Article XXXI. — ON JURASSIC STRATIGRAPHY ON THE WEST SIDE OF THE BLACK HILLS — SECOND PAPER ON AMERICAN JURASSIC STRATIGRAPHY.

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Plates LIV and LV.

During June, 1901, a party, sent out by Professor Osborn, from the American Museum of Natural History, prospected the Jurassic exposures of the west side of the Black Hills for Dinosaur remains. In connection with this work sections were made by the writer at six of the best and most characteristic exposures, to show the stratigraphy of these deposits. These were made at Professor Osborn's request for comparison with the sections previously made by the writer in the Como district of Wyoming.

The area covered extends from a little north of Hulett to fifteen miles south of Newcastle; the exposures stretching some 125 miles in length, and varying from a fourth of a mile to ten or twelve in width. The distribution of the Jurassic in the region is shown in the map accompanying the paper, as is also the location of the individual sections. The Jurassic is exposed mostly in escarpments, capped by the heavy Dakota sandstone, which makes the 'rim.' These escarpments generally face toward the centre of the Hills and continue on around the north and east sides as well as on the west side. The soft clays which predominate in the Upper Jurassic are the cause of a considerable valley all around, just inside the 'rim.' The strata dip in varying degrees away from the centre of the Hills, but are in the best exposures nearly horizontal.

The Jurassic is divisible into two parts: a lower marine, corresponding to Knight's Shirley [1]; and an upper fresh or brackish water corresponding to Scott's Como.[2] On the east

[1] W. C. Knight, 'Jurassic Rocks of Southeastern Wyoming,' Bull. U. S. Geol. Surv., Vol. XI, pp. 377–388.
[2] W. B. Scott, Introduction to Geology, p. 447 (footnote).

side of the Hills, a thick bed of sandstone immediately overlies the Triassic; but this bed is everywhere lacking on the west side of the Hills, the transition being uninterrupted, and seen only in the change from sandy red clay to sandy green clay.

On comparing the sections made on the east side of the Hills,[1] these on the west side, and similar sections made in central and eastern Wyoming,[2] it becomes clear that the Jurassic of the west side corresponds more closely with that in central Wyoming (especially on the Medicine and Como anticlines) than the west side corresponds to the Jurassic on the east side of the Black Hills. However, the upper or freshwater beds of the east and west sides correspond with one another better than the marine layers. Many of the most striking layers of the west side can be detected in the centre of Wyoming almost exactly as they occur in the Hills. To bring this out strongly, in the table where the sections are set side by side, the same series of numbers is used as in the table [3] of sections from central Wyoming, and such layers as are recognized as being equivalent are printed in heavy type.

The Triassic of the west side of the Black Hills is made up of barren red sandy clay. This grades into the green sandy clay of the base of the Shirley, which for some eight to ten feet is also barren. Here, however, *Belemnites densus* begins to appear in great abundance. This clay is then the equivalent of and like in texture to the Belemnites layer further west (No. 2). The upper part of the layer may carry thin beds of limestone as in the Inyan Kara Peak section. This is overlaid by a layer of green clay with large limestone nodules (No. 4), which vary in size from six inches to a couple of feet in diameter. It is in and on just such nodules that *Baptanodon* remains are found in the centre of the State. The layer was everywhere [4] present both on the west and east sides of the Hills. However, no trace of *Baptanodon* was found in any of the exposures; but in the stone-pile of a yard on Miller Creek,

[1] The east side sections are in manuscript; they were made by G. R. Wieland, and verified by myself.
[2] Loomis, Bull. Amer. Museum. Nat. Hist., Vol. XIV, pp. 189–197.
[3] Last cit., p. 192.
[4] Except in the Salt Creek section, which is an unusual one.

two or three *Baptanodon* vertebræ were discovered, and probably came from this horizon in some of the nearby exposures. In the centre of Wyoming this layer has a purple hue, but is otherwise similar.

