THE GEOLOGICAL SURVEY OF WYOMING

D. L. BLACKSTONE, JR., State Geologist

PRELIMINARY REPORT NO. 9

Gypsum Deposits in the Cody Area, Park County, Wyoming

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UNIVERSITY OF WYOMING
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ILLUSTRATIONS

Cover. View looking northeast toward Heart Mountain. Upper plate of Heart Mountain detachment fault consists of Ordovician Bighorn Dolomite, Devonian Three Forks and Jefferson Formations, and Mississippian Madison Limestone. Lower plate is the Eocene Willwood Formation.

GYPSUM DEPOSITS IN THE CODY AREA, PARK COUNTY, WYOMING.

by

James M. Bullock* and William H. Wilson+

INTRODUCTION

The report area is located in northcentral Park County, Wyoming, along the northwestern border of the Bighorn Basin. The area extends southward 60 miles from the Montana-Wyoming boundary to 10 miles south of the town of Cody, Wyoming. A large quantity of gypsum occurs in a narrow belt in the outcrop area of the Gypsum Spring Formation. During field work 27 sections of the Gypsum Spring Formation were measured (see Bullock, 1964). The gypsum outcrop pattern and location of measured sections of the Gypsum Spring Formation is shown on Figure 1 and Plate 1. A small amount of impure gypsum occurs in the Triassic Dinwoody Formation and in Quaternary(?) hot spring deposits.

Gypsum is a mineral that can have various origins. Most gypsum deposits are formed by precipitation from evaporating marine water. Minor amounts of gypsum have been precipitated by evaporation of saline lakes. Gypsum deposits may result from volcanic activity and from evaporation of spring solutions. Gypsum is a common mineral occurring in minor amounts in caves and as a gangue mineral in metallic mineral veins. Minor deposits of gypsum are associated with sulfur-bearing salt domes.

The chemical composition of gypsum is $CaSO_4 \cdot 2H_2O$: the water molecules being responsible for gypsum's most useful properties. Raw gypsum is used as a fertilizer or soil conditioner, as a filler for paper textiles, and as a strengthening and set-retarding agent in Portland cement. Calcined or processed gypsum is used for molding, castings, pottery, and dental plaster, and in building materials such as plasterboard, plaster, Keene's cement, tiles, and blocks.

STRATIGRAPHY

The sedimentary section in the report area is exposed in anticlines and in river gorges cutting across the strike of the strata. The stratigraphic section exposed in Shoshone Canyon and in the river trench below the Canyon shows an essentially conformable sequence from Middle Cambrian through Upper Cretaceous which is unconformably overlain by Cenozoic deposits (Johnson, 1934, p. 814; Stipp, 1947, p. 274-281).

Gypsum deposits are contained within strata of Triassic and Jurassic age in the report area. The Triassic Dinwoody Formation contains gypsiferous siltstone and the Triassic Chugwater Formation contains small amounts of gypsum as fracture fillings. The Middle Jurassic Gypsum Spring Formation contains a large quantity of gypsum. The formations containing gypsum within the report area and their correlatives in other nearby areas are listed in Table 1. The stratigraphic location of major gypsum beds in the report area and other areas is shown in this table.

Dinwoody Formation

The Lower Triassic Dinwoody Formation (Condit, 1916) disconformably overlies the Permian Phosphoria (Park City Formation of some geologists) Formation. The Dinwoody Formation represents the eastern epicontinental extension of geosynclinal rocks of the Woodside Formation (Mills, 1956, p. 14).

The Dinwoody Formation is poorly exposed in the report area. Where exposed it consists of approximately 60 feet of brown, yellow, and green shales and interbedded gypsiferous siltstone, dolomite, and limestone. Gypsiferous siltstone occurs interbedded throughout the formation, although a single layer seldom exceeds a thickness of three inches.

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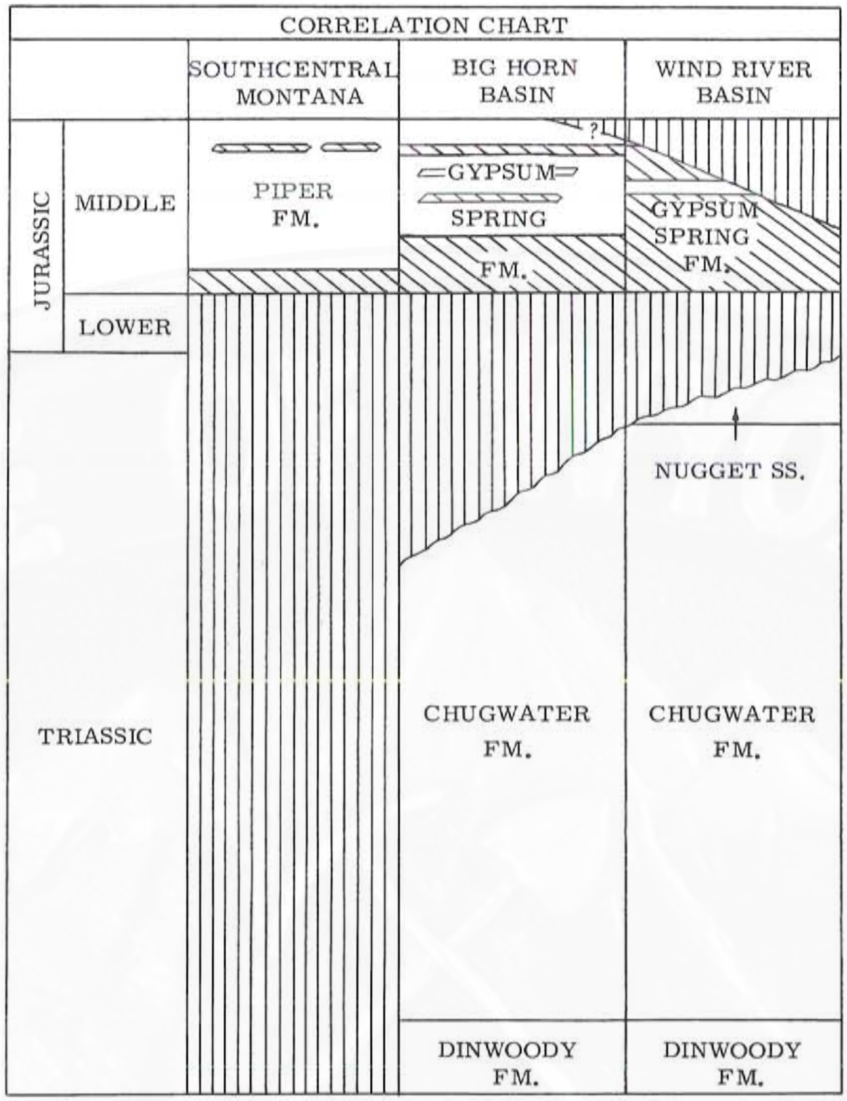
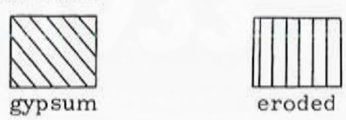


Table 1. Modified from Burk, 1958; Imlay, 1947, 1956; Love, 1939; and Anonymous, 1963.



