GEOLOGY AND COAL RESOURCES OF THE SALINA CANYON DISTRICT, SEVIER COUNTY, UTAH

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INTRODUCTION

Location and extent of the district.—The area described in this report includes a strip of land about 6 miles wide and 14 miles long, centrally located in the drainage basin of Salina Creek and extending from the divide at the headwaters of the creek westward to the lower end of Salina Canyon. It forms part of a high plain between the still higher Wasatch and Fish Lake Plateaus to the north and south, respectively, and is trenched across by the deep gorge cut by Salina Creek. Practically all the accessible coal in and near Salina Canyon lies within this area, the western edge of which is about 8 miles by road from the town of Salina, in the Sevier Valley, on the Marysvale branch of the Denver & Rio Grande Western Railroad, as shown by the index map on Plate 21.

The Salina Canyon district is directly related to the Wasatch Plateau coal field, the southeastern part of which it joins at the crest of the divide in the center of the plain above mentioned, and its coal beds are directly continuous with those of the Wasatch field. It is not yet a district in the sense of being a fully developed mining area, but it will be developed as a unit separate from the Wasatch field, and the term Salina Canyon district is applied to it on that account.

Purpose and character of the investigation.—The existence of coal in Salina Canyon was known to the pioneers in this part of Utah, and from the time of their settlement to the present day the coal has been mined intermittently in a small way to supply the domestic needs of people in the Sevier Valley. This mining has never advanced beyond the stage of prospecting and the irregular operation of " country " mines, largely because the showings of coal in Salina Canyon have not proved sufficient to encourage the development of large mines. The discovery in later years of large reserves of high-grade coal on the east face of the Wasatch Plateau has increased the interest of prospectors in this general region, and the obvious similarity between the rocks in the productive districts of the Wasatch

Plateau field and those in Salina Canyon has led to much prospecting and speculation as to the presence in Salina Canyon of valuable coal. The present work was undertaken to satisfy the demand for information that has grown up with this increase in public interest and to provide an adequate basis for the classification of the public land in the district.

The field work was done during parts of August and September, 1923, by the writers, assisted by C. F. Spieker. The geology of the area and particularly of the coal-bearing rocks was studied in detail and mapped with the plane table on a scale of 2 inches to the mile. Detailed sections of the coal beds were measured and the more important outcrops were correlated wherever possible. A complete section of the rocks exposed in the district was measured in Salina Canyon, and additional sections of the Blackhawk formation, which bears the coal, were measured at several places. The geologic structure, on which depends the possibility and plan of mining, was determined in detail. Control for the map was spread from a measured base line by a system of triangulation, and the altitudes were obtained by vertical angles read to a bench mark of the United States Geological Survey on the divide near the road between Salina and Emery. All the main stream channels were traversed with the plane table.

The mileposts set on the main road in Salina Canyon, showing the distance at every half mile from Salina, afford a very convenient set of reference points, and they are all shown on the maps in order to aid those readers who desire to use the report in the field to find their position at places on and near this road.

Land surveys.—The location of the subdivisions of the United States General Land Office is an important part of an investigation such as this, and it is obviously an essential preliminary to development of the land. The present work has disclosed a series of discrepancies in the land surveys of the district, and because of the importance of knowing exactly where the legal land subdivisions fall on the ground, the attention of prospective operators is directed toward these discrepancies, and the manner in which they are here treated is somewhat fully explained.

The surveys of the western part of T. 22 S., R. 2 E., and all of T. 22 S., R. 3 E., were made a long time ago, and many of the corner stones are no longer in place. The eastern part of T. 22 S., R. 3 E., has been surveyed more recently, and the corners of this survey that were found in the present work agree with the records of the General Land Office. According to those records, T. 22 S., R. 3 E., and T. 22 S., R. 2 E., should join with common corners and with no offset except at the north end, where T. 22 S., R. 3 E., is slightly longer than T. 22 S., R. 2 E. In the present work, however, the land lines in the center of T. 22 S., R. 3 E., were found to lie too far south to join, by normal projection, with the corners set in the latest survey of the west township boundary. The strip of land between the center of the township and the western border is exceedingly rough, and possibly it was never surveyed.

The lines joining the center of the township, where several corners were found, with the western border would have been drawn diagonally on the maps (pl. 22 and fig. 9) but for the fact that one corner on the township line, the southwest corner of sec. 7, was found to be in line with the lines projected from the center of the township; the location of this corner, however, does not agree with that given on the official plat of the township, which describes the corner as located on the ground north of the Coal Hollow mine, where it should fall with reference to the northwest corner of sec. 7. The authenticity of the stone purporting to mark the southwest corner of sec. 7, which was found south of Coal Hollow, may therefore well be doubted, but the fact is clear, on comparison of the features shown on the two township plats, that a discrepancy exists between the surveys of the two townships, and the discrepancy is equal to the amount of offset obtained by direct projection of the lines westward from the center of T. 22 S., R. 3 E. Because of the uncertainty involved in the adjustment of these surveys, the lines of the two western tiers of sections in T. 22 S., R. 3 E., are extended on the maps (pl. 22 and fig. 9) due west from the located corners, and are broken to indicate the uncertainty of their position. The map thus shows offsets on the township boundary that should not exist. If more evidence should ever be found to indicate that the two townships join with common corners, then the sections in the two western tiers of T. 22 S., R. 3 E., will be shown to be distorted in shape, and the legal boundaries of these sections can be put on the map by simply joining the easternmost section corners in T. 22 S., R. 2 E., with the corners in the middle of T. 22 S., R. 3 E.

The adjustment of these discrepancies is a difficult matter because so few of the critical section corners can be found. A disproportionate amount of time was spent in the field at this discouraging task.

Acknowledgments.—The writers are indebted for much assistance, particularly in the verification of the identity of located land corners, to Mr. B. Kenner, of Manti, Utah, whose detailed acquaintance with the district lends much added value to the results here presented. Mr. R. E. L. Kenner, resident manager of the Mountain ranch, extended many courtesies to the party. The writers desire to express their appreciation of the valuable assistance in the field work given by C. F. Spieker. Members of the United States Forest Service, espe-

cially Messrs. Barnar and Biddison, rangers in the Fish Lake National Forest, gave freely of their knowledge of the country and aided the writers in many other ways. Residents and in particular merchants of the town of Salina were very courteous and helpful in all their dealings with members of the party.

GEOGRAPHY

SURFACE FEATURES

The Wasatch and Fish Lake Plateaus are in the easternmost belt of the great plateaus known as the High Plateaus of Utah. The main masses of these two plateaus, which trend north, are separated by a lower upland about 20 miles long. The top of the Wasatch Plateau at the southern scarps of White Mountain and Musinia Peak, which mark its southern boundary, stands at about 10,800 feet above sea level, and the tops of the northernmost prominences of the Fish Lake Plateau are about 11,700 feet above sea level. Altitudes in the intervening area range from about 8,500 feet near the divide to about 5,200 feet in the valley bottoms at its western edge, giving a total relief in the general region of 6,500 feet.

The general surface of the district conforms in many ways so thoroughly with the conditions imposed by geologic structure that it is difficult to describe intelligently without mention of the structural features. It is true that in some important ways the development of surface features has gone on in total disregard of structural conditions, but in these respects, too, effective description requires a joint treatment of surface features and geologic structure. The following description, in answer to this requirement, anticipates to a certain extent the discussion of geologic structure to be found farther on in this report.

The rocks of Salina Creek drainage basin are broken into long and comparatively narrow blocks, bounded by north-south faults, or fractures, and the surfaces of the blocks are relatively high or low according to the hardness of the rocks of which the blocks are composed. The harder rocks have resisted erosion and now form the higher table-land, and the softer rocks have yielded to erosion and form the valleys. The trend of the long axes of the blocks is practically north, at right angles to the axis of the saddle but parallel to the major axes of the plateaus and also parallel to the dominant trend of the faults. The faults of the region are not limited to those that bound the blocks, for within the blocks there are many subsidiary faults, some of which have little or no surface expression; but wherever the faults have juxtaposed rocks of different hardness the result is obvious in the surface features, and the origin of all the major elements of the surface is ascribable directly to faulting of the geologic formations. If the relationship between these faults and the surface features is clearly held in mind it is much easier to comprehend the area both as a whole and in detail and to grasp the fundamental features of its geology and the distribution of the coal-bearing rocks, as well as those features of the land that will control the economic development of the area.

The easternmost block of the Salina Canyon district is the table that forms the major divide. The western border of this table is nearly coincident with the easternmost fault shown on the geologic map (pl. 22), and it is a pronounced escarpment, about 1,000 feet high, throughout its length in this district. Into this block Skumpah Creek and Spring Creek, tributaries of Salina Creek, have cut steep-walled gorges 500 to 800 feet deep. South of the area here described, where the fault dies out and the hard rocks that form the table east of the fault rise west of the fault toward an equal level, the escarpment also dies out and the surfaces merge. The entity of the surface block is thus lost as the fault disappears.

West of this block lies a valley about a mile wide. The northern part of this valley is occupied by the upper stretch of Salina Creek, and because it is formed of the upper, softer geologic formations of the district, it is flat and spacious. In the southern half of the district, however, the strata rise at a rate sufficient to bring to the surface the harder rocks of the table-land, and there the surface of the valley is more rugged, although not so rugged as the country within the blocks of higher land.

This valley is bounded on the west by a wedge-shaped ridge, the highest points on which are about 950 feet above the valley floor. The ridge is shaped somewhat like a sugar loaf, and it forms a narrow wall between the upper valley of Salina Creek and Taylor Flat. The crest of the ridge slopes southward, and it merges with the lower hills in the southern part of the eastern valley at the place where the faults bounding it come together to form the point of the wedge.

The ridge is sharply trenched by Salina and Spring Creeks, and the narrow gorges of these streams, cut through hard rock directly across the structural lines, clearly indicate that the streams existed before the faulting and warping of the rocks occurred and that because of the slowness of the fault movements they were able to maintain their courses unchanged.

The north-south valleys in the softer rocks exhibit conformity with structural conditions; the streams cutting through the ridges of harder rock exhibit disregard of structure. Salina Canyon itself is a striking example of the extent to which the streams have disregarded the buttresses of hard rock thrown up across them by the faulting; Salina Creek plunges from the broad valley of the Mountain ranch into a narrow gorge in the hard rock, continuing its straight course toward Sevier River without the slightest deviation on account of the rock in its way.

West of the wedge-shaped ridge lies a broad valley, the rolling surface of which rises gently on both sides of Salina Creek toward the bases of the steep flanks of the high plateaus. In the eastern part of the valley is a range of hills, flanking the ridge, which detract somewhat from the simplicity of the descent from the ridge into the valley, but on the west the valley floor slopes gradually and without interruption to the base of the steep escarpment that bounds the valley. The range of hills on the east side of the valley is probably the result of a fault, but exposures of the strata in the valley are so poor that the existence of the fault is not proved. The flatter land in the main bottom is due to softer rocks, in which the weathering agencies have worked rapidly and effectively, eroding away the rocks and smoothing off the surface.

West of the broad valley, in the central part of R. 3 E., is an elevated fault block, whose eastern face rises about 1,500 feet above the valley and whose highest points are about 3,000 feet higher than the lowest points in Salina Canyon. The surface of this block slopes westward, toward the Sevier Valley, and is so deeply trenched by the narrow canyons of Salina Creek and its tributaries that the appearance of the surface as viewed from the highest points is that of rugged mountainous country rather than of table-land.

The zone of faults that crosses Salina Creek between Coal Hollow and a point about half a mile west of Water Hollow has caused the rocks to become eroded into a series of ridges, each held up by a resistant bed of sandstone, that occupy positions relative to one another clearly reflective of the faulting. Browns Hole, a broad intermontane valley, owes its origin to the same set of conditions as that prevailing in the Mountain ranch valley. The U-shaped bend in Salina Creek west of Coal Hollow undoubtedly owes its origin to the masses of hard rock thrown in the way of the creek by the fault at Coal Hollow. The creek was deflected from its original course by the mass of hard sandstone; it probably once flowed straight across the bench, now about 1,000 feet above the creek bed, due west of the point on the south side of the mouth of Coal Hollow. The surface of the whole block for at least a mile north of Salina Creek west of Coal Hollow is approximately a dip slope on the Castlegate sandstone.

With the single exception of Browns Hole, the character and origin of which has been mentioned, all the drainage channels tributary to Salina Canyon are steep-walled gorges, and many of them are of imposing dimensions and considerable scenic beauty.

Salina Canyon itself, through which the Pikes Peak Ocean to Ocean Highway passes, contains many stretches of rugged canyon scenery. The real magnitude of the canyon and the grand proportions of the surrounding highland, however, are barely suggested by the views obtainable from the road in the canyon and are fully appreciated only when seen from one of the commanding points on the top of the table-land. (See pl. 20, *B*.) In fact, the broader features of the region and in particular the distribution of land forms here outlined can be understood comprehensively only when viewed from above.

DRAINAGE

The district is drained by Salina Creek and its tributaries. Salina Creek, in the part of its course contained in the area here discussed, flows continuously, and late in the summer, when its flow is not augmented by sudden storms, its discharge near the town of Salina ranges between 15 and 20 second-feet. It is supplied almost entirely by springs on the flanks of the Wasatch and Fish Lake Plateaus. During the spring run-off its flow rises to 100 second-feet and more, and in times of cloudburst it has exceeded 700 second-feet for periods not longer than one day. In midsummer it is subject to the sudden increases in volume that follow thunderstorms and cloudbursts, and during such periods of storm it usually rises to destructive heights. Much of the railroad grade built in the canyon in 1903 by the Denver & Rio Grande Railroad Co. has been utterly destroyed by such floods.

The perennial tributaries of Salina Creek are Skumpah, Spring, Meadow, Yogo, and Nioche Creeks. Skumpah Creek rises in the higher land of the depression at the base of White Mountain, the southern face of the Wasatch Plateau, and yields a small flow of water. Spring Creek is very small, and practically all the water in it that reaches Meadow Creek arises from springs near its mouth. Some water flows in its upper course, but above the gorge near its mouth it is for the most part dry except in time of rain. Yogo Creek and Meadow Creek yield continuous but small flows. Nioche Creek is perhaps the most vigorous of the tributaries. It rises in the highland flanking the Fish Lake Plateau, and despite the fact that much of its water is diverted to irrigate the broad pastures of the Mountain ranch, it contributes considerable water to Salina Creek.

Intermittent streams drain Taylor Flat and Coal Hollow, and Water Hollow Creek usually contains a small amount of water.

In times of regional rain all the stream channels of the area carry water, and the foregoing references to the volume of streams apply only to times of stability between rainstorms. The run-off of the region is rapid, and any rainstorm larger than a sprinkle causes an immediate flow of water in all channels draining the area upon which the rain falls.

The quality of the water in all the perennial streams mentioned, so far as taste and appearance can show it, is good, and only when the pollution of large herds of sheep and cattle spoils it is the water unfit to drink.

