

Article III.—FAUNAL HORIZONS OF THE WASHAKIE FORMATION OF SOUTHERN WYOMING.

BY WALTER GRANGER.

PLATES II-VI.

INTRODUCTION.

Dr. W. J. Sinclair has recently shown¹ that the rocks of the Washakie beds, like those of the Bridger, are formed entirely of volcanic material, but that the nature of this material differs markedly from that of the Bridger sediments. The older idea that both formations may have been deposited in different parts of the same lake has long been abandoned and the theory that the Washakie was deposited separately and at a somewhat later time has gradually taken its place. The chief evidence for considering the Washakie as more recent than the Bridger has been palæontological. Compared with the Bridger and Uinta beds, fossils in the Washakie are not abundant, but as material has gradually accumulated, through the efforts of Cope and Marsh, and of parties from Princeton University and the American Museum, it has finally become evident that the Washakie fauna represents two distinct facies; one closely related to that of the upper Bridger, the other to that of the Uinta. Recent studies on the Titanotheres by Professor Osborn have afforded much evidence on this point. In the summer of 1906 the writer, in company with Professor Osborn, examined thoroughly the northern part of the Washakie beds, where by far the larger part of the fossils have been obtained, a special effort was then made to determine the levels of all important specimens which have been found in the beds, for the purpose of outlining the faunal horizons. In this short article, written at the suggestion of Professor Osborn, an attempt is made to indicate these horizons and to present as clearly as possible the distinctive mammalian fauna of each.

HISTORICAL.

The first use of the name Washakie (Washakee) as applying to a geological group is in Hayden's Preliminary Field Report, 1869,² and appears to include, aside from what is now termed Washakie, strata belonging to the

¹ Paper entitled "The Washakie, A Volcanic Ash Formation" read before the Am. Soc. Vert. Palae., at New Haven, Dec., 1907.

² F. V. Hayden, 1869; Prelim. Field Report, U. S. Geol. Surv. Col. and N. Mex., p. 90.

Green River shales and to the Wasatch formation. Hayden's reference is as follows: "From Creston to Bitter Creek there are a series of purely fresh-water beds, with some beds of impure lignite, with vast quantities of fossils belonging to the genera *Unio*, *Melania*, *Vivipara*, *Helix*, etc. This group I regard as middle tertiary, and the strata are very nearly horizontal. I have regarded these beds as separated from the lower tertiary or true lignite group, and have designated them by the name of the Washakie group." This description refers more particularly to the Tertiary beds that are exposed along the Union Pacific Railway, but in his Fourth Annual Report for 1870,¹ Hayden describes the actual Washakie exposures along the Overland Stage Trail as follows: "Between La Clede and Barrel Springs the strata are very nearly horizontal. The surface is less rugged; still to the south of the road are high, rather abrupt ridges, and in the distance are quite pointed ridges three hundred feet high, composed of the somber, hard, indurated, rusty, arenaceous clays which characterize the Bridger group. Indeed, from its form and style of weathering, and the color of its sediments, it could not be distinguished from the high ridges of the Bridger beds west of our road from Henry's Fork to Green River Station. Although I have hitherto regarded the group of beds which I have denominated the 'Washakie group,' as separated from those of Green River and to the westward, yet I am now inclined to believe that the upper series is either an extension eastward of the Bridger group or synchronous with it. Fragments of turtles and other vertebrate remains are not uncommon."

Immediately following the discovery of vertebrate fossils in these Washakie bad lands both Professor Marsh and Professor Cope made collecting expeditions into the basin and the former maintained collectors there for several seasons. Little has been published by Marsh concerning the topography or geology of the basin but Cope has given a very good account of his explorations in this region, in 1872,² especially in the vicinity of Haystack Mountain, in the northern part of the basin, where he found the splendid type skull of *Eobasileus* (*Loxolophodon*) *cornutus*, and his somewhat lengthy account of the exact locality in which the skull was found serves to locate the specimens as coming from near the top of the formation.

In 1877 King in his systematic Geology of the Fortieth Parallel Survey gives the first extended description of the Tertiary deposit of the Washakie Basin. The Washakie, or Bridger group of the Washakie Basin, as he terms it, is here described, and mapped in the atlas accompanying the report, as occupying the center of the basin and resting probably unconformably

¹ Preliminary Report of the U. S. Geol. Surv. of Wyo. and Portions of Contiguous Terrs., 1871, p. 73.

² Penn Monthly Magazine, August, 1873.

upon the Green River shales and entirely surrounded by exposures of the same; the Green River shales in turn resting upon the Vermillion Creek beds (Wasatch) which are exposed in a nearly continuous circle outside. King, while believing that the sediments of the Bridger group in the Washakie and Bridger basins were of nearly contemporaneous deposition, expresses doubt as to whether they were laid down in one lake or in separate smaller lakes, but rather inclines to the latter theory, thinking it improbable that all sediment connecting the two areas should have been removed by erosion.

Professor Osborn in 1881¹ favored the separate deposition theory, pointing out not only a considerable dissimilarity between the sediments of the two basins and their mode of weathering, but in the fauna as well, and assumed that there may have been some difference in the date of their deposition. The Princeton Scientific Expedition which visited the Washakie Basin in 1878, and of which Professor Osborn was a member, was fortunate in securing an extensive and important collection, especially from the upper horizon in which mammalian remains are particularly scarce. Accompanying the memoir by Professor Osborn, cited above, is a Stratigraphic Report on the Washakie beds by Professor John B. McMaster, the leader of the Expedition. In this report the strata are described in detail, several cross-sections of the exposures are figured and, most important of all, the levels of many of the fossils found by the party are given. The thickness of the sediments described is given as about 700 feet, but there is an error in the joining of two of his sections taken at different localities; one section partly duplicating the other, instead of their forming one continuous section as he states.

