[American Journal of Science, Vol. 249, June, 1951, Pp. 439-443]

CRETACEOUS GLASSY WELDED TUFFS — LEWIS AND CLARK COUNTY, MONTANA

JULIAN D. BARKSDALE

ABSTRACT. Glassy rocks of Cretaceous age that megascopically would be classified as pitchstone porphyries are shown to be welded tuffs. The use of the terms *welded tuff* and *ignimbrite* is discussed.

INTRODUCTION

WHILE examining volcanic rocks in a large quarry, approximately one mile south of Wolf Creek and 35 miles north of Helena, Montana, on U. S. Highway 91, Professor Adolph Knopf in 1947 collected specimens of black glass which he identified in thin section as welded tuff or ignimbrite.

Professor Knopf, Mrs. Knopf, and the writer visited the locality in 1949, and the specimens on which this study is based were then collected.

The writer, who is studying welded tuffs from western Nevada, wishes to thank Professor and Mrs. Knopf for pointing out the Montana locality and for encouraging his recording of it. Thanks are also due to Mr. William Boulton for the photomicrographic work.

GEOLOGIC OCCURRENCE

Volcanic rocks which include the glassy welded tuff crop out in a belt about 2 miles wide, extending northwest and southeast of Wolf Creek, Montana, and are part of a group named by Lyons (1944, pp. 449, 459) the *Adel Mountain volcanics*. He describes them generally as

> ". . . . trachybasalt and basalt agglomerate, conglomerates and flows with numerous intrusives, analcime and augite trachybasalts in upper measures; contains plant fossils in upper conglomerates . . . ."

The thickness of the section is approximately 3,200 feet.

The southwestern boundary of the volcanics in this area is a mechanical one. A well-exposed thrust fault, striking N 35° W and dipping 20° to the south brings thinly bedded argillites of the late Precambrian Belt series over Adel Mountain volcanic rocks of Cretaceous age. The fault is probably the northern continuation of the Eldorado overthrust,

regarded by Pardee (1933, p. 130) as a subsidiary slice of the Lewis overthrust.

The glassy welded tuffs, which range in specific gravity from 2.33 to 2.355, occur in a layer from 5 to 6 feet thick, and are best exposed in a large quarry which lies several hundred feet below the projected fault surface. The rock in question has a conchoidal fracture and the luster of black pitchstone. There are small dull non-vitreous patches mottling some of the joint blocks of glass. In others, part of blocks several feet across show at first glance no glassy luster, but on closer examination sufficient unaltered glass can be found to identify the layer and permit its being traced across the quarry for several hundred feet. Fracturing and shearing below the thrust and irregular distribution of devitrification make megascopic distinction between the tuff and flow rocks impractical except where large artificial cuts have been made.

MICROSCOPIC DESCRIPTION

Thin sections of both the glassy and the dull black, apparently aphanitic, rocks were studied. Figure 1 of plate 1 is a photomicrograph of the former and figure 2 of the latter.

Both rocks are clearly seen to be of fragmental origin. Crystals and fragments of fresh labradorite (zoned An 59 to An 44), apatite, and magnetite together with rare fragments of very fine-grained porphyritic flow rocks, a few turbid brown outlines of altered ferromagnesian minerals, augite, hornblende, hypersthene, and a few fragments of secondary (?) epidote are embedded in a very compact matrix of bent and flattened, elongate fragments of glass, the index of which is >1.50, <1.505. This is the index of potash-rich glass, but no orthoclase or sanidine occurs in the slides examined. Most of the glass fragments have clear colorless rims surrounding amber to dark brown glass centers similar to fragments in the Yellowstone tuffs or collapsed pumice described

---

PLATE 1

Fig. 1. Glassy welded tuff showing linear arrangement of fragments. Note bending of fragments around labradorite crystal. Near Wolf Creek, Montana.

Fig. 2. Partly devitrified welded tuff showing characteristic bending of fragments around crystals of labradorite. Near Wolf Creek, Montana.