CULTURE

Population.—Despite the fact that this district has been known and traversed since the first settlements of central Utah, the Mountain ranch and the ranger station near it are the only settled habitations in Salina Canyon, and they are not continuously occupied. In the summer large herds of purebred cattle and thoroughbred horses are pastured at the Mountain ranch under the care of many cowboys. A ranch in the northern part of Taylor Flat is usually worked in summer by a few men, but in 1923 there was not even a permanent dwelling there. Rangers of the United States Forest Service patrol the whole area during the greater part of the year, and prospectors and coal miners visit the canyon at irregular intervals. During most of the year, however, the canyon is totally uninhabited. Travelers on the main road are at times fairly numerous, and in summer many automobile tourists pass through the canyon on their way to and from the Grand Canyon of the Colorado and other scenically interesting parts of southwestern Utah and northern Arizona.

The nearest town is Salina, in the Sevier Valley, on the Marysvale branch of the Denver & Rio Grande Western Railroad, which is about 8 miles by road from the western limit of the area shown on Plate 22. The Sevier Valley is one of the richest agricultural regions in Utah, and it contains many thriving communities. Salina is one of the better medium-sized towns, and it is a typical agricultural trading center. It began its existence as a community of people engaged chiefly in leaching salt from deposits near the town, but in recent years the salt industry has died out, and farming has become the chief activity.

The Gooseberry Valley, which adjoins the district on the southwest, is an active farming area and is accessible from Salina Canyon by a very good road that branches from the main road about 3 miles east of Salina. Besides several thriving ranches, the valley contains an experiment station of the United States Department of Agriculture and a ranger station of the United States Forest Service.

North and east of the district the country is mountainous and practically uninhabited. The nearest settlement on the east side is Emery, a small town in Castle Valley, by automobile road 52 miles from Salina and about 29 miles from the southeastern part of the district. By a more direct trail across the divide Emery is only 14 miles distant from the eastern edge of the district.

Roads and trails.—The main road in Salina Canyon, now part of the Pikes Peak Ocean to Ocean Highway, is the principal thoroughfare of the district. It connects Salina with Emery and other towns farther north in Castle Valley and is much used by travelers between the southwestern and eastern parts of Utah. In long periods of fair weather the road is very good, but during the period of summer rains it is likely to be poor because the heavy storms erode it faster than the workmen available can repair the damage. Much of its course in Salina Canyon is on the abandoned grade of the Denver & Rio Grande Railroad.

The abandoned railroad is not indicated on the maps accompanying this report because it has been so largely washed away by floods that very little of it is recognizable as a railroad. Not enough of it is left to justify mapping it even as an abandoned grade. Furthermore, if the line is ever rebuilt it will undoubtedly be changed in location at many critical places.

A few roads, shown on the map (pl. 22), branch from the main highway. The road in Spring Canyon gains the top of the plateau at the Acord Lakes, just east of the district, and leads to sawmills north of Convulsion Canyon. Formerly this road connected with Emery by way of Convulsion Canyon, but in 1923 it was impassable to wagons in the upper part of Convulsion Canyon on account of extensive washouts and a weak bridge. It affords a much shorter route from Salina Canyon to Emery than the road now used, and it is decidedly the best route for horseback travel, but it has never been opened to automobiles because in winter the snow is much deeper at the Acord Lakes than it is on the head of Meadow Creek. In 1923 automobiles could go, with some difficulty, to the Acord Lakes and to the head of Quitchupah Creek.

The road extending southward from the houses of the Mountain ranch leads by way of Nioche Creek to the Gooseberry Valley, south and west of the district. It is barely passable to automobiles in good weather, but during most of the year it is too rough. The branch road to the Mountain ranch ranger station ends just north of the station at a ranch. A short branch road in Coal Hollow leads to an abandoned coal mine. A road once existed in the upper valley of Salina Creek, but in 1923 only traces of it were left.

Trails lead at many places from the canyons and valleys to the top of the plateau and are followed by sheep herders, who drive their flocks on the high ridges all summer long, and by cattle and horses on summer range. The top south of Salina Canyon may be reached in this district by a trail leading west from the Mountain ranch or by a steep and tortuous trail in the narrow gulch southwest of milepost 16 in Salina Canyon. Other trails exist, but they are very steep and dangerous for horseback travel. Not far south of milepost 14½ a trail branches from the main road in Salina Canyon and leads by way of Browns Hole to the upper part of the Gooseberry Valley. The top north of Salina Canyon may be reached by a trail in Water Hollow, but on the whole it is not so easily accessible as the top south of the canyon. The canyon walls are nearly everywhere too steep for travel with horses, and on account of the cliffs formed by the Castlegate sandstone they are at most places unscalable by any means. The best places for climbing the walls are near faults, where the massive ledges have been sufficiently shattered to be scalable.

GEOLOGY

STRATIGRAPHY

GENERAL SECTION

The geologic formations exposed in the Salina Canyon district range from the Upper Cretaceous Blackhawk formation, the middle formation of the Mesaverde group of the Wasatch Plateau, to the upper part of the Eocene Wasatch formation. The coal occurs in the Blackhawk formation, in the lowest rocks exposed, and on that account those rocks were studied in considerable detail. A somewhat detailed study of the upper rocks was also found essential, because at many places the coal-bearing rocks lie beneath the surface, and the vertical distance to them could be estimated only through a knowledge of the upper rocks, which form the surface in such places.

Very little has been published on the geology of this region. Dutton,[1] in his monograph on the geology of the high plateau region, mentioned the Salina Canyon area briefly and illustrated the regional geology by means of cross sections of the plateau but gave no detailed information. Powell[2] in 1876 described very briefly, principally by means of a stereogram, the eastern part of the district, which had been studied in reconnaissance by Gilbert, and cited it, in a summary of several types of geologic structure in the plateau region, as a typical zone of diverse displacement. None of these

[1] Dutton, C. E., Geology of the High Plateaus of Utah, pp. 162–163 and plate opp. p. 164, U. S. Geog. and Geol. Survey Rocky Mtn. Region, 1880.

[2] Powell, J. W., Report on the geology of the eastern portion of the Uinta Mountains, pp. 16–58, U. S. Geol. and Geog. Survey Terr., 2d div., 1876.

publications deal with the stratigraphy in more than a general way, and the best general picture of the regional geology is that given in the sections by Howell published in Dutton's monograph.[3]

The following table shows the age, character, thickness, and succession of the formations exposed in the district:

Generalized section of formations in the Salina Canyon district, Utah

System and series	Group	Formation	Member	Characteristics	Thickness (feet)	Economic value
Tertiary (Eocene series).		Wasatch formation.		Variegated shale, chiefly red; sandstone, limestone, and conglomerate. The lower 500 to 1,000 feet consists chiefly of shale, sandstone, and conglomerate, and the upper part contains the limestone. Weathers to rounded slopes rather than cliffs.	1,500-2,000	Limestone in places makes good building stone, and some might be lithographic stone.
Unconformity						
Cretaceous (Upper Cretaceous series).	Mesaverde group.	Price River formation.	Upper member.	Sandstone, gray, white, and buff, coarse grained and in places conglomeratic; prominent band of white sandstone near base. Forms ledges and cliffs.	200-600	
			Castlegate sandstone member.	Massive cliff-making sandstone, white to buff, coarse grained and conglomeratic. Forms prominent cliff wherever exposed.	180-290	Contains alum-bearing sandstone of doubtful value.
		Blackhawk formation.		Buff, brown, and gray medium-grained sandstone, gray shale, and coal. Forms ledge-ridden slopes beneath cliff of Castlegate sandstone.	800-900	Coal.

Of the formations mentioned, the Price River is the only one revealed in complete section within the district. The lower part of the Blackhawk formation is not exposed here, and the thickness given for it was obtained by reckoning from the base of the Castlegate sandstone to a coal bed which is tentatively correlated with the Ivie bed of the Wasatch Plateau field, exposed on Ivie Creek, about 11 miles southeast of Salina Canyon, where the whole formation crops out. Only a part of the Wasatch formation is believed to be present in the district, though probably the whole formation is exposed to the northeast, in White Mountain, and to the west, on Salina Creek.

[3] Dutton, C. E., op. cit., plate opp. p. 164.

CRETACEOUS SYSTEM

MESAVERDE GROUP

GENERAL FEATURES

The rocks in this district assigned to the Mesaverde group have been identified by tracing them almost continuously from the east front of the Wasatch Plateau, where they are known to be Mesaverde because of their continuity with the Mesaverde rocks of western Colorado and because of the fossils they contain. In the earliest reports on this general region these rocks were called Laramie, but Richardson[4] in 1909 reported evidence showing that they should properly be referred to the Mesaverde formation, and that classification has ever since been accepted by the United States Geological Survey and by practically all geologists who have dealt with the region.

The Mesaverde group in the Wasatch Plateau has been divided[5] into three formations—a lower massive sandstone of marine to brackish-water origin, called the Star Point sandstone; an overlying coal-bearing formation, the Blackhawk formation, consisting of sandstone, shale, and coal, practically all of fresh-water origin; and at the top the Price River formation, which consists chiefly of sandstone and conglomerate. These three units, with the possible exception of the upper part of the Price River formation, are remarkably consistent, both in thickness and in general characteristics, in the east face of the Wasatch Plateau, and many individual sandstone beds, particularly those of the Star Point sandstone and the Castlegate sandstone member of the Price River formation, can be traced definitely for distances of 50 to 90 miles. The character and relations of the formations of the Mesaverde group are fully described in a forthcoming paper[6] on the geology and coal resources of the Wasatch Plateau.

The Star Point sandstone is not exposed in the Salina Canyon district. The Blackhawk and Price River formations are exposed in the structurally higher blocks mentioned in the description of the physical features of the district, but nowhere have the streams cut their canyons deep enough to lay bare the lowest part of the Mesaverde group. The lowest part exposed in the district is in Salina Canyon, near the upper gateway to the canyon, where the rocks have been locally buckled into a sharp fold, on the south flank

[4] Richardson, G. B., Reconnaissance of the Book Cliffs coal field: U. S. Geol. Survey Bull. 371, pp. 18–19, 1909.

[5] Spieker, E. M., and Reeside, J. B., jr., Cretaceous and Tertiary formations of the Wasatch Plateau, Utah: Geol. Soc. America Bull., vol. 36, pp. 435–454, 1925.

[6] Spieker, E. M., The Wasatch Plateau coal field: U. S. Geol. Survey Bull. — (in preparation).

of which, in the creek bottom, is exposed a coal bed that is probably the same as the lowest valuable coal bed of the Ivie Creek district of the Wasatch Plateau coal field. The rocks beneath this coal bed are not definitely known in the Salina Canyon district, but they may safely be assumed to be nearly the same as those exposed on Ivie Creek. One important difference may exist, however: the rocks of the Star Point sandstone, beginning 100 feet beneath the lowest rocks exposed in Salina Canyon, which are not coal bearing on Ivie Creek, may contain coal under Salina Canyon. Elsewhere in the general region the fact has been established that brackish-water sandstones, appearing in their easternmost exposures as tongues extending into the Mancos shale, change in westward progression to sandstones of continental origin, some of which contain coal. The lower part of the Blackhawk formation in the northern part of the Wasatch Plateau coal field and the western part of the Book Cliffs coal field has been shown by Clark [7] to be continuous with several tongues of brackish water to marine sandstone that project eastward into the Mancos shale and thin out, changing to marine shale. The Star Point sandstone in the southern part of the Wasatch Plateau coal field possibly once extended, in the vast region east of the plateau from which it has been eroded, into the Mancos shale as a series of similar tongues. It is known to exhibit such relations to the northern part of the field. Probably, therefore, the member changes somewhere west of Ivie Creek to a continental sandstone that may contain coal. Proof of its character under Salina Canyon could be obtained only by boring, preferably with the diamond drill.

BLACKHAWK FORMATION

In the Salina Canyon district the exposed part of the Blackhawk formation consists of about 550 feet of buff, gray, and brown sandstone, gray shale, and coal, a rock succession similar in general to the type common in the coal-bearing parts of the Mesaverde formation throughout Utah and Colorado. The lowest rocks exposed in the district crop out near the upper end of Salina Canyon, on the flank of a local fold. The lower walls of this part of the canyon are covered with vegetation and soil, and in general the rocks are very poorly exposed. However, on the north side of the canyon near the gateway at its east end the upper 540 feet of the member is very well exposed, and the character of the rocks contained in that interval is shown in the following section:

[7] Clark, F. R., Economic geology of the Castlegate, Wellington, and Sunnyside quadrangles, Carbon County, Utah: U. S. Geol. Survey Bull. 793 (in press).

Section of part of Blackhawk formation measured on north wall of Salina Canyon in the NW. ¼ sec. 21, T. 22 S., R. 3 E.

	Ft.	in.
Castlegate sandstone member of Price River formation.		
Shale, gray	2	6
Sandstone, cream-colored, fine grained, massive	12	
Sandstone and gray shale, alternating in thin layers	70	
Sandstone, gray, weathering buff, medium grained, cliff-forming	99	
Shale, gray, partly concealed	9	6
Coal		9
Shale, gray, carbonaceous at top and containing thin lenses of coal	4	
Sandstone, gray, weathering buff, medium grained, massive	8	
Shale, gray, carbonaceous at top, containing several thin bands of platy sandstone	19	
Sandstone, buff, medium grained, massive	14	
Shale, gray	2	6
Sandstone, buff, fine grained	3	
Shale, gray, containing several thin beds of sandstone	25	
Sandstone, buff, medium grained, massive, cliff-forming	23	
Concealed	16	
Shale, gray	17	
Sandstone, gray, weathering buff, medium grained, massive	6	
Shale, gray, containing several thin beds of sandstone	26	
Sandstone, buff, fine grained, with lenses of interbedded shale	39	
Shale, gray	6	
Sandstone, buff, fine grained, massive	4	
Shale, black, carbonaceous, containing lenses of coal	2	6
Sandstone, gray-buff, and gray shale, interbedded	11	
Concealed; slope shows evidence of carbonaceous shale	26	
Sandstone, buff, fine grained, massive	12	
Sandstone and shale, in thin-bedded alternation	12	
Sandstone, gray, weathering buff, fine grained, platy	22	
Shale, gray	1	6
Coal, resinous		10
Shale, gray, carbonaceous at top	6	
Sandstone, gray, fine grained, massive	4	4
Shale, gray		1
Coal, resinous	1	7
Concealed, probably shale	3	
Sandstone, buff, fine grained, massive	3	
Shale, gray	16	6
Sandstone, fine grained, gray, massive	9	
Concealed.		
	537	7

The Blackhawk formation contains in this district no individual beds that are sufficiently persistent to permit detailed tracing or recognition of the coal beds throughout the district. Certain sandstone beds may be traced for short distances, but no bed is known that would afford a key for the correlation of smaller units throughout the district. The general stratigraphic position of beds within the formation may be ascertained by reference to the overlying Castlegate sandstone, which is the most persistent unit of the district, but exact correlation by such means is impossible, because the Castlegate sandstone varies in thickness from place to place, and it is not certain that either the top or the bottom of the massive sandstone represents exactly the same stratigraphic horizon at different places.

