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DEPARTMENT OF THE INTERIOR

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IRON ORE DEPOSITS OF THE BULL VALLEY DISTRICT, WASHINGTON COUNTY, UTAH

Because of the interest in ore deposits tributary to Boulder Dam, a study of the geology of the Bull Valley district, 40 miles southwest of Cedar City, in Washington County, southwestern Utah, has been made by F. G. Wells of the Geological Survey, United States Department of the Interior. This district is in the Bull Valley Mountains. It embraces a tract 4½ miles long and slightly less than 3 miles in maximum width, in sections 19 to 36, T. 38 S., R. 17 W.

The country is extremely rugged and difficult of approach. With the exception of a small area at Garden Springs and the valley of Moody Wash, which is in some places 1,000 feet wide, the streams flow mostly on bedrock in steep-walled canyons separated by narrow ridges. The maximum relief is 1,700 feet.

Mining has never been actively carried on in the Bull Valley district, but many trenches, pits, shallow shafts, and short adits were opened on iron ore outcrops during prospecting activities in 1906. These openings, though now largely caved or filled, afford some opportunities for detailed study of many structural and mineralogical features that are not well displayed in outcrops.

Geology and structure

The larger bodies of iron ore are in the Carmel formation, of Upper Jurassic age, which is about 600 feet thick and consists of dark bluish-gray limestone with some carbonaceous shale. Overlying the Carmel formation is the Pinto(?) sandstone, which is more than 1,000 feet thick and is composed largely of fine-grained sandstone intercalated with a few beds of conglomerate. Above the Pinto are 600 feet of coarse angular conglomerates with interbedded limestone and sandstone.

The areas of sedimentary rocks are almost completely surrounded by volcanic rocks--lavas and tuffs that range in composition from basalt to rhyolite and are several thousand feet thick. Similar volcanic rocks constitute the main mass of the Bull Valley Mountains and extend eastward with some interruptions to the Iron Springs district.

The only intrusive rock in the region is a stock of biotite syenite porphyry, which occupies the center of the district and is elongate in an east-west direction. Most of the structural features of the Bull Valley area have resulted from the intrusion of this stock. The stock arched and folded the overlying rocks and broke through to the surface in places. The outcrops are characterized by close jointing, which divides the rock into sharply rhomboidal angular blocks. At many places the joint surfaces are coated with octahedra of magnetite and flakes of specular hematite. The more deeply buried sedimentary rocks contiguous to the south side of the plug were in places overturned, but the overlying volcanic rocks were only arched.

The rocks are cut by many normal faults, most of which strike nearly north. These faults are believed to have been caused by the emplacement and later settling of the underlying igneous mass and by adjustments to movements along the great normal faults, such as the Gunlock and Hurricane faults, farther east. Fault breccia cemented by iron ore shows that some of the faulting preceded mineralization.

The most evident structural feature of the Bull Valley district is the Moody Wash syncline, which is well exposed in the southern part of the area. It seems probable that this syncline was produced by the compressive forces consequent upon the intrusion of the biotite syenite porphyry plug.

Ore deposits

All the outcrops of iron ore in the Bull Valley area, with the exception of a small mass of ferruginous chert in tuff at Cove Mountain on the west edge of sec. 31, T. 38 S., R. 17 W., and a mass of mineralized limestone and latite breccia north of Willow Draw in the SE$\frac{1}{4}$SW$\frac{1}{4}$ sec. 20, are found in a tract about 3 miles long and 1$\frac{1}{2}$ miles wide. (See accompanying map.)

The iron ore occurs partly as veins of steep dip and partly as massive irregular bodies in calcareous sedimentary rocks. The veins, which fill fissures in syenite, latite, and limestone, range in width from 1 to 40 feet and have been traced by means of iron-ore float for more than 200 feet along the strike. Their orientation is diverse, though the greater number trend in a northwesterly direction, roughly conforming to the trend of many of the faults.

The largest bodies of iron ore occur in limestone blocks of the Carmel formation enclosed in syenite at altitudes between 6,000 and 6,400 feet. This ore is massive hematite and magnetite with abrupt transitions to unaltered limestone. Surface exposures and a magnetic survey show that the only large ore deposit is a roughly wedge-shaped body that lies along a gulch about 1,000 feet south of U. S. land monument No. 1. This wedge measures approximately 300 feet along the gulch, 400 feet along the base (measured at right angles to the gulch), and 300 feet in height (difference of altitude between lowest and highest outcrops). Such a body has a volume of 18,000,000 cubic feet. Available estimates indicate that the reserves in this and smaller bodies of ore may amount to as much as 2,000,000 tons and that systematic exploration may show greater tonnages.

