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EVOLUTION OF THE LATE CENOZOIC JORNADA VOLCANO, SOUTH-CENTRAL NEW MEXICO

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Abstract—The Jornada volcano is a late Cenozoic (<0.76 ± 0.1 Ma) basaltic-lava shield cone within the 435 km² Jornada basalt field in southern Socorro and northern Sierra Counties. The field consists of three major alkali olivine basalt flows emplaced from a series of north-striking fissures. The lava cone sits on top of the lava flows and covers an area of approximately 6 km². The principal volcanic features associated with the Jornada volcano include two centrally extruded lava flows, a well-developed lava tube system, and a central crater containing several cinder-spatter cones and collapse features. The most unusual feature is a moat which encircles the central crater on its west, south and east sides. The moat ranges in width from 20 to 200 m and in depth from 1 to 13 m. A number of "islands" composed of lava flow and spatter layers occur on the floor of the moat; the height of these blocks is nearly equal to the depth of the moat. The major events involved in the formation of the lava cone include alternating episodes of lava fountaining, quiet extrusion of fluid lava, and collapse (moat formation).

INTRODUCTION

The Jornada volcano (JV) is a small shield cone within the Jornada basalt field. The volcano lies east of the central portion of the field near the eastern boundary of the Pedro Armendaris, No. 33, land grant. The field is approximately 45 km northeast of Truth or Consequences in southern Socorro and northern Sierra Counties (Fig. 1). Kottlowski et al. (1956) first referred to the basalt field as the Jornada basalt because of its location within the Jornada del Muerto (Journey of Death).

The Jornada basalt field is the largest, in both area and volume, of the very young (less than 1 Ma old) volcanic areas in south-central New Mexico (Table 1). The basalt flows, radiometrically dated at 0.76 ± 0.1 Ma (Bachman and Mehnert, 1978), cover approximately 435 km² (Dane and Bachman, 1961), with an estimated volume of 7.5 km³.

A preliminary description of Jornada basalt field is included in a paper on the Cenozoic volcanic rocks of Socorro County, New Mexico (Weber, 1963). Crumpler and Aubele (1990) published a brief description of the Jornada cone.

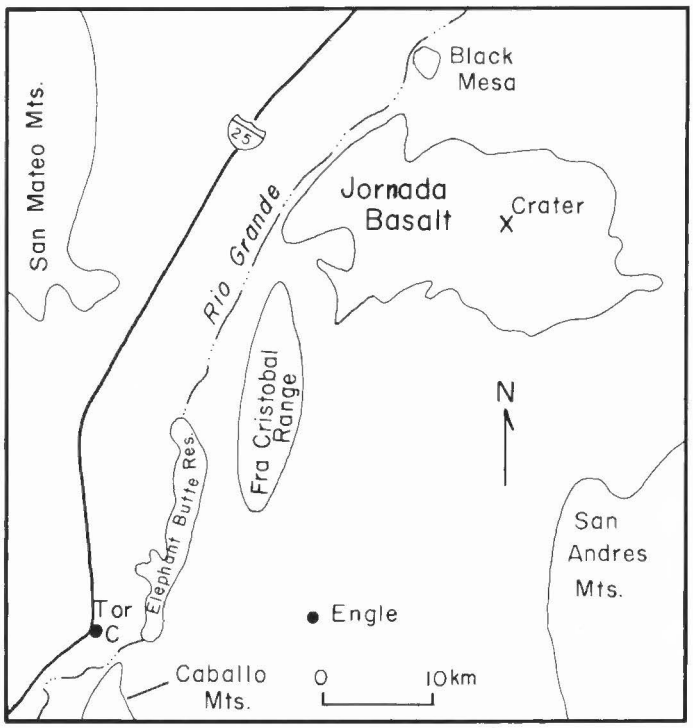

FIGURE 1. Location map of the Jornada basalt field and the Jornada crater.