The Blackhawk formation contains few types of rock that could be classed as diagnostic, but in this district the only other formation similar to it in general appearance is the Price River formation, and from that formation it may be distinguished, in isolated exposures, by the absence of very coarse grained material and of very thick and massive beds of sandstone. Where both formations are exposed together the Castlegate member of the Price River formation is normally recognizable through its massive character and cliff-forming habit, and the Blackhawk rocks may be identified without recourse to their individual characteristics. The Blackhawk formation contains numerous beds of very fine grained gray sandstone, some of which is highly calcareous and weathers out to hard brown to orange-brown plates. No such rocks are known in the Price River formation. The Blackhawk rocks may further be recognized by their content of coal; in this area no carbonaceous matter of any kind is known in the Price River formation.

PRICE RIVER FORMATION

General features.—The Price River formation overlies the Blackhawk formation, apparently conformably. Before the recent work in the Wasatch Plateau coal field was done the rocks of the Price River formation were classified as members of the Mesaverde formation, but it was found by the senior writer that the Castlegate sandstone and the overlying rocks are sufficiently different from the coal-bearing rocks here called the Blackhawk formation to demand recognition as a separate unit, and the name Price River formation was proposed[8] for this unit because the rocks, particularly the Castlegate sandstone member, are well displayed in the Price River canyon, northwest of the town of Castlegate. In the Book Cliffs coal field Clark[9] differentiated the Castlegate member from the overlying sandstones, and he has adopted the formation names herein used.

The Price River formation differs from the Blackhawk formation chiefly in the coarser grains of its sandstone and in the predominance

[8] Spieker, E. M., The Wasatch Plateau coal field: U. S. Geol. Survey Bull. — (in preparation).

[9] Clark, F. R., op. cit.

of steel-gray and white instead of buff and brown in the colors of the rocks. Neither of these differences is strikingly apparent in distant views of the rocks, because the sandstones of both formations weather to a buff color and because the coarseness of grain is not apparent except on close inspection. Where the Castlegate sandstone forms cliffs it presents a characteristic surface due to irregularly curving subsidiary bedding planes, and the buff color of its weathered surface normally has a pinkish tinge that is not present in the Blackhawk sandstones. Otherwise it is not distinguishable in distant views from the underlying sandstone of the Blackhawk formation. The superficial similarity between the two is strikingly shown in the ridge south of Salina Creek and west of Water Hollow, where the Castlegate sandstone is faulted against fairly massive sandstone of the Blackhawk formation. At first glance the fault is not at all apparent, and despite the very good exposures detailed study of the beds in the ridge is necessary to show from the evidence of that locality alone that the fault is present. The sandstone of the Blackhawk formation west of the fault is less massive than the Castlegate sandstone, but the general appearance of the two is so closely similar that they seem to be continuous. On close inspection, however, the rocks of the Price River formation are seen to be coarser in grain than those of the Blackhawk formation and to contain conglomerate, which in places is a striking feature of the formation. In the Salina Canyon district the Price River formation contains little shale and is thus further different from the Blackhawk formation, which contains considerable gray shale.

Castlegate sandstone member.—The Castlegate sandstone, so named because of its prominence in the Price River Canyon near Castlegate, is the most prominent member of the rock succession in the Salina Canyon district. At most of its exposures it forms cliffs, and its superior resistance to weathering over that of the surrounding rocks has caused the hills in which it is contained to take the shape of its outcrop. It forms prominent benches whereever it occurs, and on account of the general conformity of the land surface with it the structural features of the region are physiographically well displayed.

Because of its physical prominence it is an unusually good key bed, and its long lines of cliffs enable the geologist to perceive, in the admirable views obtainable from high points of the district, not only the broader features of the geologic structure but many of the details. It makes the determination of the many faults that cross the district comparatively easy, and the top of it affords a convenient reference plane from which the stratigraphic position of overlying beds may be approximately determined. So far as observations in the district show, it lies conformably on the rocks of the

Blackhawk formation, and thus it is probably also a good reference bed for rocks beneath it. It is certain that no structural discordance exists between the two formations, and if the contact between them represents a hiatus it is not determinable from the information available for this district.

The character of the rocks composing the Castlegate member is shown in the following section, which was measured at the head of Salina Canyon, on the spur north of the 18½-mile post:

Section of Castlegate sandstone member of Price River formation on north side of Salina Canyon

	Feet
1. Sandstone, buff, medium grained, massive	7
2. Sandstone, gray, mottled with orange, medium to coarse grained, massive	4
3. Sandstone, white, medium grained	12
4. Sandstone, similar to No. 2	16
5. Sandstone, gray, medium grained, massive	2
6. Conglomerate, pebbles of chert and quartz irregularly bedded in matrix of coarse gray sandstone	11
7. Sandstone, white, fine grained, massive	11
8. Sandstone, white, cliff-forming, coarse grained	50
9. Sandstone, white, cliff-forming, fine grained	17
10. Concealed	11
11. Sandstone, buff, and gray shale, interbedded	22
12. Sandstone, medium grained, massive, cliff-forming	55
13. Sandstone, gray, coarse grained, massive; forms base of series of cliffs	11
	229

The Castlegate member contains at this place less conglomerate and coarse-grained sandstone than it does elsewhere, but the place was chosen because the member is there sufficiently broken up into subsidiary cliffs to permit the measurement of a complete section. Normally it forms unscalable cliffs, and a continuous section of it is not accessible for detailed study. It is considerably thicker at the west end of the district than at the east end.

At the eastern border of the district the Castlegate member forms a prominent escarpment, above which the surface rises rather gently to the divide. It is very prominent in Skumpah Canyon, and it is clearly recognizable in this escarpment throughout the width of the district, but south of Spring Canyon it loses prominence, and at the Meadow Creek divide, about 4½ miles south of the border of the district, it is barely recognizable as a distinct unit, and there only after it is traced through from the prominent exposures near Spring Canyon. The thinning out of this cliff may best be seen from the top of the mountain west of the Mountain ranch. (See pl. 20.) Southeast of the district, in the border belt of Mount Hilgard, it loses entirely its identity as a cliff-forming sandstone, but the zone of coarser sediments continues, and the Price River formation may be recognized wherever the hills are high enough to contain it.

In the wedge-shaped block west of the escarpment above mentioned the Castlegate member again appears, and there it forms, on the west edge of the block, a similar escarpment about 600 feet lower than the one on the east. The cliff in this escarpment is seen in the middle ground of Plate 20, *A*.

At the head of Salina Canyon the Castlegate sandstone is recognizable more through its position in the general succession of rocks than through characteristic development. There it forms a decided change of slope but not the usual cliff, and it consists of broken ledges from the head of the canyon to a point about a mile east of Coal Hollow, where it resumes its characteristic appearance as a solid cliff. The top of the member is clearly discernible in a distant view, even where it does not form a sharp cliff. On the south side of the canyon the exposures are not very good, but the steep slopes and the bench show the position of the member very well. East of Coal Hollow the individual ledges unite to form a sheer wall of sandstone that persists westward to the point at which the member dips beneath the surface. Near Water Hollow the sandstone ledges above the Castlegate member form a similar cliff, and the canyon walls are striking. (See pl. 19, *B*.)

At the tunnel on the old railroad grade in Salina Canyon in the SW. ¼ sec. 9, T. 22 S., R. 2 E., the Castlegate member contains a bed of alum-bearing sandstone. The top of the member passes beneath creek level not far west of the tunnel, and the tunnel is cut through a projecting point of the massive sandstone. The alum-bearing bed is about 50 feet beneath the top of the member, and it consists of fine-grained dark-gray nodular sandstone, apparently impregnated throughout with alum and containing thin layers of crystalline alum in the joint planes. It contains very thin seamlets of bright coal. It is best exposed in a cavelike hollow in the cliff, about 100 yards north of the tunnel. The bed is very lenticular and is probably not worthy of attention as a commercial source of alum.

Upper member.—Throughout the region in which it is known the upper part of the Price River formation is lithologically similar to the underlying Castlegate member, except that it does not normally form a single massive cliff. The Castlegate member is differentiated from the overlying part of the formation solely because of its remarkably consistent cliff-forming habit, by means of which it may be recognized throughout the Wasatch Plateau and in the western part of the Book Cliffs. The rocks above the Castlegate member consist of gray, buff, and white sandstone, conglomerate, and comparatively small thicknesses of shale. Regionally the upper member varies considerably in its content of buff sandstone and shale, but it contains everywhere enough of the characteristic gray grit, conglomerate, and sandstone to keep clear its identity.

In the Salina Canyon district the upper member varies in thickness but is fairly uniform in lithologic character. There the most prominent bed in the member is a ledge-forming sandstone, the top of which is 200 to 250 feet above the Castlegate member and which contains a prominent band of white sandstone 20 feet thick and about 140 feet above the Castlegate member. This sandstone can be traced almost throughout the district, and the white band is especially prominent in Salina Canyon, where it affords a useful guide to the recognition of the member and particularly the distinction of it from the Castlegate member in places where faulting is complex and exposures are few.

TERTIARY SYSTEM

WASATCH FORMATION

The Wasatch formation in the Salina Canyon district includes all the rocks above the Price River formation. It has been identified both through lithologic character and by tracing from the Wasatch Plateau, where its characteristic appearance and its position in the stratigraphic column give evidence thus far considered sufficient to justify the use of the name Wasatch. The formation, as mapped in this district, includes at least two units that will probably prove, on extended regional study, to be consistently separable, but for the present they are considered together and are not distinguished on the accompanying map. They are not separated in this work chiefly because the section exposed in the lower valley of Salina Creek, west of the canyon, is very different from that exposed in the upper valley of Salina Creek, and it is considered unwise to make any differentiation until the regional geology is sufficiently understood to show which beds really represent different and consistent units.

The place at which to draw the line between the Price River and Wasatch formations is much more difficult to find in the Salina Canyon district than in most parts of the Wasatch Plateau. In all the localities where the succession is continuously exposed the transition from the gray coarse sandstone and conglomerate of the Price River formation to the cream-colored sandstone, variegated shale, and conglomerate of the Wasatch formation is gradual, and many confusing intercalations of the different sediments tend to blur the conception of distinctness between the two formations. For the purposes of the present work, the boundary was drawn as nearly as possible at the place where the lowest brightly colored shale appears.

In the lower valley of Salina Creek the Tertiary beds overlap the older rocks and are separated from them by a striking angular unconformity. The slope on which the Tertiary beds were laid down dips gently eastward and reveals, in eastward progression, lower and lower rocks above the unconformity, owing to the westward overlap of the Wasatch strata. Unfortunately, however, at the place where the unconformity dips beneath the surface the lowest beds above it are stratigraphically higher than the variegated shale succession here considered as lowest Wasatch, and positive evidence of their relation to the underlying rocks is lacking.

The following is a generalized section of the Wasatch rocks exposed in the valley of Salina Creek west of the district:

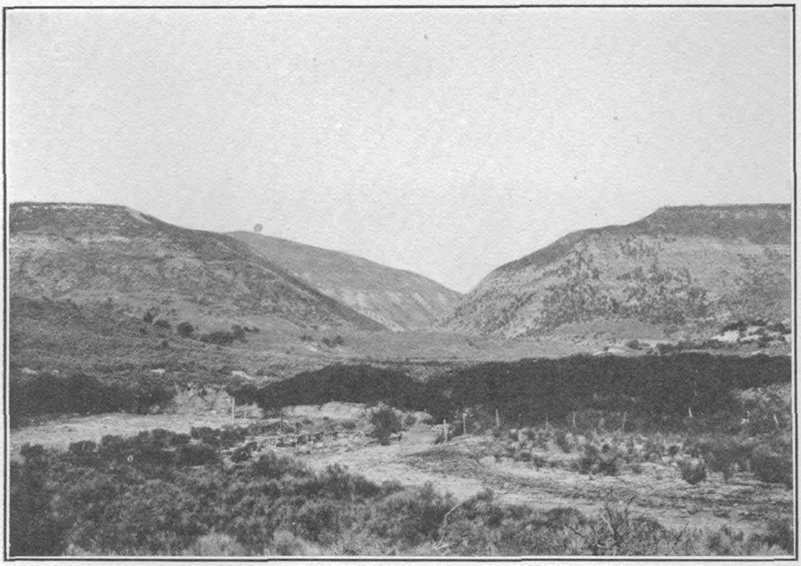
Section of Wasatch formation in Salina Creek valley

	Feet
Limestone and sandstone, predominantly white, with many streaks of bluish green	700±
Shale, sandstone, and limestone, containing a zone of deep-red rocks underlain by green and red sandstone and shale and one bed of pure-white limestone; the whole zone calcareous	250
Shale, variegated; sandstone, cream-colored and gray; and conglomerate; the whole succession extremely irregularly bedded and all individual beds nonpersistent	500
	1,450±

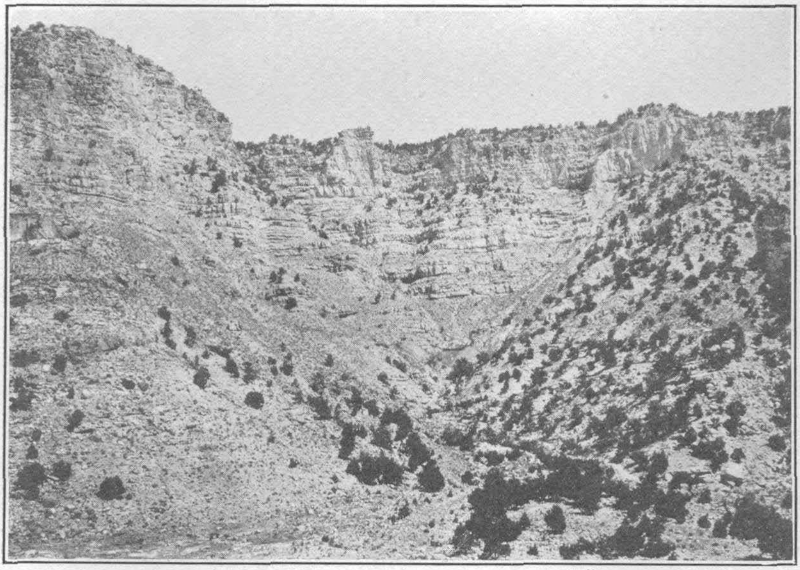
The thickness of the upper unit was estimated, but that of the other two was measured by hand leveling.

In the area shown on the map the Wasatch formation includes all of the lower two units of the foregoing section and probably also part of the upper unit. The exact amount of the limestone present is not known for the greater part of the area, because in most places the limestone is contained in the sunken blocks of fault zones, where exposures are poor. In the upper valley of Salina Creek about 250 feet of limestone appears in the easternmost block of the Musinia fault zone. Perhaps more of it is present elsewhere in the fault zone, but if so it is not known. This limestone is undoubtedly worthy of a distinguishing name, but for the present it is not separated from the variegated shale of the Wasatch formation. The transition from variegated shale to limestone is not abrupt, and considerable interfingering of the two totally different types of sediment is suggested by the relations thus far known.