Gypsiferous siltstone contained in the Dinwoody Formation is a soft, earthy mixture of silt, clay, and gypsum particles. The gypsum probably was precipitated from marine water and mixed with terrigenous silt and clay. Gypsum within the Dinwoody Formation is impure and not of significant economic value.

Chugwater Formation

The Triassic Chugwater Formation (Darton, 1904, p. 397) conformably overlies the Dinwoody Formation. The Chugwater Formation, consisting of interbedded red shales and siltstones, is well exposed in the report area. The Chugwater Formation thins northward, with the upper part progressively lost as the result of pre-Gypsum Spring erosion (Mills, 1956, p. 15).

Gypsum veinlets, derived from a thick gypsum bed in the lower part of the overlying Gypsum Spring Formation, occur in fractures in the upper part of the Chugwater Formation.

Gypsum Spring Formation

The Gypsum Spring Formation (Love, 1939, p. 42) of Middle Jurassic age, unconformably overlies Triassic strata. The type section of the Gypsum Spring Formation is in the Wind River Basin, 18 miles east of the town of Dubois. The type section is 181.5 feet thick and consists of a lower unit of massive gypsum and red shale, and an upper unit of interbedded limestone, dolomite, red shale, and some gypsum (Love, 1939). Overlying the Gypsum Spring Formation in the type locality is a red shale unit approximately 40 feet thick, designated as the lowest part of the Sundance Formation by Love (1939). However, later workers (Mills, 1956; Imlay, 1956; and Peterson, 1957) have included this red shale unit in the upper part of the Gypsum Spring Formation because of its apparent genetic relationship to the underlying gypsum beds. Under this usage the Middle Jurassic Gypsum Spring Formation includes all units lithologically equivalent to the Middle Jurassic red beds in Montana (Peterson, 1957, p. 49). The upper red shale unit appears to be genetically related to the underlying Gypsum Spring Formation as both contain gypsum and the upper red shale unit is similar to red beds in the lower part of the formation. In this report the upper red shale layer is included within the Gypsum Spring Formation.

The Gypsum Spring Formation in Park County, Wyoming, unconformably overlies the Chugwater Formation. This unconformity is indicated by the discordance of bedding between the two formations, and the irregular surface between them. In Park County, the Gypsum Spring Formation may be conveniently divided into three major lithologic units as follows: (1) a lower unit composed of interbedded gypsum, red shale, and minor limestone and dolomite; (2) a middle unit composed of interbedded fossiliferous limestone, gray shale, calcarenite, and gypsum lentils; and (3) an upper unit composed of red shale having a basal gypsum bed (Pl. 1 and Fig. 2).

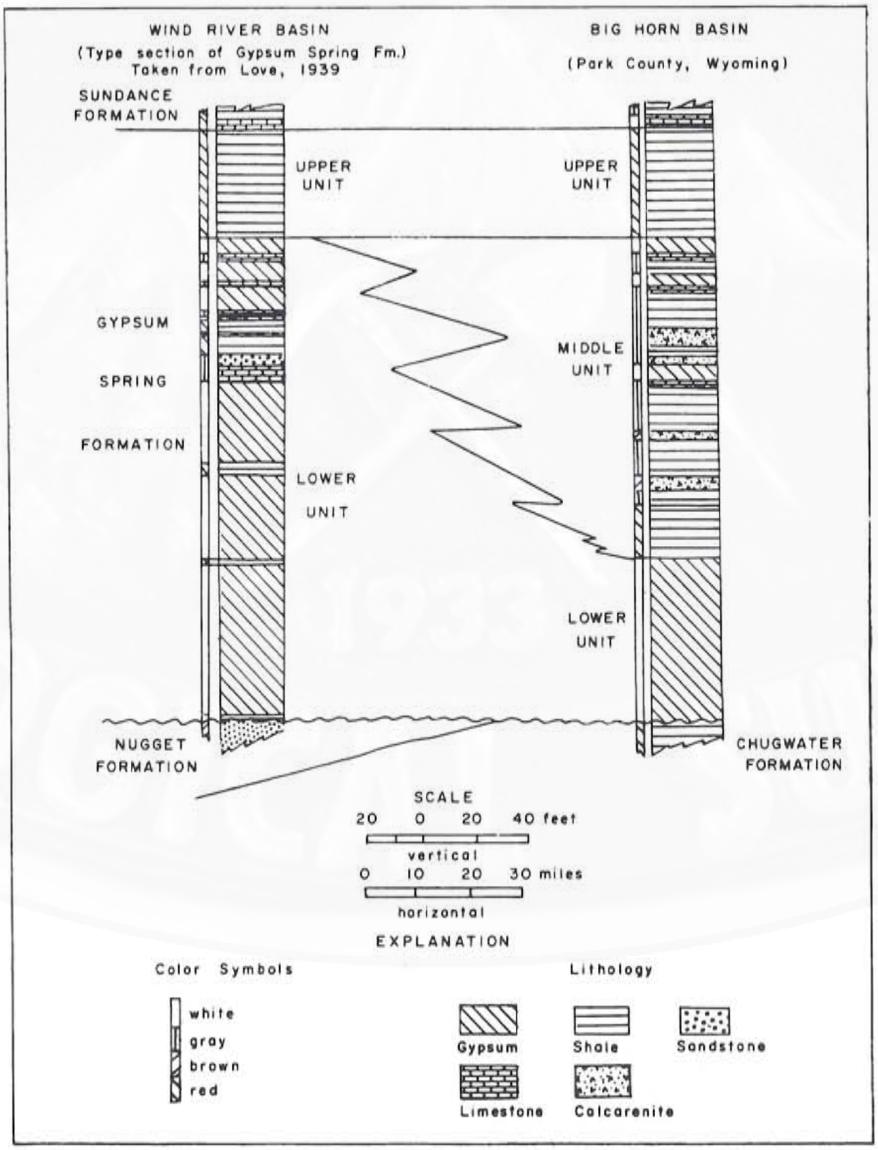


Figure 2. Facies relationship of Gypsum Spring Formation.