A sandy limestone or shell sandstone (No. 5) usually follows, which carries several invertebrate marine forms. At the Belle Fourche station, this layer held *Amaltheus cardiformis*, *Ægoceras tumidus* v. Buch, *Ostrea strigulecula* W., *Tancredia inornata* M. & H., *Pseudomonotis curta* W., *P. orbiculata* W., *Dosinia jurassica* W., *Trigonia* sp., and *Pholadomya* sp. This fauna with some variations is widely distributed at this horizon.[1]

From this horizon to the top of the marine Jurassic there is no uniformity in the character of the beds, usually, as in the Belle Fourche section, the clays alternating rapidly with thin beds of sandstone. The Salt Creek section has soft sandstones alternating with denser ones. The Beaver Creek section has nothing to represent the alternations. In central Wyoming there are several clays and sandstones. There is no uniformity except in the rapidly changing character of the deposits.

The top of the marine beds is a green clay (No. 12) of varying texture. The change to fresh- or brackish-water is a gradual one, so that a distinct boundary is difficult to find, but this bed is the highest in which any trace of marine life was found, and is, therefore, used here as a convenient separating horizon.

The base of the freshwater deposits is a bed of sandstone (No. 13), varying greatly in thickness and in character.

No. 14 is a layer of green clay, the lowest in which any traces of Dinosaurs were found. On the north side of Inyan Kara Peak a few fragments of sauropod limb bones occurred; and near the Sheldon P. O. section a few foot bones were found at this level. At the Belle Fourche station traces of Dinosaurs also occurred. In all cases the bones were uniformly hard, but very scarce.

[1] At the Sheldon P. O. station there occurred *Camponectes platissiformis* W., *Tancredia warreni* M. & H., *T. bulbosa* M. & H., *Avicula mucronata* W., and *Ostrea strigulecula* M. & H. The Kara Peak section had *Amaltheus cardiformis* M. & H., *Ægoceras tumidus* v. Buch, and *Pseudomonotis curta* W

The Inyan Kara Peak section is remarkable for its thickness. This is most marked in the No. 15 bed of sandstone which is here 75 feet thick. The layer is very generally a fairly heavy one and occurs in all the sections.

Next follow several thin layers of variable character, consisting of clays, sandstones and limestone concretions. There is no constant bed till No. 22 is reached, which is a band of maroon clay filled with tiny concretions. It is present in three of the sections and occupies the same position as a similar band in the centre of Wyoming. It is a very good horizon marker, being so distinctive in texture and conspicuous in color. Just above a very constant layer of limestone nodules (No. 23) occurs.

The layers from 24 to 28 are a series of brilliantly colored clays, red, purple, and green in color, and popularly called the "varigated clays." These clays have occasional beds of limestone nodules. In the variegated beds, especially toward the top, Dinosaur remains are not infrequent, but without exception the bones are in a wretched state of preservation, the iron in the colored beds having eaten into them till great spots are mere powder. In all the sections some traces of Dinosaurs were found at this horizon, but they were especially abundant along the lower reaches of the Inyan Kara Creek. On Inyan Kara Creek in these same beds Mr. Thompson found several specimens of *Unio baileyi* L. and *Valvata leei* L. similar to those found by Logan in the Freezeout Mountains. These variegated clays occur on the east side of the Hills, as well as on the west side, also in the Freezeout Mountains, and in the southeastern part of Wyoming.

The top of the freshwater series is everywhere a bed of olive-green clay of considerable thickness, in which Dinosaur remains are extremely rare, but do occur; and where present, the bones are in a good state of preservation. Fragments were found at the Belle Fourche station and near Inyan Kara Peak. The whole is capped by the heavy bedded Dakota sandstone. The sections are often complicated by this sandstone faulting and slipping part way down the slope of the escarpment. In fact the greatest care is required to find ex-

posures where more or less of the face has not faulted and slipped to some extent. The majority of all the Dinosaur prospects were in clays which were faulted out of place.

Of all the sections the Inyan Kara Peak one is the thickest. This is due in great part to the frequency and extra thickness of the sandstones. The Beaver and Salt Creek sections in the same general neighborhood also have larger quantities of sandstone, which fact I take to mean that in the neighborhood there was some land mass during a part at least of the Jurassic period.