Two grab samples of iron ore, (1) from an iron vein cutting biotite syenite porphyry 1,600 feet west and 400 feet south from land monument No. 1 and (2) from an iron vein cutting porphyritic biotite latite tuff at a shaft 2,600 feet west and 1,710 feet south from land monument No. 1, were analyzed, with the results tabulated below, in percent:

	(1)	(2)
FeO	4.55	10.76
Fe_2O_3	88.73	73.29
SiO_2	1.50	12.92
Al_2O_3	1.17	1.27
MgO	.81	.22
CaO	1.49	.03
TiO_2	.17	.08
MnO	Trace	Trace
P_2O_5	1.22	.09
S	.03	.04
H_2O	.75	.50
P	.533	.039

The range in phosphorus is noteworthy. The content of metallic iron in both specimens is high, (1) 65.65 percent; (2) 59.66 percent.

In most places the ore of the replacement bodies in the limestone resembles that of the veins. It consists of fine-grained massive iron oxide containing small vugs, which are lined or filled with clear quartz. In some places the ore shows distinct cyrstalline structure and the vugs are lined with octahedra of magnetite. Under the microscope all stages of replacement of magnetite by hematite can be seen.

Two grab samples of replacement iron ore, (3) from dump 2,200 feet east and 1,800 feet south from land monument No. 1 and (4) from saddle 800 feet west and 1,400 feet south from land monument No. 1, were analyzed, and the results are tabulated below, in percent:

	(3)	(4)
FeO	.97	.83
Fe_2O_3	79.72	92.92
SiO_2	10.28	1.41
Al_2O_3	4.69	.79
MgO	1.01	.80
CaO	.79	.05
TiO_2	.20	.08
MnO	Trace	Trace
P_2O_5	.29	.07
S	.08	.10
H_2O	1.78	3.42
P	.128	.030

Both of these samples are high-grade ore, assaying 56.5 percent and 65.6 percent metallic iron, respectively.

Origin of the deposits

The geologists who have studied the area believe that during the intrusion of the syenite porphyry stock the hood and overlying rock were fractured, causing a sudden release of pressure and liberating from the stock for a brief period highly heated gases, composed mainly of ferric chloride, and water. The gases found ready egress to the surface along tension fissures without appreciably heating the country rock. They deposited magnetite and hematite in the fissures and replaced the contiguous fractured limestone. Hot liquid solutions that followed the same courses during the later magmatic history deposited additional quantities of iron ore. The bodies of iron ore were probably formed under a cover of less then 5,000 feet.

Outlook for development

The following guides to development and mining are deduced: Magnetite and hematite will be the only valuable metallic minerals present in the ore bodies, and gangue minerals will be limited to such material as was present in the original rock. This material is mostly silica and alumina, and in pure limestone beds it may be as little as 6 percent by weight of limestone or about 3 percent by weight of iron ore. Calcium-silicate minerals will occur only as mineralogic curiosities. Transition from ore to unaltered limestone will be abrupt. Large bodies of ore will be limited to beds of pure limestone and to fracture zones within the limestone. Where structural conditions are favorable the ore probably persists without mineralogic change to considerable depth.

The four analyses of ore from Bull Valley indicate that this ore is similar in character to that at Desert Mound and Iron Mountain, in the Iron Springs district, 20 miles farther northeast. This similarity, however, is no basis for inferring that the relatively large ore body 1,000 feet south of land monument No. 1 would have the same average composition throughout. Additional random samples would have little value, and systematic drilling and sampling throughout the mass would be the only basis for a reliable conclusion.

The Iron Springs district includes the Iron Springs, Desert Mound, and Iron Mountain areas, in Iron County, about 20 miles southwest of Cedar City. A report on the iron ores of this district by C. K. Leith and E. C. Harder was published in 1908 as Geological Survey Bulletin 338. This report is no longer available for distribution but may be consulted in many of the larger libraries. Estimates by Leith and Harder showed the Iron Springs district to have a total tonnage of about 40,000,000 tons of iron ore, mainly magnetite and hematite.

