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# Contrasting interactions of two magmas with the same water-saturated hosts, Big Bend National Park, Texas

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ABSTRACT

Rhyolitic and mafic dikes cut lower Tertiary sediments, tuffs and mafic lavas of the Eocene–Oligocene Chisos Formation in Big Bend National Park, Texas. Two contrasting magmas injected into the same hosts under the same conditions provide a "controlled" experiment on magma–host interaction. Peralkaline rhyolite dikes are extensive and stand in bold topographic relief. On contact surfaces against mudstones, close-packed spheroids of chilled rhyolite indicate vigorous movement of magma within envelopes of fluid. Against sandstones, the rhyolite dike contacts are more irregular and locally protrude as blunt fingers into the wall rock. Against mafic lava flows, dike contacts are planar, and the rhyolite is less altered. Mafic dikes cut the rhyolite dikes. Some contacts of these mafic dikes are peperitic, indicating intrusion into soft wet sediment and tuff. The same hosts of the older rhyolitic dikes must also have been water-saturated and unconsolidated. Higher viscosity and lower temperature prevented rhyolite magma from forming detached bodies, or engulfing its host, to form peperites.

Estimated pressures and contact temperatures approximate or exceed the critical point of water, indicating that the fluid envelopes at rhyolite dike contacts were very unstable, because even small temperature fluctuations would have produced wide variations in fluid density around the critical point. The resulting volume instability triggered rapid pulsations in the fluid envelope, deforming the contacts. Where permeability of the host was low, hot fluid accumulated at contacts, but where permeability was high, fluid could escape before reaching high temperature.



## 1. Introduction

Big Bend National Park contains the southern limit of the Trans-Pecos Texas volcanic field. From 47 to 12 Ma, magmas intruded with no temporal hiatus and no discernible space–time progression. Roll-back of the subducted Farallon slab apparently kept pace with southwestern movement of the North American plate. As a result, magma sources remained nearly stationary with respect to the continental surface. Alkalic silica-undersaturated and oversaturated rocks range from tephrite/basanite to peralkaline trachytes, phonolites, and rhyolites.

Two dike swarms of different compositions and orientations occur in the studied area of 25 $km^2$ in Big Bend National Park, bordered by Ross Maxwell Scenic Drive on the west, the cliffs of the Chisos Mountains on the east, Blue Creek on the south, and Oak Spring Trail on the north (Fig. 1a). Turner et al. (2011; http//pubs.usgs.gov/sim/3142/) show the geologic context of the dikes on a 1:75,000 map.

Three peralkaline rhyolite dikes are topographically prominent. Strikes are 340° to 320°, and the dikes are vertical or dip steeply to the west, are 2 to 6 m wide, and are spaced 200 to 700 m apart. They are traceable through as much as 600 m of vertical relief and 6 km along strike (Fig. 1a, b). None was seen to bifurcate, but some segments pinch out, then continue with the same strike and dip after meters or tens of meters of lateral offset. Extension caused by dikes is less than 1%. The dikes intruded southward-dipping clay-rich flood plain sediments and reworked tuffs, channel-filling sands and gravels, and mafic lava flows of the Eocene–Oligocene Chisos Formation.

The projected SSE elongations of the dikes converge on an area within the Sierra Quemada, interpreted by Scott et al. (2007) as a "failed caldera" with an up-bowed center and breccia-filled vents, but no evidence of lavas or pyroclastic rocks coeval with the structure. Furthermore, the Sierra Quemada rocks are older than the dikes (Turner et al., 2011). There has been at least 1 km of erosion over Sierra Quemada, so it is possible that a superposed caldera and its products have been removed.

Rhyolite dikes strike toward vent areas of peralkaline Burro Mesa Rhyolite (phreatomagmatic tuff rings and lava domes) west of the Burro Mesa fault (west margin of Fig. 1a). The Burro Mesa block on the west has dropped about 1 km (Maxwell et al., 1967) along a fault that is parallel to the highway, and the dikes under study, east of that fault, may be exhumed feeders of similar, now eroded, vents. An $^{40}Ar/^{39}Ar$ age of 28.81 ± 0.10 Ma (Miggins et al., 2007) on one dike sample is close to the average of 29.33 ± 0.15 Ma for five $^{40}Ar/^{39}Ar$ ages of the Burro Mesa Rhyolite (Miggins et al., 2007),

