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MISCELLANEOUS INVESTIGATIONS 7

BASAL MIOCENE ASH IN WHITE RIVER BADLANDS, SOUTH DAKOTA

by
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INTRODUCTION

The white volcanic ash capping Sheep Mountain Table and other prominent landmarks in the White River Badlands has been assigned by various authors to the Brule Formation or to the overlying Miocene deposits. Matthew (1907) in his description of the "Rosebud" faunas from the Wounded Knee and Porcupine Creek drainages considered it to be the basal member of the Rosebud Formation. Macdonald's studies of the geology and the paleontology of the Wounded Knee area indicated that Matthew's Rosebud Formation, as described in his 1907 publication, was too inclusive. This sequence of beds has been assigned to four formational units: the Sharps Formation (Harksen, 1960; Harksen, Macdonald, and Sevon, 1961; and Macdonald, in press) which conformably overlies the Brule Formation; the Monroe Creek Formation; the Harrison Formation; and the Rosebud Formation. Nicknish (1957), working under Macdonald's direction, described the ash as the Rockyford Member of the Arikaree Formation. This was done in order to establish the name without reference to the then unpublished Sharps Formation.

Through a series of mischances, the Nicknish thesis remained unpublished, although the name Rockyford Member has appeared in several papers. The following is essentially the work of Nicknish with minor editorial changes and some additions and deletions by Macdonald.

DESCRIPTION OF BASAL MEMBER OF LOWER MIOCENE SHARPS FORMATION

LOCATION

The Rockyford Member is widely but discontinuously exposed in the White River Badlands of western South Dakota. It prominently caps many of the higher buttes and tables throughout the Badlands: it is exposed on the north and eastern rims of the Badlands basin in the Pinnacles and Cedar Pass area, and it forms a prominent marker on the cliffs south of the White River west of the mouth of Porcupine Creek. This wide distribution was noted by Matthew (1907) who considered the ash as a marker of the base of the Miocene section in this region.

The ash bed conformably overlies the middle and upper Oligocene Brule Formation in the White River Badlands. Darton (1899) suggested that this ash may be correlated with the ash bed of the Gering Formation of Nebraska.

DESCRIPTION

The basal volcanic ash of the Sharps Formation is designated as the Rockyford Member. The type section is located on the south end of Sheep Mountain Table, Shannon County, South Dakota, in the SE. 1/4, NE. 1/4,

