

UNITED STATES DEPARTMENT OF THE INTERIOR  
GEOLOGICAL SURVEY

MEASURED SECTIONS OF THE BARSTOW FORMATION, MUD HILLS,  
SAN BERNARDINO COUNTY,  
CALIFORNIA

By

Richard A. Sheppard

Open-file report

67-200

1967

CONTENTS

	Page
Introduction - - - - -	1
Measured section SM-1 - - - - -	2
Measured section SM-2 - - - - -	11
Measured section SM-3 - - - - -	13
Measured section SM-4 - - - - -	15
Measured section SM-5-6 - - - - -	20
Measured section SM-7 - - - - -	25
Measured section SM-8 - - - - -	27
References - - - - -	29

ILLUSTRATION

Plate 1.--Stratigraphic sections of the Barstow Formation, Mud Hills, San Bernardino County, California - - - - -	Pocket
--	--------

Measured sections of the Barstow Formation,  
Mud Hills, San Bernardino County,  
California

By Richard A. Sheppard

INTRODUCTION

The Barstow Formation of middle and late Miocene age (Lewis, 1964) crops out in the Mud Hills, about 10 miles north of Barstow, Calif. The formation consists of fluvial and lacustrine rocks that unconformably overlie the Oligocene(?) to Miocene(?) Pickhandle Formation (Bowen, 1954) and are unconformably overlain by Quaternary alluvium.

The Barstow Formation in the western part of the Mud Hills contains a rich vertebrate fauna (Lewis, 1964) that has received much attention since the work of Merriam (1911). However, the deposits that contain the fossils have received only cursory examination. Published descriptions of the deposits were given by Baker (1911, p. 342-347) and Durrell (1953, p. 24-26, and pl. 4). Both authors referred the deposits to the Rosamond Series, a name abandoned by the U.S. Geological Survey (Dibblee, 1958).

The measured sections described on the following pages were obtained during a study of the alteration of vitric silicic tuffs (Sheppard and Gude, 1965; Gude and Sheppard, 1966). The locations and diagrammatic representations of the measured sections are shown on plate 1.

Informal field names have been given to five of the most persistent tuffs in the upper part of the formation. Listed from oldest to youngest, these are: Yellow tuff, Skyline tuff, Camel track tuff, Dated tuff, and Hemicyon tuff. The Skyline tuff and the Hemicyon tuff are informal names that have been used by workers in the Mud Hills for at least a decade (T. W. Dibblee, Jr., oral commun., 1963). Probably the Hemicyon tuff is the same as the "Hemicyon Stratum" of Frick (1926, p. 34). The Yellow tuff is so called in allusion to the color of the tuff. The Camel track tuff is named for the characteristic casts of camel tracks on the bottom of the tuff. The Dated tuff is so named because this is the tuff (H. P. Taylor, oral commun., 1964) from which biotite yielded a K-Ar age of 15.1 m.y. (Evernden and others, 1964, p. 176).

MEASURED SECTION SM-1

Measured in the eastern part of Rainbow Basin; SW1/4NW1/4 sec. 19,  
T. 11 N., R. 1 W., and E1/2 sec. 24, T. 11 N., R. 2 W.; south  
limb of syncline

[Measured by R. A. Sheppard, February, 1964]

	<u>Feet</u>
Unconformably overlain by Quaternary gravel. ✓	
29. Mudstone, light-gray to greenish-gray, medium- to thick-bedded; breaks with conchoidal fracture where fresh but has "pop corn" coating where weathered. Greenish-brown analcimic tuff (0.4 foot thick) occurs 123 feet above base. Top of unit eroded - - - - -	133
28. Chiefly mudstone and tuff interbeds. Mudstone; mainly reddish-brown but some light-gray interbeds; medium- to thick-bedded; breaks with conchoidal fracture where fresh but has "pop corn" coating where weathered. Analcimic tuffs occur 48 feet above base and at top of unit; lower tuff (0.4 foot thick) is light brown; upper tuff (1.0 foot thick) is light green but weathers yellowish brown - - - - -	54
27. Chiefly mudstone, light-gray to yellowish-brown, medium- to thick-bedded; breaks with conchoidal fracture where fresh but has "pop corn" coating where weathered; abundant crystal molds that are filled or partly filled with calcite; calcareous concretions in upper part;	

27.---continued

Feet

basal foot of unit is maroon. A brownish,  
finely crystalline, 0.2 foot thick dolomite occurs  
53 feet above base. Analcimic tuffs occur 14 feet and  
29 feet above base; lower tuff (0.6 foot thick) is  
yellowish brown and grades upward into mudstone;  
upper tuff (1.2 feet thick) is light green and inter-  
bedded with mudstone - - - - - 92

