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ART. XVI.—*The Appalachian Type of Folding in the White Mountain Range of Inyo County, California;* by CHARLES D. WALCOTT.

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THAT portion of the White Mountain range of California, to the structure of which I wish to call attention, is situated between the road passing from Big Pine, Inyo County, in Owen's valley, through Waucobi Canyon to Saline valley, and the crest of the ridge a little south of White Mountain peak. The length of this portion of the range is about forty miles. South of the Saline valley road the range has received the name of Inyo range, and is so named in all reports upon it. Each observer, however, states that he does not see any reason for applying the two names to the range, as the Inyo portion is the southern prolongation of the White Mountain range. On the latest map* published of this region the entire range from Owen's Lake to the California–Nevada line, is called the White Mountain range.

Prof. J. D. Whitney† makes reference to the Inyo and White Mountain ranges, stating that little is known of their geology, except that, from Bend City for twenty-five miles north, their western base and slopes seem to be composed of slates and other stratified rocks, generally dipping to the southwest and often much contorted. Mr. G. K. Gilbert‡ crossed

* Map accompanying the report of Dr. C. Hart Merriam on an expedition to Death Valley, compiled under the direction of A. H. Thompson, 1892.

† Geol. Surv. California, Geology., vol. i, 1865, p. 459.

‡ Expl. and Surv. west of the One Hundredth Meridian, vol. iii, Geol., 1875, pp. 34 and 169.

the range on the line of the present toll-road from Piper's Ranch to Big Pine. A sketch of the section he made shows a broad syncline on the western side, with faulting and folding in the central and eastern portions. He also gives a section of the rocks exposed on the east face of the Inyo range, at the pass between Deep Spring valley and Owen's valley.*

Mr. W. A. Goodyear, in his account of Inyo County,† notes the contorted condition of the strata, and also gives one sketch of the folding in the strata on the slope of White Mountain, north of Silver Canyon.

During the summer of 1894, accompained by Mr. F. B. Weeks, I crossed the range opposite Big Pine and penetrated into it from the western side, in Waucobi, Black and Silver Canyons, with the special purpose of determining the stratigraphic structure of the western side of the range, after ascertaining that the rocks were of Lower Cambrian age.

My first impression, when passing south through Owen's valley and looking at the west face of the range, was that, from a point twenty miles north of Bishop creek to Tollgate Canyon, the range was formed of a monocline of quartzites, argillites and limestone. The first trip into Tollgate Canyon disproved this, and furnished the data for the tentative conclusion that this portion of the range is a syncline of quartzite and limetones, very much broken by local folding and faulting. This conclusion was verified by the sections exposed in the sides of Black and Silver canyons. I shall first describe the succession of strata exposed on the western slope of the range, as the folding and faulting will thus be more readily understood. From the summit downward the section is as follows:

1.	Compact, thin-bedded, arenaceous argillite, with layers of dark-brown, fine-grained quartzite	200 ft.
2.	Alternating beds of limestone and calcareous and arenaceous shale; a massive bed of limestone, 100 feet thick, near the base	1,000 ft.
3.	Siliceous slate and compact, dark quartzite	2,000 ft.
4.	Siliceous limestone, usually in massive beds	1,700 ft.
	Base unknown.	

The limestone series of 2 and 4 are light-colored and contrast strongly with the dark quartzites, argillites and shales. This brings out the more prominent features of structure in bold relief when viewed from the higher points of the western spurs of the range.

* California State Mining Bureau. Eighth Annual Report State Mineralogist for 1888, p. 282.

† In this connection see article in February number on Lower Cambrian Rocks in Eastern California.

