DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

GEOLOGIC ATLAS

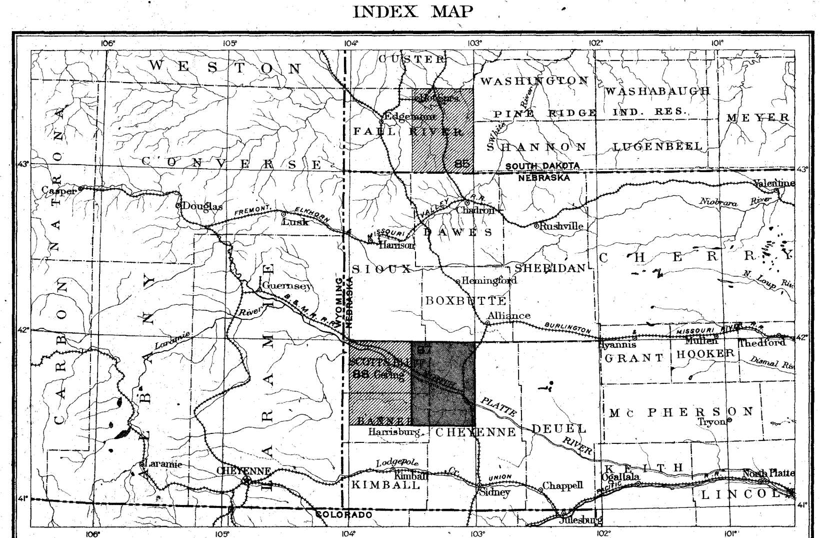
OF THE

UNITED STATES

CAMP CLARKE FOLIO

NEBRASKA

INDEX MAP



SCALE: 40 MILES-1 INCH

AREA OF THE CAMP CLARKE FOLIO

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LIBRARY EDITION

CAMP CLARKE FOLIO
NO. 87

WASHINGTON, D. C.

ENGRAVED AND PRINTED BY THE U. S. GEOLOGICAL SURVEY

GEORGE W. STOSE, EDITOR OF GEOLOGIC MAPS   S. J. KUBEL, CHIEF ENGRAVER

1903

EXPLANATION.

The Geological Survey is making a geologic map of the United States, which necessitates the preparation of a topographic base map. The two are being issued together in the form of an atlas, the parts of which are called folios. Each folio consists of a topographic base map and geologic maps of a small area of country, together with explanatory and descriptive texts.

THE TOPOGRAPHIC MAP.

The features represented on the topographic map are of three distinct kinds: (1) inequalities of surface, called *relief*, as plains, plateaus, valleys, hills, and mountains; (2) distribution of water, called *drainage*, as streams, lakes, and swamps; (3) the works of man, called *culture,* as roads, railroads, boundaries, villages, and cities.

Relief.—All elevations are measured from mean sea level. The heights of many points are accurately determined, and those which are most important are given on the map in figures. It is desirable, however, to give the elevation of all parts of the area mapped, to delineate the horizontal outline, or contour, of all slopes, and to indicate their grade or degree of steepness. This is done by lines connecting points of equal elevation above mean sea level, the lines being drawn at regular vertical intervals. These lines are called *contours*, and the uniform vertical space between each two contours is called the *contour interval.* Contours and elevations are printed in brown.

The manner in which contours express elevation, form, and grade is shown in the following sketch and corresponding contour map:

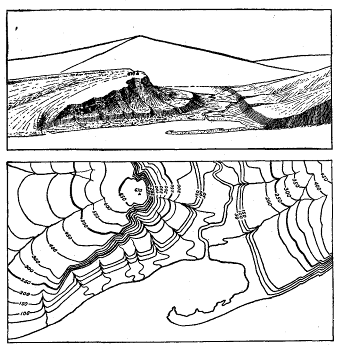


Fig. 1.—Ideal sketch and corresponding contour map.

The sketch represents a river valley between two hills. In the foreground is the sea, with a bay which is partly closed by a hooked sand bar. On each side of the valley is a terrace. From the terrace on the right a hill rises gradually, while from that on the left the ground ascends steeply in a precipice. Contrasted with this precipice is the gentle descent of the slope at the left. In the map each of these features is indicated, directly beneath its position in the sketch, by contours. The following explanation may make clearer the manner in which contours delineate elevation, form, and grade:

1. A contour indicates approximately a certain height above sea level. In this illustration the contour interval is 50 feet; therefore the contours are drawn at 50, 100, 150, 200 feet, and so on, above sea level. Along the contour at 250 feet lie all points of the surface 250 feet above sea; and similarly with any other contour. In the space between any two contours are found all elevations above the lower and below the higher contour. Thus the contour at 150 feet falls just below the edge of the terrace, while that at 200 feet lies above the terrace; therefore all points on the terrace are shown to be more than 150 but less than 200 feet above sea. The summit of the higher hill is stated to be 670 feet above sea; accordingly the contour at 650 feet surrounds it. In this illustration nearly all the contours are numbered. Where this is not possible, certain contours — say every fifth one — are accentuated and numbered; the heights of others may then be ascertained by counting up or down from a numbered contour.

2. Contours define the forms of slopes. Since contours are continuous horizontal lines conforming to the surface of the ground, they wind smoothly about smooth surfaces, recede into all reentrant angles of ravines, and project in passing about prominences. The relations of contour curves and angles to forms of the landscape can be traced in the map and sketch.

3. Contours show the approximate grade of any slope. The vertical space between two contours is the same, whether they lie along a cliff or on a gentle slope; but to rise a given height on a gentle slope one must go farther than on a steep slope, and therefore contours are far apart on gentle slopes and near together on steep ones.

For a flat or gently undulating country a small contour interval is used; for a steep or mountainous country a large interval is necessary. The smallest interval used on the atlas sheets of the Geological Survey is 5 feet. This is used for regions like the Mississippi delta and the Dismal Swamp. In mapping great mountain masses, like those in Colorado, the interval may be 250 feet. For intermediate relief contour intervals of 10, 20, 25, 50, and 100 feet are used.

Drainage.—Water courses are indicated by blue lines. If the streams flow the year round the line is drawn unbroken, but if the channel is dry a part of the year the line is broken or dotted. Where a stream sinks and reappears at the surface, the supposed underground course is shown by a broken blue line. Lakes, marshes, and other bodies of water are also shown in blue, by appropriate conventional signs.

Culture.—The works of man, such as roads, railroads, and towns, together with boundaries of townships, counties, and States, and artificial details, are printed in black.

Scales.—The area of the United States (excluding Alaska) is about 3,025,000 square miles. On a map with the scale of 1 mile to the inch this would cover 3,025,000 square inches, and to accommodate it the paper dimensions would need to be about 240 by 180 feet. Each square mile of ground surface would be represented by a square inch of map surface, and one linear mile on the ground would be represented by a linear inch on the map. This relation between distance in nature and corresponding distance on the map is called the scale of the map. In this case it is "1 mile to an inch." The scale may be expressed also by a fraction, of which the numerator is a length on the map and the denominator the corresponding length in nature expressed in the same unit. Thus, as there are 63,360 inches in a mile, the scale of "1 mile to an inch" is expressed by $\frac{1}{63,360}$. Both of these methods are used on the maps of the Geological Survey.

Three scales are used on the atlas sheets of the Geological Survey; the smallest is $\frac{1}{250,000}$, the intermediate $\frac{1}{125,000}$, and the largest $\frac{1}{62,500}$. These correspond approximately to 4 miles, 2 miles, and 1 mile on the ground to an inch on the map. On the scale $\frac{1}{62,500}$ a square inch of map surface represents and corresponds nearly to 1 square mile; on the scale $\frac{1}{125,000}$ to about 4 square miles; and on the scale $\frac{1}{250,000}$ to about 16 square miles. At the bottom of each atlas sheet the scale is expressed in three different ways, one being a graduated line representing miles and parts of miles in English inches, another indicating distance in the metric system, and a third giving the fractional scale.

Atlas sheets and quadrangles.— The map is being published in atlas sheets of convenient size, which are bounded by parallels and meridians. The corresponding four-cornered portions of territory are called *quadrangles.* Each sheet on the scale of $\frac{1}{250,000}$ contains one square degree, i. e., a degree of latitude by a degree of longitude; each sheet on the scale of $\frac{1}{125,000}$ contains one-quarter of a square degree; each sheet on a scale of $\frac{1}{62,500}$ contains one-sixteenth of a square degree. The areas of the corresponding quadrangles are about 4000, 1000, and 250 square miles, respectively.

The atlas sheets, being only parts of one map of the United States, are laid out without regard to the boundary lines of the States, counties, or townships. To each sheet, and to the quadrangle it represents, is given the name of some well-known town or natural feature within its limits, and at the sides and corners of each sheet the names of adjacent sheets, if published, are printed.

Uses of the topographic sheet.—Within the limits of scale the topographic sheet is an accurate and characteristic delineation of the relief, drainage, and culture of the district represented. Viewing the landscape, map in hand, every characteristic feature of sufficient magnitude should be recognizable. It should guide the traveler; serve the investor or owner who desires to ascertain the position and surroundings of property to be bought or sold; save the engineer preliminary surveys in locating roads, railways, and irrigation ditches; provide educational material for schools and homes; and serve many of the purposes of a map for local reference.

THE GEOLOGIC MAP.

The maps representing areal geology show by colors and conventional signs, on the topographic base map, the distribution of rock formations on the surface of the earth, and the structure-section map shows their underground relations, as far as known and in such detail as the scale permits.

KINDS OF ROCKS.

Rocks are of many kinds. The original crust of the earth was probably composed of *igneous rocks*, and all other rocks have been derived from them in one way or another.

Atmospheric agencies gradually break up igneous rocks, forming superficial, or *surficial*, deposits of clay, sand, and gravel. Deposits of this class have been formed on land surfaces since the earliest geologic time. Through the transporting agencies of streams the surficial materials of all ages and origins are carried to the sea, where, along with material derived from the land by the action of the waves on the coast, they form *sedimentary rocks.* These are usually hardened into conglomerate, sandstone, shale, and limestone, but they may remain unconsolidated and still be called "rocks" by the geologist, though popularly known as gravel, sand, and clay.

From time to time in geologic history igneous and sedimentary rocks have been deeply buried, consolidated, and raised again above the surface of the water. In these processes, through the agencies of pressure, movement, and chemical action, they are often greatly altered, and in this condition they are called *metamorphic rocks.*

Igneous rocks.—These are rocks which have cooled and consolidated from a liquid state. As has been explained, sedimentary rocks were deposited on the original igneous rocks. Through the igneous and sedimentary rocks of all ages molten material has from time to time been forced upward to or near the surface, and there consolidated. When the channels or vents into which this molten material is forced do not reach the surface, it may consolidate in cracks or fissures crossing the bedding planes, thus forming dikes, or spread out between the strata in large bodies, called sheets or laccoliths, or form large irregular cross-cutting masses, called stocks. Such rocks are called *intrusive.* Within their rock inclosures they cool slowly, and hence are generally of crystalline texture. When the channels reach the surface the lavas often flow out and build up volcanoes. These lavas cool rapidly in the air, acquiring a glassy or, more often, a partially crystalline condition. They are usually more or less porous. The igneous rocks thus formed upon the surface are called *extrusive.* Explosive action often accompanies volcanic eruptions, causing ejections of dust or ash and larger fragments. These materials when consolidated constitute breccias, agglomerates, and tuffs. The ash when carried into lakes or seas may become stratified, so as to have the structure of sedimentary rocks.

The age of an igneous rock is often difficult or impossible to determine. When it cuts across a sedimentary rock it is younger than that rock, and when a sedimentary rock is deposited over it the igneous rock is the older.

Under the influence of dynamic and chemical forces an igneous rock may be metamorphosed. The alteration may involve only a rearrangement of its minute particles or it may be accompanied by a change in chemical and mineralogic composition. Further, the structure of the rock may be changed by the development of planes of division, so that it splits in one direction more easily than in others. Thus a granite may pass into a gneiss, and from that into a mica-schist.

Sedimentary rocks.—These comprise all rocks which have been deposited under water, whether in sea, lake, or stream. They form a very large part of the dry land.