The lower unit of the Gypsum Spring Formation may be subdivided into two parts. The lower part is composed predominantly of gypsum, with minor interbedded carbonates and red beds. This gypsum bed ranges from 0 to 80 feet thick, locally pinching out and subsequently reappearing along strike. It thins or entirely pinches out where it butts into the Chugwater Formation which locally protrudes as topographically high areas developed on the erosion surface separating the Chugwater Formation and the Gypsum Spring Formation. The relief of the erosion surface separating the formations is as great as 60 feet within a lateral distance of 100 yards.

Red beds and limestones interbedded within the gypsum bed in the lower unit are commonly lenticular and seldom exceed a thickness of one foot. They comprise less than 10 percent of the total thickness of the evaporite deposit within the lower unit. Red beds within the gypsum unit are thin bedded to massive and fine grained. Limestones interbedded with gypsum are gray, massive to thin bedded, lithographic, and nonfossiliferous. Diastems occur in places in the limestones.

Highland areas of the Chugwater Formation exposed above the evaporite deposits within the topographically low areas, contain brecciated dolomitic limestone lentils. The lentils have a length of at least 100 yards and a thickness of up to four feet. The dolomitic limestone grades laterally into gypsum in sec. 26, T. 54 N., R. 104 W. Dolomitic limestone contains dolomite as angular blocks of heterogeneous size having a diameter up to three inches, and surrounded by limestone cement.

The upper part of the lower unit of the Gypsum Spring Formation consists of red shale ranging from 15 to 20 feet thick and containing numerous randomly oriented gypsum veins. This nonfossiliferous red shale is thin bedded and composed of clay-size particles.

The middle unit of the Gypsum Spring Formation consists of approximately 80 feet of interbedded gray shale, calcarenite, limestone, and gypsum lentils. The calcarenite, limestone, and gray shale are commonly abundantly fossiliferous. Fossils consist predominantly of pelecypods, but occasional ammonites, horn and colonial corals, gastropods, echinoids, and crinoid remains are represented (Imlay, 1956, pp. 582-584). The assemblage contains numerous individual specimens but the number of different genera and species is scarce.

Thin-bedded gray shale lentils up to 60 feet thick occur interbedded throughout the middle unit. They are fine grained and argillaceous, and contain a few scattered fossils.

Calcarenites within the middle unit occur as lentils ranging from 0 to 15 feet thick and showing rapid lateral changes in thickness. They are composed primarily of poorly sorted fossil debris, and contain scattered oolites and lithic fragments in places. Commonly the calcarenites are thin-bedded and show cross-bedding and occasional oscillation ripple marks.

Limestones in the middle unit seldom exceed a thickness of one foot. They are gray to pink, thin bedded to massive, lithographic, composed almost entirely of carbonate, in places are oolitic, and contain scattered fossils. The fossils are well preserved and unbroken.

Gypsum lentils occur within the middle unit and range in thickness from 0 to 12 feet and are laterally continuous for not greater than three miles. The gypsum lentils contain interbedded thin limestone and red mudstone layers. Gypsum grades laterally into gray shale and calcarenite. The gypsum lentils are more numerous in the southern part of the report area than to the north (Pl. 1).

The upper unit of the Gypsum Spring Formation consists of approximately 70 feet of gypsum and red shale. It contains a basal gypsum bed ranging from 3 to 5 feet thick containing thin limestone and red mudstone interbeds. Overlying the basal gypsum is a red shale ranging from 62 to 70 feet thick. It is thin bedded, composed of clay- and silt-size particles, and nonfossiliferous. This red shale is similar to the red shale occurring in the lower unit of the Gypsum Spring Formation. Both are lithologically similar and occur between a lower evaporite layer and upper fossiliferous beds.

Overlying the red shale layer in the upper unit of the Gypsum Spring Formation are fossiliferous limestone and claystone beds at the base of the Sundance Formation. The limestone ranges from 2 to 5 feet thick, is gray to pink, massive to thin bedded, lithographic, oolitic, and fossiliferous. It facies into gray, fossiliferous claystone in the southern part of the report area. Scattered fairly well preserved and nonbroken benthonic mollusks occur within the limestone and claystone. The contact of the Gypsum Spring Formation and the Sundance Formation appears conformable.

The Gypsum Spring Formation in Park County is classified as Middle Jurassic in age on the basis of: (1) the early Middle Jurassic ammonite Teloceras (Zemistephanus) contained within the middle unit; (2) its stratigraphic position directly below beds containing early Upper Jurassic ammonites; and (3) on lithologic and faunal similarities to the middle limestone member of the Middle Jurassic Piper Formation (Imlay, 1956, p. 584).

Although the term Gypsum Spring Formation has been applied to the Middle Jurassic sequence of gypsum, carbonates, and red beds in most parts of the Bighorn Basin of Wyoming, Imlay (1956, p. 581) objects to the use of this term for the Middle Jurassic sequence in the northwestern part of the Bighorn Basin. He states:

> The term Gypsum Spring formation is not applied to these Middle Jurassic strata in Park County (Wyoming) because they probably include more than the type section of the Gypsum Spring formation on Red Creek in the Wind River Basin and because they contain more fossiliferous limestone and claystone. The term Piper formation is not applied because it seems desirable at the present time to keep the terms used for marine Jurassic rocks in Montana separate from those used in Wyoming. Detailed mapping of the Middle Jurassic rocks in Park County should be done before formational names are applied to them.

Pierce (1966, 1968), however, indicates that the Gypsum Spring Formation is of Middle Jurassic age in both the Cody and Pat O'Hara quadrangles.

The upper and lower parts of the Gypsum Spring Formation are lithologically similar in the Wind River Basin and in the Bighorn Basin (Fig. 2). However, the middle part of the Middle Jurassic strata in the Bighorn Basin contains more fossiliferous limestone and claystone than does the type section of the Gypsum Spring Formation in the Wind River Basin. This middle unit is a facies apparently not present in the type section. The term Gypsum Spring Formation should be extended northward to include its equivalents in the Bighorn Basin, even though these rocks are not identical in lithology to those in the type section. In our opinion, the lithologic similarities outweigh the dissimilarities.

The Gypsum Spring Formation in Park County appears to be conformably overlain by the Sundance Formation which is composed of grayish-green shales, sandstones, and thin limestones. Gypsum and red beds do not occur within this formation in Park County, Wyoming.