In the eastern part of the district the variegated shale of the Wasatch formation is banded, thin bedded, and different in appearance from that in the western part. This difference introduces difficulty in the correlation of the isolated blocks of variegated shale in the eastern part of the district with the known succession of the

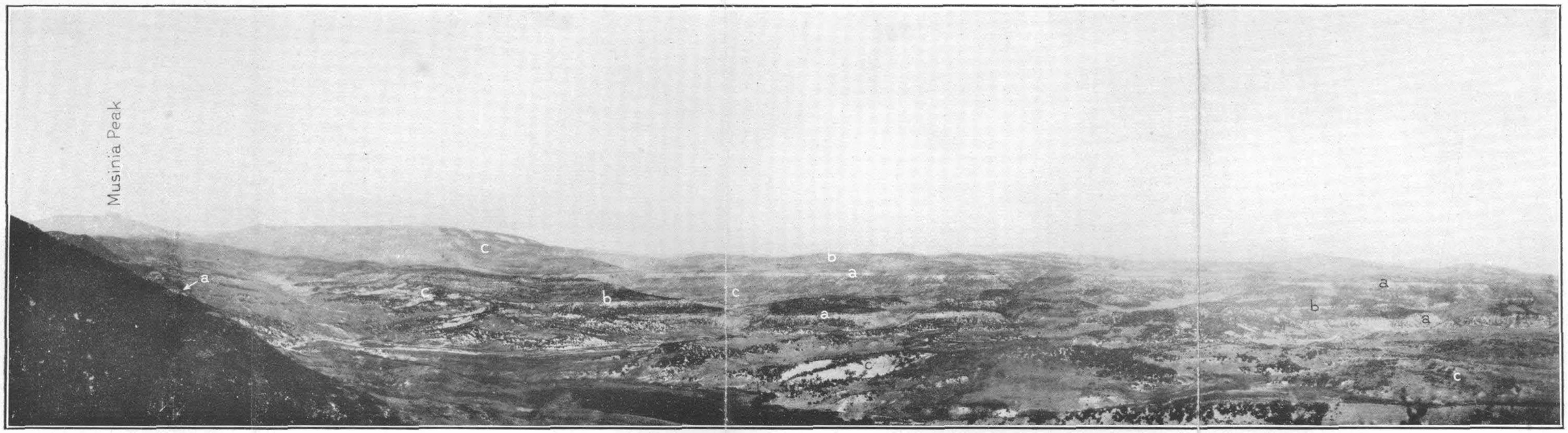


A. HEAD OF SALINA CANYON, UTAH, AS SEEN FROM PIKES PEAK OCEAN TO OCEAN HIGHWAY NEAR SPRING CANYON



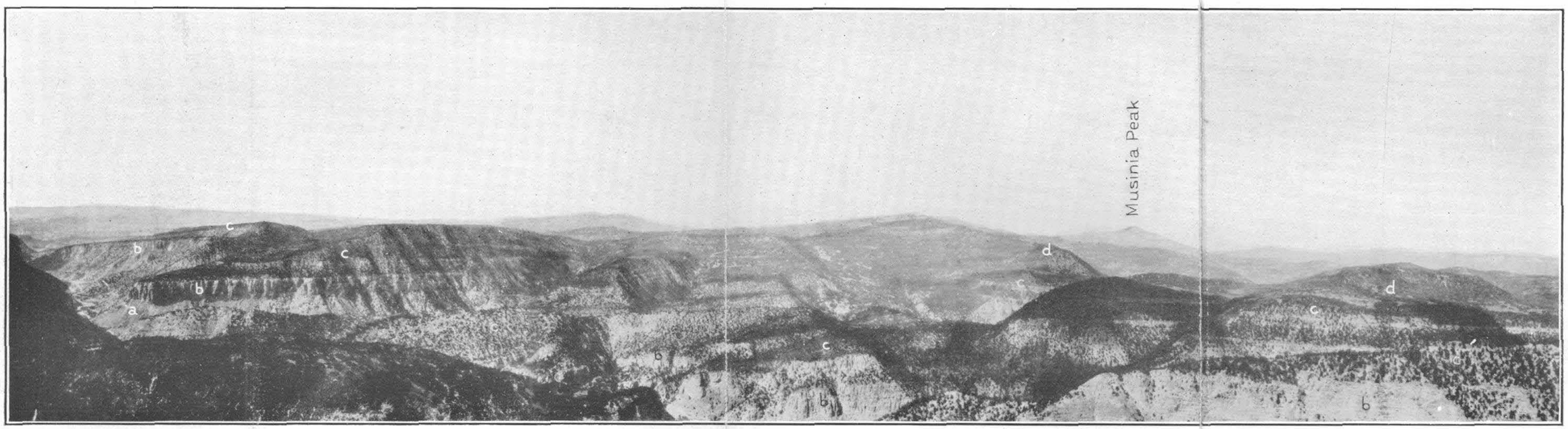
B. CLIFFS OF CASTLEGATE SANDSTONE AND UNDERLYING BLACKHAWK FORMATION IN SALINA CANYON WEST OF WATER HOLLOW

The Wilson mine is near the center of the view, and the base of the Castlegate sandstone about 170 feet higher



A. VIEW FROM TOP OF ESCARPMENT WEST OF MOUNTAIN RANCH, LOOKING EAST ACROSS MUSINIA FAULT ZONE

Musinia Peak on left sky line; eastern escarpment of Musinia fault zone in center and right background; fault zone extends through middle ground from left center to right foreground. a, Castlegate sandstone; b, upper member of Price River formation; c, Wasatch formation



B. VIEW FROM TOP OF SOUTH SIDE OF SALINA CANYON SOUTH OF MILEPOST 16, LOOKING NORTH AND NORTHWEST ALONG WATER HOLLOW FAULT ZONE

Musinia Peak and White Mountain in right distance; lower Salina Canyon and Sevier Valley in extreme left distance. a, Blackhawk formation; b, Castlegate sandstone member of Price River formation; c, upper member of Price River formation; d, Wasatch formation

PANORAMIC VIEWS OF FAULT ZONES OF SALINA CANYON DISTRICT, UTAH western part, and until detailed studies are made of the Tertiary rocks in the part of the Wasatch Plateau adjoining on the north it will be impossible to determine satisfactorily the stratigraphic position of the variegated beds in the Musinia fault zone and hence the exact displacement of several of the faults.

STRUCTURE

GENERAL FEATURES

The geologic structure of the Salina Canyon district is like that of the western half of the Wasatch Plateau, and it embodies the same general features as those found farther north. The eastern part of the district, which is continuous with the belt of flat-lying rocks in the center of the Wasatch Plateau, contains rocks dipping at low angles and cut by zones of normal faults that trend northward into the plateau. The western part of the district represents the great monoclinal fold that bounds the Wasatch Plateau on the west, and there the rocks dip consistently westward, at angles considerably gentler, it is true, than those of the outstanding monocline farther north, but sufficiently great to indicate clearly the position of the belt in the structural scheme of the region. The part of the district occupied by the monocline is noticeably less faulted than the corresponding belt farther north, but the eastern part is faulted quite as intensely as the higher part of the plateau to the north.

The faults of the district are by far the most pronounced structural features, and they deserve the careful consideration of geologist, engineer, and coal producer alike because they determine, in large measure, the boundaries of areas in which the coal of the district may be profitably mined. Several of the faults have involved displacements of the coal-bearing strata so great that they put out of reach, for present-day mining, the coal in large blocks of ground. Most of the smaller faults have not so profoundly altered the mining value of the ground they cross, but in places they have cut the rocks into segments, the outlines of which should be known as fully as possible before mining is planned.

The faults are naturally grouped into two zones, each of which forms a graben, or sunken prism, and the sunken blocks are cut by minor faults. The eastern zone was studied by Gilbert, in the early exploration of the plateau region, and it was described by Powell [10] as the Musinia fault zone, so named because the main faults of the zone form a valley just east of Musinia Peak, a prominent peak at

[10] Powell, J. W., Report on the geology of the eastern portion of the Uinta Mountains, pp. 16–17, U. S. Geol. and Geog. Survey Terr., 2d div., 1876.

the southern edge of the Wasatch Plateau. (See pl. 20, *A*.) The western zone is called the Water Hollow zone, because of the prominence of the faults in Water Hollow, a canyon tributary to Salina Canyon.

MUSINIA FAULT ZONE

The Musinia fault zone is bounded by two faults of large displacement, and the sunken block between them is cut by subsidiary faults into smaller blocks that are tilted at diverse angles with respect to one another and to the higher blocks of flat-lying strata on the east and west. The diversity in displacement of the faults and in the attitude of the faulted blocks within this zone led Powell[11] to adopt it as typical of a class of structural features in the plateau region which he called "zones of diverse displacement." The sharp variance in dip between some of the tilted blocks is well seen in the views of the fault zone to be had from the edge of the escarpment west of the fault valley. One such view is shown in Plate 20, *A*, where the variegated shale beds of the Wasatch formation, dipping southward, are faulted against the prominent sandstone ledges of the Price River formation, which dip northward. Plate 20, *A*, gives a general view of the fault zone, in which several of the divergently dipping blocks may be discerned.

An important result of this variance in attitude of the component segments in the Musinia fault zone is a marked difference at different places in the displacement of individual faults. The easternmost segment of the zone, for example, is tilted northward, and its displacement with reference to the block east of the zone increases rapidly from south to north. At the south end of the district the displacement of this segment is about 500 feet; at Spring Canyon it is about 1,050 feet; and between Skumpah Creek and the north edge of the district it ranges between 2,000 and 2,500 feet. From south to north successively higher beds appear at the surface of this block, because of the northward dip of the strata. North of the district the fault probably diminishes in amount of displacement and finally dies out, but the appearance of surface features in line with the fault in the Wasatch Plateau suggests that it continues northward 5 miles or more. South of the district this fault dies out, and at the crossing of the Pikes Peak Ocean to Ocean Highway, near the head of Meadow Creek, it is barely recognizable.

West of the northward-tilted segment is a raised block, in which the sandstone beds of the Price River formation form the surface. North of Salina Creek this block is tilted gently northward, but south of Salina Creek it lies nearly flat. It is wedge-shaped, the point of the wedge being formed by the southward convergence of

[11] Op. cit., p. 16.

the faults bounding it. Between Spring Creek and Salina Creek the block is 450 to 530 feet higher, structurally, than the eastern block. North of Salina Creek the displacement increases gradually, owing to the stronger northward dip of the strata in the eastern block. The raised block is structurally about 600 feet lower than the block east of the entire fault zone.

West of the raised block is a broad sunken block in which the Tertiary rocks appear at the surface throughout its length in this district. The sunken block is doubtless split by subsidiary faults into many minor segments, but the detailed stratigraphy of the Wasatch rocks is not well enough known to permit more than broad conclusions concerning this lesser faulting, and the rounded, soil-covered slopes habitually formed by the Wasatch formation effectually mask those faults of moderate displacement which do not cause the surface to transgress the limits of the softer rocks. Certain broad features, however, suggest strongly the presence of faults, the existence and location of which is not proved, but the inferred positions of the faults are indicated by means of dashed lines on Plate 22.

Just west of the point of the wedge-shaped block above described is a segment of Wasatch rocks, tilted strongly northward, that is downthrown about 800 feet at the southern edge of the district, and about 1,500 feet at Salina Creek. North of Salina Creek this segment probably wedges out against the raised block on the east. West of this segment is another segment of Wasatch rocks, tilted southward, which forms a range of hills that rises directly to the flank of the median ridge east of the Mountain ranch ranger station but trends due south, diverging from the ridge near Salina Creek and standing alone south of Salina Creek, on the Mountain ranch. This range of hills breaks up in the latitude of the ranch buildings, probably because of structural irregularity, and it merges into rolling country south of the district. A long, narrow ridge east of the road leading up Nioche Creek from the ranch buildings suggests the presence of a fault block, but the exposures are not sufficient to prove it.

In the range of hills is well exposed a succession of variegated shale of the Wasatch formation that is decidedly different from the shale of the formation exposed west of the district on Salina Creek, where the complete stratigraphic succession of the region is best available for study. The shale in these hills undoubtedly belongs to the Wasatch formation, and the best evidence of its relations to the underlying rocks obtainable in the area is that available in the easternmost segment of the zone, where the northward tilt of the strata brings to view a fairly complete succession of the rocks above the Castlegate member of the Price River formation. Whether this succession is undisturbed by faulting is not certain, but if it is not the stratigraphic section measured there gives an approximate key to the position of the shale beds exposed in the hills west of the median ridge, and on the basis of such measurements the rocks west of the ridge are estimated to have been displaced downward not less than 1,000 feet. The southward dip of the strata in the hills, contrasted with the northward dip of the strata in the median ridge, brings about a considerable increase in displacement south of the ranger station.

West of the range of shale hills lies a flat valley, the surface of which is similar to that ordinarily formed by the limestone beds of the Wasatch formation. It is certainly dissimilar to the surface formed by the variegated shale, and nowhere among the many low hills in the valley has any outcrop of the shale similar to those in the range of hills been found. It seems almost certain that the rocks underlying this valley have dropped at least 300 or 400 feet lower than the rocks in the hills. A fault, shown by dashed lines, is indicated on the map at the place where it seems most likely to exist.

West of this valley rises the escarpment of the westernmost fault of the zone, the displacement of which at Salina Creek is probably not less than 2,000 feet. This fault is continuous across the district, and probably extends several miles north of it into the Wasatch Plateau. The southward continuation of the fault is not known, but it may well be continuous with faults known to exist farther south in the Fish Lake Plateau.

WATER HOLLOW FAULT ZONE

An unbroken stretch of rocks about 2½ miles wide separates the Musinia fault zone from the Water Hollow fault zone, and in the flat-lying rocks of this block is carved the eastern part of Salina Canyon. The Water Hollow fault zone is a sunken block, but it has not sunk so much as the Musinia fault zone. The rocks exposed in the cross section of it afforded by Salina Canyon, however, are all sufficiently resistant and distinctive in character to show clearly the minor details of the structure, and many faults, of great range in displacement and extent, are discernible in the main sunken block.

The faults of the zone that were recognized and determined in the present work are shown on the map (pl. 22), which presents in graphic form practically all the valuable information necessary for the purpose of this report, and therefore the known faults will not be discussed in detail. The displacements of the faults and the resulting disposition of the formations at the surface are better shown graphically than verbally.

Altitudes determined on the top of the Castlegate sandstone show that each of the limiting faults of the block has a displacement, in Salina Canyon, of about 650 feet. The deepest part of the sunken block has dropped about 850 feet. The former dip of the Castlegate sandstone across the zone was very gentle, but some of the dropped blocks are tilted at angles as high as 10°.