Prof. Scott, 1889,² in reviewing the faunæ of the Bridger, Washakie and Uinta beds, points out the differences between the fauna of the Washakie and that of the Bridger and states that "where the fauna of the Washakie basin departs from that of the Bridger basin, it does so in the way of resemblance to the Uinta," and concludes, therefore, that the Washakie beds represent a somewhat later date of deposition than the Bridger.

Since the Princeton Expedition there have been three collecting expeditions made into the basin by the American Museum. The first, in 1893, under Dr. J. L. Wortman, discovered a rich field in the lower part of the formation in what was entered on the field records as the "Lower Brown Sandstone." This stratum yielded numerous skulls and skeletal parts of *Uintatheres* and *Titanotheres*. In 1895, Dr. Wortman conducted the

¹ Cont. from E. M. Museum of Geol. and Archæ. of the College of N. J., Vol. I, No. I, p. 13.

² Am. Phil. Soc. Trans., 1889, Vol. XVI, Pt. iii, pp. 462-470.

second expedition into the basin, when the party discovered an outcrop of this same Brown Sandstone in the extreme southern part of the basin, in the vicinity of the Cherokee Trail, which proved rich in the forms found to the north in the same layer. The third expedition, in charge of the writer, in 1906, examined quite thoroughly the entire northern half of the exposures, making a special effort to collect fossils from the upper horizon, collecting a complete series of the rocks and making stratigraphic notes.

The observations made on the expedition together with the results previously obtained may now be set forth.

TOPOGRAPHY AND GEOLOGY.

The Washakie Formation occupies a somewhat circular area of over three hundred square miles; the northern border extends to within twenty miles of the Union Pacific Railroad between the stations of Red Desert and Bitter Creek, and nearly the entire area lies between the old Overland Stage Trail, on the north, and the Cherokee Trail to the south: it is separated from the nearest exposures of the Bridger beds to the west by a distance of about fifty miles. The Overland Trail, five miles east of La Clede Station, passes up over the lowest bench of the formation near its northern limit and after running along the bench for five miles turns down again at Tadpole station into the underlying beds of the Green River group.

The limits of the formation are outlined, except to the southwest by a prominent bench which is capped with a conspicuous layer of hard, rusty, brown sandstone. The face of this bench, which weathers nearly vertically, is nearly 100 feet high along its northern border but to the southeast and southwest it gradually diminishes in height until it finally merges into the plain and the sandstone layer is lost beneath the growth of sage brush. A few miles south of the northern part of this bench there arises abruptly from the plain a long ridge of bad lands, partly covered with cedars, and reaching an elevation above the plain in places of 400 feet. The ridge extends in an east and west direction for six miles. To the east the elevation terminates suddenly in a partly isolated conical butte; to the west an obtuse angle is formed and the elevation gradually drops away to the southwest and four or five miles distant is lost in the plain. The entire ridge is known locally as Haystack Mountain and on the field records of most of the collecting parties it appears as such. Professor Cope, though, in his description of the region apparently uses the name only for the conical butte at the eastern end; the rest he calls "Mammoth Buttes."

Haystack Mountain forms the northern border of an extensive semi-

circular central basin, the rim of which reaches from the western end of Haystack Mountain southward almost to the southern limit of the formation.

This basin is open to the eastward and is drained by Sand Creek. The creek is nothing more than a dry sand arroyo except during times of rain or melting snow. From the edge of the rim the sage brush plain falls away abruptly giving the basin something the appearance of a gigantic crater. McMaster aptly likened it to a great arena. The floor of the basin is rather level and regular, being broken only by a few low tables and buttes which have, by reason of hard sandstone cappings, withstood the erosion, but the sides, which are cut down below the plain from two to four hundred feet, present one of the most extraordinary examples of bad land topography to be found in our western Tertiary beds. The innumerable, deep, vertical-walled cañons, the great variety of architectural forms and the brilliant coloring, especially just after a rain, make a magnificent spectacle.

Between the rim of this basin and the sandstone ledge, mentioned as being at the base of and outlining the formation, a distance of from one to five miles, the surface is rolling prairie covered with a dense growth of sage brush, broken here and there by low benches of sandstone and bad land 'pockets,' none of any great extent. To the north and west of Haystack Mountain the region is drained by the upper reaches of Bitter Creek; to the southwest and running along nearly parallel with the rim of the central basin is Shell Creek, a tributary of Vermillion Creek. These creeks are usually without running water during the summer. Two springs of importance occur in the northern part of the region. The first, called La Clede spring, flows from the banks of Bitter Creek one mile below the La Clede Station and eight miles from the northwest point of Haystack Mountain. The other is in the open prairie twelve miles southwest of La Clede and is known as Kinney Spring. The drainage here is into Shell Creek. It is five miles directly east from Kinney Spring to the edge of the central basin. The bad lands at this part of the rim are known, because of their peculiar form of weathering, as "Adobe Town."