GYPSUM DEPOSITS

All common varieties of gypsum occur within the report area, including satin spar, selenite, gypsite, massive rock gypsum, and alabaster. Alabaster is the only variety occurring in significant amounts.

Satin spar is a fine, silky, fibrous variety of gypsum. It occurs as veins within alabaster beds and as veins within strata directly above and below alabaster beds.

Selenite, a coarsely crystalline, transparent variety of gypsum, occurs in claystone beds. These selenite-bearing claystone beds are closely associated with alabaster beds in the Gypsum Spring Formation. Selenite crystals also occur in Quaternary(?) sulfur-gypsum spring deposits. Most crystals are less than one inch in diameter.

Gypsite is an earthy mixture of gypsum and foreign particles. It is the major variety of gypsum in Quaternary(?) sulfur-gypsum spring deposits. Gypsite in the spring deposits was precipitated from solution as gypsum within previously deposited silt, sand, and gravel.

Massive rock gypsum is a variety of gypsum composed of loosely cemented gypsum particles. It is soft and has a porous texture. Massive rock gypsum grades into alabaster with depth and is apparently the product of weathering.

Alabaster is a hard, massive, fine-grained variety of gypsum. It is usually whitish-gray on weathered surface and pure white on fresh surface. The alabaster variety of gypsum constitutes nearly all of the gypsum occurring within the Gypsum Spring Formation.

Contorted Structure

Contorted structures are secondary features shown in the alabaster beds within the Gypsum Spring Formation. Contorted structures include: swellings, knotty structures, and folds. According to Carozzi (1960, p. 417), these are structures common in gypsum which has been altered from anhydrite. Anhydrite ($CaSO_4$) is converted to gypsum ($CaSO_4 \cdot 2H_2O$) by the addition of water resulting in a volume increase of 30 to 50 percent (Pettijohn, 1957, p. 479). Contorted structures are produced by the volume increase during the conversion from anhydrite to gypsum.

Gypsum Veins

A red shale layer approximately 20 feet thick directly overlies the gypsum bed in the lower unit of the Gypsum Spring Formation. The most striking features in this shale layer are numerous, randomly oriented veins composed of hard, fibrous gypsum. The gypsum veins are usually one or two inches in width and up to 12 inches wide.

A given body of anhydrite and the requisite water for alteration to gypsum occupy a greater volume than does the resulting gypsum. The requisite space for the addition of water is attained through solution of the anhydrite bed and removal of anhydrite as veins in adjacent strata (Bundy, 1956, p. 247). The gypsum veins occurring in strata directly overlying the gypsum bed in the lower unit of the Gypsum Spring Formation formed during the conversion of anhydrite to gypsum, as indicated by the connection of the veins to the underlying gypsum bed. Carozzi (1960, p. 417) attributes fibrous gypsum veins to secondary deposition from interstitial water. Compaction occurring under the influence of gravity and continued sedimentation cause the interstitial water to follow the path of least resistance and move upward, transporting dissolved and suspended gypsum. The process of solution, transportation, and precipitation was repeated many times as shown by numerous cross-cutting gypsum veins.

Gypsum veins also occur in the upper part of the Chugwater Formation directly underlying the thick gypsum bed in the lower unit of the Gypsum Spring Formation. These gypsum veins occupy fracture openings in the Chugwater Formation. The gypsum is derived from the overlying gypsum bed in the Gypsum Spring Formation.

Sulfur-Gypsum Spring Deposits

Minor amounts of gypsum occur associated with sulfur in spring deposits southwest of Cody, in sections 3, 10, and 15, T. 52 N., R. 102 W. (Fig. 1). They occur on the southeastern flank of the Rattlesnake Mountain-Cedar Mountain anticline within the Permian Phosphoria (Park City) Formation and within and directly overlying Pleistocene(?) terrace gravel deposits. The terrace gravel deposits, which unconformably overlie older strata, are probably Pleistocene in age (Pierce, 1941, p. 158).

The sulfur-gypsum deposits have an areal extent of approximately 25 acres and a maximum exposed thickness of 25 feet. Sulfur-gypsum deposits underlie travertine capped cone-shaped structures. Gypsum, occurring as gypsite and as selenite, surrounds sulfur which occurs in pockets and narrow channels. The occurrence of sulfur in channels and its association with travertine indicates spring deposition. The close association of gypsum with sulfur suggests a similar origin for the gypsum.

Table 2. Chemical analyses* of DeMaris Spring ($SW\frac{1}{4}NW\frac{1}{4}$ sec. 3, T. 52 N., R. 102 W.) near Cody, Wyoming.

Chemical Content	Sample WRL-429 (milligrams/liter)	Sample WRL-430 (milligrams/liter)
Silica (SiO_2)	18	18
Iron (Fe)	.06	.20
Manganese (Mn)	--	--
Calcium (Ca)	354	369
Magnesium (Mg)	72	63
Sodium (Na)	33	33
Potassium (K)	16	16
Bicarbonate (HCO_3)	952	993
Carbonate (CO_3)	0	0
Sulfate (SO_4)	422	418
Chloride (Cl)	21	20
Fluoride (F)	2	2
Nitrate (NO_3)	.1	.1
Dissolved solids		
Residue on evaporation (180° C.)	1460	1450
Hardness as $CaCO_3$	1180	1180
pH	6.9	7.1
Temperature	82° F.	81° F

* Analyses by Water Resources Division, U. S. Geological Survey

Springs are formed wherever underground waters flow to the surface through natural openings in the ground (Emmons, Thiel, Stauffer, and Allison, 1955, p.129). Spring waters may be of two types: meteoric water which circulates through pervious strata; and juvenile water which is derived from underlying igneous rock. Clarke (1924, p.214), in discussing the distinction between meteoric and juvenile water, states that meteoric water commonly contains carbonates of lime and magnesium, sulfates, or chlorides. Juvenile water commonly contains sodium carbonate, alkaline silicates, and heavy metals with sulfates or chlorides only occurring as accessories, and practically no carbonates of the alkaline earths. The abundance in inactive spring deposits of calcium carbonate as travertine, and calcium sulfate as gypsum, indicate deposition from meteoric water. Active spring waters within the area have been analyzed for chemical content (Table 2). The active spring waters contain an abundance of calcium and magnesium with sodium and silicates in considerably lesser amounts. This indicates a meteoric rather than juvenile source of the spring water.

Active springs in the area currently (1968) issue water as hot as 82° F., although Bartlett (1926) indicated temperatures as high as 100° F. Two different heat sources for the spring water have been proposed. Woodruff (1907, p.454) postulated a magmatic body underlying the spring deposits at depth. Fisher (1906, p.62) suggested that the spring water was heated by the normal increase in temperature caused by depth.