On Salina Creek the distinctive sandstone beds of the Price River formation show the details of the fault zone very well, but north and south of Salina Canyon the rock exposures are poor in critical places, and the exact determination of structure is not possible. In Water Hollow, for example, the rocks display the faults very well as far north as the SE. ¼ sec. 11, T. 22 S., R. 2 E., but beyond sec. 11 the faults are nearly all concealed as far as the eastern edge of the fault zone, where the massive escarpment of the Castlegate sandstone gives plain evidence of the fault. South of Salina Canyon the zone is occupied by Browns Hole, a valley similar in origin to that occupied by the Mountain ranch, and a long ridge west of it. South of Salina Canyon the strata in the dropped block dip southward and the massive sandstones pass beneath the softer rocks of the Wasatch formation, which yield their typical smooth-sloped terrane, in which evidence of detailed structure is lacking. The section across the zone in Salina Canyon is probably typical of it, and smaller faults certainly exist throughout the length of the zone in this district, but they are not evident in the soil-covered country underlain by the softer rocks, and it is impossible to show them on the map.

COAL

DISTRIBUTION OF THE COAL BEDS

The known coal of the Salina Canyon district occurs in the upper member of the Blackhawk formation of the Mesaverde group, and the rocks immediately surrounding the coal beds consist of a succession of sandstone and shale of the type common in the Blackhawk formation of the well-known Book Cliffs and Wasatch Plateau coal fields. About 550 feet of the Blackhawk formation is exposed in Salina Canyon, and it is inferred from knowledge of neighboring parts of the Wasatch Plateau field that about 300 feet of the formation lies underground. In the exposed part of the formation 18 beds of coal, ranging in thickness between 5 inches and 10 feet 10 inches, are known, but nine of these beds are less than 1 foot thick, and only two are at any place more than 6 feet thick. It is impossible to determine, without drilling, how many coal beds are present in the part of the formation that lies underground, but it is known that in the Wasatch Plateau coal field the lower part of the Blackhawk formation is much richer in coal than the upper part, and it may safely be assumed that beneath the surface of Salina Canyon the formation contains several coal beds, some of which may be of commercial importance. One coal bed thick enough to be valuable is exposed in the bottom of Salina Creek, near the head of the canyon proper, where the lowermost rocks exposed in the district have been thrust up in a local buckling of the strata, and this coal bed is thought to be the same as the most valuable bed of the Ivie Creek district of the Wasatch Plateau coal field. The stratigraphic relations of the rocks are much obscured at this exposure, however, and it is not possible to determine exactly the position of the coal bed with reference to the beds exposed elsewhere in Salina Canyon.

The most persistent and distinctive sandstone beds of the Blackhawk formation occur in its lower part and hence are not exposed in this district. The prominent sandstone beds of the upper part of the formation are ordinarily neither persistent nor distinctive enough to be used as key beds, and the only stratigraphic horizon to which the coal beds may be referred throughout the district is the top of the Blackhawk formation, or, in other words, the base of the overlying Castlegate sandstone member of the Price River formation. In general, this contact is perhaps unreliable as a datum for detailed correlation, but in the comparatively small area covered by Salina Canyon it probably varies little, and the correlations based on it are probably valid for the groups of coal beds, if not for the individual beds.

The coal beds exposed in the Salina Canyon district, with the single exception of the bed exposed in the sharp upfold near the head of Salina Canyon, are all thin and much more irregular in thickness than the coal beds in the lowest part of the Blackhawk formation in the large mining centers of the Wasatch Plateau coal field. The coal beds in the upper part of the Blackhawk formation in the Salina Canyon district fall naturally into two groups, each of which includes one of the more prominent beds. The higher group occupies the stratigraphic interval between 150 and 200 feet below the base of the Castlegate standstone. The only economically important bed in this group is the Wilson bed, named from the Wilson mine, in sec. 10, T. 22 S., R. 2 E. The second group of coal beds occupies a vertical interval from 300 to 385 feet below the base of the Castlegate sandstone. The lowest and most valuable coal bed in this group is the Sevier bed, named from the Sevier Valley mine, in sec. 20, T. 22 S., R. 3 E., where the bed has been mined in a small way, chiefly in the course of prospecting. The position in the Blackhawk formation of these groups of coal beds is shown in the columnar sections on Plate 21.

The lowest coal bed known in the Salina Canyon district is exposed in the bed of Salina Canyon at location 2. (See fig. 9.) Between locations 2 and 3 the rocks of the Blackhawk formation on the south bank of Salina Creek are tilted at high angles, owing to a local crumpling or buckling of the strata, and in the area covered by these disturbed rocks the lowest rocks of the Blackhawk formation known in the district appear at the surface. The rock exposures surrounding this small disturbed area are poor, and it is difficult to determine the stratigraphic relations of the coal bed to the nearest recognizable beds of the Blackhawk formation, but the best estimate now possible suggests strongly that it is the same as the Ivie coal bed, which is known to be a valuable bed in the part of the Wasatch Plateau coal field east of the Salina Canyon district.[12] The economic importance of this bed is discussed in the detailed description of the coal beds.

In the part of Salina Canyon west of the Water Hollow fault zone the rocks of the Blackhawk formation are very well exposed, and even where the coal beds are concealed it is possible to trace the horizons of the beds by means of the sandstone ledges, irregular though they are, because of the excellence of the exposure. In the Water Hollow fault zone, however, and east of it, the exposures of the Blackhawk formation are not good enough to permit the tracing or recognition of coal beds except by reference to the base of the Castlegate sandstone.

Natural exposures of the coal beds, even in the form of blooms, are rare, and most of the measurements made in the present work were obtained in abandoned prospect openings and mines. As far as possible the beds exposed in these openings were correlated by tracing with the eye the horizon at which the coal bed should appear, and, for short distances, by reference to a near-by sandstone bed, but such methods are applicable in few places.

TONNAGE ESTIMATES

Estimates of the quantity of coal present in the thickest beds have been made for all parts of the district where the thickness of the beds is known. The areas for which these estimates have been made were determined by the length of outcrop in which the thickness of the coal beds is known, and they represent the largest areas for which it is safe to assume the persistence of the beds. It is impossible to determine, without prospecting and mining, whether the beds continue beyond the areas covered by the estimates. The

[12] Spieker, E. M., The Wasatch Plateau coal field: U. S. Geol. Survey Bull. — (in preparation).

limits of the areas have been drawn as here set forth for that reason, and not because it is assumed that no coal exists beyond them.

In order to have an accurate basis for the estimation of tonnage, samples of the coal for the determination of specific gravity were taken at three places in Salina Canyon. The results of the determinations are as follows:

Specific gravity of coal from the Sevier bed in the Salina Canyon district, Sevier County, Utah

[Analyses made at the Pittsburgh laboratory of the U. S. Bureau of Mines; A. C. Fieldner, chemist in charge]

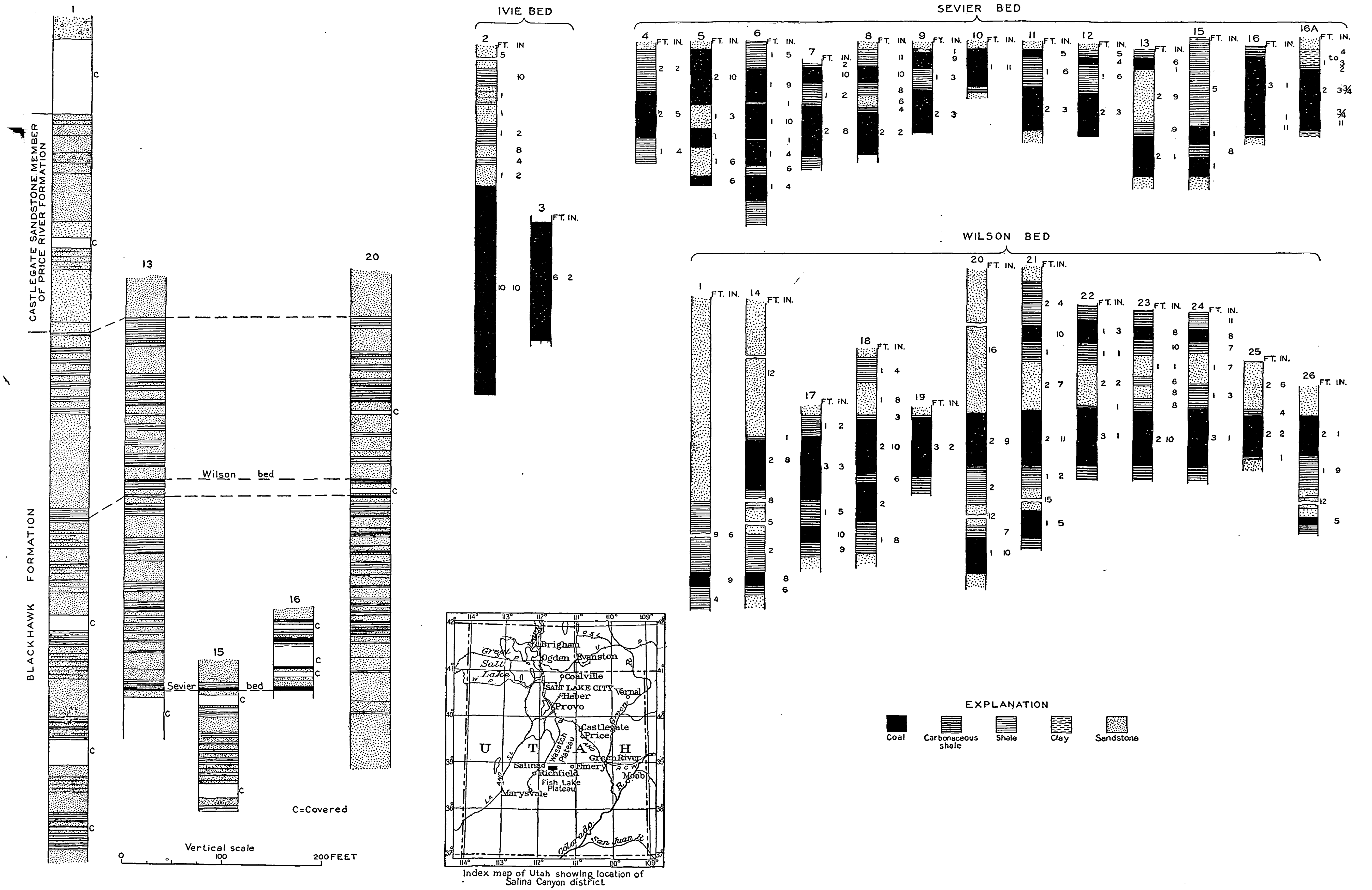
Location on figs. 9 and 10	Laboratory No.	Specific gravity
6	82238	1.321
7	82239	1.381
16	82237	1.328

An acre of coal 1 foot thick, of specific gravity 1.33, contains roughly 1,800 tons, and the estimates given in this report are based on that figure. The estimates for the different beds are given with the descriptions of the beds. A summary of the tonnage in the district for which tentative estimates can be made shows that in an area of about 30 square miles 170,000,000 tons of coal is probably present. This area includes all the land in which workable coal may be presumed to be within reach of mines. Of the total amount more than 140,000,000 tons is estimated to be contained in one bed, the Ivie (?) bed, which is underground throughout the district but which should be accessible for mining in areas aggregating about 20 square miles.

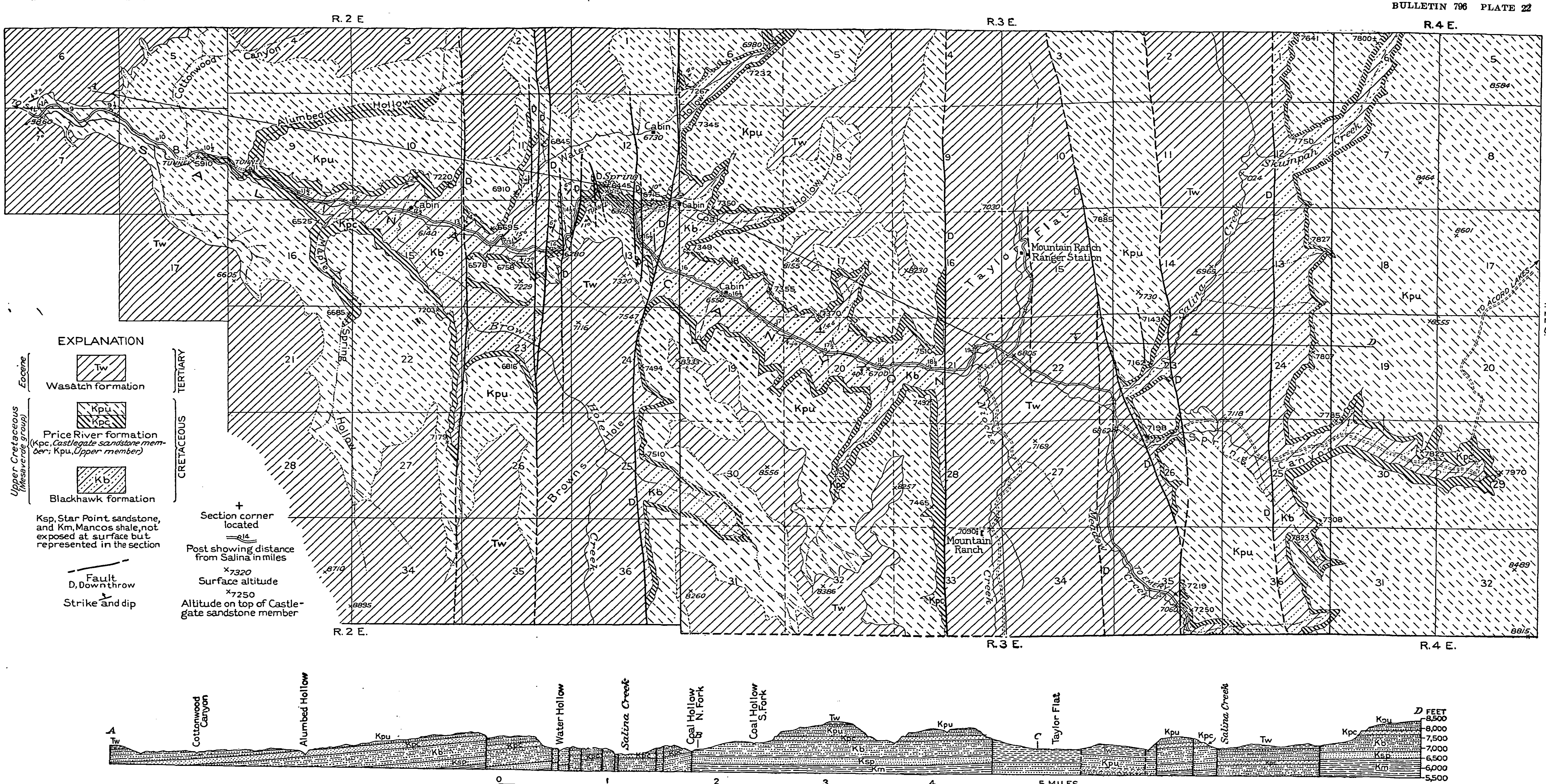
COAL BEDS

The following detailed description of coal beds, supplemented by the graphic sections in Plate 21, is intended to record the observations made during the present examination and to give such estimates and assumptions concerning the amount of coal present in the district as seem reasonable. The thicknesses of the coal beds are given on Plate 21, and the locations of the places at which the sections were measured are shown on the detailed maps, Figures 9 and 10. The numbers of these locations are arranged in geographic order from east to west, without regard for the stratigraphic position of the coal bed represented. The graphic sections of the coal beds are arranged according to beds and in sequence from east to west.