26. Chiefly mudstone with thin limestone and tuff interbeds.  
Mudstone, yellowish-gray to yellowish-brown, thick-bedded; breaks with conchoidal fracture where fresh but has "pop corn" coating where weathered.  
Limestone, thin-bedded; weathers brownish. Thin tuffs occur 14 feet and 36 feet above base; lower tuff (0.3 foot thick) is white and feldspathic; upper tuff (0.2 foot thick) is yellowish brown and analcimic - - - - - 166
25. Chiefly mudstone with thin calcareous sandstone and tuff interbeds. Mudstone, yellowish-gray to brownish-gray, thick-bedded; breaks with conchoidal fracture where fresh but has "pop corn" coating where weathered.  
Gray, calcareous tuffs occur 62 feet and 75 feet above base; both tuffs weather dark brown; lower tuff (0.7 foot thick) is the Camel track tuff that is biotite-rich and locally has casts of camel tracks and (or) casts of mud cracks on bottom; upper tuff (0.5 foot thick) is the Dated tuff that is crystal-rich, analcimic, and has abundant euhedral biotite. Casts of mud cracks are common on the bottom of the Dated tuff - - - - - 148
24. Skyline tuff; light brown in middle but white in upper and lower parts; locally siliceous at top and bottom; forms conspicuous ledge - - - - - 4

23. Chiefly mudstone with siltstone and tuff interbeds.  
Mudstone, greenish-gray, thick-bedded; breaks with  
conchoidal fracture where fresh but has "pop corn"  
coating where weathered. Siltstone in upper part.  
Yellowish tuff (0.3 foot thick) occurs 22 feet above  
base - - - - - 40
22. Limestone, gray but weathers brownish, thin- to medium-  
bedded, wavy-bedded; interbedded with greenish  
mudstone in upper part - - - - - 11
21. Mudstone and silty mudstone, light-gray to light-green,  
medium- to thick-bedded - - - - - 30
20. Sandstone, greenish, fine- to very coarse-grained,  
thin- to thick-bedded, angular, poorly sorted;  
local lenticular calcareous segregations - - - - - 24
19. Mudstone and tuff interbeds. Mudstone, light-gray  
to light-green; local thin-bedded, wavy-bedded  
limestone and calcareous concretions. Yellowish  
tuffs occur at base, 8 feet above base, and at top  
of unit; lowest tuff (1.0 foot thick) is the Yellow  
tuff that is zeolitic and locally spherulitic;  
middle tuff (0.2 foot thick) is analcimic; upper  
tuff (0.7 foot thick) is feldspathic and crystal-  
rich - - - - - 22
18. Siltstone, grayish-green, calcareous, micaceous;  
calcareous concretions; grades downward into  
sandstone - - - - - 10

17. Sandstone, conglomerate, and limestone. Sandstone, yellowish-green, fine- to coarse-grained, thick-bedded, angular, poorly sorted, locally calcite-cemented. Conglomerate, lenticular, angular to subrounded granitic rock up to 3 feet in diameter. Limestone at base of unit; light-gray, finely crystalline; weathers brownish; sandy in lower part - - - - - 44
16. Sandstone, light-green, fine- to medium-grained, medium- to thick-bedded, angular; scattered fragments of vertebrate fossils in lower part - - - - - 12
15. Siltstone, greenish-gray, calcareous. Analcimic tuff (1.6 feet thick) occurs 15 feet above base; yellowish except for lowest 0.02 foot which is white and powdery - - - - - 22
14. Sandstone and conglomerate. Sandstone, light-green, fine- to medium-grained, thick-bedded, angular to subangular; cemented by calcite in upper part. Conglomerate, lenticular; pebbles, cobbles, and boulders of mainly granitic rock and minor reddish and greenish lavas - - - - - 36
13. Siltstone, grayish-green, locally calcareous, laminated; numerous calcareous concretions - - - - - 22

- 12. Mudstone and silty mudstone, greenish-gray to brownish; interbeds of thin brown-weathering limestone. Tuffs occur 30 feet, 70 feet, and 104 feet above base; lowest tuff (0.1 foot thick) is yellowish and analcimic; middle tuff (0.4 foot thick) is yellowish and feldspathic; uppermost tuff (1.5 feet thick) is white to yellowish and feldspathic - - - 108
  
- 11. Mudstone and siltstone, greenish to greenish-gray, thin-bedded; common calcareous concretions; common gypsum as fracture fillings. Yellowish crystal tuff (0.7 foot thick) occurs at base - - - - - 40
  