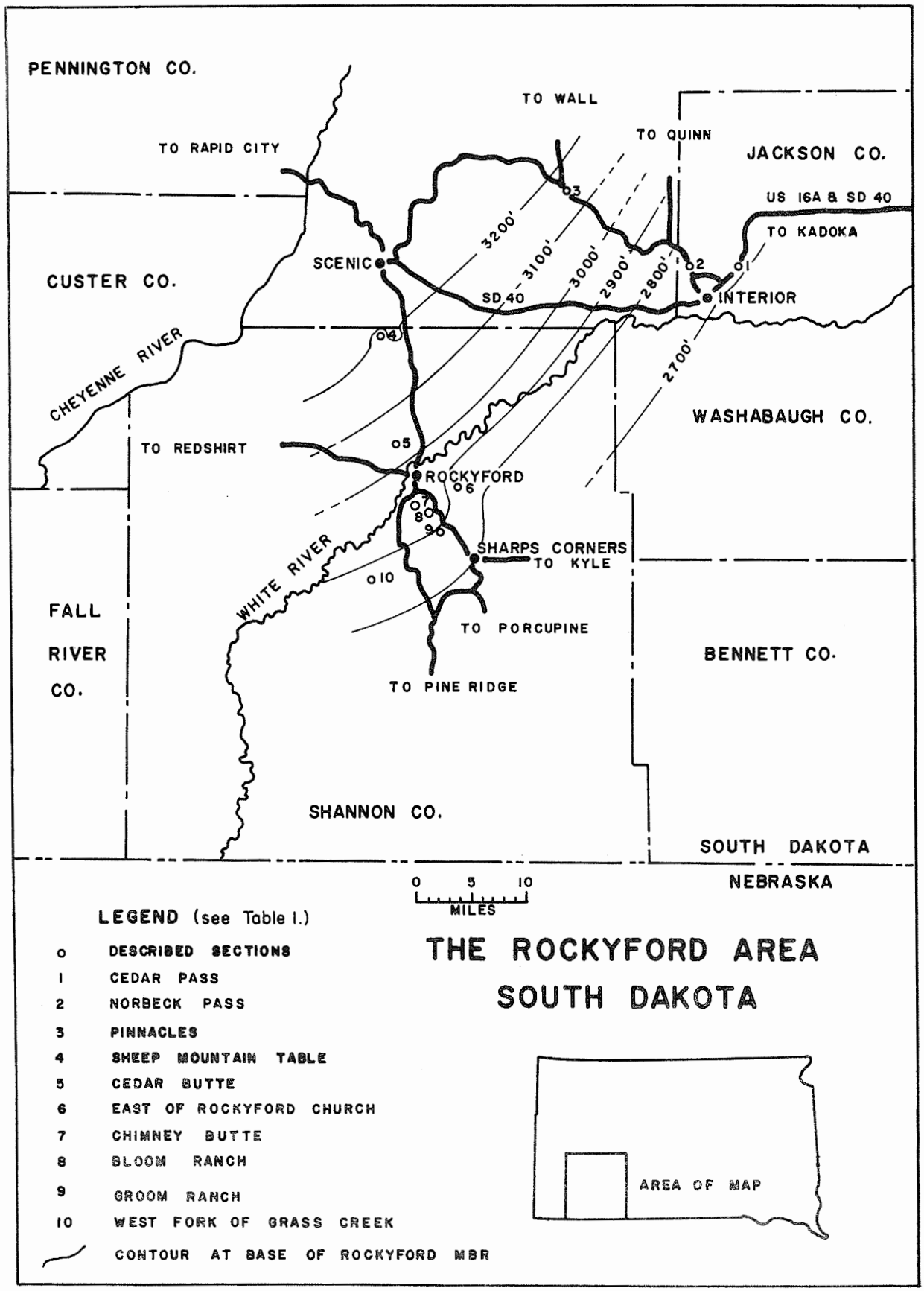
PENNINGTON CO.
TO WALL
TO QUINN
TO RAPID CITY
JACKSON CO.
US 16A & SD 40
TO KADOKA
3200'
3100'
3000'
2900'
2800'
2700'
SCENIC
CUSTER CO.
SD 40
INTERIOR
CHEYENNE RIVER
WASHABAUGH CO.
TO REDSHIRT
ROCKYFORD
SHARPS CORNERS
TO KYLE
WHITE RIVER
FALL RIVER CO.
TO PORCUPINE
BENNETT CO.
TO PINE RIDGE
SHANNON CO.
SOUTH DAKOTA
NEBRASKA
0 5 10
MILES
LEGEND (see Table I.)
0 DESCRIBED SECTIONS
1 CEDAR PASS
2 NORBECK PASS
3 PINNACLES
4 SHEEP MOUNTAIN TABLE
5 CEDAR BUTTE
6 EAST OF ROCKYFORD CHURCH
7 CHIMNEY BUTTE
8 BLOOM RANCH
9 GROOM RANCH
10 WEST FORK OF GRASS CREEK
CONTOUR AT BASE OF ROCKYFORD MBR
THE ROCKYFORD AREA
SOUTH DAKOTA
AREA OF MAP

Figure 1.