The following descriptions cover only the thicker and more persistent beds known in the district. Many thin and lenticular beds



COAL SECTIONS AND COLUMNAR SECTIONS IN SALINA CANYON DISTRICT, UTAH



GEOLOGIC MAP AND STRUCTURE SECTION OF SALINA CANYON DISTRICT, UTAH are exposed in Salina Canyon, but they are not mentioned in detail because of their unimportance.

IVIE (?) BED

The coal bed that crops out in the bed of Salina Creek at location 2, near the head of Salina Canyon, is the lowest known bed of the district. It occurs in the area of local disturbance mentioned on page 151, and its exact relation to the other beds of the district is not known, but it is thought, on the basis of the meager structural data available, to occupy the same stratigraphic position as that of the Ivie bed, which is the most valuable coal bed in the Ivie Creek district, east of the Salina Canyon district and across the divide.[13] In the Salina Canyon district this bed appears only at locations 2 and 3 (fig. 9), at both of which the rocks dip steeply southward. The structural relations at these places, which are discussed on page 151, are difficult to determine, but it seems likely that the Ivie (?) coal bed passes beneath the surface both east and west of locations 2 and 3 and that it is underground throughout the rest of the district.

The Ivie bed extends at least 11 miles in a north-south direction at its outcrop on the east side of the plateau, and the westernmost point on the outcrop is only 3 miles east of the edge of the Salina Canyon district as outlined on Plate 22. The bed is therefore probably persistent at least as far west as the western boundary of T. 22 S., R. 4 E., and if the bed in Salina Canyon is correctly identified as the Ivie bed the grounds for believing it to be persistent westward are considerably strengthened. On this assumption it is estimated that the Ivie bed has an average thickness of 6 feet throughout the district east of the Musinia fault zone, and its depth beneath the surface, calculated on the basis of stratigraphic intervals obtained east of the present district, should be about 300 feet at the mouth of the canyon of Skumpah Creek, in sec. 12, T. 22 S., R. 3 E., and about 400 feet at the mouth of Spring Canyon, in sec. 25, T. 22 S., R. 3 E. In this area the bed dips westward from 90 to 125 feet to the mile.

The amount of coal present in the Ivie bed in the west half of T. 22 S., R. 4 E., is estimated to be 123,550,000 tons, of which about 86,000,000 tons should be recoverable by ordinary mining methods, Both the original estimate and the estimate of recoverable coal are conservative, and it is highly probable that the amount of coal to be won from this tract is much greater. A similar tonnage may be

[13] Spieker, E. M., The Wasatch Plateau coal field: U. S. Geol. Survey Bull. — (in preparation).

expected to exist in the west half of T. 23 S., R. 4 E., southeast of the area shown on Plate 22.

In most of the area covered by the Musinia fault zone the Ivie bed lies too far beneath the surface to be considered for present-day mining, but it is by no means beyond the range within which shaft mining is possible, and at some distant time the reserve of coal held by the bed in this fault zone may be mined. In the lower valley bottoms of this area the bed at its deepest is probably not more than 2,300 feet beneath the surface, and at many places its depth is considerably less than that. In the raised block in the center of the fault zone it is probably between 600 and 650 feet beneath the surface on Salina Creek, in the NW. 1/4 SW. 1/4 sec. 23, T. 22 S., R. 3 E., and at about the same depth on Spring Creek, in the NE. 1/4 NW. 1/4 sec. 26, T. 22 S., R. 3 E. In this block the bed may contain as much as 17,250,000 tons available to a shaft mine started on Spring Creek or Salina Creek. In the southeastern part of the fault zone the Ivie bed is also not far from the surface, and at the southern border of the area shown on Plate 22 it is probably between 750 and 800 feet beneath the surface on the main road at the southern boundary of T. 22 S., R. 3 E.

The tonnage present in the Ivie (?) bed in the part of the Musinia fault zone included on Plate 22 is probably similar to that present in the west half of T. 22 S., R. 4 E., but the value of the coal is considerably lessened by its depth and by the faulting within the zone. The amount of recoverable coal in the fault zone is considerably smaller because of the sheared condition of the rocks near the faults, and at many places in the zone, because of subsidiary faults, it may not be profitable to mine the coal even under conditions that would justify deep mining.

In the part of the Salina Canyon district west of the Musinia fault zone the presence of the Ivie (?) bed is difficult to predict, except for a relatively narrow strip adjacent to the fault zone, and the detailed character of the entire lower third of the Blackhawk formation can be determined by diamond drilling only. In a strip not more than a mile wide west of the Musinia fault zone the Ivie (?) bed is presumably present, as shown by the exposure at location 2 (fig. 9). At location 3 two tunnels, one directly over the other, and a pit disclose a steeply dipping coal bed about 6 feet thick, and the lower tunnel shows a second coal bed about 5 feet thick and apparently 30 feet stratigraphically beneath the 6-foot bed. The data at this place were obtained in 1921 by H. I. Smith, of the Bureau of Mines. In 1923, when the present work was done, the lower tunnel, where the critical data concerning the structural relations are to be obtained, was too full of water to permit examination. One of the beds exposed at location 3 may be the same as the bed at location 2, but the structure in this part of the canyon is so irregular and the exposures are so poor that exact correlation is impossible. The bed at location 2 is over 10 feet thick, and it is entirely possible that the two beds exposed at location 3 converge eastward and unite to form the single bed at location 2. It is also possible that the strata at location 3 are faulted and that the two beds in the lower tunnel there are the same. A fault that would duplicate the bed in the lower tunnel would have to be a thrust fault, and the only position it might occupy would nearly coincide with the bedding planes of the rock, so that the fault would be difficult to detect. Thrust faults are not known elsewhere in the Wasatch Plateau, but the attitude of the rocks at this place shows clearly that some crumpling has taken place, and the force that produced the crumpling may well have been a lateral thrust.

Whatever may be the true interpretation of the relations at locations 2 and 3, it seems probable that the Ivie (?) bed is present at both places, and if that is true the bed either thins or splits westward from location 2 at a rate that makes its condition underground west of location 3 open to question. The information afforded by these exposures makes it worth while to prospect by drilling for the Ivie (?) bed at places outside of the severely faulted areas in Salina Canyon west of location 3.

It is unsafe, on the sole basis of the exposures at locations 2 and 3, to predict the presence of the Ivie (?) bed for any considerable tract of land west of the Musinia fault block, and no estimate of the tonnage present in the bed is made for this part of the district. It is probable that there is at least 1 square mile adjacent to the fault zone and divided equally by Salina Creek in which the bed is not less than 6 feet thick, and such a tract would contain nearly 7,000,000 tons of coal. This amount would be sufficient to support a 200,000-ton mine for 25 years or more, and if the coal is present a shaft mine on Salina Creek somewhere in the W. ½ sec. 21, T. 22 S., R. 3 E., would be a profitable undertaking. The tonnage available to such a mine and the ease of mining might be considerably reduced by the structural irregularity of the rocks immediately under Salina Creek, and it would be unwise to plan mining there without drilling on both sides of the canyon, as far from Salina Creek as is economically possible, to determine the amount and depth of the coal present. One hole has already been drilled southeast of location 2, but the work was done by private interests, and the results are not available for presentation in this report.

SEVIER BED

The Sevier bed is so named because it has been prospected by the Sevier Valley Coal Co. in sec. 20, T. 22 S., R. 3 E. It is stratigraphically about 385 feet below the base of the Castlegate sandstone and about 215 feet below the Wilson coal bed. Its position with reference to the Ivie (?) bed is not known exactly, but it is believed to be about 280 feet higher. Attempts have been made to mine coal from the bed at the Sevier Valley mine (location 6, fig. 9), the Boston Acme mine (location 12, fig. 9), and the Coal Hollow mine, formerly known as the Kearn & Duggins mine (location 16, fig. 10). The Coal Hollow mine is the only one of the three that has advanced beyond the stage of first prospecting. Many other prospect pits and tunnels have been dug on the bed in Salina Canyon in the western part of T. 22 S., R. 3 E., and practically all the information in this report concerning the extent and thickness of the bed was obtained in these openings. Between the openings the bed is concealed by rock débris, soil, and vegetation, and consequently can not be traced directly, but it was identified at the several exposures as the same bed by its alinement, as shown by altitudes, with the trend of the better-exposed strata above it, and in some short stretches by the actual tracing of prominent sandstone beds to which it could be referred. Sections were measured on the bed at locations 4 to 13, 15, and 16, and they are shown graphically in Plate 21. The bed is very irregular, and only at a few places is it worth mining.

The only part of the district in which the extent and thickness of the Sevier bed are at all known is the belt of nearly flat-lying rocks between the Musinia and Water Hollow fault zones. The part of the Blackhawk formation in which the bed occurs is above drainage level in a narrow strip at the base of the escarpment east of the Musinia fault zone, but the rocks are concealed in this strip, and the existence of the coal bed there is not known. It is deeply buried, if present, throughout the Musinia fault zone, except in the wedge-shaped raised block in the center of the zone, where the horizon at which it should occur is probably not far beneath the surface in the gorges of Spring and Salina Creeks. In all of the Water Hollow fault zone the bed is underground, but in the monoclinal block west of the fault zone the part of the Blackhawk formation in which it should occur is above creek level for a short distance west of the fault zone. At location 20, where a section of the exposed part of the coal-bearing rocks was measured (pl. 21), the general group of coal beds in which the Sevier bed occurs was found, but it seems likely, in comparison of this section with the others measured in the district, that the Sevier bed itself is absent. It is thus probable that the western limit of the swamp in which the Sevier bed was laid down lies somewhere in the area now occupied by the Water Hollow fault zone. The extent of the bed north and south of Salina Canyon is not known because it passes under the heavy cover of the high table-land in which the canyon has been cut.

The Sevier coal bed offers promise of being profitably workable at only two places, the prospect tunnels of the Sevier Valley Co. (location 6, fig. 9) and the Coal Hollow mine (location 16, fig. 10). It is thickest at the westernmost tunnel of the Sevier Valley Co., and its character there is shown by the following section:

Section of the Sevier coal bed measured at the westernmost tunnel of the Sevier Valley Coal Co., location 6

	Ft.	in.
Shale, gray	1	5
Coal	1	9
Shale, gray		1
Coal	1	10
Bone		1
Coal	1	4
Shale, gray		6
Coal	1	4
Shale, gray.		
	8	4
Total coal	6	3

The extreme variability of the Sevier bed is well shown by the sections measured at locations 4, 5, and 6, shown on Plate 21. At location 6 the bed contains over 6 feet of coal; at location 5, hardly 50 feet away, it contains 4 feet 4 inches of coal; and at location 4, 250 feet farther away, it contains only 2 feet 5 inches of coal. Location 4 is the easternmost known exposure of the Sevier bed, and the fact that it thins eastward to this place suggests that it might disappear altogether somewhere west of the head of Salina Canyon. A columnar section (No. 1, pl. 21) measured at the head of the canyon shows no coal in the vertical interval within which the Sevier bed should appear.

The Sevier bed at the Coal Hollow mine has fewer partings than it has at the Sevier Valley prospects, but the total amount of coal is less. In the Coal Hollow mine the bed ranges in thickness between 4 feet 3 inches and 3 feet 3 inches, and it would probably never have paid to open a mine on so thin a bed of coal in this region were it not for the fact that the bed is immediately overlain by a bed of carbonaceous shale and clay that is easily brushed out to make haulageways of requisite height.

At the known exposures between the Sevier Valley prospects and the Coal Hollow mine the Sevier bed is fairly consistent in thickness and appearance, but it is thin and split by a valueless parting of shale, carbonaceous shale, and sandstone. The many prospect tunnels and pits on the bed between locations 7 and 15 bear witness to repeated attempts to determine the character of the bed, none of which have led to further development, evidently because the coal is too thin and too badly split to be of value.

The area for which it is safe to estimate the tonnage contained in the Sevier bed includes about 5.3 square miles, approximately distributed in the following land subdivisions:

T. 22 S., R. 2 E.:
- Sec. 12, small strip in southeast corner.
- Sec. 13, strip on east edge 0.1 to 0.3 mile wide.
- Sec. 24, strip on east edge about 0.4 mile wide.

T. 22 S., R. 3 E.:
- Sec. 7, southern third.
- Sec. 18, all.
- Sec. 19, all.
- Sec. 17, western two-thirds.
- Sec. 20, NW. ¼; W. ½ SW. ¼; NW. ¼ NE. ¼.

For the purpose of calculation, the thickness of the Sevier bed in this area is taken to be 2.5 feet. This assumption is moderate and should provide for all irregularities in the bed away from the outcrop. The amount of coal in the Sevier bed in the tract outlined above is estimated, on the basis of that thickness, to be 15,300,000 tons, and the amount of coal recoverable under ordinary mining conditions is estimated to be 10,700,000 tons, though many places may exist in the tract where it is unprofitable to mine the coal.

WILSON BED

The Wilson bed, which takes its name from the Wilson mine, in sec. 10, T. 22 S., R. 2 E., is the only bed in the district that was being mined at the time of this examination. It lies about 170 feet beneath the Castlegate sandstone and is the highest coal bed of economic importance in the district. It probably extends throughout the part of Salina Canyon between the head of the canyon and milepost 11½, but at the head of the canyon it is very thin, and in most of the area shown on Figure 9 it is probably not workable.