EXPLANATION OF THE PLATES.

Fig. I, Map of the country on the west side of the Black Hills, covered by the prospecting party of the American Museum of Natural History in June, 1901.

Line A–B, Belle Fourche Section.
C–D, Inyan Kara Creek Section.
E–F, Sheldon P. O. Section.
G–H, Inyan Kara Peak Section.
I–J, Salt Creek Section.
K–L, Beaver Creek Section.

The map is modified from Scott's Mineral and Geological Map of the Black Hills.

Fig. II, Belle Fourche Section.

The vertical and longitudinal enlargements are the same in all the sections.

Fig. III, Inyan Kara Creek Section.
Fig. IV, Sheldon P. O. Section.
Fig. V, Inyan Kara Peak Section.
Fig. VI, Salt Creek Section.
Fig. VII, Beaver Creek Section.

		BELLE FOURCHE SECTION.		INYAN KARA CREEK SECTION.		SHELDON P. O. SECTION.	
			Ft.		Ft.		Ft.
31		Dakota sandstone...	180+	Dakota sandstone...	80+	Dakota sandstone...	50+
30		Olive-green clay....	70	Olive-green clay....	40	Olive-green clay....	30
29				Light green clay....	12		
28 — 24	Variegated Clays	Yellow-green clay with small concretions.....	12	Maroon clay with small concretions.	10		
				Green clay with small concretions.	5		
				Red clay.....	5		
						Limestone concretions.....	1
				Green clay.....	5	Green clay.....	10
		Maroon clay.....	10	Maroon clay.....	6	Maroon clay.....	5
		Green clay.....	6	Green clay.....	20	Yellow-green clay...	9
						Red clay.....	5
		Limestone concretions.....	1	Limestone concretions.....	1	Limestone concretions.....	
23		Green clay.....	6			Green clay.....	8
22		Maroon clay with small concretions.	6			Limestone concretions.....	1
21		Green clay with small concretions.....	10			Red clay.....	3
20				Yellow sandstone...	9		
				Dense gray sandstone.....	8		
		Limestone concretions.....	1				
19	Freshwater Jurassic.	Green clay.....	4			Green clay.....	12
18							
17							
		Limestone concretions.....	1			Limestone concretions.....	1
16		Green clay.....	6			Green clay.....	12
15		Soft yellow sandstone.....	2	Yellow sandstone..	5		
14		Green clay.....	7	Limestone concretions.....	1		
13		Soft yellow sandstone.....	2	Yellow sandstone...	12	Gray sandstone.....	2
12a				Limestone concretions.....	1		
		Green clay weathering brown.....	25	Green clay.....	8	Yellow-green clay...	2
12		Limestone concretions.....	1	Gray sandstone.....	2		
		Green clay weathering brown.....	20	Green clay with nodules.....	6		
11		Gray sandstone....	2	Soft sandstone.....	10	Soft sandstone.....	10
8		Green clay.....	10				
		Gray sandstone.....	2	Gray sandstone.....	4		
		Green clay.....	7	Olive clay.....	5		
		Gray sandstone.....	1	Sandstone with shells.....	2		
7	Marine Jurassic.	Green clay.....	4	Olive clay.....	5		
		Gray sandstone.....	1	Sandstone with shells.....	2		
		Green clay.....	6	Olive clay.....	5		
		Gray sandstone.....	1	Gray sandstone.....	2		
6		Sandy clay.....	14				
5		Shell limestone.....	3				
		Sandy clay.....	10	Olive clay.....	1+	Olive-green clay with nodules.....	35
4						Concretions.....	1
						Olive-green clay with nodules.....	12+
		Green clay with Belemnites densus	20+				
2							
1a							
		Total.....	271+	.....	191+	.....	159+
1							

Note.—Numbers in heavy type indicate that the layer can be recognized in the centre of Wyoming