- 10. Sandstone and conglomerate. Sandstone, grayish-green to yellowish-brown, chiefly medium- to coarse-grained, thick-bedded, fair to poor sorting, angular to subangular, common biotite, locally calcite-cemented; lower part is thin bedded with thin limestone lenses. Conglomerate, lenticular, channeling; consists of pebbles, cobbles, and boulders that are chiefly granitic rock but some pinkish and greenish lavas; pebbles are angular to subrounded, but boulders are subrounded to rounded.- - - - - 170
  
- 9. Mudstone and silty mudstone with interbeds of sandstone, limestone, and tuff; thin dolomite bed at top of unit. Mudstone and silty mudstone, greenish-gray and brownish, thick-bedded. Limestone, silty, thin-bedded; weathers brownish. Sandstone, greenish-gray, coarse-grained,

9.--continued

angular; conspicuous sandstone at base and 20  
feet above base. Analcimic tuffs occur 36 feet  
and 43 feet above base; lower tuff (1.1 feet thick)  
is yellowish; upper tuff (0.2 foot thick) is light  
brown - - - - -

67

8. Chiefly mudstone and interbeds of limestone and tuff.  
Mudstone, brownish and greenish-gray, thick-bedded; breaks with conchoidal fracture where fresh but has "pop corn" coating where weathered; gypsum commonly fills fractures. Limestone, thin-bedded; weathers brownish. Thin analcimic tuffs occur 31 feet and 63 feet above base; lower tuff (0.2 foot thick) is light gray; upper tuff (0.5 foot thick) is yellowish brown - - - - - 78
7. Tuff and tuffaceous siltstone interbeds. Tuff, white, zeolitic; individual beds are 0.02 -0.5 foot thick. Siltstone, light-green, ripple-laminated - - - - - 6
6. Mudstone, brownish, locally silty or sandy, mainly thick-bedded; breaks with conchoidal fracture where fresh but has "pop corn" coating where weathered; thin brown-weathering limestone beds are common - - - - 82
5. Chiefly siltstone and interbeds of mudstone, conglomerate, limestone, and tuff. Siltstone, greenish, thin-bedded, locally tuffaceous; some beds contain abundant charcoal. Pebbles in conglomerate are subangular to subrounded granitic rock and minor pinkish and greenish-gray lavas. Zeolitic tuffs occur at base, 40 feet above base, and at top; lowest tuff (0.9 foot thick) is yellowish; middle tuff (1.2 feet thick) is white; uppermost tuff (1.3 feet thick) is yellowish - - - - - 51

4. Mudstone, chiefly brownish but some greenish, thick-bedded; breaks with conchoidal fracture where fresh but has "pop corn" coating where weathered; gypsum common as fracture fillings; calcareous concretions locally common. A conspicuous sandstone (6 feet thick) occurs 50 feet above base; sandstone is pale green, medium to coarse grained, and consists chiefly of angular granitic detritus. Yellowish tuffs occur 24 feet and 70 feet above base; lower tuff (0.4 foot thick) is calcareous; upper tuff (0.3 foot thick) grades upward into sandstone - - - - -	162
3. Mudstone, chiefly grayish-green but some brownish, locally calcareous, laminated to thick-bedded, poorly exposed; silty in lower part; abundant calcareous concretions - - - - -	70
2. Sandstone and conglomerate lenses. Sandstone, gray to yellowish-gray, fine- to coarse-grained, chiefly medium-bedded, angular to subangular, locally calcite-cemented. Conglomerate consists chiefly of subangular to subrounded granitic pebbles - - - -	95
1. Mudstone, grayish-green to yellowish-green, locally calcareous, laminated to medium-bedded; common calcareous concretions; some beds are charcoal-rich. White analcimic tuff (0.05 foot thick) occurs 120 feet below top. Base of unit not measured . - - -	158
Total measured - - - - -	<u>1,957</u>

MEASURED SECTION SM-2

Measured south of Rainbow Basin; SE1/4SW1/4 sec. 24 and NE1/4NW1/4 sec. 25, T. 11 N., R. 2 W.; south limb of syncline

[Measured by R. A. Sheppard, February 1964]

	<u>Feet</u>
6. Sandstone, yellowish-gray, fine- to coarse-grained, fine- to medium-bedded; gradational into underlying unit; top of unit not measured - - - - -	25
5. Mudstone and silty mudstone, grayish-green to yellowish-green, laminated, poorly exposed; numerous calcareous concretions; abundant gypsum fracture fillings - - - - -	162
4. Chiefly sandstone with siltstone interbeds and conglomerate lenses. Sandstone, yellowish-gray to greenish-gray, mainly fine- to medium-grained, thin-bedded, angular to subangular; some beds are locally cemented by brown-weathering calcite - - - - -	43
3. Chiefly mudstone with silty mudstone interbeds, grayish-green to yellowish-green, poorly exposed; abundant calcareous concretions throughout unit - - - - -	184
2. Chiefly sandstone with interbeds of conglomerate, siltstone, mudstone, limestone, and tuff. Sandstone, yellowish-gray and greenish-gray, fine- to coarse-grained, thin- to thick-bedded, angular to subangular. Conglomerate consists mainly of granitic fragments with minor volcanic rocks. Mudstone is greenish and has common calcareous concretions. Yellowish, lenticular, analcimic tuff (0.05 foot thick) occurs 38 feet above base. Basal 2 feet of unit is yellowish and tuffaceous - - - - -	96