When the materials of which sedimentary rocks are composed are carried as solid particles by water and deposited as gravel, sand, or mud, the deposit is called a mechanical sediment. These may become hardened into conglomerate, sandstone, or shale. When the material is carried in solution by the water and is deposited without the aid of life, it is called a chemical sediment; if deposited with the aid of life, it is called an organic sediment. The more important rocks formed from chemical and organic deposits are limestone, chert, gypsum, salt, iron ore, peat, lignite, and coal. Any one of the above sedimentary deposits may be separately formed, or the different materials may be intermingled in many ways, producing a great variety of rocks.

Sedimentary rocks are usually made up of layers or beds which can be easily separated. These layers are called *strata.* Rocks deposited in successive layers are said to be stratified.

The surface of the earth is not fixed, as it seems to be; it very slowly rises or sinks over wide expanses, and as it rises or subsides the shore lines of the ocean are changed: areas of deposition may rise above the water and become land areas, and land areas may sink below the water and become areas of deposition. If North America were gradually to sink a thousand feet the sea would flow over the Atlantic coast and the Mississippi and Ohio valleys from the Gulf of Mexico to the Great Lakes; the Appalachian Mountains would become an archipelago, and the ocean's shore would traverse Wisconsin, Iowa, and Kansas, and extend thence to Texas. More extensive changes than this have repeatedly occurred in the past.

The character of the original sediments may be changed by chemical and dynamic action so as to produce metamorphic rocks. In the metamorphism of a sedimentary rock, just as in the metamorphism of an igneous rock, the substances of which it is composed may enter into new combinations, or new substances may be added. When these processes are complete the sedimentary rock becomes crystalline. Such changes transform sandstone to quartzite, limestone to marble, and modify other rocks according to their composition. A system of parallel division planes is often produced, which may cross the original beds or strata at any angle. Rocks divided by such planes are called slates or schists.

Rocks of any period of the earth's history may be more or less altered, but the younger formations have generally escaped marked metamorphism, and the oldest sediments known, though generally the most altered, in some localities remain essentially unchanged.

Surficial rocks.—These embrace the soils, clays, sands, gravels, and bowlders that cover the surface, whether derived from the breaking up or disintegration of the underlying rocks by atmospheric agencies or from glacial action. Surficial rocks that are due to disintegration are produced chiefly by the action of air, water, frost, animals, and plants. They consist mainly of the least soluble parts of the rocks, which remain after the more soluble parts have been leached out, and hence are known as residual products. Soils and subsoils are the most important. Residual accumulations are often washed or blown into valleys or other depressions, where they lodge and form deposits that grade into the sedimentary class. Surficial rocks that are due to glacial action are formed of the products of disintegration, together with bowlders and fragments of rock rubbed from the surface and ground together. These are spread irregularly over the territory occupied by the ice, and form a mixture of clay, pebbles, and bowlders which is known as till. It may occur as a sheet or be bunched into hills and ridges, forming moraines, drumlins, and other special forms. Much of this mixed material was washed away from the ice, assorted by water, and redeposited as beds or trains of sand and clay, thus forming another gradation into sedimentary deposits. Some of this glacial wash was deposited in tunnels and channels in the ice, and forms characteristic ridges and mounds of sand and gravel, known as osars, or eskers, and kames. The material deposited by the ice is called glacial drift; that washed from the ice onto the adjacent land is called modified drift. It is usual also to class as surficial rocks the deposits of the sea and of lakes and rivers that were made at the same time as the ice deposit.

AGES OF ROCKS.

Rocks are further distinguished according to their relative ages, for they were not formed all at one time, but from age to age in the earth's history. Classification by age is independent of origin; igneous, sedimentary, and surficial rocks may be of the same age.

When the predominant material of a rock mass is essentially the same, and it is bounded by rocks of different materials, it is convenient to call the mass throughout its extent a *formation*, and such a formation is the unit of geologic mapping.

Several formations considered together are designated a *system*. The time taken for the deposition of a formation is called an *epoch*, and the time taken for that of a system, or some larger fraction of a system, a *period*. The rocks are mapped by formations, and the formations are classified into systems. The rocks composing a system and the time taken for its deposition are given the same name, as, for instance, Cambrian system, Cambrian period.

As sedimentary deposits or strata accumulate the younger rest on those that are older, and the relative ages of the deposits may be discovered by observing their relative positions. This relationship holds except in regions of intense disturbance; sometimes in such regions the disturbance of the beds has been so great that their position is reversed, and it is often difficult to determine the relative ages of the beds from their positions; then *fossils*, or the remains of plants and animals, are guides to show which of two or more formations is the oldest.

Strata often contain the remains of plants and animals which lived in the sea or were washed from the land into lakes or seas or were buried in surficial deposits on the land. Rocks that contain the remains of life are called fossiliferous. By studying these remains, or fossils, it has been found that the species of each period of the earth's history have to a great extent differed from those of other periods. Only the simpler kinds of marine life existed when the oldest fossiliferous rocks were deposited. From time to time more complex kinds developed, and as the simpler ones lived on in modified forms life became more varied. But during each period there lived peculiar forms, which did not exist in earlier times and have not existed since; these are characteristic types, and they define the age of any bed of rock in which they are found. Other types passed on from period to period, and thus linked the systems together, forming a chain of life from the time of the oldest fossiliferous rocks to the present.

When two formations are remote one from the other and it is impossible to observe their relative positions, the characteristic fossil types found in them may determine which was deposited first.

Fossil remains found in the rocks of different areas, provinces, and continents afford the most important means for combining local histories into a general earth history.

Colors and patterns.—To show the relative ages of strata, the history of the sedimentary rocks is divided into periods. The names of the periods in proper order (from new to old), with the colors and symbol assigned to each, are given in the table in the next column. The names of certain subdivisions and groups of the periods, frequently used in geologic writings, are bracketed against the appropriate period names.

To distinguish the sedimentary formations of any one period from those of another the patterns for the formations of each period are printed in the appropriate period-color, with the exception of the one at the top of the column (Pleistocene) and the one at the bottom (Archean). The sedimentary formations of any one period, excepting the Pleistocene and the Archean, are distinguished from one another by different patterns, made of parallel straight lines. Two tints of the period-color are used: a pale tint is printed evenly over the whole surface representing the period; a dark tint brings out the different patterns representing formations. Each formation is furthermore given

Period.		Symbol.	Color.
Cenozoic	Pleistocene	P	Any colors.
	Neocene (Pliocene, Miocene)	N	Buffs.
	Eocene, including Oligocene	E	Olive-browns.
Mesozoic	Cretaceous	K	Olive-greens.
	Juratrias (Jurassic, Triassic)	J	Blue-greens.
Paleozoic	Carboniferous, including Permian	C	Blues.
	Devonian	D	Blue-purples.
	Silurian, including Ordovician	S	Red-purples.
	Cambrian	Є	Pinks.
	Algonkian	A	Orange-browns.
	Archean	Æ	Any colors.

a letter-symbol composed of the period letter combined with small letters standing for the formation name. In the case of a sedimentary formation of uncertain age the pattern is printed on white ground in the color of the period to which the formation is supposed to belong, the letter-symbol of the period being omitted.

The number and extent of surficial formations, chiefly Pleistocene, render them so important that, to distinguish them from those of other periods and from the igneous rocks, patterns of dots and circles, printed in any colors, are used.

The origin of the Archean rocks is not fully settled. Many of them are certainly igneous. Whether sedimentary rocks are also included is not determined. The Archean rocks, and all metamorphic rocks of unknown origin, of whatever age, are represented on the maps by patterns consisting of short dashes irregularly placed. These are printed in any color, and may be darker or lighter than the background. If the rock is a schist the dashes or hachures may be arranged in wavy parallel lines. If the metamorphic rock is known to be of sedimentary origin the hachure patterns may be combined with the parallel-line patterns of sedimentary formations. If the rock is recognized as having been originally igneous, the hachures may be combined with the igneous pattern.

Known igneous formations are represented by patterns of triangles or rhombs printed in any brilliant color. If the formation is of known age the letter-symbol of the formation is preceded by the capital letter-symbol of the proper period. If the age of the formation is unknown the letter-symbol consists of small letters which suggest the name of the rocks.

THE VARIOUS GEOLOGIC SHEETS.

Areal geology sheet.—This sheet shows the areas occupied by the various formations. On the margin is a *legend*, which is the key to the map. To ascertain the meaning of any particular colored pattern and its letter-symbol on the map the reader should look for that color, pattern, and symbol in the legend, where he will find the name and description of the formation. If it is desired to find any given formation, its name should be sought in the legend and its color and pattern noted, when the areas on the map corresponding in color and pattern may be traced out.

The legend is also a partial statement of the geologic history. In it the symbols and names are arranged, in columnar form, according to the origin of the formations—surficial, sedimentary, and igneous—and within each group they are placed in the order of age, so far as known, the youngest at the top.

Economic geology sheet.—This sheet represents the distribution of useful minerals, the occurrence of artesian water, or other facts of economic interest, showing their relations to the features of topography and to the geologic formations. All the formations which appear on the historical geology sheet are shown on this sheet by fainter color patterns. The areal geology, thus printed, affords a subdued background upon which the areas of productive formations may be emphasized by strong colors. A symbol for mines is introduced at each occurrence, accompanied by the name of the principal mineral mined or of the stone quarried.

Structure-section sheet.—This sheet exhibits the relations of the formations beneath the surface.

In cliffs, canyons, shafts, and other natural and artificial cuttings, the relations of different beds to one another may be seen. Any cutting which exhibits those relations is called a *section*, and the same name is applied to a diagram representing the relations. The arrangement of rocks in the earth is the earth's *structure*, and a section exhibiting this arrangement is called a *structure section*.

The geologist is not limited, however, to the natural and artificial cuttings for his information concerning the earth's structure. Knowing the manner of the formation of rocks, and having traced out the relations among beds on the surface, he can infer their relative positions after they pass beneath the surface, draw sections which represent the structure of the earth to a considerable depth, and construct a diagram exhibiting what would be seen in the side of a cutting many miles long and several thousand feet deep. This is illustrated in the following figure:

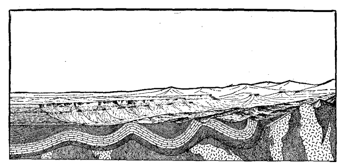


Fig. 2.—Sketch showing a vertical section in the front of the picture, with a landscape beyond.

The figure represents a landscape which is cut off sharply in the foreground by a vertical plane, so as to show the underground relations of the rocks.

The kinds of rock are indicated in the section by appropriate symbols of lines, dots, and dashes. These symbols admit of much variation, but the following are generally used in sections to represent the commoner kinds of rock:

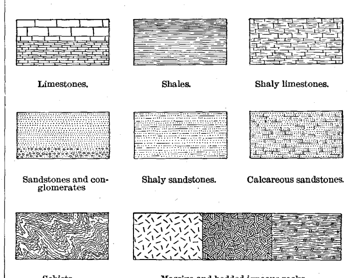


Fig. 3.—Symbols used to represent different kinds of rock.

The plateau in fig. 2 presents toward the lower land an escarpment, or front, which is made up of sandstones, forming the cliffs, and shales, constituting the slopes, as shown at the extreme left of the section.

The broad belt of lower land is traversed by several ridges, which are seen in the section to correspond to beds of sandstone that rise to the surface. The upturned edges of these beds form the ridges, and the intermediate valleys follow the outcrops of limestone and calcareous shales.

Where the edges of the strata appear at the surface their thickness can be measured and the angles at which they dip below the surface can be observed. Thus their positions underground can be inferred. The direction that the intersection of a bed with a horizontal plane will take is called the *strike*. The inclination of the bed to the horizontal plane, measured at right angles to the strike, is called the *dip*.

When strata which are thus inclined are traced underground in mining, or by inference, it is frequently observed that they form troughs or arches, such as the section shows. The arches are called *anticlines* and the troughs *synclines*. But the sandstones, shales, and limestones were deposited beneath the sea in nearly flat sheets. That they are now bent and folded is regarded as proof that forces exist which have from time to time caused the earth's surface to wrinkle along certain zones. In places the strata are broken across and the parts slipped past one another. Such breaks are termed *faults*.

