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Geology
of the
MOLINO PEAK QUADRANGLE

by

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Geologic quadrangle maps for the Socorro-Magdalena area, Socorro County, New Mexico

Several hundred square miles of detailed geologic mapping have now been completed on the volcanic rocks of the northeastern Datil-Mogollon volcanic field in the Socorro-Magdalena area. Most of this mapping has been available since completion as New Mexico Bureau of Mines and Mineral Resources open file reports consisting of individual thesis maps and accompanying texts. Over the years, however, the stratigraphic nomenclature has changed to the point that comparison between these individual maps is difficult. Several publications are currently being prepared to help resolve this stratigraphic confusion. The first of these is Stratigraphic Chart 1 which will present the current stratigraphic nomenclature in its entirety and provide a glossary and other correlation aids to relate this nomenclature to previously used names. This map-sheet size chart should be available by December 1981.

Concurrent with the preparation of Stratigraphic Chart 1, the thesis maps are being compiled in quadrangle format and placed on open file under the umbrella of open file 139. Each quadrangle will be assigned a prefix letter (such as 139 a) and will be available separately. An explanation and, in many cases, a short text will be available with the map. Nomenclature and map symbols for widespread units will be standardized. The mapping within these areas, while generally excellent, is not all of uniform quality, particularly in the treatment of Quaternary units. Additionally, most quadrangles have unmapped portions, usually in areas of extensive basin-fill alluvium.

Initially the maps will be compiled as they are and unmapped portions will remain. As time becomes available, holes will be filled in and problem areas field checked and upgraded. Obviously any errors in geology will remain and it is inevitable in recompiling this much geology that drafting errors will be made. A short note describing the known problem areas and the amount of checking that has been done will be included with each quadrangle. We ask you the users of these maps to notify us of any problem areas that you might find. Please send us a note as to the exact location and nature of the problems and we will make every effort to field check and correct them.

Thank you for your help.

C. E. Chapin
G. R. Osburn

INTRODUCTION

During the past 11 years a very large data base of detailed geologic mapping has been accumulated for the northeastern part of the Datil-Mogollon volcanic field -- the Socorro-Magdalena area. This mapping has mainly been done by graduate students of the New Mexico Institute of Mining and Technology working on the New Mexico Bureau of Mines and Mineral Resources Magdalena Project. The project has been supervised by C. E. Chapin and, since 1978, G. R. Osburn. Because of incomplete coverage and problematic stratigraphy, this mapping has not previously been compiled and published. Mapping and stratigraphic studies have now progressed to the point that selected areas can be compiled and released as geologic quadrangle maps. The first quadrangle to be released is the Molino Peak quadrangle located approximately 10 miles southwest of the town of Socorro.

In previous studies within this area and throughout the Socorro-Magdalena area, informal names have been used for many of the volcanic units. Several publications are now in preparation establishing a formal, and hopefully lasting, nomenclature for volcanic rocks in this area. This new nomenclature is used on this map sheet and for that reason direct reference to previous studies is problematical. Publications in preparation consist of a stratigraphic chart designed to introduce the new nomenclature and to facilitate comparison to previously used nomenclature, and the initial two circulars describing in detail the Datil Group (formerly the Spears Formation in this area) and the Hells Mesa Tuff. Stratigraphic Chart #1, Stratigraphic Nomenclature for volcanic rocks of the Socorro-Magdalena area, Datil-Mogollon volcanic field, is a prototype of a new series of New Mexico Bureau of Mines and Mineral Resources publications. Several location figures, stratigraphic columns and a glossary are provided on this sheet which the serious reader of this map will find indispensible.

PREVIOUS AND PRESENT WORK

Little previous geologic work has been done in or near the Molino Peak quadrangle. Earlier mapping by Kalish (1953) and Krewedl (1974) covered the northwestern corner of the quadrangle and mapping by Miesch (1956) and Willard (unpub.) covered a narrow strip along the eastern border.

Geologic mapping used in compiling this quadrangle includes most of the M. S. thesis maps of Osburn (1978) and Petty (1979) and small amounts of the M. S. thesis map of Roth (1980) and the dissertation map of Chamberlin (1980). In addition, the southern third of the quadrangle was mapped by Osburn during 1978 and 1979 while employed by the New Mexico Bureau of Mines and Mineral Resources. These areas of mapping responsibility are shown on fig. 1 (Plate 2). Mapping is available for much of the surrounding areas, mainly as thesis maps on open file with the New Mexico Bureau of Mines and Mineral Resources. An index to this mapping is included on Stratigraphic Chart 1 as fig. 2.