TABLE 1. Age and extent of late Cenozoic basalt flows (less than 1.0 Ma) in central and southern New Mexico (1—Renault, 1970; 2—Seager et al., 1984; and 3—Bachman and Mehnert, 1978).

Location	Area (km²)	Volume (km³)	Age (Ma)
Carrizozo, Socorro and Lincoln Counties	329	4.2	<0.001[1]
Aden-Afton, Dona Ana County	142	2.0	0.530 ± 0.04[2]
Black Mountain-Santo Tomas, Dona Ana County	34	0.12	0.490 ± 0.03[2] 0.550 ± 0.03[2]
Jornada, Socorro and Sierra Counties	435	7.5	0.760 ± 0.10[3]

VOLCANIC STRATIGRAPHY

The Jornada basalt field is composed of three extensive olivine-basalt lava flows that erupted from a series of generally north-striking fissures (Hoffer and Corbitt, 1991). The flows, from oldest to youngest, are informally designated J-1, J-2 and J-3. The individual flows range in thickness from less than 5 m to 12 m. At Hackberry Well, approximately 5.5 km southwest of Jornada cone, a total of 25 m of basalt were penetrated during drilling through the lower two flows (J-1 and J-2; Fig. 2) (personal comm., Dave Mauldin, Mauldin Drilling Co., 1989). The youngest of the lower flows (J-3) averages 5 m in thickness, which

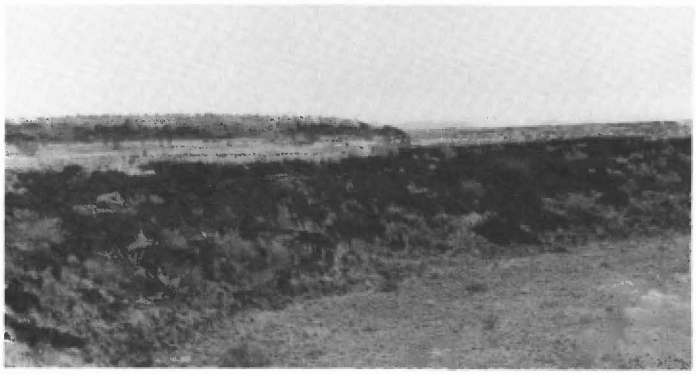

FIGURE 2. View to east showing a collapse depression in the oldest flow of the lower basalt (J-1) overlain by a younger flow of the lower basalt (J-2) in the background.

would indicate a total minimum thickness of approximately 30 m for these lower flows. The most characteristic feature of the older lava flows is the occurrence of numerous collapse depressions. These collapse features range from elongate to irregular in plan view and show general north and northeast alignment. The depressions range in size from less than 100 m^2 to more than 1.0 km^2; most are less than 10 m in depth.

The lava cone rests on top of the lava flows. The volcano forms a broad shield, with a central crater at the top, and covers an area of approximately 6 km^2. Two small lava flows have been extruded from the central crater. The largest and oldest flow (M-1), south of the volcano, covers approximately 5.7 km^2. The youngest flow (M-2) west of the cone covers about 1.0 km^2 (Fig. 3).

JORNADA VOLCANO

General description

The Jornada volcano is a small shield volcano or lava cone. The base of the volcano is composed of a number of thin basaltic lava flows extruded from central vent(s). The base of the volcano is about 3.0 km in diameter (Fig. 3). A central crater is located on top of the volcano; its outer wall rises about 40 m above the shield. The crater is almost completely encircled by a 10–15 m rim of lava and spatter. The rim is breached in several places where basaltic lava flowed out from the central crater. The 0.4 km^2 central crater is floored by a series of lava flows. A collapse depression at the southeast end of the crater floor is probably the former vent for these flows. A moderate-sized cinder-

