PRELIMINARY REPORT ON DOLOMITE AS A SOURCE OF MAGNESIUM IN WYOMING

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U.S. BUREAU OF MINES

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INTRODUCTION

This report is the result of a brief examination trip through Wyoming to take character samples of various dolomitic formations to determine the feasibility of using them as a source of metallic magnesium.

Information was also accumulated on other resources needed in processing, such as availability of power, natural gas, silica, iron and petroleum coke. The accessibility with respect to transportation and housing facilities is evaluated.

The writer acknowledges and appreciates the assistance rendered by Dr. Horace D. Thomas, Wyoming State Geologist, Chas. B. Stafford of the War Production Board of Casper, and C. J. Hare, Chief Geologist, Ohio Oil Company, of Casper. Numerous others with special interest in obtaining a plant in their locality or having certain deposits in their control, contributed of their time.

Examination of the dolomites of Wyoming was made from February 20 to 25 and March 3 to 8, 1942.

The factors affecting the choice of a site which are discussed in this report are as follows:

1. Distribution of dolomite, its grade and availability for mining by low-cost methods.
2. Availability of power at various localities and potential supplies in event additional is required.
3. Availability of natural gas, distribution and possibilities for expansion.
4. Availability of other raw materials as scrap iron, iron ore, silica and petroleum coke.
5. Situation of raw materials with respect to transportation, plant sites and housing facilities.

DISTRIBUTION OF DOLOMITE AND GENERAL GEOLOGY

Dolomites occur in Wyoming principally in the Paleozoic limestones and samples have been taken and analyzed from the Amsden formation of the Pennsylvanian, the Embar (Phosphoria) formation of the Mississippian, the Madison of the Mississippian and the Big Horn formation of the Ordovician. Limited sampling of the latter limestones indicates that little dolomite occurs in them. Occasional patches of a marbleized dolomite occur in Archean rocks.

Paleozoic dolomitic limestones are exposed along the western front of a series of mountains from the vicinity of Red Lodge in Montana to Cody, Wyoming, in the Salt River Range in western

Wyoming along the Wind River range on the continental divide northwest of Lander in the Owl Creek range between Thermopolis and Shoshoni, particularly in Wind River Canyon, along the Big Horn Mountains in north Central Wyoming, in the Casper Mountains south of Casper along the Laramie Mountains in Southeastern Wyoming, and in isolated exposures elsewhere. The occurrences of marbleized dolomite of Archean age occur northwest, west and southwest of Wheatland.

Reference to the accompanying map shows the approximate location of samples taken and represent the more accessible occurrences.

DESCRIPTION OF DEPOSITS

The following table gives the analysis of character samples taken on dolomitic limestone deposits in Wyoming. It also gives a key numeral that refers to the location on the attached map.

The deposits sampled at Cody are situated about 4 to 8 miles east of the town. They comprise the Big Horn dolomite which is about 450 feet thick in this area. By doing some stripping of overburden, the depth of which is not known, an adequate tonnage would be available for any sized plant and for any period. The samples taken were lower in MgO than the theoretical maximum. However, drilling may disclose areas of better grade.

The dolomite outcrops on both sides of Shoshone Canyon in steep cliffs. However, it is generally not so well suited to cheap mining because of the existence of overlying strata in the cliffs above.

The Embar (Phosphoria) formation comprising a poor grade of dolomite is about 50 feet thick 5 miles south of Thermopolis. It forms a dip slope on the north side of the Owl Creek range and is exposed on both sides of the entrance to Wind River Canyon. Large areas are completely exposed with little or no overburden.

The deposit is ideally situated with regard to cheap mining and proximity to adequate plant sites and water.

The road and railroad passing through Wind River Canyon cut the Big Horn dolomite at road level 9 miles from Thermopolis for a distance of over a mile. A gentle dip to the south causes the entire thickness of possibly 150 feet to be cut by the road in this distance. The entire exposure is clean massive dolomite containing nearly the maximum theoretical amount of MgO

Any ore mined from any exposure in the canyon would have to be mined from underground as the walls are nearly vertical for hundreds of feet.

At the north entrance to the Wind River Canyon other exposures of the Big Horn occur within fairly easy access for open cut mining (see attached photograph). The magnesia content is near the theoretical maximum. The last exposures of dolomite occur about a mile north of that shown in the accompanying photograph. Here several million tons occur adjacent to the highway and railroad. The beds are exposed as low hills with all overburden removed.

The deposits contain near the maximum theoretical magnesium for dolomite. They are ideally situated for cheap mining and loading for transportation.

