are believed by the prospectors to indicate the presence of boron minerals. The colemanite beds vary in thickness from a few inches to 3 feet.

Stimulated by the discovery of borates in the White Basin, F. M. Lovell and George D. Hartman of St. Thomas, Nev., who were prospecting under a grubstake agreement, discovered the Callville Wash colemanite deposit on January 23, 1921. As soon as it became known that the deposit was valuable, a number of intending purchasers tried to purchase the property, but they were outplayed by F. M. (Borax) Smith, who, in the early

24/ Noble, L. F., Colemanite in Clark County, Nev.: U. S. Geol. Survey Bull. 735-B, 16 pp.

days, was the dominating personality in the borax industry of the world. Smith, after examining the property, made an offer and arranged an initial deposit of $50,000 to bind the bargain. The contract was drawn up in the field on the leaf of a notebook, and the purchase price is said to have been $250,000. In July 1922 the West End Chemical Co., of which Smith was the leading figure, established a camp and began production. In 1928 operations ceased because the colemanite could not compete with the kernite deposits mined by the Pacific Coast Borax Co. near Kramer, Calif.

According to J. W. Wilson of Las Vegas, Nev., formerly superintendent of the property (which is known as the Anniversary mine), the production of crude colemanite averaging about 20 percent B_2O_3 from 1922 to 1928 was about 200,000 tons. During the period of greatest activity 175 tons of crude ore were mined per day, and from this amount of ore about 65 tons of calcines were obtained averaging about 40 percent B_2O_3. The calcines were hauled 24 miles to the railroad and shipped to refineries on the Pacific coast.

The West End Chemical Co. owns a group of 21 lode claims, 12 of which are patented. The lode claims are also covered by seven placer locations.

Entry to the Anniversary mine is made by two adits. Underground workings comprise approximately 7,000 feet. An electrically operated aerial tramway 12,000 feet in length was employed for transporting the ore from the portal of the main adit to the calcining plant, 250 feet lower than the adit elevation. Calcining equipment comprises two rotary, oil-fired, double-tube kilns, each 60 feet long and 6 feet outside diameter. The inner chamber of each kiln is 3 feet in diameter. Indirect firing was employed in the kilns. The annular space between the two tubes constituted the firing chamber. Power for mining and milling was furnished by a 4-cylinder, Fairbanks-Morse, Y-type, Diesel engine connected to a generator. The mine workings, camp, and equipment are still intact and in fairly good condition. It is reported that nearly $2,000,000 was invested in this property.

The geology of the Anniversary mine has been described by Noble[25] and by Callaghan and W. W. Rubey[26]. The colemanite bed dips from 45° to 60°, averaging 50°, and is traceable on the surface for a distance of about 3,000 feet. It is interbedded with shale and limestone in a synclinal basin whose axis trends east and west. The width of the bed ranges from 6 to more than 22 feet, the average minable width being about 8 feet. According to Callaghan and Rubey, the ore reserves are at least 400,000 tons.

The shrinkage-stope method of mining was employed. Due to the fact that colemanite breaks into tabular pieces, its angle or repose is greater than that usually encountered in metalliferous deposits. Where the bed was steep enough, the stopes were kept filled with broken colemanite, and in the

25/ Noble, L. F., Work cited.
26/ Callaghan, Eugene, and Rubey, W. W., Mineral Resources of the Region Around Boulder Dam: U. S. Geol. Survey Bull. 871, 1936, pp. 106-113.

flatter portions as much ore as possible was retained in the stopes and small pillars or ore were left for support at irregular intervals. The only timber used in mining was for manways and chutes, the latter spaced at intervals of 20 feet. Where the colemanite bed was too flat to permit the ore to run readily, the final cleaning up of the stopes was effected by scrapers. About 90 percent of the ore was recovered in mining. The ore was trammed by hand in 1-ton cars to the tramway loading terminal at the portal of the main adit.

At the calcining plant the ore was crushed to 1-inch size and fed to the two rotary kilns. The calcined material was discharged on an electric vibrating screen, which separated the colemanite from most of the associated impurities. The separation of colemanite from the impurities is possible by screening because of the fact that the former disintegrates to a fine powder while the latter do not. The screened product, averaging about 40 percent B_2O_3, was hauled in trucks to the railroad for shipment.

Gypsum Deposits

Gypsum occurs in the Muddy Mountains about 2 1/2 miles southwest of Comstock, Nev. The deposit is 3 1/2 miles from the Union Pacific R.R. C. C. McDonald, of Overton, Nev., and associates own 320 acres, and the Pacific Portland Cement Co. owns 640 acres, the latter purchased from McDonald in 1922. Prior to purchasing the property, the Pacific Portland Cement Co. explored the deposit by diamond drilling. The gypsum bed is 150 feet thick and dips 45°. At a depth of about 100 feet the gypsum changes to anhydrite. Analyses indicate that the material is nearly pure.

Deposits of gypsum and gypsite occur several miles from Lake Mead on the east side of Boulder Wash, which drains into Lake Mead at the east end of Boulder Canyon. The gypsum and gypsite outcrop over an area of several square miles, but no attempt has ever been made to exploit the deposits because of their inaccessibility. When the water in Lake Mead rises to the crest of Boulder Dam the gypsum can be transported readily by barge to Boulder City, 12 miles distant.