The entire thickness of the Washakie beds, measured from the brown sandstone at the Overland Trail to the summit of Haystack Mountain, is approximately 650 feet; below the brown sandstone there is exposed in the northern part of the basin a hundred feet of gray sandy shales which, so far as a careful examination has shown, are unfossiliferous. On the other hand, the overlying brown sandstone is the richest in mammalian remains of any of the Washakie strata, and in layers immediately above the Sandstone bones are found in some abundance. There seems to be no unconformity between the sandstone and the underlying shales. Accumulations of soil obscure contact between these shales and beds of undoubted Green River

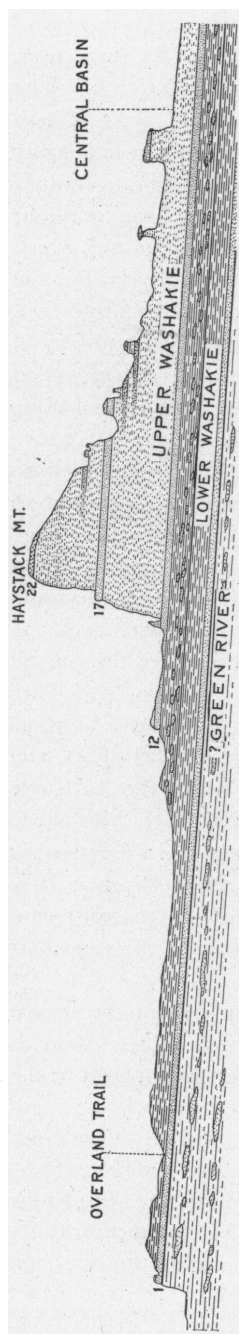


Fig. 1. Cross section through the northern part of the Washakie formation; looking east. A horizontal distance of about five miles is represented. The numbers correspond with those of the section on p. 19.

age, and whether they should be included in the Washakie or not the writer is in doubt. King has recorded a difference of dip of several degrees between the Green River beds and the nearest definite Washakie beds in the southern part of the basin.

Throughout the greater part of the formation the beds show a decided dip, and always toward the center of the basin. In the northern part the dip averages 6° , and the lowermost strata pass under the base of Haystack Mountain and under the central basin at a considerable depth, although the floor of the center of the basin is lower than the brown sandstone outcrop to the north and west. This has led to some confusion regarding the levels of certain important specimens, such as the skulls of *Achænedon* and *Amynodon* collected by the Princeton party and which were recorded as coming from the lower levels because they were found at the base of the bad lands inside the central basin. This level if traced out carefully to the north side of Haystack Mountain would be found well up on the side of the mountain. In the roughly sketched section (Fig. 1) the relation of the upper and lower horizons to the Mountain, plain and central basin are shown. In Professor McMaster's sections that numbered 2 was taken inside the basin and is therefore duplicated by his section number 1 which was taken from the summit of Haystack Mountain down to a bench well out in the plain toward the basal sandstone.

The section given below was taken at the east end of Haystack Mountain, because a more perfect exposure exists there, especially of the lower beds. The Lower Brown Sandstone here approaches to within a mile of the base of the mountain, and not more than half of the intervening area is

covered with soil or vegetation. The term 'sandstone' is applied to those strata which have been generally termed sandstones. According to Dr. Sinclair, quartz does not enter, in any appreciable quantity, into the structure of Washakie rocks.¹

Section of the Washakie beds taken from the Summit of Haystack Mountain, at the east end, down to the Basal Sandstone at Tadpole Stage Station on the Overland Trail.

Top.

22. Very coarse and very hard greenish sandstone, weathering brown . . . 15 feet.
Not fossiliferous. This layer breaks up into enormous blocks weighing many tons each which are found strewn over the side of the mountain.
21. Gray, green, salmon colored and purple sandstones and sandy shales with a few thin bands of clay shales 150 feet.
To the westward the salmon tints give way to pink. From Cope's description it was apparently in this division and a few miles to the west that he found the skull of *Eobasileus cornutus*.
20. Light gray (nearly white) coarse sandstone, cross bedded and of only local occurrence 20 feet.
19. Gray and brown sandy shale and loosely compacted gray sandstone. 45 feet.
On approximately this level and in very light gray sandstone, on the northwestern face of the mountain, was found the skull of *Dolichorhinus hyognathus*.
18. Light brown clay shale 8 feet.
17. Very coarse loosely packed gray sandstone, containing pebbles and clay pellets in layers 15 feet.
Except in the uppermost and lowermost strata this is the most constant layer found in these beds. To the westward it is of a pale yellowish green color and can be traced around the point of the mountain and then to the southwest until it is lost under the plain. The type skull of *Metarhinus earlei* and the skull of an undescribed species of *Limnocyon* are from this stratum.
16. Gray sandy shale, with one thin band of gray sandstone 5 feet.
15. Gray, greenish and yellowish sandy shales and soft sandstones . . . 50 feet.
Represented to the westward chiefly by light gray and pink sandstone.
14. Green and blue-gray sandstone, weathering vertically 15 feet.
13. Greenish gray sandy shale and soft sandstone 50 feet.
The disintegrated material on the surface of this stratum is a foot or more deep.
12. Hard, fine, green and greenish gray sandstone 2 feet.
11. Light gray sandy shale, weathering white 4 feet.
This was a rather conspicuous stratum and quite constant at the east end of the mountain. To the west the stratum passes under the plain.

¹ The sandstones have been classified by Dr. Sinclair as Tuff Sandstone and Feldspar conglomerate.