The presence of snow in the Casper Mountains made it impossible to make a completely satisfactory examination. Several beds were examined on the west end of the mountains. However, only one bed about 30 feet thick proved to be virtually pure dolomite. This deposit is about 10 miles west of Casper and occurs in a steep walled canyon with sandstone in the cliffs above it. Mining of such a deposit would be expensive. However, it is the writer's opinion that further examination, when access to the mountains is possible, will show a large quantity of good grade dolomite as the Paleozoic rocks are exposed higher up.

In the vicinity of Wheatland marbleized dolomite deposits occur as isolated small knolls protruding above the level of the plains. These are pendants in a wide expanse of Archean sedimentary and igneous rocks. The dolomite is a beautiful hard crystalline rock.

The samples taken did not quite measure up to expectations. The deposits have not been opened up and the samples may be lower than would be the case if they came from little depth. It was noted that the surface exposures contained numerous small fractures that apparently were siliceous; whether this condition would extend to depth is problematical. It is the writer's opinion that the siliceous condition will not extend to any appreciable depth.

TRANSPORTATION

Cody is served by a branch of the Burlington Railroad from the main line at Frannie. Dolomite deposits are located within about 3 miles of the railhead at Cody.

The main line of the Burlington extends south from Frannie through Thermopolis and Wind River Canyon. Large quantities of the Big Horn dolomite occur along the railroad and are particularly accessible within a few hundred feet of the railroad near the south entrance of the canyon.

Both the Burlington and the Chicago and Northwestern Railroads pass through Casper. The dolomite deposits examined are within 10 miles of Casper and near a paved highway.

A branch of the Colorado and Southern Railroad extends from a junction of the Chicago and Northwestern, north of Wheatland, south through Wheatland to Cheyenne.

Paved highways are adjacent to the dolomite deposits at Cody, Thermopolis (Wind River Canyon) and Casper. The deposits at Wheatland are from 4 to 20 miles from a paved highway. However, the country is flat and the cost of road construction would be inconsequential.

A plant located at Cody would require haulage of dolomite about 3 miles by truck to the site. A plant located at a site 5 miles south of Thermopolis would require a train haulage of about 15 to 20 miles. At Casper the trucking distance is about 10 miles and at Wheatland the trucking distance from various deposits to Wheatland ranges from 15 to 30 miles.

At all sites the grades are either flat or favor the loaded carrier.

NATURAL RESOURCES FOR PRODUCTION OF MAGNESIUM

The natural resources needed for the production of magnesium from dolomite by the ferro-silicon process and the quantities are estimated in the following table. Since the process has not been used commercially, the estimates may be altered by further investigation. The process has been discussed with members of the Metallurgical Division and others and it is believed the estimates are sufficiently accurate for the purposes of this report.

Some allowance has been made for impure materials and for loss in efficiency in the process, but the figures cannot be considered final.

Power

The enclosed map of Wyoming shows the situation and capacity of hydro-electric and steam generating plants and situation and capacity of the power distributing system. The availability of power in excess of present peaks at the location of Cody, Thermopolis, Casper and Wheatland is discussed hereafter. All locations are interconnected; however, line capacities are not necessarily adequate to draw surplus from one area to another.

It is estimated that in excess of 30,000 KW of firm power will be needed to make ferro-silicon for a 1000-ton plant.

Cody

A hydro-electric plant of 7,000 KVA capacity is operating on water furnished from the Shoshone reservoir about 6 miles west of Cody. The plant comprises two 1,100-horsepower and one 6,000-horsepower units.

According to S. O. Harper, Chief Engineer, U. S. Bureau of Reclamation, 4,000 kilowatts and approximately 30,000,000 kilowatt hours per year can be made available immediately from existing facilities in the Cody area. A new hydro-electric generating plant will be added to the interconnected power system in 1943 and beginning about April 1, 1943, it would be possible to supply up to 10,000 kilowatts of firm continuous power in the area.

A proposed hydro-electric plant at the Heart Mountain siphon which crosses the Shoshone River about midway between Shoshone Dam and Cody is planned to have an installed capacity of 10,000 Kilowatts. This plant operating in conjunction with the existing plant at Shoshone Dam would make available an additional block of 5,000 killowatts of firm continuous power. This new plant could be completed in about 18 months from the time funds were available and construction authorized.

Thermopolis

In order to obtain sufficient power at a plant site, 5 miles south of Thermopolis, it would have to be drawn through the interconnected system from plants at Cody, Pilot Butte, and Casper.

About 5,000 to 7,500 kilowatts are available for Thermopolis in excess of present peak. However, it appears that some line capacity would have to be added and power developed.

Casper

The net available power over peak load at Casper at present is estimated to be 8,000 kilowatts, by L. W. Edwards of Casper.

