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PYROCLASTIC ROCKS ASSOCIATED WITH THE TAYLOR CREEK RHYOLITE, SCALES CANYON, NEW MEXICO

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Abstract—Pyroclastic deposits formed during the emplacement of the 28.6 my old Taylor Creek Rhyolite are exposed in a 2 km long section in Scales Canyon. As much as 50 m of pyroclastic fall, surge, and flow deposits as well as eolian sandstone have been recognized in five measured sections. Three eruptive sequences are proposed: I – a lower, predominantly pyroclastic flow and surge sequence; II – a middle pyroclastic fall sequence; and III – an upper sequence of two coarse pyroclastic breccias. Paleomagnetic measurements on clasts from the two units within sequence III indicate the lower unit was emplaced as a hot (>500°C) pyroclastic flow, whereas the upper unit was emplaced as a mixture of hot (>500°C) and cold (<300°C) clasts. Both units apparently represent dome-collapse breccias. The lower unit contains only hot material from the interior of the dome, whereas the upper unit also contains a component of the cooler dome carapace.

The Scales Canyon pyroclastic deposits were apparently erupted over a short span of time from two or more nearby dome-related vents. Individual vents cannot be identified because the deposits are mineralogically similar.

INTRODUCTION

Pyroclastic eruptions associated with the emplacement of domes may follow a pattern (Newhall & Melson 1983, Heiken & Wohletz in press). Preceding emplacement of a dome, the eruptive sequence begins with vent-clearing Plinian and phreatomagmatic eruptions which produce fallout and surge deposits. Concomitant with dome emplacement, less energetic eruptions produce pyroclastic flow deposits (ignimbrites). Collapse of portions of the dome form nuée ardentes, resulting in the deposition of pyroclastic breccias (block and ash deposits). Late-stage phreatic eruptions may further contribute to destruction of the dome.

A well-exposed sequence of pyroclastic deposits formed during the emplacement of Taylor Creek Rhyolite domes in the Black Range of New Mexico was examined to establish the pyroclastic eruptive sequence, for comparison with the generalized sequence described above. The pyroclastic deposits are exposed in Scales Canyon, about 24 km west–northwest of Winston, New Mexico (Eggleston & Norman 1986: fig. 3). Five sections were measured and described. In addition, paleomagnetism of two pyroclastic breccias was investigated in order to determine emplacement temperature.

GEOLOGIC SETTING

Topaz-bearing, high-silica Taylor Creek Rhyolite occurs mainly as small domes and flows, with lesser pyroclastic deposits over a 1,200 km^2 area, in the Black Range (Eggleston & Norman 1986: fig. 3). With the exception of an eruptive center at Taylor Creek, the rhyolites are mineralogically and chemically similar. Emplacement of the numerous domes was a relatively brief event about 28.6 my ago (McIntosh et al. 1986, Eggleston & Norman 1986). Fifteen eruptive vents for the rhyolite are presently known, but detailed mapping and further studies are likely to define additional vents.

Widespread (but small in volume) pyroclastic deposits associated with the emplacement of the Taylor Creek Rhyolite domes mantle and surround the domes (Eggleston & Norman 1986). It is likely that pyroclastic deposits also underlie the domes, but these are not exposed. The exposed deposits are crystal-rich pyroclastic flow, fall, and surge deposits. The pyroclastic flows are generally non-welded, and include ignimbrite and block and ash deposits. Welded ignimbrites do, however, occur in Nugget Gulch and Paramount Canyon.

