GL01976

UNIVERSITY OF UTAH
RESEARCH INSTITUTE
EARTH SCIENCE LAB.

A WELDED-TUFF DIKE IN SOUTHERN NEVADA

By P. W. LIPMAN, Denver, Colo.

Work done in cooperation with the U.S. Atomic Energy Commission

Abstract.—A small welded-tuff dike in an ash-flow sheet is thought to represent an underlying nonwelded tuff that was remobilized and intruded into a dilatant tensional fracture in the still-hot sheet.

During mapping of the 7½-minute Thirsty Canyon SE quadrangle in southern Nevada, a small tuff dike with welded pyroclastic textures was observed in intrusive contact with ash-flow tuff wallrock. Although a relatively minor feature, this dike is significant because pyroclastic intrusives, despite relatively widespread occurrence, rarely show compaction or welding features and are not known to occur within ash-flow sheets as feeders (Smith, 1960a, p. 817–818). A welded-tuff dike might readily be interpreted as a fissure vent, but in the present occurrence, substantial evidence favors an alternative interpretation—that the dike is part of a stratigraphically lower ash-flow tuff that was emplaced upward into hot dilatantly fractured volcanic country rock. Such an origin would be analogous to formation of clastic sandstone dikes.

The dike occurs at lat 37°02′15″ N., long 116°35′12″ W. (about 15 miles northeast of Beatty, Nev., at the Nevada Test Site), in a talus block near the contact between two petrologically distinct cooling units [1] of ash-flow tuff of the Rainier Mesa Member of the Piapi Canyon Formation (Pliocene or younger) (Poole and McKeown, 1962). The lower cooling unit of the Rainer Mesa Member is nonwelded to partly welded near the dike locality and contains 20 to 30 percent phenocrysts (varying mainly with degree of welding). The dominant phenocrysts are alkali feldspar and quartz, with minor plagioclase. Biotite forms 1 percent or less of the phenocrysts, and clinopyroxene is very scarce (absent in most thin sections). The upper cooling unit, eroded at its top, is densely welded to its base at the dike

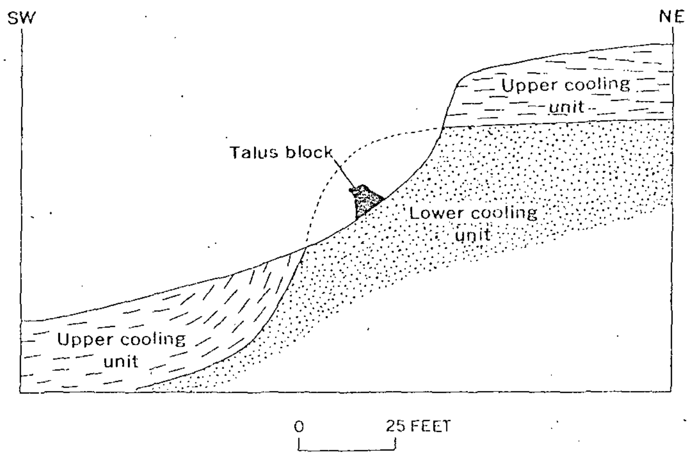

FIGURE 1.—Sketched cross section, showing relations between lower cooling unit and upper cooling unit of the Rainier Mesa Member, and location of talus block containing the dike. Patterning of upper cooling unit indicates approximate orientation of eutaxitic foliation.

locality and averages about 35 percent phenocrysts. Its phenocryst proportions contrast strikingly with those of the lower cooling unit—plagioclase is almost twice as abundant as quartz, biotite averages 4 to 5 percent of the phenocrysts, and augite is fairly abundant.

The upper cooling unit overlies the lower cooling unit unconformably, but the surface of uncomfority is barely discordant in most places. In a few places, including the dike locality, the upper cooling unit was deposited on an irregular surface of several hundred feet of relief eroded on the lower cooling unit. Zones of welding in the lower cooling unit are truncated, and the compaction foliation of the upper unit dips at high angles, locally approaching vertical. The structural relations between the two cooling units at the dike locality are shown in figure 1.

[1] Terminology of ash-flow tuffs as used by Smith (1960a, 1960b).