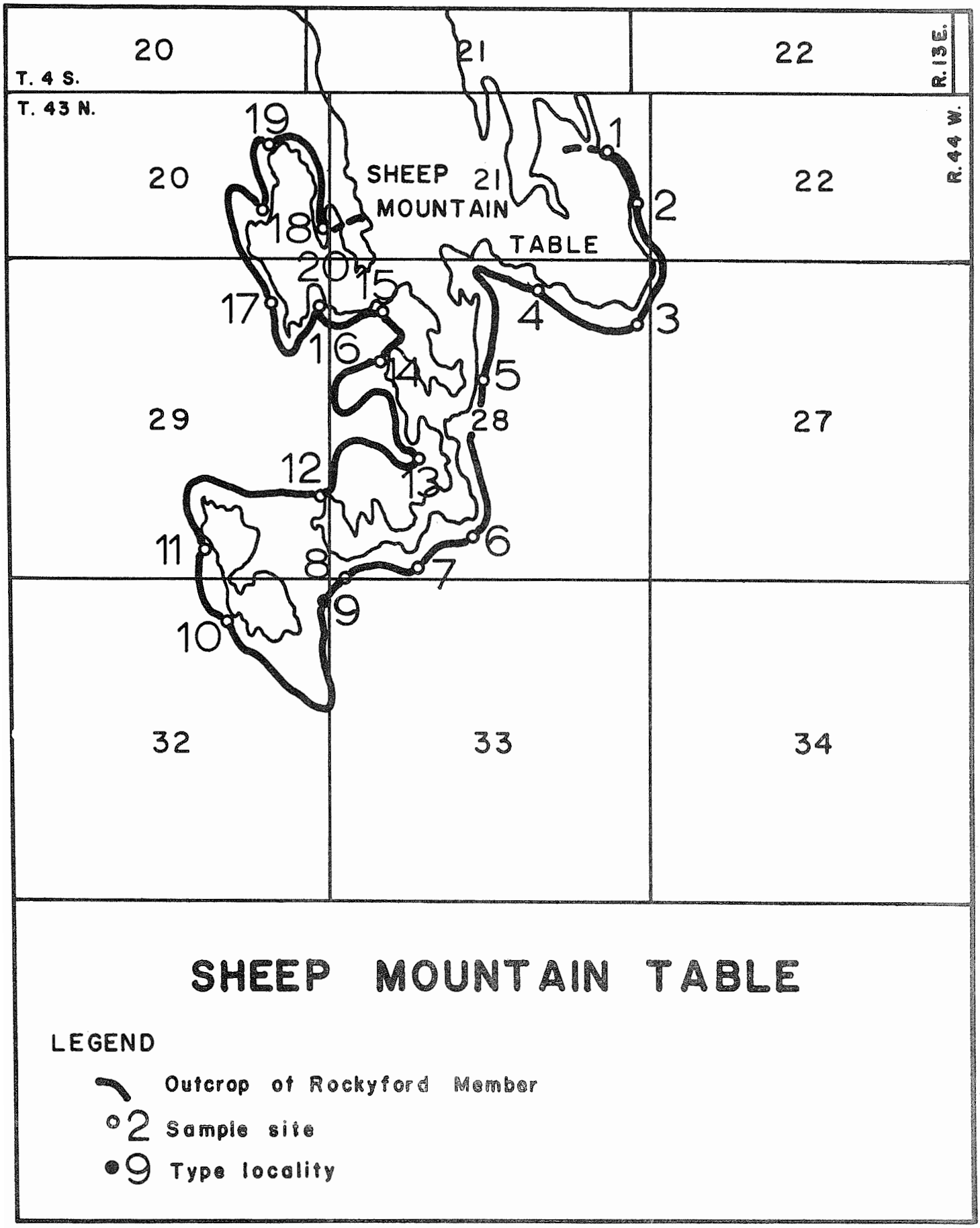
T. 4 S.
T. 43 N.
R. 13 E.
R. 44 W.
20
21
22
SHEEP MOUNTAIN TABLE
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
29
28
27
32
33
34
SHEEP MOUNTAIN TABLE
LEGEND
Outcrop of Rockyford Member
2 Sample site
9 Type locality

Figure 2.

NE. 1/4, sec. 32, T. 43 N., R. 44 W. (Sheep Mountain Table Section No. 9, Table I). The name is taken from the town of Rockyford, South Dakota, located in the SE. 1/4, NW. 1/4, SE. 1/4, sec. 25, T. 41 N., R. 44 W. Rockyford is centrally located within the outcrops of the ash.