On the right of the sketch the section is composed of schists which are traversed by masses of igneous rock. The schists are much contorted and their arrangement underground can not be inferred. Hence that portion of the section delineates what is probably true but is not known by observation or well-founded inference.

In fig. 2 there are three sets of formations, distinguished by their underground relations. The first of these, seen at the left of the section, is the set of sandstones and shales, which lie in a horizontal position. These sedimentary strata are now high above the sea, forming a plateau, and their change of elevation shows that a portion of the earth's mass has swelled upward from a lower to a higher level. The strata of this set are parallel, a relation which is called *conformable*.

The second set of formations consists of strata which form arches and troughs. These strata were once continuous, but the crests of the arches have been removed by degradation. The beds, like those of the first set, are conformable.

The horizontal strata of the plateau rest upon the upturned, eroded edges of the beds of the second set at the left of the section. The overlying deposits are, from their positions, evidently younger than the underlying formations, and the bending and degradation of the older strata must have occurred between the deposition of the older beds and the accumulation of the younger. When younger strata thus rest upon an eroded surface of older strata the relation between the two is an *unconformable* one, and their surface of contact is an *unconformity*.

The third set of formations consists of crystalline schists and igneous rocks. At some period of their history the schists were plicated by pressure and traversed by eruptions of molten rock. But this pressure and intrusion of igneous rocks have not affected the overlying strata of the second set. Thus it is evident that an interval of considerable duration elapsed between the formation of the schists and the beginning of deposition of the strata of the second set. During this interval the schists suffered metamorphism; they were the scene of eruptive activity; and they were deeply eroded. The contact between the second and third sets, marking a time interval between two periods of rock formation, is another unconformity.

The section and landscape in fig. 2 are ideal, but they illustrate relations which actually occur. The sections in the structure-section sheet are related to the maps as the section in the figure is related to the landscape. The profiles of the surface in the section correspond to the actual slopes of the ground along the section line, and the depth from the surface of any mineral-producing or water-bearing stratum which appears in the section may be measured by using the scale of the map.

Columnar section sheet.—This sheet contains a concise description of the rock formations which occur in the quadrangle. It presents a summary of the facts relating to the character of the rocks, the thicknesses of the formations, and the order of accumulation of successive deposits.

The rocks are described under the corresponding heading, and their characters are indicated in the columnar diagrams by appropriate symbols. The thicknesses of formations are given in figures which state the least and greatest measurements. The average thickness of each formation is shown in the column, which is drawn to a scale—usually 1000 feet to 1 inch. The order of accumulation of the sediments is shown in the columnar arrangement: the oldest formation is placed at the bottom of the column, the youngest at the top, and igneous rocks or surficial deposits, when present, are indicated in their proper relations.

The formations are combined into systems which correspond with the periods of geologic history. Thus the ages of the rocks are shown, and also the total thickness of each system.

The intervals of time which correspond to events of uplift and degradation and constitute interruptions of deposition of sediments are indicated graphically and by the word "unconformity."

CHARLES D. WALCOTT,
Director.

Revised January, 1902.

DESCRIPTION OF THE CAMP CLARKE QUADRANGLE.

By N. H. Darton.

GEOGRAPHY.

Position and extent.—The Camp Clarke quadrangle embraces the quarter of a square degree which lies between parallels 41° 30′ and 42° north latitude and meridians 103° and 103° 30′ west longitude. It measures nearly 34.5 miles from north to south and 25.8 miles from east to west and covers about 892 square miles. It includes the northwest corner of Cheyenne County and the eastern portions of Scotts Bluff and Banner counties, Nebraska, and is crossed by the North Platte, which flows from west-northwest to east-southeast and drains its whole extent.

Relation to Great Plains.—The region is a portion of the Great Plains, which in general present wide tabular surfaces sloping eastward, with isolated buttes and outlying ridges, and with shallow river valleys margined by irregular and often deeply incised slopes. The topographic features, however, vary considerably, and it is difficult to make concise statements that will apply to the entire province.

The flatness of the plains is due partly to extensive erosion at a uniform slope, but also to the great sheet of sedimentary deposits which has been spread over them. In western Nebraska the plains rise to altitudes of from 5000 to 5300 feet. They are traversed by the broad valleys of the North Platte, South Platte, and Republican rivers, and are cut away around the Black Hills uplift by White River and by the South Fork of Cheyenne River in South Dakota. Their northern edge in northwestern Nebraska is a high escarpment known as Pine Ridge, at the foot of which lies the wide valley extending across to the southern margin of the Black Hills. In this region they are composed largely of widespread Tertiary deposits, which were laid down on a relatively irregular floor of Cretaceous formations. These deposits cover nearly all of western Nebraska and extend across eastern Wyoming to the foot of the Rocky Mountains and through western Kansas, far southward. In valleys cut through these deposits in Pleistocene time the Cretaceous rocks are bared, especially in the wide depression adjoining the Black Hills. Alluvial formations of moderate extent are spread over the valley bottoms. The smooth, tabular divides of the Plains in central northwestern Nebraska are covered for thousands of square miles by vast accumulations of sands, derived largely from the loosely bedded members of the Tertiary formations, which, being spread by wind, formed sand dunes. It is possible also that a portion of the sand-hill area was originally occupied by earlier Pleistocene sands constituting a portion of the *Equus* beds, as the *Equus* fauna is found in this region.

Local topographic features.—In the Camp Clarke quadrangle the larger topographic features are the wide valley of North Platte River; the table-land surmounted by sand hills to the north; Pumpkin Creek Valley; the ridge which separates this valley from that of the North Platte; and the spurs of the table-land on the south, which is part of the high plain extending to the valley of Lodgepole Creek, near the southern border of the State. The valley of North Platte River lies from 500 to 600 feet below the general level of the adjoining highlands, having an altitude of about 3630 feet on the east and 3815 feet on the west, with a fall of 6 feet to the mile. Along the center of the valley there is a level plain on either side of the river extending from 1 to 2 miles to slopes and low terraces which reach back several miles farther, to a line of buttes and promontories rising abruptly to the highland level. On the northern side of the valley the edge of the table-land is incised by canyons which head about 10 miles back from the river. The intervening promontories are steep sided, deeply gullied, and bounded by cliffs and slopes of bare clays and sands. On the table-land to the north there are level or gently undulating areas at altitudes varying from 4200 feet on the eastern edge to about 4500 feet on the west, and the northwest corner of the quadrangle includes about 70 square miles of sand hills, which rise rather abruptly from 10 to 120 feet higher, in zones trending northwest and southeast, with a width of about 2½ miles and with irregular margins. They are more or less widely separated by level-floored depressions known as hay valleys, and generally sustain a growth of coarse grass, but there are many bare spots from which the sand is blown.

As the ridge between North Platte River and Pumpkin Creek is high and narrow it is much eroded, and deep canyons occur at frequent intervals along its sides. These canyons head abruptly near the crest of the ridge and leave between them little of the high table-land from which the ridge was sculptured. The ridge begins in Jail Rock and Courthouse Rock, which rise abruptly near the mouth of Pumpkin Creek to an altitude of 4000 and 4100 feet respectively. Jail Rock is shown in fig. 18. To the west the ridge is low and rolling until it rises again abruptly to 4255 feet at Roundhouse Rock and still farther beyond attains an altitude of 4400 feet. It is cut by Birdcage Gap at an altitude of 4028 feet, and, 2½ miles farther west, by Redington Gap, at an altitude of about 4130 feet. West of Redington Gap its height rapidly increases to over 4500 feet, which is the average altitude at the western margin of the quadrangle. Its width increases also, and a spur extends far northward near the western margin of Cheyenne County, where it terminates in Chimney Rock, a very picturesque monolith that has an altitude of 4242 feet, the more slender portion of the shaft rising 140 feet above the sloping base. Westward the ridge consists of a high backbone with long projecting spurs separated by deep canyons, which usually head in gaps, such as Hubbard Gap, which has an altitude of 4494 feet, and Williams Gap, which reaches 4420 feet. Remnants of the formerly continuous table-land are preserved in isolated buttes, of which Sheep Mountain is the largest, while others are known as Roundtop, Coyote Rock, Steamboat Rock, Table Rock, and Castle Rock. Smokestack Rock and the Twin Sisters, illustrated in figs. 20 and 19, are two of the many picturesque features which characterize this rugged ridge. Along the northern edge of the ridge there are extensive accumulations of sand dunes, which south of Camp Clarke extend eastward across the low saddle between Courthouse and Roundhouse rocks nearly to the mouth of Pumpkin Creek. Sand hills have also accumulated along the foot of the spur extending to Chimney Rock and, in smaller measure, along the ridge terminating at Castle Rock.

Pumpkin Creek Valley extends across the southern quarter of the quadrangle just south of the ridge above described, and empties into North Platte River a mile above Lapeer. The bottom of the valley is a level plain varying in width from a half mile to 1½ miles, through which the creek meanders. On the northern side there are steep slopes reaching to the foot of a line of cliffs which extend along the south side of the central ridge. To the south there is a wide series of terraces and slopes rising gradually to the foot of the cliffs, which are surmounted by the area of high table-land. These slopes and terraces are traversed by shallow valleys containing creeks heading in canyons in the table-land, among which Lawrence Fork, the largest, heads several miles southwest of the quadrangle. Greenwood Creek, which enters Pumpkin Creek near its mouth, rises in canyons not far south of the southeast corner of the quadrangle. The projections of high table-land along the south margin present smooth summits having an altitude of 4300 feet just west of Greenwood Creek and of 4700 feet in range 54. At the northern margin of the high table-land there are cliffs and steep slopes and many deep, steep-sided canyons.

Surface waters.—The North Platte is a constantly flowing stream which occupies a bed averaging over a half-mile in width. For a portion of the year the water is several feet deep, but in summer it dwindles greatly and finally occupies only shallow channels among sand banks.

For several years a gaging station was maintained by the United States Geological Survey at Camp Clarke, where daily readings were made of the river heights from April to October, and from these the volume of flow is calculated. The averages since June, 1896, are as follows:

Estimated monthly discharge of North Platte River at Camp Clarke, Nebraska, 1896 to 1900.

Month.	Maximum.		Minimum.		Mean, 1896–1900.
	Year.	Sec.-feet.	Year.	Sec.-feet.	Sec.-feet.
April	1899	11,030	1898	675	4,315
May	1899	19,050	1898	2,350	8,685
June	1899	23,560	1896	3,100	8,892
July	1899	20,500	1900	770	3,955
August	1899	5,335	1898	60	1,112
September	1899	1,858	1898	60	583
October	1899	1,814	1898	110	694

As a large volume of water is taken out of the river at intervals by the various irrigation canals in Nebraska and Wyoming, the records of flow at the gaging station do not indicate the total volume of water which flows down the valley. It should be borne in mind also that under the bed of the river there is a considerable thickness of coarse sand which contains an underflow of greater volume than that flowing over the surface in the long period of dry weather.

The various creeks which rise in the canyons north of the valley do not contain sufficient water to flow on the surface to the river, except in times of unusually heavy rainfall. Pumpkin Creek is a flowing stream throughout the year, having in summer a volume of about 20 second-feet. It has no flowing branches on the north, but on the south, in times of precipitation, it receives overflow from Lawrence Fork, Greenwood Creek, and some other small streams. Lawrence Fork and Greenwood Creek are flowing streams for portions of their courses, but the water sinks near their mouths. Doubtless some of it reaches Pumpkin Creek as underflow, a phenomenon which is general throughout those larger valleys of the region that contain considerable accumulation of coarse materials through which waters can readily percolate.

Springs.—In the canyons, particularly north of the river and south of Pumpkin Creek, there are many small springs. Near the forks of Indian Creek, at an altitude of about 3960 feet, the water comes out of the bottom of the valley in small seeps, and, giving rise to pools, flows a few miles down the valley, where it sinks in the sands. On Red Willow Creek and in West Water Canyon there are similar conditions at an altitude of 4100 feet, and in the canyons at the foot of the table-land near the southern margin of the quadrangle there are springs of considerable volume. From one at the head of Chalk Creek, at an altitude of 4350 feet, there issues a stream which runs about a mile in dry weather; at the head of Hackberry Creek there are several springs at an altitude of 4400 feet which furnish water for a stream that usually flows to the mouth of the canyon; at the head of Middle Creek there are similar springs at an altitude of 4100 feet; and on the East Fork of Middle Creek are Dugger Springs, at an altitude of 4040 feet. In dry weather Middle Creek has no surface flow for several miles, but the waters emerge from the valley gravel at an altitude of 3830 feet, with considerable volume, and sink within the next mile.