	<u>Feet</u>
1. Sandstone and conglomerate, light-brown to reddish-brown.	
Sandstone, fine- to coarse-grained, generally	
thick-bedded, angular to subangular; poorly indurated	
except where cemented by calcite. Conglomerate	
consists of pebbles, cobbles, and boulders of chiefly	
granitic rock with minor volcanic and metamorphic	
rocks. Base of unit not measured - - - - -	40
	<hr style="width: 10%; margin-left: auto; margin-right: 0;"/>
Total measured - - - - -	550

MEASURED SECTION SM-3

Measured in northwest part of Rainbow Basin; NW1/4NE1/4 sec. 24,

T. 11 N., R. 2 W.; north limb of syncline

[Measured by R. A. Sheppard, February, 1964]

	<u>Feet</u>
9. Mudstone, grayish-brown; abundant calcareous concretions. Gray, conspicuous tuffs occur 20 feet and 35 feet above base; lower tuff (0.3 foot thick) is the Camel track tuff that is biotite-rich and feldspathic; upper tuff (0.5 foot thick) is the Dated tuff that is analcimic, calcareous, and crystal-rich. The Dated tuff contains abundant coarse euhedral biotite and has characteristic casts of mud cracks on the bottom. Top of unit not measured - - - - -	50
8. Skyline tuff, mostly white, multiple-bedded, chiefly zeolitic, subconchoidal fracture; thin layers at top and bottom are greenish and feldspathic - - - - -	5
7. Mudstone, brownish; "pop corn" coating where weathered; several interbeds of thin, wavy-bedded limestone - - -	27
6. Mudstone with greenish, coarse-grained sandstone near middle. Mudstone, greenish, silty - - - - -	11
5. Limestone, light-gray, wavy-bedded; mudstone interbeds in lower part; sandy upper part - - - - -	7
4. Chiefly mudstone with sandstone and limestone interbeds. Mudstone, brownish, silty. Sandstone, greenish, fine-grained, thin-bedded - - - - -	26
3. Sandstone, greenish, fine- to medium-grained, thin- to thick-bedded; thin interbeds of brown-weathering	

	<u>Feet</u>
3.--continued	
limestone in upper part - - - - -	24
2. Mudstone, silty; brownish in lower part but grayish brown in upper part; abundant calcareous concretions. Analcimic tuffs occur at base, 5 feet above base, and 17 feet above base; lowest tuff (0.3 foot thick) is granular and greenish; middle tuff (0.05 foot thick) is white; upper tuff (0.4 foot thick) is probably the Yellow tuff that is yellowish brown and ripple marked - - - - -	46
1. Mudstone, brownish; breaks with conchoidal fracture where fresh but has "pop corn" coating where weathered; abundant calcareous concretions; base of unit not measured - - - - -	10
Total measured - - - - -	206

MEASURED SECTION SM-4

Measured along washes in the eastern part of the Mud Hills; E1/2 sec. 20 and NE1/4 sec. 29, T. 11 N., R. 1 W.; north limb of syncline

[Measured by R. A. Sheppard, February, 1964 and A. J. Gude, 3d and R. A. Sheppard, October, 1965]

	<u>Feet</u>
Unconformably overlain by Quaternary gravel.	
22. Sandstone and conglomerate, yellowish-brown to reddish-brown, poorly consolidated except where cemented by calcite. Sandstone, thin- to thick-bedded, fine- to coarse-grained. Conglomerate, lenticular; fragments are chiefly subangular to subrounded granitic and volcanic rocks. Top of unit eroded - - - - -	205
21. Limestone, greenish-gray where fresh but weathers brownish; wavy-bedded; irregular, siliceous segregations. Lower part interbedded with greenish sandstone, greenish calcareous mudstone, and yellowish tuff (0.2 foot thick); tuff is zeolitic and occurs 2 feet above base - - - - -	14
20. Chiefly mudstone, brownish and greenish; interbeds of thin-bedded sandstone, limestone, dolomite, and tuff. Thin, grayish dolomite beds occur 24 feet and 50 feet above base. The Dated tuff occurs 27 feet above base; tuff is grayish, calcareous, and crystal-rich with abundant euhedral biotite. Another tuff (3.0 feet thick) occurs 31 feet above base; tuff is grayish and feldspathic - - -	82
19. Skyline tuff, white but weathers buff, zeolitic, conchoidal fracture; forms ledge - - - - -	4

