MANGANESE-IRON CONCRETIONS IN NORTHWESTERN SOUTH DAKOTA

Robert E. Curtiss
South Dakota State Geological Survey, Vermillion

INTRODUCTION

During the field seasons of 1951-53, the South Dakota State Geological Survey mapped and appraised a portion of South Dakota's coal resources and prospected currently exploited and potentially important mineral resources. This report is of a preliminary nature, designed primarily to summarize the physical and chemical characteristics of manganese-iron concretions and not to judge the magnitude of the deposits in terms of tonnage and value.

LOCATION AND ACCESSIBILITY

The manganese-iron deposits described lie in Corson, Dewey, and Ziebach Counties, South Dakota (see Fig. 1). Similar deposits exist in Perkins and Harding Counties to the west, but these are not included in this report. The area under consideration is located about 100 miles northwest of Pierre and approximately 60 miles west of Mobridge.

This sparsely populated area is served by the mainline of the Chicago, Milwaukee, St. Paul and Pacific Railroad and U. S. Highway 12 between Mobridge and North Dakota via Lemmon, and a branch line connects Mobridge and Isabel, the terminal. State Highway 8 links Mobridge and Isabel and points west. There are several secondary all-weather roads in this locale.

PREVIOUS INVESTIGATIONS

Many geoglogists have made detailed stratigraphic and lithlogic studies of the Hell Creek formation which bears the manganese-iron concretions; however, no chemical composition of the concretions in South Dakota has been reported.

LITHOLOGY OF THE HELL CREEK FORMATION

Concretionary layers are horizontally disposed in the relatively flat-lying Hell Creek formation (Brown, 1907) of Upper Cretaceous age.

The Hell Creek formation in this area is subdivided into three units: Lower Hell Creek, Isabel-Firesteel coal member, and upper Hell Creek.

The lower Hell Creek is characterized by lenticular sands, silts, and clays or mixtures of these size fractions, sometimes calcareous and gypsiferous, with thin beds of brown plant matter and clay (peat-clay), and minor amounts of rusty brown limonitic concretions. Much of this rock unit is impregnated with disseminated bentonite. This unit varies in thickness between 60 and 100 feet.