Gypsum is produced by the reaction of sulfuric acid and limestone, with the sulfuric acid probably produced by oxidation of hydrogen sulfide (Snider, 1913, p.12-13). According to Woodruff (1907, p.452) active hot spring solutions in the area contain large quantities of hydrogen sulfide. Because sulfur occurs in ancient spring deposits the spring solutions of the past must have also contained hydrogen sulfide. In the Bighorn Basin, hydrogen sulfide is associated with and probably derived from Permian limestones (Crawford, 1952, p.96). Spring water originating at depth must come in contact with hydrogen sulfide-bearing Permian limestones on its way to the surface. Thus, hydrogen sulfide-rich spring solutions originating as underground water at depth reacted with limestone to produce gypsum at the surface.

Gypsum Quality

Gypsum is chemically composed of calcium sulfate with two water molecules ($CaSO_4 \cdot 2H_2O$). Standard specification (American Society for Testing Materials Designation C 22-50) (Havard, 1960, p.471) states that minimum purity for material to be called gypsum is 70 percent $CaSO_4 \cdot 2H_2O$. The percent by weight of the chemical constituents of pure gypsum is: 32.5 percent CaO, 46.6 percent SO_3, and 20.9 percent H_2O.

Gypsiferous siltstone deposits within the Dinwoody Formation and Quaternary (?) sulfur-gypsum spring deposits do not contain 70 percent gypsum. Gypsum deposits in the Gypsum Spring Formation are composed of well over 70 percent gypsum.

Chemical analyses of four gypsum samples from the gypsum bed in the lower unit of the Gypsum Spring Formation is listed in Table 3. These analyses show that the gypsum bed is composed of nearly pure gypsum. The slight excess of CaO in these samples suggest a small amount of calcium carbonate within the gypsum.

Table 3. Chemical analyses of gypsum deposits in the lower unit of the Gypsum Spring Formation.

	Section* #2	Section* #6	Section* #9	Section* #19
CaO % weight	32.98	32.75	32.91	32.85
SO_3 % weight	45.95	43.92	46.23	46.07
H_2O-250 C. % weight	20.06	20.07	20.28	20.53
R_2O_3	00.15	00.28	00.22	00.20
Insolubles	00.05	00.22	00.20	00.22
TOTAL	99.19	97.24	99.84	99.87
Indicated Gypsum Purity (from SO_3 value)	98.80	94.50	99.40	99.00

* Location of analyses shown in Figure 1, index map on Plate 1.

Analyses by B. Davis and R. Tremain, Natural Resources Research Institute, Laramie, Wyoming.

GYPSUM RESERVES

The Gypsum Spring Formation contains the largest amount of gypsum occurring within the report area. These deposits are composed of nearly pure gypsum, but the gypsum deposits within the Dinwoody Formation and Quaternary(?) spring deposits are impure. Only the gypsum deposits of the Gypsum Spring Formation are considered as commercial gypsum for use in calcined gypsum products. In addition, only the gypsum bed within the lower unit of the Gypsum Spring Formation is considered in reserve estimates, because it is the only thick gypsum bed that is laterally persistent.

Outcrop reserves were computed by measuring the width, length, and thickness of the gypsum bed. An average value of 2.32 was used for specific gravity. Because the gypsum bed is commonly overlain by a thick sedimentary rock sequence a width of one foot is used in calculating the gypsum reserve. Gypsum crops out almost continuously for a distance of 60 miles (Fig. 1, Pl. 1). The thickness of the gypsum bed ranges from 0 to 80 feet, generally thickening southward. The outcrop reserves are estimated at 1 million short tons. About two-thirds of the total outcrop reserves occur within the southern half of the report area.

MINING AND MILLING PROCEDURE

The plasterboard manufacturing plant located in Cody, Wyoming, obtains its supply of raw gypsum from a nearby quarry (secs. 13 and 14, T. 52 N., R. 102 W.) in the lower part of the Gypsum Spring Formation. A simplified flow diagram showing the steps in the manufacture of raw gypsum into plasterboard is shown in Figure 3. Raw gypsum brought to the plant is first crushed. Primary crushing is done by hammermills. Raymond mills are used for final crushing and to remove micro-fine material. The latter operation is important because a uniform particle size is necessary to insure a uniform finished product.

