SCALE 1:5000
CONTOUR INTERVAL 40 FEET DATUM IS MEAN SEA LEVEL

USGS
U.S. GEOLOGICAL SURVEY
L. A. GARDNER
UC-66a
Issued: December 1980

GEOLOGIC MAP OF THE SULPHUR SPRINGS AREA, VALLES CALDERA GEOTHERMAL SYSTEM, NEW MEXICO

by
Fraser E. Goff and Jamie N. Gardner
1980

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

DISCUSSION

Sulphur Springs is the most active and extensive hot spring system that discharges within Valles Caldera, New Mexico, and is the only vapor-dominated system known in the southwestern United States. Small volume acid springs, mud pots, and gas vents issue within an area of about 1/4 km² and similar, but less extensive, features evolve from nearby canyons. Springs and fumaroles of the type found at Sulphur Springs usually denote the presence of a vapor-dominated geothermal reservoir (White et al., 1971; Woodsworth, 1974). Possibly, the Sulphur Springs area overlies a high temperature hot water geothermal reservoir similar to the one being explored by Union Oil Company several kilometers to the east. We have prepared this map to provide a geologic base for detailed study of structural controls, fluid chemistry, and alteration mineral assemblages in this small vapor-dominated system.

Geologic and Tectonic Setting: Valles Caldera is a 1.1 Myr old silicic volcano that formed during catastrophic eruption of over 300 km³ of dacite tuff (Smith and Bailey, 1966; Bailey et al., 1969; Smith et al., 1970). These large-scale ignimbrite eruptions represent the major culminating phase of evolution of the present Jemez Mountains volcanic fields. After formation of the caldera, a resurgent structural dome bulged about 1000 m above the caldera floor to form Redondo Peak. Bulding of the structural dome was followed by eruption of a series of rhyolites (1.0-0.1 Myr) in the east area between the resurgent dome and caldera walls (Doell et al., 1966).

Valles Caldera and its east rhyolites overlie earlier extensive volcanic sequences of the Jemez Mountains, the Tschicoma Formation (7-3 Myr) consisting of latite and dacite domes to the north and east of the caldera, and Paliza Canyon Formation (10-0 Myr) consisting primarily of andesites to the south of the caldera (Bailey et al., 1969). The lateral extent and thickness of these formations directly beneath the caldera is somewhat speculative, and is only now being resolved by deep exploration drilling by Union Oil Company (Siodowski, 1970).

The Jemez Mountains lie at the intersection of the tectonically active Rio Grande rift and the volcanically active Jemez Lineament (Chapin, 1974). The Jemez fault zone, which trends northeast toward Valles Caldera, is a surface tectonic expression of the Jemez Lineament, and is the westernmost rift fault in the area (Goff et al., in press). Displacement of Paleozoic units along the Jemez fault zone is roughly 230 m, whereas displacement of Quaternary dacite tuff is about 50 m (Goff and Kron, 1980). Apparent offset of Quaternary travertines and locations of epicenters of microearthquakes along the Jemez fault zone suggest that it is active (Goff et al., in press). It is noteworthy that the trends of faults within the resurgent dome of Valles Caldera are parallel and on strike with the Jemez fault zone.

Geology of Sulphur Springs: Sulphur Springs lies on the north-west side of a west-dipping graben on the west flank of the resurgent dome. Major faults that bound the graben are the Sulphur Creek, Fossil Canyon and Short Canyon faults. These faults and the graben trend northeast, parallel to the Jemez fault zone and the Keystone-graben faults of the resurgent dome to the east. The structural configuration of the Sulphur Springs graben, and association of an older rhyolite vent adjacent to the Fossil Canyon fault, suggest the graben formed during, and soon after, evolution of the resurgent dome and coeval eruptions of Redondo Creek rhyolite (Middle Rhyolite of Doell et al., 1966) about 1 Myr ago.

Spectacular exposures of hydrothermally altered fault breccia within Redondo Creek rhyolite occur along the Sulphur Creek fault. The zone of displacement and shearing is 350 m wide and consists of megacrystic and pyrite-laced with enstatite-bearing shear planes that have high-angle dips. Other faults were mapped using topographic alignments, offset units, gouge and breccia, fumaroles or gaseous springs, and linear zones of hydrothermal alteration and mineralization. Most faults do not appear to have as wide a zone of disruption as the Sulphur Creek fault.

The relatively small size of the Sulphur Springs graben and the large number of faults within it suggest the graben is composed of relatively small fault blocks that are not deeply rooted. Very

probably the dips of fault planes of major bounding faults decrease with depth.

Sulphur Springs was formed at the intersection of the Sulphur Creek fault and a 3-d short normal fault of southeast trend. The extensive fumarole area in the mouths of Alamo and Short Canyons has also formed at or near fault intersections, but more subdued thermal phenomena and hydrothermal alterations are not restricted to intersections of structures and occur throughout the Sulphur Springs graben.