	<u>Feet</u>
18. Chiefly sandstone, fine-grained, locally ripple-marked; interbeds of limestone and mudstone; common brownish calcareous concretions in lower part - - - - -	57
17. Mudstone, brownish; breaks with conchoidal fracture where fresh but has "pop corn" coating where weathered; calcareous concretions are common; base of unit is concealed - - - - -	20
16. Concealed - - - - -	15
15. Chiefly silty mudstone, greenish; interbeds of greenish- gray, thin-bedded, fine-grained sandstone and thin- bedded limestone; top and base of unit is concealed. Yellowish tuffs occur 10 feet and 32 feet above base; lower tuff (0.8 foot thick) is the Yellow tuff that is locally spherulitic; upper tuff (0.7 foot thick) is feldspathic and crystal-rich - - - - -	85
14. Concealed - - - - -	75
13. Chiefly silty mudstone, greenish; local thin-bedded, fine- grained sandstone and thin-bedded limestone; top of unit concealed. A yellowish, calcareous tuff (1.0 foot thick) occurs 15 feet above base - - - - -	20
12. Mudstone and limestone interbeds. Mudstone, greenish, locally calcareous; calcareous concretions are common. Limestone, brownish, locally siliceous, lenticular; forms ledges. Tuffs are common in upper and lower parts of unit: greenish tuff (0.4 foot thick) occurs 55 feet above base; white, calcareous tuff (0.6 foot thick)	

12.--continued

	<u>Feet</u>
occurs 72 feet above base; greenish-yellow, calcareous tuff (0.6 foot thick) occurs 80 feet above base; yellowish tuff (0.2 foot thick) occurs 119 feet above base; yellowish, calcareous tuff (1.1 feet thick) occurs 266 feet above base; white, feldspathic tuff (0.5 foot thick) occurs 278 feet above base; yellowish and greenish tuff (0.6 foot thick) occurs 304 feet above base; yellowish, feldspathic tuff (0.3 foot thick) occurs 306 feet above base - - - -	330
11. Mudstone, greenish, calcareous; breaks with conchoidal fracture where fresh but has "pop corn" coating where weathered; calcareous concretions are common.  Yellowish tuff (0.7 foot thick) at base - - - - -	40
10. Mudstone, brownish, poorly exposed; abundant calcareous concretions that weather brown - - - - -	28
9. Mudstone, greenish, calcareous; breaks with conchoidal fracture where fresh but has "pop corn" coating where weathered; contains abundant calcareous lenses and concretions that weather brown - - - - -	115
8. Siltstone and mudstone interbeds, grayish-green to buff; local calcareous lenses and nodules. Light-yellow zeolitic tuffs occur at base of unit, 23 feet above base, and 31 feet above base. Lowest tuff (0.5 foot thick) is analcimic; middle tuff (3.5 feet thick) is clinoptilolite-rich; uppermost tuff (0.8 foot thick) is clinoptilolite-rich and siliceous at base - - - - -	33

7. Sandstone with siltstone and limestone interbeds and conglomerate lenses. Sandstone, greenish-gray to reddish-brown, fine- to medium-grained, thin- to thick-bedded, locally calcareous. Conglomerate consists of granitic and volcanic pebbles. Zeolitic tuffs occur 70 feet and 169 feet above base; lower tuff (2.2 feet thick) is white to yellow; upper tuff (3.0 feet thick) is white - - - - - 187
6. Siltstone with interbeds of mudstone and thin limestone. Siltstone, light-green to grayish-green, locally laminated. Mudstone, greenish, locally calcareous. Thin zeolitic tuffs occur 65 feet and 150 feet above base; lower tuff (0.5 foot thick) is gray; upper tuff (0.3 foot thick) is white - - - - - 170
5. Mudstone, greenish-yellow to greenish-gray; contains thin limestone interbeds and small calcareous concretions; local concentrations of nodular strontianite-rich rock - - - - - 68
4. Sandstone, greenish-gray to buff, tuffaceous, fine- to coarse-grained, thin- to thick-bedded, even-bedded; abundant white pumice lapilli in upper part of some beds. Conglomerate lenses of chiefly granitic rock in lower part of unit. Zeolitic tuff (2.0 feet thick) occurs 20 feet above base and is white and calcareous - - 52