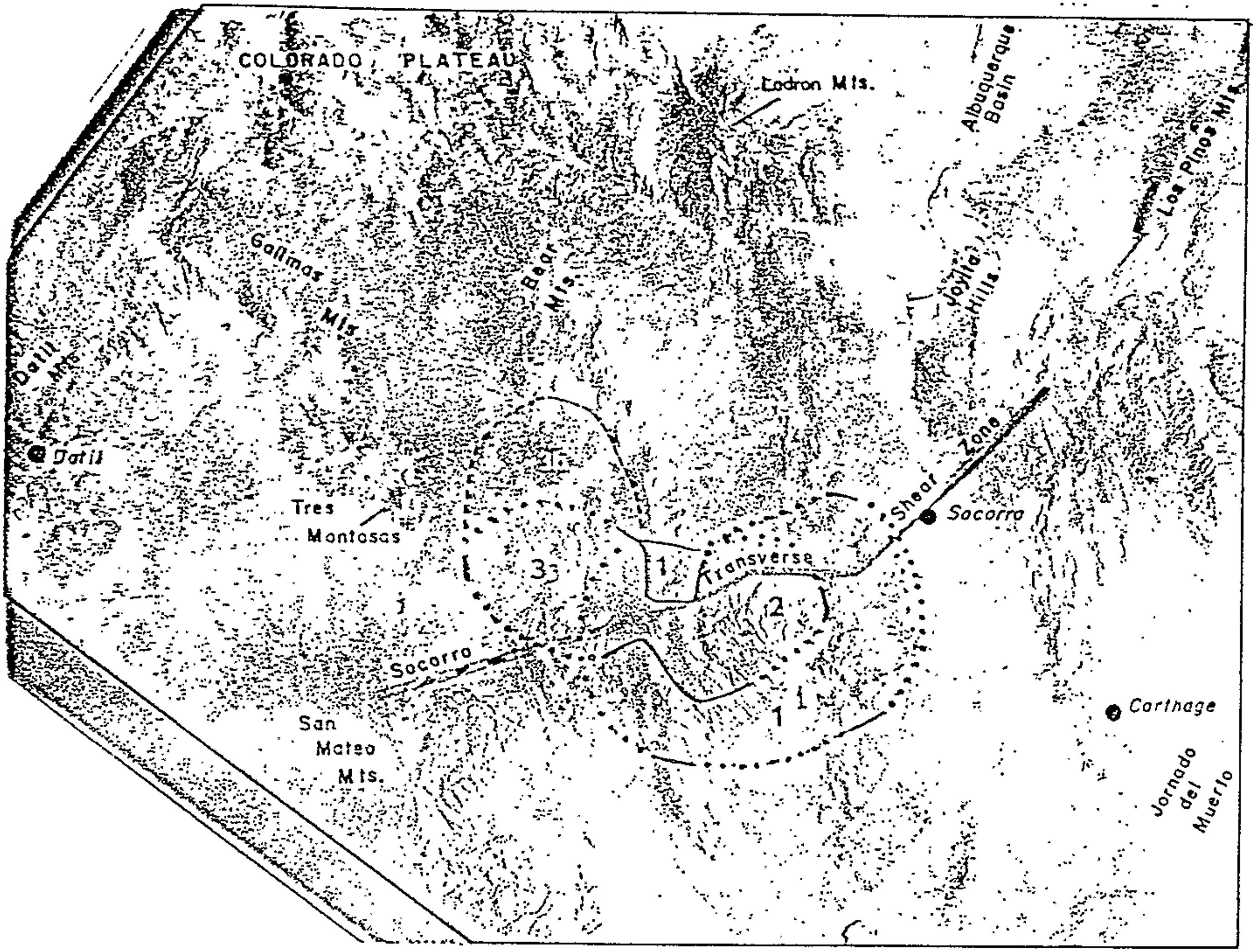
ACKNOWLEDGMENTS

The authors are indebted to many people whose efforts and sport have greatly improved this publication. We owe a major debt to the many workers who have established the stratigraphic base which made possible the mapping and interpretation of stratigraphic relationships in this very complex terrain. These early workers are easily forgotten since many of their interpretations have been changed with the acquisition of additional data. Individual workers and their study areas are detailed in Osburn and Chapin, 1981 (New Mexico Bureau of Mines and Mineral Resources, Stratigraphic Chart 1). We would also like to thank Smokey Pound and the ------ ------- Cattle company for access to their private lands and Tenneco Minerals for permission to map areas in which they own the mineral rights. The New Mexico Bureau of Mines and Mineral Resources provided field support for thesis studies and additional mapping.

STRATIGRAPHIC UNITS

All of the rocks exposed in this quadrangle are either Tertiary volcanic rocks or sedimentary rocks derived from the volcanic rocks. The oldest and most voluminous rocks are two Oligocene cauldron-facies ash-flow tuffs and their related cauldron-fill sequences. These are closely followed in time by two major outflow-facies ash flows and by interbedded mafic lava flows. The less voluminous Miocene and Pliocene volcanic rocks are mostly basalt and rhyolite lava flows which are intercalated with with basin-fill sediment of the Santa Fe Group. Short descriptions of each stratigraphic unit are given in the explanation with this map and, for most units, a more detailed stratigraphic description is not included in this text. The reader seeking more information is directed to Stratigraphic Chart #1, (Osburn and Chapin, 1981) or to the appropriate circular describing the specific unit (these to be released in parts beginning in 1981).

Ash-flow tuff cauldrons, while structural in nature, cause facies relationships which dominate the stratigraphy of this area. Figure 2 shows the relationship of the Molino Peak quadrangle to the surrounding cauldron complex and fig. 3 (Plate 2) is a generalized geologic map of the quadrangle showing in a simplified manner the relationships of the rocks related to these two cauldrons. This quadrangle is entirely within the large Socorro cauldron which erupted the Hells Mesa Tuff and was filled by the Luis Lopez Formation. These units, the oldest rocks exposed in the map area, are now restricted in exposure because in the northern two thirds of the area they have been downfaulted by the younger Sawmill Canyon cauldron. The Sawmill Canyon cauldron erupted one member of the La Jencia Tuff and was filled by the Sawmill Canyon Formation.



COLORADO PLATEAU
Ladron Mts.
Albuquerque Basin
Los Pinos Mts.
Gallinas Mts.
Bear Mts.
Joyita Hills
Datil Mts.
Datil
Tres Montosas
Socorro
Shear Zone
Transverse
Socorro
San Mateo Mts.
Carthage
Jornado del Muerto
1
2
3
1
1

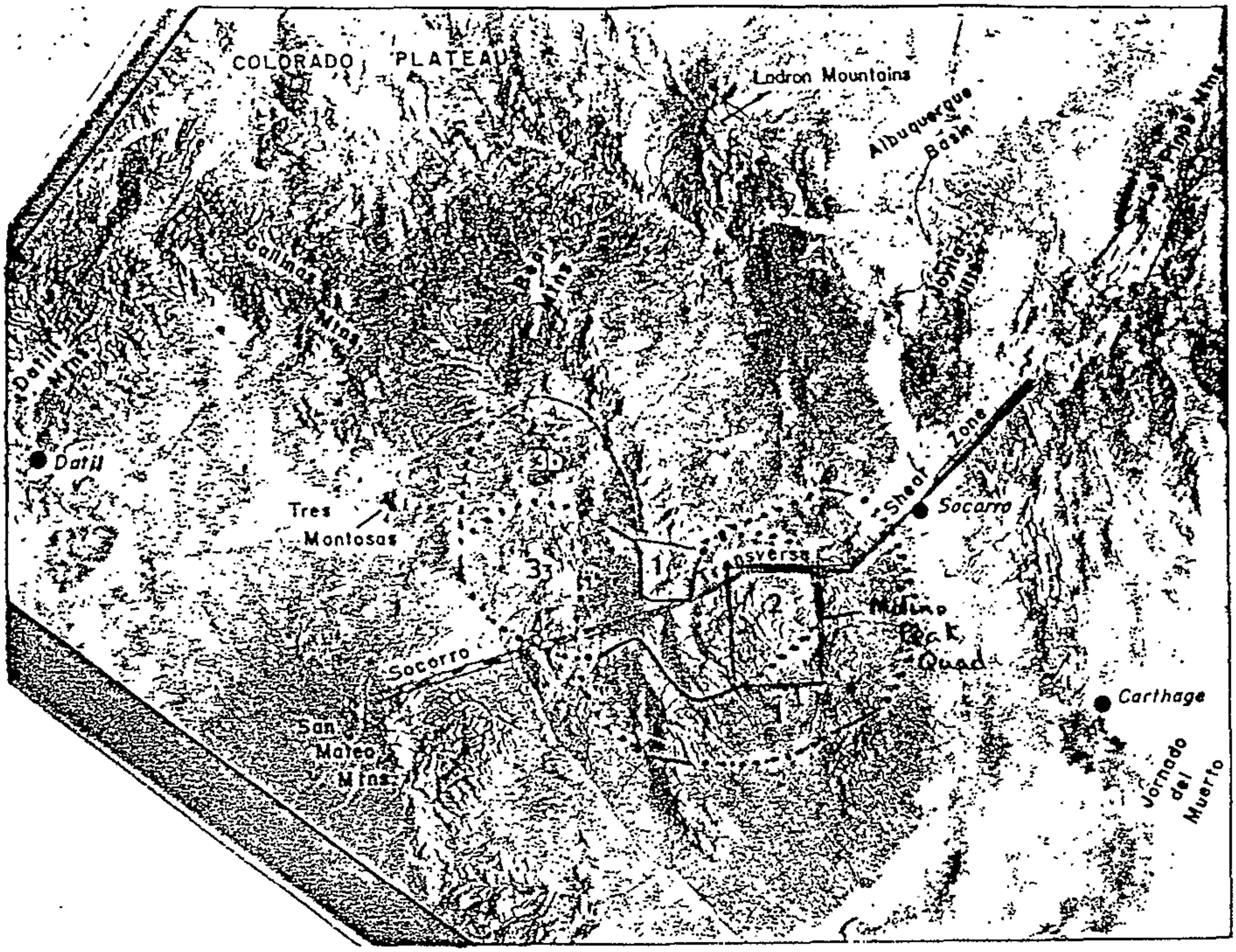


FIGURE 2. Location map showing the relationship of major volcanic structures and the transverse shear zone to topographic and cultural features. Base is reproduced from a NASA Skylab infrared photograph (G30A026195000). Solid lines mark exposed cauldron-wall segments; cauldron margin intervals inferred beneath younger units are dotted. The margins of the northern half of the Magdalena cauldron (3b) are well located but of problematic interpretation. This margin is shown as a dashed line. The Socorro cauldron (1) is the source for the Hells Mesa Tuff, and the composite Sawmill Canyon-Magdalena cauldrons (2, 3 and 3b) are thought to be the sources for the La Jencia Tuff. The north half of the Magdalena cauldron (3b) is apparently a structural bench which underwent relatively minor collapse after eruption. Source cauldrons for the Lemitar and Chocle Well Tuffs are thought from reconnaissance to be in the northern and central San Mateo Mountains. The transverse shear zone represents a domain boundary between fields of tilted fault blocks that have undergone rotation in opposite directions (see Chapin and others, 1978).