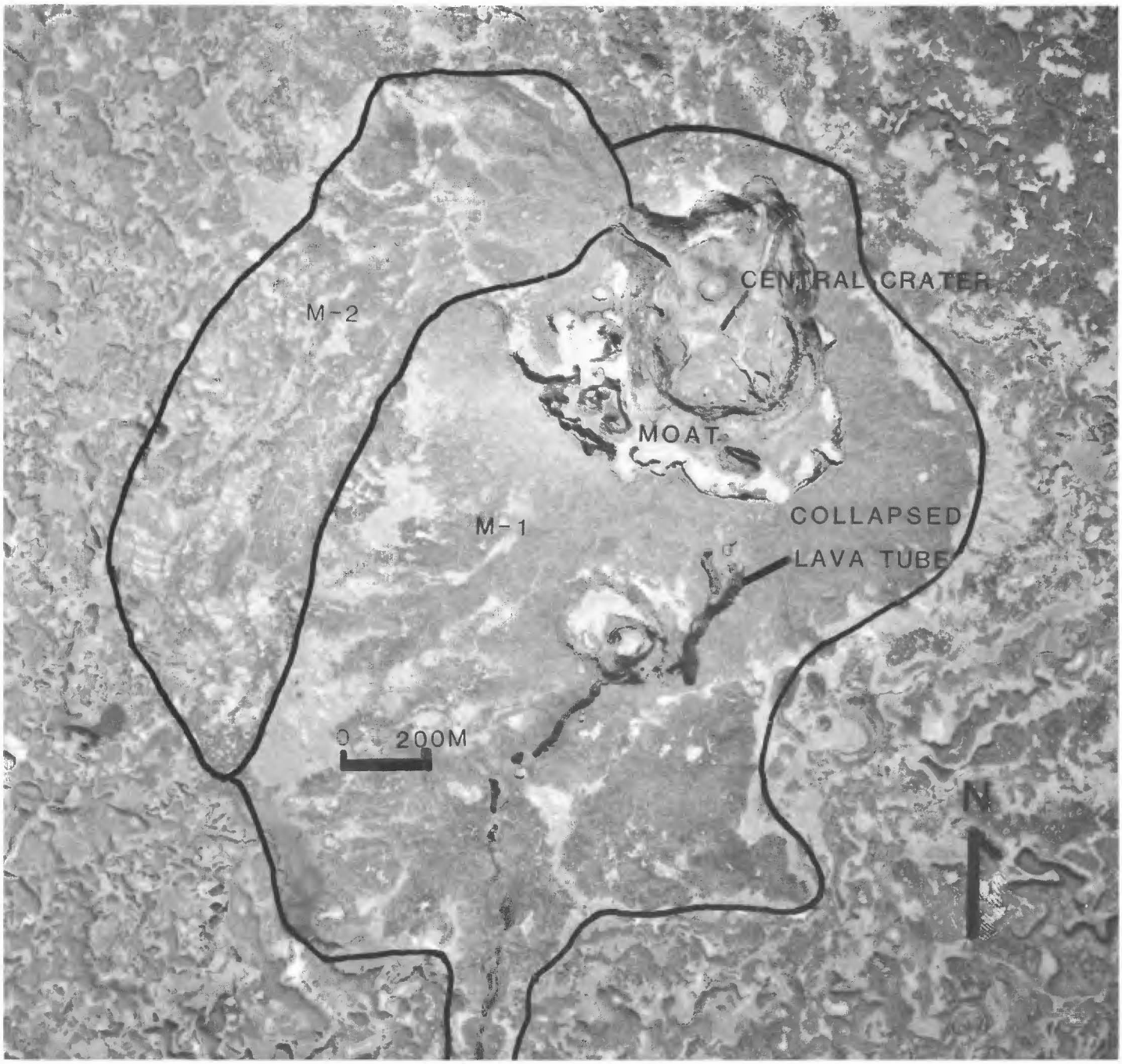

FIGURE 3. Jornada volcano and associated lava flows. Dark elongate patches south of the crater represent collapsed roof sections of lava tubes.

spatter cone, near the north end of the crater, has a diameter of about 180 m and height of 30 m. Several smaller cinder cones occur on the north and west flank of the cinder cone.

