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EVIDENCE OF FORMER HIGHER TEMPERATURES FROM ALTERATION MINERALS, BOSTIC 1-A WELL, MOUNTAIN HOME, IDAHO

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ABSTRACT

Cuttings from the silicic volcanics in the Bostic 1-A well near Mountain Home, Idaho have been examined petrographically with the assistance of x-ray diffraction and electron microprobe analyses. Our results indicate that these rocks have been subjected to much higher temperatures than were observed in the well in 1974, when a static temperature log was run. It is not known to what extent the alteration may be due to greater depth of burial in the past, or whether it resulted from an early hydrothermal system of higher temperature than the one now observed.

INTRODUCTION

The Bostic 1-A well near Mountain Home, Idaho (S25, T4S, R8E) (Fig. 1) was originally drilled to 9676 ft as an oil and gas wildcat by Al Griffith in 1973. In 1974 Gulf Mineral Resources Co. took over the well as a geothermal prospect and ran additional logs. In 1978 the well was acquired by Union Oil Co., who attempted to clean it out. It was plugged and abandoned in October 1978.

The Bostic 1-A first came to our attention in 1977 when it was proposed as a site for the Los Alamos Geothermal Well Stimulation Program. At that time it was reported to have bottomed in Mesozoic granite of the Idaho Batholith with a bottom hole temperature of 195°C and no fluid production.

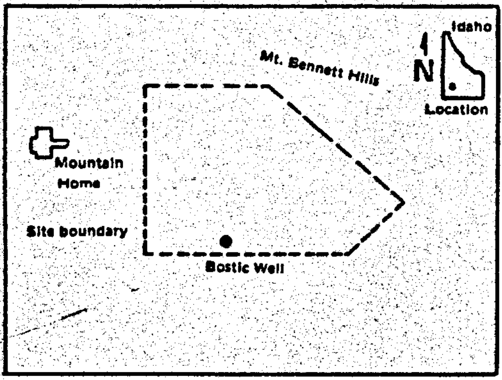

Figure 1. Map showing location of Bostic 1-A well in Idaho.

When the area east of Mountain Home, Idaho was selected for further study as a potential hot dry rock (HDR) geothermal site, a study of the Bostic 1-A cuttings was begun. It was then discovered that the well in fact bottomed in silicic volcanics of the Idavada Formation instead of granite. Believing that Idaho Batholith lay beneath the silicic volcanics, as indeed it does just north of the HDR prospect (Malde et al., 1963), a more detailed study of the volcanic stratigraphy in the well and in the Mt. Bennett Hills was performed to allow an estimate of depth to granite (Gardner and Wood, in preparation; Arney et al., in preparation). Subsequent gravity modeling, however, suggests that no granite lies beneath the volcanics at the Bostic location. Rocks beneath the bottom of the Bostic 1-A well are basalts approximately 3 km thick, probably associated with the opening of the Snake River Plain (Arney et al., 1981).

IDAVADA VOLCANIC ROCKS IN THE BOSTIC 1-A

Silicic volcanics are first intercepted at a depth of 7150 ft (Fig. 2). Unlike Idavada Formation exposed in the Mt. Bennett Hills to the north (Malde et al., 1963; Gardner and Wood, in preparation), the siilicic volcanic sequence in the Bostic 1-A is interrupted by several basaltic intervals (Fig. 3). The thinner basalt intervals are very fresh, and are interpreted as dikes cutting the Idavada. The basalt units greater than 40 ft thick are more altered, contain abundant zeolites both as amygdale and fracture fillings, and are interpreted as interbedded flows. Some have oxidized tops and/or bottoms.

ALTERATION OF THE IDAVADA

The silicic volcanics are mostly very altered, with little of the original mineralogy remaining. Identification as Idavada is made on the basis of chlorite pseudomorphs after olivine and pyroxene, in which the original crystal morphology is well preserved. Idavada Volcanics as described by Malde et al. (1963) contain phenocrysts of andesine, clinopyroxene, hypersthene, and magnetite. Subsequent work by Gardner and

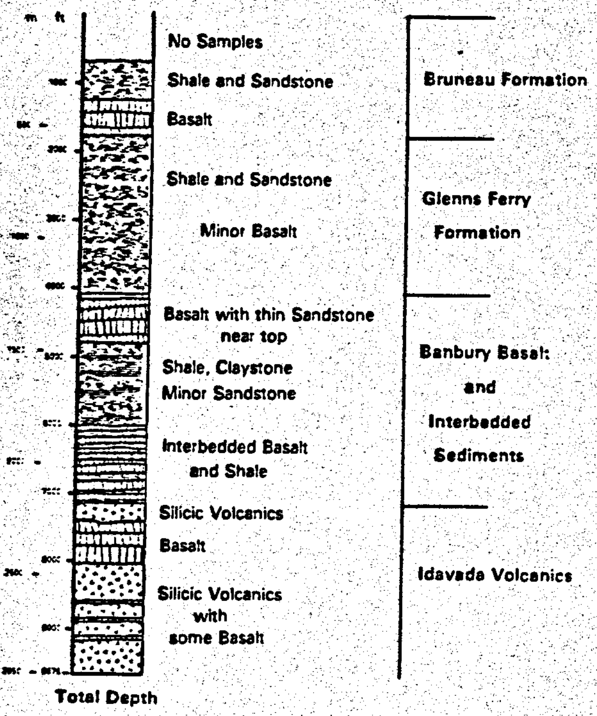

Figure 2. Bostic 1-A lithology log.

