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SOME FEATURES OF THE SQUAW FORMATION NEAR LANDER, WYOMING

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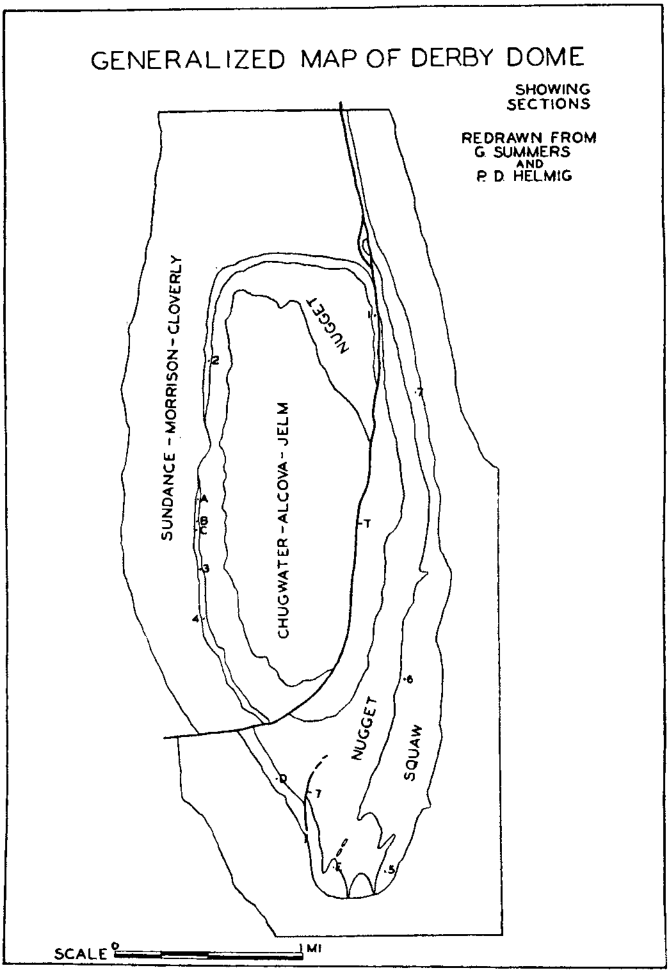
LOCATION AND DESCRIPTION OF THE AREA

The studies of the Squaw formation of the "Chugwater" series were conducted in the vicinity of Lander, Fremont County, Wyoming. Most of the observations were made at Derby Dome which is located in parts of T31N and T32N, R98W fifteen miles southeast of Lander. Others were made at Dallas Dome, nine miles southeast of Lander, and at Squaw Canyon, the type section, about four miles west of Lander. The region is one of moderately high, but not mountainous relief. The elevation at Lander is about 5350 feet, Derby Dome being somewhat less and Squaw Canyon somewhat more. Since it is situated on the flank and to the lee of a high mountain range, rainfall is scanty, and drainage mostly by intermittent streams.

PREVIOUS WORK

Most of the articles referring to the beds included in the Squaw formation in this area have been written by E. B. Branson. The most detailed description is found in his paper "Origin of Red Beds of Western Wyoming." (4) He states that at the top of the Chugwater, above a pink, cross-bedded sandstone is a series of gypsum and dark red shaly beds. He describes the gypsum as follows: "In the Lander region the gypsum ranges from a few inches to 40 feet in thickness, but maintains a thickness of a few feet for long distances along the outcrop. The thick deposits are limited in extent, rarely running more than a mile, and seem to be fillings of depressions in the main basin floor when the deposition took place." (p. 222) "The gypsum is almost pure from top to bottom, though the beds may thin rapidly from 40 feet to 0." (p. 221.)