10.	Gray and greenish gray sandy shales, a harder layer at the top forming a bench	15 feet.
9.	Flinty hard greenish sandstone	2 feet.
	A bench of considerable extent is formed by this layer.	
8.	Gray sandy shale, with two layers of nodular sandstone	35 feet.
7.	Hard, brittle, shaly sandstone, weathering brown	1 foot.
6.	Gray and greenish sandy shale alternating with gray, brown-weathering sandstone, the lower twenty feet having thin bands of mottled clay weathering red	60 feet.
5.	Area of one half mile covered with sage brush; represented at other localities by numerous layers of gray nodular sandstones (weathering rusty color) interstratified with gray sandy shales.	
	Fossils fairly abundant	approx. 75 feet.
4.	Gray sandy shale	10 feet.
3.	Brown sandstone (local)	10 feet.
2.	Gray sandstone, bluish and gray sandy shale and hard fissile shale	40 feet.
	The fissile shales are pale green in places, particularly near La Clede Station and toward the Kinney Spring. Remains of the smaller mammals are rather abundant in the division.	
1.	Hard sandstone, weathering rusty brown, nodular in places and very uneven as to thickness. In some places it consists of several thin layers separated by sandy shale, in others of a single solid stratum. This is the Lower Brown Sandstone of the Amer. Mus. Expedition of 1893 and 1895. It extends in a nearly continuous rim around the Basin and marks the limits of the Washakie formation.	
	Rich in Mammalian remains, especially of Uintatheres and Titanotheres. Average thickness	15 feet.
Total thickness		642 feet.

There is no evidence of a break in sedimentation from the base to the summit of the Washakie series but the beds seem to fall into two horizons; the lower 250 feet and the upper 400 feet. Divided in this manner, the upper horizon is characterized by coarse white, pink and salmon-colored sandstones and by the extremely coarse green sandstones, or feldspar conglomerates; the lower horizon is characterized by the rusty brown nodular sandstones. The fine green tuff-sandstones occur in both horizons. In general appearance the lower beds are dull and somber while the upper ones are bright and often highly colored. Stratum No. 11, a nearly white sandy shale, was selected, for the purpose of field labelling, as dividing the lower from the upper beds, which were termed respectively horizons A and B. Fossils found immediately below stratum No. 11 (*Manteoceras* and *Sinopa*) pertain to that phase of the fauna which more nearly resembles the fauna of the Bridger, while the first fossils found, about 60 feet above the datum plane, pertain to the Uinta phase. The layer was selected because it was continuous and easily recognized. Most of the subdivisions recognized in

the section given above do not exist, with any uniformity of character, over

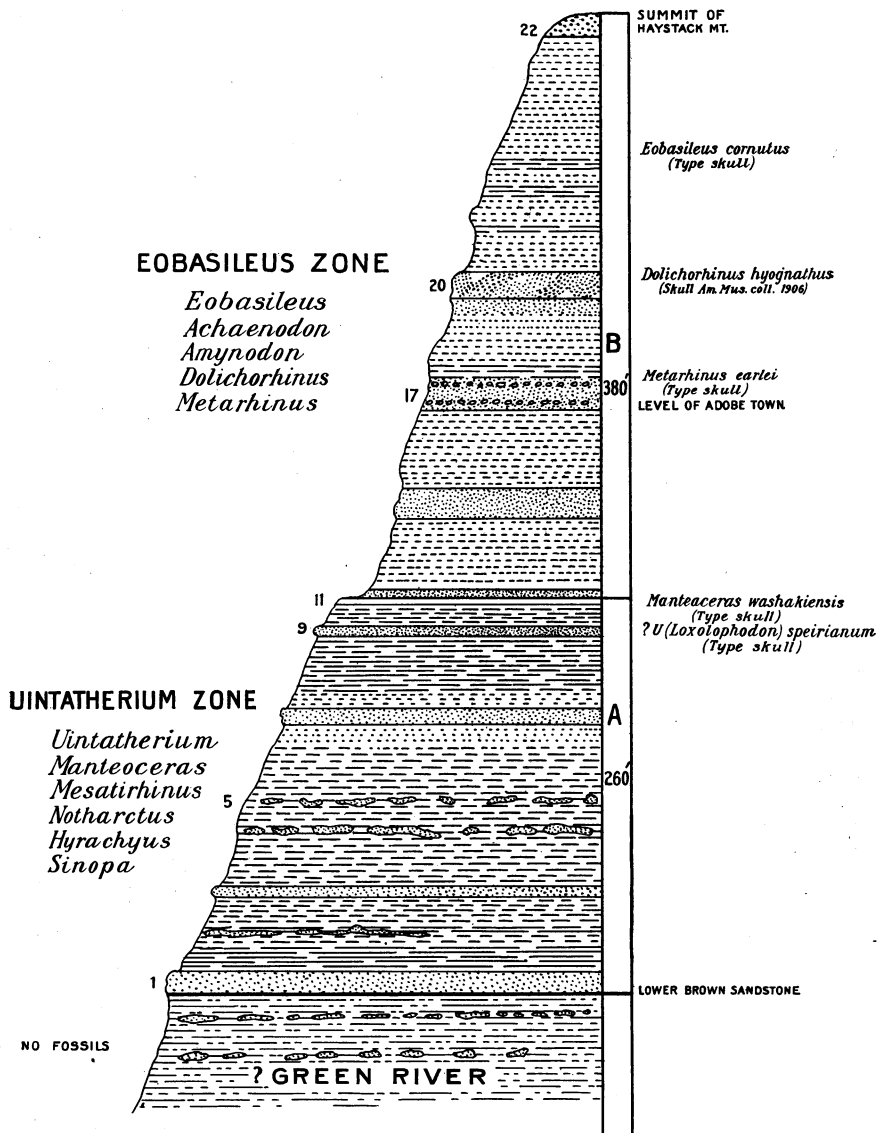


Fig. 2. Columnar section of the Washakie beds.

any great area. It is possible that strata Nos. 12 and 13 (55 feet) should be included in the lower horizon.