Along Pumpkin Creek there are several springs due to seepage of water from beneath the valley filling. Greenwood Creek heads in springs of considerable size, of which the flow extends far across township 18. Along the north face of the ridge lying between Pumpkin Creek and Platte Valley there are several small springs in the deeper canyons, and there are small seeps of water at some points in canyons along the south side of this ridge.

Timber.—This region contains but little timber, but there is a sufficient supply for local use. On the ridge extending west from Redington Gap are scattered pine trees of moderate size, and there are also a few pines on the slopes ascending to the high table at the southern margin of the quadrangle. This tree is the Rocky Mountain pine (*Pinus ponderosa*), and it attains a diameter of from 1 to 2 feet where the conditions are most favorable. A moderate number of young pines start at some localities on the ridges, but few of them attain maturity. The zone of cottonwoods, so characteristic of most western streams, is absent along North Platte River, and there are only a few small trees and bushes; but the valley of Pumpkin Creek contains cottonwoods in some places. The principal deciduous growths are found in some of the ravines, where they comprise cottonwood, box elder, wild plum, and a few other varieties. The largest number are on Lawrence Fork; there are a few on Greenwood Creek, and scattered clumps are found in several of the ravines.

Climate.—Western Nebraska has a climate of typical Plains character. It is dry and hot in summer, moderately moist in late spring, and cold with a little snow in winter. There is considerable variability in climatic features from year to year, more than is found farther south or north, and some local variations from point to point, particularly in rainfall. The following table gives average monthly rainfall from 1886 to 1897, calculated from observations made at Kimball, Fort Sidney, Alliance, Gering, Fort Robinson, and Hay Springs, Nebr.

Table of average rainfall in western Nebraska, 1886 to 1897.

[In inches.]

Month.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
January	0.50	1.33	1.06	1.00	0.63	1.42	1.29	1.19	1.10	1.00	1.00	1.70
February	1.00	1.50	1.33	1.00	1.00	1.17	1.08	1.20	1.25	1.25	1.00	1.35
March	1.00	1.00	1.33	1.33	1.25	1.66	1.00	1.50	1.25	1.75	2.20	2.00
April	1.33	2.00	1.25	2.33	2.25	1.66	4.00	1.40	3.00	2.00	2.00	1.80
May	1.92	3 66	5.50	2.66	2.00	3.00	3.60	1.25	2.40	2.50	3.00	3.20
June	2.58	2.00	2.75	3.00	2.00	3.30	5.30	1.75	2.66	3.80	3.95	2.40
July	3.00	2.66	2.50	2.75	2.50	3.33	1.75	1.20	2.33	1.80	2.40	3.50
August	2.17	3.33	2.25	2.40	1.79	2.00	2.00	1.80	1.33	1.00	1.60	2.60
September	1.33	2.67	0.50	1.00	0.75	1.50	1.25	1.00	1.35	1.20	2.20	1.25
October	1.25	5.00	1.00	1.50	1.00	0.83	4.00	1.33	1.50	0.80	1.00	1.25
November	2.33	2.00	1.00	0.80	1.50	1.17	1.00	1.25	1.00	1.00	1.00	1.20
December	1.33	1.00	0.94	1.19	1.00	1.16	1.00	1.00	1.12	0.90	0.50	1.40

GEOLOGY.

STRATIGRAPHY.

The formations appearing at the surface in the Camp Clarke quadrangle are clays, sands, soft sandstone, calcareous grits, volcanic ash, and mixtures of sand and gravel. They are all of sedimentary origin—that is, they were deposited by water, except some dunes of blown sand. In greater part they are in sheets lying one above another, and having a general downward slope to the east. The valleys being cut through or into them, the outlines of the remaining masses are more or less complex, but the order of superposition is regular. In the valleys there are thin sheets of materials brought by the streams and spread over the eroded surfaces of the older formations, and on the uplands there are extensive areas of wind-blown sands, forming dunes. The formations are of relatively modern geologic age, the earliest being of the Oligocene epoch of the Eocene period. The general structural relations are shown in the section forming fig. 1, and the accompanying table gives the formations in the order of their age, with a brief statement of their general character and thickness.

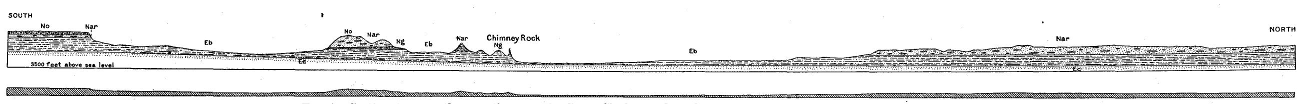


FIG. 1.—Section from south to north across the Camp Clarke quadrangle along the line A–A shown on the Areal Geology map.
No, Ogallala formation; Nar, Arikaree formation; Ng, Gering formation; Eb, Brule clay; Ec, Chadron formation.
Horizontal scale, 1 inch = 3 miles; vertical scale, 1 inch = 3000 feet, approximately. Natural profile is shown in shaded drawing below section.

It will be seen from the section (fig. 1) that the formations lie in widely extended sheets, but there are certain local variations in the order and thickness of some of the deposits. There is a general basement of Brule clay which is several hundred feet thick and apparently has not been cut through by the deepest valleys, and on its surface lies a lens-shaped mass of sands and soft sandstone of the Gering formation, which is most extensively developed in the ridge lying between Pumpkin Creek and North Platte River. Next above comes the Arikaree formation, which occupies the high plateau north of the Platte and constitutes the greater part of the bare slopes of the ridge south of that stream. This formation thins to the south and southeast along the upland south of Pumpkin Creek Valley, where it is capped by the Ogallala formation, which to the east overlaps on the Brule clay beyond a wedge of the Arikaree formation that thickens westward. Apparently also the Ogallala caps some of the higher summits north of the valley of Pumpkin Creek. The Pleistocene deposits in the larger valleys lie on the bottom lands and terraces. The latter contain much coarse material, and the more recent alluvium along the streams consists mainly of fine silts or sands and loams. The dune sands constitute the sand hills in the northeast corner of the quadrangle, are banked against the north slopes of the ridge south of the river, and occur at intervals along Pumpkin Creek Valley.

Table of geologic formations in the Camp Clarke quadrangle.

Age.		Name.	Predominating characters.	Thickness.
				Feet.
Pleistocene		Dune sand	Loose, light-gray sand	0–100
		Alluvium	Sand and loam, pebbly in places	20–60
		Upland gravels, sand, and loam	Gravels, loams, and sands	40
Neocene	Pliocene ?	Ogallala formation	Calcareous grit, sandy clay, and conglomerate	0–100
	Miocene	Arikaree formation	Gray sand, with beds of pipy concretions; contains much volcanic ash and several old channels filled with conglomerate	0–350
		Gering formation	Coarse sands, soft sandstone, and conglomerate	0–200
Eocene	Oligocene	Brule clay	Pinkish clays, hard, massive, and more or less arenaceous	300+

EOCENE PERIOD.

OLIGOCENE EPOCH.

Brule clay.—The entire area of the Camp Clarke quadrangle is underlain by the Brule clay, which extends under a wide area of western Nebraska and the adjoining regions. In its typical development it is a pale-buff or flesh-colored sandy clay of compact texture and massive structure, called "hardpan" locally, and in exceptional cases contains thin beds of sand and conglomerate of limited extent. About 350 feet of this clay is exposed in the slopes of North Platte Valley, and it may extend somewhat deeper below the surface. In its upper portion are two beds of volcanic sand and dust called "volcanic ash," which vary much in purity, especially the lower one, which is often so intermixed with silt as not to be distinctly recognizable. The upper bed is, however, often quite pure, and has a thickness varying from 6 to 12 feet. It is particularly well exposed near Chimney Rock, and also near Castle and Smokestack rocks, and is shown in fig. 23. Under the microscope the volcanic ash is seen to consist of very small, thin flakes and shreds of glassy volcanic rock, mostly sharp edged and angular in outline. It was ejected, apparently at several periods, from volcanoes probably in the Rocky Mountain region, carried far by wind, and probably deposited directly in water where the Brule clay was being laid down. It is possible, however, that, in whole or part, it may have been brought by streams from some distance and deposited like the other sediments.

The wide valleys of North Platte River and Pumpkin Creek are excavated in the Brule formation, but along their lower terraces the clay is usually overlain by alluvial deposits, and in gentle slopes it is also extensively hidden by a wide-spread wash from the cliffs. At intervals, however, there are gullies which expose the formation, and along the higher ridges there are many cliffs in which its upper beds may be seen. This is notably the case on both sides of the high ridge lying between Pumpkin Creek and North Platte River, about Courthouse Rock and Jail Rock, and from Roundhouse Rock westward to Castle Rock. The only exposure occurring by the river is just south of Bayard, where it constitutes a low ridge of typical flesh-colored sandy clay rising along the south bank.

Owing to its softness and homogeneous structure the Brule clay, where exposed to erosion on steep slopes, is sculptured into badlands, such as may be seen in miniature on the lower slopes of Jail Rock (illustrated in fig. 18), in Birdcage Gap, notably on the eastern slope, at Redington Gap, and in places about Chimney Rock and Castle Rock. Roundtop, Sheep Mountain, and the outlying buttes and cliffs exhibit extensive outcrops, and Steamboat and Table rocks consist entirely of the formation. In some of the deeper hollows east of Chimney Rock and Castle Rock local streaks of conglomerate occur in it about 250 feet below its top. These consist of a mixture of coarse, gray sand and flesh-colored clay pebbles and fragments which may possibly belong to the top of the underlying Chadron formation. The Brule clay appears frequently in slopes and canyons in the escarpment north of the river and in the cliffs below the edge of the table-land along the southern side of the quadrangle. Fossil bones of various mammals and turtles characteristic of the Oligocene occur occasionally in the Brule clay. The principal species collected were *Merycoidodon* (*Oreodon*) *gracilis*, *M. culbertsoni*, *Poëbrotherium wilsoni*, *Elotherium mortoni*, *Hyracodon nebraskensis*, *Leptomeryx evansi*, *Miohippus bairdi*, *Cœnopus occidentalis*, and *Stylemys*. These fossils were determined by F. A. Lucas of the National Museum.

NEOCENE PERIOD.

Gering formation.—Overlying the Brule clay, in a portion of the quadrangle, there is a layer of coarse sand, often containing pebbles, which has been distinguished as the Gering formation. It is separated from the Brule clay by a distinct erosional unconformity, but appears to merge upward into the Arikaree formation, through a few feet of passage beds. Though a prominent feature in the ridge extending west from Jail Rock—where it has an average thickness of about 125 feet and locally reaches 200 feet—it appears to be absent north of the river and in the edge of the table-land south of Pumpkin Creek. In the vicinity of Chimney Rock, of which it constitutes the spire, the formation has a thickness of 145 feet, and it is over 100 feet thick in Courthouse Rock and in the vicinity of Birdcage Gap and Redington Gap. In the canyons north of Freeport it is not well characterized, either thinning out or assuming the character of the Arikaree formation, so that it is not distinctive in appearance. North of North Platte River and south of Pumpkin Valley it is not recognized, but possibly it is there represented either by clayey members not distinguishable from the Brule clay, or by fine sand, with concretions, resembling the Arikaree beds.

The Gering formation presents many local variations in its components, but in general it consists of laminated, massive, and cross-bedded, light-gray, mainly coarse sands and soft sandstone. It often comprises two members more or less separated by erosional unconformity. At the base there is more or less conglomerate of local origin, and in some cases where the formation is thought to be absent there is seen to be unconformity between the Arikaree beds and the Brule clay.