Socorro Cauldron

Cauldron facies Hells Mesa Tuff and the Luis Lopez Formation comprise the Socorro cauldron rocks exposed in this quadrangle. The Hells Mesa Tuff crops out sporadically along Ryan Hill Canyon for about three miles. The Luis Lopez Formation is exposed along this same trend and in scattered outcrops eastward to the edge of this map. Only one thick exposure of Hells Mesa Tuff is present in this quadrangle (sec. 7, T. 5 S., R. 2 W.). This exposure contains two distinctive zones which are similar to zoning in more extensive outcrops in the Chupadera Mountains further east (see figs. 4 & 5). This correlation confirms that the extensive outcrops in the Chupadera Mountains are Hells Mesa Tuff rather than Lemitar Tuff as previously hypothesized (Chamberlin, 1980). The lower zone is usually dark red to brown, densely welded, and quite lithic rich (5 to 30%). Common lithic fragment types include rhyolitic and andesitic lavas and several Precambrian plutonic and metamorphic lithologies. This lower zone is overlain by a light-gray, moderately welded, unit which contains numerous angular to partially flattened clasts of Hells Mesa lithology, but few other lithic fragments. The clasts are typically darker red than the matrix, but indistinguishable otherwise. This deposit has been interpreted (Chamberlin, 1980) as a "lag-fall" deposit (Wright and Walker, 1978) of partially solidified clots of Hells Mesa magma which were dropped early from the ash-flow cloud because of their greater density. The material may have been partially solidified Hells Mesa magma which accumulated in a vent or material disrupted from a hypabyssal intrusive, either of which could have formed during a hiatus in eruption and then been fragmented by continuing volcanism.

Exposures of the Luis Lopez Formation within this quadrangle, except for the two northern outcrops in Ryan Hill Canyon, are a relatively straight-forward layered sequence. They consist of a lithic-rich, poorly welded, crystal-poor tuff, overlain in turn by one or more andesitic lava flows and a thick sequence of rhyolitic lavas which are often underlain by an associated ash-flow tuff. The rhyolite lava in Ryan Hill Canyon probably represents a dome complex which is discordant to the section described above. On a larger scale, the Luis Lopez Formation varies laterally in a complex manner. This complexity together with limited exposures makes a detailed understanding of this formation virtually impossible. The best exposures of the Luis Lopez Formation are in the Chupadera Mountains and are described in detail by Chamberlin, 1980, Eggleston, in progress, and Osburn and others, in preparation.

La Jencia Tuff

The upper member (outflow) of the La Jencia Tuff crops out in only one area in the extreme southeastern corner of the map. The lower member is present in this outcrop area, and in several other small outcrops along the southern edge of the quadrangle. The lower member has strongly lineated pumice which yield transport directions south and southeast (radially?) away from the Sawmill Canyon cauldron.

Sawmill Canyon Cauldron

The cauldron-facies La Jencia Tuff and the Sawmill Canyon Formation comprise the Sawmill Canyon cauldron related rocks exposed in this quadrangle. Large and very thick exposures of cauldron-facies La Jencia Tuff are found along Ryan Hill Canyon along the west side of this quadrangle and in Sawmill Canyon just to the west (see fig. 3). These rocks are tentatively correlated with the lower member of the La Jencia Tuff because of the presence of strongly lineated pumice which is characteristic of parts of the lower member. Both members of the La Jencia Tuff have similar petrographic characteristics and no straight-forward discrimination method is known.

In contrast to the "dirty" (lithic-rich) cauldron-facies Hells Mesa Tuff, the intra-cauldron La Jencia Tuff is remarkably clean throughout most of its exposure. Although few small lithic-fragments are present, several large "mega-blocks" are present in the Sawmill Canyon area, and in both canyons a thin rhyolite lava has been mapped within the upper part of the tuff. This lava may occupy the break between lower and upper members or, alternatively, may have been erupted during a hiatus in eruption of the lower member. An anomalously crystal-rich (15-35%) zone is present at the top of the cauldron-facies La Jencia Tuff in a few places (Bowring, 1980); however, this zone has not been mapped separately.

The cauldron-filling Sawmill Canyon Formation, where it is exposed in the western third of the cauldron, is a sequence of andesitic and rhyolitic lavas, sedimentary rocks and ash-flow tuffs. Together the units are at least 800 m, and possibly 1000 m in thickness. Within the lower two thirds of this section, andesitic lavas which predominate in the north interfinger in a complex manner with rhyolitic lavas and tuffs which are more abundant in the south. Throughout most of the area, a fairly extensive and thick "moat-fill" tuff, the Tuff of Caronita Canyon makes up the upper third of the section.

The Sawmill Canyon Formation pinches out southward against the southern topographic wall of the Sawmill Canyon cauldron.

This north-sloping unconformity trends northeastward across the southern part of this map area, but is very irregular in detail due to later structural offset and original scalloping. The rocks exposed beneath this unconformity are the Hells Mesa Tuff and the heterolithic Luis Lopez Formation.

A conspicuous northward thickening of the Sawmill Canyon Formation off of the topographic wall can be seen by comparing the stratigraphic interval between the Luis Lopez Formation and the overlying lower Lemitar Tuff in sec. 9, T. 5 S., R. 2 W. with the same interval farther north along Ryan Hill Canyon. In section 9, this interval consists of about 50 m of La Jencia Tuff; whereas, farther north about 800 m of Sawmill Canyon Formation overlies at least 800 m of La Jencia Tuff which has no exposed base (these thick La Jencia Tuff outcrops occur just off the western edge of the Molino Peak quadrangle; see Petty, 1979).

The actual pinch-out of the Sawmill Canyon Formation can be seen at two locations west of, and one location northeast of Torreon Springs (sec 8, T. 5 S., R. 2 W.). The reader is cautioned that these relationships show better at map scale than on the ground. Many outcrops are poor in this area of low relief and, more importantly, the rocks of the Luis Lopez Formation and the Sawmill Canyon Formation are quite similar lithologically. A detailed understanding of the local stratigraphy is required in order to properly separate the various rock units and to filter out the many post-cauldron structures.

At these pinch-outs, the Tuff of Caronita Canyon can be seen to thin and pinch out while the overlying Lemitar Tuff continues across the contact apparently unchanged. Actually, the Lemitar Tuff approximately doubles in thickness in a distance of about one mile, and thus served as the last fill of the Sawmill Canyon cauldron.

Outflow

Outflow stratigraphic units which post-date the filling of the Sawmill Canyon cauldron are the Lemitar and Chocle Well Tuffs and an interlayered tongue of La Jara Peak Basaltic Andesite. Both of the tuffs are texturally zoned upward from crystal-poor to more crystal-rich. In addition, the Lemitar Tuff shows complex chemical zoning from a basal high-silica rhyolite upward through a quartz-latite interval back to a rhyolitic composition at the top. The textural zoning in both units and the chemical zoning of the Lemitar Tuff from rhyolite upward to quartz latite can be explained using a relatively simple zoned-magma-chamber model (see Lipman and others, 1966); however, the change in the upper part of the Lemitar from quartz-latite back to rhyolite requires a more complex explanation. The concurrent eruption of two magma sources is a possible explanation.

Basin-Fill Sedimentary and interlayered volcanic rocks

Deposits overlying the Chocle Well Tuff, consisting of basin-fill sedimentary rocks and several interbedded volcanic members, comprise the Santa Fe Group within this quadrangle. In detail, the sedimentary deposits are quite complex. The lowest sedimentary interval consists of coarse red, well-indurated mudflow deposits and conglomerates. These deposits are thick in the northeast and southwestern parts of the quadrangle and just north of the northwestern corner of the map on Water Canyon Mesa. Within these areas transport directions in the northern areas is northward and in southern areas is southward. These opposing transport directions suggest the presence of a highland in the central part of the quadrangle during early Santa Fe time. There are a few outcrops of Popotosa within the area of this proposed highland; however, these appear to be localized in paleovalleys.