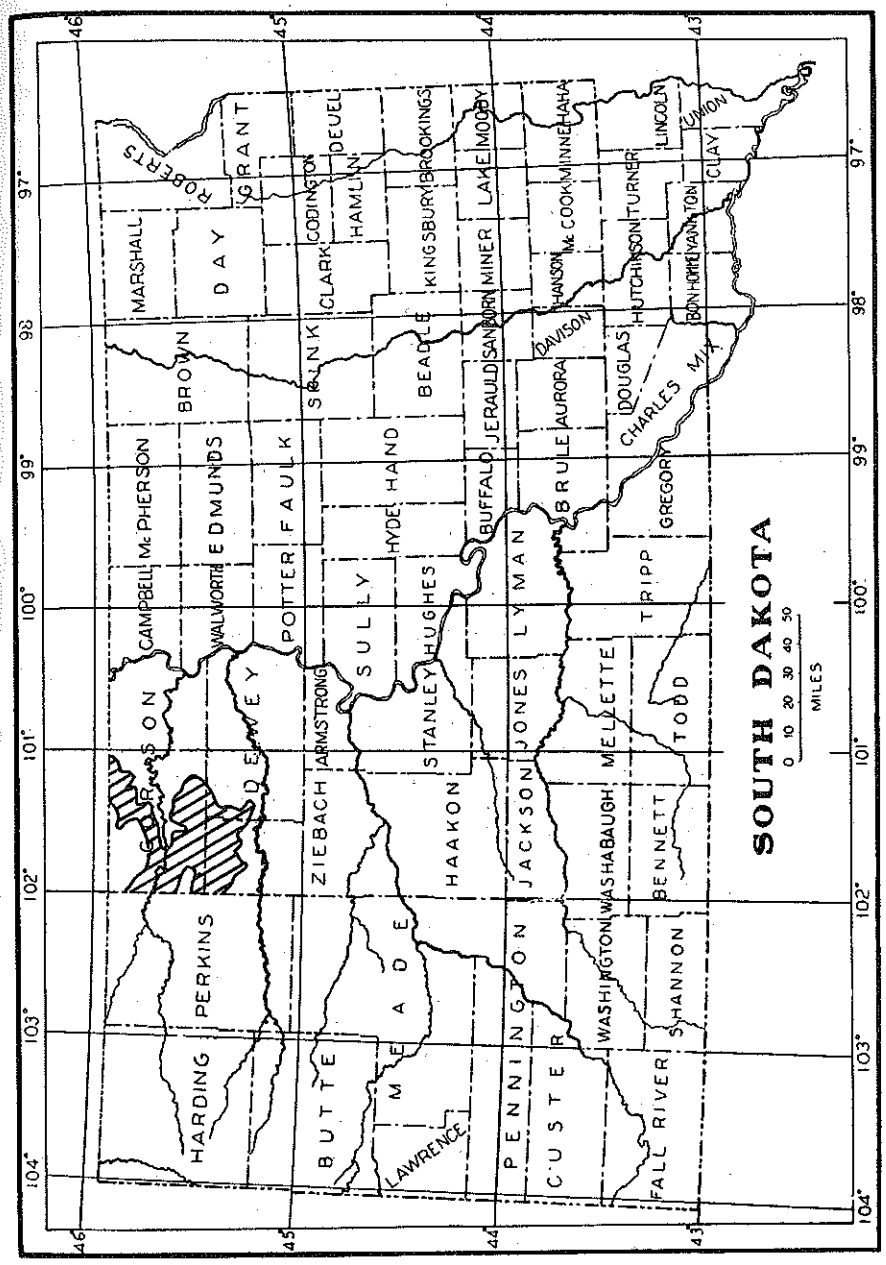

FIGURE 1. LOCATION OF MANGANESE-IRON DEPOSITS DESCRIBED IN REPORT

The Isabel-Firesteel coal member (Curtiss, 1952) overlies the lower Hell Creek unit and attains an average thickness of about 20 feet. The upper portion of this sedimentational sequence has been eroded over much of the area. Measured thicknesses range from 135 to 250 feet. Manganese-iron concretions are ubiquitous in occurrence, attested by the fact that the concretions are prevalent in practically every outcrop in the area. Their occurrence is not restricted to one stratum. These oxidized masses occur as concretionary layers, numbering as many as six in a 92-foot vertical section. The host rocks which contain the concretions are silty bentonitic clays, bentonitic clayey silts, sandy silts, and silty sands. These strata alternate in super- and subjacent positions in respect to the concretionary layers.

PHYSICAL CHARACTER OF CONCRETIONS

The upper Hell Creek manganese-iron concretions are dusky brown (5YR 2/2) in color, while the limonitic concretions of the underlying Fox Hills formation (Upper Cretaceous age) and the overlying Ludlow formation (Paleocene age) are rusty brown in color.

The deposits occur predominately as concretions (nodular to fairly rounded masses, differing in mineral and chemical character from the enclosing rock, and generally with a successive-layered or concentric structure indicating depositional growth around nuceli or cores). However, minor quantities are found as lenses and solid layers. Various shapes were noted, for instance, disk-shaped, subrounded or subspherical, and flat-spheroidal. The sizes range from a fraction of an inch to about two feet in diameter. Solid layers may be 15 feet long.

These concretions weather and break down to smaller sizes. In some cases, the concretions form "lag" gravel surfaces or thin veneers over eroded areas where slightly inclined planes, similar to desert pediments, are found at bases of numerous upper Hell Creek exposures. Here the concretions lag behind as the lighter sand, silts, and clays are removed by water and wind erosion.

Manganese-iron oxides occur as oxidized coatings or shells around light olive gray (5Y 6/1), dense, hard chert or siliceous claystone nuclei or cores. Hares (1, p. 21) reported many concretions with iron carbonate cores in southwestern North Dakota. Laird and Mitchell (2, p. 10) found concretions with "gray fine-grained sandy limestone or siliceous shale cores" in southern Morton County, North Dakota. The oxidized concretions have a shiny luster resembling varnish, a specific gravity of 3.2, a hardness of about 4, and very dusky red (10 R 2/2) streak.