3. Sandstone and lenses of conglomerate. Sandstone, grayish, calcareous, fine- to coarse-grained, thin- to thick-bedded; detritus is chiefly granitic; some thin beds are ripple laminated. Conglomerate consists of angular to subangular pebbles and cobbles; some beds consist mainly of granitic fragments but others consist mainly of greenish and reddish lavas. Zeolitic tuff (0.3 foot thick) occurs 102 feet above base and is white and discontinuous- - - - -	105
2. Sandstone and conglomerate, greenish; detritus is chiefly granitic. Brown-weathering limestone and calcareous sandstone lenses are common in upper part; top of unit marked by 13 feet of resistant limestone and calcareous beds - - - - -	68
1. Conglomerate and sandstone, greenish, calcareous, indistinct and irregular bedding; channeling is common; fragments are chiefly granitic rock; gradational with overlying unit. Basal conglomerate bed contains abundant fragments of lapilli tuff from the underlying Pickhandle Formation - - - - -	72
Unconformably overlies the Pickhandle Formation.	
Total measured - - - - -	<hr/> 1,845

MEASURED SECTION SM-5-6

Measured in Fossil Canyon and northern tributary to Fossil Canyon;

SE1/4SE1/4 sec. 10, NW1/4NW1/4 sec. 14, and N1/2NE1/4 sec. 15,

T. 11 N., R. 2 W.; north limb of syncline

[Measured by R. A. Sheppard, March, 1964]

	<u>Feet</u>
16. Sandstone with siltstone and mudstone interbeds and conglomerate lenses. Sandstone, light-gray to greenish-gray, fine- to coarse-grained, thin- to thick-bedded, angular, locally tuffaceous, locally calcareous; ripple marks, cross bedding, and channeling are rare. Mudstone, greenish-gray, "pop corn" coating. Conglomerate consists of volcanic and granitic pebbles; local concentrations of rounded, white to pink, zeolitic, pumice lapilli. Top of unit eroded - - - - -	100
15. Chiefly mudstone and limestone interbeds. Mudstone, greenish-gray, poorly exposed, common "pop corn" coating. Limestone, light-gray, locally siliceous, uneven bedding; weathers white to buff - - - - -	60
14. Mudstone and interbeds of siltstone, sandstone, and thin white limestone. Mudstone, greenish-gray but reddish-brown near middle; common calcareous concretions - - -	35
13. Mudstone, silty mudstone, siltstone, and white limestone. Mudstone, greenish-gray to light-gray; common calcareous concretions. Fragmental vertebrate fossils were found in place about 35 feet above base; fossils	

13.--continued

Feet

are common as float on lower part of unit. Light-  
brown zeolitic tuff (1.0 foot thick) occurs at top  
of unit - - - - - 64

12. Siltstone and tuff. Siltstone, greenish-gray, locally  
tuffaceous, calcareous. White zeolitic tuffs occur  
at base, 4 feet above base, and at top of unit;  
lowest tuff (0.8 foot thick) breaks with sub-  
conchoidal fracture; middle tuff (3.5 feet thick)  
is the Hemicyon tuff that is multiple bedded and  
breaks with a conchoidal fracture; uppermost tuff (1.0  
foot thick) has a platy fracture and a siliceous  
base - - - - - 27

11. Mudstone, greenish, calcareous, locally silty; interbeds  
of tuff and white-weathering, locally siliceous  
limestone; common calcareous concretions. Zeolitic  
tuffs occur 8 feet, 19 feet, and 30 feet above base;  
lowest tuff (1.0 foot thick) is yellowish; middle tuff  
(0.7 foot thick) is white and interbedded with  
limestone in upper part; uppermost tuff (0.8 foot thick)  
is yellowish where fresh but weathers light gray and  
grades upward into tuffaceous, silty mudstone - - - - - 102

10. Mudstone and silty mudstone, greenish; poorly exposed;  
common calcareous concretions. Analcimic tuff (0.3  
foot thick) occurs at base and is greenish and  
calcareous - - - - - 28

9. Mudstone, mainly brownish but some greenish; interbeds of brown-weathering limestone, sandstone, and tuff. The Dated tuff (0.4 foot thick) occurs 40 feet above base and grades upward into sandstone; the tuff is crystal-rich, analcimic, calcareous, and has abundant euhedral coarse biotite - - - - - 115
8. Skyline tuff, white, zeolitic, multiple-bedded, conchoidal fracture; ripple marks locally in upper part; forms ledge - - - - - 4
7. Mudstone, mainly brownish but some greenish, thick-bedded; breaks with conchoidal fracture where fresh but has "pop corn" coating where weathered; interbeds of brown-weathering limestone and greenish-gray, coarse-grained sandstone - - - - - 88
6. Mudstone, brownish, medium- to thick-bedded; breaks with conchoidal fracture where fresh but has "pop corn" coating where weathered; common interbeds of brown-weathering limestone and calcareous concretions. Analcimic tuffs occur 67 feet, 124 feet, and 146 feet above base; lowest tuff (0.2 foot thick) is white and has small pumice lapilli in upper part; middle tuff (0.4 foot thick) is greenish and biotite-rich; uppermost tuff (0.4 foot thick) is greenish and calcareous - - - - - 161