Moat

An unusual feature associated with the volcano is the well-developed moat, which partly encircles the central crater on its west, south and east sides (Figs. 4, 5). The moat ranges in width from 20 to 200 m and in depth from less than 1 m to 13 m. The moat depth is greatest on the southwest side of the crater. Within the moat, "islands" of nearly horizontally dipping flow rock and minor spatter layers occur. The height of these blocks is nearly equal to the depth of the moat.

Collapse pits are numerous within the moat, where they occur at the base of the outer moat wall, at the outer base or on top of the basalt blocks, and adjacent to the outer moat wall within the lava flows on the flanks of the volcano. At the south end of the crater a series of collapse features can be traced across the moat floor, into the lava flows, onto the flank of the cone and hence into a series of large collapsed lava tubes. This tube system can be traced continuously southward for a distance of 2.2 km by the alignment of large roofless tube sections, skylights and collapse depressions. Based on the observation of numerous tube cross sections in the outer walls of the moat, the collapse depressions within the moat represent the locations of lava tubes radiating outward from the central crater.

Lava tube system

The well-developed system of lava tubes on the south flank of the volcano (Figs. 6, 7) were responsible for the emplacement of the basalt

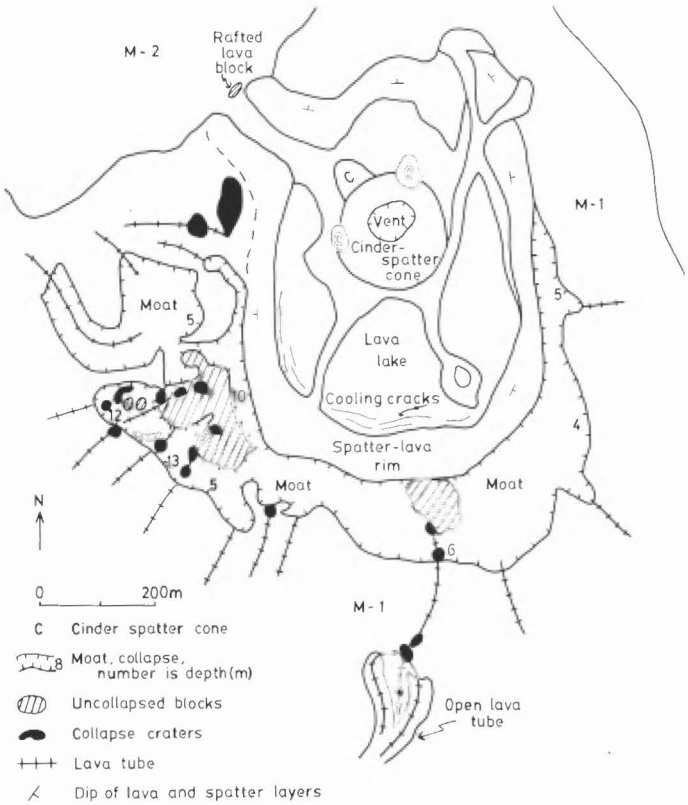

FIGURE 4. Volcanic features of the Jornada cone.

