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Geology of the North Half of the Pelona Quadrangle, Catron County, New Mexico

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PLATE
1. Geologic map north half of Pelona thirty-minute quadrangle.. in pocket

Abstract

The north half of the Pelona quadrangle lies in the Datil-Mogollon volcanic plateau of west-central New Mexico. The area includes the western third of the San Agustin Plains, a broad intermontane basin on the continental divide.

Pre-Tertiary rocks, including Yeso, Glorieta, and San Andres formations, and Triassic(?) Sandstone crop out in one small area. They are overlain unconformably by about 3000 feet of volcanic and associated sedimentary rocks, assigned to the mid-Tertiary(?) Datil Formation. In the mapped area, the lower third of the formation is volcanic conglomerate, sandstone, and siltstone. Rhyolite, latite, and andesite flows, breccias, and tuffs, together with sedimentary beds, comprise the upper two thirds of the formation. Variations in the nature of materials erupted from various centers at various times have led to complex intertonguing of the several facies. Individual lithologic units can be mapped readily in an area of this size, but they cannot be expected to maintain their identity in areas of much greater extent.

The Datil Formation is overlain with mild unconformity by a younger volcanic formation, given no formal name here, which attains a maximum thickness of 2500 feet locally. Basalt and ande site-basalt comprise by far the greatest volume of the younger volcanic formation, but rhyolite, latite, andesite, and alluvial materials are intercalated locally. The formation is probably of late Tertiary and Quaternary age.

The San Agustin Plains occupy a graben, with inferred structural relief of at least 4000 feet. The graben is younger than the younger volcanic formation. More than half the structural relief has been reduced by sedimentation. Most of the sediments antedate extinct Lake San Agustin, which occupied the graben in Wisconsin time. There is no evidence of tectonic activity in the graben younger than extinct Lake San Agustin.

Volcanic rocks in the uplands peripheral to the graben are gently warped and broken by numerous normal faults. A broad dome, the crest of which lies southwest of Horse Mountain, is older than the younger volcanic formation, as are some normal faults near the south boundary of the mapped area. A broad basin in Tularosa Mountains, the rim of which is an essentially continuous horst, and a series of arcuate, tilted fault blocks between the Tularosa Mountains and the Mangas Mountains are younger than the younger volcanic formation. A structural high between

the area of arcuate fault blocks and the San Agustin Plains is probably continuous across the mouth of Patterson Canyon, between the Tularosa Mountains and the structural dome southwest of Horse Mountain.

Introduction

LOCATION AND GENERAL FEATURES

The north half of the Pelona quadrangle is in northern Catron County, west-central New Mexico. State Highway 12, between Datil and Reserve, crosses the area from east to west. A good gravel road in the west half of the area leads south from the highway toward Collins Park and, eventually, to Mogollon. Fair-weather roads (pl. 1) provide ready access to most of the area.

The map area (pl. 1) includes the western third of the San Agustin Plains, a broad intermontane basin on the continental divide, and the surrounding uplands of the Datil—Mogollon volcanic plateau. That portion of the basin included trends east-northeast and is from six to ten miles wide in 22 miles of length. A broad playa (6775 ft) occupies about 35 square miles at the west end of the basin. Eastward, the basin surface rises to a little more than 6925 feet at the east edge of the quadrangle.

Surrounding uplands rise abruptly from the basin floor. South of the Plains, the map area includes lower portions of upland slopes on the flank of Pelona Mountain (9204 ft). West of the Plains, the irregularly dissected Tularosa Mountains include many elevations between 8500 and 9200 feet. The Mesa (8625 ft) at the northeast corner of the mountains directly overlooks the playa. Between the Tularosa Mountains and the Mangas Mountains, just outside the quadrangle to the north, is an area of low ridges and broad, alluviated valleys, with a moderate west-northwest grain. In this area, divides between tributaries eastward to the San Agustin Plains and westward to the Tularosa River lie between 7400 and 7500 feet. Horse Mountain (9450 ft) in the northeast corner of the quadrangle is an isolated summit which extends the topographic boundary of the Mangas Mountains eastward.

NATURE AND SCOPE OF INVESTIGATION

This investigation was undertaken to explore the feasibility of subdivision of the volcanic rocks in a part of the Datil-

Mogollon volcanic plateau and to elucidate further the general structure of the area, particularly the San Agustin Plains.

During the summers of 1952, 1953, and 1954, the distribution of volcanic rocks in the uplands and littoral deposits of extinct Lake San Agustin were plotted on contact aerial prints, scaled approximately 2 miles to 1 inch. This information was assembled, using a Reed focalmatic projector, to approximately the same scale on an enlargement of the U. S. Geological Survey Pelona quadrangle map (1918), which shows topographic features well but not precisely. Transfer from photographs to the enlarged map therefore involved some distortion. Because of the common relationships between topography and geology, however, the distortion is believed to be less important than the illustrative value of a topographic base. Cultural features have been revised from the Horse Springs quadrangle map of the New Mexico State Highway Department (1956) and some local observations.

PREVIOUS WORK

Bryan (1926, p. 81-87) described the general character of the San Agustin Plains and called attention to the shore features of extinct Lake San Agustin, which once occupied the west end of the Plains. At his suggestion, Powers (1939) mapped the ancient shore features and at the same time made reconnaissance observations of the volcanic rocks of the surrounding uplands (Powers, 1941). Bushman and Valentine (1954) assembled data on ground water in the Pelona quadrangle. Clisby et al. (1956) and Foreman et al. (1959) have reported sedimentological and palynological data obtained from a core of sediments underlying the San Agustin Plains.

Contiguous quadrangles are nearly completely covered by reconnaissance geologic maps (Fries and Butler, 1943; Willard, 1957a, 1957b; Willard and Givens, 1958; Weber and Willard, 1959).

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Stratigraphy

PRE-TERTIARY ROCKS

Brown to gray limestone crops out in a small hogback between Horse Mountain and State Highway 12 (approximately NW1/4, sec. 20, T. 4 S. , R. 12 W.). Megafossils collected on the crest and back slope of the hogback imply that the limestones belong to the San Andres Formation (R. H. Flower, letter, July 1954).

The outcrop is nearly surrounded by pediment gravels. The hogback originally formed a small residual above the gravels, but the area of outcrop has been increased several times by recent dissection. Dr. Frank Kottlowski and Mr. Roy Foster of the New Mexico Bureau of Mines and Mineral Resources have measured a section of the rocks exposed, including Ye so, Glorieta, and San Andres formations and Triassic(?) Sandstone (Appendix). Beds below the limestone crop out chiefly in a gully at the west end of the hogback. In another gully, at the east end of the outcrop area, slightly consolidated sandstone, mudstone, and conglomerate containing cobbles of granite, chert, and limestone are poorly exposed. The beds dip 10 to 15 degrees north and appear to overlie the limestone unconformably. A contact is not exposed, however, and its nature is not clear.

Limestone crops out in the east side of a gully approximately one-half mile southwest of the principal outcrop. Reddish volcanic conglomerate, sand, and silt crop out on the west side of this gully, perhaps separated from the limestone by a fault.

These outcrops are of chief interest in that they indicate that (1)pre-Tertiary rocks lie at shallow depths below the exposed volcanic rocks peripheral to the San Agustin Plains and (2) that rocks at least as young as Triassic(?) occur locally in the pre-volcanic sequence. North of the Datil Mountains, or some 35 miles north of Horse Mountain, Cretaceous and early Tertiary(?) sedimentary rocks dip gently southward beneath the Datil-Mogollon volcanic plateau (Willard, 1957b). Within the plateau, pre-Tertiary rocks are rarely exposed. In the Magdalena Mountains, however, 40 miles east of Horse Mountain, and in the Black Range, 50 miles southeast, the Tertiary volcanic sequence rests unconformably on the Abo Formation and older rocks. Thus, the north half of the Pelona quadrangle appears to lie on the northwest flank of an early Tertiary structural high in an area where the Datil Formation laps southward to progressively older pre-Tertiary rocks.

PRE-DATIL VOLCANIC ROCKS

In south-central and southwestern New Mexico, volcanic rocks significantly older than the Datil Formation are widespread. Mineral deposits of considerable value are related to closely associated intrusive rocks. The distribution of the older volcanics is therefore of some interest. Thickness of the Datil Formation nowhere exceeds 3000 feet, and pre-Datil rocks must lie at shallow depth in most of the Pelona quadrangle.

No rocks of the older volcanic sequence have been identified in the Pelona quadrangle. Paleozoic rocks are probably overlain directly by the Datil Formation in the northeast quadrant, and basal(?) beds of the Datil Formation are the oldest exposed on the west edge of the quadrangle. The nearest outcrops of the older volcanic sequence are on the northeast side of the Luera Range, six miles east of the Pelona quadrangle (Willard, 1957a). Hence, one would infer that the north half of the Pelona quadrangle lies near but outside the northwest margin of an area in which the older volcanic sequence is preserved at depth.

DATIL FORMATION

The exposed Tertiary rocks of the north half of the Pelona quadrangle are predominantly of volcanic origin. In part, they are essentially continuous (Willard and Givens, 1958; Tonking, 1957) with the Datil Formation (Winchester, 1920, p. 9) in its type area 30 miles to the northeast, although there is considerable lithologic variation in the intervening distance. Within the map area (pl. 1), the formation has a maximum inferred thickness of 3000 feet.