The dike is nowhere exposed in place. The talus block in which it occurs is about 5 feet across and lies about 20 feet below the base of the upper cooling unit (fig. 1). Despite the detrital nature of this block, the original position of the dike can be closely determined because of certain zonal welding and crystallization changes in the upper cooling unit. Both the wallrock of the dike and the lithologically similar basal part of the upper cooling unit are dark gray because of the presence of abundant microlites of magnetite. Since the upper cooling unit changes color and becomes red brown about 10 feet above its base because of oxidation of the magnetite microlites to hematite, the block containing the dike must have come from within a few feet of the contact between the upper and lower cooling units.

The dike is red brown, in contrast to the dark-gray wallrock; it has generally planar parallel contacts and averages about 16 inches in width (fig. 2). Its exposed length is about 4 feet. It truncates the well-developed eutaxitic foliation of its country rock at about 65° and contains a lenticular inclusion of the country rock oriented parallel to the walls of the dike. The eutaxitic foliation of the inclusion is at an angle of about 25° to foliation in the wallrock, indicating rotation of the inclusion during emplacement of the dike. This inclusion shows that the dike was emplaced after welding of the upper cooling unit. The pyroclastic texture of the dike is obscure in outcrop, but is evident in thin section (fig. 3). Pumice lapilli are thoroughly compacted and are parallel to sides of the dike at a large angle to foliation in the wallrock.

Petrographically the dike closely resembles tuff of the lower cooling unit of the Rainier Mesa Member, except that it shows a greater degree of welding. The proportions of major and minor phenocrysts are strikingly similar. As in the lower cooling unit, the phenocrysts in the dike are mainly alkali feldspar and quartz, with little plagioclase; only about 1 percent of biotite is present, and clinopyroxene is absent. Figure 4,

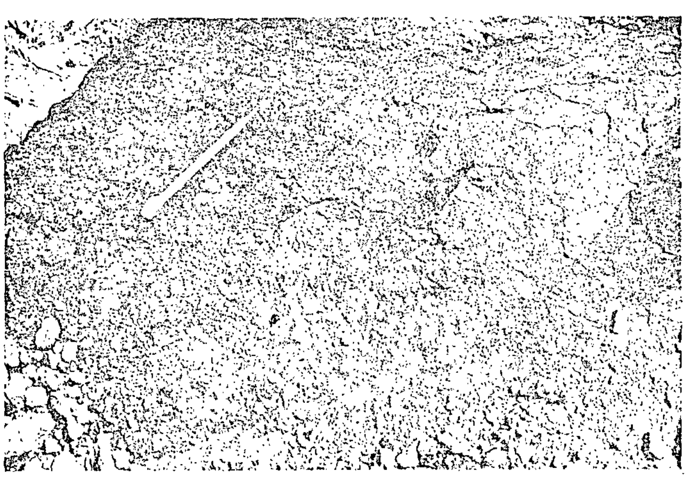

FIGURE 2.—Welded-tuff dike cutting upper cooling unit of the Rainier Mesa Member. Dark inclusions in center of dike are recognizable wallrock. Pencil on wallrock shows scale.

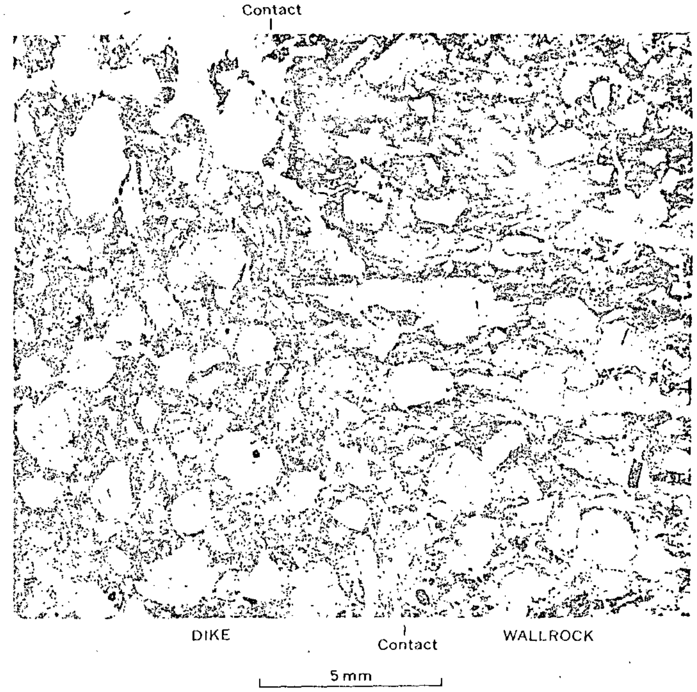

FIGURE 3.—Photomicrograph showing truncation of wallrock foliation by eutaxitic foliation of dike.

