THE GRANBY ANTICLINE, GRAND COUNTY, COLORADO

By T. S. Lovering

LOCATION AND DISCOVERY

An anticline in Middle Park, Grand County, Colo., was discovered and studied in 1928 by the writer during the course of cooperative investigations made by the Geological Survey and the Colorado Metal Mining Association. The anticline is a narrow fold with a northerly trend that has been traced for a distance of 15 miles. Near its south end it crosses the Colorado River and the Denver & Salt Lake Railroad about midway between the towns of Hot Sulphur Springs and Granby. (See pl. 6.) It is here named the Granby anticline.

The anticline is masked in large measure by extensive flows of basalt and andesite, as well as by deposits of clay, sand, gravel, and conglomerate. For this reason it appears not to have been recognized by the comparatively few geologists who have visited the region, beginning with A. R. Marvine, of the Hayden Survey, who studied the geology of Middle Park in 1873.

STRATIGRAPHY

The rocks that are exposed on the anticline consist of sandy shale of Cretaceous age that contains a Pierre fauna, but younger and also older rocks are exposed near by. The distribution of all these rocks on and near the anticline is shown on the accompanying map, and they are described below in the order of age, the oldest first.

CONCEALED ROCKS ON GRANBY ANTICLINE

Pre-Cambrian.—Crystalline rocks of pre-Cambrian age probably lie beneath about 5,000 feet of sedimentary rocks in the highest parts of the Granby anticline. In exposures a few miles east and south of the anticline the pre-Cambrian rocks consist of hornblende gneiss and biotite-sillimanite schist into which a pink biotite granite has been intruded.

Morrison (?) formation and Dakota sandstone.—Beds of gray and maroon shale and light-gray sandstone that are here assigned

to the Morrison (?) formation and Dakota sandstone do not crop out on the Granby anticline but are revealed at places near by to the east and south, where they rest upon the pre-Cambrian crystalline rocks. The maroon shale directly overlies the crystalline rocks and is tentatively correlated with the Morrison formation, which it closely resembles, but for convenience it is here mapped with the Dakota sandstone. The Morrison (?) includes shale and some soft sandstone and ranges in thickness from 150 to 200 feet; it is overlain by a conglomeratic sandstone 15 to 25 feet thick, which contains many pebbles of black chert and is thought to be the basal member of the Dakota. The conglomeratic sandstone is overlain by a few feet of shale, which is in turn overlain by a white quartzitic sandstone about 80 feet thick.

Marine Cretaceous shale.—Beds of Benton, Niobrara, and early Pierre age are not exposed on the Granby anticline, but their character is inferred from scattered outcrops at other localities in the region and also from a knowledge of the stratigraphy of North Park and the western border of Middle Park. The correlations and thickness as given here are therefore only tentative.

A dark-colored shale of probable Benton age overlies the Dakota at Hot Sulphur Springs and measures about 500 feet in thickness. The limy shale of the Niobrara is about 700 feet thick and is separated from the underlying Benton by a brown sandy limestone and from the overlying Pierre by a thin shaly sandstone. Shale of Pierre age, about 3,500 feet thick, contains in its lower part 1,500 feet of black shale, in the middle 800 feet of shale with some limy sandstone in several beds apparently 20 to 40 feet thick, and at the top 1,200 feet of black shale. The use of the name Pierre is only tentative, because the name Steele shale may later prove to be more appropriate, as the overlying sandstone is also of Pierre age and may possibly be referable to the Mesaverde formation of the region west and northwest of Middle Park.

Marine Cretaceous sandstone.—Resting on the black shale is a sandy unit which includes at the base about 100 feet of interbedded sandy shale, shaly sandstone, and limy sandstone, followed, as inferred from exposures in near-by areas, by about 300 feet of dark sage-colored sandy shale, with some lignitic shale.