An exceptionally well-exposed sequence of the pyroclastic deposits occurs in Scales Canyon (Figs. 1, 2). They are part of an apron flanking Boiler Peak–Paramount Canyon dome. The deposits are preserved in a broad, shallow paleovalley that parallels Scales Canyon for 2 km (Fig. 1). The deposits are underlain by the 28.76 my old La Jencia Tuff, a regional, densely welded, crystal-poor ignimbrite erupted from the Sawmill Canyon–Magdalena cauldrons in the Magdalena Mountains near Socorro (Kedzie et al. 1985, Osburn & Chapin 1983). The sandstone of Inman Ranch overlies the Scales Canyon pyroclastic deposits and consists of more than 200 m of fine to coarse sandstone, siltstone, and conglomerate of dominantly fluvial origin. In some places the sandstone of Inman Ranch is missing and the pyroclastic deposits are overlain by the tuff of Garcia Camp (Fig. 1). This tuff is a poorly welded, crystal-rich ignimbrite believed to be related to the Indian Peaks eruptive center of the Taylor Creek Rhyolite (Lawrence & Richter in press). The tuff of Garcia Camp is restricted to a paleovalley that trends north from Scales Canyon (Fig. 1). The contact relations between the tuff of Garcia Camp and the Inman Ranch are not exposed, thus the relative stratigraphic position is a matter of conjecture. Regional dip in the Scales Canyon area is 10–12° west.

SCALES CANYON SECTIONS

Five measured sections through the pyroclastic deposits in Scales Canyon are shown in Fig. 3. The sections indicate that these deposits consist of flow, fall, and surge deposits which have been divided into three eruptive sequences (Fig. 2).

I – A lower, predominantly pyroclastic-flow and surge sequence.
II – A middle pyroclastic fall sequence.
III – An upper coarse pyroclastic breccia sequence.

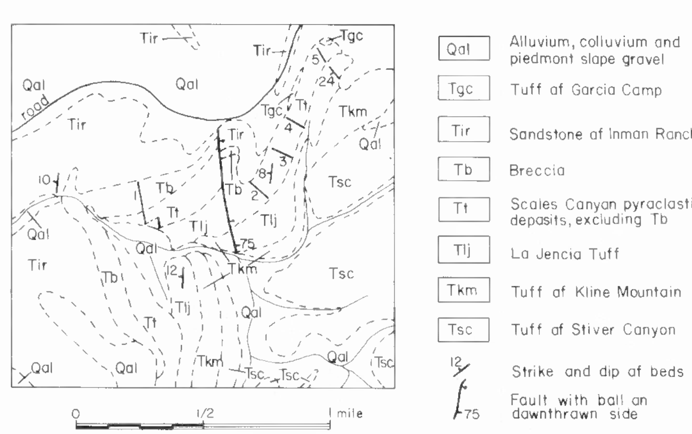

FIGURE 1—Geologic map of Scales Canyon showing location of five measured sections through the pyroclastic deposits (from Eggleston in preparation).

FIGURE 2—General view of section 1 at Scales Canyon showing the three eruptive sequences. I, Predominantly pyroclastic flow deposits; II, fall deposits; and III, pyroclastic breccia. Sequence II is about 5 m thick (person in shadow for scale). Photo G.R. Osburn.

Eruptive sequence I

The oldest deposits observed in the sections are predominantly pyroclastic flow and surge deposits with rare pyroclastic fall deposits and eolian deposits. Rocks of this eruptive sequence conformably overlie the La Jencia Tuff and are found in all five measured sections.

This lower sequence is dominated by thin (<1 m), non-welded ignimbrites which are poorly sorted lapilli tuffs. Lithic clasts are typically concentrated near the base of each ignimbrite and show normal grading. Pumice clasts up to 5 cm in diameter show reverse grading and in a few cases form segregations at or near the top of the ignimbrites. Interior parts of these deposits are massive or show weak, plane-parallel bedding.

Accidental lithic clasts up to 5 cm in diameter include dense, flow-banded rhyolite, green sandstone, and andesite. Rhyolite clasts are lithologically similar to the Taylor Creek Rhyolite lavas. Origin of the sandstone clasts is undetermined.