In the north half of the Pelona quadrangle, the Datil Formation includes rocks of four principal facies, which interfinger locally and have been mapped as members or tongues. A volcanic sedimentary facies (Tdvs) includes conglomerate, sandstone, siltstone, and mudstone (graywacke) of fluviatile and (locally) eolian origin. Detrital materials were derived chiefly from volcanic rocks. Thin beds of tuff are intercalated locally but most beds were deposited by streams. At two localities, the lowermost few tens of feet exposed contain well-rounded cobbles of granite, chert, limestone, and other sedimentary rocks. These beds were not mapped separately. A rhyolite facies includes thick flows (Tdrf) and widespread tuffs and tuff-breccias (Tdrp). A latite facies includes thick flows and flow-breccias (Tdl). An andesite facies (Tda) includes andesite flows and breccias of characteristic appearance. The four facies contain volcanic materials erupted from centers mostly outside the mapped area, interfingering with each other and with contemporaneous sedimentary deposits. Changes in the stratigraphic succession take place laterally as well as vertically, and the succession established in one locality does not correspond to that several miles away. Individual units are widespread and mappable, and their stratigraphic succession is remarkably uniform throughout considerable portions of the mapped area. Hence, by moderately detailed mapping, intertonguing relationships can be worked out and some general features of the paleogeography of the Datil Formation can be derived.

Lithologic descriptions of the map units (pl. 1) are grouped under the facies to which they belong. The intertonguing relationships of the units are treated in a summary.

Volcanic Sedimentary Facies

The volcanic sedimentary facies has been mapped in three principal units: a lower, a middle, and an upper unit.

Lower Sedimentary Unit ($Tdvs_1$)

The lower sedimentary unit probably overlies Paleozoic rocks unconformably at the base of Horse Mountain, although a contact is not exposed. The top of the unit was mapped at the base of the first cuesta-forming tuff, above which beds of conglomerate occur, but tuff predominates in the section. The contact mapped may not lie everywhere at the same horizon, which occurs in a zone of transition. It has approximate value, however, and serves to illustrate the general distribution of the lower sedimentary unit. The lower unit crops out in two principal areas, in each of which it is the basal member of the Datil Formation.

The first and larger area is the broad lowland between Horse Springs and Horse Mountain, extending eastward along the base of Horse Mountain. Most of the lowland is veneered by pediment and fan gravel. Outcrops are small, discontinuous, and chiefly confined to the slopes of cuestas capped by tuffs of the overlying rhyolite pyroclastic facies or to local reaches where arroyos have cut through the overlying gravel. The most extensive exposures are along the North and South Forks of Alamocito Canyon. A continuous section is nowhere exposed,

Rare exposures in the lowland are siltstone and mudstone. The finer-grained beds are commonly red, and reddish subsoil colors the banks of several arroyos well beyond the small area of actual outcrop. Fine-grained beds in the banks of Alamocito draw, upstream from the Stevens Ranch, are greenish-gray and buff.

The exposed beds along the west and north margins of the lowland, presumably highest in the section, are chiefly conglomerate. Moderately well-rounded cobbles of volcanic rock, up to 8 inches in diameter, occur in a sandy matrix. Beds range from light gray, commonly greenish, to brown or red-brown. Characteristic sandstone float covers many slopes with little true outcrop. Thin beds of massive tuff are intercalated.

Between the outcrop of Paleozoic rocks and Horse Mountain, exposures are poor. Immediately north of the limestone hogback are beds of slightly consolidated, varicolored sandstone, siltstone, and mudstone, locally containing well-rounded cobbles of chert and limestone 2 to 4 inches in diameter. Higher beds appear to contain volcanic pebbles and cobbles. Along the main gulch heading in the central core of Horse Mountain, discontinuous exposures of red volcanic conglomerate, separated by covered intervals of presumably finer-grained beds, dip consistently 10 to 13 degrees north. This section, if continuous, includes 1200 to 1500 feet of predominantly water-laid beds,

In low cliffs overlooking the San Agustin Plains, south of Horse Springs, massive red-brown conglomerate at the top of the unit contains rounded boulders as much as 18 inches in diameter. This single group of exposures is conspicuously coarser than any others observed in the area.

In the North Fork of Alamocito Canyon, just above the fork, massive andesite of the lower andesite unit (Tda_1) crops out for about one-half mile. Only the top of the andesite is exposed. Just 25 to 40 feet of conglomerate separate the andesite from a massive tuff thought to be the base of the rhyolite pyroclastic facies ($Tdrp_1$). This andesite unit was not found elsewhere east of The Mesa, although below the North Fork of Alamocito Canyon at least 200 feet of conglomerate are exposed in tributary gulches on the west side. The outcrop of ande site is taken to be a fortuitous exposure, with very limited lateral extent in the vicinity, but which may indicate the approximate stratigraphic position of the lower andesite unit (Tda_1) in this part of the area.

The second area in which the lower volcanic sedimentary unit crops out is a strip approximately one mile wide below the north-facing scarps of The Mesa and Wagontongue Ridge. Scattered exposures along the eastern two thirds of the scarp are chiefly red conglomerate and rare siltstone. The head water areas of three gulches, draining west to Tularosa Creek, provide more extensive outcrops.

What are presumed to be the lowermost beds crop out in the southernmost and smallest of the three gulches. In an area approximately one-eighth mile square, gully sides are characterized by abundant roundstone float of red granite and gray limestone, although such rocks are virtually absent in the local pediment gravel. Three poor exposures show that the roundstones come from gray-white beds of sandy conglomerate in which only nonvolcanic rock types occur. The beds are nearly horizontal and no more than 40 to 50 feet were observed. The base was not found. Upstream and higher in the section, nonvolcanic conglomerate is overlain by volcanic conglomerate.

At least 300 feet of beds are well exposed in gullies on east and west sides of a local basin at the head of the northernmost gulch. Both outcrops are capped by massive andesite of the lower andesite unit (Tda1,), which appears continuously along the scarp of Wagontongue Ridge. The sedimentary beds at each end of the basin therefore occupy the same stratigraphic position. The two outcrops are strikingly different, however.

The west outcrop is well-indurated and well-bedded conglomerate, sandstone, and siltstone. The overall aspect is bluish-gray, but beds of greenish-gray and, at the top of the section, reddish-brown occur. Well-rounded cobbles up to 6 inches in diameter are not uncommon, but pebbles 1/2 inch to 2 inches in diameter predominate. Many beds break through, rather than around, pebbles. Lenses of siltstone range from a few inches to 20 feet thick and are gray, greenish-gray, buff, and reddish-buff.

The east outcrop is chiefly one large gully head, opened in at least 250 feet of predominantly reddish-brown clay and siltstone, with intercalated beds of chalcedony 1/2 inch to 3 feet thick, associated with and probably replacing gypsum. The chalcedony is brightly variegated red and white. Many Indian artifacts found locally were undoubtedly made from it. A few greenish-gray beds of volcanic roundstones in a silty matrix were observed, as was one bed of sticky, greenish-gray (bentonitic?) clay.

These two are the best and most extensive outcrops of the lower volcanic sedimentary unit in the north half of the Pelona quadrangle. Although only one mile apart, and undoubtedly at the same stratigraphic horizon, they are strikingly different and well illustrate the rapid textural changes which probably characterize the unit as a whole.

Middle Sedimentary Unit ($Tdvs_2$)

Fluviatile and eolian beds occupying the approximate stratigraphic po s iti on of the lower rhyolite pyroclastic unit ($Tdrp_1$), and locally interfingering with it, have been mapped as a younger volcanic sedimentary unit. West of Patterson Canyon, the unit separates lower and upper units of the andesite facies (Tda_1 and Tda_2).

On the east and northeast flanks of The Mesa, a few hundred feet of volcanic sandstone and conglomerate crop out discontinuously. Conglomerates are reddish-brown or red. A conspicuous and illustrative outcrop, freshened by wave action in extinct Lake San Agustin, is adjacent to the traveled road (SE1/4, sec. 1, T. 6 S. , R. 15 W.). At the northeast corner of The Mesa, Powers (1941, p. 211, Sec. A) traversed 420 feet of beds belonging to this unit; 285 feet were covered. The beds are overlain by white rhyolite tuff near the top of the lower rhyolite pyroclastic unit ($Tdrp_1$).

Between Patterson Canyon and the continental divide, both north and south of State Highway 12, the upper andesite unit (Tda_2) is underlain by at least 200 feet of beds in which well-sorted, medium-grained white sand and soft sandstone appear to predominate. No very good exposures were found, but several slopes, particularly in the triangular rincon lying chiefly in secs. 23 and 26, T. 14 S., R. 15 W., are underlain by sand remarkably free from coarser fragments. Interbedded fine conglomerate crops out in the next rincon to the east (sec. 24, T. 4 S., R. 15 W.). Float and rare exposures of gray pumiceous tuff between the sand and overlying andesite porphyry show that the sand occupies the approximate stratigraphic position of the lower rhyolite pyroclastic unit ($Tdrp_1$)*

Sand at the same stratigraphic horizon is widespread in quadrangles north and west of the Pelona quadrangle. Fairly good exposures maybe seen on the west margin of the Sand Flats, outside the northwest corner of the Pelona quadrangle (T. 4 S., R. 16 W.), and in rincons on the south side of the Gallo Mountains. Cuts along the road leading north out of the Sand Flats show massive, cross-bedded sand which is probably eolian. Much of the uniform sand in the Pelona quadrangle must have similar character.

On the south side of the San Agustin Plains, east of the mouth of Patterson's Cut-off (Powers, 1941, p. 212, Sec. C), well-bedded and well-sorted gray tuffaceous sandstone crops out between massive tuffs of the lower rhyolite pyroclastic unit ($Tdrp_1$). The sandstone is water-laid. Its thickness increases southward from about 40 feet near Powers' section to about 100 feet one-half mile farther south. Its beds dip 8 degrees south. The north limit of outcrop is a fault, thrown down to the north. Near the fault, the lowermost beds exposed are 45 feet of rudely stratified pink-buff volcanic conglomerate, containing boulders up to 2 feet across in coarse lenses. Boulders and cobbles are commonly stained red, and many tuff fragments are punky to the hammer. The uppermost 5 to 10 feet of conglomerate, immediately underlying massive tuff ($Tdrp_1$), are also stained deep red. Much of the red color in the upper beds, and in individual cobbles below, appears to have developed in situ, probably by weathering contemporaneous with deposition.