FAUNA.

Conforming with the petrographic differences between the upper and lower horizons is a marked difference in their faunæ, representing, nearly, the difference between the fauna of the Upper Bridger and the Lower Uinta. The following table, compiled with the assistance of Dr. W. D. Matthew, includes the genera known to occur in the Washakie with the horizons of their occurrence given wherever known.

Occurrence of Washakie Mammalian Genera.

	Bridger	Washakie		Uinta
		Hor. A.	Hor. B.	Hor's. A. & B.
Hemiacodon	*	*		
Notharctus	*	*		
Hyopsodus	*	*	?*	*
Miacis	*	*		
Thinocyon	*	*		
Sinopa	*	*		
Synoplotherium (incl. Dromocyon)	*	*		
Patriofelis	*	*		
Harpagolestes	*		*	*
Limnocyon	*		*	
Uintatherium	*	*		
Eobasileus			*	?*
Amynodon			*	*
Hyrachyus	*	*	?*	
Triplopus			?*	
"Triplopus" amarorum ¹			?*	*
Desmatotherium		?*		
Dilophodon		*		
Palæosyops	*	*		
Manteoceras	*	*		
Telmatherium	*	*		
Mesatirhinus	*	*		
Dolichorhinus			*	*
Metarhinus			*	*
Homacodon	*	*		
Achænodon			*	*
(?) Protylopus			*	*
Paramys	*	*	*	*

¹ The type of *Triplopus amarorum* Cope is from the Washakie, level uncertain. It does not belong to this genus as defined by the generic type *T. cubitalis* Cope.

From the above table it will be seen that the genera of the Lower Washakie are, almost without exception, found in the Bridger, and, it may be added, are represented by species closely allied to Upper Bridger species and in some cases identical with them. None of them excepting *Hyopsodus* and *Paramys* pass through to the Uinta.

The genera of the Upper Washakie are mostly distinct from those of the Lower Washakie or Bridger and are represented in the lower horizons of the Uinta by closely allied or identical species. Two Bridger genera of Carnivora, *Harpagolestes* and *Limnocyon*, are represented in the Upper Washakie and not in the Lower, but the species differ widely from those of the older horizon.

The entire absence from the Washakie of such a group as the Hyracothers can be accounted for only by the fact that fossils, and this is true especially of the smaller forms, are comparatively rare there; that the animals existed there at that time but that their remains have not yet been discovered.

So far as discoveries have gone, however, they tend to show that faunally the Lower Washakie corresponds with the Bridger C and D (Middle Eocene) and the Upper Washakie with the Uinta A and B (Upper Eocene).