J. G. Bartram (1) gives a section at Dallas Dome which is rather generalized. He shows a bed of gypsum 60′ — 70′ thick in his sections which is approximately correct for the total thickness of gypsum. He also mentions an "oolitic limestone" which he states can be traced over wide areas. This bed appears to be either the uppermost limestone bed of the Squaw or the lowermost bed of



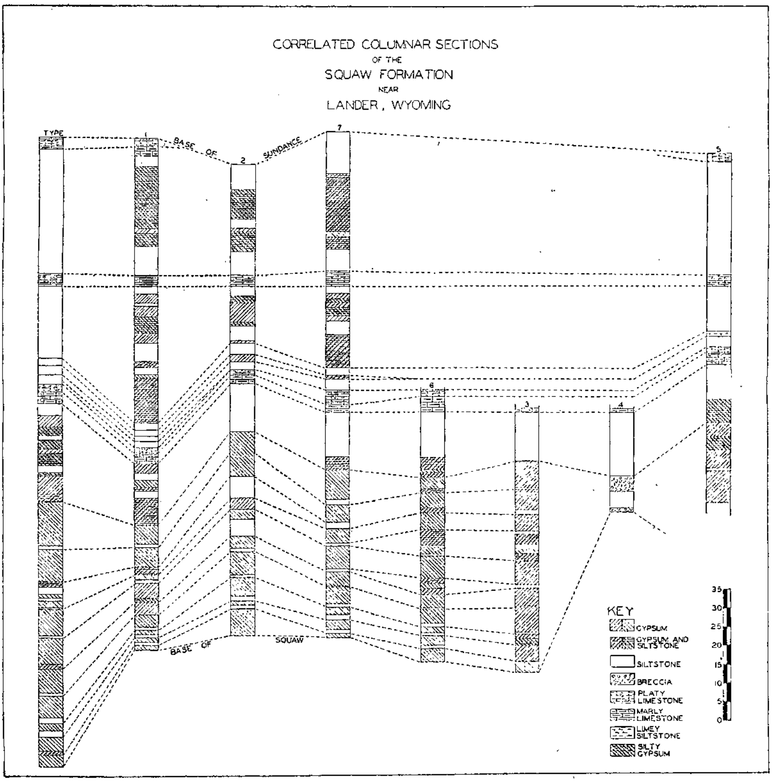
the Sundance or both in juxaposition. Since Bartram and Jones (2) have suggested that this bed marks the upper boundary of the Twin Creek limestone and its equivalents, it seems probable that the uppermost limestone of the Squaw formation is the bed intended.

Methods of Study

Field work was conducted during the month of July, 1938. Detailed sections were measured of selected exposures after they had been cleaned off with a mattock. The sections were plotted, and correlations made with their aid, and the thickness of various units computed. In several places, the formation was too covered by slump to allow the measurement of detailed sections. At these stations only general observations could be made.

Structure

The type section of the Squaw formation is located on Squaw Canyon on the northeastern limb of the huge anticline which forms the Wind River Range. The dip is about 15° NE at this point. The sections at Derby Dome are in an entirely different structural setting. Derby and Dallas Domes are two of some five closures on the anticline which stretches along the entire eastern front of the Wind River Mountains. The Domes are asymmetrical, the steep side facing the mountains. In places the west flank is nearly vertical to overturned. There are a number of thrust faults, the greatest being the Derby Dome thrust which cuts across most of Derby Dome and part of Dallas Dome. All this points to the action of a strong compressive force acting from the direction of the mountains.



General Character of the Normal Formation

The name "Squaw" has been applied by E. B. Branson to the uppermost, gypsum-bearing part of the Red Beds on the eastern flank of the Wind River Mountains. It has been named from exposures in Squaw Canyon west of Lander, Wyoming. It has been referred both to the Triassic and Jurassic by various writers. The age of the formation will be discussed later.

The Squaw formation in this region is essentially a series of red siltstones and sandy siltstones, and gypsum totaling about 160 feet in thickness. It is underlain by a thick, massive, pink, medium-grained, crossbedded sandstone, the Nugget, and overlain by the gray Sundance formation of the Jurassic system. Above the fairly hard and resistant, massive sandstone is a thickness of 10 to 30 feet of soft red sandstone which is intergradational with that below. The base of the Squaw has been placed in the lower part of this zone at a soft, thin, white, silty layer. The writers have found that this white layer is not everywhere present. In this paper, therefore, the base of the Squaw, pending more detailed investigations, is placed at the base of the first gypsum bed above the massive sandstone.

With the lower boundary established at this level, the basal part of the Squaw at the type section consists of about 100 feet of alternating gypsum and red siltstone and sandy siltstone beds. At this place, there are nine main gypsum beds ranging from two to twelve feet in thickness, and a number of beds of lesser thickness; the total amount of the gypsum being about 70 feet.