Small ignimbrites in this eruptive sequence show some of the features expected from the model of an idealized ignimbrite (Sparks et al. 1973, Sheridan 1979, Fisher & Schmincke 1985). Layer 1 ground surge deposits are rarely preserved and are difficult to recognize. Layer 2a, consisting of fine material from the base of the flow, is locally present, but is usually very thin. All of the exposed ignimbrites exhibit 2b layers (Fig. 4) which commonly exhibit density grading, with normally graded lithics at their base and reverse-graded pumice at the top of the bed. Fine co-ignimbrite fallout ash or ash-cloud surge deposits of layer 3 were not recognized.

Some pyroclastic surge deposits occur in eruptive sequence I. They are typically poorly sorted lapilli tuffs which show subtle and subdued crossbedding. Apart from the crossbedding, the general appearance and mineralogy of the surge deposits are similar to the ignimbrites.

Within eruptive sequence I, a distinctive pair of thin fall deposits is found in sections 2, 3, and 4 (Fig. 3). The two fall deposits cap a prominent unconformity which ranges from 26 to 30 m above the top of the La Jencia Tuff. The lower unit is bimodally sorted and averages

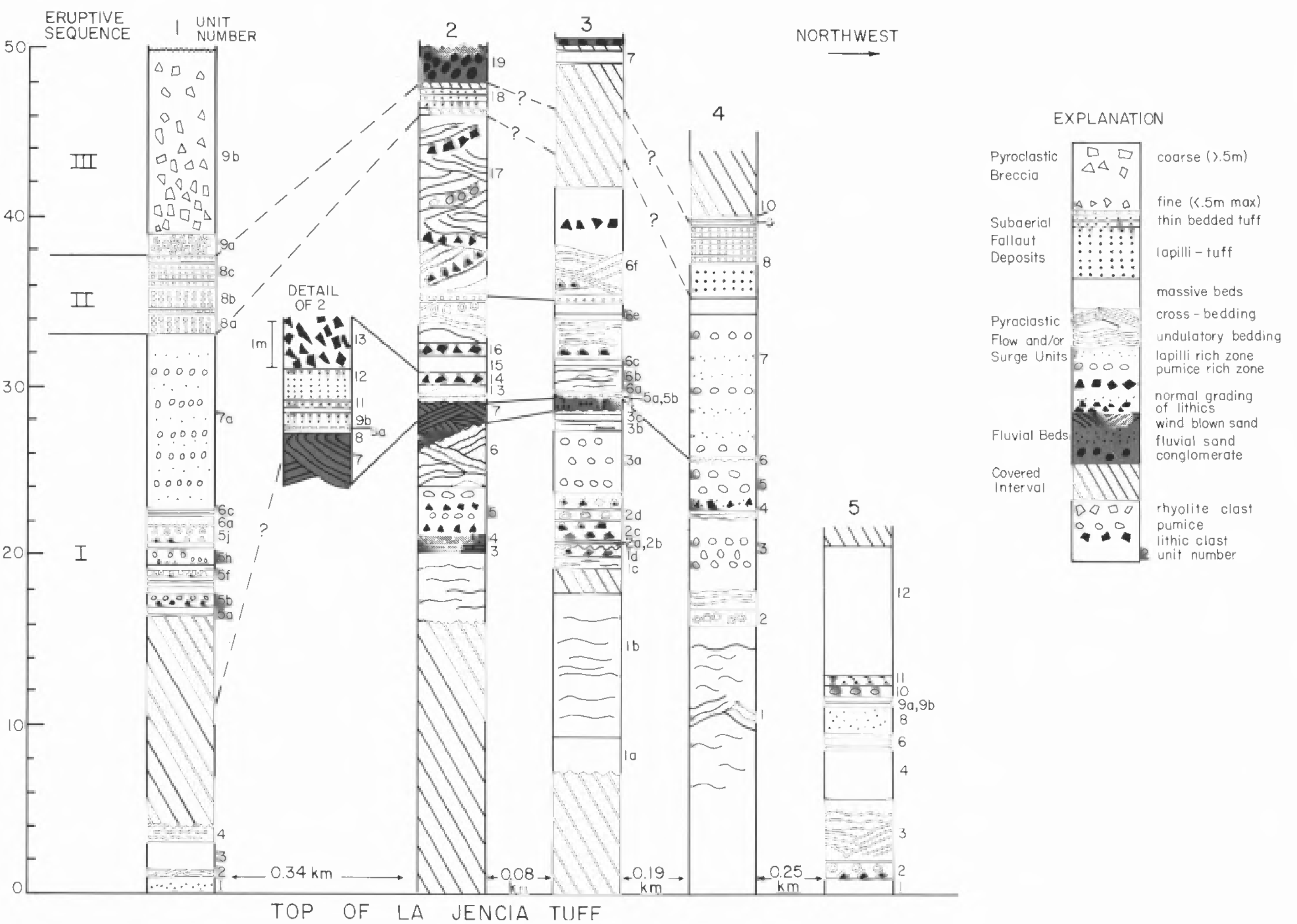

FIGURE 3—Simplified measured sections through pyroclastic deposits exposed in Scales Canyon.

FIGURE 4—Small ignimbrites of eruptive sequence I seen in section 1, Scales Canyon. Lens cap is 58 mm in diameter. Top and bottom of a single flow are outlined in dashed lines on left. Erosional unconformity at top of photograph. Location is shown in Fig. 3. Photo G.R. Osburn.

about 2 cm in thickness. It is massive and composed of pumice lapilli in a distinctive purple to lavender, fine-ash matrix. Although the unit is poorly sorted, atypical of fall deposits (Fisher & Schmincke 1984), it does show mantle bedding and can be easily traced for 1 km. We believe the ash matrix was flushed out of the atmosphere by rain, which could account for the color that resulted from oxidization in the eruption cloud. No accretionary lapilli were found.

A 10–15 cm thick white, well-sorted lapilli fall deposit overlies the purple unit. It also mantles the bedding and can be traced for over 1 km.