In the part of Salina Canyon contained in T. 22 S., R. 3 E., the Wilson bed has been measured at two places only (locations 1 and 14, fig. 9), and in the intervening stretch of the canyon it is concealed under rock débris. At the east end of the canyon it is too thin to be noticed but for the fact that its position in the stratigraphic column identifies it as the probable correlative of the bed at the Wilson mine, but at location 14 it is enough thicker to suggest that it might be worthy of attention in sec. 18, T. 22 S., R. 3 E. However, at location 14 it is not quite 3 feet thick, and under present conditions a coal

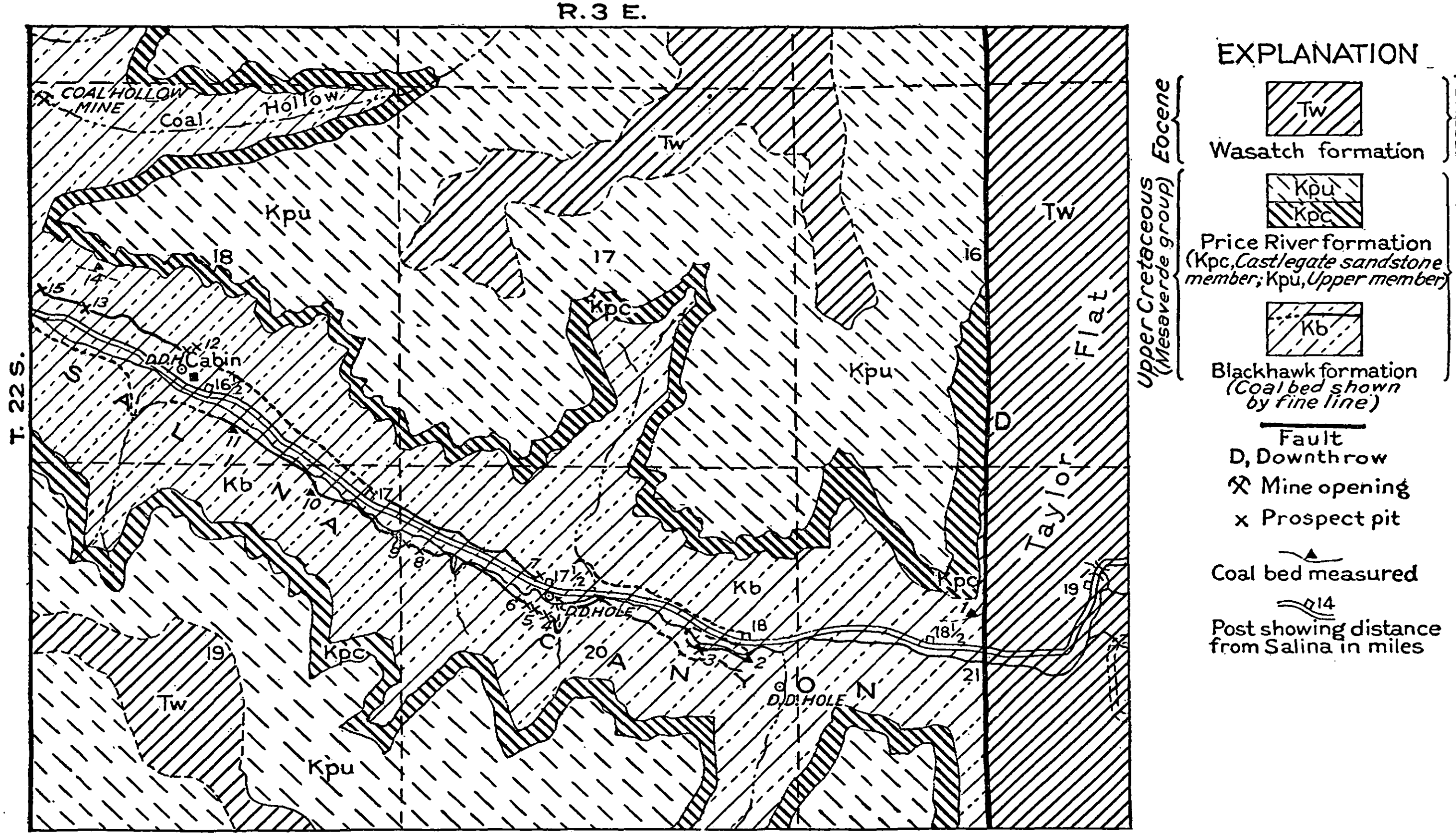


FIGURE 9.—Map of the part of Salina Canyon, Utah, in T. 22 S., R. 3 E., showing details of coal outcrops. Scale, 1 inch = one-half mile

bed in this region much less than 4 feet thick can hardly be mined with profit, even on a small scale. The character of the Wilson bed and associated rocks at location 14 is shown in the following section:

Section of Wilson coal bed and associated rocks at location 14

	Ft.	in.
Sandstone, buff	12	
Shale, gray		1
Coal	2	8
Shale, gray	8	
Sandstone, buff-gray	5	
Shale, gray	2	
Coal		8
Shale, carbonaceous		6
Sandstone.		
	30	11

In T. 22 S., R. 2 E., the bed is thicker and has been prospected and mined to a small extent. It is beneath the surface in the Water Hollow fault zone as far west as the fault block west of milepost 14, but it appears in the westernmost block of the fault zone, and there it is thicker than at any other part of the district as shown by the sections measured at locations 17, 18, and 19. (See pl. 21.) South of Salina Canyon the bed passes under cover, and north of the canyon, where the outcrop is above drainage level in the western wall of Water Hollow, it is concealed by the rock débris on the slopes.

The part of the bed in this fault block that is accessible to mines in Salina Canyon or Water Hollow probably contains enough coal to support one or two mines of moderate size for a number of years, but the prospect of large-scale development in the near future is small, because the bed is split by a considerable parting and does not contain enough clear coal to compete with the thicker coal beds available in near-by regions. Furthermore, the evidence obtainable at the outcrop of the bed just west of this fault block, near location 20, suggests that the coal in the fault block thins down to about 3 feet or less about half a mile north of its outcrop in Salina Canyon. However, it is possible that the bed maintains its thickness north of location 19, and the available evidence would be interpreted, in terms of engineering advice, to mean that, under economic conditions which would justify starting a mine at location 19, the coal bed is worthy of prospecting to determine its nature in the part of the block north of Salina Canyon.

A carefully prepared estimate, based on the evidence obtained in this examination, of the amount of coal present in this fault block and within reach of mines in Salina Canyon, is as follows:

Estimated available tonnage in Wilson coal bed in westernmost block of Water Hollow fault zone

Tract	Tons of coal	
	Present	Recoverable [a]
Part of block extending 2 miles north of Salina Canyon	3,000,000	2,150,000
Part of block extending 1 mile south of Salina Canyon	2,300,000	1,630,000

[a] Based on an extraction of 70 per cent.

In the part of the fault block north of Salina Canyon the bed is assumed to be thicker for about half a mile from the outcrop than it is farther north. The area in the block extending half a mile north of location 19 is estimated to contain 1,220,000 tons, of which at least 850,000 tons is recoverable.

The northern and southern limits of the areas for which these estimates are made represent the maximum distances from the outcrop to which it is safe to assume that the coal extends in the thickness known at the outcrop, and they are not meant to represent the limits of minable coal. Estimates are not made for areas so far from the outcrop that the projection of outcrop measurements is unsafe. The extension of the coal beyond these limits must be determined either by diamond drilling or by mining.

In the monoclinal area west of the Water Hollow fault zone the Wilson bed is well exposed at a number of places on the north side of Salina Canyon, and in 1923 it was being mined at the Wilson mine (locations 21 and 22, fig. 10). The strata in this area dip consistently westward, and the Wilson bed passes beneath creek-level near location 26, 1.4 miles down Salina Creek from the western limit of the fault zone. Sections were measured on the bed in this stretch at locations 20 to 26. (See pl. 21.)

The Wilson bed is the central and thickest bed of a group of three coal beds that are recognizable almost throughout this part of the district. A section of this group measured at the Wilson mine is as follows:

Section of Wilson coal bed and associated rocks at Wilson mine, location 21

	Ft.	in.
Sandstone, gray, massive.		
Shale, carbonaceous, brown	2	
Coal, resinous		10
Shale, carbonaceous, black	1	
Sandstone, massive, gray	2	7
Coal, resinous (Wilson bed)	2	11
Shale, gray, carbonaceous at top	1	2
Shale and sandstone, thin-bedded	15	
Coal, resinous	1	5
Shale, carbonaceous, brown.		
	26	11
Total coal	5	2

The Wilson bed is fairly constant in thickness in sec. 10, T. 22 S., R. 2 E., but in sec. 9, just before it passes beneath the surface, it gives evidence of thinning. (See sections 24 to 26, pl. 21.) At its greatest known thickness in this part of the district it probably is not thick enough for any present-day development larger than a "country" mine. Estimates of the tonnage present in the Wilson bed in secs. 9, 10, 15, and 16, T. 22 S., R. 2 E., are as follows:

Tonnage in Wilson coal bed in secs. 9, 10, 15, and 16, T. 22 S., R. 2 E.

Section	Total	Recoverable
9	2,300,000	1,600,000
10	2,900,000	2,000,000
15	2,000,000	1,400,000
16	2,300,000	1,600,000
	9,500,000	6,600,000

The estimates are not extended beyond these four sections, because it is regarded as unsafe to estimate the thickness of the bed, on the basis of outcrop measurements, for a larger area. The estimates for secs. 9 and 16 are probably equally as accurate as those for secs. 10 and 15, but in considering them it should be remembered that the coal bed is probably not more than 2 feet thick in those sections, and if so is not believed to be profitably workable at present.

A summary of the tonnage estimates for the Wilson bed shows that in the area immediately bordering Salina Canyon about 10,421,500 tons of coal is recoverable from this bed by ordinary mining. Little more than half of that tonnage, however, is contained in tracts where the coal is thick enough to be profitably mined at present, even on a small scale.

QUALITY OF THE COAL

The coal of the Salina Canyon district is similar in almost all characteristics to that of the other parts of the Wasatch Plateau coal field. It is bituminous in rank and of good quality almost throughout. It is black, hard, and lustrous, and its stocking qualities are very good. Lumps of the coal that had lain on the dump of the Wilson mine for many months were in 1923 very little affected by the weather. All the coal contains resin in thin lenses on the parting planes, and some of the coal in the Sevier bed contains an unusual amount of resin. The resin in no way detracts from the value of the coal; it is rich in hydrogen and may safely be assumed to increase the heating value of the coal, but where it is present in large quantities it may cause considerable smoke if the coal is not burned in modern and efficient fire boxes.

The following table of analyses shows the chemical quality and the heating value of the coal in Salina Canyon. The result of an

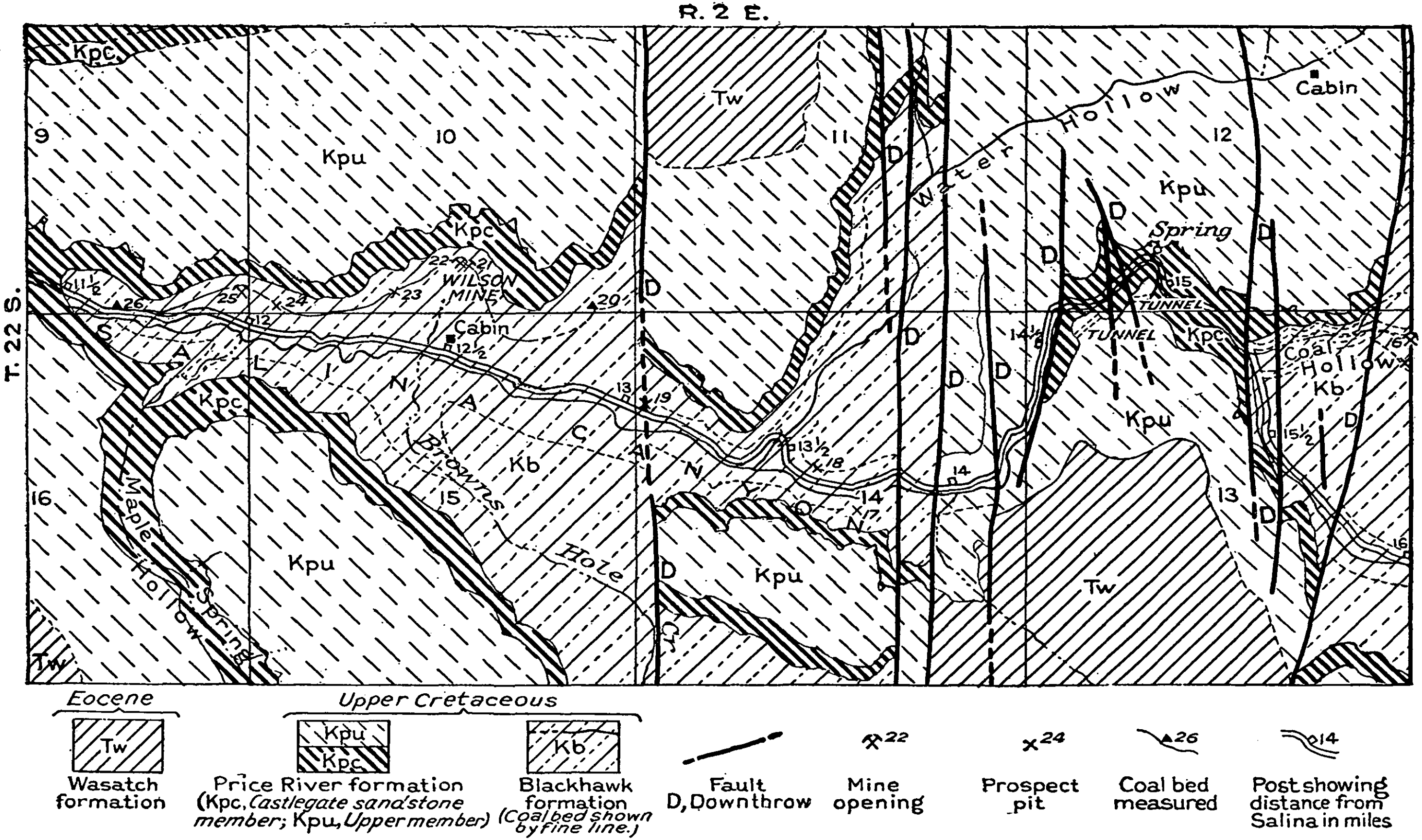


FIGURE 10.—Map of the part of Salina Canyon, Utah, in T. 22 S., R. 2 E., showing details of the coal outcrops. Scale, 1 inch = one-half mile

analysis of a sample of the Ivie coal bed from Ivie Creek is also given, and, for comparison, analyses of samples from the Castlegate coal bed in the Castlegate No. 1 mine, Castlegate, and from the Hiawatha bed at the Mohrland mine at Mohrland. Samples of the Sevier bed were taken at the Coal Hollow mine, location 16; at a prospect of the Sevier Valley Coal Co. at location 5; and at a prospect pit at location 7, across Salina Creek from location 5. The samples of the Sevier bed were taken in 1921 by H. I. Smith, of the Bureau of Mines, and the samples of the Hiawatha and Castlegate beds by other members of the Bureau of Mines.

The analyses are given in the table in four forms, A, B, C, and D. Form A is the analysis of the coal as it is received at the laboratory, and is not suitable for comparison with other analyses, as the coal may contain moisture not inherent in the coal, but accidentally present. Form B is an analysis of the coal after the free moisture has been removed by drying at a standard temperature for a fixed period. This form of the analysis usually represents fairly well the coal as it reaches the consumer, and on the whole it is best suited for use in comparing different coals. Form C represents an analysis of moisture-free coal, and form D a theoretical analysis of the coal in a supposedly moisture-free and ash-free condition. Forms C and D are obtained by recalculation of form B, and they are of value chiefly for the purpose of comparing and studying pure coal substance of different coals.