On the north flank of Shaw Peak, two miles west and across the mouth of Patterson's Cut-off, sandstone at the same stratigraphic position is about 250 feet thick. It is strongly cross-bedded. In several outcrops, individual foresets 15 to 20 feet long dip as much as 20 degrees. The bulk of the sandstone is believed to be eolian. At the base of the cliffs, poor exposures show that similar sandstone is interbedded with white, buff, and pink-brown tuffs ($Tdrp_1$) in an aggregate thickness of at least 150 feet. At the west end of the cliffs, cross-bedded sandstone and underlying tuff cut out rapidly westward. Only the uppermost tuff (Tdrp), overlying sandstone, continues westward, directly overlying latite (Tdl).

This series of cliff exposures, on both sides of Patterson's Cut-off, illustrates intercalation of the middle volcanic sedimentary unit ($Tdvs_2$) as a tongue within the lower rhyolite pyroclastic unit (Tdrp1).

Upper Sedimentary Unit ($Tdvs_3$)

On both sides of Patterson's Cut-off, 40 to 250 feet of gray and buff, slightly consolidated tuffaceous sandstone overlie the upper rhyolite pyroclastic unit ($Tdrp_2$). Most of the rare exposures seen are strongly cross-bedded and probably eolian. The sandstone is overlain by basalt (TQb) around Shaw Peak and by latite (TQl) on south and east sides of the Cut-off. Underlying tuffs dip gently but consistently south. Tuffaceous sandstone thickens southward and appears to fill in swales between cuestas(?) on the underlying tuff, so that basalt (TQb) and latite (TQl) rest on a surface with appreciably less relief than that at the base of tuffaceous sandstone. It is by no means clear whether the southward divergence between base and top of the tuffaceous sandstone is initial, formed during deposition <u>above</u> a gently dipping surface of unconformity, or whether the top of the tuffaceous sandstone is an erosional unconformity bevelling gently dipping beds. The latter interpretation is implied here by grouping the unit with the Datil Formation, only because an alternative is necessary. Further data from adjacent areas may show that it is, in fact, part of the younger volcanic formation.

<u>Rhyolite Facie s</u>

The rhyolite facies includes three map units, flow rocks (Tdrf) exposed only along the south margins of the mapped area and two pyroclastic units ($Tdrp_1$ and $Tdrp_2$).

Rhyolite Flow Unit (Tdrf)

Flow rhyolite crops out in two small areas: in Shaw Canyon, on the southeast margin of the mapped area, and in two tributaries to Long Canyon, on the southwest margin of the mapped area. Both areas of outcrop are isolated windows, undoubtedly continuous beneath younger cover; similar rocks are more extensively exposed in the south half of the Pelona quadrangle (Fries and Butler, 1943). In neither area has the base of the flow rhyolite been seen.

Flow rhyolite is dense, flow-banded, and characteristically bluish-gray. Phenocrysts of bluish sanidine and quartz may be conspicuous. Spherulitic texture occurs in some outcrops. The rock is commonly broken by large, rather close-spaced joints, and in some instances is contorted by large-scale flow(?) structure.

In Shaw Canyon, flow rhyolite is overlain by the upper rhyolite pyroclastic unit ($Tdrp_2$), which cuts out southward against the flow rhyolite under basalt (TQb) and latite (TQ1). In the tributaries to Long Canyon, flow rhyolite is overlain by 0 to 50 feet of buff alluvium, containing abundant fragments of the rhyolite, not mapped separately, and by basalt (TQb). In Long Canyon itself, similar alluvium overlies the upper rhyolite pyroclastic unit ($Tdrp_2$) and underlies basalt (TQb). He r e, as in Shaw Canyon, the upper rhyolite pyroclastic unit ($Tdrp_2$) is presumably younger than flow rhyolite, but cuts out southward against it beneath an unconformity at the base of basalt (TQb).

Lower Rhyolite Pyroclastic Unit ($Tdrp_i$)

The lower rhyolite pyroclastic unit crops out chiefly in a broad arc swinging northward from the vicinity of Horse Springs, eastward along the north edge of the quadrangle to Horse Mountain, and east of Horse Mountain. The unit overlies the lower volcanic sedimentary unit ($Tdvs_1$) and is separated from it by a transitional zone in which one or more tuff beds are interbedded with volcanic conglomerate. The base of the lower rhyolite pyroclastic unit was assumed to be the base of the first cuesta-forming tuff, above which volcanic conglomerate occurs, but pyroclastics predominate in the section. As mapped, the base may not lie everywhere at the same horizon in the zone of transition from dominantly sedimentary to dominantly volcanic material, but the stratigraphic range is not great. It serves to illustrate the generally domal structure of the lowland between Horse Springs and Horse Mountain.

The lower rhyolite pyroclastic unit is an aggregate, in which only a generalized tripartite succession has been distinguished. A basal division of tuffs and welded tuffs includes at least five cuesta-forming beds of gray, brown, and purple tuff and tuff-breccia; water-laid tuffaceous sandstone, siltstone, and clay; and, at least locally, volcanic conglomerate. A principal middle division of coarse, buff to gray-white tuff-breccia at least 500 thick feet contains abundant heterogeneous fragments of pumiceous tuff (up to 18 in.), gray quartz monzonite porphyry (up to 6 in.), various gray and red latite porphyries (up to 6 in.), and black or red nodular aggregates of specularite and quartz or chert. An upper division of tuff and tuffaceous sandstone includes two distinctive beds of tuff widely distributed throughout the mapped area. The first (lower) is a massive white tuff with abundant bipyramidal quartz crystals, which commonly breaks up into a characteristic float of small, angular, chalk-like fragments. The second is a massive, gray, generally pumiceous tuff which marks the top of the pyroclastic unit.

Near and north of Horse Springs, the lower rhyolite pyroclastic unit overlies the lower volcanic sedimentary unit and is overlain by latite. Between Alamocito Canyon and Horse Mountain, the pyroclastic unit is overlain by pediment gravels sloping northward out of the quadrangle. On the west and east flanks of Horse Mountain, late andesite (TQa) unconformably overlies the lower rhyolite pyroclastic unit.

Powers (1941, p. 214, Sec. F) measured an incomplete section near Horse Springs in which 235 feet are the basal succession of tuffs and480 feet the middle tuff-breccia, here forming the massive cliffs of Cerro Caballo. In both divisions, the measured thicknesses are less than, but probably near, the total thicknesses. Structure sections imply that between Horse Springs and the South Fork of Alamocito Canyon the lower rhyolite pyroclastic unit has an aggregate thickness of about 1000 feet, more than half of which is the middle tuff-breccia. The thick middle tuff-breccia crops out only in this area and is very probably a local member, erupted from a center at no great distance.

East of Horse Mountain only the basal division is represented. At least six prominent beds of tuff crop out and the aggregate thickness is 500 feet. The basal division appears to thicken eastward toward Datil, possibly at the expense of the middle division. Portions of the basal division are equivalent, in part, to the Hells Mesa member of the Datil Formation in the type area (Tonking, 1957, p. 29-30).

On the northeast and east sides of The Mesa, the two distinctive tuff beds of the upper division crop out in a series of low cuestas, underlying the upper andesite unit (Tda_2). They overlie sandstone and conglomerate of the middle volcanic sedimentary unit ($Tdvs_2$), which here appears to occupy the stratigraphic position of the thick middle tuff-breccia. North of The Mesa and west of Patterson Canyon, discontinuous exposures beneath the upper andesite unit (Tda_2), not mapped separately, suggest that the gray pumiceous tuff is present nearly everywhere. The underlying chalky tuff was not seen in this area.

South of the San Agustin Plains, tuffs resembling those of the basal division near Horse Springs crop out beneath sandstone and conglomerate ($Tdvs_2$) east and west of Patterson's Cut-off. At one locality east of the Cut-off, volcanic conglomerate is the lowest bed exposed. In the cliff section west of the Cut-off, similar tuffs interbedded with tuffaceous sandstone aggregate at least 150 feet, but the base is not exposed. Massive, gray welded tuff with scattered lithic fragments ($Tdrp_1$), overlying the middle volcanic sedimentary unit (Tdvs2), is the gray pumiceous tuff of sections north of the San Agustin Plains. This welded tuff is thicker (125 ft) in the vicinity of Patterson's Cutoff than anywhere else. The middle volcanic sedimentary unit in this vicinity occupies the stratigraphic position of the middle tuff-breccia near Horse Springs. The combined thickness of the lower rhyolite pyroclastic unit ($Tdrp_1$) and intercalated middle volcanic sedimentary unit ($Tdvs_2$) increases from 325 feet east of Patterson's Cut-off to at least 500 feet west of the Cut-off. The latter value is still only half that of the lower rhyolite pyroclastic unit ($Tdrp_1$) near Horse Springs.

Upper Rhyolite Pyroclastic Unit ($Tdrp_2$)

The upper rhyolite pyroclastic unit crops out nearly everywhere in the area, immediately overlying upper andesite (Tda). Between Patterson Canyon and Alamocito Canyon, along the north side of the quadrangle, the unit is locally absent and basalt (TQb) rests directly on upper andesite (Tda_2). South of Long Canyon, the upper rhyolite pyroclastic unit is locally absent and basalt (TQb) rests directly on flow rhyolite (Tdrf). In Shaw Canyon, the upper rhyolite pyroclastic unit rests successively on latite (Tdl), upper andesite (Tda_2), and flow rhyolite (Tdrf). In Patterson's Cut-off, the upper rhyolite pyroclastic unit ($Tdrp_2$) rests directly on the lower ($Tdrp_1$). Elsewhere, the occurrence of the upper rhyolite pyroclastic unit ($Tdrp_2$) over upper andesite (Tda_2) and under basalt (TQb) is uniform.