Small eolian deposits occur in eruptive sequence I. They consist of well-sorted, thin, crossbedded sandstone. The sand includes crystals, pumice, and small lithic fragments similar to those in the pyroclastic deposits. The eolian sands are restricted to channels along unconformities. These channels probably formed by fluvial erosion, although erosion by pyroclastic flows cannot be excluded. The fluvial sediments are locally overlain by a 4–6 cm thick, fines-depleted lapilli tuff. This pyroclastic unit has locally overturned the bedding of the underlying sandstone and may represent a low-aspect-ratio ignimbrite (Walker et al. 1980).

Correlation

Correlation of the thin, discontinuous ignimbrites is impossible. However, it has been possible to make direct correlations between section 2, 3, and 4 based on the presence of unconformities and a fall deposit.

Two unconformities have been identified (Fig. 3). The lower unconformity formed a channel by erosion. Eolian sands then were deposited in the channel. The unconformity is overlain by a thin ignimbrite and has been correlated between sections 2, 3, and 4 (Fig. 3). In section 1 this unconformity is covered by colluvium and was not recognized. The unconformity varies from 5 to 20 m above the La Jencia Tuff.

The upper unconformity is 6–9 m above the lower unconformity and is marked by erosion channels which were in turn filled by eolian deposits. Overlying the eolian deposits is a thin sequence of ignimbrites and the distinctive lavender fall deposits (see the description above) that can be correlated in three of the five measured sections. The lavender fall unit has not been found in section 1; however, two unconformities have been recognized in section 1 and one of them may correlate with the unconformity marked by the lavender fall deposit.

Eruptive sequence II

The middle eruptive unit consists entirely of well-bedded, well-sorted fall deposits. This unit is best exposed in section 1 (Figs. 2, 3), but has been also identified in sections 2 and 4. Two units were recognized.

The lower unit is about 2.7 m thick, well sorted and normally graded. Pumice at the base reach 7 cm in diameter and grade to about 1–2 cm at the top. A thin (5 cm) bed of well-sorted, fine ash is present about 1.3 m above the base. The thin layer is probably the result of rain flushing of the eruption plume. The upper unit is characterized by thin bedding of well-sorted, coarse ash. Vitric clasts to 2 cm are common. Tephra in this sequence is considered to result from a Plinian or sub-Plinian eruption.