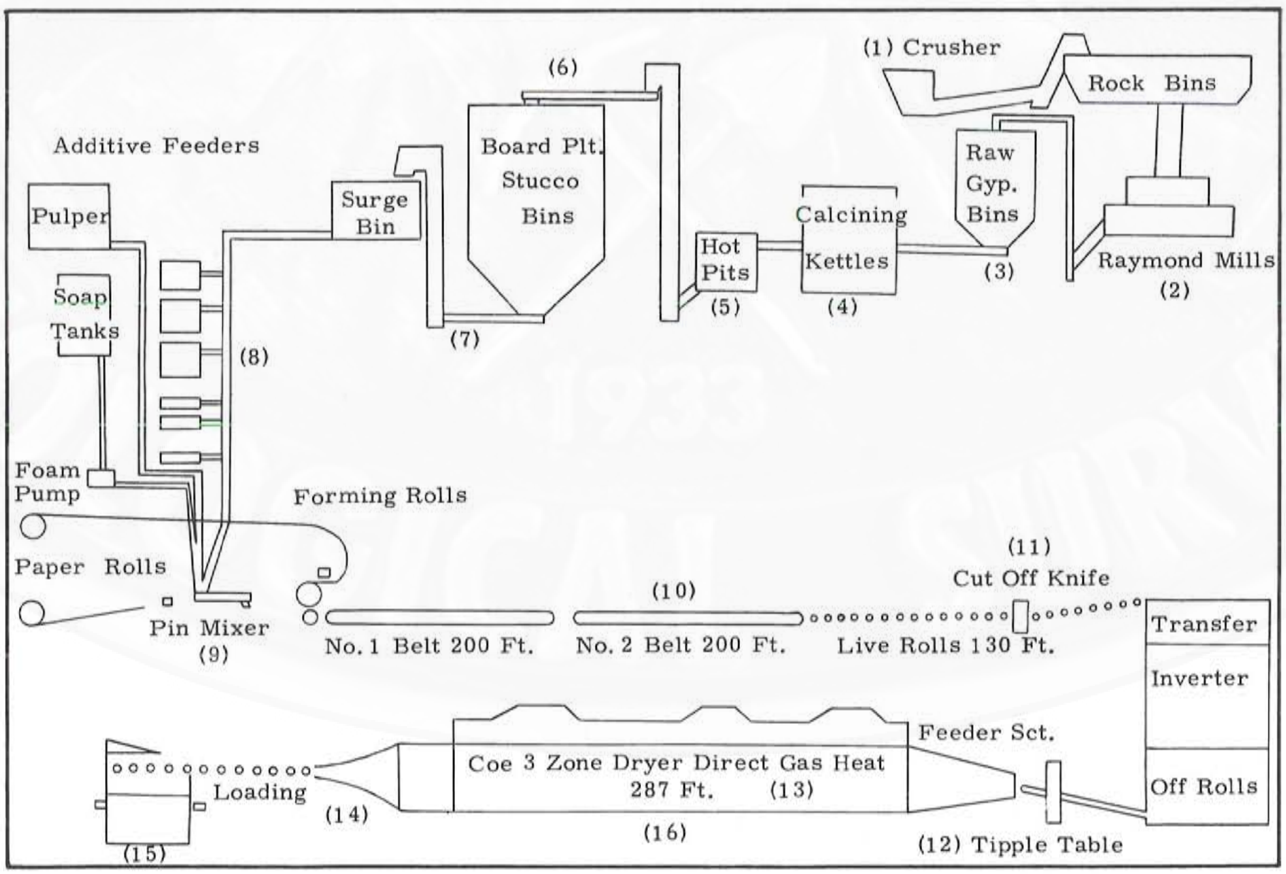


Figure 3. Flow diagram of gypsum plant. (courtesy of Big Horn Gypsum Co.)

The crushed gypsum is transported from the crushers to large storage bins prior to calcination. Calcination consists of cooking (heating) raw gypsum in large steel kettles having a capacity of 15 tons. The raw gypsum is "cooked" at a temperature of 400° F. for one and a half to two hours or until approximately two-thirds of the combined moisture content of the gypsum is removed. After the gypsum has been cooked it must be quickly cooled. This is accomplished by dumping the cooked gypsum into a "hot pit". After the raw gypsum has been cooked it is referred to as stucco, the basic ingredient of plasterboard.

The stucco is stored in large bins or silos until used at the board machine. Conveyors transport stucco from the storage bins to the mixing station, where additives are mixed in to cause it to become pliable, quick drying, and light in weight. Additives include water, calcium chloride, starch, soap bubbles, and paper shreds. Water and calcium chloride slow the setting of stucco, allowing it to be formed into the desired shape before it hardens. Starch causes stucco to adhere to the cover paper. Soap bubbles and paper shreds are added to make the finished plasterboard light in weight.

After the additives have been mixed with stucco, the mixture automatically spurts from the mixing machine onto the bottom cover paper which moves slowly by on a conveyor. The bottom cover paper transports the mixture to forming rollers where the thickness of the plasterboard is determined. After passing through the forming rolls, the top cover paper of the plasterboard is laid on and the edges of the plasterboard are formed. The plasterboard is then transported on a conveyor where the soft plasterboard is smoothed and formed. When the plasterboard comes to the end of the conveyor it is hard enough to be cut into desired length.

The plasterboard is then turned over and automatically put into a dryer by a device called a tipple table. The tipple table removes the plasterboard section from a conveyor and elevates it onto one of eight separate levels in the dryer. The plasterboard moves on conveyors through the dryer under a temperature ranging from 250° F. to 400° F. The heat is varied to compensate for any change in water content of the plasterboard, maintaining a uniformly dried product.

After passing through the dryer the plasterboard is automatically cut into the exact size specified and either stored or loaded onto train cars or trucks for shipment to market.

PRODUCTION

The gypsum plant was built by the Big Horn Gypsum Company. Plasterboard production began in 1961. In 1963, the plant was purchased by Celotex Corporation.

Plasterboard is the only product manufactured. The plasterboard is four feet wide, any length up to 16 feet 6 inches, and can have a thickness of 1/4, 3/8, 1/2, 5/8, 3/4, 7/8, or one inch. The types of plasterboard manufactured are form board and insulating board. The plant has a capacity of one million board feet of plasterboard annually (1964).

The manufactured plasterboard is marketed in Wyoming, Colorado, Montana, Idaho, Utah, Washington, Oregon, and northern California. It is shipped to markets primarily by rail, but some is shipped by truck.

Spring deposits of gypsum associated with sulfur have been utilized as a soil conditioner. These sulfur-gypsum deposits were exploited by small companies who sold their product to local farmers to improve soil drainage. Poor soil drainage results from the accumulation of sodium carbonate in porous openings of the soil, and gypsum reacts with sodium carbonate to form calcium carbonate and sodium sulfate which are not harmful to plants (Withington and Jasper, 1960, p. 4). Thus, removal of sodium carbonate restores original porosity to the soil improving soil drainage and consequently increasing crop yields. Quarries in the sulfur-gypsum spring deposits are not presently active (1968). Various unsuccessful attempts have been made to extract sulfur from these deposits. A flotation mill was constructed nearby to beneficiate these deposits, but very little production occurred.

SUGGESTIONS FOR PROSPECTING

The largest amount of good quality gypsum occurs in the lower unit of the Gypsum Spring Formation. The pattern of gypsum outcrop is controlled by structural deformation and subsequent erosion. Deformation during the Laramide orogeny produced the Rattlesnake Mountain anticline, Pat O'Hara anticline, and the Beartooth uplift, all located along the western margin of the Bighorn Basin. Subsequent stream erosion has removed non-resistant strata and resistant beds remain as hogbacks outlining the anticlines. The thick gypsum bed in the lower unit of the Gypsum Spring Formation outcrops near the crest of one such hogback formed by the upper part of the Chugwater Formation and the Gypsum Spring Formation (Fig. 4). This hogback is usually separated from the adjacent mountain flank by a strike valley eroded into the Dinwoody Formation and the lower part of the Chugwater Formation.

Figure 4. Gypsum Spring Formation (light gray) overlying Chugwater Formation near Dead Indian - Sunlight Road in secs. 29 and 30, T. 54 N., R. 103 W.