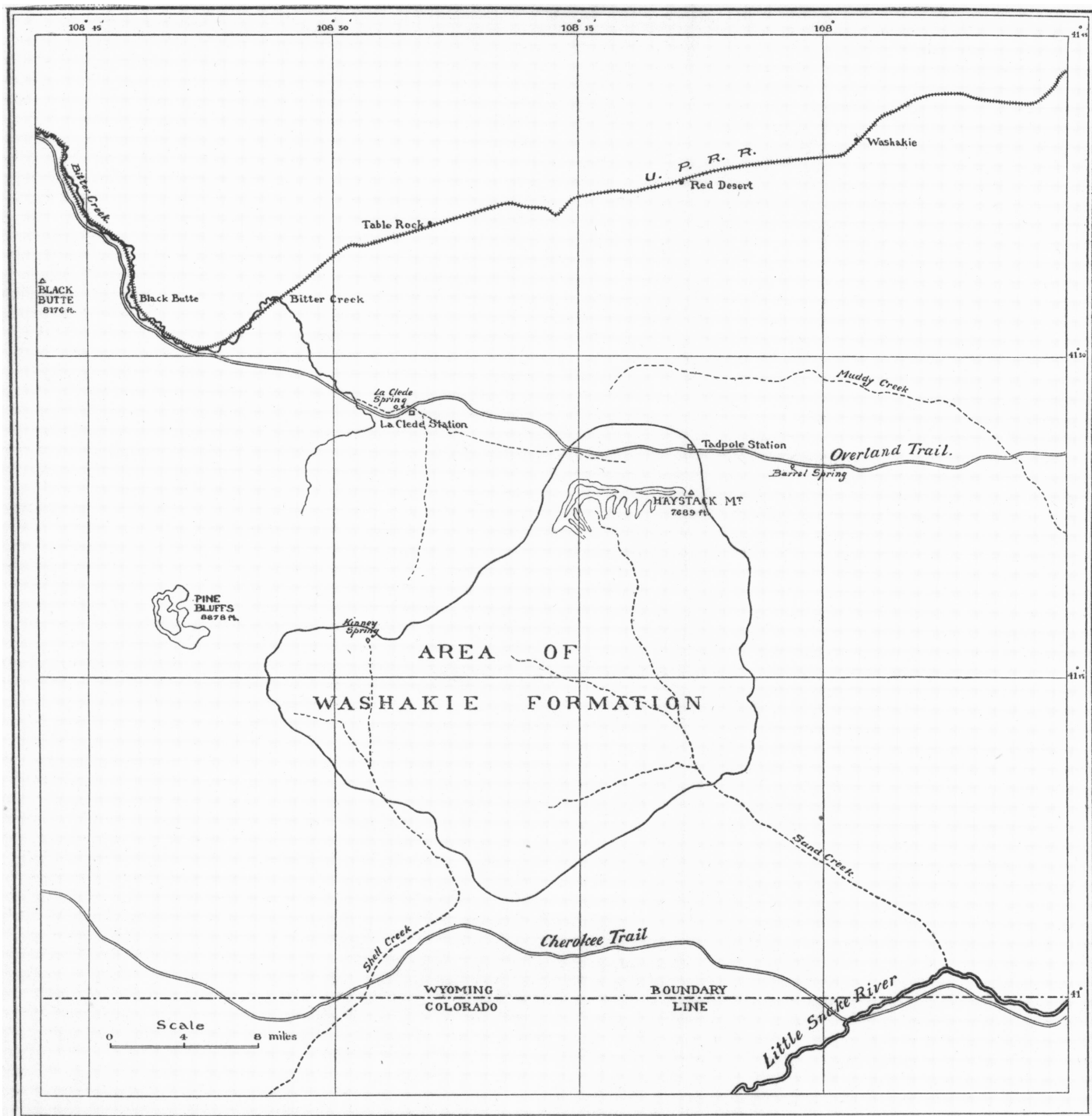
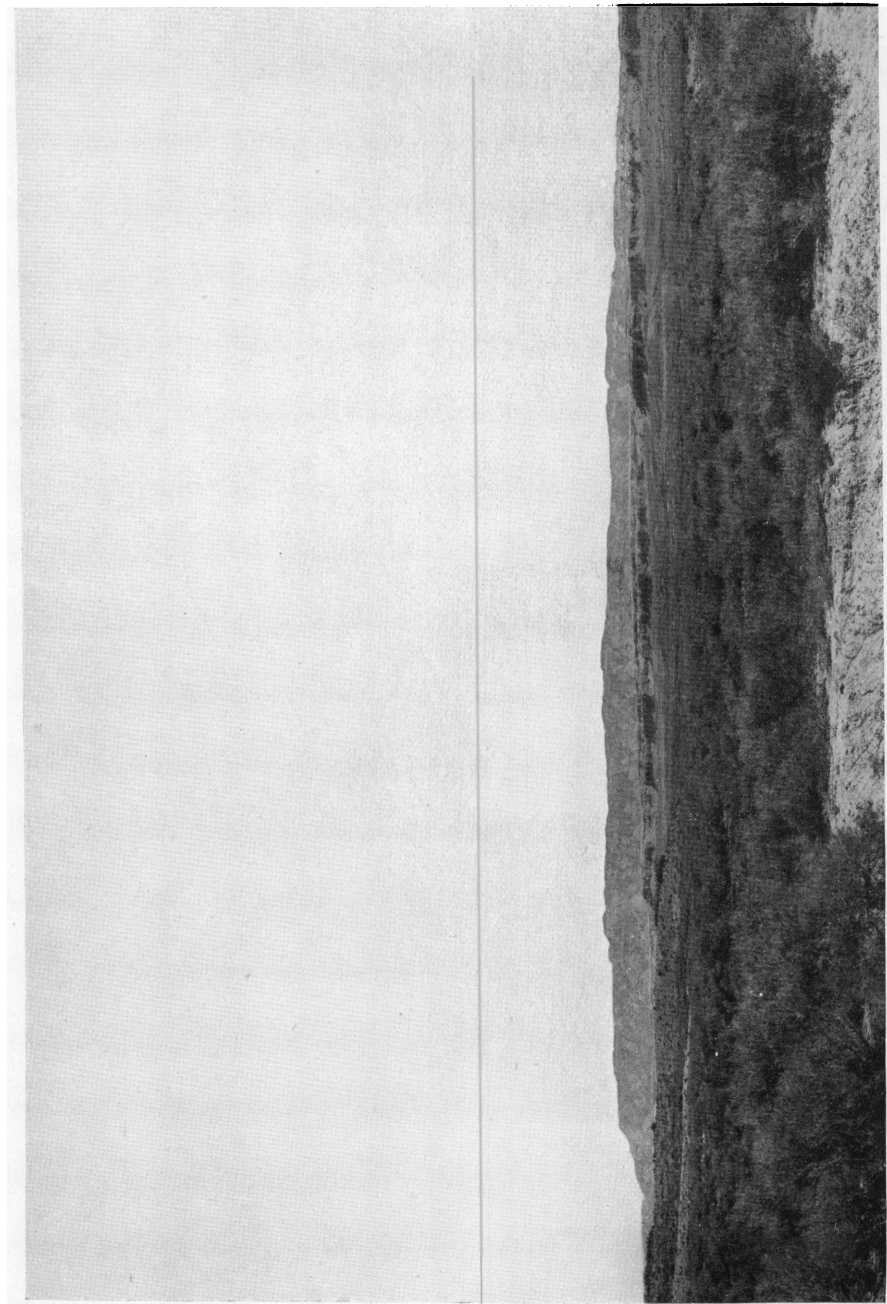