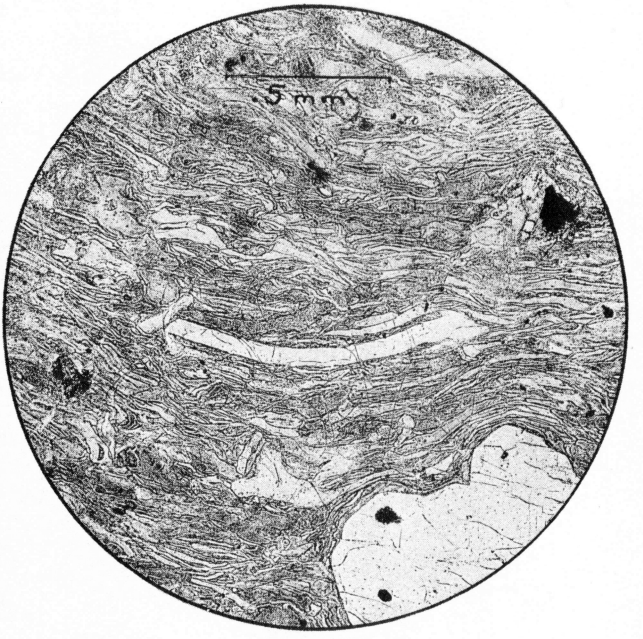

FIGURE 1

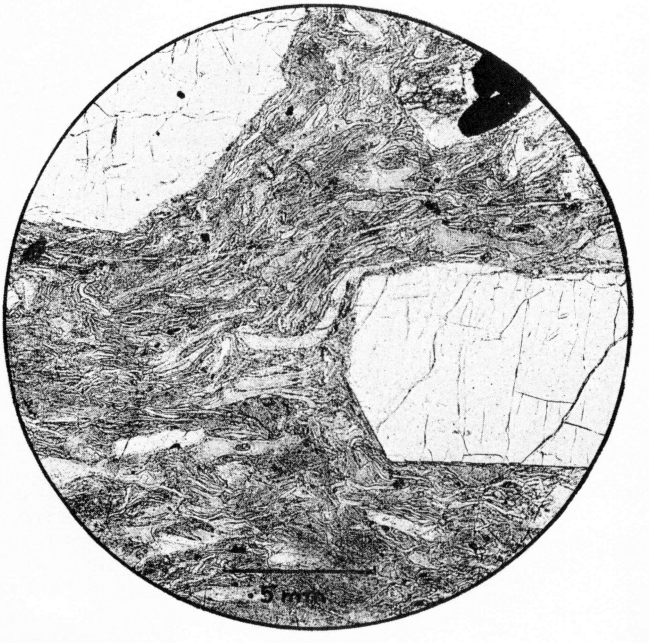

FIGURE 2

by Iddings (1899, pp. 404-406; 1909, pp. 331-332). Mansfield and Ross (1935, p. 317) noted similar occurrences in southeastern Idaho, and the writer has found the same type of occurrence in the welded tuffs in western Nevada. Some of the larger fragments are colorless throughout as illustrated by the large bent fragment in the center of plate 1, figure 1.

The glass fragments are molded around the solid feldspar crystal without breaking. This is taken as evidence that the fragments of glass were welded while still hot and viscous to form a solid rock. The curved cracks in the section have a perlitic pattern; individual glass fragments show no lateral displacement along these cracks.

There is no discernible devitrification of the glass fragments in the rocks illustrated by plate 1, figure 1, except along the perlitic cracks. Birefringence along the cracks causes the perlitic pattern to show up better under crossed nicols than in plain light. The dull aphanitic-appearing rock (plate 1, fig. 2), is essentially glass; but it has begun to devitrify since there is a faint birefringence in the finest particles and dustlike filling between the larger glass fragments. The perlitic cracking of this rock is also made noticeable by faintly birefringent outlines.

NOMENCLATURE AND AGE OF THE WELDED TUFFS

The rocks described are doubly interesting in that first they are true welded tuffs formed as Iddings (1909, p. 331-2) said

> ". . . . when exploded fragments of molten magma, large and small, fall together in a still heated condition . . . . they may be plastic enough to weld together into a more or less compact coherent mass."

The term *ignimbrite* was proposed by Marshall (1935, p. 323)

> ". . . . for rocks thought to have been deposited from immense clouds of showers of intensely heated but generally minute fragments of volcanic magma. The temperature of these fragments is thought to have been so high that they were viscous and adhered together after they reached the ground."