Above this sequence there is a decided change in lithology, the upper part consisting, in ascending order, of a 5 foot bed of platy and marly limestone, 25 feet of siltstone, and a 3 foot bed of platy limestone, 33 feet of siltstone, and capped by three feet of platy limestone which is not everywhere present. The base of the Sundance often contains fragments of this limestone, indicating an erosional interval between the deposition of the Squaw and the Sundance.

The writers believe that the break in lithology occurring at the base of the first limestone above the base of the section to be important enough to justify the division of the Squaw into two members, hereafter referred to as the Lower and Upper members. The Upper Squaw is not very resistant to erosion and commonly forms a slope which is poorly exposed to almost unexposed. The Lower Squaw, on the contrary, characteristically forms a cliff upheld by gypsum. A detailed section of the type section is given below. The location of the various sections and stations are shown in figure 1.

TYPE SECTION

(Sundance)

1. Limestone, blue-gray, thinly laminated, hard. 3′
2. Siltstone, somewhat sandy to the top. Dominantly red, with thin zones of gray to greenish siltstone. 32′ 8″
3. Gray siltstone, becoming hard and grading into limestone beneath. 6″
4. Limestone, blue-gray, thinly laminated, hard. 3′
5. Siltstone, mostly red with zones of gray to greenish, and red and green mottled siltstone. 19′
6. Siltstone, gray, sandy, center foot very hard and blocky. 1′ 9″
7. Siltstone, red and blue-gray, somewhat sandy. 2′ 4″
8. Variegated silty shale. 2′ 8″
9. Limestone, blue-gray, hard and thinly laminated above, marly below. 5′
10. Siltstone, gray above, becoming red below. 3′ 3″
11. Gypsum. 3′
12. Siltstone, red and green mottled. 2′ 3″
13. Gypsum. 9″
14. Siltstone, red, blocky. 1′
15. Gypsum. 4″
16. Siltstone, red, blocky. 1′ 3″
17. Gypsum. 2″
18. Siltstone, red and green with gypsum streaks. 2′ 3″
19. Gypsum, silty in the middle. 1′ 2″
20. Siltstone, sandy, red and green with gypsum streaks. 3′
21. Gypsum. 1″
22. Siltstone, red and blue-green mottled, sandy. 2′
23. Gypsum. 4″
24. Siltstone, blue-green, gyptiferous. 3″
25. Siltstone, red, blocky, sandy. 3″
26. Single unit. Gypsum at top, going through red silty gypsum, hard, red, gyptiferous siltstone to red sandy siltstone with gypsum streaks at the base. 7′
27. Gypsum. 12′
28. Siltstone, red and green mottled. 1′
29. Gypsum, silty at base, grading into bed beneath. 9′
30. Siltstone, red and blue-gray. 3′
31. Gypsum, pink, silty. 1′ 2″
32. Siltstone, red, blocky, gyptiferous at top. 2′
33. Gypsum. 1′ 4″
34. Siltstone, red, blocky. 1′
35. Gypsum. 1′ 10″
36. Interbedded hard, blue-gray and red gyptiferous siltstone and gypsum. 5″
37. Gypsum. 7′
38. Siltstone, red, hard, blue-gray at top. 10″
39. Gypsum. 7′ 4″
40. Siltstone, red, sandy, gyptiferous at top. 6″

41. Gypsum. 3″
42. Siltstone, red, sandy. 10″
43. Gypsum, 6′ 6″
44. Siltstone, red, blocky, with gypsum streaks. 9″
45. Gypsum. 6′
46. Siltstone, red and green with an inch of gypsum at center. 1′ 9″
47. Gypsum. 1′ 10″
48. Siltstone, red, and green mottled, blocky. 2′
49. Gypsum. 4′
50. Siltstone, red, gyptiferous. 8″
51. Gypsum. 3″
52. Siltstone, red. 4″
53. Gypsum. 3′ 4″
    Base of Squaw.
54. Sandy siltstone, grading down into massive pink sandstone below. Exposed, 16′
55. Massive pink, cross-bedded sandstone.

Abnormalities

With all the severe compressive forces which operated to form the domes affecting a mobile substance such as gypsum, it would be surprising indeed if nothing had happened to the Squaw formation. The writers believe that the evidence of Tables I and II, and the detailed sections prove that something has happened. In Tables I and II, interval I is from the top of the Squaw to the first limestone beneath; interval II is from this limestone to the first limestone above the base of the Squaw; and interval III is from the base of the Squaw, as herein defined, to the first limestone above.