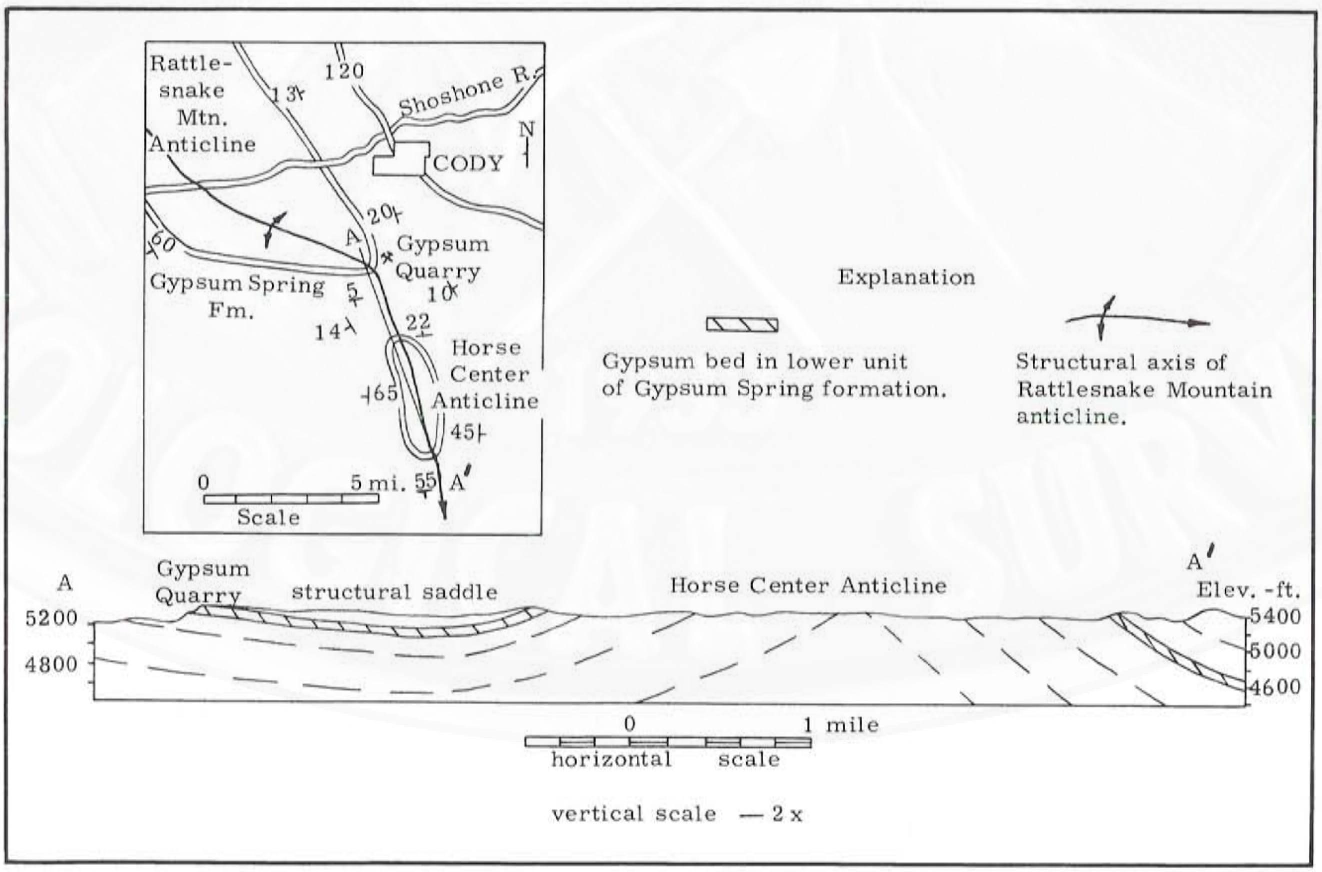


Figure 5. Cross section along structural axis of the southern nose of Rattlesnake Mountain-Cedar Mountain anticline.

The gypsum bed in the lower unit of the Gypsum Spring Formation is variable in thickness and is discontinuous in places. The thickness of the gypsum bed in the lower unit is controlled by the depth of the topographic lows on the underlying erosion surface of the Chugwater Formation. In general, the gypsum bed is more persistent and thicker in the southern part of the report area.

Gypsum is produced most economically where the lowest regional dip occurs and where the least overburden overlies the gypsum deposit. In the southern part of the report area, the lowest dips and smallest amounts of overburden occur.

The southeastern nose of Rattlesnake-Cedar Mountain anticline would be especially favorable for gypsum mining. In T. 52 N., R. 102 W., the Rattlesnake-Cedar Mountain anticline plunges the gypsum bed in the lower unit of the Gypsum Spring Formation underground at a dip of 5° SE. The structure rises again to the south on Horse Center anticline (Pierce and Andrews, 1941, Pl. 11). Here, the gypsum bed dips 20°N. Although the gypsum bed does not crop out between the two plunging folds (Fig. 5), it is estimated to exist at a maximum depth of 250 feet within a width of one mile along the structural axis of the Rattlesnake-Cedar Mountain and Horse Center anticlines.

Since the gypsum bed in the lower unit of the Gypsum Springs Formation changes thickness within short lateral distances, drill holes will be necessary to determine the thickness as well as to determine whether the bed is actually gypsum or anhydrite. Providing that the outcrop thickness of the gypsum bed persists in the subsurface, the subsurface reserves in the structural saddle are estimated to contain approximately 250 million short tons at a depth not greater than 250 feet.