	KARA PEAK SECTION	Ft.	SALT CREEK SECTION.	Ft.	BEAVER CREEK SECTION.	Ft.
31	Dakota sandstone..	15+			Dakota sandstone..	20+
30					Brown-green clay..	15
29					Olive-green clay....	66
28 — 24 Variegated Clays	Red clay.....	3			Green clay with small concretions.....	15
					Maroon clay with small concretions	6
	Green clay.....	3			Green clay.....	15
	Cream sandstone...	8				
	Blue-green clay.....	6				
	Red clay.....	1				
23	Limestone concretions.....	1				
	Purple clay.....	3			Maroon clay with small concretions.	12
22	Red clay.....	2			Green clay.....	6
21	Cream sandstone...	2				
20						
19	Green clay.....	3				
18	Cream sandstone...	2				
17	White sandstone....	11				
16	Black clay.....	2			Limestone concretions	1
	White sandstone....	8				
15	Yellow sandstone...	75	Dark red sandstone	20		
14	Slate-green clay....	50			Olive-green clay....	8
13	Gray sandstone.....	15			Buff sandstone.....	12
12a			Olive-green clay with Belemnites densus	12	Green clay with gypsum.....	20
12	Yellow-green clay..	6	Pink sandstone.....	8	Gray sandstone....	1
	Olive-green clay....	6	Buff sandstone.....	4		
11			Soft pink sandstone	4		
8			Dense buff sandstone	15		
	Sandstone	1	Soft buff sandstone.	8		
	Green clay with nodules.....	3				
7	White sandstone....	12	Buff sandstone.....	8		
6						
5						
	Green clay with nodules.....	12				
4	Soft gray sandstone.	8				
	Green clay with nodules.....	82			Green clay with nodules.....	30
	Belemnites densus bed	2				
	Green clay.....	20	Olive-green clay....	35	Olive clay with Belemnites densus	60
2	Belemnites densus bed	10				
	Limestone layer....	½				
	Sandy green clay...	16			Sandy green clay...	10
1a	Total.....	373½	Gypsum	3	.....	277
			.....	117		
1	Red Triassic sandy clay.....	50+	Red Triassic sandy clay.....	90+	Red Triassic sandy clay.....	40+

Marine Jurassic.

Freshwater Jurassic.