Eruptive sequence III

Two deposits of coarse pyroclastic breccia which cap the Scales Canyon sequence consist of a poorly indurated lower unit and a well-indurated upper unit. They are found only in section 1 (Fig. 3), but are also well exposed farther downstream in Scales Canyon, west of section 1. The lower unit is clast-supported, 1.1 m thick, and contains vesiculated vitric clasts of Taylor Creek-like lava up to 30 cm in diameter. Only minor matrix material is present between the blocks. The upper unit is about 10 m thick and contains rhyolite-lava blocks up to 1.5 m in diameter. The blocks are clast-supported and exhibit a crude normal grading with the largest blocks resting on the underlying layer. Pipe-like structures in this layer are interpreted as fumarole pipes. Induration is possibly due to silicification along clast edges, but has not been investigated. These two breccia units are interpreted to be block and ash deposits (Wright et al. 1980) formed by nuées ardentes from collapse of a dome, flow, or spire of the Taylor Creek Rhyolite.

A large clast at the base of the lower breccia unit scoured into the underlying pyroclastic fall beds and overturned a small segment. A flow direction from south to southwest can be inferred from the deformation.

Paleomagnetic study

A paleomagnetic study was undertaken to assess emplacement temperatures of the two pyroclastic-breccia units. Although possible elutriation structures were observed in the upper unit, field evidence was not sufficient to confidently determine the emplacement mechanisms of these units. Possible mechanisms range from cold rock avalanches to lahars to hot Merapi-style dome-collapse pyroclastic flows (Fisher & Schmincke 1984: 220). A quantitative determination of emplacement temperature would help constrain the emplacement mechanism of the Scales Canyon breccias.

A number of workers have applied paleomagnetic techniques to the determination of emplacement temperatures of volcaniclastic rocks. Early workers (Aramaki & Akimoto 1957) used simple conglomerate tests to determine whether or not clasts had been deposited above their Curie temperatures. Later workers (Hoblitt & Kellogg 1979) employed progressive thermal demagnetization to refine temperature estimates. The latter approach was used in this study.

Twenty oriented core samples were drilled from clasts in the two breccia units (nine from the lower unit, eleven from the upper). Natural remanent magnetization (NRM) of a standard-sized specimen from each core was then measured on a spinner magnetometer. One specimen from each sample was subjected to progressive stepwise alternating field (AF) demagnetization in fields of up to 40 milliteslas (mT). Specimens from selected samples from each unit were next subjected to stepwise thermal demagnetization to 725°C. Susceptibility of each specimen was monitored throughout thermal demagnetization to safeguard against possible mineralogical changes produced by laboratory heating.

The NRM vectors of samples from the lower unit are tightly grouped (Fig. 5a, b). Their average direction (declination $= -59.1$, inclination $= 166.6$, $\alpha_{95} = 4.3$) is reversed and within 10° of the average Oligocene field direction for their location (Beck et al. 1977). Both AF and thermal demagnetization produced nearly univectoral decay toward the origin (Fig. 6a, b), suggesting that the samples possess a single-component magnetization. This magnetization apparently represents a thermoremanent magnetization (TRM) acquired during cooling after the samples came to rest at a temperature above their maximum blocking temperature (approximately 550–600°C).

NRM directions of seven of the eleven samples of clasts from the upper breccia were well grouped with a mean direction statistically indistinguishable from the mean direction of the upper unit (Fig. 5c).