Table I

Section	Type	1	1a	2	3	4	5	6	7	Sta. A
Interval I, Gypsum	0′	6′9″		4′6″			0′		8′4″	0′
Interval I, Siltstone	33′	27′9″		25′9″			30′		26′	23′
Interval II, Gypsum	0′	16′4″	9′	8′			0′		11′8″	0′
Interval II, Siltstone	26′	29′	21′	17′			16′6″		17′	34′
Interval III, Gypsum	69′	33′		45′	48′	0′	30′	42′	39′	0′
Interval III, Siltstone	34′	19′		23′	19′	29′		33′	25′	8′
Total Gypsum, I — II	0′	23′		12′6″			0′		20′	0′
Total Gypsum, I — II — III	69′	59′		57′6″					59′	0′
Total Siltstone	83′	73′		65′6″					68′	65′
Total Squaw	152′	132′		123′					127′	65′
Dip	52°	23°	23°	23°	35°	50°	15°	32°	24°	65°

Table II

Station	Dip	Observations
A	65°	Interval I = 23′; Interval II = 34′; Interval III = 8′; no Gypsum or Breccia
B	45°	Breccia only, no Gypsum
C	37°	Both Gypsum and Breccia present, mostly Gypsum
D	42°	Few feet of Breccia at base, almost entirely Gypsum
E	11°	A little Breccia at top and base of Interval III

One thing which will be immediately noted in Table I is the extreme variability in the amount of gypsum present in the different intervals at the various sections, and to a lesser extent, in the siltstone. Sections 1 and 1a, interval II, are perhaps most striking. These two sections were taken not more than 25 feet apart, yet the gypsum in section 1a is but 55% as thick as in section 1, and the siltstone but 72% as thick. The interval between is well exposed so that it can be seen in the field that the thickening is not due to duplication by faulting.

Again referring to Table I, sections 1, 2, and 7, it may be seen that there appears to be a relationship between the amount of dip and the total amount of gypsum present in the formation. The dips of sections 1, 2, and 7 are 23°, 23°, and 24° respectively, while the total thickness of gypsum present amounts to 59 feet, 57½ feet, and 59 feet. The writers place little importance on the near identity of these thicknesses but consider the fact that they are so similar to be highly significant. It is especially to be noted, that in these sections (see also figure 2) the thickness of the gypsum in the individual intervals and beds varies in the different sections in an erratic manner, and it is only when the section is viewed as a whole that the above relatonship is evident.

Another interesting series is formed by Stations A, B, C, D, and section 4. At station C, the dip is 37°, and the formation carries both gypsum and breccia. This breccia is composed of fragmented red siltstone with minor amounts of gypsum cemented by lime. It always occurs in the Lower Squaw which normally carried gypsum. At station D the dip is 42° and again both gypsum and breccia are present. At station B the dip increased to 45° and breccia alone is present. At section 4 the dip is 50°, and again there is only breccia with no gypsum. Finally, at station A, the dip rises to 65°, and neither gypsum or breccia is present. This is unusual, as at Dallas Dome breccia is found on dips of equal or greater magnitude. The following relationship is thus presented: When the dip is between 30° and 40° breccia begins to appear in the formation. As the dip increases, the breccia becomes more prominent, and at a dip of about 45° gypsum is no longer present, and breccia takes its place.

The presence or absence of gypsum might be explained either on the basis of variation in original deposition or on the basis of variation due to squeeze during diastrophism. Variation in the thckness of the gypsum in this region has been ascribed to differences in original deposition. This, however, does not explain why equal dips would carry equal amounts of gypsum in spite of the variation in thickness of individual beds, why there is a relationship between the presence of gypsum and the dip of the formation, or why the breccia is present only on high dips, except by appealing to coincidence.

If the above features are explained by diastrophism, a consistent picture is obtained. Other things being equal, places where the formations have the same dip would suffer approximately the same intensity of diastrophic forces. Where the dip is higher, it would follow that relatively more severe forces would have operated and vice versa. Under these conditions, gypsum, as a mobile substance, would tend to move away from places which had a high dip and to maintain approximately the same thickness in places of equal dip. This seems to be precisely what has happened in these domes. Absolutely no direct evidence was seen that would point with certainty to differences in original deposition. Furthermore all the 9 main gypsum beds (Figure 2), which are readily traceable throughout the region, although exhibiting small variations in thickness, accountable by squeeze, maintain their identity throughout the entire distance except where replaced by breccia. As we have mentioned above, E. B. Branson[4] records a great variability in the gypsum content of the Squaw formation in the vicinity of Lander. In the case of Derby Dome and also in Dallas Dome, where the situation is exactly similar with regard to the gypsum, the differences seem best accounted for by the theory of variation due to squeeze rather than to differences in original deposition.