Thickness of the upper rhyolite pyroclastic unit ranges from a feather edge in eastern tributaries of Patterson Canyon to 325 feet at the mouth of T-H Canyon. It is not clear to what extent variations in thickness are original and to what extent they reflect erosion before extrusion of andesite-basalt (TQb) of the younger volcanic formation.

The upper rhyolite pyroclastic unit crops out in three divisions. A basal division, commonly ledge-forming, ranges from mottled red, indurated tuff, in which abundant white feldspar and some black biotite simulate porphyritic texture, to light pink, slightly indurated tuff, with scattered crystals of sanidine and biotite. A middle division, usually the thickest, is massive and platy gray, with simulated porphyritic texture, and rings to the hammer. The upper division is buff, gray, or white, slightly indurated tuff. Quartz is rarely conspicuous in the lower division, more often visible in the upper two. Feldspar is chalky in the basal division, but irridescent blue sanidine is characteristic of the upper two.

Latite Facies (Tdl)

Porphyritic latite crops out west and north of Horse Springs where it overlies the older rhyolite pyroclastic unit ($Tdrp_1$) and underlies andesite porphyry (Tda2). Similar rocks are the base of the exposed volcanics south of the San Agustin Plains, between Shaw Canyon and Bat Cave, and are overlain by andesite porphyry (Tda2) or the upper rhyolite pyroclastic unit ($Tdrp_2$).

In the hills between Horse Springs and the TUT Ranch, latite forms a prominent shoulder below cliff-forming andesite porphyry (Tda_2). Scattered outcrops at the base are massive, flow-banded, red latite porphyry (3-10 ft observed) overlying tuffaceous sandstone. Not seen exposed, but indicated locally by abundant float, is a coarse basal flow breccia of red or brown latite porphyry and highly vesicular black glass in a pasty, tuff-aceous matrix. Judging from float, this basal flow breccia may be as much as 25 to 30 feet thick and at least as common as massive, basal latite porphyry. Scattered outcrops on the round of the shoulder are massive latite porphyry, commonly red or brown, and flow-banded. Slopes between basal and upper out-crops are generally veneered by uniform float of platy fragments of gray or blue-gray latite porphyry, which crops out rarely. Above the shoulder, an interval of 50 to 75 feet is covered. As much as 25 feet of buff tuffaceous sandstone crops out locally at the top of the covered interval. Float of red and brown latite porphyry, black vesicular glass, and buff tuffaceous matrix implies that most of the covered interval is occupied by coarse flow breccia like that present locally at the base, and that a thick, brecciated flow top is probably present everywhere.

These outcrops are interpreted as those of a single, thick flow, with thick flow breccia at the top and, locally, bottom. The flow is about 500 feet thick but at the west end of the hills cuts out abruptly westward, so that in outcrops less than one-half mile apart andesite porphyry (Tda_2) rests on thick latite (Tdl) to the east and on the lower rhyolite pyroclastic unit (Tdrp1) to the we st.

North of the Horse Springs Canyon road, the latite flow thins, and in cliffs overlooking Alamocito Canyon it is only 75 to 150 feet thick. Flow breccia is rarely observed north of the road and may be absent from much of this area. Furthermore, in most of the area north of the road, a dense, black andesite-basalt flow crops out beneath the latite and forms the base of the latite, as mapped. The latite unit was not found west of Patterson Canyon.

South of the San Agustin Plains, as mentioned, a similar latite porphyry and breccia crop out at the base of the exposed section between Shaw Canyon and Bat Cave. East of Shaw Canyon, latite cuts out abruptly within one-quarter mile, and its apparent stratigraphic position is occupied by both the lower rhyolite pyroclastic unit (Tdrp1) and the middle volcanic sedimentary unit (Tdvs2). In and west of Shaw Canyon, the highest tuffs of the lower rhyolite pyroclastic unit (Tdrp1) crop out locally between latite and overlying ande site porphyry (Tda_2), but they were not mapped separately (pl. 1). Thus, the latite porphyry south of the San Agustin Plains is probably slightly older than that north of the Plains and is separated in time by an interval represented chiefly by a single eruption of tuff, but their stratigraphic positions are very nearly the same. Furthermore, in Shaw Canyon, andesite porphyry (Tda_2) pinches out both northward and southward and appears to occupy a saddle between flow latite (Tdl) to the north and flow rhyolite (Tdrf) to the south. Latite (Tdl) and flow rhyolite (Tdrf) occupy approximately the same stratigraphic position, and somewhat younger andesite porphyry (Tda_2) probably occupies an initial topographic saddle between two older flow fronts.

Ande site Facie s

Rocks of the andesite facies have been mapped as two units, the younger of which is more widely exposed. Similar rocks are widespread in the Gallo Mountains and the north half of the Reserve quadrangle, northwest and west of the Pelona quadrangle. Within the Pelona quadrangle, the two units are distinct in lithologic habit as well as stratigraphic position.

Lower Andesite Unit (Tda_1)

The lower andesite unit includes massive andesite and andesite breccia. Principal exposures are in north-facing cuestas at the foot of north-facing scarps along The Mesa and Wagon-tongue Ridge. In the principal outcrop along Wagontongue Ridge, andesite is at least 300 feet thick, but an unknown additional thickness has been removed by erosion. Scattered outcrops form a linear series one mile north of and parallel to the north-facing cuestas. An isolated outcrop is along the North Fork of Alamocito Canyon, just above its junction with the South Fork.

Massive andesite is characteristically dark gray or red. The dark gray rocks are porphyries, in which feldspar pheno-crysts are rarely conspicuous in a f e It e d, medium -grained groundmass. Some outcrops exhibit platy jointing, and some are finer grained and flow-banded. Ande site breccia is principally red or red-brown, but gray, blue, purple, and pink also occur. Chalky feldspars make most outcrops conspicuously porphyritic.

Outcrops along the scarps of The Mesa and Wagontongue Ridge overlie the lower volcanic sedimentary unit ($Tdvs_1$); only pediment gravel and landslide debris were observed to overlie the andesite. Only the top of an andesite body is exposed in the North Fork of Alamocito Canyon, apparently interbedded in the uppermost portion of the lower volcanic sedimentary unit ($Tdvs_1$),

Upper Andesite Unit (Tda_2)

The upper, younger, andesite unit is a series of flows of dark porphyritic ande site of basaltic habit. North and west of the San Agustin Plains, it occurs throughout the area west of Alamo-cito Canyon and north of the Tularosa Mountains, South of the Plains, it crops out continuously from Shaw Canyon west to Bat Cave Wells. A single outcrop, just at the edge of the Pelona quadrangle, is the westernmost of extensive exposures east in the Luera Spring quadrangle.

The upper andesite unit is cliff-forming, usually capped by the upper rhyolite pyroclastic unit ($Tdrp_2$). Rude columnar jointing characterizes most cliff exposures. Individual flow units are 40 to 75 feet thick, but in the hills east of the TUT Ranch two flow units aggregate 250 feet (Powers, 1941, p. 214, Sec. G). Partings of sandy or tuffaceous material are rare. The andesite is massive or vesicular. Outcrops commonly weather to a highly irregular surface bounded by close-spaced incipient joints, and the rocks almost invariably break along similar joints. Andesite boulders are rare on slopes below cliff exposures, but rounded boulders up to 10 feet across are common in gravels on the top of Wagontongue Ridge, in the valley one mile north of Wagontongue Ridge, and on the saddle between Horse Mountain and Mangas Mountain.

The flow rocks are characteristically andesite porphyry, with abundant plagioclase phenocrysts as much as 1/4 inch X 1/2 inch X **1-1/2** inches in a felted matrix of plagioclase and dark minerals. The phenocrysts share the color of the rock itself in hand specimen and are conspicuous only by cleavage reflections. The rock type is distinctive and remarkably uniform throughout the mapped area. Dense andesite-basalt is intercalated locally and is the uppermost flow in most of the area between Horse Springs and Patterson Canyon.

In nearly all the area, the unit is 50 feet to 250 feet thick. Thicknesses greater than 400 feet occur in a central area including Bat Cave, The Mesa, and hills near the TUT Ranch. South of the San Agustin Plains, andesite porphyry begins at Shaw Canyon in a single flow 25 to 50 feet thick. Westward toward Bat Cave, thickness of the unit increases regularly until, in a fault scarp west of the Cave, 650 feet of andesite porphyry are exposed beneath capping rhyolite tuff ($Tdrp_2$); underlying rocks do not appear.* Thickness increases southward in canyons west of Shaw Canyon, and isopachs appear to trend northwest-southeast.

North of the San Agustin Plains, the upper andesite unit is about 200 feet thick in hills east of the TUT Ranch, except at the west end, where 300 feet are exposed and the base is not (Powers, 1941, p. 214, Sec. G). In The Mesa, thickness of the upper andesite unit increases from about 350 feet in T-H Canyon to about 500 feet at the northeast corner of The Mesa.t West of Patterson Canyon, thickness of the upper andesite unit increases from 150 feet (NE1/4 sec. 3, T. 5 S. , R. 15 W.) to about 250 feet (NE1/4 sec. 27, T. 4 S., R. 15 W.). These scattered observations suggest that maximum thickness of the upper andesite

* Powers **(1941,** p. 212, Sec. B) gives 1000 feet at Bat Cave, surely derived by estimate from local relief. His section does not include the capping rhyolite tuff and basalt, and his estimate for the upper andesite unit is therefore too high.

t Powers (1941, p. 211, Sec. A) gives 755 feet at the northeast end of The Mesa. His traverse crossed a fault, and repetition of beds yielded too great a thickness.

unit occurs in a central area trending southeast from the NE1/4 sec. 23, T. 4 S. , R. 15 W. past the northeast end of The Mesa to the vicinity of Bat Cave. Maximum thickness in this central area increases southeastward from 250 to more than 650 feet.