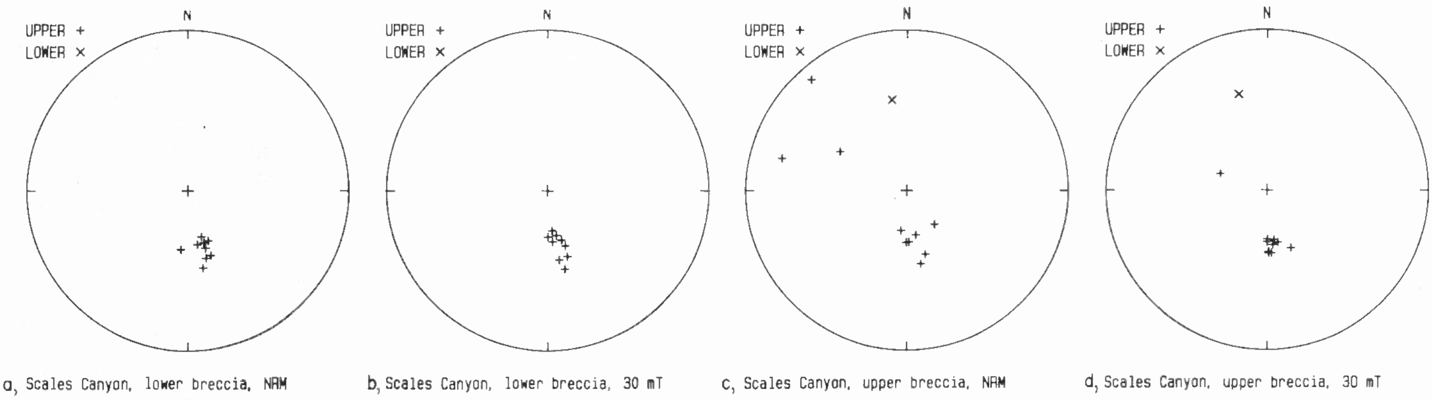

FIGURE 5—Stereographic projections of paleomagnetic directions of clast samples from Scales Canyon pyroclastic breccias before and after AF demagnetization to 30 mT.

These samples also showed single-component and thermal-demagnetization behavior nearly identical to the behavior of clasts from the lower breccia (Fig. 6c, d).

NRM directions of the remaining four clasts were scattered (Fig. 5c). Two of these four scattered samples showed multi-component AF and thermal-demagnetization behavior (Fig. 6e, f). After demagnetization, the directions of these two samples became nearly coincidental with the mean direction of the seven well-grouped samples (Fig. 5d). Directional changes were produced by peak fields of 10 mT or less (Fig. 6f), and apparently reflect removal of lightning-induced components of isothermal remanent magnetization (IRM). Demagnetization at peak fields greater than 10 mT produced only univectoral decay toward the origin (Fig. 6f). These two samples, as well as the upper breccia's seven well-grouped samples, apparently possess a TRM that was acquired during cooling after emplacement at a temperature above their maximum blocking temperature (approximately 500–600°C).

The remaining two scattered clasts (Fig. 5d) showed single-component AF and thermal-demagnetization behavior (Fig. 6g, h). Their scattered paleomagnetic directions cannot be explained by IRM components. Apparently, these two clasts cooled in one orientation and then were transported and emplaced at a temperature below their maximum blocking temperatures (approximately 200–300°C).

Results of the paleomagnetic study indicate that the lower breccia was deposited as an entirely hot pyroclastic flow, probably a nuée