Matthew (1907) recognized the ash as Miocene when he discussed the "Rosebud" beds. He states, "The western part of the formation attains a thickness estimated at 500 feet on Porcupine Creek, a southern tributary of the White River. The base is taken at a heavy white stratum which appears to be identical with the stratum capping the White River Formation on Sheep Mountain in the Big Badlands. This stratum can be seen extending interruptedly across the river to Sheep Mountain, about 30 miles distant, capping several intervening buttes and projecting points of the underlying formation." A discussion of the stratigraphy of the "Rosebud" beds south of the White River may be found in Macdonald's (in press) discussion of the "Wounded Knee faunas."

The dip of the Rockyford Member as determined on outcrops on Sheep Mountain Table, the Pinnacles, and the Bloom Ranch is 18.8 feet per mile S. 41° E. Based on outcrops at Norbeck Pass, Sheep Mountain Table, and the Bloom Ranch, the dip is 25.8 feet per mile S. 57° E. It ranges in thickness from 0 to 55 feet, with maximum thickness on the south end of Sheep Mountain Table. Lying conformably, with a relief of approximately 538 feet, on the Brule Formation, the ash was deposited on late Oligocene flood plains and in the stream channels. In some areas it has been cut by post-Rockyford streams whose channels were later filled by Miocene stream deposits. The latter may be correlated with the later deposits of the Sharps Formation and may also be physiographically and temporally correlated with the stream deposits of the Gering Formation in western Nebraska.

In Nebraska, the basal member of the Gering Formation (Darton, 1899) contains an ash ranging in thickness from 0 to 8 feet which is possibly correlative with the Rockyford Member. The chemical composition corresponds closely with that of the South Dakota ash. Emission spectrograph analyses of the Rockyford Member from six localities are shown in Table II as well as a comparison with the Gering ash.

According to the G.S.A. Color Chart, the color of the ash is pinkish gray, 5 Y R 8/1. Sections measured and the locations are shown in Table I.

The index of refraction of the glass shards varies between 1.492-1.504 (Table I) indicating a rhyolitic glass. Identifiable minerals found within the ash are quartz, biotite, sanidine, andesine, clay, and an amphibole. Reworking is unlikely, since the quartz grains are not rounded although the glass has been slightly devitrified. In the Grass Creek exposure, two different ranges of indices of refraction are obtained, indicating some admixture with either the overlying or underlying beds.

PIPE CONCRETIONS AND ASSOCIATED CLASTIC DIKES

A prominent feature found in restricted areas of the Rockyford ash are the small concretions locally called "pipe concretions." They are concentrated on the south end of Sheep Mountain Table and the north end of Cedar Butte. These concretions are oriented vertically. They range in diameter