Beginning at Jail Rock there are extensive exposures of these features at frequent intervals westward to the vicinity of the Twin Sisters. At Courthouse Rock the relations shown in fig. 2 are presented. At an altitude of 3940 feet the distinctive Brule clay is unconformably overlain by the Gering formation, which apparently comprises two members, separated by marked unconformity by erosion, each containing basal coarse beds with local conglomerate, and merge upward into sand and finally into sandy clay, the total thickness being 110 feet. Characteristic Arikaree formation caps Courthouse Rock, beginning abruptly, but without apparent unconformity to the underlying Gering sandstone. Jail Rock, shown in fig. 18, is capped by the Gering formation. At Birdcage Gap the two members of this formation present about the same relations, shown in fig. 3, but they have somewhat greater thickness. A view of the exposure at Birdcage Gap, where the unconformity between the Brule clay and the Gering formation is very marked, is given in fig. 21. At Redington Gap the two members of the Gering formation are not distinguishable, and the total thickness is less than it is to the east. A local bed of volcanic ash 5 feet thick appears to mark the top of the formation. The principal features are shown in fig. 4. Four miles southeast of Chimney Rock is found the section shown in fig. 5, the Gering formation here presenting the usual basal beds of coarse material lying unconformably on the Brule clay (see fig. 17). The change to the Arikaree formation above is abrupt, but is not marked by any unconformity. Farther north, toward Chimney Rock, are presented the features shown in figs. 6 and 7. The thickness of the Gering formation here averages only 125 feet, and there is much local variation in stratigraphy. Coarse basal beds are found exposed lying unconformably on the Brule clay. A thin local bed of volcanic ash is conspicuous in some places. Chimney Rock consists of a spire of the Gering formation rising from a conical hill of Brule clay. The material is a gray, thinly bedded, soft sandstone with slightly coarser material at its base. The unconformable contact with the Brule clay is at an altitude of 4100 feet, and is marked by considerable carbonaceous material, strongly suggestive of an old soil. At an altitude of 4135 feet there is a faint unconformity in the Gering formation, and a short distance above are two thin beds containing volcanic ash. A view of Chimney Rock is given in fig. 23, and its stratigraphic relations are shown in fig. 8. Southwest of Chimney Rock the Gering formation is much thinner, but it continues to present its characteristic features as shown in figs. 9 and 10, and the two members are well characterized as far as the east slope of Sheep Mountain (see fig. 10). In places along the south side of this butte the basal member of the Gering formation is not distinctly separable. At the curiously sculptured Twin Sisters the unconformity at the top of the Brule clay is finely exhibited, as shown in fig. 19, the Gering formation, consisting of coarse sands and soft sandstones, merging upward into a 6-foot bed of pinkish sandy clay, at the top of which there is a moderately sharp break, followed by an upper member of gray sand which constitutes the head and shoulders of the "Sisters." The Gering formation appears to be absent at the Smokestack and at Roundtop, Coyote Hill, and Castle Rock. In Castle Rock, shown in fig. 11, the Brule clay becomes sandy in its upper portion, but presents no suggestion of stratigraphic break until the base of the well-characterized Arikaree deposits is reached, at an altitude of 4340 feet, where there is an unconformity marked by a bed of white clay a foot thick lying on a carbonaceous surface strongly suggestive of old soil, from which it might be inferred that there was a land surface here while the Gering formation was being deposited to the south.

Fossil bones occur occasionally in the Gering formation and are believed to represent a fauna of early Miocene age. The species collected comprise *Deinictis major*, *Merycochœrus rusticus*, *Leptauchenia decora*, *L. nitida*, *Aceratherium platycephalum* and rhinoceros, according to determinations by F. A. Lucas of the National Museum.

Arikaree formation.—The Arikaree formation occupies the wide, high plain north of Platte River, the crest of the ridge extending west from Roundhouse Rock, and the summit of Courthouse Rock. A thin layer of it appears also beneath the Ogallala formation in the edge of the high table-land in the southwest corner of the quadrangle. The formation consists mainly of fine sand characterized by included layers of hard, fine-grained, dark-gray concretions, often consisting of long, irregularly cylindrical or pipe-shaped masses, which for convenience have been called "pipy concretions." They vary in diameter from a few inches to several feet, but from 10 to 15 inches is a fair average, and their longer axes trend east-northeast and west-southwest with surprising regularity. They occur often in groups many yards in extent. The sands of the Arikaree formation, which are uniformly light gray and in some layers are argillaceous, vary in texture from loose to moderately compact, but, owing to the presence of the hard concretions, the formation generally gives rise to ridges of considerable prominence. It lies on the Gering formation in the ridge extending west from Roundhouse Rock, and on Courthouse Rock, but north of Platte River, south of Pumpkin Valley, and in the ridge and knobs north of Smokestack Rock it appears to rest immediately on the surface of the Brule clay. Usually there is an abrupt change in the character of the materials, as the coarse beds of the Gering formation give place to the fine, massive Arikaree sand containing the "pipy" concretions. There is a possibility that the Gering formation is part of early Arikaree deposits which were laid down along the course of the channel of a stream or locally strong current. In the areas in which the Arikaree formation appears to lie directly on the Brule clay there is usually only a faint suggestion of erosional unconformity between the two formations, or simply a very rapid change from sandy pinkish Brule clay with some small concretions to fine gray sands with the typical character and "pipy" concretions of the Arikaree formation. Fig. 12 shows the relations usually presented in exposures along the northern side of Platte Valley. In the high table-land north of North Platte River, where its surface has been more or less eroded, the Arikaree formation has a thickness of about 300 feet; in the region extending west from Roundhouse Rock about the same thickness remains; but south of Pumpkin Valley, in the southwestern corner of the quadrangle, the formation is thinned to a few feet (see fig. 13). East from the boundary line between Cheyenne and Banner counties it is absent, the Ogallala formation resting directly on the Brule clay, except locally in the region southeast of Langs Point, where there are a few thin outlying lenses of the Arikaree formation, one of which is shown in fig. 15. At Smokestack Rock and in the adjoining ridge the Arikaree formation, 30 or 40 feet above its base, includes a bed of coarse conglomerate marking the course of an old stream channel. An outlier about 20 feet thick gives rise to Smokestack Rock, shown in fig. 20, and on the ridge farther west there are several other detached masses, parts of a series extending from the Scotts Bluff quadrangle. The conglomerate consists of pebbles and bowlders of gray sandstone, generally firmly cemented by a siliceous matrix. The Arikaree deposits contain a large amount of volcanic ash, mainly as an admixture in the sand. The fossils are fresh-water mollusks and several species of vertebrate remains which are regarded as of Miocene age. *Dæmonelix* fibers (fossil plants) occur at various points in the soft sandstone of the formation, but none of the large corkscrew forms, such as occur on the northern face of Pine Ridge, have been observed.

Ogallala formation.—The Ogallala formation is the uppermost Tertiary deposit of this region. It covers a wide area in southern Nebraska, but reaches only a short distance into the Camp Clarke quadrangle, capping the table-land lying south of Pumpkin Valley, and resting on the Arikaree formation to the west and the Brule clay to the east. The material in general is an impure calcareous grit or sand, cemented with carbonate of lime, but at the base there are often beds of conglomerate with pebbles of gray sandstone or limestone, and throughout the mass are thin ledges of sandstone, streaks of pebbly sand, and scattered pebbles of crystalline rocks, apparently from the Rocky Mountains. Some of the softer intercalated sandy beds are light pinkish, the harder calcareous beds are of white or cream color, and high cliffs of the formation at the margin of the table-land south of Pumpkin Valley consist of a white grit rock and conglomerate. At Langs Point the conglomerate lies unconformably on the Brule clay (see fig. 14), and a typical exposure of this contact at a point 10 miles eastward is shown in fig. 16. There are some small outliers of calcareous grit on the top of the high ridge at the head of Logan Canyon, which probably represent the Ogallala formation, but there is no definite evidence of their identity.

PLEISTOCENE PERIOD.

Alluvial deposits.—On the lower slopes adjacent to North Platte River and along other streams there has been deposited a greater or less amount of material brought by them from the higher lands. The lower part of the valley occupied by the North Platte is deeply filled with alluvium, which forms a flood plain about 3 miles wide, to which the river adds at every freshet, and which consists mainly of sandy loams with occasional coarse constituents. On some of the higher terraces is found a mantle of sand and gravel, shown as "upland gravel and sand" on the geologic map, which were deposited when the river channel was not so deeply cut as it now is, and which contain many pebbles and bowlders from the Rocky Mountains, comprising granite of various kinds, quartzites, chalcedonic veinstones, and a small variety of basic igneous rocks. Varying in size from coarse sand to moderately large bowlders, the coarser deposits give rise to long, narrow ridges or lines of knobs, while the materials of intermediate coarseness cover terraces which in some cases extend back from the river bottom for several miles, as is the case north of Bayard. In the valley of Pumpkin Creek there is a similar sequence of alluvial deposits, one series of fine-grained materials of recent origin extending along the lower part of the valley, and higher terraces south of the creek being mantled by coarser material, similar to that occurring in the higher terraces of the valley of North Platte River.

On the plateau at the head of Dugout and Bratton creeks, at an altitude of over 4300 feet, there is a small area of gravel of unknown age but supposed to be of earlier Pleistocene. It is overlain by dune sand, and presents no evidence as to its age or history.

Sand dunes.—Sand dunes are a conspicuous feature in the Camp Clarke quadrangle. There is a large accumulation of them on the summit of the high plain in the northeastern corner of the quadrangle; they occur in an extensive belt along the south side of Platte Valley; in some places they reach up to the base of the steep slope of the ridge west of Courthouse and Roundhouse rocks; and sand hills are scattered in Pumpkin Valley. They are of recent origin, and much of the material is still loose and travels with the wind. On the plateau the sand is derived either entirely from the Arikaree formation or in part also from a deposit of later age. South of North Platte River it has been blown out, mainly from the alluvial flats along the river, and carried southeastward by the prevailing strong northwestern winds, and in Pumpkin Valley it has been derived from local sources. Moving over the surface of the ground the sand lodges against obstructions, and there builds up dunes of greater or less size.

UNDERGROUND FORMATIONS.

There are no deep borings in the Camp Clarke quadrangle to indicate the nature of the formations underlying the Brule clay, but from an examination of surrounding districts the principal features of these formations have been ascertained. They constitute a series of nearly level sheets of sedimentary deposits several thousand feet thick, lying on a floor of granite or metamorphic rocks. The district is in a zone in which the formations change considerably between the mountains on the west and the Missouri and Mississippi valleys on the east, and there is, in consequence, some uncertainty as to the precise thickness and succession of some of the beds. Next below the Brule clay is the Chadron formation, the top of which is not far underground along North Platte Valley. The sands of this formation are light gray or greenish gray, and vary from coarse to fine, merging into clays in some of the beds. Their thickness is about 100 feet in the region north and west, but, as they thin to the southeastward, they may be much less than 100 feet thick in the southeastern part of the quadrangle. The eastern edge of the Laramie formation probably extends into and may extend across the quadrangle under the Chadron formation, for it is known to underlie the greater part of the Scotts Bluff quadrangle. It consists of soft, yellowish, or light-greenish sandstones and gray clays, with occasional thin beds of coal. Its thickness can not be estimated closely, but it is probably not over 200 or 300 feet thick. There is no question that the quadrangle is underlain by the next succeeding formation, the Pierre shale, for the formation is known to underlie all of western Nebraska, northwestern Kansas, eastern Colorado, and Wyoming, and the greater part of the Dakotas. It is about a thousand feet thick and consists throughout of a dark clay or soft shale, with occasional harder shale layers and thin beds of iron pyrite. Owing to its plasticity it is extremely difficult to penetrate in well-boring operations. It is underlain by 200 feet of light blue-gray chalk rock and limy shale, known as the Niobrara formation. This is succeeded by a series of shales, probably considerably over 500 feet thick, of the Benton formation, which has in its middle a thin but persistent series of limestones containing large numbers of a characteristic shell known as *Inoceramus labiatus*. Next below is the Dakota sandstone and possibly the underlying Lakota sandstone, several hundred feet of coarse gray to buff sandstones which carry water available for artesian wells. The depth of this sandstone in North Platte Valley is probably about 2000 feet, but it may be considerably more. In eastern Nebraska the Dakota sandstone lies on Carboniferous limestones, but in the Black Hills and Rocky Mountains it is separated by clays and shales and a thick mass of Red Beds, and there is no evidence as to how far these intervening formations extend under western Nebraska. The Carboniferous limestones doubtless have a thickness of several hundred feet under the Camp Clarke quadrangle, and are separated from granites or other old crystalline rocks by a sheet of sandstones of Cambrian age.