The surface configuration of the concretions is relatively smooth for the large part, but some forms exhibit intricate ridge-like markings that resemble septaria. This interesting phenomenon may be attributed to dessication or shrinkage during the oxidizing period. Some broken concretions reveal columnar structure at right angles to the surface between the coating and core. The contact between the coating and core is generally sharply defined.

Weathering eventually reduces many of the concretions to a dark yellowish orange (10YR 6/6)-moderate reddish brown (10 R 4/6) powder imparting considerable iron stain which is prevalent throughout much of the unit.

The concretions may be a combined result of both syngenetic or primary and epigenetic or secondary processes operating in predominately silty sand and sandy silt host rocks through the media of solution, transportation, and deposition. Possibily the deposits formed during all stages in the sedimentational history of the Hell Creek episode as the rate of concretionary growth depends on availability of iron and manganese, rate of ground water movement and solvent ability, and the activity of the precipitating agent. During Hell Creek time, which was characterized by terrestrial sediments with lake (lacustrine) and swamp (paludal) environments, considerable vegetation flourished. Some of the concretions may have formed syngenetically. Solution from decaying plant matter may have dissolved iron and manganese oxides and/or carbonates and silica. Iron and manganese oxides might have settled out of solution. Silicon dioxide, in salt water lakes, may flocculate and form a silica gel in the presence of an electrolyte with the resulting diagenetic formation of chert. Some of the concretions may have an epigenetic origin. This type of concretion is generally found in sand or sandstone and to a less extent in clays or shales. The Hell Creek sands permit migration of solutions. Round concretions imply free movement of solutions from all sides. Flat disk-shaped concretions are largely confined to thin sandy beds in which the vertical growth is restricted.

CHEMICAL COMPOSITION

One specimen, collected in Sec. 2, T. 18 N., R. 21 E., Corson County, about 40 miles southwest of Lemmon and approximately 15 miles northwest of Isabel, was analyzed at the South Dakota State Chemical Laboratory, Vermillion, under the direction of Mr. Donald J. Mitchell, State Chemist, and the results are as follows:

TABLE I

CHEMICAL ANALYSIS OF MANGANESE-IRON CONCRETION

Chemical Constituents	Per Cent
Volatile Matter, Moisture	2.06
Loss on Ignition	10.20
Silicon Dioxide ($Si0_2$)	8.98
Manganese Dioxide ($Mn0_2$)	3.39
Calcium Oxide (CaO)	1.34
Ferric Oxide (Fe_20_3)	73.45
Magnesium Oxide (MgO)	1.00
Aluminum Oxide ($A1_20_3$)	1.46
TOTAL	101.88

The metallic iron content of the concretion is 51.34%, almost identical to a large quantity of the iron found on the Mesabi Iron Range, Minnesota.

Laird and Mitchell (2, p. 11) report the following chemical analysis of one specimen from southern Morton County, North Dakota:

TABLE II

CHEMICAL ANALYSIS OF MANGANESE-IRON CONCRETION, NORTH DAKOTA

Chemical Constituents	Per Cent
Moisture, Water of Hydration, and Volatile Matter	9.04
Residue insoluble in HCl	10.28
Ferric Oxide (Fe_2O_3)	47.37
Manganese Dioxide (MnO_2)	8.01
Soluble Aluminum, Calcium Sulphate, and undetermined	25.30
TOTAL	100.00

Comparative analyses between the South and North Dakota specimens reveal that the South Dakota concretion contains 26.08% more ferric oxide (Fe_2O_3), and that the North Dakota sample contains 4.62% more manganese dioxide (MnO_2).

CONCLUSIONS

No attempt has been made to evaluate the manganese-iron deposits in northwestern South Dakota. However, preliminary studies yield some encouraging facts and interesting possibilities.

1. Chemical analysis indicates a sufficiently high quantity of metallic iron to warrant detailed field and laboratory investigations.

2. Future chemical analyses of a multitude of samples may classify these deposits economically significant.

3. These deposits would have to be mapped in detail to calculate recoverable volumes and potential value.

4. Manganese deposits suitable for use in the manufacture of the types of manganese-iron alloys most desired in steel plants are uncommon. Spiegeleisen is a manganese-iron alloy containing only 18 to 22 per cent of manganese.

5. Manganese-iron deposits in northwestern South Dakota might contribute to the State's future economy.

BIBLIOGRAPHY

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