A more difficult problem is presented in the upper part of the Squaw. Although the type section and section 5 do not contain any gypsum in the Upper Squaw, other sections show a considerable thickness of it. Here again the presence of the gypsum might be accounted for either on the basis of original deposition or diastrophism. The writers believe that the gypsum probably was not laid down during the deposition of the Upper Squaw but that it may have been squeezed in during the formation of the dome.

The following evidence indicates that the gypsum was not originally present. First is the extreme variability in the number of beds of gypsum present; for example 6, 10, and 18 beds are found in Interval I, and 4, 12, 13, and 17 beds are found in Interval II at the various sections within a distance of three miles. As mentioned before, section 5, which is the least deformed section of the dome, has no gypsum present in the Upper Squaw and apparently never has had. The chances are astronomical against having twenty beds of gypsum being deposited in one place and none three miles away. This, of course, does not prove that there may not have been twenty beds of gypsum in the Upper Squaw of section 5 originally, and which have since been squeezed out. However, in view of the fact that section 5 has the lowest dip taken in Derby Dome and so, presumably, suffered the least in the diastrophism, it seems strange that the beds would be squeezed out here and retained on the higher dips.

Evidence for the gypsum having been squeezed in also lies in two other facts. The first is the presence of gypsum beds containing siltstone fragments, and the second is the presence of small dikes of gypsum connecting gypsum beds in the Upper Squaw. The writers realize that this evidence is by no means conclusive. Moreover, the presence of thin beds of gypsum $\frac{1}{2}$ to 1 inch in thickness seems incompatible with the theory of injection. The writers, however, have tentatively adopted the theory of the injection of the gypsum into the Upper Squaw, pending more detailed studies.

Thus it seems that the picture of the deformation is as follows: During the early stages of the formation of the dome, the Squaw formation suffered but little. As the deformation became more severe, the gypsum began to be squeezed out of the Lower Squaw into regions of lesser pressure. As the dip reached 40° to 45°, the gypsum was squeezed out with enough force to brecciate the surrounding siltstone. While the gypsum was migrating away from the regions of higher pressure, part of it was squeezed into the Upper Squaw. Most of the time it was squeezed in with little difficulty; however, in some places the siltstone was brecciated during the injection.

Correlation and Age

There are several beds in the Squaw formation which serve as excellent markers and which can be used in correlating the various sections. Figure 2 shows in some detail the correlations which have been made. It is to be noted that all correlations possible within Derby Dome may also be made with the type sections some 17 miles away. This suggests that the individual gypsum beds may be quite extensive in area.

G. D. Johnson (5) describes a gypsum-bearing member of the upper Chugwater at the southern end of the Beartooth Mountains near Cody, Wyoming. He found extreme local variation in the thickness of the gypsum which he attributes to squeeze during deformation. Brainerd and Keyte (3) note the occurrence of a persistent zone of thin limes, gypsum, and red shale at the top of the "Chugwater" in the Bighorn district and collected a marine Sundance fauna from the limes. The writers have not visited either of these localities, but on the basis of the published descriptions, suggest that the beds referred to may correlate, in whole or in part, with the Squaw formation.

As stated before, there has been considerable discussion as to the age of the beds included in this formation. Branson [4] placed the top of the Triassic at the top of the beds here included in the Squaw. Bartram (1) and others have, however, placed the top of the Triassic at the top of the Jelm (Popo Agie) and correlating the thick sandstone beneath the Squaw with the Nugget. This correlation is used by the writers. More recently, Bartram and Jones (2) have suggested that the Squaw represents an eastward evaporite facies of the Twin Creek limestone of southwestern Wyoming. If such a correlation could be made, it seems to the writers that the beds should be referred to by some such term as "the Squaw facies of the Twin Creek limestone" in order to emphasize the difference between the two formations as they are typically exposed.

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