Nearly everywhere, the upper andesite unit overlies the uppermost tuff of the lower rhyolite pyroclastic unit (Tdrp$_1$), a gray pumiceous tuff mapped separately only east of Shaw Canyon, where the tuff is especially thick and andesite porphyry is absent (pl. 1). Exposures of gray tuff beneath andesite porphyry are discontinuous but so persistent as to imply a nearly universal association of the two in space and, presumably, in time. East of Patterson Canyon, andesite porphyry overlies and the gray tuff underlies latite (Tdl). At most places, the upper andesite unit is overlain by the upper rhyolite pyroclastic unit (Tdrp$_2$).

Summary

Where observed in the mapped area, the lower third of the Datil Formation is chiefly an alluvial deposit in which volcanic debris predominates. Nonvolcanic beds at two localities are the lowermost beds exposed. The bulk of the lower volcanic sedimentary unit (Tdvs1) was deposited in alluvial fans peripheral to areas of volcanism outside the mapped area. One such area probably lay to the northeast, where the lower sedimentary unit (Tdvs1) of the Pelona quadrangle probably interfingers with and is, in part, contemporaneous with latitic volcanics of the Spears Ranch member of the Datil Formation. Other source areas of debris and the general outline of the sedimentary basin cannot be defined. Playa deposits mark a topographically low area between major fans, but they may have only local significance.

The locally thick lower andesite unit (Tda$_1$) is intercalated in the upper portion of the alluvial beds (Tdvsd. In the east half of the mapped area, aggradation by streams was finally overshadowed by deposition of rhyolite tuffs (Tdrp$_1$). In part, the tuffs are lateral equivalents of the Hells Mesa member of the Datil Formation farther east. The locally thick middle tuffbreccia, exposed near Horse Springs, may have been erupted closer at hand. The lower rhyolite pyroclastic unit (Tdrp$_1$) interfingers westward and southwestward with alluvial and eolian beds (Tdvs$_2$•) South of the San Agustin Plains, thick latite (Tdl) occupies an equivalent stratigraphic position, but along the south edge of the mapped area, thick rhyolite (Tdrf) occupies the equivalent stratigraphic position. North of the Plains, a single(?) thick latite flow marks what in that vicinity is the top of the lower rhyolite pyroclastic unit.

The upper andesite unit (Tda_2) appears to have accumulated chiefly in a pre-existing topographic low, the lowest portion of which trended northwest-southeast between latite (Tdl) to the northeast and alluvial and eolian beds ($Tdvs_2$) to the southwest. The upper rhyolite pyroclastic unit ($Tdrp_2$) blanketed the ensuing topography, in most of the area overlying the upper andesite unit (Tda_2), but locally spreading to somewhat older units where andesite was absent. If the unusually great thickness on the southwest side of The Mesa be significant, the upper rhyolite pyroclastic unit ($Tdrp_2$), unlike most of the lower rhyolite pyroclastic unit ($Tdrp_1$), may have been derived from the southwest. It is overlain, in the southeast corner of the mapped area only, by fluviatile and eolian beds ($Tdvs_3$) of limited known extent and still ambiguous relationships.

The resulting blanket of interfingering volcanic, alluvial, and eolian beds was gently warped and locally faulted. The principal structural feature which can be ascribed to this episode of deformation is a broad dome, the crest of which lies southwest of Horse Mountain. Younger units of the Datil Formation, if they were ever deposited in the mapped area, were removed in a subsequent interval of erosion. A younger volcanic formation, next to be described, was deposited on the erosion surface developed in this interval, cutting across units of the Datil Formation with mild unconformity.

YOUNGER VOLCANIC FORMATION

Volcanic rocks younger than the Datil Formation and separated from it by mild angular unconformity are grouped here in a <u>younger volcanic formation,</u> without assignment of a formal name. Like the Datil Formation, the younger volcanic formation includes a variety of volcanic rocks erupted from various centers. Locally derived alluvial deposits are interbedded in some areas. The several facies have been mapped separately.

The younger volcanic formation is itself deformed. Initial volcanic features are nowhere preserved. Conspicuous topographic features, however, such as Horse Mountain north of the San Agustin Plains and Shaw Peak south of the Plains, owe their present elevations to locally thick accumulations of lava. Farther south in the Pelona quadrangle, the Pelona and 0-Bar-0 Mountains, although much dissected, still preserve the general outline of broad lava domes. Subdued flow margins can still be identified locally on the flanks of Pelona Mountain. The younger volcanic formation is certainly not very old and must, at least in part, be as young as Pleistocene.

Basalt Facies (TQb)

Most widespread of the younger volcanic rocks are dense medium gray or reddish-brown to black basalt and andesite-basalt (TQb). These rocks are primarily a monotonous succession of flow, usually not well exposed. Individual flow units do not appear to be more than several tens of feet thick. Minor amounts of pyroclastic material are interbedded locally.

South of Wagontongue Ridge and The Mesa, basalt and andesite-basalt probably aggregate at least 2500 feet in thickness. Individual centers of eruption have not been identified, but thick pyroclastic materials suggest that the centers were local. In the northwest corner of the mapped area, similar rocks are at least 1000 feet thick. Greater thicknesses are preserved in the Mangas Mountains, farther north of and outside the mapped area. On the south side of the San Agustin Plains, between Bat Cave and Shaw Canyon, ridge-capping basalts are distal portions of flows from Pelona Mountain. Surface flows west of Bat Cave are related to a small, local center of eruption. East of Shaw Canyon, on both sides of Patterson's Cut-off, capping basalts are part of a much eroded lava dome, the former center of which probably lay near the present mouth of the Cut-off. Shaw Peak is the highest point still preserved.

Basalt and andesite-basalt from the several centers of eruption have been mapped as a single unit. Northeast of John Kerr Peak, bas alt and andesite-basalt (TQb) unconformably overlie rhyolite (TQr)which, in turn, overlies basalt and andesite-basalt (TQb) with apparent conformity. The unconformity cannot be traced beyond the area of rhyolite outcrop into the area where it presumably separates a younger from an older unit of basalt and andesite-basalt. It is not known, therefore, whether the unconformity records slight deformation and erosion of only local significance (in space and in time), or whether the basalt and andesite-basalt as mapped in the Tularosa Mountains (TQb) include two discrete units of more than local significance.

Rhyolite Facies (TQr)

Near John Kerr Peak, in an area at least four miles broad and six miles long, rhyolite is interbedded with basalt and andesite-basalt (TQb). The rhyolite is characteristically bluish-gray, although reddish- and purplish-gray are not uncommon. Phenocrysts of sanidine, large and commonly chalky, quartz, plagioclase, hornblende, and biotite are carried in a dull gray groundmass. Near John Kerr Peak at least 700 feet of rhyolite is preserved. Massive flows and flow breccias are the most abundant rock types. Water-laid breccias and tuffs are associated with and are particularly abundant in marginal areas of outcrop where they interfinger with basalt (TQb). Massive rhyolite capping two small summits between Cottonwood Canyon and upper Long Canyon exhibits broad fans of steeply dipping joints. These summits are probably exhumed lava domes, each about 500 feet thick and one-half mile in diameter. Structural details within the principal area of outcrop around John Kerr Peak were not studied. The rapid transition, however, from predominantly massive rock types in this central area to marginal water-laid materials implies a local area of rhyolite eruption (TQr), not much larger than the present area of outcrop, contemporaneous with the more widespread accumulation of basalt and andesite-basalt (TQb) which surrounds it.

On the south flank of an unnamed ridge extending eastward from John Kerr Peak, overlooking the north branch of Cottonwood Canyon, b a s alt and andesite-basalt (TQb) overlie rhyolite breccias and tuffs (TQr) unconformably. Basalts in the ridge are essentially horizontal, as is the contact with underlying rhyolite. The bedded rhyolite breccias and tuffs, in large part water-laid, dip persistently 5 to 10 degrees west as do basalts underlying the rhyolite at the east limit of outcrop. The unconformity cannot be traced farther east, where it presumably separates younger basalt from older basalt.

Ande site Facies (TQa)

Horse Mountain is a highly dissected volcanic pile. In a way, a predominantly brecciated core is surrounded and capped by massive flows. Both rock types are mapped together (TQa). Fine-grained intrusive rock (TQai) occupies an elliptical area, one-half mile wide and a little more than one mile long, located eccentrically in the present mass but probably more central to the original volcano. The prominent, fluted crest line north of the highest peak, visible from State Highway 12 opposite the large southeast-graining canyon, is carved from intrusive rock.

Massive flows are best exposed in the prominent southeast scarp and locally in gulches on other flanks. Individual flows are 100 feet thick on the average, usually medium gray but locally reddish-brown or black. Breccia is best exposed in the deep canyon draining southeast from near the highest peak and the longer canyon draining northeast, then east, from the summit area. The breccia is massive, coarse, brown, red, and purple. Fine-grained andesite of the central intrusion (TQai) is best exposed in the jagged crest line north of the highest peak and in the canyon heading on its south flank. The rock is characteristically gray and massive with a dull, pasty surface on fracture.