Intersections of faults and fractures at depth are obvious targets for exploration drilling. Unfortunately, Baca geothermal wells #1, 2, and 3 did not encounter large hot water entries at depth. Baca #1, which has a total depth of roughly 1100 m, appears, from its location along the Sulphur Creek fault, to have penetrated the fault block west of the Sulphur Springs graben for most of its length. Baca #1 and 2, which are only about 400 m deep, probably did not reach intersecting fractures or faults near the base of the graben.

The hydrothermal alterations displayed in outcrops and thin sections show extensive silicification and formation of clay with loss of permeability. Suctle differences in mineral assemblages that may indicate evolution of the hydrothermal system have not yet been evaluated, but the intensity of hydrothermal alteration is greatest in the vicinity of Sulphur Springs proper and near the bottom of Sulphur Creek.

ACKNOWLEDGEMENTS

We thank Ross Union of Union Oil Company, Bill Amst, and Baca Land & Cattle Company for giving us access to the Sulphur Springs area. Rosemary Vidale, Bob Charles, Chuck Griggs, and Ron Aguilar, who are participating in alteration and fluid chemistry investigations, have given us additional insights that have enhanced this discussion. Becky Sternberg, University of California, Berkeley, assisted with some of the field work. Dave Mann, Tim Lucero, and Nancy Mayola provided us with excellent thin sections. Barbara Hahn and Connie Wilson helped with typing, drafting, and layout of the map.

REFERENCES

Bailey, R.A., Smith, R.L., and Ross, C.S., 1969, Stratigraphic nomenclature of volcanic rocks in the Jemez Mountains, New Mexico: U.S. Geol. Survey Bull. 1274, 12 p.

Chapin, C.E., 1974, Evolution of the Rio Grande rift: A summary in Rieck, R.E., ed., Rio Grande Rift: Tectonics and Magmatism, Amer. Geophys. Union, Washington, D.C., pp. 1-14.

Doell, R.H., Dalrymple, G.B., Smith, R.L., and Bailey, R.A., 1966, Paleogeographic, Potassium-Argon ages, and geology of rhyolites and associated rocks of the Valles Caldera, New Mexico: Geol. Soc. Amer. Memoir 116, pp. 211-246.

Donnadille, R.F., 1976, Geologic characteristics of the Valles Caldera geothermal system, New Mexico: Geoth. Resour. Council Trans., v. 2, pp. 157-160.

Goff, F.E., Griggs, C.B., Trujillo, P., Douce, D., and Kron, R., (in press), Geology, water geochemistry, and geothermal potential of the Jemez Springs area, Canon de San Diego, New Mexico: submitted to Jour. Volcan. and Geothermal Research.

Goff, F., and Kron, R., 1980, In-progress geologic map of Canon de San Diego, Jemez Springs, New Mexico, and lithologic log of Jemez Springs geothermal well: Los Alamos Scientific Laboratory Informal Map, LA-8634-MF, 1 sheet.

Siodowski, T.R., 1976, Geothermal geology of the Redondo Creek area, Baca Location, New Mexico: Union Oil Company Open-File Consulting Report, 5 p. unpubl.

Smith, R.L., and Bailey, R.A., 1966, Resurgent Calderas: Geol. Soc. Amer. Memoir 116, pp. 61-66.

Smith, R.L., Bailey, R.A., and Ross, C.S., 1970, Geologic map of the Jemez Mountains, New Mexico: U.S. Geol. Survey Miscell. Geol. Invest. Map 1-671, 1 sheet.

White, D.E., Huffer, L.J.P., and Truesdell, A.H., 1971, Vapor-dominated hydrothermal systems containing high-temperature systems: Economic Geology, v. 66, No. 1, pp. 75-97.

CORRELATION OF MAP UNITS

Map showing Sulphur Springs and tectonic features mentioned in text.

SYMBOLS

- contact; dashed where approximate; dotted where concealed
- fault; dashed where approximate; dotted where concealed; ball and bar on down-dropped block; arrow indicates dip of fault plane
- sheared or brecciated rock; arrow indicates dip of shear zone
- strike and dip of bedding
- strike and dip of volcanic foliation
- strike and dip of joints
- volcanic vent
- Baca well number and location
- hydrothermal alteration; generally kaolinite and silica; includes sulphur and soluble sulphates near gaseous springs and fumaroles; lim and py indicate occurrence of limonite and pyrite, respectively
- spring
- thermal and/or gaseous spring
- fumarole
- indicates uncertainty
- marks limit of geologic mapping

GEOLOGIC MAP OF THE SULPHUR SPRINGS AREA, VALLES CALDERA GEOTHERMAL SYSTEM, NEW MEXICO

by
Fraser E. Goff and Jamie N. Gardner

1980

LA-8634-MAP
UC-66a
Issued: December 1980