Analyses of coal samples from the Salina Canyon district and Wasatch Plateau coal field, Utah

[Made at the Pittsburgh laboratory of the Bureau of Mines; A. C. Fieldner, chief chemist]

Bed	No. on figs. 9 and 10	Laboratory No.	Air-drying loss	Form of analysis	Proximate analysis					Heating value	
					Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Calories	British thermal units
Sevier	5	82238	7.2	A	9.96	37.56	48.32	4.16	0.49	6,587	11,856
				B	2.98	40.47	52.07	4.48	.53	7,097	12,775
				C	--------	41.71	53.67	4.62	.54	7,316	13,168
				D	--------	43.75	56.27	--------	.57	7,671	13,807
Do	7	82239	11.2	A	14.94	36.25	40.37	8.44	.41	5,383	9,690
				B	4.23	40.81	45.46	9.50	.46	6,061	10,910
				C	--------	42.62	47.46	9.92	.48	6,339	11,392
				D	--------	47.31	52.89	--------	.53	7,026	12,646
Do	16	82237	3.5	A	5.86	45.48	37.82	10.84	.49	6,603	11,886
				B	2.50	47.10	39.17	11.23	.51	6,839	12,311
				C	--------	48.31	40.18	11.51	.52	7,014	12,626
				D	--------	54.59	45.41	--------	.59	7,927	14,268
Ivie bed at Ivie Creek.	------	82235	6.7	A	13.85	35.18	43.67	7.30	.62	5,856	10,540
				B	7.63	37.72	46.82	7.83	.66	6,278	11,300
				C	--------	40.84	50.69	8.47	.72	6,797	12,235
				D	--------	44.62	55.38	--------	.79	7,426	13,367
Hiawatha bed at Mohrland mine.	------	81009	4.6	A	6.02	41.43	47.11	5.44	.60	7,125	12,826
				B	1.45	43.45	49.40	5.70	.63	7,472	13,450
				C	--------	44.08	50.13	5.79	.64	7,581	13,648
				D	--------	46.79	53.21	--------	.68	8,047	14,487
Castlegate bed at Castlegate No. 1 mine, sec. 2, T. 13 S., R. 9 E.	------	80170	1.0	A	3.85	42.98	47.68	5.49	.45	7,173	12,912
				B	2.85	43.43	48.17	5.55	.45	7,248	13,046
				C	--------	44.70	49.59	5.71	.47	7,460	13,429
				D	--------	47.41	52.59	--------	.50	7,912	14,242

The analyses show that the quality of the coal in the Sevier bed is not greatly different from that of the coal at Mohrland and Castlegate. The Ivie bed also is of about the same quality. The high moisture content in the sample from Ivie Creek suggests that this sample was somewhat weathered, thus accounting for the low content of volatile matter and the low heating value, as well as the higher percentage of fixed carbon. It is noteworthy that the content of sulphur in the Sevier bed is lower than that of the Ivie bed and of the beds farther north. The variability in ash content of the Sevier bed may be partly explained by the irregular presence of partings in the bed that are too thin to be culled out in mining.

The coal from the Wilson bed, for which no analyses are available, is reported by domestic consumers of coal in Salina to yield a high heat but to burn rapidly as compared with coal from the northern part of the Wasatch Plateau coal field.

MINING

PRESENT MINING

Sevier Valley was settled soon after 1850, and the coal in several parts of the region was discovered by the settlers there. It is not known when coal was first discovered in Salina Canyon, but it was doubtless soon after the first settlement. From the time of discovery the coal was prospected in a desultory way until about 1900, but since 1900 many small mines have been operated, and in recent years numerous prospect pits have been dug in the upper 7 miles of the canyon. The coal beds in the upper part of the Blackhawk formation, which crop out in Salina Canyon, have been thoroughly prospected by these mines and prospect pits. In 1922 and 1923 private corporations undertook some diamond-drill prospecting at three localities near the head of the canyon to determine the presence and extent of coal beds in the lower unexposed part of the coal measures, but the results of this exploration are not known to the writers.

All the mines in Salina Canyon, except the Wilson mine, were inactive in 1923. This mine, which was formerly known as the Nephi Anderson mine, is high on the north side of Salina Canyon, near milepost 12½. Hand-drawn cars transport the coal to the mouth of the mine, where it is dumped through a chute into a small bin from which wagons are loaded. All the coal from this mine is taken to Salina and adjacent towns for domestic use. The amount of coal produced at the mine is but a small part of the total amount of coal used at Salina and vicinity.

The largest of the country mines in the Salina district is in Coal Hollow, about half a mile from Salina Canyon. This mine was formerly known as the Kearn & Duggins mine. It has not been in operation since the summer of 1914, and the road to the mine has been destroyed by floods and landslides. The remains of coal bins and other equipment standing at the mine give evidence of considerable activity there in past years. The workings are fairly extensive. The main entry extends to the north and east nearly 350 feet from the mouth and large rooms have been mined out on each side of the entry. A crosscut from the main entry reaches the surface at the falls in Coal Creek. The mine was equipped with rails and steel cars for transporting the coal to the surface. The coal was hauled to Salina by wagon.

A prospect tunnel on the Sevier bed has been driven by the Boston Acme Mining Co. at location 12, near milepost 16½ in Salina Canyon. This tunnel trends N. 45° E. and had been driven 182 feet in 1923. The coal bed is only 2 feet 3 inches thick as measured at the mouth of the mine, but between the coal and a good sandstone roof are 1 foot 6 inches of shale, 4 inches of coal, and 5 inches of shale, and by mining out the overlying shale the tunnel was made high enough for work. A prospect pit has been dug on a higher coal, above the tunnel of the Boston Acme Co., but this coal is only 1 foot 4 inches thick.

A mile east of the Boston Acme tunnel and on the south side of Salina Canyon opposite milepost 17½ are three tunnels excavated by the Sevier Valley Coal Co. At location 4 the tunnel has been driven a little west of south about 125 feet. At location 5 is a tunnel about 50 feet long. The depth of the tunnel at location 6 is not known.

FUTURE MINING

The Salina Canyon district is favorably located with respect to the existing coal markets of the West, and if the present estimates of the amount of workable coal in it are accurate it has many important advantages in favor of its development. The town of Salina, which is at present the nearest railroad point to the coal-bearing area, is 152 miles from Salt Lake City, which is the distributing center for much of the coal from the Wasatch Plateau coal field and is the place from which nearly all Utah coal shipped to San Francisco and points on the northern Pacific coast has a common haul. If the railroad, contemplated years ago, connecting Castle Valley and northeastern Utah with Los Angeles by way of Salina Canyon is ever built, the district will enjoy a considerable advantage over all other high-grade bituminous fields of Utah in the haul to

Los Angeles. At present the distance by railroad from Salina to Los Angeles is 781 miles, and even that distance is 119 miles shorter than the distance from the nearest present bituminous coal shipping center of Utah.

In addition to these distant markets, an important market for coal from the Salina Canyon district is near at hand, in the Sevier and Sanpete Valleys. The demand in the many communities in these valleys for domestic coal alone is worthy of the consideration of prospective operators, and fuel for commercial use is needed by many beet-sugar mills in the valleys and by mines near Marysvale. The Salina Canyon district has a decided advantage in location with respect to these markets.

Of the coal beds exposed in Salina Canyon only the Ivie (?) coal bed is worthy of consideration for large-scale development. Other thick beds may, however, underlie the district, and diamond drilling should therefore be done to afford a basis for intelligent exploitation.

The tracts of land in the district that are probably underlain by the Ivie bed are outlined in the description of that bed (pp. 153–155). To reach the bed in any of the places favorable for mining either a shaft or a slope will be necessary, and the choice involves largely the difference in length of railroad spur necessary to reach shaft and slope sites and the difference in mining costs between the two methods.

The choice of mine sites depends on the type of mine planned. Slopes to reach the coal in the structurally highest blocks east of Salina Canyon might be located at a number of places in the valleys, a choice among which would depend on details of engineering into which it is impossible to go here. Good shaft sites are also available in the parts of the district where the Ivie (?) coal, if present, is within easy reach. In Spring Canyon, near the center of sec. 25, a good site can easily be found. This place is accessible for a railroad and favorable for a town site, and it is a good mine site because the slight dip of the rocks forms a shallow syncline whose axis is near the creek. This dip of the rocks would favor underground transportation of the loaded cars to the bottom of the shaft. The dip of the rocks east of the fault block on upper Salina Creek is in general to the north, but as the dip is less than 1° it would have little influence on mining operations. At the base of the cliffs south of Skumpah Creek there are several favorable localities for shaft mines, because the coal is there at moderate depth, a large area of coal to the east is available, the mines would be accessible for railroad transportation by a line projected through the gorge of upper Salina Creek, and the valley of Salina Creek offers a good location for a town site.

The wedge-shaped raised block in the middle of the Musinia fault zone constitutes a physically separate mining unit. The coal in this block is at a lower altitude than that east of upper Salina Creek, and a deeper shaft would be required. The dip in this block north of Salina Creek is about 7° NW., and a mine at the mouth of the gorge of upper Salina Creek, which is the most favorable site so far as railroad accessibility and depth of shaft are concerned, would have the disadvantage of a long haul on a steep grade to the foot of the shaft. The coal that lies south of Salina Creek, in the tapering block between the faults, is small in quantity, but the hauling of the coal underground would be favored slightly by gravity. The main supply of coal for such a mine would lie to the north. If extensive mining operations were planned it would perhaps be more economical to choose a site farther north, where the shaft would have to be deeper but where the coal from a large area could be hauled on a down grade to the foot of the shaft.

At the east end of Salina Canyon the Ivie (?) coal bed is probably present in an area large enough to warrant a mine of moderate size, and the site for such a mine would naturally be selected in Salina Creek, near the railroad. The shaft in this part of the district would probably not be much deeper than 200 feet, and in places less than that. Shaft mines are possible at many places in Salina Canyon, except in the stretch between Coal Hollow and milepost 14, where the faulting is too complex to encourage mining, and it is undoubtedly worth while to prospect for coal with the drill throughout the structurally unbroken area. As a guide to drilling, the following table gives the depths at selected places in Salina Canyon beyond which it will probably not pay to go. In considering these figures, however, the fact should be borne in mind that they are based on the known thickness of the coal-bearing strata in the Ivie Creek district, 10 miles southeast of Salina Canyon. It is entirely possible that the strata equivalent to the Star Point sandstone (the basal formation of the Mesaverde group in the Wasatch Plateau) may be coal bearing beneath Salina Canyon, and one drill hole 400 feet deeper than the maximum depth given in the table would be a thorough test of the rocks for available coal. It is also true that the strata equivalent to the Emery sandstone member [14] of the Mancos shale of the Wasatch Plateau might here bear coal, but to reach those beds the drill would have to penetrate at least 1,000 feet deeper than the depths given in the table, and to prospect them thoroughly it would have to go possibly 1,800 feet deeper. Coal at such depths is beyond the reach of profitable mining at the present time.

[14] Spieker, E. M., and Reeside, J. B., jr., op. cit.

Probable maximum depths of drilling for coal in Salina Canyon

Location of bore hole	Maximum depth (feet)		Location of bore hole	Maximum depth (feet)	
	For coal in Blackhawk formation	For possible coal in Star Point sandstone		For coal in Blackhawk formation	For possible coal in Star Point sandstone
Milepost 10½	1,050	1,450	Milepost 15½	825	1,225
11½	900	1,300	16½	300	700
12½	400	800	17½	350	750
13½	600	1,000	18½	325	725

TRANSPORTATION OF COAL

The transportation of coal from mine sites in the Salina Canyon district to markets of the West presents no serious difficulties. The nearest railroad point to the district is Salina, which is on the Marysvale branch of the Denver & Rio Grande Western Railroad. A branch line was built in 1903 from Salina to the site of a town called Nioche, in sec. 22, T. 22 S., R. 3 E., but this line was never operated, and it has been so largely destroyed by floods in Salina Canyon that very little of it is now recognizable as a railroad. Plans have been promulgated in recent years to rebuild this line in order to reach the sites of proposed coal mines, and if diamond-drill prospecting yields favorable results it is probable that before many years the coal-bearing areas in and near Salina Canyon will be opened to large-scale development. Practically all parts of the district that offer promise for coal mining are easily accessible by spurs from the main line of such a railroad.

The transportation of coal from the mine mouth to the railroad, which is so expensive an item in the production of coal on the steep cliffs of the east front of the Wasatch Plateau, involves no difficulty in this district, because all mines will probably be located on the railroad. This advantage is to some extent neutralized by the additional expense of shaft or slope mining as compared with drift mining, but on the whole it is believed that the operation of shafts will not be so expensive as that of the long tramways that are necessary in parts of the field where the coal is far above drainage level in rugged canyons.

MINING NECESSITIES

Water and timber, two of the main requisites in mining, are available for any mining activity that may develop in the Salina district. Salina Creek carries a strong flow of water, and all its larger tributaries are perennial streams. If, as seems likely, mining towns grow up on all parts of Salina Creek within the district, precautions will be necessary against pollution of the supply of potable water, and pipe lines to springs or reservoirs near the heads of the perennial streams will probably be necessary. Ground water may possibly be available in the Musinia fault zone, where the Wasatch formation, which is commonly water bearing, underlies the surface, and at places near Salina Creek south of Taylor Flat an artesian flow might be obtained. The Wasatch rocks in this part of the fault zone dip southward, and the water gathered in the higher ground north of Taylor Flat may accumulate in these strata under artesian pressure near Salina Creek. If circumstances demand it, a prospect well somewhere in sec. 22, T. 22 S., R. 3 E., would be worth while.

Timber suitable for mine use is not available within the Salina Canyon district, but north and east of it timber is plentiful on the higher slopes. In the vicinity of the Acord Lakes, at the head of Spring Canyon there are large groves of trees suitable for mine timber. The wagon road in Spring Canyon affords a short down-grade haul to the mine sites of the Salina Canyon district, and an abundant supply of mine timber could be obtained at moderate cost.

Large-scale mining operations mean the employment of hundreds of workmen and the necessity of laying out and developing town sites to house the mine employees. There is a good location for a townsite on upper Salina Creek in the wide flat made by the down faulting of the Tertiary rocks. This wide valley contains ample room for a town, and it is conveniently located for mining operations either in the fault block west of the valley or in the Skumpah region, east of the valley. Another favorable town site is situated on Spring Creek, where the creek crosses the same down-faulted block as that in which upper Salina Creek lies. A town at this place would be close to mining operations in upper Spring Canyon and would enjoy all the natural advantages of a town on upper Salina Creek. At the head of Salina Canyon ample space for a mining town is also present. Most of the canyon is very narrow, and the small flats adjacent to the creek are hardly large enough to contain towns of the size necessary for large mines. Towns constructed in the canyon will necessarily consist of long single rows of houses and will suffer the inconveniences of such planning that are well known in camps in similar canyons in other parts of the Wasatch Plateau and in the Book Cliffs coal field.