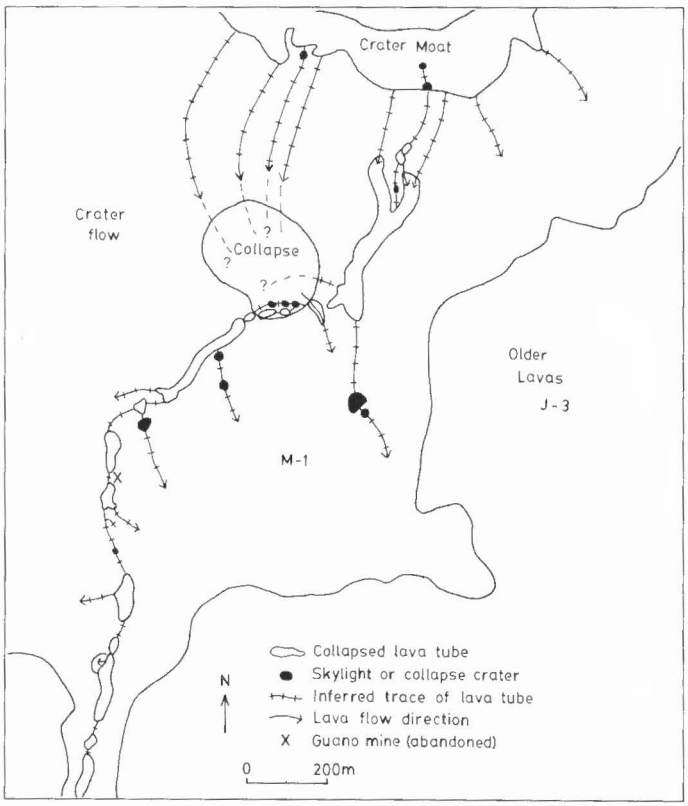

FIGURE 6. Lava tubes on the south flank of Jornada (see Fig. 3 for aerial view of collapsed portions of the tube system).

FIGURE 5. View of moat on the southwest ridge of the central crater, sloping rim deposits on the right. View is to northwest.

FIGURE 7. Rim of the central crater on Jornada volcano (background), and uncollapsed portion of a lava tube (foreground), looking north.

flow which crops out around the southern and western ends of the volcano. At least seven major lava tubes appear to emerge from the crater moat on the south side of the volcano. To the west, four lava tubes can be traced from the crater to the south. Approximately 400 m south of the moat, the tubes appear to have coalesced and their roofs collapsed, forming a large collapse crater approximately 200 m wide and 10 m deep. To the east about 300 m, three additional lava tubes are well exposed 150–200 m south of the moat. These tubes strike southward and within 150 m converge, producing one large collapse tube nearly 40 m wide and 15 m deep. The tube continues southward for nearly 300 m and then bifurcates into west- and south-trending branches. The south-trending tube can be traced for approximately 350 m before its surface expression disappears. The west-striking tube appears to merge into a large collapse crater, continues to the southwest and then to the south for a distance of 1.5 km. Within this distance, the main tube bifurcates at least five time, producing tubes that extend to the southeast and west. From the large collapse depression to the end of the lava flow the main tube averages about 25 m in width, 15 m in height, and where present, the arched roof is 1–3 m in thickness. Near the southern end of the open tube a small volume of lava overflowed the tube and flowed a short distance to the west.

Studies of lava tubes from Hawaii (Greeley, 1971, 1987; Peterson and Swanson, 1974), Mount Etna (Guest et al., 1980), and the Bandera field in northwestern New Mexico (Hathaway and Herring, 1970) indicate that the formation of lava tubes reflects a particular style of volcanism. Tubes develop in basalt lavas from eruptions that generally involve (1) moderate rates of extrusion (2–5 m/sec.), (2) eruptions that last more than one or two days, and (3) extrusions of very fluid lava, such as pahoehoe that has not been degassed.

The uncollapsed portions of the lava tubes are now inhabited by bats. Fitzsimmons (1955) reported the exodus of an estimated 125,000 to 150,000 bats at dusk during a visit to the tubes in 1953. The only commercial production of nitrate in New Mexico was from the mining of bat guano in these lava tubes. From 1900 to 1935 approximately 4000 tons of guano were mined and shipped to the west coast (Talmage and Wooton, 1937).

ORIGIN OF THE JORNADA VOLCANO

The principal features associated with the volcano include two centrally extruded lava flows, a well-developed lava tube system, a central crater containing a solidified lava lake with several cinder-spatter cones, and a moat that nearly encircles the south end of the crater (Hoffer and Corbitt, 1991). The major events involved in the formation of the cone include alternating episodes of lava fountaining, quiet extrusions of lava and collapse. The stages in the development of the lava cone are outlined below and summarized in Fig. 8.