BRIEF GEOLOGIC HISTORY OF THE CENTRAL GREAT PLAINS REGION.

The sedimentary rocks of the Camp Clarke quadrangle, including those underground, afford a record of physical geography from Cambrian time to the present, but, owing to lack of knowledge of the relations of some of the deeply buried rocks, the geologic history of the region can not be outlined as completely as in the adjacent mountain regions where all the beds are uplifted and exposed at the surface. There were undoubtedly many marine submergences, and several periods of emergence in which the surface was sculptured by running waters, especially in the later epochs. The basal sedimentary member, the Cambrian sandstone, which is widespread in the United States and is brought to view in nearly every uplift, lies on and against granites and other old crystalline rocks. It marks one of the great events in North American geologic history, the wide expansion of an interior sea over the western-central region. Its first products were coarse deposits, gathered by the streams and waves and laid down on sea beaches, partly in shallow waters offshore and partly in estuaries. The later products of the submergence were finer grained and are now represented by the Cambrian shales and limestones. From the close of the Cambrian to early Carboniferous time the central region presents a scanty record, the Silurian and Devonian being absent or thin in the greater part of the uplifts to the west and north.

In early Carboniferous times there was widespread transgression of the ocean over the region, and there accumulated great deposits of carbonate of lime, represented by limestones many hundred feet thick. In the later portion of the period a gradual general uplift diminished the depth and extent of submergence and coarser sediments began to appear. This epoch is represented by alternations of sandstones and limestones, sandy limestones, and red shales. In Permian times there was still further emergence, resulting in a shallow basin which extended across the western portion of the central Plains region and far to the northwest. In this basin there were laid down the great mass of red shales of the "Red Beds" with their extensive interbedded deposits of gypsum, products of an arid climate. The sandy clay of the gypsiferous Red Beds accumulated in thin layers to a thickness of 500 feet or more, as now represented by the formation, and it is so uniformly of a deep-red tint that this is undoubtedly the original color. This color is present not only throughout the extent of the formation, but through its entire thickness, with the exception of an occasional lighter colored bed, as is also shown by deep borings, and therefore is not due to later or surface oxidation. This deposition of red mud was interrupted from time to time by chemical precipitation of comparatively pure gypsum in beds ranging in thickness from a few inches to 30 feet, and often free from mechanical sediment. It is apparent that these beds are the products of evaporation while mechanical sedimentation was temporarily suspended, a condition indicative of greatly diminished rainfall, otherwise it is difficult to understand their nearly general purity. Whether this deposition of the Red Beds extended into or through Triassic times in the central Plains region is not known, but it is thought that the uplift to which they were due finally brought the region above the water at the close of the Permian, and that during most if not all of the Triassic there was no deposition and probably some slight erosion, during an epoch which extended well into Jurassic time.

In later Jurassic time there was a sea that covered the region in which the Laramie and Bighorn mountains and the Black Hills now rise, and doubtless extended for some distance over the northwest corner of Nebraska. The conditions varied somewhat from shallow to deep waters, but marine waters prevailed. The materials are nearly all fine grained and indicate waters without strong currents, except along some portions of the shores, where coarse sandstones were laid down, some of them of bright-red color, which probably derived their sediments from adjacent land surface of the Red Beds. Generally, however, clay was the first sediment, and it was followed by ripple-marked sandstone, evidently laid down in shallow water and probably the product of a time when sedimentation was in excess of subsidence, if not during an arrest of subsidence. The red color in the medial part of the Jurassic deposits in some districts may represent a transient return to arid conditions similar to those under which the gypsiferous Red Beds were laid down. The thick mass of shales with thin limestones which followed is indicative of deeper waters. After this stage there was widespread uplift, which, in the northern-central area, marked the beginning of Cretaceous time. There were fresh waters in which the principal deposit was the widespread clay of the Morrison formation, now extending from Montana to Oklahoma, where it gives place to marine sediments of the Lower Cretaceous. Probably the Morrison deposition extended over the western part of Nebraska, but its eastern margin is not located. It was succeeded by a period of shallower waters with shore conditions and strong currents, marked by the coarse sands of the Lakota formation in the region of the Black Hills and to the northwestward; and later, under similar conditions, there was deposited the wide sheet of Dakota sandstone which extends over the entire central and northern Plains region. Several hundred feet of these sands are exposed along the Rocky Mountain front, and in the Black Hills, Bighorns, and region northwestward, and they appear in eastern South Dakota and eastern Nebraska, and extend in a broad belt at or not far under the surface in southeastern Colorado and southern and central Kansas.

Following the deposition of this great sheet of sandy sediments there was a rapid change to clay deposition, of which the first representative is the Benton shale, a formation even more extensive than the underlying Dakota sandstone. This was the later Cretaceous submergence, in which marine conditions prevailed, and it continued until several thousand feet of clays were deposited during the Benton, Niobrara, and Pierre epochs. In Benton times there were occasional deposits of sand, and one thin but very widespread lime stratum of the Greenhorn limestone in the middle of the Benton sediments. The shale of the Benton is followed by several hundred feet of impure chalk, now constituting the Niobrara formation, and this in turn by many hundred feet of Pierre shale, which thickens rapidly to the westward, attaining 1200 feet or more in western South Dakota and over 7000 feet adjacent to the Rocky Mountains in a limited area west of Denver.

The retreat of the Cretaceous sea corresponds with the Foxhills epoch, during which sands were spread in an extensive sheet over the clay beds, and resulted in extensive bodies of brackish waters, and then of fresh waters, which deposited the sands, clays, and marsh material of the Laramie and earliest Tertiary. Apparently these last-mentioned formations were not laid down much east of longitude 101° in Nebraska, for they thin rapidly to the east, although, as we do not know the extent of post-Laramie erosion, their former limits can only be conjectured.

In earlier Tertiary times the domes of the Black Hills and other mountains lying farther west were uplifted, but this uplift appears not to have affected the strata in the central Plains region. Where the great mass of eroded material was carried is not known, for in the lower lands to the east and south there are no early Eocene deposits nearer than those on the Gulf Coast and Mississippi embayment, but in small part they are represented by the sandstones and conglomerates overlying the Laramie formation in the vicinity of the mountains.

Later in Tertiary time, after the outlines of the great mountain ranges to the north and west had been carved, there was a long period in which streams of moderate declivity flowed across the central Great Plains region; these, with frequently varying channels and extensive local lakes, due to damming and the sluggish flow of the waters, laid down the widespread mantle of Oligocene or White River deposits. These begin with the sands of the Chadron formation, which show clearly the course of old currents by channels filled with coarse sandstone and areas of slack water and overflow in which fuller's earth and other clays were laid down. The area of deposition of this series extended across eastern Colorado and Wyoming and western Nebraska and South Dakota, and probably also farther northward, for the deposits have been found in western Canada. Doubtless the original extent was much wider than the area in which we now find the formation, for much has been removed by erosion. The White River epoch was continued by the deposition of the Brule clays under conditions in which the currents were less strong and local lakes and slack-water overflows were more extensive. The Brule clay which resulted has about the same area as the Chadron, and originally it was much more extensive than it is at present.

At the beginning of Miocene time the general conditions had not changed materially, but doubtless for a while an extensive land surface existed in the central Plains area. In one of the stream channels extending across this surface the Gering formation was laid down, one channel extending across this quadrangle. Next came the deposition of a widespread sheet of sands derived from the mountains to the west, probably spread over the entire central Plains region by streams, aided to a minor extent by the winds. The streams of this time shifted their courses across the plains, spreading the débris from the mountains in a sheet which in some portions of the area attained a thickness of 1000 feet. This is the Arikaree formation, and it buried some of the lower ranges of the uplifts, as shown by its high altitude on the slopes of Rawhide Butte and along the front of the Laramie Range. It has been so widely eroded since the time of its deposition that we do not know its original extent, but doubtless it covered most of the central Plains far to the east. It was followed by uplift and erosion, erosion which removed the Arikaree and parts of underlying formations from the south and east, leaving the thickest mass of the deposit in western Nebraska and eastern Wyoming. Next came the epoch in which the streams began depositing the thin mantles of sands of the Ogallala and other late Pliocene formations, especially in southern Colorado, southern Nebraska, Kansas, and regions farther south. The deposition at this time appears to have been mainly in the southern region above described, erosion probably predominating in the district lying farther north.

These alternating conditions of later Tertiary deposition and erosion, first in the north and next in the south, were undoubtedly determined by differential uplift, the uplifted region suffering erosion and the depressed or stationary region receiving deposits from streams which did not have sufficient declivity to carry off their loads. This condition also is a feature of the semi-arid climate of the Plains, the mountain torrents and resulting vigorous erosion furnishing large amounts of débris which the streams of low declivity and constantly diminishing volume on the Plains were unable to carry to the sea. Even if such a region is traversed by valleys cut during a time of uplift or increased rainfall, when cutting ceases these valleys will soon be filled by sediments, and when they are full the streams at times of freshet, and to a less extent in the dry portion of the year, will shift their courses so as finally to spread a wide mantle of deposits over the entire area in which there is sluggish drainage.

During the early portion of the Pleistocene period there was uplift and increased precipitation, which resulted in widespread denudation of the preceding deposits, so that they were entirely removed in the eastern portion of the area, where there were glacial floods, and widely and deeply trenched in the western portion. To the west there extended to the foot of the mountains a great high plain, of wonderful smoothness, mantled mostly by the Arikaree to the north and by the Ogallala and possibly some later deposits to the south, the product of later Tertiary deposition. As the Black Hills dome rose somewhat higher than the general uplift, there was deep erosion around it, so that the High Plains, whatever their extent may have been in that region, were largely removed, and now their northern edge is presented toward that uplift in the great escarpment of Pine Ridge. Farther south, across Nebraska, Colorado, Kansas, and Texas, the High Plains present wide areas of tabular surface, but the streams of Pleistocene time have cut into them deeply and removed them widely. Erosion is still in progress, especially in the smaller streams, where the water has sufficient declivity to carry away its load; but in the larger streams the valleys are building up, as in the later Tertiary periods, for the volume of water is not adequate to carry away the waste from the adjoining slopes. Without further uplift the valleys will in this way be filled, the streams will again wander over the divides, and the Great Plains will receive a new mantle similar to those of whose remnants they consist.

ECONOMIC GEOLOGY.

UNDERGROUND WATERS.

The principal supplies of underground waters in this region are in the lower portion of the Arikaree and Ogallala formations on the high table-lands, and in the alluvial deposits in the valleys, especially in the wide bottom lands along North Platte River. On the extensive valley slopes the amount varies greatly, and it is seldom large, though many of the smaller depressions contain shallow deposits of loose material in which more or less water accumulates, and additional supplies are often obtainable from crevices in the clays below. The slopes of Brule clay are particularly barren of water. On the broad bottom lands adjoining North Platte River there are numerous wells, varying in depth from 15 to 30 feet in greater part, the shallower wells usually being nearer the river. The available amount of water varies somewhat, but it is nearly always adequate for domestic use. It is of fair quality, but in places there is considerable alkali in the shallower well waters. In Pumpkin Valley wells sunk at frequent intervals have usually reached moderate supplies of fairly good water at depths of from 20 to 40 feet.

The high table-land north of North Platte Valley is sparsely settled, but there are wells which indicate the existence of water in the lower portion of the Arikaree sands at depths of from 100 to 200 feet—or at about the level of the springs which flow out in the canyons. Similar conditions exist in the high table-land south of Pumpkin Valley, where water is found at the base of the Arikaree or Ogallala formations, at depths of from 200 to 300 feet. The quality of these high table-land waters is excellent and the volume is usually large. Both the Arikaree and Ogallala formations are of such porous nature that they collect much water from the rainfall, and this water sinks to the lower beds, the outcrops of which in the canyons are usually marked by occasional springs, some of which yield a moderately large volume of water. Some notable springs from this source are Duggers Springs and those at the head of Chalk, Hackberry, Red Willow, and Indian creeks.