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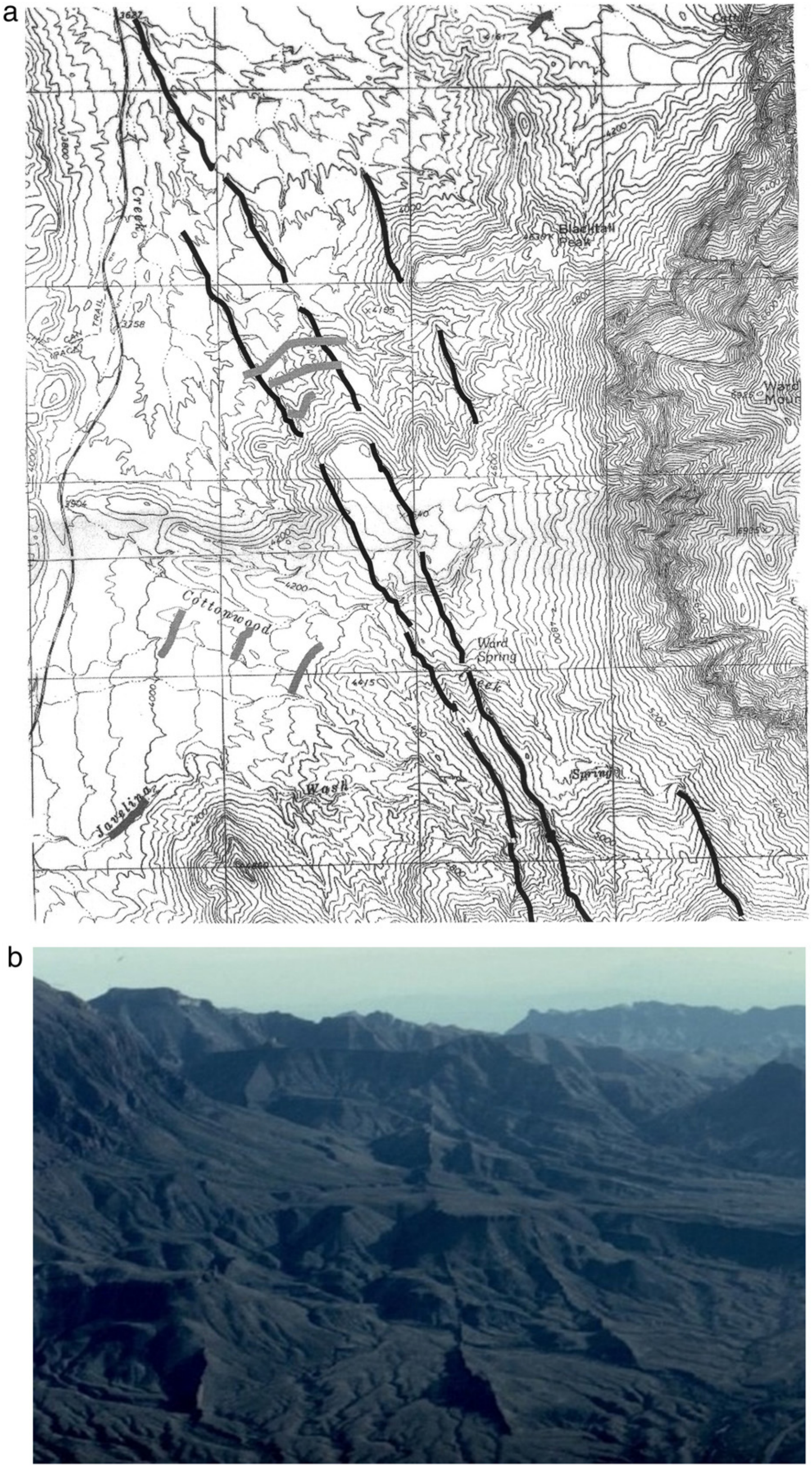


**Fig. 1.** a. Schematic dike map, on a base derived from The Basin and Emory Peak 7.5′ quadrangles. Grid lines are 1 km apart. Black lines = peralkaline rhyolite dikes. Gray lines = mafic dikes and sills (widths exaggerated for clarity). Right edge is 103°20′W, left edge is at 103°22.5′W, top is at 29°16.5′N, bottom is at 29°14′N. b. Low-angle oblique air photo from the north, showing three prominent rhyolite dikes.

and to an average of 28.91 ± 0.56 Ma for $^{40}Ar/^{39}Ar$ ages for another four samples of Burro Mesa Rhyolite (Copeland et al., 1992). These data support a conjecture that the rhyolite dikes fed parts of the Burro Mesa Rhyolite flows that have now eroded away. Table 1 shows that the upper part of the Upper Burro Mesa Rhyolite has a similar modal composition to the dikes.