ROCKS EXPOSED IN AND NEAR GRANBY ANTICLINE

Marine Cretaceous sandstone.—An additional 300 feet of sandy beds as revealed in exposures on the Granby anticline is composed of sandstone and sandy shale which carry marine invertebrate fossils belonging to the Pierre fauna.

Middle Park formation.—A bed of volcanic breccia, 400 to 600 feet thick, forming the basal member of the Middle Park formation, rests upon the Cretaceous sandstone. It is easily recognized and is a valuable key to the geologic section, for it usually stands out in bold ridges and crops out continuously for long distances. It is composed largely of andesitic pebbles and boulders and to a less extent of pre-Cambrian fragments in a matrix of andesitic material. Near the southern part of the region mapped andesite flows alternate with beds of breccia and conglomerate, but the flows apparently thin out and disappear to the north. There is little evidence of unconformity between the breccia and the underlying sandstone, and wherever closely spaced outcrops permit comparison the bedding planes of the breccia and of the sandstone are perfectly concordant. The breccia is overlain by a thick succession of grit, sandstone, conglomerate, and shale. The lower part of the succession is predominantly a mustard-colored andesitic grit that contains many greenish bands or blotches of chlorite. This andesitic material changes upward in the section to clean arkosic grit and sandstone; and only local conglomerates containing pebbles of monzonite and andesite porphyries show that volcanic rocks were still sources of the Middle Park sediments after they had become 1,000 feet thick. Shale was rarely observed in the section near Hot Sulphur Springs, but shaly members, some of which are distinctly lignitic, become more and more abundant toward the north. The total thickness of the Middle Park formation is about 5,000 feet. The Middle Park formation is lithologically similar to the Denver formation and contains a similar flora. It is therefore tentatively referred to the Eocene, in accordance with the Geological Survey's present classification of the Denver formation.

Dikes of andesitic porphyry are common in the southern part of the region and seem to be later than the Middle Park formation and earlier than the White River(?) beds. None of the dikes, however, cut the rocks on the Granby anticline.

White River group(?).—A series of beds of grayish-white clay and brown conglomerate lie unconformably upon all the formations described above. They are in large part confined to the topographic basin near Granby, but they effectually conceal many important structural relations. Their exact age is unknown, but they lie between the Eocene Middle Park formation and beds of Miocene age and are separated from both by pronounced unconformities. They closely resemble the White River group as developed in the Laramie and Sherman quadrangles of Wyoming and are provisionally assigned to that group.