Silver Canyon penetrates deep into the range, and about four miles from its mouth cuts across a great synclinal fold. This is outlined in fig. C, page 173. A short distance above the mouth of the canyon the siliceous argillites, with the interbedded layers of quartzite, dip to the eastward about 20°. This dip increases until the beds are in places vertical. Usually at the bed of the canyon there is still a slight eastward dip. As the strata rise on the side of the canyon they become vertical, and finally, about three and one half miles from the mouth, they are overturned to the eastward so as to assume a westward dip and to produce a rough fan structure in the section between the mouth of the canyon and the limestones. The series of argillites and quartzites is broken by minor faults and closely compressed folds. The synclinal structure is clearly shown by the limestone series. The dip of the western limb of the syncline next to the quartzite is from 70° to 80° west. This increases to about 60° near the center of the syncline. The strata of the eastern limb dip westward at about 60° at a point nearest the center, and from that down to 40° near the quartzite.

The section of the syncline exposed on the north side of Silver Canyon is over 2,000 feet in depth, and when viewed from the high ridge on the south side of the canyon, is beautifully exhibited, both in the canyon and in its extension to the northward, along the western face of the range. Frequently the eastern limb of the limestone of the syncline rises to the summit of the range, but as a whole the upper limestone syncline rests against the western side of the range for twenty miles or more north of Silver Canyon.

At the mouth of Black Canyon the lower limestone (No. 4) is exposed. It dips eastward and passes beneath the quartzite (No. 3) at an angle of from 25° to 30°. A fault breaks the section along the line of the north fork of Black Canyon, but by following the section northward about two miles and viewing it from the high ridges to the south of Black Canyon, it is seen that the dip of the quartzites above the limestone increases to the vertical, and at the western edge of the syncline formed by the upper limestone the dip is to the westward.

The lower limestone, owing to the northward pitch of the syncline, passes beneath the Pleistocene beds on the margin of the valley, before reaching Silver Canyon. In fig. B, I have theoretically restored the synclinal section of the range so as to include the lower limestone. What comes out from beneath the limestone on the eastern side of the range is unknown to me, as I was unable to reach that portion of the section. Viewed from the distance, it is apparently a dark-colored rock,

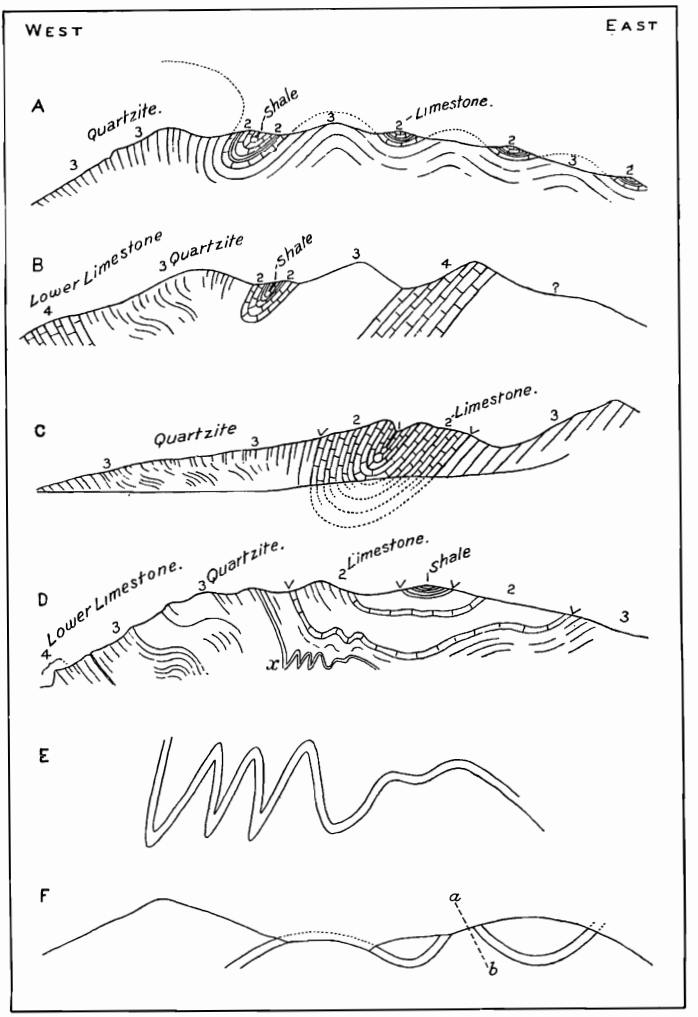
very much broken up and covered with massive granitic eruptives. This is on the line north of Silver Canyon. South of Silver Canyon about five miles, the section as viewed from the high ridge south of Tollgate Canyon is diagrammatically represented in fig. A. The quartzite of the western limb of the syncline is hidden by an intervening ridge, but the syncline of the upper limestone and the two minor synclines to the eastward are clearly defined. The most easterly, on the eastern slope of the range, was not seen at near view, but it appeared to be as represented in fig. A.