TABLE I. MEASURED SECTIONS OF ROCKYFORD MEMBER

Location	Elevation on Base of Rockyford Member (Feet)	Thickness (Feet)	Index of Refraction
Cedar Pass			
SW 1/4, SW 1/4, sec. 26, T. 3 S., R. 18 E.	2,714	20	1.492-1.496
Norbeck Pass			
NW 1/4, NE 1/4, sec. 30, T. 3 S., R. 17 E.	2,718	25	1.492-1.496
Pinnacles			
NW 1/4, NE 1/4, sec. 20, T. 3 S., R. 16 N.	3,164	22	
Sheep Mountain Table			
1. SE 1/4, NE 1/4, SE 1/4, sec. 21, T. 43 N., R. 44 W.	3,228	2	
2. NE 1/4, SE 1/4, SE 1/4, sec. 21, T. 43 N., R. 44 E.	3,242	13	
3. SE 1/4, NE 1/4, NE 1/4, sec. 28, T. 43 N., R. 44 W.	3,206	5	1.496-1.500
4. NE 1/4, NW 1/4, NE 1/4, sec. 28, T. 43 N., R. 44 W.	3,191	14	
5. NW 1/4, SE 1/4, NW 1/4, sec. 28, T. 43 N., R. 44 W.	3,173	26	
6. NW 1/4, SE 1/4, SW 1/4, sec. 28, T. 43 N., R. 44 W.	3,150	49	1.500-1.504
7. SW 1/4, SE 1/4, SW 1/4, sec. 28, T. 43 N., R. 44 W.	3,158	55	
8. SW 1/4, SW 1/4, SW 1/4, sec. 28, T. 43 N., R. 44 W.	3,168	50	
9. SE 1/4, NE 1/4, NE 1/4, sec. 32, T. 43 N., R. 44 W.	3,176	30	1.496-1.500
10. SE 1/4, NW 1/4, NE 1/4, sec. 32, T. 43 N., R. 44 W.	3,182	13	
11. SE 1/4, SW 1/4, SE 1/4, sec. 29, T. 43 N., R. 44 W.	3,194	22	
12. NE 1/4, SE 1/4, SE 1/4, sec. 29, T. 43 N., R. 44 W.	3,157	20	
13. SE 1/4, NW 1/4, SW 1/4, sec. 28, T. 43 N., R. 44 W.	3,168	20	1.496-1.500
14. NE 1/4, SW 1/4, NW 1/4, sec. 28, T. 43 N., R. 44 W.	3,168	20	
15. SE 1/4, NW 1/4, NW 1/4, sec. 28, T. 43 N., R. 44 W.	3,177	12	
16. NE 1/4, NE 1/4, NE 1/4, sec. 29, T. 43 N., R. 44 W.	3,177	14	1.496-1.500
17. SW 1/4, NE 1/4, NE 1/4, sec. 29, T. 43 N., R. 44 W.	3,186	21	1.496-1.500
18. NW 1/4, SE 1/4, SE 1/4, sec. 20, T. 43 N., R. 44 W.	3,193	11	
19. SW 1/4, NE 1/4, SE 1/4, sec. 20, T. 43 N., R. 44 W.	3,196	2	
20. SE 1/4, SE 1/4, SE 1/4, sec. 20, T. 43 N., R. 44 W.	3,189	2	
Cedar Butte			
1. SW 1/4, SW 1/4, SW 1/4, sec. 15, T. 41 N., R. 44 W.	3,079	5	
2. NE 1/4, NE 1/4, SE 1/4, sec. 16, T. 41 N., R. 44 W.	3,079	6	

Table 1.--Continued

Location	Elevation on Base of Rockyford Member (Feet)	Thickness (Feet)	Index of Refraction
3. NE 1/4, NE 1/4, SE 1/4, sec. 16, T. 41 N., R. 44 W.	3,084	12	
4. SW 1/4, SE 1/4, SE 1/4, sec. 16, T. 41 N., R. 44 W.	3,091	5	
5. NW 1/4, NW 1/4, NW 1/4, sec. 22, T. 41 N., R. 44 W.	3,080	6	
East of Rockyford Church			
1. SW 1/4, SE 1/4, NE 1/4, sec. 33, T. 41 N., R. 43 W.	2,861	14	
2. SE 1/4, NW 1/4, SE 1/4, sec. 33, T. 41 N., R. 43 W.	2,852	7	
3. NE 1/4, NE 1/4, NE 1/4, sec. 6, T. 40 N., R. 43 W.	2,857	2	
Chimney Butte			
1. NE 1/4, NE 1/4, NE 1/4, sec. 10, T. 40 N., R. 44 W.	2,910	4	
2. SW 1/4, SW 1/4, NW 1/4, sec. 11, T. 40 N., R. 44 W.	2,923	21	
3. NW 1/4, NW 1/4, NE 1/4, sec. 15, T. 40 N., R. 44 W.	2,954	12	
4. SE 1/4, SW 1/4, NE 1/4, sec. 15, T. 40 N., R. 44 W.	2,888	10	
5. SE 1/4, SE 1/4, SE 1/4, sec. 15, T. 40 N., R. 44 W.	2,907	9	
6. NE 1/4, NW 1/4, NW 1/4, sec. 23, T. 40 N., R. 44 W.	2,994	14	
7. SE 1/4, NW 1/4, SW 1/4, sec. 23, T. 40 N., R. 44 W.	2,922	7	
Bloom Ranch			
1. SE 1/4, NE 1/4, SW 1/4, sec. 13, T. 40 N., R. 44 W.	2,930	14	1.500-1.504
2. NW 1/4, SW 1/4, SE 1/4, sec. 13, T. 40 N., R. 44 W.	2,930	14	
Groom Ranch			
SE 1/4, NW 1/4, NW 1/4, sec. 29, T. 40 N., R. 44 W.		Top exposed	
Grass Creek			
SW 1/4, NW 1/4, NE 1/4, sec. 23, T. 39 N., R. 45 W.	2,880	2	1.500-1.504 1.512-1.514