In the northeastern part of the quadrangle and in adjacent areas further north (Chamberlin, 1980), the red mudflow deposits are overlain by red, brown or greenish claystones. These units are members of the Popotosa Formation (Denny, 1940; Machette, 1978). In the southwestern part of the quadrangle the red mudflow deposits are overlain by a white, crystal-poor tuff which is tentatively correlated with the tuffs associated with the Pound Ranch Rhyolite. This tuff is overlain by buff to tan, poorly to moderately indurated fanglomerates. Similar fanglomerates directly overly the basalt of Madera Canyon in the southeastern corner of this quadrangle. Dips within these fanglomerates flatten upward to nearly horizontal and the deposits extent to the base of the highest mesa-capping basalt flow in the eastern part of the area and to the tops of the highest piedmont slopes in the west. The oldest of these upper fanglomerates are clearly Popotosa and the tops are at least as young as part of the Sierra Ladrones Formation. No lithologic breaks or sharp angular relationship is present to mark the beginning of Sierra Ladrones time; therefore, these upper fanglomerates are mapped as a single unit -- upper Santa Fe gravels. These gravels overly the Pound Ranch Rhyolite tuffs, basalt of Madera Canyon, or the basalt of Bear Canyon and Popotosa claystones in the southwest, southeast and northeast parts of the quadrangle respectively.

Several informal volcanic units and one formation are mapped within the Santa Fe Group in this area. The rhyolitic lavas in the center part of the quadrangle are here called the Pound Ranch Rhyolite for exposures south of Pound Ranch. This rhyolite consists of two small domes (lower member), a fairly extensive upper lava flow (upper member), and thin associated ash-flow tuffs. Exposures of ash-flow tuffs in the southwestern corner of the quadrangle, where they are interbedded in the upper Santa Fe gravels and physically isolated from the rhyolitic lavas flows, are tentatively correlated with the Pound Ranch Rhyolite because of similar phenocrysts content and stratigraphic position.

At least three basaltic lava flows are interbedded in the Santa Fe deposits. The lowermost of these is here named the basalt of Madera Canyon for exposures south and east of Madera Canyon in the central part of this quadrangle. This basalt normally lies, with slight angular unconformity, on the eroded top of the Chocle Well Tuff; however, locally it is underlain by Popotosa sedimentary rocks in paleovalleys.

The second mafic lava, the basalt of Bear Canyon (Chamberlin, 1980), is interbedded in Popotosa Formation claystones in the northeastern part of the quadrangle. This basaltic lava is traceable southward in scattered outcrops to Broken Tank in the east central part of the map and a basaltic lava flow is found in a similar stratigraphic position just off the southeastern corner of the quadrangle. No claystones are exposed at this southern exposure and the thin-section textures are somewhat different; therefore, no direct correlation is possible.

The youngest basaltic lava flow in the area, the basalt of Broken Tank, is here informally named for Broken Tank in the east-central part of the quadrangle. Here, it forms the mesa rimrock, overlying several hundred feet of upper Santa Fe gravels. One mile to the east the basalt flow laps across a major fault and directly overlies the Hells Mesa Tuff (fig. ___). This same basalt interval also crops out at the rimrock on mesas just east of the southeastern corner of the quadrangle.

Piedmont slope, alluvial fan, and stream deposits which occur throughout the area are mainly deposits of older generations of presently existing drainages with similar sediment source areas. A wide strip of these deposits occurs in the valley between the Chupadera and Magdalena mountains. The oldest of these deposits have a thick, well-developed caliche cap and may be as old as middle Pleistocene.

STRUCTURE

All known faults within this quadrangle are younger than the two cauldrons and have normal displacement. The cauldron faults which must be present are apparently buried by younger volcanic units. The dominant structural trend is N 10 to 25 W and almost all of the faults are down-to-the-west. Small areas of down-to-the-east faulting are present along the western side of the map (secs. 2 and 11, T. 5 S., R. 3 W.) and (secs. 1,2,11,12, T. 4 S., R. 3 W., unsurveyed). The southern of these down-to-the-east fault zones is thought to be a small antithetic horst and graben system caused by dilation along a normal fault. The larger graben just south of South Canyon and the down-to-the-east faults trending south from it apparently penetrate from the north. Grabening is the typical structural style on Water Canyon Mesa which lies just across South Canyon to the north. In this area, South Canyon lies on the Socorro transverse shear zone, a structural domain boundary across which beds and fault planes have been rotated in opposite directions (Chapin and others, 1978). Locally, relationships may be quite complex along this domain boundary; the grabening along South Canyon is thought to be an area where structural elements from opposite sides of the zone interfinger. Alternatively, the northern down-to-the-east faults may be younger structures, extensions of the down-to-the-east fault that bounds the east side of the northern Magdalena Mountains.

A zone of anomalous northeast-trending structures can be traced diagonally northeastward from the southwest corner of this map. Most of these faults can be followed for only short distances and in many cases the displacement can be shown to join a north-west trending fault. The preferred interpretation for these off-trend faults is that they are jogs where north-west trending faults have adjusted laterally along previously existing transverse structures. These transverse faults are then, in fact, segments of north-west trending down-to-the-west faults. This zone of transverse faulting follows quite closely the zone between the ring fractures and outer topographic rim of the southern Sawmill Canyon cauldron. It, therefore, seems probable that the transverse elements of the younger structure are reflecting the presence of the older cauldron-related structures.

ALTERATION AND MINERALIZATION

Alteration within this quadrangle consists of a widespread and pervasive alkali metasomatism and minor areas of presumed supergene alteration along Ryan Hill Canyon (sec. 1, T. 5 S., R. 3 W.). The alkali metasomatism affects units as young as the upper member of the Pound Ranch Rhyolite and all of the quadrangle north of the approximate trace of the southern Sawmill Canyon cauldron margin. Regionally, the area of alteration includes most of the Magdalena, Chupadera and Lemitar Mountains (see Chapin and others, 1978).

This form of alkali exchange alteration causes quite distinct petrographic and chemical changes but has a relatively minor effect on hand specimen or outcrop characteristics. Most plagioclase feldspar is altered to clay minerals or to alkali feldspar, which are usually plucked out during thin section preparation, and sphene is altered to leucoxene. Other minerals, including alkali feldspar, biotite, quartz, and magnetite are apparently unaffected. Chemically the major changes include net addition of potassium, and net losses of calcium, sodium, magnesium, (see DeAndrea, 1981). It is somewhat startling that a rock which has been changed so much chemically looks so fresh. Rock color, groundmass and pumice texture, and most phenocrysts are normal in appearance. Sanidine is usually clear and biotite is black or coppery and shiny.

Reasonable success in field identification of this type of alteration has been possible using, as a criterion, the presence of two distinct types of feldspar in a rock that otherwise appears unaltered. The sanidine is clear to slightly milky with good cleavage while the other feldspar (presumably plagioclase) is chalky with no cleavage. This alteration has been hypothesized to be the result of alkali exchange in an ancient geothermal system (Osburn, 1978; Chapin and others, 1978).

Manganese-oxide mineralization occurs at scattered locations throughout this quadrangle. Most occurrences are small and have been explored by bulldozer trances. Some ore has been produced from several open cuts along Chaves and Molino Canyons. Another prospect west of Ryan Hill Canyon (sec. 2, T. 5 S., R. 3 W.) may have produced some ore as there is an aerial tramway in position there; however, the amount of excavations near the head of this tramway does not suggest very much production.

The manganese mineralization occurs mainly as fracture and breccia fillings of manganese oxides, black and white calcite and quartz. Minor galena is present at one prospect (sec. 2, T. 5 S., R. 3 W.). The spatial coincidence of the manganese mineralization with the alkali metasomatism suggests a genetic relationship between the two.