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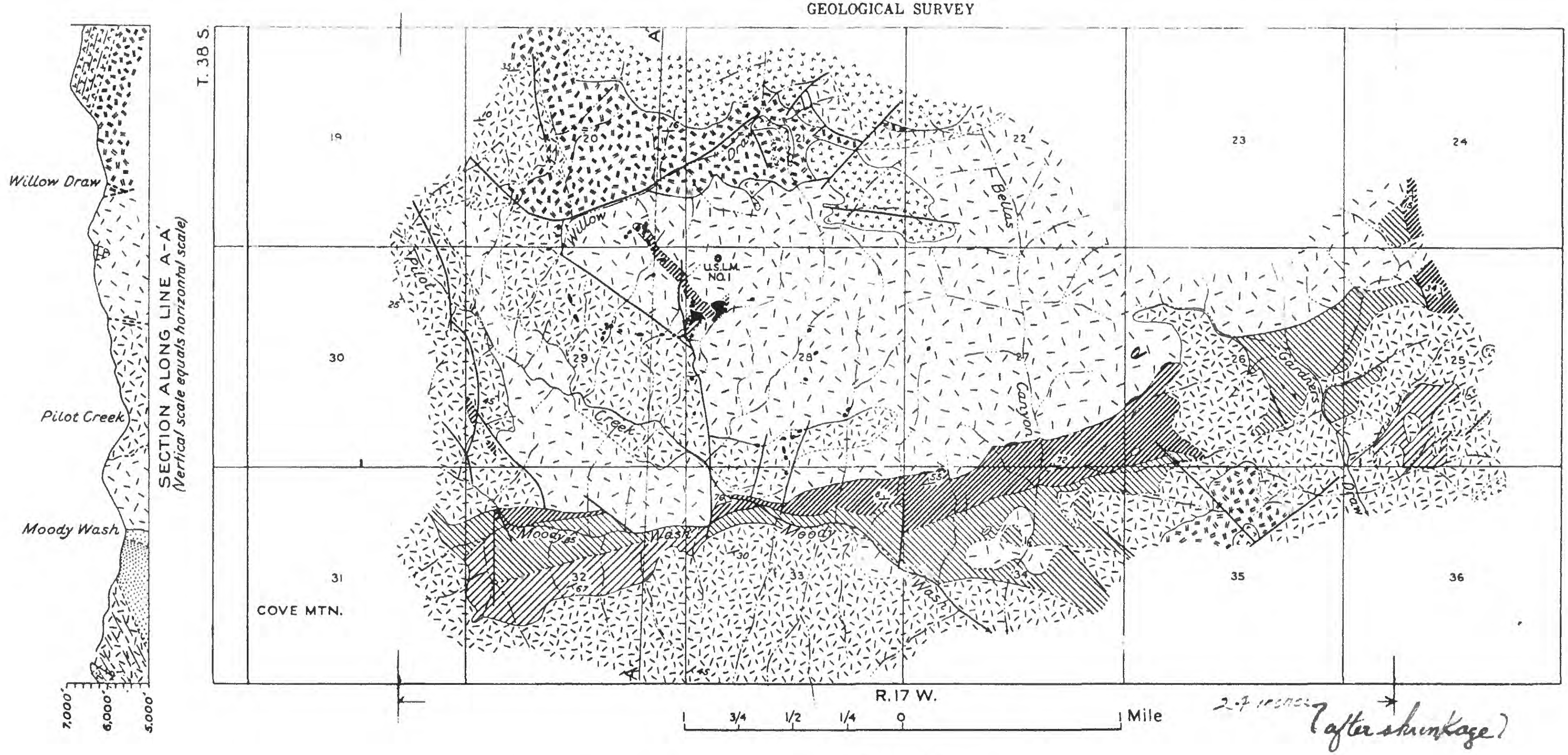

EXPLANATION

SEDIMENTARY ROCKS

- Limy sandstones and conglomerates — EOCENE(?)
- Pinto(?) sandstone — JURAS-CRETA-CEOUS
- Carmel formation — JURASSIC

VOLCANIC ROCKS

- Porphyritic rhyolite — LATE TERTIARY
- Younger volcanics (largely agglomerates) — LATE TERTIARY
- Older volcanics (largely latite) — MIOCENE(?)

INTRUSIVE ROCKS

- Biotite syenite porphyry — MIOCENE(?)

Fault

Strike and dip

Iron deposits (replacement bodies and veins)

GEOLOGIC MAP AND SECTION OF THE BULL VALLEY DISTRICT, UTAH

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