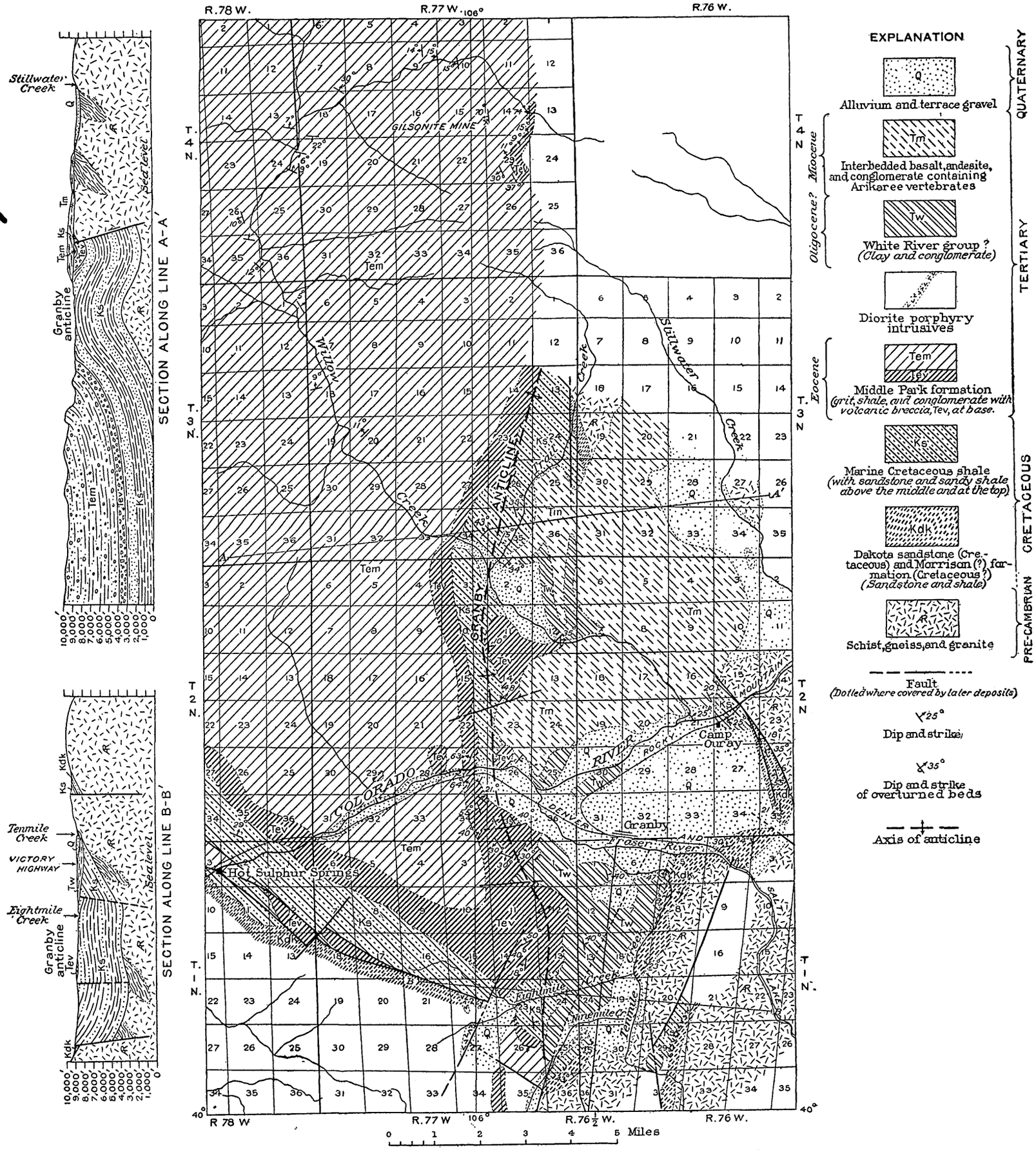
Miocene beds.—In the small area studied the rocks of lower Miocene age consist of andesite (at the base), light-colored tuffaceous clay, conglomerate, and chocolate-colored shale, interbedded with basalt flows. The andesite and basalt flows furnished most of the pebbles for the upper beds of conglomerate, but a few fragments of pre-Cambrian granite also occur in them. L. B. Graff, the writer's assistant, found several bones in these beds which Dr. H. J. Cook, of the Colorado Museum of Natural History, has identified as belonging to an ancient deer, undoubtedly a *Blastomeryx;* an extinct camel, comparable to *Procamelus;* an early horse, comparable to the larger species of *Parahippus;* and a chalicothere, *Moropus* cf. *M. elatus* Marsh. Doctor Cook states that this group is characteristic of the lower Miocene and is definitely an Arikaree fauna. The aggregate thickness of these beds, which can be definitely correlated with the Arikaree formation, is not known but is thought to be at least 1,000 feet.

Quaternary deposits.—Outwash gravel from Pleistocene glaciers forms extensive terraces near Granby, and alluvial flats occupy areas more than a mile wide at many places along the Colorado River.

STRUCTURE

The Granby anticline runs nearly due north and probably extends from sec. 26, T. 1 N., R. 77 W., to sec. 23, T. 3 N., R. 77 W. It is narrow and asymmetric, being steep on the west side, where the strata are inclined at angles of 40° to 64° at most places, and gentler on the east side, where the strata dip mainly at angles of 10° to 40°.