Marshall (p. 323) further qualifies the term in that ignimbrite is regarded as formed by an eruptive process similar in nature to that described by Fenner (1925, p. 198) at Katmai in the Valley of Ten Thousand Smokes, Alaska.

The term *ignimbrite* has not been generally used. Fenner (1948, p. 882-883) points out that deposits resulting from volcanic action similar to the Katmaian tuff-flow type are of several kinds. No one name will suffice.

Fenner (1948, p. 883), following the original usage of Iddings, would apply the term *welded tuff* to those deposits in which the heat of the accumulated mass is so high after emplacement that pumice inclusions collapse and the small fragments or shards of glass of the matrix become softened and are pressed down and aligned by the weight of the material above them to form a rock which megascopically may appear like a felsitic rhyolite or even a structureless obsidian. For those in which induration is primarily the result of recrystallization, and for those in which the fragments have little cohesion, another term is desirable. Fenner (1948, p. 883) has described such tuffs from the vicinity of Arequipa, Peru, using for them the local term *sillar*.

Secondly, a large proportion of the Wolf Creek welded tuffs have not been devitrified although they are of late Upper Cretaceous age. The basis for the age determination is a collection of fossil plants made by Lyons from conglomerates in the upper part of the Adel Mountain volcanics one mile north of Craig, Montana, and determined by Erling Dorf as indicating late Upper Cretaceous, probably Montana age (Lyons, 1944, p. 465).

Previously described occurrences of glassy welded tuffs—Iddings (1899, 1909), Fenner (1923), Mansfield and Ross (1935), Marshall (1935), Gilbert (1938), Williams (1942), Wilkinson (1950)—are all mid-Tertiary or younger in age. The oldest previously reported glassy welded tuffs are those described by Mackin and Nelson (1950) from the Iron Springs district of Utah. These rest conformably upon Pink Cliffs Wasatch (Eocene) sediments and have Wasatch-type sediments interbedded in the upper part of the volcanic sequence.

The undevitrified glass of the welded tuffs of the Adel Mountain volcanics of late Upper Cretaceous age is thought to be the oldest of its type so far recorded.

References

Fenner, C. N., 1923. The origin and mode of emplacement of the great tuff deposit of the Valley of Ten Thousand Smokes: Nat. Geog. Soc. Contr. Tech Papers, no. 1, pp. 1-74.

———, 1925. Earth movements accompanying the Katmai eruption. II: Jour. Geology, vol. 33, pp. 193-233.

———, 1948. Incandescent tuff flows in southern Peru: Geol. Soc. America Bull., vol. 59, pp. 879-893.

Gilbert, C. M., 1938. Welded tuff in eastern California: Geol. Soc. America Bull., vol. 49, pp. 1829-1862.

Iddings, J. P., 1899. Geology of the Yellowstone National Park: U. S. Geol. Survey Mon. 32.

———, 1909. Igneous rocks, vol. 1, New York.

Lyons, J. B., 1944. Igneous rocks of the northern Big Belt Range, Montana: Geol. Soc. America Bull., vol. 55, pp. 445-472.

Mackin, J. H., and Nelson, W. H., 1950. Early Tertiary welded tuffs in the Iron Springs District, Utah. Presented at April meeting, Cordilleran Section, Geol. Soc. America (Abstract).

Mansfield, G. R., and Ross, C. S., 1935. Welded rhyolitic tuffs in southeastern Idaho: Am. Geophys. Union Trans., 16th Ann. Meeting, part 1, pp. 308-321.

Marshall, P., 1935. Acid rocks of the Taupo-Rotorua volcanic district: Roy. Soc. New Zealand Trans. and Proc., vol. 64, pp. 323-366.

Pardee, J. T., and Schrader, F. C., 1933. Metalliferous deposits of the Greater Helena mining region, Montana: U. S. Geol. Survey Bull. 842.

Wilkinson, W. D., 1950. Welded tuff member of the Rattlesnake formation. Presented at April meeting, Cordilleran Section, Geol. Soc. America (Abstract).

Williams, Howel, 1942. The geology of Crater Lake National Park, Oregon. Carnegie Inst. Washington Pub. 540.

University of Washington
Seattle, Washington