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EXPLANATION

Quaternary Alluvial Deposits

[Qa] ALLUVIAL DEPOSITS: Quaternary alluvial deposits within this map have been separated into geomorphologic classes (such as alluvial fan, piedmont slope, or valley alluvial deposits) as much as was practical. Most deposits, except for colluvial and talus deposits, have also been separated by age. All those deposits with little or no soil development are classed as young with the addition of a suffix letter "y". Older deposits with appreciable soil development are classed as old and denoted with an "o". Age sequences within piedmont slope deposits are numbered from youngest to oldest. Most units are greater than 1 meter thick where mapped and locally include minor alluvial deposits of other morphologies.

[Qvy]
[Qvo] Valley Alluvium (0-50 ft, 15 m) SAND, GRAVEL, AND FINE-GRAINED COLLUVIAL DEPOSITS: Sands and gravel in active stream channels, or finer grained deposits (mainly silt and clay) in alluviated valleys.

[Qfy] ALLUVIAL FAN DEPOSITS: Minor alluvium with alluvial fan morphologies along steep scarps.

PIEDMONT SLOPE DEPOSITS (0-150 ft, 45 m) CONGLOMERATES, SANDSTONES, AND BOULDER ALLUVIUM: Fanglomerates, containing mixed clasts of all major rocks types exposed in present highlands

[Qpy] piedmont slope deposits with little, if any, soil development

[Qpo1] older piedmont slope deposits with appreciable soil development.

[Qpo2] Map units within these deposits are separated by soil development and relative topographic level. These units are numbered from youngest to oldest.

[Qtc] talus/colluvium -- unconsolidated talus, soil-stabilized talus and slope wash deposits.

[Qg] unassigned gravels -- mainly piedmont and valley alluvium, now isolated within bedrock areas and not readily assignable to another map unit.

SANTA FE GROUP -- Tertiary Basin-Fill Sediments

[Tsu] Upper Santa Fe gravels undivided (0-500 ft, 150 m) FANGLOMERATES and SANDSTONES: Buff to tan, poorly indurated, pebble to cobble conglomerates and sandstones. Formerly mapped as Sierra Ladrones Formation (Osburn, 1978; Petty, 1979). The lack of a clear-cut unconformity with the underlying Popotosa Formation prevents this correlation.

Popotosa Formation [Denny, 1940] (0-3000 ft, 900 m) FANGLOMERATES, MUDFLOW DEPOSITS, MUDSTONES, and SANDSTONES: Bolson deposits interbedded locally with contemporaneous volcanic rocks. Within this quadrangle, the lowermost rocks are usually red well-indurated mudflow deposits which are overlain by a thick sequence of playa claystones; regionally, however, these lithologies grade into, or intertongue with, other facies. One formations and several informal volcanic members have been mapped interbedded with the Popotosa Formation.

[Tpp] playa facies -- red, brown or green claystones with minor gypsum. These deposits become thinner and possibly interbedded with other lithologies to the south.

[Tpl] Lower Popotosa -- red, well indurated mudflow deposits and minor conglomerates.

VOLCANIC ROCKS INTERBEDDED IN BASIN-FILL SEDIMENTARY ROCKS

Pound Ranch Rhyolite

[Tpr2] upper member [Osburn, 1978] 10.5 ± 0.4 m.y. (0-650 ft, 200 m) QUARTZ LATITE LAVA FLOWS: Dense, porphyritic, quartz-latite lava flows. Texturally zoned from basal black vitrophyre, to middle red, finely flow-foliated interval, to upper pale-red, crudely flow-foliated interval. Contains 10-25% phenocrysts of plagioclase, biotite, and hornblende.

[Tprl] lower member [Osburn,1978] 11.8 ± 0.5 m.y. lavas (0-400 ft, 120m) RHYOLITE LAVAS: Dense, crystal-rich, pale-red-brown rhyolite lavas. Apparently consists of two small domes or thick lava flows. Crudely flow-foliated. Contains 25-40% phenocrysts of plagioclase, quartz, sanidine, biotite and a trace of hornblende.

[Tprt] ash-flow tuffs associated with the Pound Ranch Rhyolite -- ASH-FLOW AND AIR-FALL TUFFS: Two sequences with distinct lithologies present in many places, but usually compiled together. Lower, buff, poorly welded interval has mineralogical composition similar to the lower lava; the upper, usually vitric, densely welded tuff is similar in mineralogy to the upper lava.

Tpt] ASH-FLOW TUFFS (0-150 ft, 45 m): Light-colored, crystal-poor, poorly welded ash-flow tuffs. Contain 10 to 20 per cent total phenocrysts consisting of quartz, plagioclase, sanidine, biotite, and hornblende. Probably correlative with Tprt.

[Twr] Rhyolite lavas of Water Canyon Mesa (0-500 ft, 150 m) SILICIC LAVA FLOWS: Pink to grayish-red, phenocryst-rich, quartz-latite lavas. Contains 15 to 40 per cent total phenocrysts consisting of plagioclase, biotite, hornblende and traces of quartz. Most of this unit has been strongly altered by K2O metasomatism.

Basaltic Lavas

[Tbtb] Basalt of Broken Tank (0-150 ft, 45 m) BASALTIC LAVA FLOWS: Grayish-black, micro-vesicular, slightly porphyritic basaltic lava flow. Contains sparse phenocrysts of plagioclase and clinopyroxene in a coarse-grained groundmass with subophitic texture.

[Tbb] basalt of Bear Canyon [Chamberlin, 1980] (0-50 ft, 15 m) BASALTIC LAVA FLOW: Dense, black, fine-grained basalt with well-developed ophitic texture.

[Tmb] basalt of Madera Canyon [New Name] (0-600 ft, 185 m) BASALTIC LAVA FLOWS: Gray to black, dense basaltic to basaltic andesite lavas containing a few percent pyroxene and plagioclase phenocrysts. Locally some flows containing abundant olivine clots to 2 cm.

TERTIARY ASH-FLOW TUFFS AND REGIONAL LAVAS

[Tcw] Chocle Well Tuff 26 m.y. (0-650 ft, 200 m) ASH-FLOW TUFFS: Simple to compound cooling unit of quartz-rich, one-feldspar rhyolite tuff. Lower member of light-gray to brownish-gray, crystal-poor (1-4%) tuff and an upper member of medium-gray to purple-gray, moderately crystal-rich (15-25%) one-feldspar tuff with abundant chatoyant sanidine and euhedral quartz. The two members are mapped together. Source unknown.

[Tlp] La Jara Peak Basaltic Andesite Tongue (0-500 ft, 150 m) BASALTIC ANDESITE LAVAS: Dark gray to purple, fine-grained, mafic lava flows Usually contain 1-5% red, altered ferro-mag. and occasionally plagioclase phenocrysts.

[Tr] RHYOLITIC LAVA FLOWS (0-250 ft, 75 m): Pink to gray, crystal-poor, silicic lava flows. Contains few, if any, phenocrysts, but usually contains prominent spherulites. Crops out in two small separate areas (sec. 19, T. 4 S., R. 2 W., and sec. 35, T. 4 S., R. 3 W.). These separate outcrops may be two small domes or parts of a lava flow which was localized in a paleo-valley.

[Trt] The southwestern of these two outcrops is underlain by as much as 300 feet of pink to brown, crystal-poor, lithic-rich ash-flow tuffs and interbedded coarse-grained, immature sandstones and conglomerates.

Lemitar Tuff 28 m.y. (500 to 1500 ft, 450 m) ASH-FLOW TUFFS: Strongly zoned, simple cooling unit of ash-flow tuff. Divided into two members at an increase in phenocryst content.