Basal flows of the volcanic pile, where exposed on its flanks, rest unconformably on volcanic sedimentary rocks (Tdvs) or rhyolite tuffs ($Tdrp_1$) of the Datil Formation. For one and one-half miles along the southeast flank, the first flow above the unconformity is dark andesite-basalt (TQb). A moderate fault between rhyolite tuff (Tdrp1) and lower volcanic sedimentary rock ($Tdvs_1$) is truncated by the unconformity in this vicinity. The unconformity at the base of the Horse Mountain andesite is the same unconformity which, six miles farther west, separates basalt and ande site-basalt (TQb) from older rocks of the Datil Formation. The Horse Mountain volcano is essentially the same age as the late basalt (TQb) of Mangas Mountain, but individual flows are thicker and more limited in geographic distribution,

Latite Facies (TQ1)

Portions of a single, thick latite flow crop out south and east of Patterson's Cut-off in the southeast corner of the mapped area. The flow is more extensively preserved south and east beyond this area. Within this area, the flow is 100 to 250 feet thick and consists chiefly of massive, flow-banded gray latite with a few small phenocrysts of plagioclase, augite, and biotite. On some slopes, the rock has platy jointing and is poorly exposed. On the south side of Patterson's Cut-off, just outside the mapped area, several gully heads expose 40 to 60 feet of coarse breccia in a soft matrix at the base of the flow.

Within the mapped area, the latite flow rests on rhyolite tuff ($Tdrp_2$) or, in the south part of Patterson's Cut-off, on water-laid and eolian sandstone ($Tdvs_3$) overlying the tuff. In gulches tributary to Shaw Canyon, alluvium with abundant latite fragments

(TQa1) occupies a local area north of the latite flow and is overlain by late basalt (TQb). At one locality, the basalt laps a short distance onto the latite flow itself. East of Patterson's Cut-off, basalt (TQb) overlies latite (TQ1), locally separated from it by alluvium (TQal). The latite flow (TQ1) is slightly older than the local basalts (TQb). South of the mapped area, the head of Shaw Canyon is a still-undrained depression, dammed locally where andesite-basalt (TQb) from Pelona Mountain abuts the west margin of the latite flow (TQ1).

Volcanic Sedimentary Facies (TQal)

At several localities, alluvial beds occur within the younger volcanic formation. The occurrences are for the most part local, and all were not mapped separately.

In a tributary east of Shaw Canyon, along the south edge of the map area, gray fluviatile sandstone 0 to 80 feet thick between rhyolite tuff ($Tdrp_2$) and andesite-basalt (TQb) carries abundant angular fragments of blue-gray latite. Most fragments are 1/4 inch to 3 inches in diameter, but some blocks are 18 inches across. The fragments are of adjacent latite (TQ1), and the sandstone appears to have been deposited in an alluvial apron along the north side of the latite flow prior to burial by andesite-basalt. Similar material was not seen in Patterson's Cut-off, but fine, sandy gravel with pebbles chiefly of basalt (TQb) crops out between latite (TQ1) and basalt (TQb) in several knolls east of the Cut-off. This gravel may be the lateral equivalent of the latite-rich alluvium in Shaw Canyon.

Buff to brown sandstone and conglomerate, containing abundant fragments of rhyolite, crop out locally between flow rhyolite (Tdrf) and basalt (TQb) in tributaries south of Long Canyon (not mapped separately). In the narrows just inside the forest boundary, similar beds crop out between rhyolite tuff ($Tdrp_2$) and basalt (TQb). Alluvial beds in a corresponding stratigraphic position were not seen in T-H Canyon, on the south side of The Mesa.

In tributaries to Tularosa Creek, at the west edge of the Pelona quadrangle, slightly consolidated, buff sandy alluvium (TQal) is both interbedded with and faulted against basalt (TQb). Gravel lenses in the alluvium contain cobbles of andesite porphyry (Tda_2), rhyolite tuff ($Tdrp_2$), and basalt (TQb). The alluvium is continuous with more extensive beds in the Reserve quadrangle, mapped as Gila conglomerate (Weber and Willard, 1959).

SURFICIAL DEPOSITS

Alluvium and bolson deposits, landslide debris, and littoral deposits of extinct Lake San Agustin postdate deformation of the younger volcanic formation and maintain genetic relationships with present topographic features. These surficial deposits are late Pleistocene to Recent.

Alluvium and Bolson Deposits

Broad valleys tributary to the San Agustin Plains are floored with alluvium of indeterminate thickness. Along most streams the principal fill has been trenched. Coarse gravel terraces on several streams, such as those in Patterson and Alamocite Canyons, record one or more episodes of fill-and-cut, Also in Patterson Canyon, north of State Highway 12, at least 30 feet of bouldery gravel is exposed locally in fresh scarps cut in older terraces.

Reconnaissance implies that the scattered terrace remnants are not readily susceptible to systematic differentiation and mapping. One gains the impression that terrace surfaces converge downstream, toward the Plains. In most valleys, the youngest fill is predominantly silt, comparable to young arroyo fills elsewhere in the Southwest. Here, the youngest fill is trenched, and one would infer that gullies are being extended by active erosion. Comparison of 1938 aerial photographs with ground conditions in 1954, however, revealed no local evidence of extension.

Except for well-defined littoral deposits of extinct Lake San Agustin, the detailed distribution of surficial deposits on the San Agustin Plains has not been mapped. The playa to the southwest is the lowest elevation on the Plains. As Powers pointed out (1939, p. 348), surficial deposits in the playa are clay, Peripheral to the playa, surficial deposits are coarser toward the margin of the Plains. Eastward, on the surface of the Plains, sandy silt is the coarsest material over wide areas. As made clear by Powers' map (1939, fig. 1), the form of the surface outside the playa is dominated by alluvial fans opposite principal tributary valleys. Cliffs were cut in the fans by Lake San Agustin, and the bulk of the fan deposits antedate the Lake. Sedimentation in the Lake itself did not obscure the pre-existing fan forms.

Certain high-level gravel deposits, the topographic positions of which are more or less anomalous, deserve special comment.

On the south slopes of Wagontongue Ridge, extending to its crest a distance of more than a mile, coarse bouldery gravels contain rounded boulders of andesite porphyry (Tda_2), as much as 10 feet in maximum diameter, as their most distinctive component. No source has been found for the boulders north of the Ridge. Its present north-facing scarp, however, is a reversed fault scarp. The coarse gravel on the Ridge must have been deposited when the fault scarp still faced south and when andesite porphyry (Tda2) still cropped out in a higher ridge north of the present Wagontongue Ridge.

Similar andesite porphyry (Tda_2) boulders occur north of Wagontongue Ridge in younger gravels, in sec. 7, T. 5 S, R. 15 W., between the westernmost tributary to Dark Canyon and an unnamed tributary leading west to Tularosa Creek in the Reserve quadrangle. These gravels slope northward toward the "Dry Lakes" at the northeast corner of the section and when deposited were an alluvial divide between eastward and westward drainage. The north-facing scarp of Wagontongue Ridge had been established, and it is likely that the andesite porphyry boulders were secondarily derived from gravels on Wagontongue Ridge, rather than from the outcrop capping the intervening horst. In subsequent stages of dissection, the former divide between eastward and westward drainage shifted a mile east through headward erosion of the tributary to Tularosa Creek.

The high gravels on Wagontongue Ridge and the lower gravels north of it record two stages in erosion of the horst north of the Ridge. When the high gravels were deposited, the horst was topographically as well as structurally high. Drainage from its south scarp flowed across Wagontongue Ridge. By the time the lower gravels were deposited, more rapid retreat of the north scarp of the horst had reduced the structural high to a topographic low. The former drainage divide on the horst had shifted a mile southward until it lay in the old alluvial apron on the structurally low block south of the horst.

Gravels at the north edge of the map, between Alamocito Canyon and Horse Mountain, rest on a broad erosion surface sloping northward into the Pinonville quadrangle. Conspicuous among constituents of these gravels are large boulders of andesite porphyry (Tda_2), probably derived from outcrops south-southwest of the gravels. The erosion surface originally sloped northward from a divide some distance south of the present limit of outcrop.

Landslide Deposits

Several high scarps are mantled locally by landslide deposits. Some larger landslides have the internally coherent form of Toreva blocks and have been mapped as narrow slices bounded by arcuate faults, as on the west flank of Horse Mountain. Other landslides broke up during movement into jumbled masses of relatively large individual blocks, as on the east scarp of The Mesa, or into more highly fragmented debris flows, as on the north scarp of The Mesa. No direct evidence of continued movement was found. Most of the landslides are moderately dissected and mantled by alluvium at their toes. Along the east scarp of The Mesa, cliffs were cut in several landslide masses by Lake San Agustin.

Littoral Deposits of Extinct Lake San Agustin

The shore lines of extinct Lake San Agustin are marked locally by littoral deposits. As pointed out by Bryan (1926) and Powers (1939), these have the well-developed form of beaches, spits, and bars. The present study failed to disclose such features not mapped by Powers (1939, fig, 1), Associated with the more characteristic beach ridges are broader and topographically lower deposits, distinguishable locally by either somewhat coarser grain than that of adjacent materials or terrace-like form. These deposits were primarily subaqueous and continuous with those portions raised above water level in beach ridges.

The highest level of extinct Lake San Agustin was 6940 feet. At this level, it was 34 miles long and 11 miles wide. In the area of the present playa, it was 165 feet deep. Studies of the Lake sediments and their contained pollen (Clisby et al. and Foreman et al.) leave little doubt that it reached its highest level during the Wisconsin glacial stage. Both the present elevation of shore line features and the absence of identifiable fault scarplets indicate that, within the Pelona quadrangle, the Lake basin has not suffered important deformation in post-Wisconsin time.

Structure

SAN AGUSTIN PLAINS

The major structural and topographical feature of the area is the San Agustin Plains. It is a graben, the principal development of which is younger than the volcanic rocks mapped.