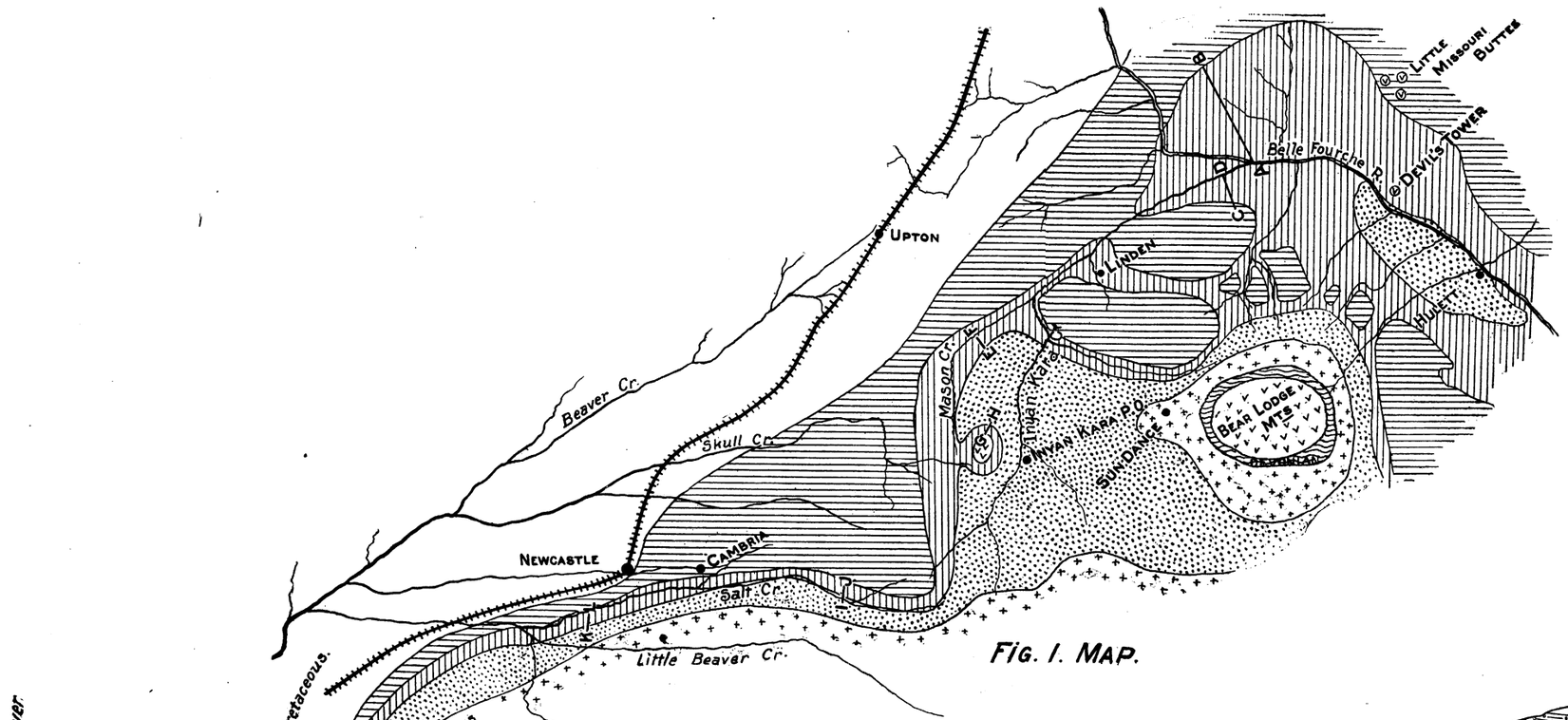

FIG. I. MAP.

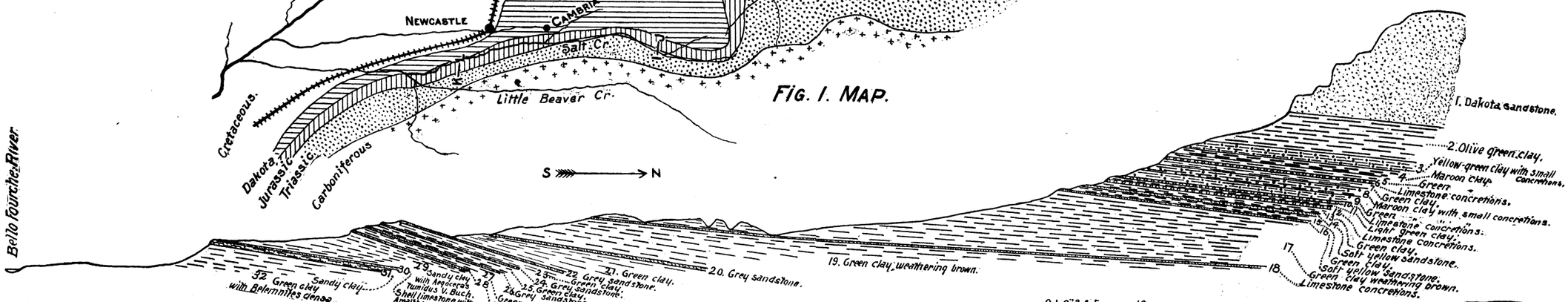

FIG. II. BELLE FOURCHE SECTION.