[Tlu] Upper member - Medium-red to light-yellowish-gray, reversely zoned, crystal-rich tuffs. Zoned from lower, plagioclase-rich, quartz-poor quartz latite at base which contains 25 to 35% total phenocrysts consisting of plagioclase, biotite, sanidine and hornblende, and traces of magnetite, to quartz-rich rhyolite at top which contains sanidine, quartz, biotite, plagioclase and traces of magnetite and sphene. Rhyolite commonly contains red clots of quartz-latitic magma similar to the lower parts of the member.

[Tll] Lower member - Light-gray to pale-red, crystal-poor (5-15%), homogeneous rhyolitic tuffs, commonly containing a lithophysal zone near the middle. Contains 5 to 15% sanidine, quartz and biotite and traces of plagioclase, sphene and magnetite.

[Tj] LA JENCIA TUFF [New Name] 30-32 m.y. (0-650 ft, 200 m--outflow, >3000 ft, 900 m--cauldron facies) ASH-FLOW TUFFS: Two cooling units of densely welded, crystal-poor, one-feldspar tuff. Both members contain 3 to 10% sanidine, minor small rounded quartz phenocrysts and traces pf plagioclase, biotite and magnetite. The members, while quite similar lithologically can usually be separated by texture and stratigraphic position.

[Tju] upper member -- gray to purple gray, poorly to densely welded tuff containing large partially collapsed pumice which commonly have interior parts replaced by large euhedral vapor phase crystals of quartz and feldspar. These pumice typically are surrounded by a light-colored rind.

[Tjl] lower member -- light-pinkish-gray to lavender tuff that is commonly densely welded to the base. Usually has strongly lineated pumice and gas cavities in center parts of unit. Within this quadrangle the lineations trend between N 20 W and N 50 W.

[Tjc] cauldron-facies La Jencia tuff -- Extremely thick section of densely welded, very crystal poor, pumiceous ash-flow tuff. Commonly light to medium-gray with dark-reddish-brown to purple pumice. The pumice are usually strongly lineated in a generally east west direction. Tentatively correlated with the lower member because of the lineated pumice.

[Thm] HELLS MESA TUFF: (Chapin, 1974) 33 m.y. (>1600 ft, 500 m) ASH-FLOW TUFFS: Simple to compound cooling unit of crystal-rich (25-50%), quartz-rich, two-feldspar, rhyolite tuffs. Pink to reddish-brown when fresh and densely welded, gray when poorly welded or propylitically altered (mainly in western half of the cauldron). Lithic-rich zones, mesobreccias and large exotic blocks common, as are "lag-fall" breccias (see text) near the top of the section.

CAULDRON FILL UNITS

[Tx] Sawmill Canyon-Magdalena cauldron fill

Sawmill Canyon Formation [New Name] (0-2500 ft, 750 m) ANDESITE LAVAS, RHYOLITE LAVAS, ASH-FLOW TUFFS, CONGLOMERATES, and MUDFLOW DEPOSITS: Heterolithic fill of Sawmill Canyon Cauldron. In northern part, the fill consists largely of andesitic lavas and interbedded mud- and debris-flow deposits. To the south, andesite lavas interfinger with rhyolite lavas and conglomeratic sandstones, and are overlain by a thick intra-caldera ash-flow tuff, the Caronita Canyon Tuff [New Name] 29.4 m.y.

[Txc] Tuff of Caronita Canyon [Petty, 1979] 29.4 ± 1.1 m.y. (0-1200 ft, 365 m) ASH-FLOW TUFFS: Multiple-flow, simple-cooling-unit of ash-flow tuffs showing strong reverse zoning. Usually divided into two members at a sharply gradational upward increase in phenocryst content and change to rhyolitic mineralogy.

[Txcu] upper member-- White to medium gray, crystal-rich, moderately to densely welded tuff. Contains 30-50% phenocrysts of sanidine, quartz, biotite and minor magnetite. Quartz is often large and prominently dipyramidal. Locally (secs. 5 & 6, T. 5 S., R. 2 W.) contains at least one thin sandstone parting.

[Txcl] lower member -- Brown to reddish, moderately crystal-poor, poorly to densely welded ash-flow tuffs. Contains 5-20% phenocrysts of plagioclase, biotite, magnetite, and traces of clinopyroxene, quartz, and sanidine. Locally has black basal vitrophyre.

[Txrp] porphyritic rhyolite lava (0-1200 ft, 365 m)
RHYOLITIC LAVA FLOWS:

[Txrpt] Brown to pinkish-gray, porphyritic lava flow. Contains 5-30% phenocrysts of sanidine, quartz, and minor magnetite and biotite. Usually contains 1 to a few per cent brownish-gray, partially embayed andesite lithic fragments.

[Txr] CRYSTAL-POOR RHYOLITIC LAVAS, and DOMES (0- 1000 ft, 300 m):

[Txrt] Fine-grained, pink, gray or brown, crystal-poor to crystal-free, flow-banded rhyolitic lavas, locally overlying minor tuffs of similar lithology . Consists of several intrusive plugs in Sawmill Canyon (Roth, 1980) and lava flows in both Sawmill and Ryan Hill Canyons.

[Txa] ANDESITIC LAVAS (0-1500 ft, 450 m): Variable sequence of andesitic lavas including both fine-grained and porphyritic lithologies. Plagioclase porphyritic lavas are concentrated in the northern part of the cauldron along Sixmile and South Canyons. The uppermost andesites are similar to the La Jara Peak Basaltic Andesite.

[Txs] MUDFLOW DEPOSITS, CONGLOMERATES, AND SANDSTONES (0-650 ft, 200m): Northern exposures consist of coarse, angular, heterolithic mudflow deposits and minor conglomerates shed from the northern cauldron margin. These are interbedded with andesite lavas. Southern deposits consist of conglomerates, mudflow deposits and sandstones interbedded with rhyolites as well as andesites. Clast lithologies in the northern deposits include Spears-type andesites, Hells Mesa Tuff and rhyolitic lavas. Southern deposits contain all of the lithologies found in the north plus numerous clasts of the Luis Lopez Formation which crops out just to the south.

[Tz] Luis Lopez Formation [NEW NAME] (0-3500 ft, 1100 m) RHYOLITE LAVAS, MAFIC LAVAS, ASH-FLOW TUFFS, AND SEDIMENTARY ROCKS: Heterolithic fill of the Socorro Cauldron. Occurs between underlying cauldron-facies Hells Mesa and the overlying La Jencia Tuff.

[Tzr] Rhyolite lavas (0- 1600 ft, 500 m) Crystal-poor, variegated (white, tan, pink, or gray), rhyolitic lavas. Usually contains abundant red spherulitic devitrification structures and local vitric zones. Contains traces of biotite and sanidine phenocrysts. Locally underlain by:

[Tzrt] an ash-flow tuff of similar lithology

[Tza] Andesitic lavas (0-150 ft, 45 m) One or locally more dark-gray, to purple, plagioclase-porphyritic andesitic lava flows. Contains from 5 to 15% plagioclase, clinopyroxene and biotite phenocrysts.

[Tzt] Ash-flow tuffs (0-200 ft, 60 m) White to tan, crystal-poor pumiceous, and lithic-rich tuffs. Common clast lithologies include andesitic and rhyolitic lavas, Hells Mesa Tuff and several varieties of Precambrian plutonic and metamorphic rocks. The clasts average about 6 inches, but may be as large as 1 meter. Tuff matrix contains a few per cent quartz and sanidine phenocrysts, but the pumice are largely crystal-free.

[Tzs] TUFFACEOUS SANDSTONES (0-200 ft, 60 m): Yellow to buff, cross-bedded, tuffaceous sandstones and tuffs. May be base surge deposits associated with Tzr.

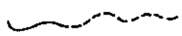
INTRUSIVE ROCKS

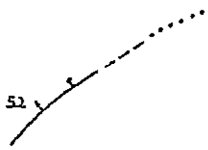
[Tri] RHYOLITE INTRUSIONS: Pink to tan, moderately phenocryst-poor flow-banded rhyolitic intrusions. Consists of two small plug-like masses (to 500 ft across) and at least two small dike-like masses. Contain a few per cent subhedral to euhedral sanidine phenocrysts.