No attempts have been made to bore through the Brule clay in this portion of North Platte Valley to reach the Laramie sandstones which may possibly lie at no very great depth and which might furnish artesian flows. It is probable also that the Dakota sandstone is within reach of the well borer, and possibly it would furnish flowing water in large amount and of good quality. Its depth can not be estimated accurately, for the overlying formations vary in thickness under western Nebraska and there is no direct evidence as to their amount in this district. The sandstone is overlain by shales and chalk rock almost certainly 2000 feet thick and possibly considerably more. The shales are difficult to penetrate, owing to their softness and plasticity, and necessitate experienced well borers, heavy casing, and occasional diminution in size of casing as the depth increases.

IRRIGATION.

In this quadrangle there is considerable acreage under cultivation with the aid of irrigation. There are extensive canals along the valley of North Platte River, and there is a small ditch out of Pumpkin Creek. The results of irrigation have been so satisfactory that increased facilities are being provided for obtaining water, and, with the new railroad line in the region, prospects of profitable farming are most encouraging. At present nearly all of the wide alluvial flat along North Platte River is provided with water by the Bayard and Browns Creek canals on the north side of the river, and the Castle Rock, Chimney Rock, and Belmont canals on the south side of the river, an acreage of about 90 square miles, only a small portion of which is now being farmed. The soils of the valley are usually thick and rich, and, although somewhat alkaline, respond satisfactorily to culture. The wide bottom lands are flat and easy of access and the water of the river supplies a large volume to the ditches. The principal crops are wild hay, alfalfa, corn, and wheat. Oats and garden vegetables are also irrigated extensively. The yield per acre of crops under irrigation is somewhat variable. Wheat usually harvests from 30 to 40 bushels per acre; potatoes, 150 to 200 bushels; and hay, $1\frac{1}{2}$ tons. Alfalfa yields 2 tons to the cutting and is cut three times each season.

The cost of irrigation varies mostly from 30 to 75 cents an acre; the average obtained from 7500 acres is 40 cents an acre. In many cases the water is paid for partly by labor.

VOLCANIC ASH.

This material is mined at several points in the West for polishing powder, and the extensive deposits of volcanic ash in this region may possibly be of value at some time. The upper bed in the Brule clay, extending from Chimney Rock to Castle Rock, is the largest and most accessible deposit and it would furnish a large supply of excellent ash. Other local beds often occur in the Gering and Arikaree formations at various points.

GOLD.

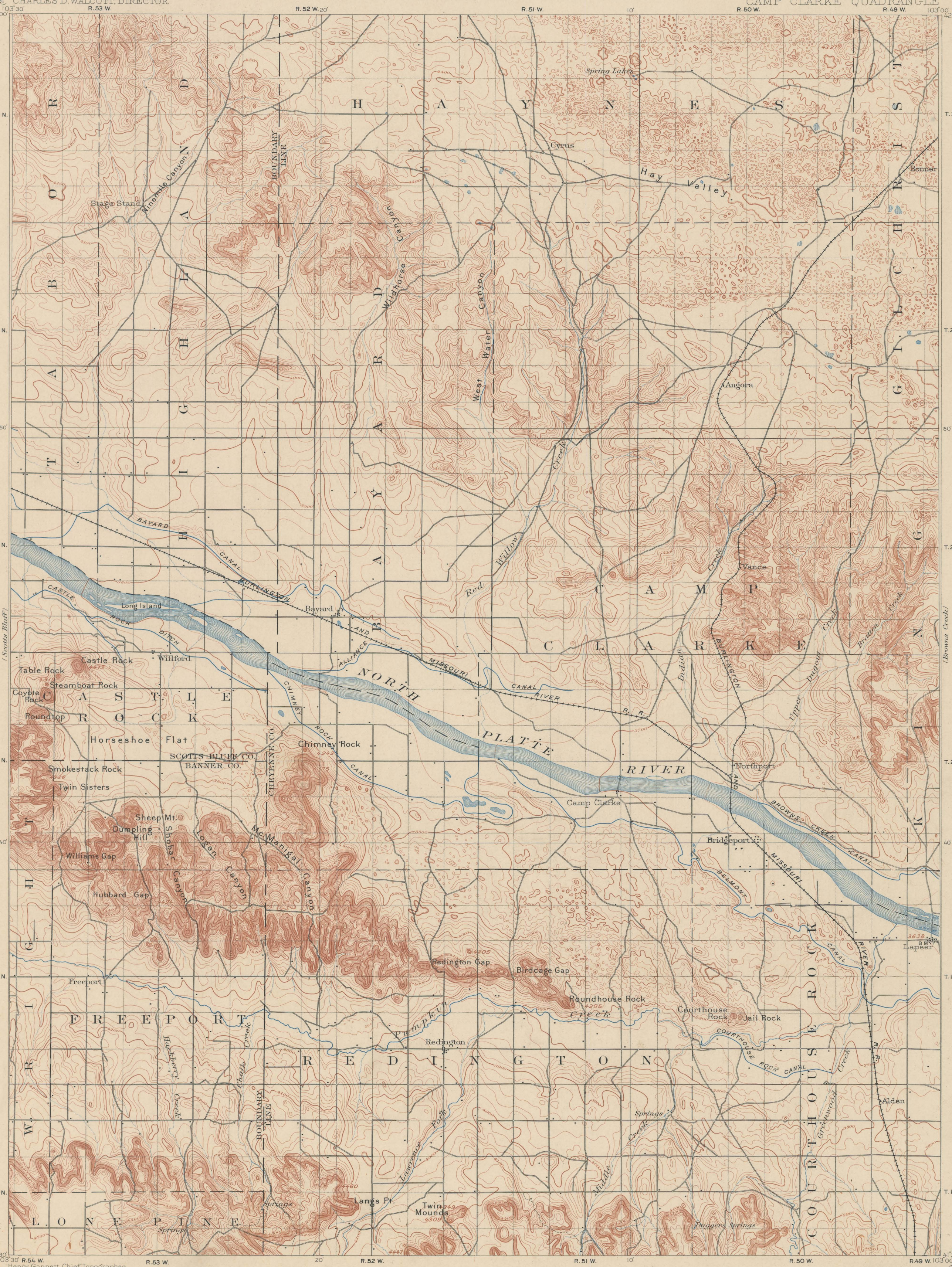
Traces of fine-grained placer gold have been reported in the gravels on the wide upper terrace north of Bayard, but the amount obtained has been too small to sustain the hope that the deposits may prove valuable.

June, 1901.

U.S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

TOPOGRAPHIC SHEET

NEBRASKA
CAMP CLARKE QUADRANGLE



LEGEND

RELIEF (printed in brown)

- Figures (showing heights above mean sea level instrumentally determined)
- Contours (showing height above sea, horizontal form, and steepness of slope of the surface)
- Depression contours

DRAINAGE (printed in blue)

- Streams
- Intermittent streams
- Canals and ditches
- Ponds
- Intermittent ponds
- Springs

CULTURE (printed in black)

- Roads and buildings
- Trails
- Bridges
- Fords
- U.S. township and section lines
- County lines
- Township lines
- Bench marks
- Railroads

Henry Gannett, Chief Topographer.
Jno. H. Renshawe, Topographer in charge.
Control by E. M. Douglas, U.S. Engineer Corps, and General Land Office.
Topography by H. B. Blair.
Surveyed in 1895.

Scale 1/125000

0 1 2 3 4 5 Miles

0 1 2 3 4 5 Kilometers

Contour interval 20 feet.
Datum is mean sea level.

Edition of July 1902.

U.S. GEOLOGICAL SURVEY
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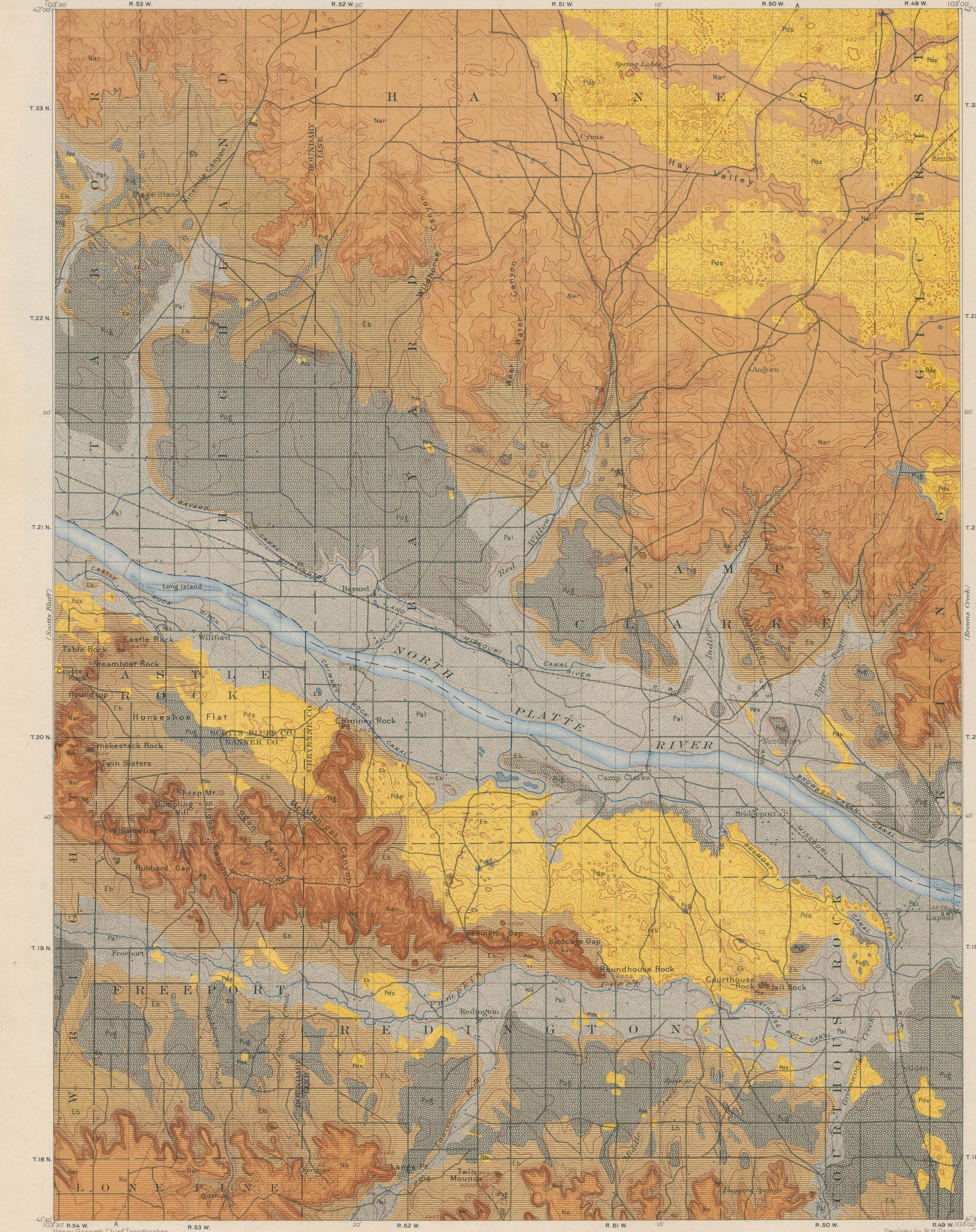
AREAL GEOLOGY SHEET

NEBRASKA
CAMP CLARKE QUADRANGLE



LEGEND

SURFICIAL ROCKS
(Areas of Surficial rocks are shown by patterns of dots and circles.)

PLEISTOCENE

- Pds — Dune sand
- Pal — Recent alluvium *(only the larger deposits represented)*
- Pug — Upland gravel and sand *(on older terraces and slopes; limits very indefinite)*

SEDIMENTARY ROCKS
(Areas of Sedimentary rocks are shown by patterns of parallel lines.)