Wood (in preparation, 1982) has shown that the Idavada Volcanics in the Mt. Bennett Hills also contain olivine. The older Challis Volcanics are distinguished by the presence of biotite and/or hornblende (Malde et al., 1963). The cuttings from the Bostic 1-A contain no biotite or hornblende or psuedomorphs of these minerals.

Alteration of the silicic volcanics increases dramatically with depth. The uppermost silicic interval (from 7150-7420 ft)* contains saussuritized plagioclase, chlorite after pyroxene, sphene, and trace zircon. No potassium feldspar phenocrysts remain which can be analyzed by microprobe, but the orthoclase peaks are significant on the x-ray diffraction (XRD) patterns. Euhedral quartz phenocrysts are present in small amounts throughout the silicic interval. At this upper interval magnetite still survives and pyrite is not observed. Calcite occurs as vein fillings and partial replacement of plagioclase. Laumontite occurs primarily as fracture fillings. Analcime appears in the cuttings as euhedral crystals and in minor amounts on the XRD patterns.

The next silicic interval begins at 8170 ft, beneath a thick basalt and sedimentary sequence, and extends to 8440 ft. The plagioclase is almost completely recrystallized to albite plus calcite. Chlorite replaces pyroxene phenocrysts and occurs in the groundmass. Orthoclase is sufficiently preserved to be analyzed by microprobe. Small amounts of sphene are present. Magnetite still survives but is rounded. Pyrite is not observed. Druzy chartreuse crystals believed to be epidote first appear at 8410 ft. Laumontite peaks are much more prominent on the XRD pattern and analcime appears in trace amounts.

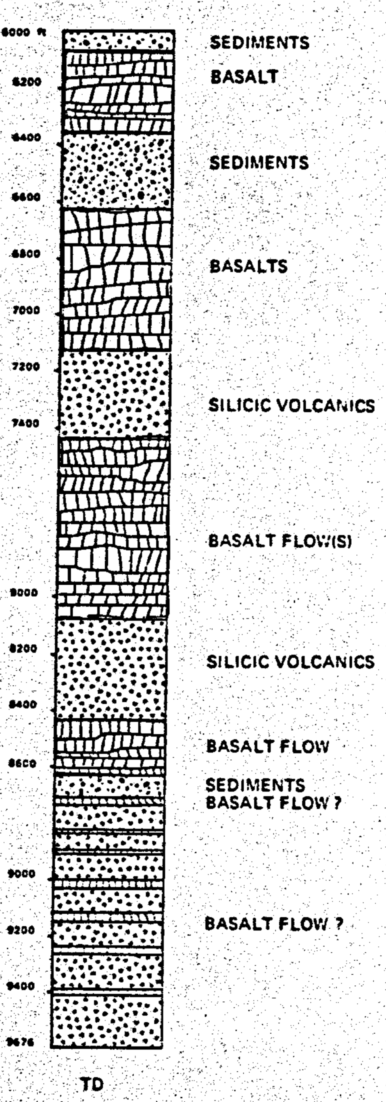

Figure 3. Detail of volcanic sequence below 6000 ft in Bostic 1-A.

The next silicic interval occurs from 8673 to 8710 ft between two basalt and sediment sequences and is highly altered. Pyrite first appears at 8700 ft as euhedral crystals up to 0.25 mm diameter.

Beneath a thin basaltic and sedimentary sequence silicic volcanics occur again from 8750 to 9080 ft and are interrupted by three thin basaltic intervals interpreted as dikes, and possibly a thin sedimentary layer. This silicified sequence is characterized by complete replacement of plagioclase by albite plus calcite. Calcite and chlorite patches permeate the groundmass, and calcite fills fractures. Orthoclase decreases on the x-ray pattern and is not distinguishable in thin section. Anorthoclase

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*Cuttings depths are not corrected for lag.

appears at 8970 ft in the thin section along with two chlorite compositions reflecting the two original pyroxene compositions. Magnetite nearly disappears in this interval. Pyrite occurs as finely disseminated euhedral crystals increasing in abundance with depth. Epidote occurs as fine chartreuse coatings, especially toward the base of the interval.

There is a thin silicic interval from 9150 to 9220 ft which contains minor disseminated pyrite and abundant terminated quartz and epidote crystals coating surfaces and filling veins.