[Twi] WHITE-RHYOLITE DIKES: White to light-gray, fine-grained rhyolite intrusions. Typically have a light color and silicified texture. There are several varieties containing varying amounts of phenocrysts.

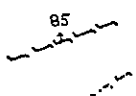
[Tmi] MAFIC DIKES: Several thin (1 - 20 ft, 6 m) fine grained dikes occur along Sixmile Canyon. These are usually badly altered.

SYMBOLS


geologic contact, dashed where approximate

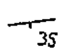


fault, dashed where approximate, dotted where covered, bar and ball on downthrown block, arrow and number give dip direction and angle of fault plane



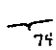
shear zone with no provable stratigraphic offset


gravity slide block



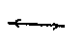
strike and dip of bedding or compaction foliation in ash-flow tuffs


horizontal and vertical bedding



strike and dip of flow foliation in lavas and intrusions.


horizontal and vertical foliation


flow lineation in flow-banded ash-flow tuffs and lavas


transport direction in conglomerates (pebble imbrications)


adit


prospect, most are bulldozer trenches


open pit excavation

OPEN FILE REPORT 139 A
PLATE 1

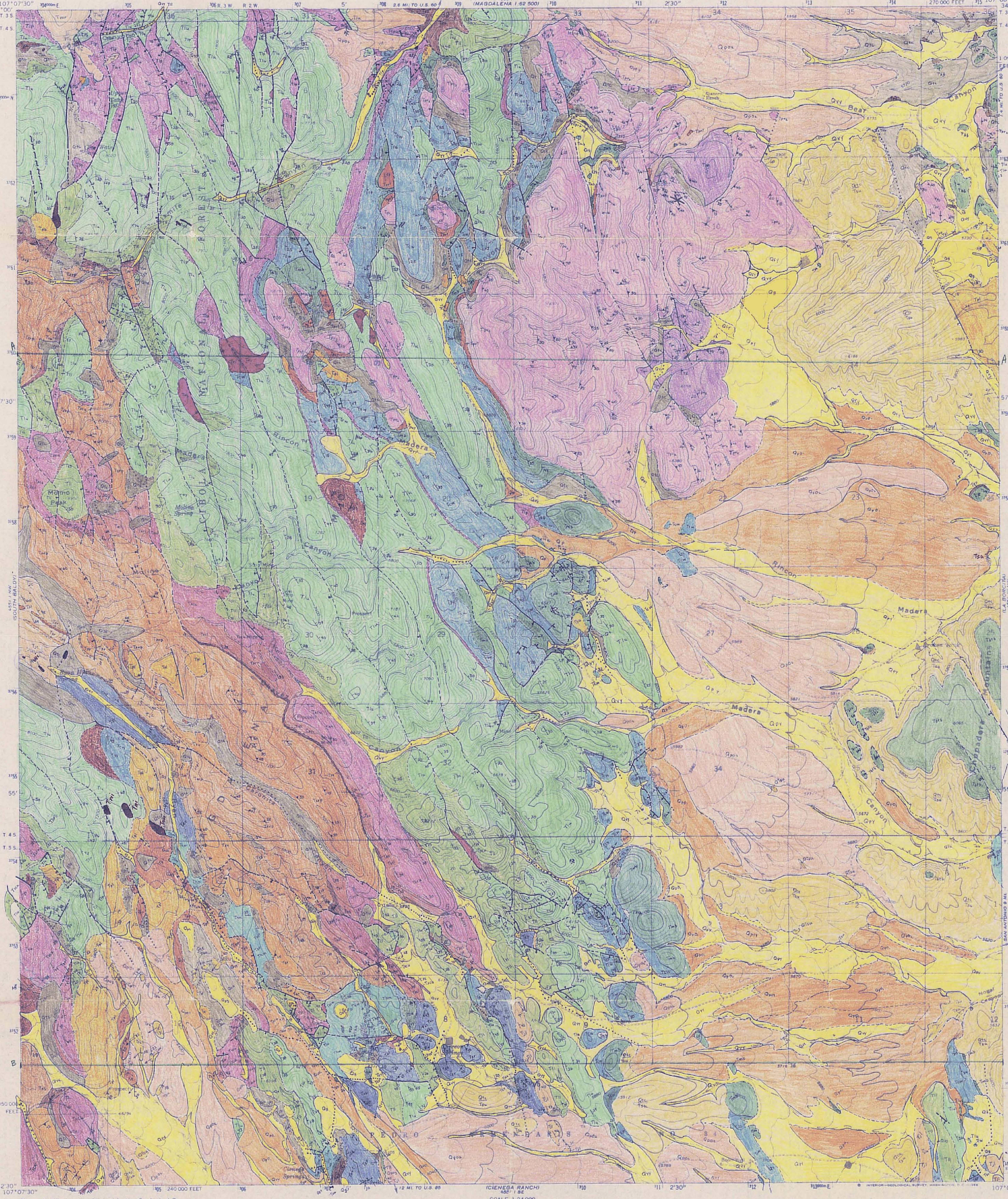
GEOLOGY of the MOLINO PEAK QUADRANGLE, SOCORRO COUNTY, NEW MEXICO

by
G. ROBERT OSBURN DAVID L. PETTY and C. E. CHAPIN

1980

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

MOLINO PEAK QUADRANGLE
NEW MEXICO–SOCORRO CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)



Mapped, edited, and published by the Geological Survey

Control by USGS and USC&GS

Topography by photogrammetric methods from aerial photographs taken 1964. Field checked 1965

Polyconic projection. 1927 North American datum
10,000-foot grid based on New Mexico coordinate system, central zone
1000-meter Universal Transverse Mercator grid ticks, zone 13, shown in blue

Fine red dashed lines indicate selected fence lines

Where omitted, land lines have not been established

UTM GRID AND 1965 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 40 FEET
DATUM IS MEAN SEA LEVEL

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR WASHINGTON, D. C. 20242
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

NEW MEXICO
QUADRANGLE LOCATION

ROAD CLASSIFICATION
Light-duty ——— Unimproved dirt - - - - -

MOLINO PEAK, N. MEX.
N3352.5—W10700/7.5
1965
AMS 4551 I NE—SERIES V881

PLATE 2

OPEN FILE REPORT 139 A

PLATE 2

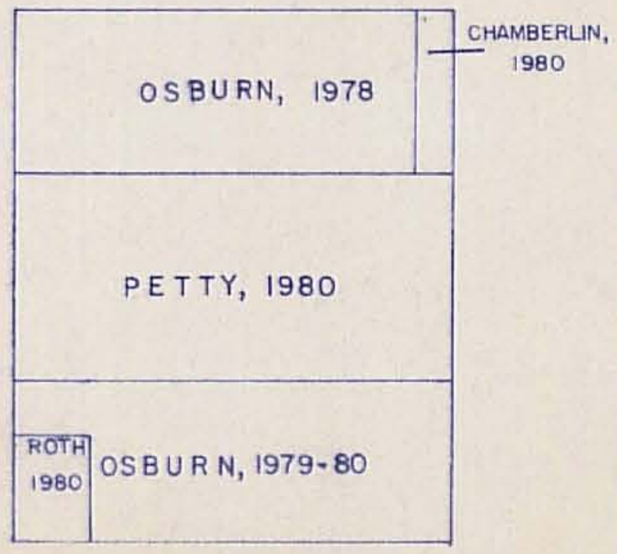


Figure 1: Mapping used in this compilation.