The east fork of Black Canyon cuts entirely through the quartzite (No. 3) and into the lower limestone. The syncline has flattened out, and its western limb is nowhere overturned to the eastward. The quartzite (No. 3) is much contorted and broken by minor faults. This is most noticeable about midway of the section and also within a few hundred feet of the upper limestone, where there is a series of sharp anticlinal and synclinal folds, as shown in fig. D, as well as in the enlarged view, fig. E. The depth of these minor synclines is about 300 feet. They appear to have been formed largely by the slipping and compression of a series of argillaceous and thin-bedded quartzites that are between the upper limestone and other portions of the quartzite series. The upper limestones form a broad, somewhat shallow, irregular syncline, upon which, at the summit, rest about 200 feet of arenaceous shales and thin, interbedded quartzites. This shallow syncline extends southward to Tollgate Canyon, where it is much broken, as shown in the sketch made by Mr. Gilbert.* South of Tollgate Canyon there appears to be a broad, broken syncline, with the upper limestone (No. 2) at the summit.

Viewing the White Mountain range from the western slope of the Sierra Nevada, north of Big Pine, it is evident that several transverse or oblique faults break the syncline that rests on the western slope of the range. The strata are displaced on the south side of Black Canyon, and also about five miles to the north. About twenty miles north of Silver Canyon the sedimentary strata are more broken and are apparently covered by eruptive rocks that form the higher portions of the range near White Mountain peak.

The only point that I visited on the eastern side of the range was the section exposed on the northern and western side of Deep Spring valley. On the northern side eruptive granites conceal the greater portion of the sedimentary rocks, but on the western side, nearly southwest of Antelope Spring, are some very fine illustrations of open anticlinal and synclinal folding. This is shown by fig. F.

* Loc. cit.



DESCRIPTION OF FIGURES.

FIG. A.—Diagrammatic section of the White Mountain range as viewed from the high ridge south of Tollgate Canyon. 2, upper limestone; 3, quartzite and shale series.

FIG. B.—Theoretical section of range south of Silver Canyon, to illustrate character of syncline. 2, upper limestone; 3, quartzite and shale series; 4, lower limestone.

FIG. C.—Syncline on the north side of Silver Canyon. 1, upper shale; 2, upper limestone; 3, quartzite and shale series.

FIG. D.—Section on the east fork of Black Canyon. 1, upper shale; 2, limestone; 3, quartzite series; 4, upper portion of the lower limestone.

FIG. E.—Anticlinal and synclinal folds occurring at *x* in fig. D.

FIG. F.—Outline of folding of limestone imbedded in quartzite and shales, western side of Deep Spring valley. *a–b*, fault.

As seen from the western slopes of the White Mountain range, the next range to the eastward, Silver Peak, is apparently a monocline facing westward ; but from the known structure of the Great Basin ranges, such as those of the Eureka district, Nevada, the Oquirr range, Utah, and others illustrated by the geologists of the Wheeler Survey, it appears that in the broad Paleozoic area between the Sierra Nevada on the west and the early Paleozoic shoreline on the east (Colorado) a period of folding and thrust faulting was followed by a period of vertical faulting, which displaced the strata that had been folded and faulted in the preceding epoch. The extent and character of this disturbance can be determined only by a careful study of each of the mountain ranges for a distance of over five hundred miles east and west and probably a thousand miles north and south; and the great geologic problems will not be fully solved until the areal geology of the region between the 109th and 119th meridians shall have been mapped.