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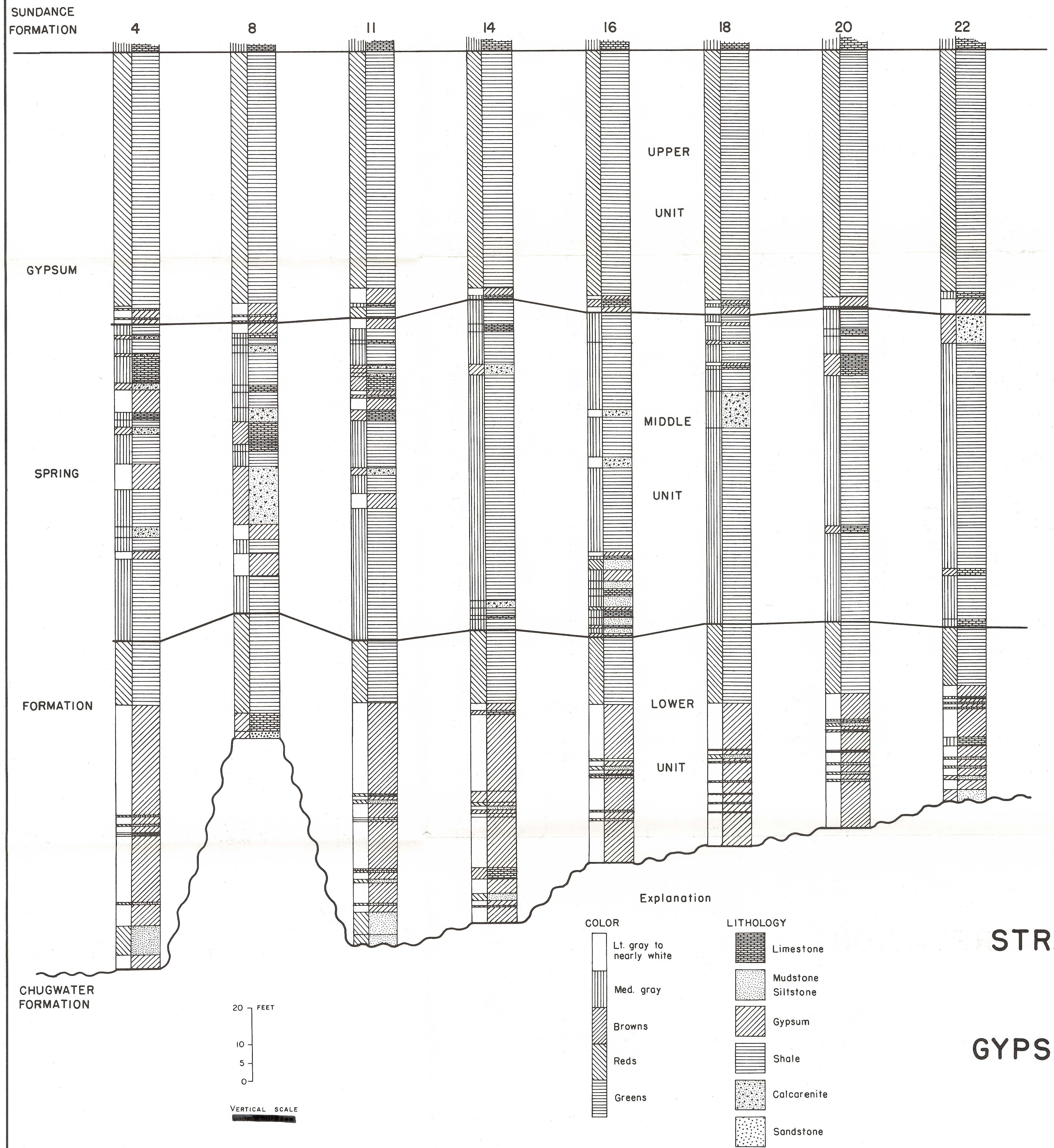

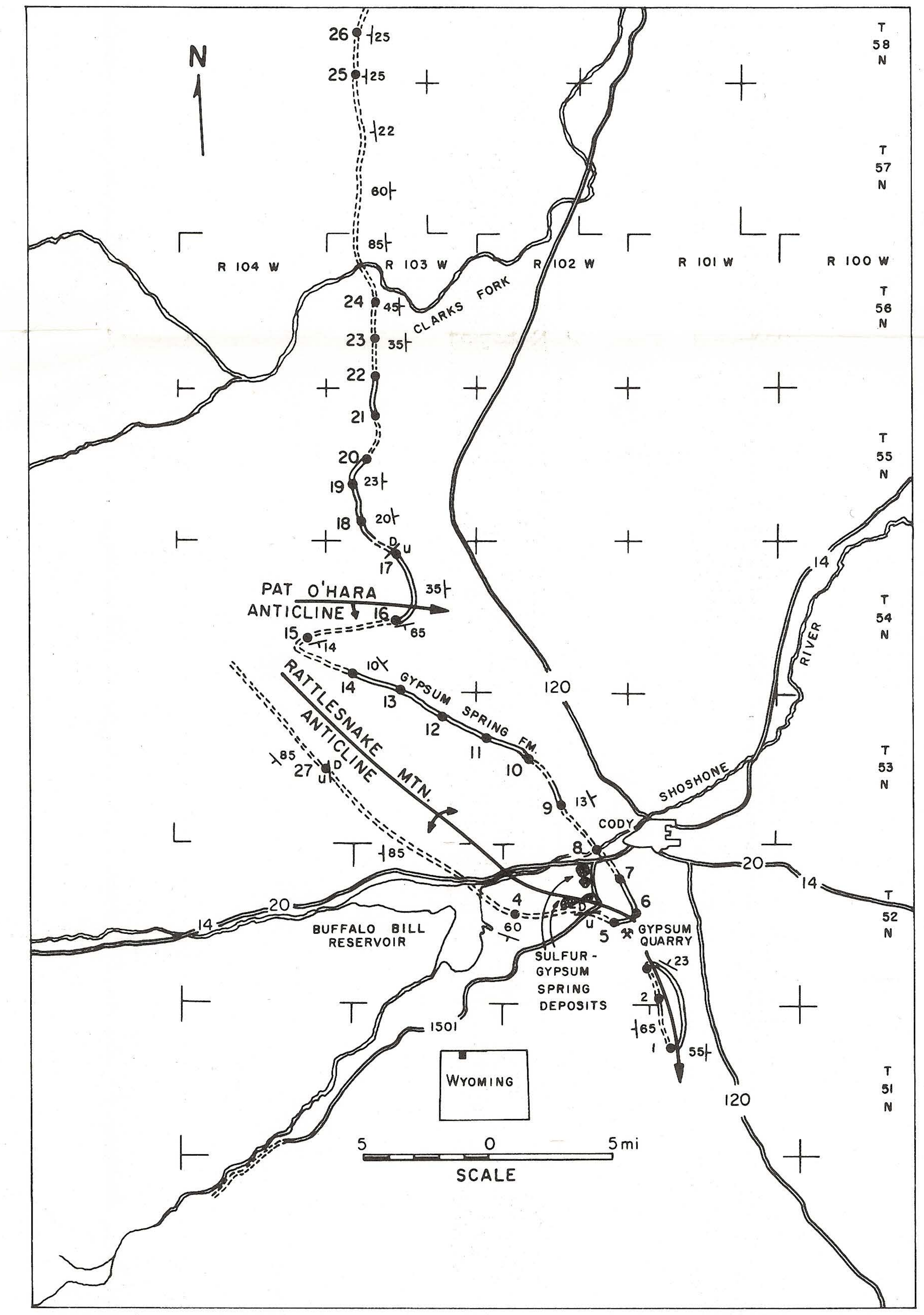

Figure I. Index map showing outcrop pattern of Gypsum Spring Formation and location of measured sections.

STRATIGRAPHIC RELATIONS WITHIN THE GYPSUM SPRING FORMATION