Silica-Sand Deposits

An extensive deposit of white silica sand occurs on the west side of the Muddy Mountains, 8 miles southwest of Crystal, Nev. The deposit is covered by the Lucy Etta group of five unpatented placer claims, totaling 800 acres owned by C. D. Wyatt of Boulder City, Nev. The former loading station of the American Borax Co. on the Union Pacific R.R. at Crystal is 8 miles from the deposit. The freight rate to Los Angeles, Calif., is $2.30 per ton and to San Francisco $3.60 per ton. No water is available for a washing plant in the vicinity of the deposit. The only production has been four carloads of sand shipped, without treatment, to the Technical Glass Co. of Los Angeles in 1934, that analyzed as follows:

	Percent
Calcium	0.042
Iron	.022
Aluminum	.22
Magnesium	.045
Silica	99.04

Both white and pink varieties of sand occur on the Wyatt claims in a sandstone formation. The white sand is loosely consolidated and when crushed consists largely of very fine grains.

Silica in the form of quartzite occurs 13 miles northwest of Crystal in the Arrow Canyon Mountains. The deposit is owned by Seth E. Evans of Goodsprings, Nev., and in 1936 it was under lease to W. M. Tiffany of Long Beach, Calif. While this deposit is not in the Muddy Mountains area, it is included here for convenience. Very little work has been done on the deposit and there is no information on any production.

The silica grains are tightly cemented and the exploitation of this deposit depends on using the material in lump form as ganister or for purposes requiring lump silica. Under the glass the silica appears virtually free from any impurities.

Bentonite Deposits

Small deposits of bentonite types of clay occur in the Muddy Mountains area. One of the deposits, covered by three unpatented lode claims owned by Robert A. Baker of Las Vegas, Nev., is northwest of Muddy Peak 9 miles southeast of Crystal. Development work consists of a shaft 30 feet deep and several scattered open-cuts. The bentonite occurs between limestone and sandstone, and the width varies from 6 to 14 feet. None has ever been produced.

Sodium Sulphate Deposit

A deposit of sodium sulphate owned by B. R. McKenna of Moapa, Nev., outcrops along the side of a prominent cliff in the White Basin about 3 miles south of the former American Borax Co. mine. It is accessible by poor automobile road from Crystal, Nev., a station on the Union Pacific R. R., 24 miles to the northwest. No attempt has been made to exploit the deposit. The sodium sulphate is intimately associated with siliceous impurities.

ST. THOMAS (VIRGIN RIVER) DISTRICT

(Silica Sand, Magnesite, Gypsum, Salt, Sodium Sulphate)

The St. Thomas or Virgin River district comprises a large, vaguely defined area in the vicinity of St. Thomas, Nev. The town of St. Thomas has been abandoned, as eventually it will be flooded by the water impounded

by Boulder Dam. The district is particularly rich in industrial mineral deposits, including silica sand, magnesite, gypsum, salt, and sodium sulphate; but due to their inaccessibility and distance from consuming centers, only silica sand and salt have been produced. The salt deposits have been worked mainly to supply local demand. The Los Angeles & Salt Lake R.R., a part of the Union Pacific System, passes through Moapa, Nev., 14 miles northwest of Overton. From Moapa a branch railroad runs southeast to St. Thomas, a distance of 21 miles. About 5 miles of the southern part of this branch line will be abandoned when the water in Lake Mead reaches its maximum flow line.

The production of silica sand in Clark County is a comparatively recent industry, having been established less than 10 years. Production statistics are not available, but the total from the St. Thomas deposits is probably more than 200,000 tons. During the first quarter of 1937 the average monthly production was 3,500 tons, consisting of 2,500 tons of washed white sand and 1,000 tons of pink sand, the latter shipped without treatment. The bulk of the white sand was produced by the Morledge and Veitch Co., formerly the Sparton Silica Co.

Both white and pink varieties of silica sand occur in the sandstone formations in the Valley of Fire northwest of St. Thomas. These sandstone beds of Jurassic age and of great thickness have been eroded into fantastic shapes that exhibit many hues of red, yellow, brown, pink, and white, which, in the bright light and heat of the desert, give the Valley of Fire its name.

In Clark County the production of a white glass sand suitable for the better grades of glassware depends upon a supply of water for washing to remove small amounts of clay, iron, and amorphous silica. Although extensive deposits occur in other parts of the County, it is doubtful whether they can produce a high-grade glass sand without washing. In the St. Thomas area, water for washing is available from the Muddy River, which joins the Virgin River a little below St. Thomas.

With the present import tariff of $1 per long ton on silica sand, the St. Thomas deposits compete with imported Belgian sand in the growing glass and foundry industries of southern California. The white sand, after washing, is suitable for the manufacture of fancy glassware and sodium silicate; the pink variety is shipped without treatment and is used for molding purposes and manufacture of the cheaper grades of colored glassware. Production of silica sand in Clark County is on a close-margin basis at the present time, with a chance to expand if industries requiring this material are established in the vicinity of Boulder Dam.

Morledge & Veitch Co.

The white silica-sand deposit owned by F. L. Morledge and Lloyd Veitch is covered by two placer locations of 40 acres each 3.8 miles southwest of the washing plant. The washing plant is on the St. Thomas branch of the Union Pacific R.R. 5 miles south of Overton, Nev. In March 1937,