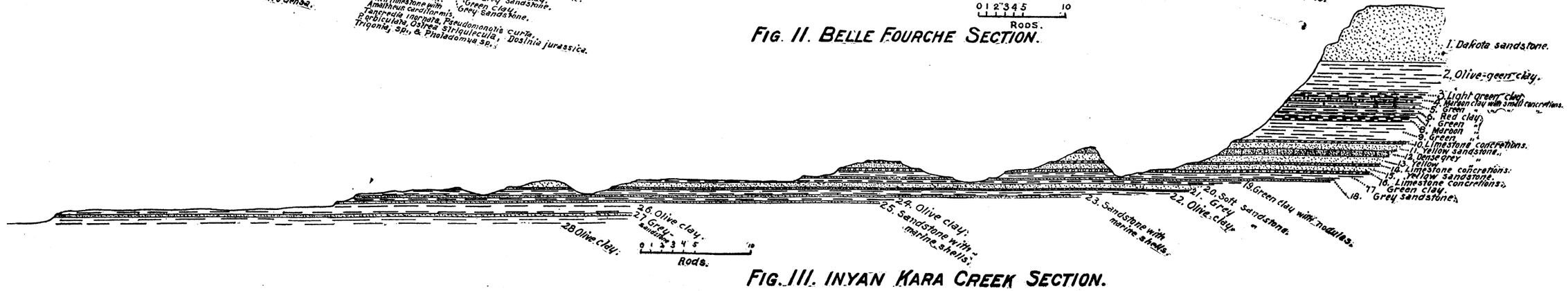

FIG. III. INYAN KARA CREEK SECTION.

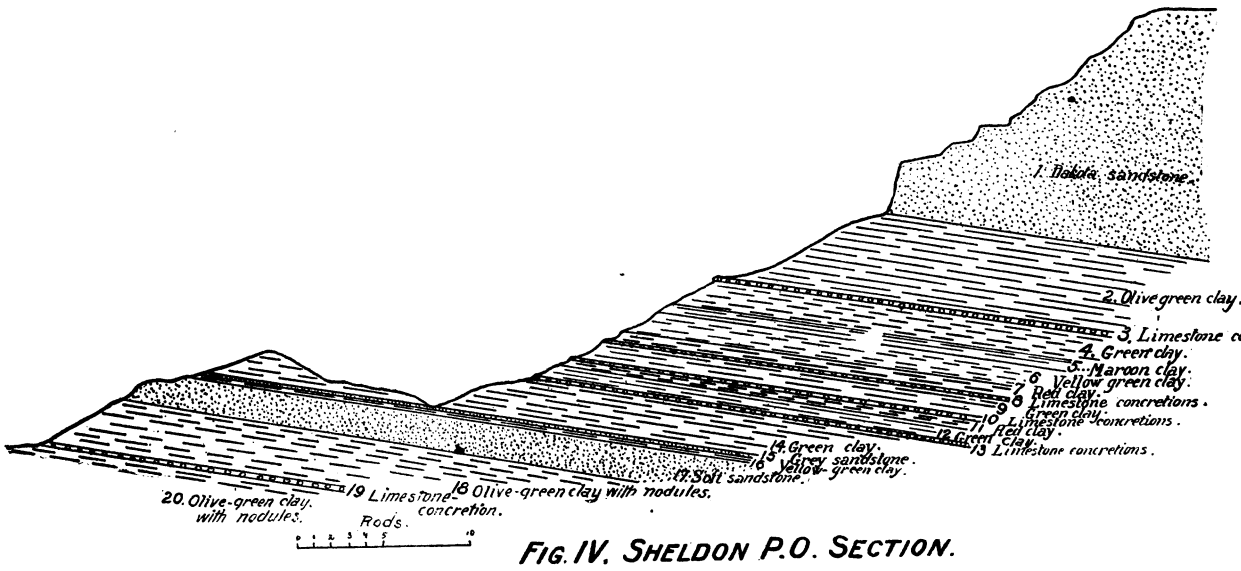

FIG. IV. SHELDON P.O. SECTION.