TABLE II. CHEMICAL ANALYSES OF ROCKYFORD MEMBER AS DETERMINED BY EMISSION SPECTROGRAPH

Locality	SiO_2	Al_2O_3	CaO	Fe_2O_3	MgO	MnO_2	TiO_2	Na_2O	K_2O
Cedar Pass	68.00	13.50	2.20	2.80	1.10	0.043	0.54	1.20	3.40
Norbeck Pass	69.00	13.20	2.40	2.80	1.30	0.030	0.52	1.00	3.30
Sheep Mountain Table	64.50	12.60	2.40	2.60	1.30	0.051	0.53	1.60	3.60
Cedar Butte	64.50	11.70	2.20	2.10	0.90	0.030	0.33	1.00	4.20
Bloom Ranch	70.00	12.70	2.40	2.60	1.20	0.077	0.47	2.50	3.60
Grass Creek	68.00	13.60	2.60	3.30	1.70	0.051	0.61	1.70	3.10
Gering Ash[1]	69.09	13.09	1.76	1.82	1.98	none	1.33	2.30	3.97
Samples of:									
Pipe Concretion	80.00	11.30	1.50	1.90	0.90	0.012	0.40	2.60	3.50
Green Clastic Dike	77.00	8.60	2.30	2.30	1.30	0.015	0.40	0.70	2.30

[1]After Swineford, Frye, and Leonard (1955). Also shows traces of P_2O_5 and SO_3.

from pencil-size to slightly larger than a man's thumb, and few exceed 3-4 inches in length. The upper end is generally rounded. Many have a small hollow core a few millimeters in diameter that usually contains zeolites. Wanless (1923) suggested that these concretions were formed in pipes resulting from the explosions of gas or by the upward excape of imprisoned water, CO_2, or air. He further suggested that the zeolites in the concretions were produced by the crystallization of material from the ash.

In addition to the concretions, the ash contains many clastic dikes with vertical crenulations resembling slickensides, and some areas show extensive systems of chalcedony dikes. It appears that all of these phenomena are related in origin.

The clastic dikes are usually composed of the same material as the host rock. Many of the dikes are stained green; in some places the stain penetrates the wall for several inches. Samples of a green dike and the wall rock were sent to R. E. Grim, University of Illinois, to be analyzed. In a personal communication (November 13, 1956) he states in part, "In the sample labelled vein there is another constituent present in considerable abundance which appears to be talc. In the other sample no definite indication of this additional mineral, which is probably talc, is present."

The writers suggest that the dikes, both clastic and chalcedony, developed in cracks resulting from the compaction of the underlying Tertiary sediments on the unevenly eroded Cretaceous foundation. The clastic dikes were formed by the filling of these cracks with local material. Cementation and the deposition of chalcedony and other minerals was the result of upward welling of hot water. The presence of talc in the dikes suggests that alkaline solutions moved upward through the fractures. The magnesium was probably obtained from the wall rocks and the talc deposited only in the dikes which allowed free passage of the solutions.

It is further proposed that the pipe concretions were formed by water and air filtering through the ash in restricted areas. Cementation and filling of the concretions by silica, the formation of zeolite crystals, and the deposition of chalcedony represent varying conditions in the pressure and temperature of the thermal waters. The concretions are most abundant in the thickest section of the ash. This is to be expected, as it is here that the ash was less compacted and more permeable.

ORIGIN AND HISTORY

Volcanic activity at the end of the Oligocene in the Yellowstone and (or) the Colorado Rocky Mountains appears to be the only likely origin for the Rockyford ash.

The Rockyford ash shows no evidence of being substantially reworked except in the peripheral areas in the Grass Creek drainage. This is an indication that deposition took place in a relatively short time period.

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