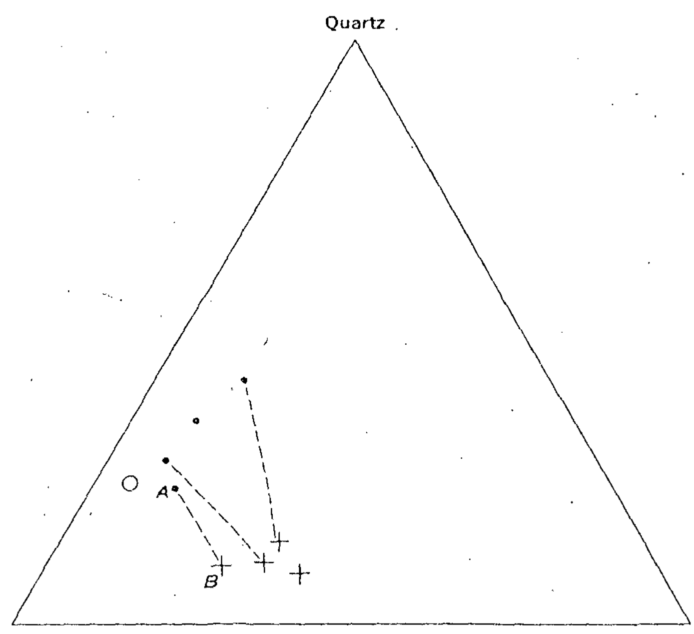

FIGURE 4.—Triangular diagram showing variations in proportions of quartz and feldspar phenocrysts in the dike (open circle), the lower cooling unit (dots), and the upper cooling unit (crosses) of the Rainier Mesa Member. Dashed lines are tie lines connecting samples from the same vertical section.

based on modal counts of 1,400 to 2,000 points in single thin sections, shows proportions of feldspar and quartz, which together account for most of the phenocrysts in both ash-flow and dike rocks. All samples of the Rainier Mesa Member were collected within 1 mile of the dike locality and either within a few feet above the base of the upper cooling unit or within a few feet below the uppermost exposures of the lower cooling unit. Samples *A* and *B* are from an outcrop immediately above the dike locality. The compositional range of the lower cooling unit is greater than that of the upper, probably because irregular erosion of its top has led to sampling of different despositional levels within the cooling unit. In contrast, all samples of the upper cooling unit should be from the same depositional level, and the spread of points for these samples in figure 4 probably represents the expectable degree of scatter from sampling and counting inaccuracies.

The petrologic similarity of the dike to the lower cooling unit and the structural position of the dike only a few feet above the contact between cooling units strongly suggest that the dike was formed by secondary mobilization of tuff from the lower cooling unit and that it is not a primary igneous feature. By this hypothesis the heat for welding ("fusion") of the dike would have come from the wallrock, and intrusion of the dike would have immediately followed emplacement and welding of the upper cooling unit. Perhaps a tensional fracture developed in the upper cooling unit as a result of small-scale flowage during welding and compaction on a slope and provided structural control for intrusion of the dike. The nonwelded tuff of the lower cooling unit then would have been mobilized by the pressure potential arising from dilatant fracturing, perhaps assisted by expansion and volatilization of interstitial water heated by the overlying ash-flow sheet. A similar mechanism of emplacement has been deduced by Walton and O'Sullivan (1950) for a clastic sandstone dike that was injected into a hot dolerite sill.

REFERENCES

Poole, F. G., and McKeown, F. A., 1962, Oak Spring Group of the Nevada Test Site and vicinity, Nevada: Art. 80 *in* U.S. Geol. Survey Prof. Paper 450–C, p. C60–C62.

Smith, R. L., 1960a, Ash flows. A review: Geol. Soc. America Bull., v. 71, p. 795–842.

Smith, R. L., 1960b, Zones and zonal variations in welded ash flows: U.S. Geol. Survey Prof. Paper 354–F, p. 149–159. [1961]

Walton, M. S., Jr., and O'Sullivan, R. B., 1950, The intrusive mechanics of a clastic dike: Am. Jour. Sci., v. 248, p. 1–22.