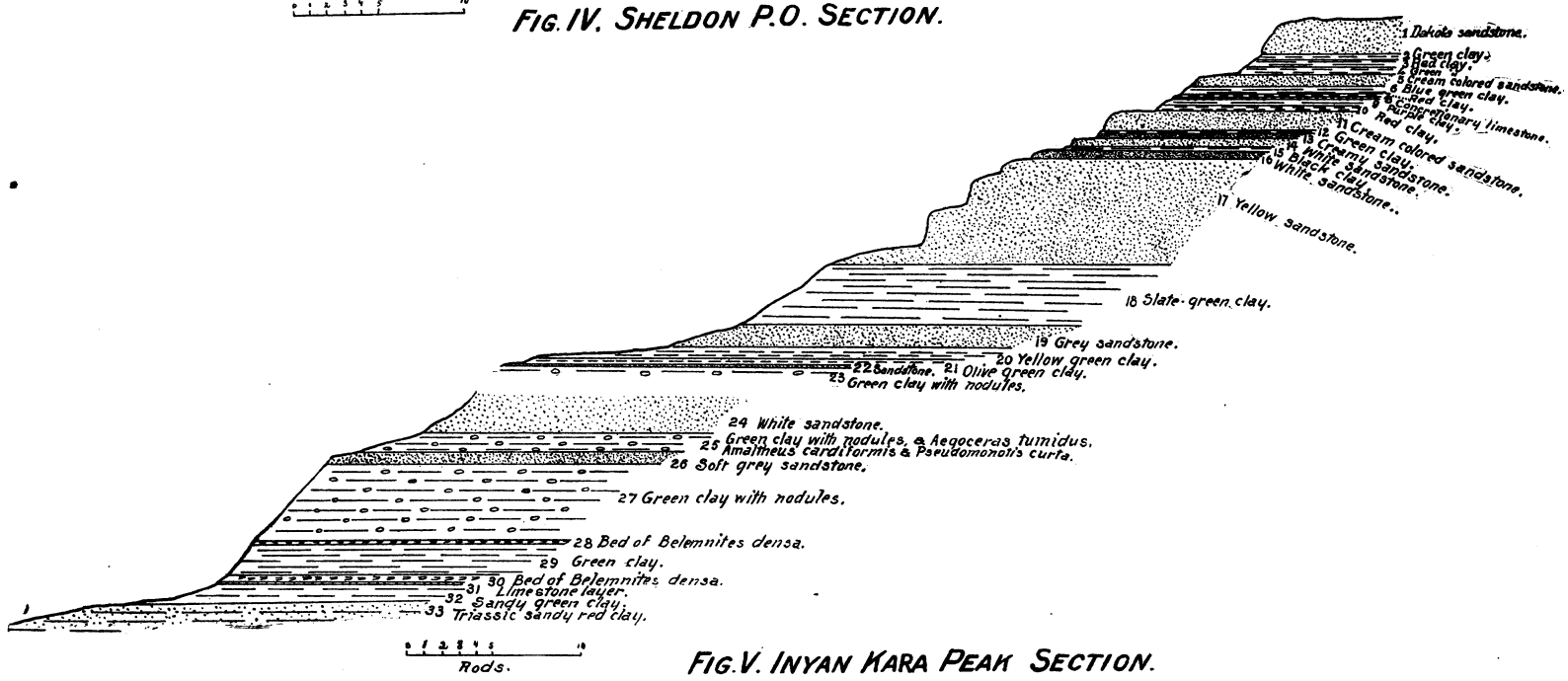

FIG. V. INYAN KARA PEAK SECTION.

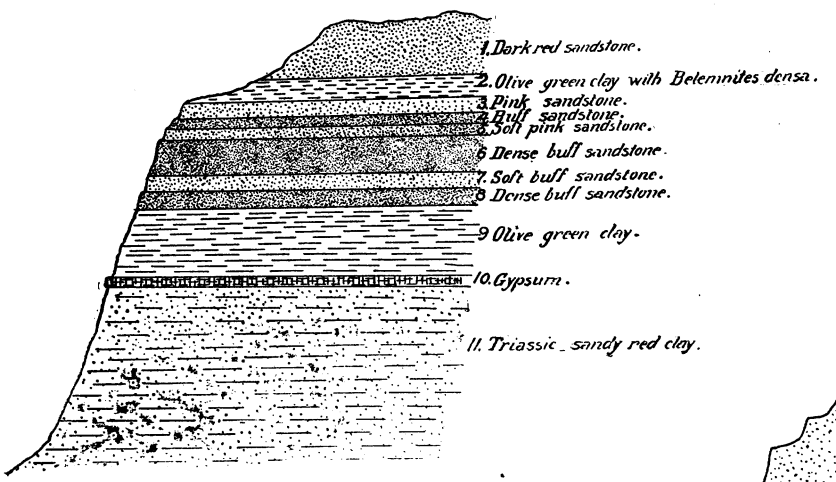

FIG. VI. SALT CREEK SECTION.