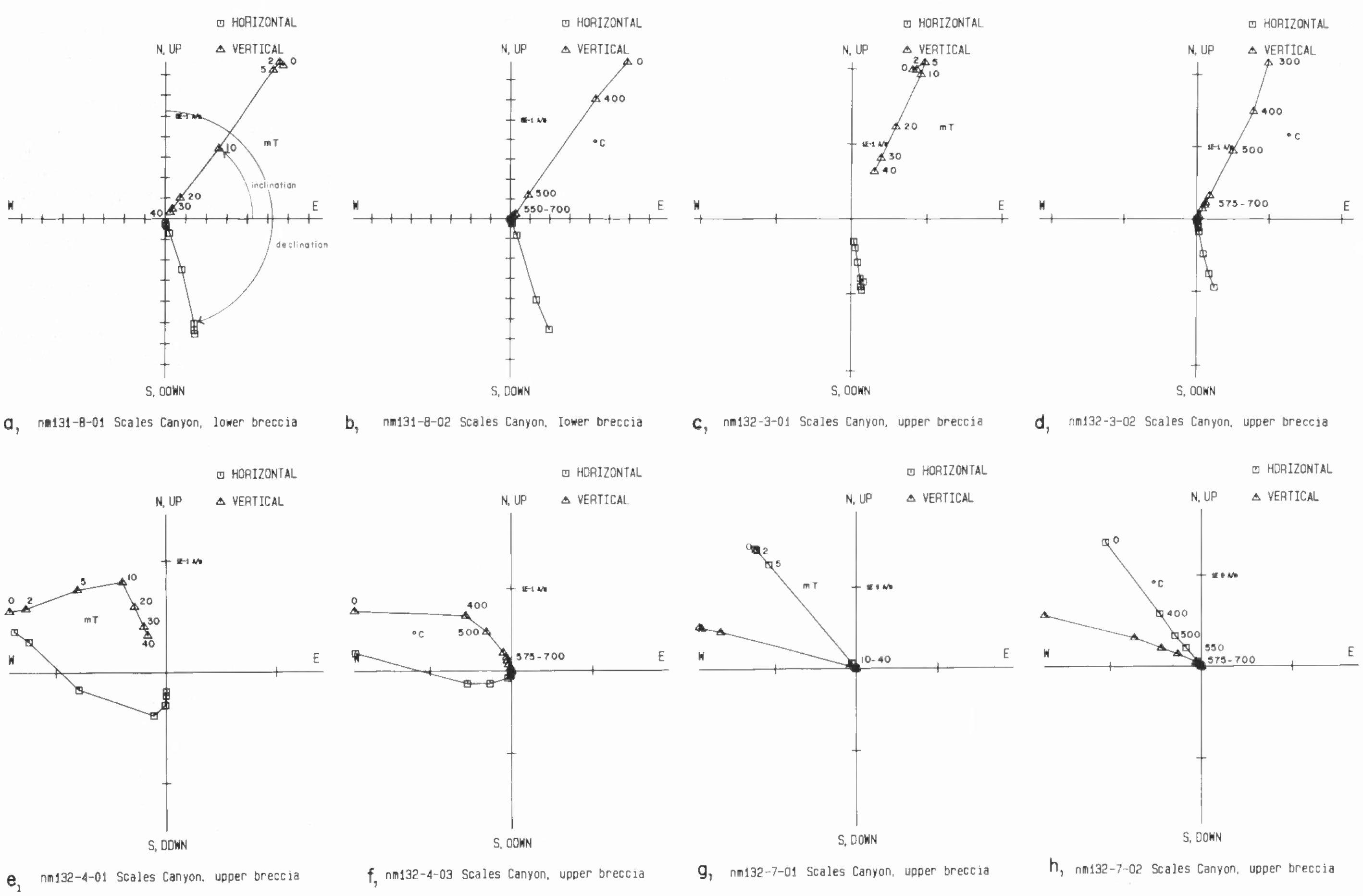

FIGURE 6—Orthogonal plots of AF and thermal demagnetization of representative samples. a–d, univectoral behavior of well-grouped sample directions; e, f, removal of lightning induced IRM components; g, h, single-component behavior of divergent sample.

ardente derived from collapse of a nearby ignimbrite dome. The upper breccia, however, represents a mixture of hot (>500°C) and cold (<300°C) clasts. This deposit may have been derived from a dome-collapse event in which substantial quantities of cool rhyolite from the outer carapace were mixed with hotter material from the dome's interior.