Stages

The initial event consisted of central eruptions of fluid basaltic lava that produced small thin flows. These flows were extruded radially outward from the vent and built up a small shield volcano. The first stage was followed by lava fountaining from one or more vents, constructing a rim of spatter around the top of the shield. With a reduction in gas content, the lava again rose in the vent and fluid lava was quietly extruded. The spatter rampart served to dam the flows and produced a lava lake within the crater. The lava rose above (or partially breached) the spatter rim and flowed down the south slopes of the volcano, producing flow M-1. This flow was emplaced through a series of lava tubes exposed today around the south end of the crater.

At the end of the volcanic activity, much of the lava in the central crater drained back down the vent. This was followed by collapse of the crater floor and formation of the moat by collapse on the west, south and east flanks of the crater. The exact cause of the moat collapse is unknown, but possibly the surface magma retreated downward, thereby removing some of the support under the crater.

Volcanic activity initiated again within the central crater at a new vent. Lava fountaining constructed a series of cinder-spatter cones at the north end of the crater. This was followed by renewed extrusion of fluid lava from the vent at the southeast end of the crater. The lava flowed in channels across the center floor, breached the northwest rim, and continued down the southwest flank of the volcano (flow M-2). In addition, minor extrusions of lava breached the northeast and southwest section of the central crater rim. Final activity consisted of magma withdrawal down the vent with subsequent collapse over the vent and solidification of the lava within the crater interior.

AGE OF THE VOLCANO

The only published radiometric date from the Jornada basalt field is 0.76 ± 0.1 Ma (Bachman and Mehnert, 1978). According to the sample location, 33°33′N Lat., 106°59′W Long., the dated basalt is from the J-1 flow (oldest of the lower basalts) on the west side of the field (Bachman and Mehnert, 1978).

The Jornada cone was formed after the emplacement of the three lower basalt flows and is therefore younger than the reported age date of 0.76 ± 0.1 Ma. Based upon the surface morphology of the cone and comparison to other dated basaltic features in south-central New Mexico, it is probably less than 0.5 Ma old (Hoffer, 1988).

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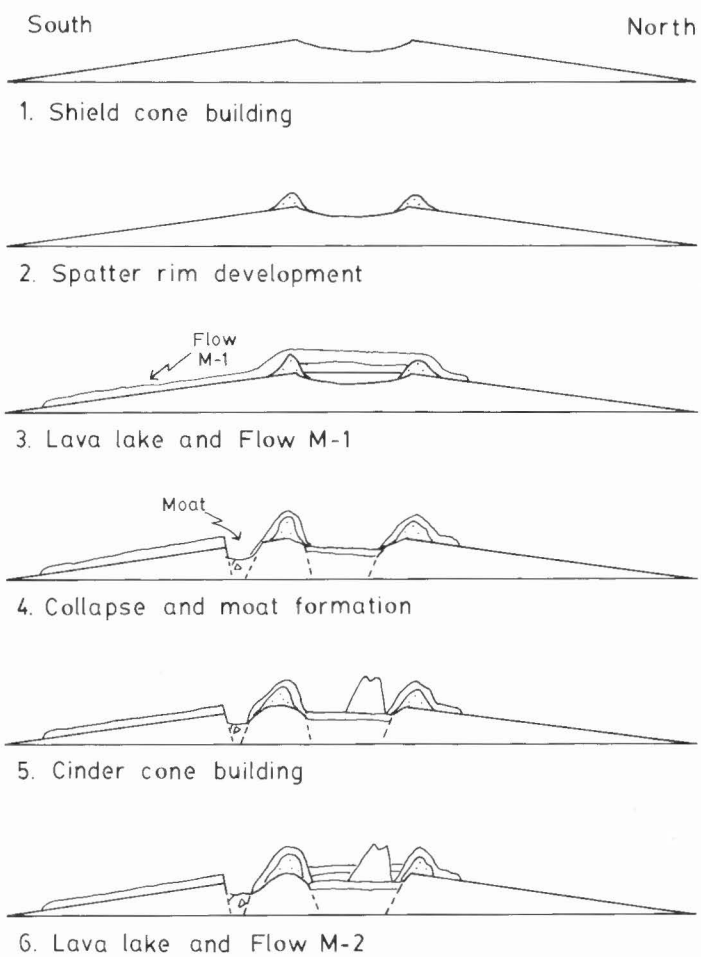

FIGURE 8. Sequence in the development of Jornada volcano (see text for details).