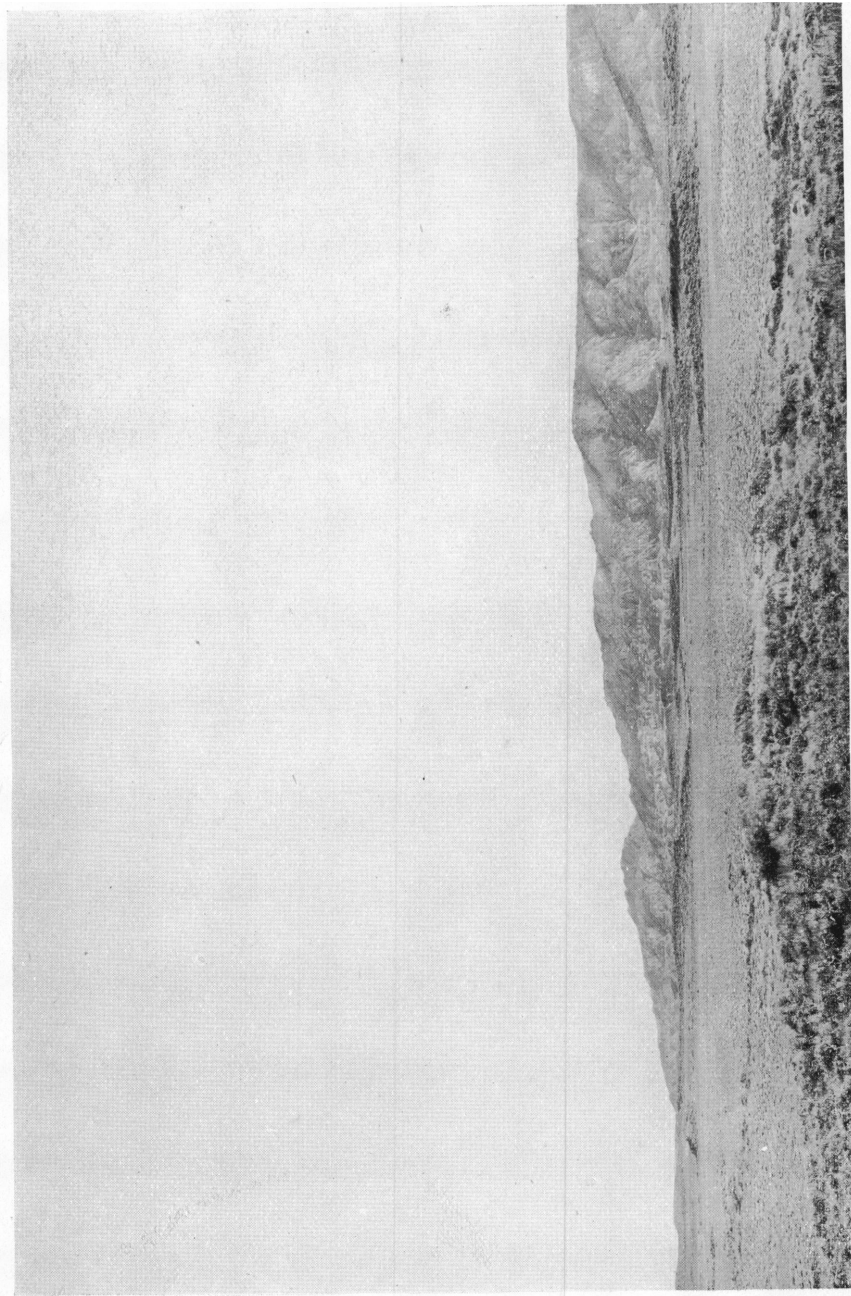
Fig. 3. Sketch map of the Washakie Basin region, southern Wyoming. From King, with additions and slight alterations.



Detail of bad lands along the northwestern face of Haystack Mountain (Hor. B). Showing talus of heavy blocks of coarse green sandstone (No. 22) from the uppermost stratum. The skull of *Dolichorhinus hypognathus* was found near this point.