NEOCENE

PLIOCENE ?
- No — Ogallala formation *(sand and gravel cemented by lime)*

MIOCENE
- Nar — Arikaree formation *(soft sandstone with pipe-like concretions)*
- Nac — Conglomerate lenses in Arikaree formation
- Ng — Gering formation *(soft sandstone, sandy clay, and conglomerate)*

EOCENE

OLIGOCENE
- Eb — Brule clay *(hard, sandy, pinkish clay with thin lenses of sandstone and limestone, mostly covered by talus and wash)*

Section

Henry Gannett, Chief Topographer.
Jno. H. Renshawe, Topographer in charge.
Control by E. M. Douglas, U.S. Engineer Corps, and General Land Office.
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Scale $\frac{1}{125000}$

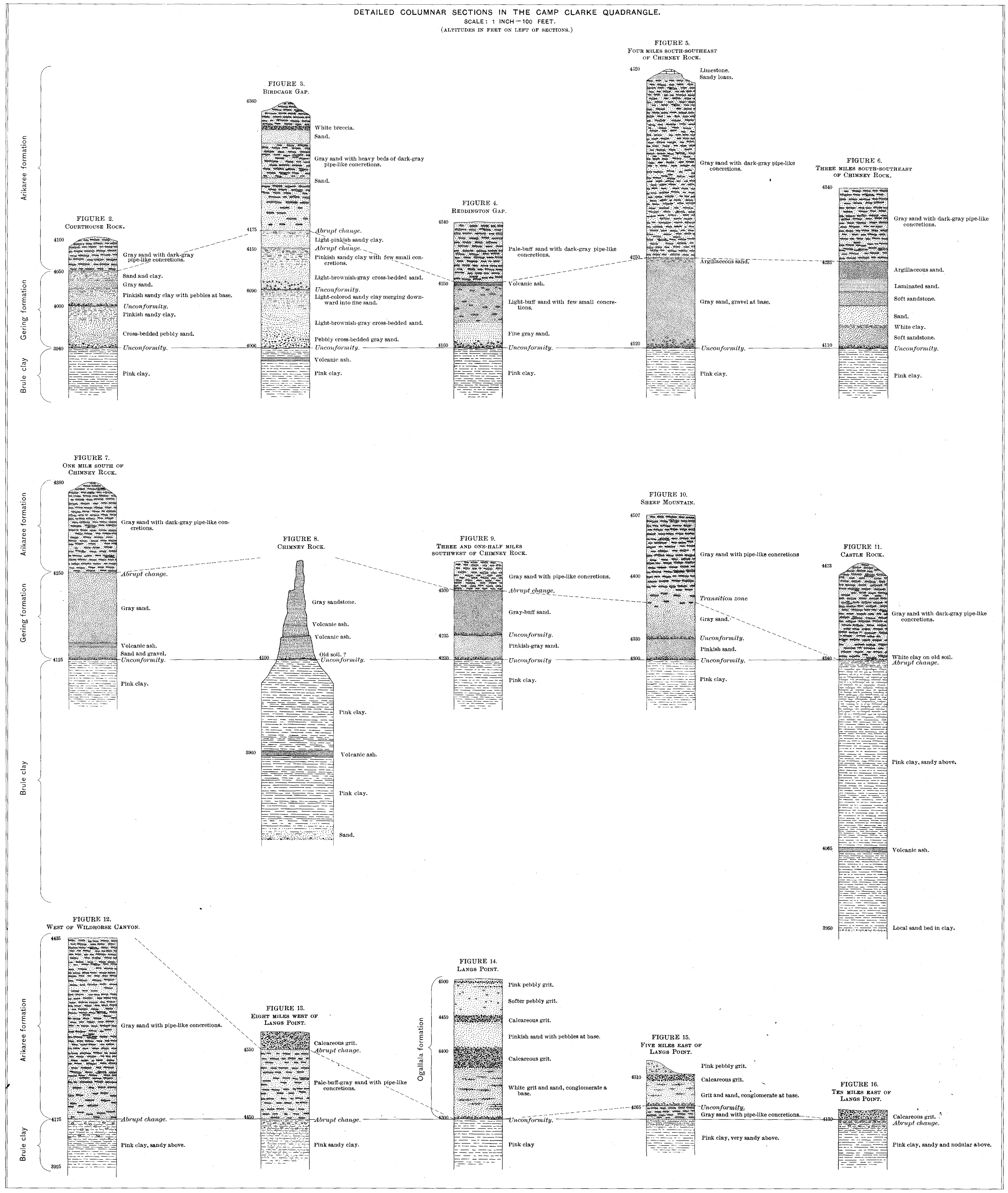
1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet.
Datum is mean sea level.
Edition of July 1902.

Geology by N. H. Darton.
Surveyed in 1897.

COLUMNAR SECTION SHEET



N. H. DARTON,
Geologist.

ILLUSTRATION SHEET

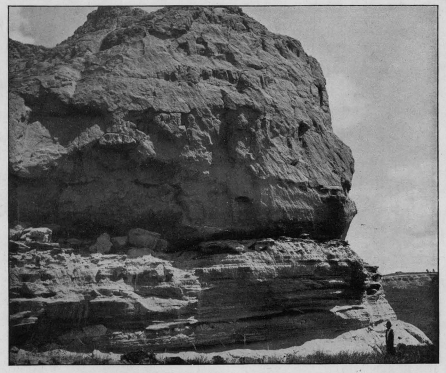


FIG. 17.—CONGLOMERATE BED IN THE GERING FORMATION LYING UNCONFORMABLY ON BRULE CLAY.

Northwest of Redington, Nebr. The man's hand is at the contact.

FIG. 18.—JAIL ROCK, SEEN FROM COURT-HOUSE ROCK.

Showing castellated form of weathering of the Gering formation. Slopes are Brule clay. Valley of North Platte River in the distance.

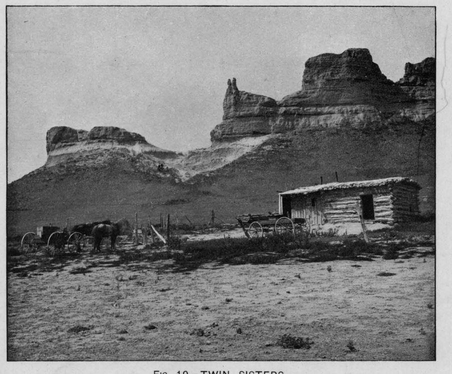


FIG. 19.—TWIN SISTERS.

Characteristic weathering of Gering formation. Shows also the unconformity between the Gering and the Brule clay.

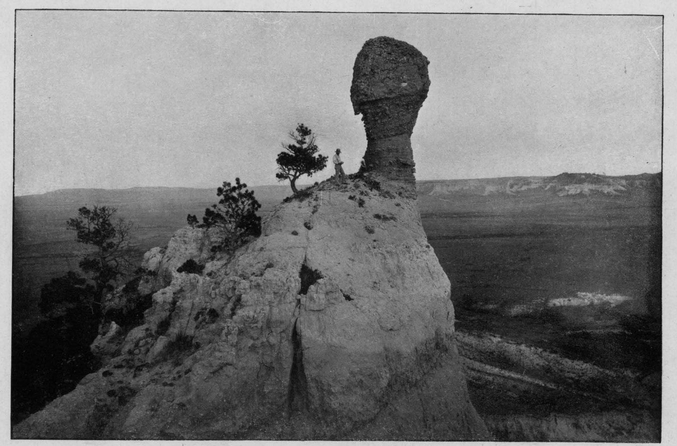


FIG. 20.—SMOKESTACK ROCK.

Composed of conglomerate of the Arikaree formation.

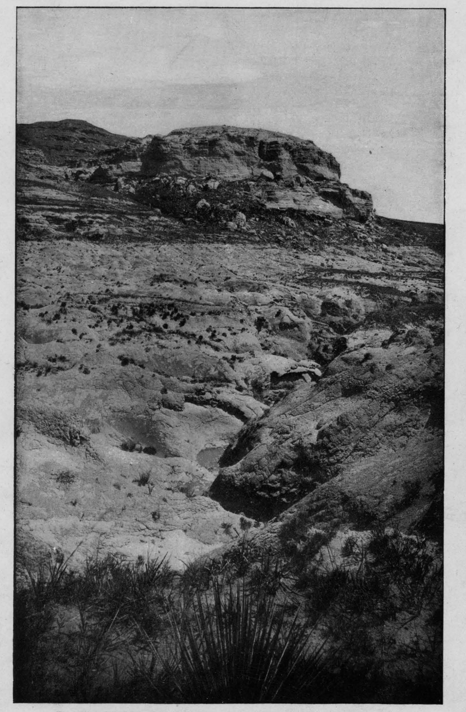


FIG. 21.—CLIFFS OF GERING FORMATION ON BRULE CLAY.

Looking southeast into Birdcage Gap, northeast of Redington, Nebr. In the foreground the Brule clay is deeply eroded. Arikaree formation at the top of the hill

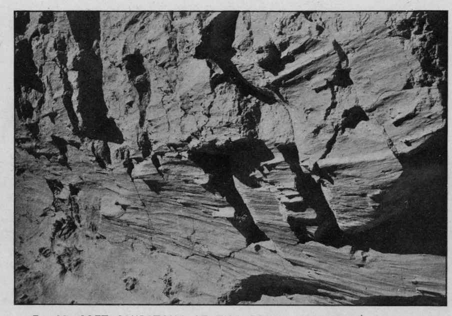


FIG. 22.—SOFT SANDSTONE OF THE GERING FORMATION, SHOWING WIND EROSION.

Banner County, Nebr.

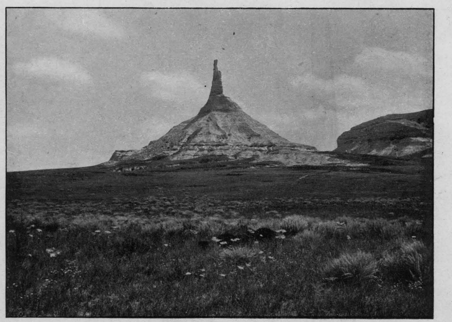


FIG. 23.—CHIMNEY ROCK, SEEN FROM THE WEST.

Statue-like form composed of Gering formation resting on Brule clay. A bed of white volcanic ash may be seen near the base of the hill.

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39	Truckee	California	25
40	Wartburg	Tennessee	25
41	Sonora	California	25
42	Nueces	Texas	25
43	Bidwell Bar	California	25
44	Tazewell	Virginia-West Virginia	25
45	Boise	Idaho	25
46	Richmond	Kentucky	25
47	London	Kentucky	25
48	Tenmile District Special	Colorado	25
49	Roseburg	Oregon	25
50	Holyoke	Mass.-Conn.	50
51	Big Trees	California	25
52	Absaroka	Wyoming	25
53	Standingstone	Tennessee	25
54	Tacoma	Washington	25
55	Fort Benton	Montana	25
56	Little Belt Mountains	Montana	25
57	Telluride	Colorado	25
58	Elmoro	Colorado	25
59	Bristol	Virginia-Tennessee	25
60	La Plata	Colorado	25
61	Monterey	Virginia-West Virginia	25
62	Menominee Special	Michigan	25
63	Mother Lode District	California	50
64	Uvalde	Texas	25
65	Tintic Special	Utah	25
66	Colfax	California	25
67	Danville	Illinois-Indiana	25
68	Walsenburg	Colorado	25
69	Huntington	West Virginia-Ohio	25
70	Washington	D. C.-Va.-Md.	50
71	Spanish Peaks	Colorado	25
72	Charleston	West Virginia	25
73	Coos Bay	Oregon	25
74	Coalgate	Indian Territory	25
75	Maynardville	Tennessee	25
76	Austin	Texas	25
77	Raleigh	West Virginia	25
78	Rome	Georgia-Alabama	25
79	Atoka	Indian Territory	25
80	Norfolk	Virginia-North Carolina	25
81	Chicago	Illinois-Indiana	50
82	Masontown-Uniontown	Pennsylvania	25
83	New York City	New York-New Jersey	50
84	Ditney	Indiana	25
85	Oelrichs	South Dakota-Nebraska	25
86	Ellensburg	Washington	25
87	Camp Clarke	Nebraska	25
88	Scotts Bluff	Nebraska	25

* Order by number.
† Payment must be made by money order or in cash.
‡ These folios are out of stock.

Circulars showing the location of the area covered by any of the above folios, as well as information concerning topographic maps and other publications of the Geological Survey, may be had on application to the Director, United States Geological Survey, Washington, D. C.