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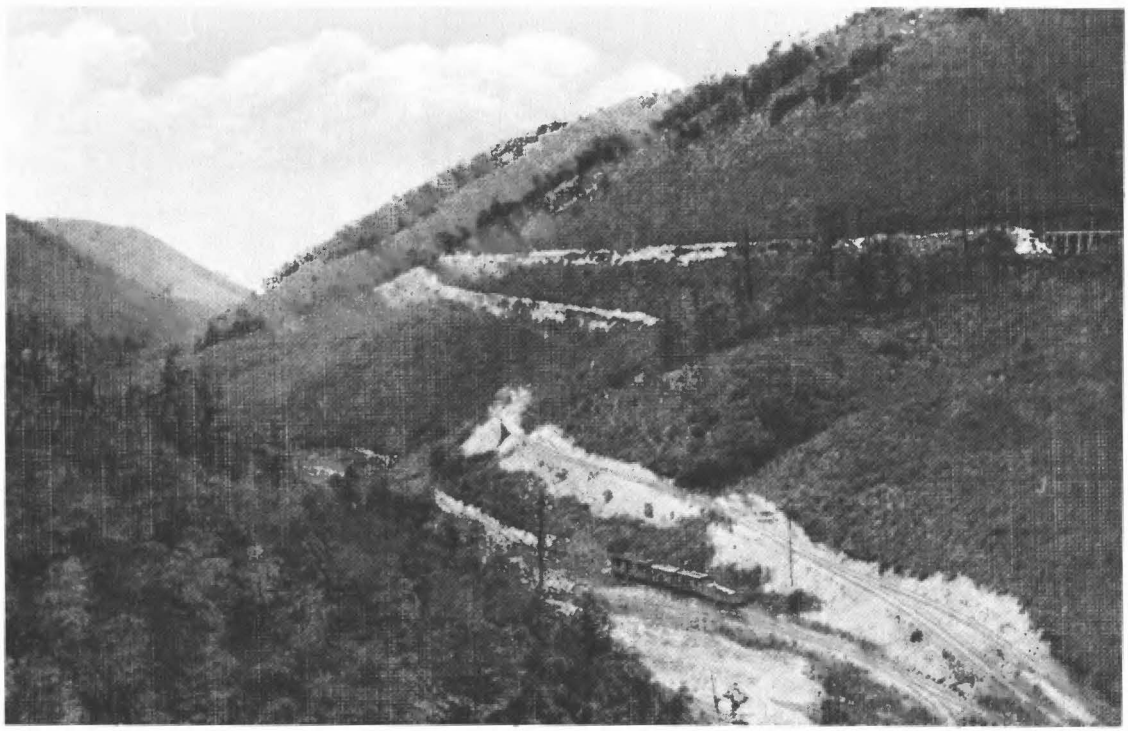

View to west from Cloudcroft over switchbacks toward a distant White Sands. Note railcars on siding and trestle at upper right. From the postcard collection of Spencer Wilson.

Bonita City, or Bonito as it is known today, was established as a supply point for the old Parsons (a/k/a Hopeful) mine. The Bonito post office, established in 1882, dominates this photo made about 1900. The area is now beneath the waters of Bonito Lake. Bonito's population dropped to just two hardy souls and passed into history in 1911. The gentleman decked out in vest, white shirt and tie may well have been the postmaster. Photo courtesy of Rio Grande Historical Collections, Ms 98, RG78-17/5, New Mexico State University, Las Cruces.