The source, capacity and availability of power in this area is indicated in the following tabulation:

		Capacity - KW
Casper -	Modern steam plant of Mountain States Power Company	2500
Guernsey -	Hydro-electric plant of USBR on North Platte River of 6000 KVA capacity connected to Casper over 100-mile 57 KV line, with capacity estimated at	2000
Seminoe -	Hydro-electric plant of USBR on North Platte River of 36000 KVA capacity. This plant also serves loads in Laramie, Wyoming; Cheyenne, Wyoming; and Colorado. Seminoe plant connected to Casper by 57 KV transmission line with capacity estimated at	6000
Shoshone-Pilot	Hydro-plants of USBR located near Cody and Riverton, Wyoming, with total capacity of 9000 KVA. These plants now serve load of 6000 KVA peak in Cody-Lander area but due to firm water supply can supply large amounts of off-peak KWH to Casper to conserve water in North Platte or fuel. Connected to Casper over 57 KV line. Estimated minimum firm capacity	2000
Stanolind -	Modern 2500 KVA steam power plant of Stanolind Oil and Gas Company near Midwest, Wyoming, connected to Casper over 57 KV transmission lines with excess line capacity of 2000 KW when Casper refinery in operation	2000
	TOTAL	145000

Less Guernsey line as in normal operation all available water at Guernsey needed elsewhere on USBR system	2000	
Present Casper system (annual)	4500	6500
Net available on peaks		8000 KW

DAILY REQUIREMENTS OF
RESOURCES FOR THE PRODUCTION OF MAGNESIUM
FROM DOLOMITE BY THE FERRO*SILICON PROCESS

	500-ton PLANT	1000-ton PLANT
Plant capacity - dolomite per day - tons.....	500	1000
Magnesium produced daily from 20 percent MgO ore - Tons.....	60	120
Ferro-silicon at 1 pound per pound of metal, tons	60	120
Silica for ferro-silicon.....tons	100	200
Iron scrap for ferro-silicon.....tons	15	30
or		
Iron ore 50 percent Fe.....tons	30	60
Petroleum coke for ferro-silicon at $2\frac{1}{2}$ pounds per pound silicon.....tons	113	225
Power for ferro-silicon at 6500 Kw. Hr. per Ton of ferro-silicon - Kilowatts....	16,250	32,500
Natural gas - millions of cubic feet.....	4 to 5	8 to 10

To the above possibly could be added the capacity of the 25,000 KVA Stanolind steam plant at Salt Creek. The Standard Oil Company refinery at Casper now uses about 4,000 Kilowatts which with the amount used in the Salt Creek Field leave available approximately 4,500 kilowatts. A line 50 miles long to carry this additional power would have to be installed.

L. W. Edwards estimates this line could be installed for $150,000 plus $35,000 for a substation at Midwest or a total cost of $185,000. The total available power with this installation would be at least 12,000 kilowatts.

A multiple-purpose power plant of 30,000-kilowatt capacity is being proposed at Kortes on the North Platte River known as the Kendrick project. This plant would produce 101,000,000 kilowatt-hours of firm energy annually and 61,000,000 kilowatt-hours of secondary to be marketed over the interconnected system. The present cost estimated by the U.S.R.S. would be $8,310,000 including transmission lines cost. It appears that this plant would have to be erected to insure adequate power in Wyoming for a 1000-ton magnesium plant.

Wheatland

Wheatland is less favorably situated than any of the other locations under consideration for power facilities.

To furnish any where near an adequate amount of power to Wheatland would require the construction of a 60-mile transmission line from a point near Rocky River. This would connect

with the 30,000 KW U SBR transmission line from the Seminoe hydro-electric plant to Laramie.

Natural Gas

The enclosed map of Wyoming shows the situation and reserves of the principal producing natural gas fields. It also shows the location and size of the distributing pipe lines.

It is estimated that 8,000,000 to 10,000,000 cubic feet daily of natural gas will be required to operate a plant treating 1,000 tons of dolomite daily by the ferro-silicon process. The reserves of natural gas appear to be adequate through the area under consideration from Cody through Thermopolis, and Casper to Wheatland. However, generally the distributing system is inadequate and will require some additional pipe lines.

Natural gas in some fields is "sour "; however, as near as the writer has been able to determine the presence of the sulphur will have no deleterious effects in the process and "sweetening" will not be necessary.

Cody

At present the Rocky MountainGas Company of Casper, a subsidiary of the Ohio Oil Company, supplies natural gas through a 4-inch line from the Oregon Basin field 12 miles to Cody. The gas is "sour" and has to be "sweetened" for domestic purposes. The line appears to be barely adequate for supplying Cody.