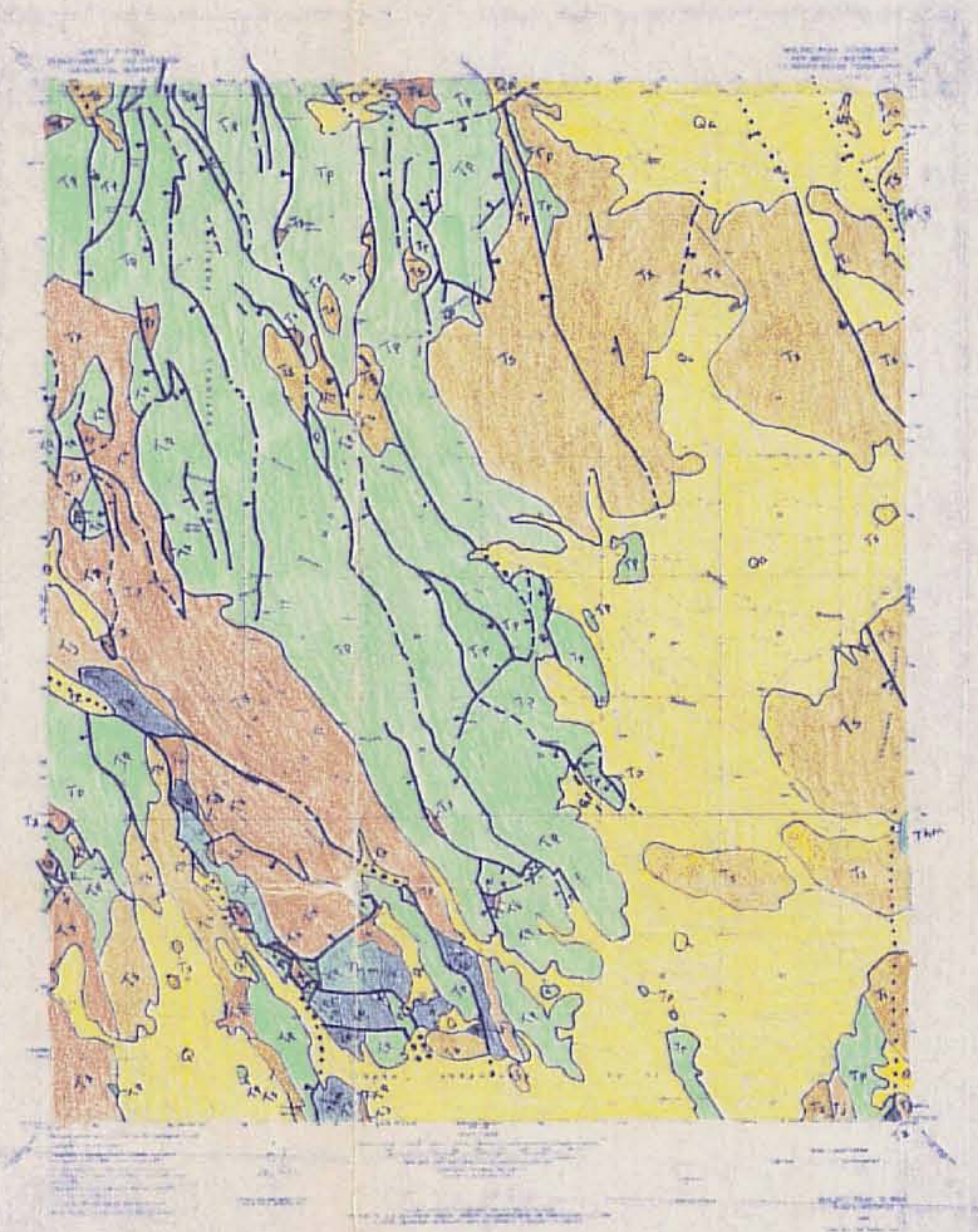
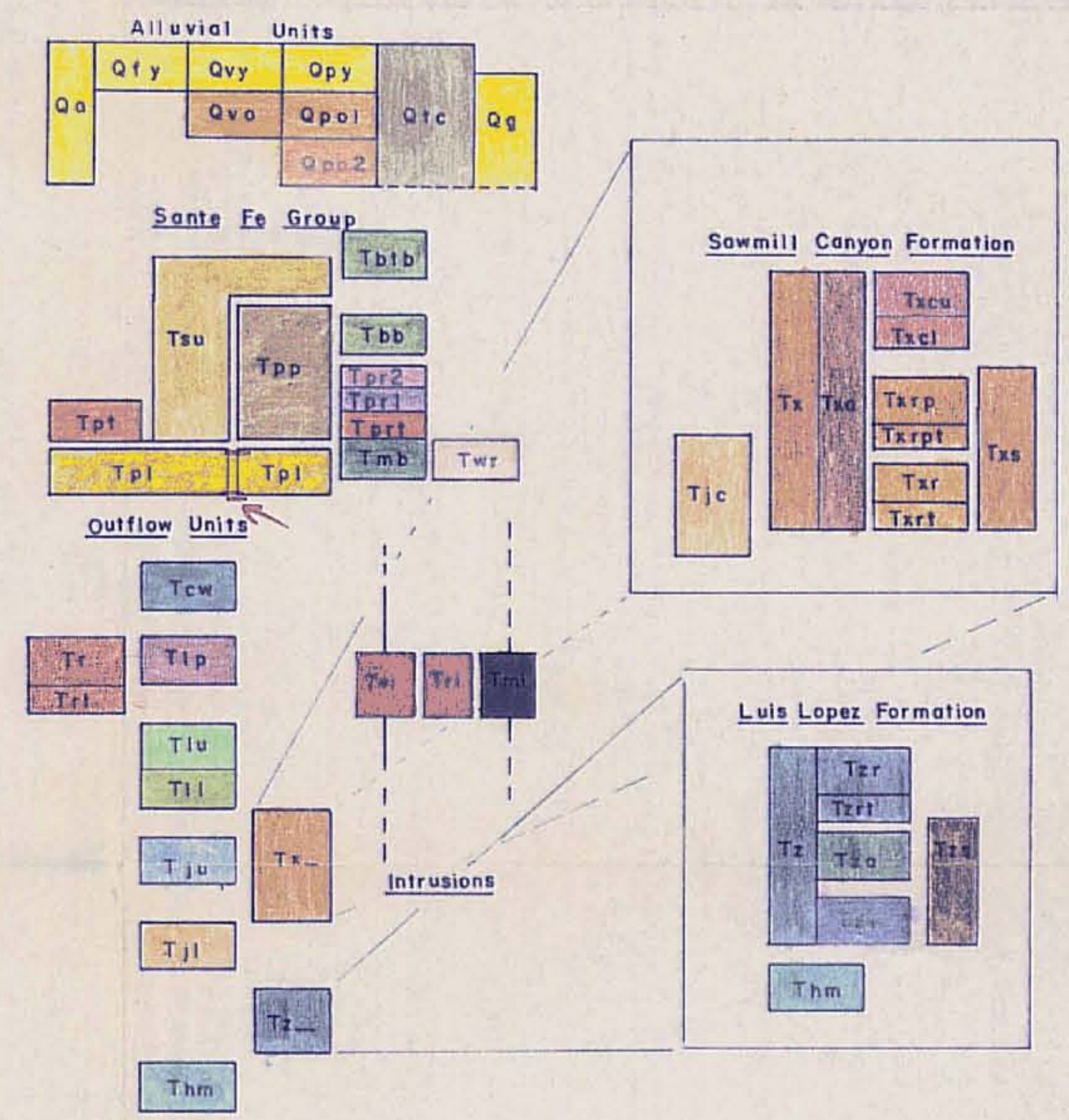


Figure 3: Generalized Geologic Map showing distribution of cauldron-related rocks.

- Qa — alluvium
- Ts — Sante Fe Group
- Tp — Volcanics younger than local cauldrons
- Tx — Sawmill Canyon Formation
- Tj — La Jencia Tuff
- Tz — Luis Lopez Formation
- Thm — Hells Mesa Tuff
- Contact
- Fault, ball on down side

STRATIGRAPHIC CORRELATION DIAGRAM



GEOLOGIC CROSS SECTIONS