5. Silty mudstone, brownish and light-greenish, calcareous, thin- to thick-bedded. Abundant interbeds of thin, brown-weathering limestone. Analcimic and feldspathic tuffs occur 70 feet, 102 feet, and 132 feet above base; lowest tuff (0.4 foot thick) is greenish; middle tuff (0.1 foot thick) also is greenish; uppermost tuff (0.7 foot thick) is yellowish and grades upward into silty mudstone - - - - - 145
4. Mudstone and silty mudstone, mainly greenish but some brownish, calcareous; poorly exposed. Thin, brown-weathering limestone interbedded mostly in upper part; some have casts of mud cracks on bottoms. Brownish analcimic tuff (0.2 foot thick) occurs 120 feet above base - - - - - 132
3. Interbedded conglomerate, sandstone, siltstone, silty mudstone, tuff, and limestone; light-green to grayish-green. Sandstone, locally tuffaceous, fine- to coarse-grained, thin- to thick-bedded, angular. Some siltstone is laminated or ripple laminated. Conglomerate consists of granitic and volcanic fragments, but some consist mainly of volcanic fragments. Greenish zeolitic tuff (2.0 feet thick) occurs 40 feet above base and is interbedded with tuffaceous mudstone - - - 73

Feet

2. Chiefly tuffaceous sandstone with interbeds of conglomerate, siltstone, and limestone. Sandstone, light-green, zeolitic, fine- to coarse-grained, thin- to thick-bedded, angular, locally cross-bedded. Conglomerate is lenticular and consists chiefly of angular to sub-rounded granitic rock - - - - -	35
1. Conglomerate, grayish-green, indistinct bedding; fragments are chiefly angular to subangular granitic rock up to 3 feet in diameter and rare volcanic rocks. Base of unit not exposed - - - - -	70
Total measured - - - - -	<hr/> 1,239

MEASURED SECTION SM-7

Measured in Coon Canyon; NE1/4NW1/4 sec. 23, T. 11 N., R. 2 W.; south limb of syncline

[Measured by R. A. Sheppard, March, 1964]

	<u>Feet</u>
8. Mudstone and tuff interbeds. Mudstone, greenish-gray and reddish-brown; silty in lower part; breaks with conchoidal fracture where fresh but has "pop corn" coating where weathered; common calcareous concretions. Tuffs occur at base and 23 feet above base; lower tuff (3.5 feet thick) is the Hemicyon tuff that is white, zeolitic, multiple-bedded, and breaks with conchoidal fracture; upper tuff (0.1 foot thick) is yellowish and analcimic. Top of unit not measured - - -	35
7. Chiefly siltstone with mudstone in upper part and sandstone in lower part. Siltstone, greenish-brown to reddish-brown; common calcareous concretions. Analcimic tuff (0.5 foot thick) occurs 37 feet above base and is light brown and granular - - - - -	40
6. Sandstone, light-brown, fine- to medium-grained, medium-bedded, angular to subangular; locally cemented by calcite - - - - -	22
5. Chiefly brownish and greenish mudstone with limestone and sandstone interbeds. Sandstone, greenish-gray and yellowish-brown, fine- to medium-grained, medium- to thick-bedded; locally cemented by calcite. Analcimic	

5.--continued

	<u>Feet</u>
tuff (1.5 feet thick) occurs 100 feet above base and is brownish except basal 0.1 foot which is yellowish green - - - - -	120
4. Limestone with greenish and brownish, calcareous mudstone interbeds. Limestone, brownish-gray, medium- to thick-bedded, wavy-bedded - - - - -	18
3. Sandstone, conglomerate lenses, and tuff interbeds. Sandstone, yellowish-brown, fine- to very coarse-grained, medium- to thick-bedded, angular to subangular, locally calcareous. Conglomerate consists of pebbles, cobbles, and boulders up to 3 feet in diameter; fragments chiefly granitic rock but some beds are about half volcanic rocks. Analcimic tuffs occur 40 feet, 60 feet, and 69 feet above base and all grade upward into sandstone; lowest tuff (1.0 foot thick) is light green; middle tuff (0.3 foot thick) is the Dated tuff that is gray, crystal-rich, and calcareous; uppermost tuff (0.6 foot thick) is yellowish brown - - - - -	117
2. Skyline tuff, white, zeolitic, subconchoidal fracture; locally sandstone from overlying unit channeled through tuff - - - - -	1
1. Sandstone, yellowish-brown, fine- to medium-grained, medium- to thick-bedded. Base of unit not measured - -	10
Total measured - - - - -	363