A major fault boundary northwest of the Plains is inferred from the following observations:

1. Between Horse Mountain and State Highway 12, outcrops of basalt (TQb) and andesite (TQa) are 300 to 400 feet lower than the base of the same rocks in Horse Mountain, and dip toward the Plains. The position and attitude of the rocks are most easily explained by a sharp, local flexure produced by drag adjacent to a major fault.
2. The southeast limits of outcrop of these and other outcrops between Horse Mountain and State Highway 12 lie on a nearly straight line, trending N. 60° E. parallel to the southeast scarp of Horse Mountain.
3. The hills southeast and southwest of Horse Springs rise from the Plains along a moderately regular boundary, clearly transverse to the internal structure of the hills.
4. Projection of the linear form from one upland to the next develops a rather smooth line, swinging from about N. 60˚ E. opposite Horse Mountain to N. 55˚ E. opposite Horse Springs. The boundary transects both the broad structural dome southwest of Horse Mountain and a predominantly west-northwest fracture system in the upland areas.

The southeast margin of the Plains, although indented along stream canyons, can be described approximately as a smooth, doubly inflected curve from Patterson's Cut-off west to Bat Cave. The eastern inflection, opposite Patterson's Cutoff, is made apparently sharper by the flare of the canyon mouth. West of Bat Cave, the upland rocks drop about 1000 feet on the west side of a north-south fault. The fault scarp, extending at least 10 miles in a broad arc south of the mapped area, is the east margin of an embayment of the Plains. Volcanic rocks crop out in the floor of the embayment, and the major structural boundary of the Plains continues west from Bat Cave, within the mapped area.

Along the upland margin, between Shaw Canyon and Bat Cave, volcanic rocks are broken by gently sinuous, predominantly east-west faults of small displacement. Those faults farthest from the Plains are more persistent and are also older than basalt (TQb). Those within one and one-half miles of the upland margin are shorter, anastomosing, and predominantly downthrown toward the Plains. Several cut basalt (TQb). They are logically interpreted as parallel and sympathetic to a major fault at the upland margin. They support the inferences both that the southeast border of the Plains is a major fault and, like the andesite south of Horse Mountain, that principal movements on the major fault postdate basalt (TQb).

The east scarp of The Mesa has the same linear character as does the north scarp, which is demonstrably a fault scarp. The east scarp trends N. 20° E. and is believed to reflect a major cross-fault which, projected across the mouth of Long Canyon, is the west boundary of the Plains. Darton (1928, p. 345) regarded the Plains as a former stream valley, dammed by younger lavas at the southwest end. In fact, the volcanic rocks at the southwest end are the same age as those surrounding the basin as a whole. The southwest margin, like those northwest and southeast, is a fault.

Within the area of the Plains, most of the wells are less than 200 feet deep (Bushman and Valentine, 1954). Two older wells are reported to have penetrated 1100 feet of fill. In sec. 14, T. 5 S. , R. 13 W. , however, unconsolidated sediments have been cored to a depth of 2000 feet (Foreman et al.) without encountering volcanic rocks. This site i s not quite midway between the northwest and southeast margins of the Plains. It is conceivable (although unlikely) that volcanic rocks of the younger volcanic formation never covered the site of this core. At least the upper rhyolite pyroclastic unit ($Tdrp_2$) and probably other units of the Datil Formation were originally continuous across the Plains in this vicinity. One must infer that volcanics of the Datil Formation lie deeper than 2000 feet. A minimum structural relief of 4000 feet is implied between these rocks at the drilling site and their equivalents in the upland area near Horse Springs. Only 3000 feet need be inferred between volcanic rocks at depth in the Plains and their equivalents south between Shaw Canyon and Bat Cave. These figures are minima, however, and may be too low by a factor of 2. In any event, the eroded fault scarps separating upland and basin reveal less than half the displacement on the faults to which they are related. The structural relief of the west end of the Plains has been reduced more than half by sedimentation in the graben.

In summary, the San Agustin Plains within the mapped area occupies a graben formed after eruption of basalt (TQb) and related volcanics. Structural relief of the graben is at least 4000 feet, more than half of which has been reduced by sedimentation. The northwest boundary fault system may have a rather regular trace, swinging from N. 55° E. near the west end to N. 60° E. opposite Horse Mountain. The southeast margin is more sinuous, with an average trend swinging from nearly east-west at the west end to N. 40° E. at the east edge of the mapped area (the N. 40° E. trend continues seven miles in the adjacent Luera Spring quadrangle). The west limit of the graben is a cross-fault trending N. 20° E.

SOUTH OF SAN AGUSTIN PLAINS

Within the mapped area, volcanic rocks south of the Plains are relatively flat-lying. Maximum structural relief does not exceed 1500 feet, which is only 50 per cent greater than displacement on a single fault west of Bat Cave. East of Shaw Canyon, rocks of the Datil Formation dip south and southeast about 200 feet a mile. The younger volcanic formation rests on a more nearly horizontal erosion surface. Along a northwest-trending fault east of Patterson's Cut-off, all rocks are dropped about 100 feet to the northeast. Shaw Canyon appears to follow a northwest-trending fracture system, of small displacement, down to the northeast.

Between Shaw Canyon and Bat Cave, volcanic rocks of the upland dip toward the Plains about 200 feet a mile. Within a mile from the upland border, the rocks are broken by normal faults believed to be related to the fault border of the Plains. Along the south edge of the mapped area, east-west normal faults, of sinuous trace and displacements of about 100 feet, are older than andesite-basalt (TQb) from Pelona Mountain. These faults are part of a system more extensively developed beyond the mapped area.

West of Bat Cave, volcanic rocks of the upland are dropped about 1000 feet to the west along an arcuate fault forming the east margin of an embayment of the Plains lying chiefly south of the mapped area. Within the mapped area, basalts from a local center (TQb) are broken by one more fault, down to the northwest, and farther west are chiefly concealed by alluvium.

NORTH OF SAN AGUSTIN PLAINS

North of the San Agustin Plains, the Datil Formation is gently warped and broken by normal faults. Maximum structural relief is at least 3000 feet, but it may not be much greater. Dips are gentle, for the most part less than 500 feet a mile. Maximum displacement on a few faults exceeds 2000 feet, but only a few others have displacements in excess of 100 feet. The more numerous faults of smaller displacement can be mapped rather easily in some areas of outcrop of the Datil Group having strong lithologic contrast, It is assumed that comparable fractures also occur locally within the broad areas of basalt (TQb), where more uniform lithology does not reveal the fracture pattern.

Probably the highest structural elevation is the crest of a broad, gentle dome underlying the lowland southwest of Horse Mountain. The general form of the dome can be deduced from contacts between the lower volcanic sedimentary unit ($Tdvs_1$) and lower rhyolite tuff ($Tdrp_1$) of the Datil Formation, peripheral to the lowland. East and west of Horse Mountain, these rocks dip gently north. In Alamocito Canyon, the same rocks dip gently north-northwest, and in low hills east of Horse Springs, they dip gently south-southwest. Prevolcanic rocks crop out locally between Horse Mountain and State Highway 12, where volcanic rocks have been stripped from the crest of the dome. Comparable prevolcanic rocks are probably more widespread, underlying alluvium at shallow depths, in the lowland west of the actual outcrops. Structural relief on the dome, between an inferred crest southwest of Horse Mountain and the strong northwest fault in the hills southwest of Horse Springs, is about 1500 feet. Faults of small displacement, trending west-northwest and north-northwest, break the exposed rocks on the flanks of the dome. One fault in the South Fork of Alamocito Canyon and a second fault east of Horse Mountain are older than basalt (TQb) and andesite (TQa) of the younger volcanic formation. Very probably most of the faults between Alamocite Canyon and Horse Mountain, are the same age as the structural dome. On the west flank of the dome, from Patterson Canyon east to Horse Mountain, basalt (TQb) rests on successively older rocks from upper rhyolite tuff ($Tdrp_2$) to the lower volcanic sedimentary unit ($Tdvs_1$) of the Datil Formation.

From Horse Springs west to the edge of the quadrangle, volcanic rocks dip generally south-southwest and south, broken by numerous faults. The area mapped is about half that lying between the San Agustin Plains on the east and an area of numerous northeast-trending faults farther west, in the Reserve quadrangle. The structural pattern, only partly included in the mapped area, connects major structures east and west of it and is presumably related to both.

Principal fault systems trend west-northwest and are responsible for the pronounced grain in topography north of Wagontongue Ridge and The Mesa. Faults of small displacement trend west-northwest, east-northeast, and no rthe a st. Several faults, required to explain the distribution of rocks on either side, are largely concealed by alluvium, but their presence is reasonably certain. They are believed to be of primary importance in the general structural pattern and are mapped (pl. 1).

The broad area of basalt (TQb) in the southwest corner of the mapped area is basin-like (cf. cross section, pl. 1). Two faults trending north-northeast in the area of interbedded rhyolite (TQr), in conjunction with faults just west in the Reserve quadrangle, bound a small graben centering near John Kerr Peak which locally accentuates the basin form. Certainly the faults in the Reserve quadrangle and possibly those in the Pelona quadrangle are older than the upper part of the basalt (TQb). The faults in the Reserve quadrangle are truncated by the unconformity at the base of the upper unit. This graben was probably the locus of eruption of rhyolite in the younger volcanic formation (TQr) and may be genetically related to the extrusion of magma. East-west faults of small displacement, recognized locally along the base of Long Canyon Mountain, may be continuations of the fracture system (without its large displacement) which forms the south boundary of the San Agustin Plains.