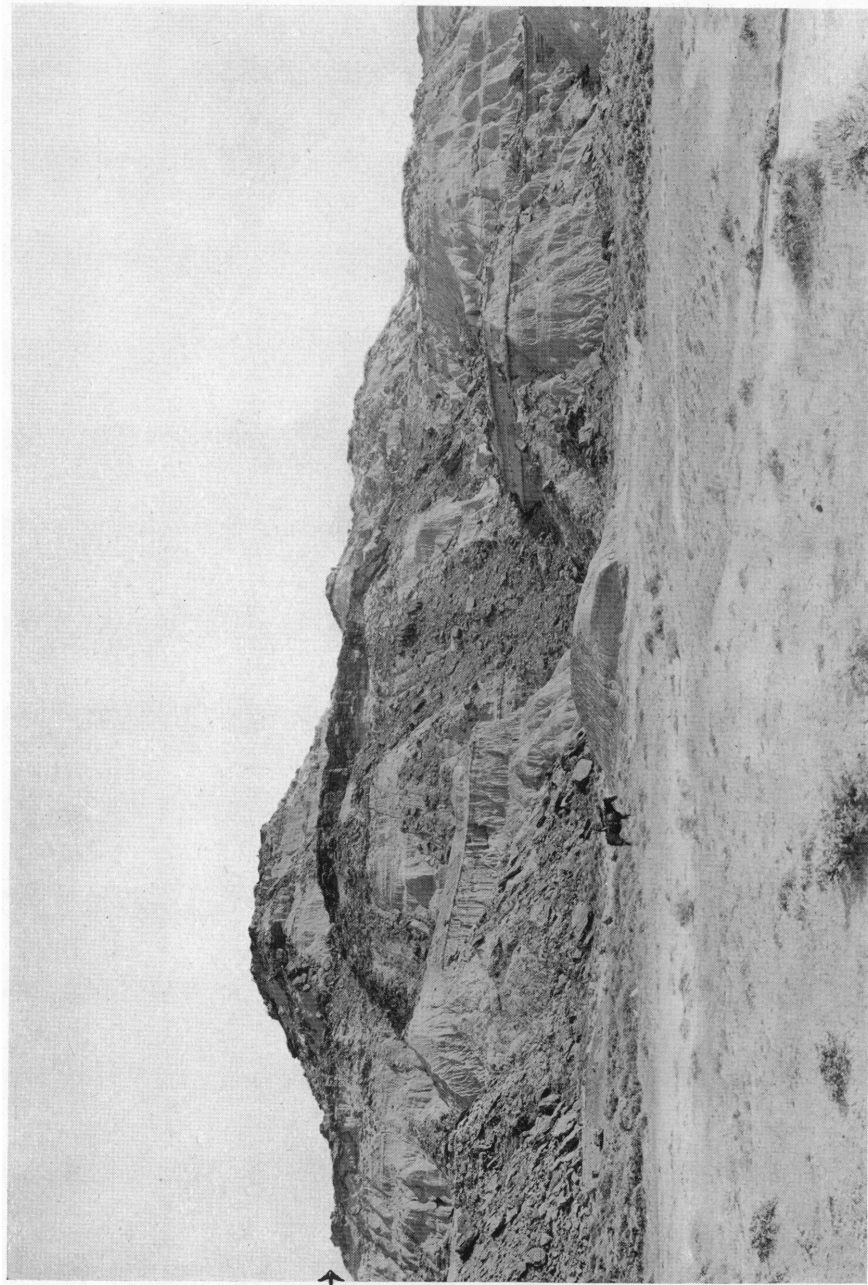


Haystack Mountain from La Clede Station, looking southeast, up Bitter Creek. The Lower Brown Sandstone rim is shown in the middle distance.

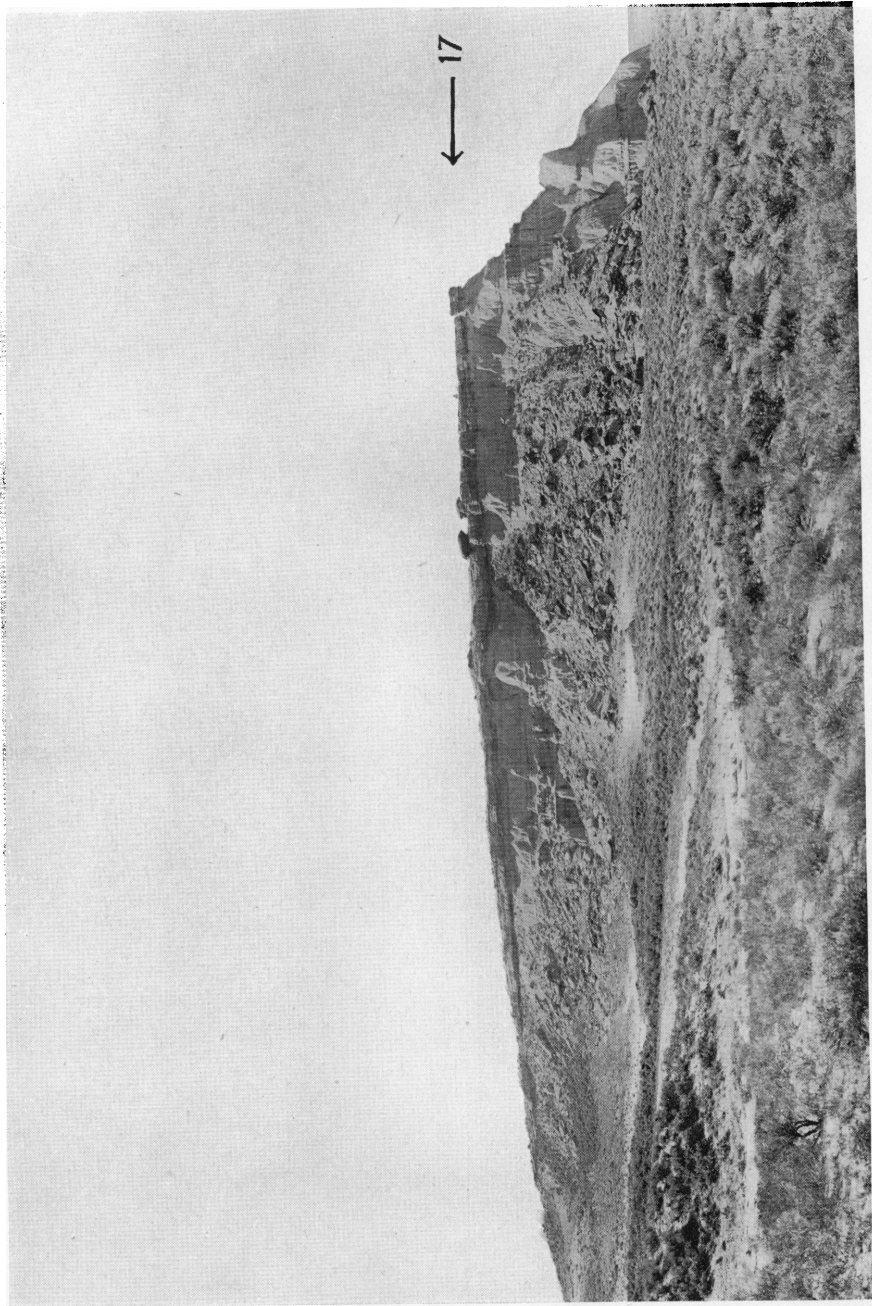


Eastern end of Haystack Mountain. Looking southeast from the Overland Trail. The top of horizon A is at the base of the mountain at this point.

17 →



Northwestern point of Haystack Mountain (Hor. B). The white and pink sandstones are well shown in this view. The coarse green sandstone (No. 17) occurs about half way up the mountain.



Outlier along northwestern face of Haystack Mountain (Hor. B), showing dip of strata. The butte is capped by the coarse pale green sandstone stratum (No. 17).