Local easterly cross folds on the anticline are indicated at a few places, and it is probable that there are several closed portions of the anticline, if the near-by northward-trending faults, concealed beneath the Tertiary beds, do not swing to the west and cut off the eastern limb of the fold, thus destroying the closure. It is probable that the portion of the anticline lying between sec. 26, T. 2 N., R. 77 W., and sec. 35, T. 3 N., R. 77 W., is closed, but a detailed study of the region will be needed before it is possible to verify that inference. A dome may also be present on the crest of the anticline in secs. 13, 14, 23, 24, and 26, T. 1 N., R. 77 W., and a small dome on the anticline is indicated in sec. 35, T. 2 N., R. 77 W., and sec. 2, T. 1 N., R. 77 W. In all these higher portions of the Granby anticline the oldest rocks exposed at the surface are the sandy shales forming the local top of the marine Cretaceous. Thus the depth to the Dakota sandstone, which yields oil near Walden, Jackson County, Colo., would be approximately 5,000 feet—the assumed



GEOLOGIC MAP OF THE GRANBY ANTICLINE, GRAND COUNTY, COLORADO

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thickness of the Cretaceous formations that the drill would penetrate in order to reach the Dakota sandstone.

The gilsonite mined in sec. 14, T. 4 N., R. 77 W., lies directly in line with the axis of the Granby anticline, but the writer did not have an opportunity to trace the fold farther north than sec. 23, T. 3 N., R. 77 W., some 6 miles south of the mine. The gilsonite occurs in cracks and fissures in the andesitic grit near the base of the Middle Park formation, which dips 75° W. As shown on the map, the presence of an anticline is suggested 1½ miles southeast of the mine, but the writer did not have an opportunity to study the region on the east and learn whether the suggested anticline is closed by eastward-dipping sediments. However, it seems highly probable that the gilsonite represents an ancient oil seep from a fractured portion of the Granby anticline.

The structural relations of the rocks of the anticline are illustrated by the two structure sections on the geologic map. These sections and the map show several faults in a portion of the region. The faults, as well as the folds, near Granby trend nearly due north but are crossed by minor faults and folds striking about N. 80° E.

The pre-Cambrian crystalline rocks extend westward from the eastern edge of the Front Range to a point within 2 miles of Granby. Near the western border of the pre-Cambrian mass a few downfaulted wedges of Cretaceous sediments can be found, but in general the structural unity of the ancient crystalline rocks is well preserved.

A fault striking N. 10° E. limits the pre-Cambrian unit about 6 miles south of Granby, on Ninemile Creek, and brings biotite schist, Dakota sandstone, and Benton shale against the Middle Park formation. The Dakota formation to the east of the fault dips 43° W.; the Middle Park formation west of the fault dips about 20° S. The fault is concealed beneath the White River(?) beds to the north but probably passes under Granby. At Camp Ouray, 3 miles northeast of Granby, the pre-Cambrian is limited by a thrust fault striking about N. 40° W., which brings granite on the northeast against Cretaceous shale that dips toward the granite at about 25°. This fault passes into an overturned fold a mile southeast of Camp Ouray.

SUGGESTIONS FOR EXPLORATION FOR OIL AND GAS

The Granby anticline has not been penetrated by a drill, but its structural features and the probable character of the rocks involved in it appear to warrant its exploration for oil and gas. Such exploration should, however, be preceded, if possible, by more detailed geologic studies than the limited opportunities of the writer permitted him to make, though his reconnaissance studies appear to

have revealed all the salient geologic features. The higher portions of the anticline should be tested first. Although it is possible that beds of sandstone, 20 to 40 feet thick, near the middle of the Pierre shale may contain oil and gas at an estimated depth of 1,200 to 2,000 feet, it is more probable that any oil and gas that may be developed on the anticline will come from the Dakota sandstone, which is the chief oil-bearing formation near Walden, Jackson County, Colo. The estimated depth of the Dakota sandstone below the higher portions of the Granby anticline is about 5,000 feet.