The final silicic sequence intercepted by the well extends from 9260 ft to TD at 9676 ft and is interrupted by a thin basalt interpreted to be a dike. The interval from 9400 to 9460 ft may be more intermediate in composition. In this final sequence chlorite is everywhere: after pyroxene, in cracks, and in the groundmass. There is no more calcite replacement of plagioclase or groundmass. Epidote appears as patches in the groundmass and in feldspar phenocrysts and as fracture fillings. Magnetite is completely altered. Pyrite occurs as finely disseminated crystals. Quartz occurs as fracture fillings, both in microfractures and as crystals up to 2 mm long.

DISCUSSION OF TEMPERATURE

A static temperature log run by Agnew and Sweet for Gulf in August, 1974 shows a nearly linear gradient and a bottom hole temperature at 8898 ft of 188.7°C (Fig. 4). Extrapolating the gradient to 9676 ft gives a temperature of 393°F or 200.5°C.

Secondary mineral assemblages in the cuttings suggest that the silicic volcanics in the well have seen significantly higher temperatures than those indicated by the static temperature survey. Alteration of the plagioclase to albite plus calcite is nearly complete by 8170 ft (176.6°C on survey). In silicic volcanics in the geothermal fields of New Zealand albite replaces andesine only at temperatures over 230°C (Browne and Ellis, 1970). Laumontite disappears below 8270 ft, but wairakite, which is the high temperature zeolite found in Wairakei, New Zealand, and Onikobe, Japan (Miyashiro, 1973) is not seen in any of the XRD patterns.

In the sedimentary rocks of Cerro Prieto, epidote forms at 230 to 250°C and is usually accompanied by wairakite (Elders et al., 1979). In silicic volcanics in New Zealand, epidote does not form below 250° at Wairakei and not below 260°C at Ohaki (Browne and Ellis, 1970). It first appears in the Bostic 1-A cuttings at 8410 ft (181°C on the temperature survey), though it does not form distinct peaks on the XRD until 9420 ft.

Though it is not possible to put an exact temperature on the alteration at the bottom of the well because of unknown pressure and fluid composition at the time, it seems reasonable to conclude that the temperature was once at least 250°C and probably 300°C. How much of the increased temperature was a result of greater depth of burial at the time, and how much can be attributed to a hotter hydrothermal system is unknown. Some idea of the age of the thermal event could possibly be obtained by dating the fresher basalts which are found in the Idavada sequence. It is not believed they were the direct cause of the alteration, as it does not seem more intense adjacent to the inferred dikes. They appear to have been emplaced after the main thermal event. A study of alteration in the basalts is planned.

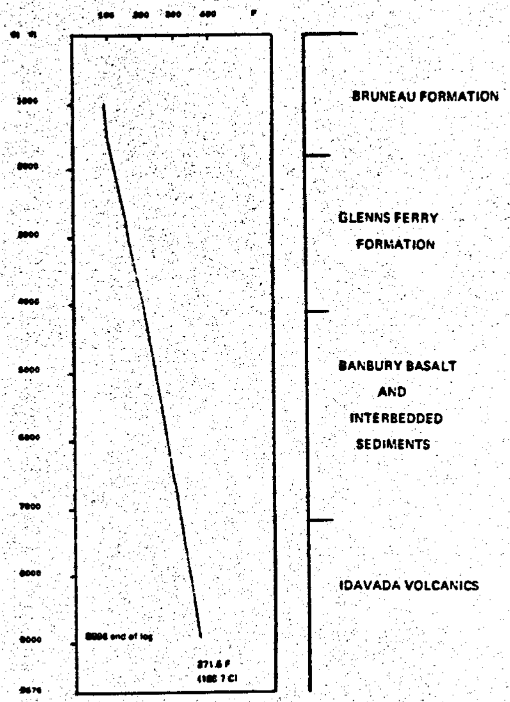

Figure 4. Static temperature survey of Bostic 1-A (August 15, 1974).

SUMMARY

The top of the silicic volcanics in the Bostic 1-A well shows fairly advanced replacement of andesine by albite plus calcite, chlorite replacement of pyroxene, and minor amounts of laumontite and analcime. Laumontite increases then disappears below 8270 ft. Pyrite appears at 8700 ft. Saussuritization of plagioclase is complete by 8750 ft. Epidote first appears at 8410 ft and is fairly abundant by 9220 ft. The alteration assemblage at the bottom of the well is chlorite-epidote-quartz-albite, typical of greenschist metamorphism.

CONCLUSIONS

The albite-epidote-quartz-chlorite assemblage in the silicic volcanics at the bottom of the Bostic 1-A well suggest temperatures significantly higher than the 200°C measured in 1974. Both silicic volcanics and intercalated basalt flows show progressive alteration with depth but thinner basalt units interpreted as dikes appear much fresher. Presumably the highest thermal pulse had passed before the intrusion of these dikes. Alteration of the basalt intervals will be examined to verify this conclusion.

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