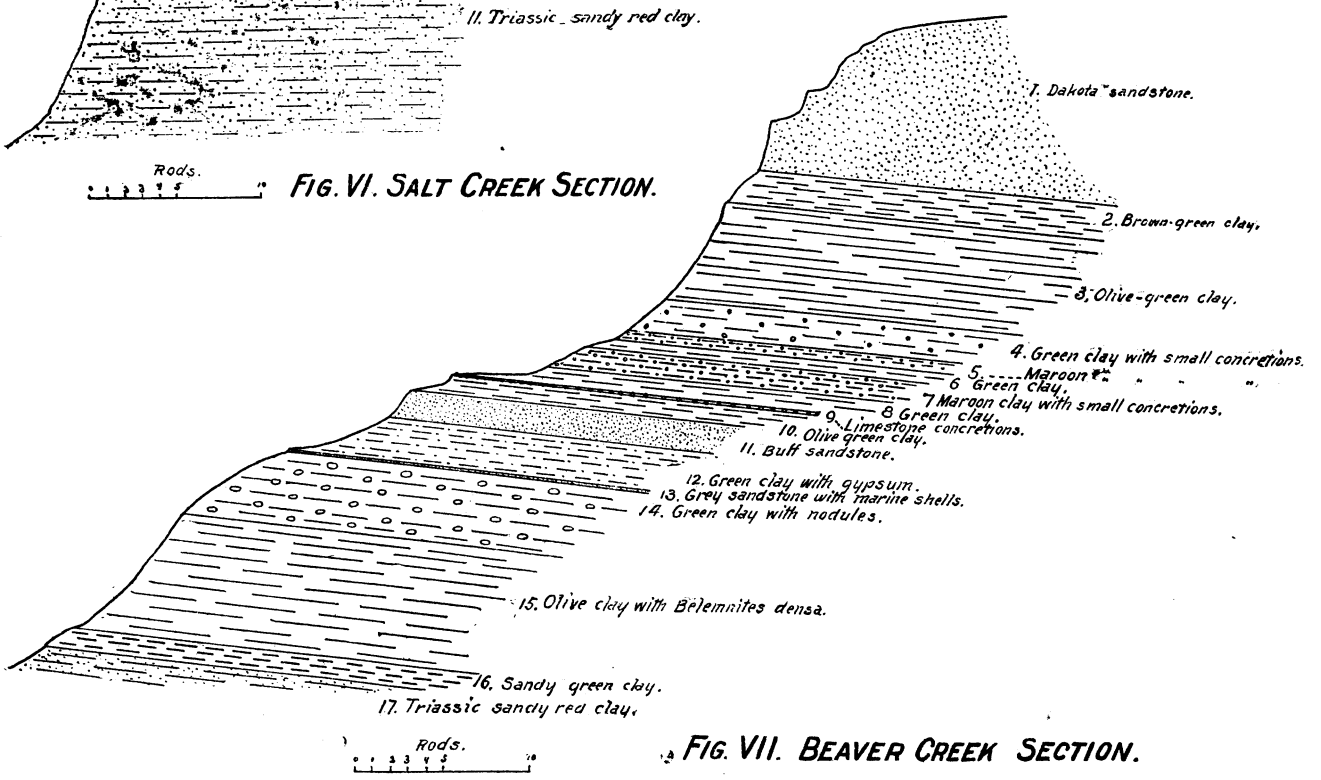

FIG. VII. BEAVER CREEK SECTION.