ER 21579

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 91, NO. B2, PAGES 1779–1798, FEBRUARY 10, 1986

Explosive Rhyolitic Volcanism in the Jemez Mountains: Vent Locations, Caldera Development and Relation to Regional Structure

STEPHEN SELF,[1] FRASER GOFF,[2] JAMIE N. GARDNER,[2] JOHN V. WRIGHT,[3] AND WILLIAM M. KITE[4]

The Jemez volcanic field straddles the western margin of the Rio Grande rift where the rift is intersected by the Jemez lineament in north central New Mexico. The field has a record of volcanism extending back to before 13 Ma. Initial basaltic activity was related to active rifting, with minor rhyolitic eruptions occurring along N-S rift-bounding faults. Between 10 and 7 Ma, voluminous andesitic volcanism took place in the central Jemez Mountains area, overwhelming contemporaneous basaltic and rhyolitic magmatism. An apparent tectonic lull took place from 7 to 4 Ma, accompanied by lower eruption rates. During this interval, dacitic magmas were erupted to form the Tschicoma volcanic center, but mafic and rhyolitic volcanism virtually ceased. Since 4 Ma, accompanying resumption of rifting, a growing silicic magma system has been present under the central part of the Jemez Mountains, ultimately evolving to the magma body that produced the voluminous rhyolitic Bandelier tuffs. Explosive rhyolitic eruptions from this large magma body have occurred many times since 3 to 4 Ma. Early eruptions, 3.6–2.8 Ma, produced high-silica rhyolite ignimbrites restricted to the southwest part of the Jemez Mountains; formation of these units may have been accompanied by caldera collapse. These events were followed by the two caldera-forming Bandelier Tuff ignimbrite eruptions, 1.45 and 1.12 Ma. Post caldera explosive and effusive rhyolite eruptions have also tapped the magma body from vents generally located along ring fractures after both Bandelier events. Vent and caldera locations for the rhyolitic eruptions during 3–4 Ma have been inferred from grain size characteristics, dispersal patterns, and facies variations in the Plinian deposits and ignimbrites. Lithic breccia zones of the pre-Bandelier ignimbrites indicate possible caldera sources in the southwest part of the present Valles caldera. During the eruption of both Bandelier tuffs, initial plinian falls and early pyroclastic flows emanated from vents centrally located in the Jemez Mountains. In the lower Bandelier Tuff eruption a transition to ring fracture vents occurred before the emission of later pyroclastic flows, but there is no strong evidence to suggest such a transition occurred during the upper Bandelier eruption. Calderas associated with the lower and upper Bandelier tuffs (Toledo and Valles, respectively) are almost identical in location, as are the Plinian vent sites for these two large eruptions. The Toledo embayment, northeast of the Valles caldera, contains lava domes from up to 3.6 Ma and may be a caldera or crater associated with early explosive dacitic volcanism in the Tschicoma volcanic center. Post-1.4 Ma lava domes also fill this depression. The main volcanic features of the Jemez Mountains field, including the Valles caldera complex, eruption vents, and the apical graben of the post-Valles-Redondo resurgent block, appear to be aligned along the NE-SW trending Jemez fault zone. This zone, the local expression of a Precambrian basement feature (the Jemez lineament), has exerted strong control on the location and style of eruptions from the Bandelier rhyolitic magma system.

INTRODUCTION

The Jemez Mountains volcanic field of New Mexico is located at the intersection of the western margin of the north-south trending Rio Grande rift and the northeast trending Jemez lineament (Figure 1). The field contains one of three recently active silicic resurgent caldera systems in the continental United States, the Valles Caldera. This caldera was created by a series of catastrophic ignimbrite eruptions, the most recent of which formed the Tshirege Member of the Bandelier Tuff (here called the Upper Bandelier Tuff, UBT) at about 1.12 Ma [*Smith and Bailey*, 1966; *Doell et al.*, 1968; *Izett et al.*, 1981]. An earlier ignimbrite eruption formed the 1.45 Ma Otowi Member of the Bandelier Tuff (Lower Bandelier Tuff, LBT), accompanied by formation of the older Toledo caldera [*Smith et al.*, 1970]. These two rhyolitic, ignimbrite-forming eruptions are regarded as the culminating phase of volcanism within the Jemez Mountains volcanic field [*Smith*, 1979]. The Valles caldera and its associated rocks are best known from the pioneering work of R. L. Smith, R. A. Bailey, and C. S. Ross on ring-dike emplacement, formation of resurgent calderas, and eruption of compositionally zoned ignimbrite sheets [*Smith et al.*, 1961; *Smith and Bailey*, 1966, 1968]. For these reasons, many geologists consider it to be the "type" resurgent caldera. The volcanic history of the Jemez Mountains field is quite diverse and long-lived; it has produced voluminous mafic, intermediate, and silicic pyroclastic rocks, lava flows, and domes almost continuously since 13 Ma [*Bailey et al.*, 1969; *Smith et al.*, 1970; *Gardner*, 1982, 1983; *Gardner and Goff*, 1984; *Gardner et al.*, this issue].

The Valles caldera is also a major target for geothermal resource development due to its recent volcanic activity (most rhyolites as young as 0.1 Ma [*Doell et al.*, 1968]) and hot springs. A neutral chloride liquid-dominated geothermal system at temperatures of 260°330°C [*Dondanville*, 1978] has been extensively drilled by Union Oil Company beneath the apical graben in the resurgent dome. Exploration by both private and public organizations continues today [*Laughlin*, 1981; *Goff and Grigsby*, 1982]. Because of the high conductive heat flow associated with the caldera, the first Hot Dry Rock geothermal system has been engineered in the Precambrian basement underlying the west flank of the Jemez Mountains [*Heiken and Goff*, 1983]. Recently, the Valles caldera has been considered to be a prime candidate as a site for the Continental Scientific Drilling Program (CSDP) [*Riecker*, 1983; *Goff et al.*, 1984*b*] which proposes to drill into an active magma-hydrothermal system to study the roots of the heat transfer zone between crystallizing magma and overlying convecting hot waters. The first CSDP shallow hole has been drilled in the southwesternmost zone of the Valles caldera, and it penetrated several of the ignimbrites discussed herein [*Goff et al.*, this issue].

In this paper we summarize recently acquired data on the

[1] Department of Geology, University of Texas at Arlington.
[2] Earth and Space Sciences Division, Los Alamos National Laboratory, Los Alamos, New Mexico.
[3] Sheffield, England.
[4] Department of Geology, Arizona State University, Tempe.

Copyright 1986 by the American Geophysical Union.

Paper number 5B5510.
0148-0227/86/005B-5510$05.00

14624