In order to supply adequate gas to the area for a 1,000-ton plant one or more of the following lines will be required: (1) A 12-inch line 12 miles long from Oregon Basin: (2) a 12-inch line 32 miles long from Little Buffalo Basin or, (3) a 12-inch line 30 miles long from the Garland field.

The estimated reserve of the Oregon Basin field is 4 to 6½ billion cubic feet which may become exhausted, when it would be necessary to tap one of the more distant fields.

Thermopolis

Natural gas lines from Little Buffalo field to Thermopolis are old and at capacity already. The line comprises an 8-inch reduced to 6-inch and to 5-inch into Thermopolis.

The estimated reserve in the Little Buffalo Basin field is 40 to 80 billion cubic feet which should prove adequate for the contemplated program. A 12-inch line 35 miles long would be needed to supply gas to a plant at Thermopolis or a 55-mile line to furnish gas to a plant at the south end of Wind River Canyon.

Casper

The principal sources of natural gas at Casper are the Muskrat field 20 billion cubic feet reserves and the Big Sand Draw 120 billion cubic feet reserve. Some excess gas line capacity to Casper is available; however, in order to furnish sufficient gas for a 1,000-ton plant probably a 6- or 8-inch line 80 to 100 miles long will have to be installed.

Wheatland

In order to make sufficient gas available at Wheatland, pipe line capacity would have to be increased the entire distance to the Big Sand Draw field west of Casper. Further investigation may disclose other sources nearer; however, new pipe lines installations would be needed.

PETROLEUM COKE

Carbon is one ingredient used in the production of ferro-silicon. This is available in Wyoming in the form of petroleum coke. It is estimated that 2 pounds of carbon are required for each pound of silica or about 2.5 pounds of petroleum coke.

Two Casper Oil refineries produce jointly from 28,000 to 36,000 tons of petroleum coke annually. This quantity, if all was available for making ferro-silicon, would hardly be sufficient for a 500-ton plant. Other refineries in the state produce some coke that may be available.

IRON

Information from the Metallurgical Division of the Bureau of Mines indicates that either scrap iron, an iron ore or a siliceous low-grade iron ore would be suitable for the production of ferro-silicon in the process.

The American Pipe and Supply Company of Casper, the largest dealers in scrap iron advise that from 200 to 500 tons of scrap is accumulated or moves through Casper weekly. The Colorado Fuel and Iron iron mines at Sunrise are producing from ore. The available scrap or ore appears to be adequate for any size of magnesium plant contemplated.

SILICA

The sources of silica have not been investigated, but no doubt the supply in the form of quartzite, sandstone or as siliceous iron ore are adequate near any site chosen.

CONCLUSIONS

It appears that a good grade of dolomite can be found at any of the localities examined; however, with the exception of the deposits sampled in Wind River Canyon the location of the exact site most favorable for cheap mining still remains to be definitely established. Since high grade deposits likely can be found at Cody, Thermopolis, Casper, Wheatland and elsewhere, it appears that the choice of a deposit and plant site will be governed by their relation with respect to power, gas, and other raw materials, transportation and housing.

Providing that a good supply of high grade dolomite can be developed in the Paleozoic rocks on Casper Mountain that are easily accessible for cheap mining, Casper appears to be best

situated for establishing a plant for recovering magnesium from dolomite. Casper is a town of about 18,000 inhabitants and could more easily accommodate the personnel needed for a large plant.

It is best situated for power, petroleum coke, scrap iron and transportation. It is not as well situated for gas as Cody, or Thermopolis, as it will require possibly twice the pipe line length.

The demands on the Muskrat and Big Sand Draw fields are already heavy, the gas being used at Casper and the oil fields for commercial and domestic use and for repressuring. It may be the fields cannot produce enough gas for a 1,000-ton magnesium plant without impairing production of oil and curtailing other essential operations. If such is the case, it appears logical that a plant should be erected in the vicinity of Thermopolis or Shoshone.

Cheap high grade dolomite is available near the south end of Wind River Canyon. Assuming sufficient gas could not be made available at Big Sand Draw the Little Buffalo Basin field would be the source of gas. Power would have to be transmitted from the proposed Kortes power project on the North Platte River.

Should a good grade of dolomite be found at Cody it probably would be the next choice for a plant.

Since sufficient power is not now available for a 1,000-ton plant anywhere in Wyoming, an alternate plan is possible in order to speed production. Most of the power required in the process is for manufacture of ferro-silicon. It is possible the 120 tons daily could be manufactured elsewhere, possibly in the northwest, and shipped into Wyoming.