MEASURED SECTION SM-8

Measured in the western part of Rainbow Basin; SEL/4NW/4 sec. 24,

T. 11 N., R. 2 W.; south limb of syncline

[Measured by R. A. Sheppard, April, 1964]

	<u>Feet</u>
10. Mudstone, reddish-brown but brown in upper part. Analcimic tuffs occur 60 feet and 65 feet above base; lower tuff (0.5 foot thick) is brownish; upper tuff (3.0 feet thick) is greenish brown in upper and lower parts but light gray in middle. Top of unit eroded - - - -	78
9. Chiefly sandstone and conglomerate lenses; yellowish limestone at top of unit. Sandstone, yellowish-brown, medium- to coarse-grained, medium- to thick-bedded, angular, fair to poor sorting; locally cemented by calcite. Conglomerate consist mainly of angular to subangular granitic pebbles - - - - -	72
8. Mudstone, mainly brownish but some greenish-gray. Analcimic tuff occurs 33 feet and 44 feet above base; lower tuff (0.2 foot thick) is dark brown; upper tuff (0.7 foot thick) is greenish and white - - - - -	53
7. Chiefly sandstone with mudstone, siltstone, and limestone interbeds - - - - -	28
6. Mudstone and thin grayish siltstone interbeds. Mudstone, brownish. Light-brown analcimic tuff (0.1 foot thick) occurs at top - - - - -	44

	<u>Feet</u>
5. Interbeds of limestone, fine-grained sandstone, and greenish mudstone. Yellowish tuff (0.5 foot thick) occurs 17 feet above base and is feldspathic - -	22
4. Chiefly mudstone with interbeds of limestone and tuff. Mudstone, greenish-gray and brownish. Gray, conspicuous tuffs occur 19 feet and 38 feet above base; lower tuff (0.2 foot thick) is the Camel track tuff that contains abundant fine-grained biotite; upper tuff (0.3 foot thick) is the Dated tuff that contains abundant coarse euhedral biotite and has casts of mud cracks on the bottom - - - - -	55
3. Mudstone, greenish; interbeds of brown-weathering limestone - - - - -	10
2. Skyline tuff, white to light-green, multiple-bedded, zeolitic, conchoidal to blocky fracture; middle part contains abundant detrital grains - - - - -	7
1. Mudstone, greenish; base of unit not measured - - - - -	10
Total measured - - - - -	379

## REFERENCES

- Baker, C. L., 1911, Notes on the later Cenozoic history of the Mohave Desert region in southeastern California: California Univ., Dept. Geol. Sci. Bull., v. 6, p. 333-383.
- Bowen, O. E., 1954, Geology and mineral deposits of Barstow quadrangle, San Bernardino County, California: California Div. Mines Bull. 165, p. 1-185.
- Dibblee, T. W., Jr., 1958, Tertiary stratigraphic units of western Mojave Desert, California: Am. Assoc. Petroleum Geologists Bull., v. 42, no. 1, p. 135-144.
- Durrell, Cordell, 1953, Geological investigations of strontium deposits in southern California: California Div. Mines Spec. Rept. 32, 48 p.
- Evernden, J. F., Savage, D. E., Curtis, G. H., and James, G. T., 1964, Potassium-argon dates and the Cenozoic mammalian chronology of North America: Am. Jour. Sci., v. 262, p. 145-198.
- Frick, Childs, 1926, The Hemicyoninae and an American Tertiary bear: Am. Mus. Nat. History Bull., v. 56, p. 1-119.
- Gude, A. J. 3d, and Sheppard, R. A., 1966, Silica-rich chabazite from the Barstow Formation, San Bernardino County, southern California: Am. Mineralogist, v. 51, p. 909-915.
- Lewis, G. E., 1964, Miocene vertebrates of the Barstow Formation in southern California, in Geological Survey Research 1963: U.S. Geol. Survey Prof. Paper 475-D, p. D18-D23.
- Merriam, J. C., 1911, A collection of mammalian remains from Tertiary beds on the Mohave Desert: California Univ., Dept. Geol. Sci., v. 6, p. 167-169.
- Sheppard, R. A., and Gude, A. J. 3d, 1965, Potash feldspar of possible economic value in the Barstow Formation, San Bernardino County, California: U.S. Geol. Survey Circ. 500, 7 p.