DISCUSSION

Although the correlations between measured sections are somewhat tentative, three eruptive episodes are recognized at Scales Canyon. The first episode consists of ignimbrites associated with minor eolian and surge deposits and two thin fall deposits. The second eruptive episode is represented entirely by fall deposits. Overlying coarse pyroclastic breccias comprise the third eruptive episode. The episodic nature of these deposits suggests that either the source eruptions were episodic or multiple source vents were involved. Either interpretation is tenable. Episodic eruptions from single vents are common phenomena (Newhall & Melson 1983). Alternatively, the four discrete domes located within a few kilometers of Scales Canyon (Eggleston & Norman 1986: fig. 3) represent ample potential for multiple vents. We have not yet developed criteria by which we can recognize specific source vents for individual pyroclastic deposits. The Taylor Creek rhyolites are chemically and mineralogically nearly identical, so ejecta cannot be lithologically correlated with individual centers.

When the three periods of pyroclastic eruption are compared with the idealized sequence of Heiken & Wohletz (in press), it is obvious that they do not correspond to their idealized model. Using the idealized sequence as a model, we suggest that the pyroclastic deposits in Scales Canyon represent eruptions from at least two eruptive centers. The pyroclastic fall deposits of eruptive sequence II probably represent the initial vent-opening stage in the formation of a dome. It is unlikely that these fall deposits were derived from the same center or centers as the underlying pyroclastic flows of sequence I. However, the dome-collapse block-and-ash deposits of eruptive sequence III may have been derived from the same source which produced the sequence I pyroclastic flows. Although speculative, these conclusions are consistent with the idealized model of Heikan & Wohletz (in press).

CONCLUSIONS

Pyroclastic deposits in Scales Canyon represent three eruptive episodes probably derived from a minimum of two dome-related vents. Because the lavas of the Taylor Creek Rhyolite are chemically and mineralogically similar, the eruptive vents cannot be identified.

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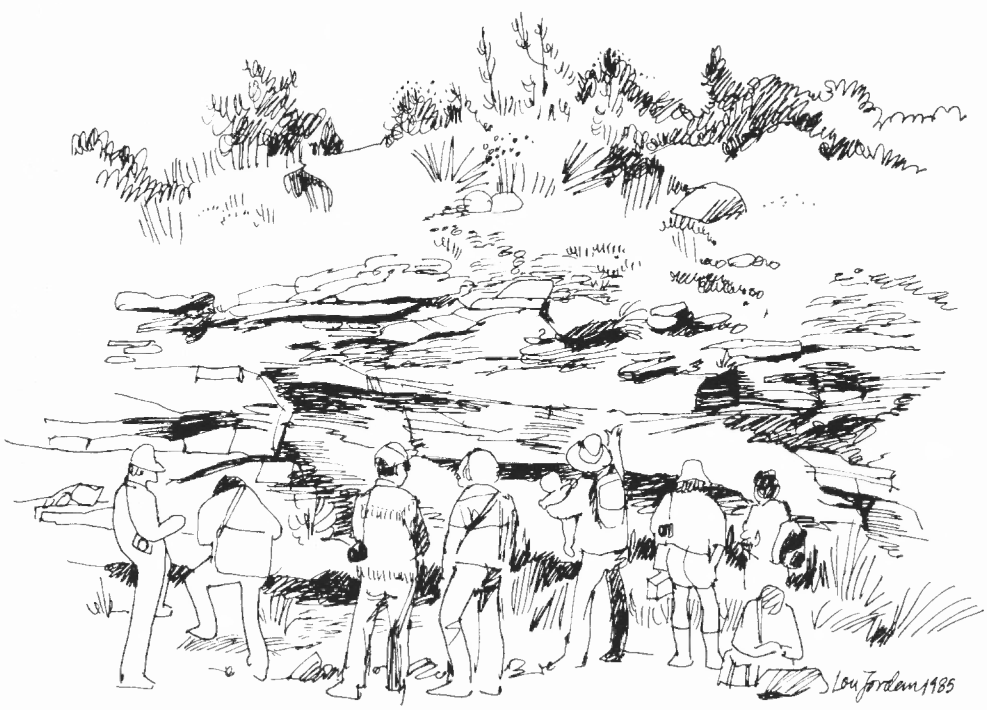

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