The broad basin underlain by basalt (TQb) is very nearly continuously rimmed on north and east margins by a horst. A southerly fault system can be traced in the north-facing scarp of Wagontongue Ridge from the west edge of the quadrangle to Dark Canyon. Estimated displacement, down to the south (in the sense opposite to the escarpment) increases from 1000 feet at the edge of the quadrangle to 1500 feet at Dark Canyon. A nearly parallel fault system, about one mile north of the first, is largely concealed by alluvium. It is thrown down to the north, with an estimated displacement of 500 feet at the edge of the quadrangle and of more than 2000 feet along most of the distance to Dark Canyon. The two faults, within the mapped area, bound a narrow horst. *

At Dark Canyon, the southerly fault is offset about one mile to the south by a cross fault. The northerly fault probably continues eastward under alluvium, but an oblique branch fault

* Farther west, in the Reserve quadrangle, the two faults diverge. Other faults appear and the identity of the horst is lost.

carries about half its displacement south, nearly impinging upon the southerly fault. Between Dark Canyon and The Mesa, the separate identity of these faults is lost in a complex pattern of oblique faults. The sense of the horst continues, however. At The Mesa, the branch of the northerly fault swings northward along the base of the north-facing escarpment. Displacement equivalent to that of the southerly fault is about equally divided between another branch trending east-northeast across The Mesa (roughly parallel to the branch of the northerly fault) and a branch trending nearly north-south down Rael Canyon to the mouth of T-H Canyon. This latter branch fault, in conjunction with the fault boundary of the San Agustin Plains, defines a broader and lower horst trending north-northeast on the east margin of the basin underlain by basalt (TQb). The Mesa forms a rim less pronounced than that on the north margin of the basin, but no less real.

Farther north of Dark Canyon, a fault can be traced from the low escarpment south of Tularosa Creek *(sec.* 36, T. 4 S. , R. 15 W.) four miles east along the north side of an unnamed ridge. Estimated displacement increases from about 200 feet to about 500 feet down to the north in this distance. A parallel fault, one-half mile south of the first and with comparably increasing displacement, swings north to join the first. From the junction (sec. 33, T. 4 S., R. 15 W.), where combined displacement is 1000 feet down to the north, the fault system continues eastward at least three miles under alluvial cover, probably with decreasing displacement. The general effect of this system is to raise an arcuate block seven miles long, convex to the north and downthrown side, by displacements increasing from 0 at the ends of the block to about 1000 feet at its mid-point. The raised block is broken internally by numerous faults, trending chiefly northeast and east-northeast.

North of State Highway 12, in T. 4 S. , R. 15 W. and T. 4 s., R. 14 W., discontinuous exposures in ridges reveal portions of a series of arcuate faults of small displacement, convex toward and chiefly down to the north. The writer suspects that these fractures lie within a block bounded still farther north by an arcuate fault system of larger displacement, not identified within the lithologically uniform basalt (TQb). A northwest-trending fault in sec. 7, T. 4 S., R. 14 W. must continue at least three miles to the southeast along the base of a ridge of rhyolite tuff ($Tdrp_2$) capped by basalt (TQb), separating these rocks from basalt (TQb) under alluvial cover to the northeast. In the northwest corner of the mapped area, if basalts cropping out along the north edge of the map maintain their southward dip beneath alluvium, an east-northeast fault or faults may be required between the alluviated valley and outcrops of basalt and older volcanics on its south side. These two faults may be east and west portions, respectively, of the inferred arcuate fault. Faults exposed in sec. 36, T. 3 S. , R. 15 W. and sec. 8, T. 4 S., R. 14 W. may be fragments of the east half of still another arcuate fault system, culminating north of the mapped area.

The hills southwest of Horse Springs are, in part, sliced by a rather close-spaced series of faults trending west-northwest. The closely faulted area to the southwest is separated from a nearly unbroken area to the northeast by a northwest-trending fault, down to the southeast. Northwest of State Highway 12, displacement on the latter fault decreases rapidly. The prominent scarp on the west side of the closely faulted area is probably a fault scarp. Near State Highway 12, the fault at its base separates lower rhyolite tuff ($Tdrp_1$) from upper rhyolite tuff ($Tdrp_2$) and must trend northeast, thrown down to the northwest about 500 feet. For some distance to the southwest, displacement probably increases between b a salt s (TQb) under alluvial cover to the northwest, dipping south, and older volcanics in the hills to the southeast, with appreciably smaller average dip. In effect, the older volcanics form a small horst between the San Agustin Plains to the southeast and an area to the northwest also thrown down, although less than the Plains.

The mouth of Patterson Canyon, between the faulted upland southwest of Horse Springs and The Mesa, is an alluviated valley two miles wide. It is reasonable to infer that volcanic rocks beneath alluvial cover in the valley, like those northeast and southwest of it, are broken by faults in a complex pattern. Is it also reasonable to infer that, beneath the alluvial cover, the structurally high area southwest of Horse Springs and the structurally high area of The Mesa are essentially continuous between the major graben of the San Agustin Plains to the southeast and a less depressed area to the northwest, in secs. 3, 4, and 5, T. 5 S. , R. 14 W. ? Is the important Patterson Spring, in sec. 9, T. 5 S. , R. 14 W. , a "rise" where ground water in relatively thick alluvium to the north encounters bedrock at shallower depths in a horst between the alluviated valley to the north and the San Agustin Plains to the south? The inferences are reasonable, but the structure at the mouth of Patterson Canyon can be only inferred. Direct evidence from adjacent areas suffices only to show that in detail the structure is probably complex.

SUMMARY

In summary, the area mapped west and northwest of the San Agustin Plains appears to comprise (1) a broad, gentle dome to the northeast, older than the younger volcanic formation (TQb and, in Horse Mountain, TQa); (2) a broad,, gentle basin to the southwest, younger than basalt (TQb) and interbedded rhyolites (TQr), the rim of which is an essentially continuous horst; and (3) a series of arcuate fault blocks, dipping successively southward, between the Mangas Mountains north of the mapped area and the rim of the broad basin in the southwest portion of the mapped area. Culminations of the fault blocks are about 1000 feet lower than structural elevations in the Mangas Mountains to the north and the rim of the basin to the southwest. The low portions of each block, at the east and west ends, lie 500 to 1500 feet lower than their culminations. A structural high between the area of arcuate fault blocks and the San Agustin Plains is probably continuous from The Mesa across the mouth of Patterson Canyon to the hills southwest of Horse Springs.

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Measured Section of pre-Tertiary Rocks near Horse Mountain (Sec. 20, T. 4 S. , R. 12 W.)

De scription	Thickness (in feet)
TRIASSIC(?) SANDSTONE	
Sandstone, grayish orange and light red, weathers orange to pinkish brown; beds 1 to 3 feet thick; medium grained, subangular to rounded and frosted quartzite grains, scattered pebbles of quartz; lenses of pebbles near base, pebbles, angular to well rounded, of sandstone, quartzite, and chert; uppermost bed brecciated and silicified; upper contact concealed	39
Covered; scattered outcrops like underlying unit	35
Sandstone, reddish orange, argillaceous, calcareous, fine grained, friable; scattered pebbles of quartz and chert; bedding poorly shown	12
Covered	10
Sandstone, speckled by dark reddish-brown spots, very light gray; beds massive to thin, friable; fine to medium grained, cross-laminated; contains 5% ferromagnesium minerals as well as ironstone concretions	7
Covered	11
Total thickness of Triassic(?) Sandstone more than	114

SAN ANDRES LIMESTONE

Limestone, very light gray; beds 1/2 foot to 2 feet thick; argillaceous, finely granular, fo ssil - iferous	30
Covered, in stream bottom	45
Limestone, light gray; beds 1/4 to 1/2 foot thick; finely crystalline, cherty and silicified; scattered chert nodules and silicified fossil fragments; thickness measured down dip slope	60
Limestone, gray to dark gray; beds 1/2 to 1 foot thick; fine grained, algal to oolitic, many tiny fossil fragments; ridge top	55
Limestone, brownish-gray; massive, cliff-forming, argillaceous, finely granular, porous and vuggy, fetid	32
Limestone, gray to grayish-brown; beds 1/2 foot to 3 feet thick; very finely crystalline, abundant vugs partly filled with calcite crystals, scattered silicified fossil fragments; 50 feet above base are numerous brachiopods, algae, gastropods, and crinoids	195
Total thickness of San Andres Limestone	417

GLORIETA SANDSTONE

Sandstone, very light gray to white; medium grained, siliceous to calcareous, hard to friable, local cross-lamination, subrounded to well rounded and frosted grains	82
Sandstone, very light gray; lenticular beds 1 to 2 feet thick; veryfine grained to medium grained, friable, calcareous; grains subangular, frosted	13
Total thickness of Glorieta Sandstone	95

YESO FORMATION

Limestone, grayish-brown; beds 2 to 24 inches thick, poorly exposed in scattered ledges; porous, oolitic, vugs partly filled with calcite crystals	30
Covered; some thin ledges of gypsum	32
Sandstone, light gray to light red; fine grained to very fine grained; calcareous, porous, friable	9
Covered; scattered outcrops(?) of gray limestone and pink, soft sandstone	70
Fault breccia, pink, gypsiferous	3
Limestone, gray; finely crystalline	3
Fault gouge	15
Dolomite, light gray tinted pink to olive; very finely crystalline, argillaceous, silty	2
Fault gouge; brecciated limestone and pink sandstone cemented by veins of acicular aragonite and gypsum	15
Covered; top 2 feet like underlying unit	15
Sandstone, mottled light gray and light red; lenticular beds 9 to 24 inches thick, small scale cross-laminations; fine grained, calcareous, friable, well sorted; base not exposed	7
Total thickness of (faulted) Ye so Formation more than	201
Total thickness of pre-Tertiary rocks exposed	827

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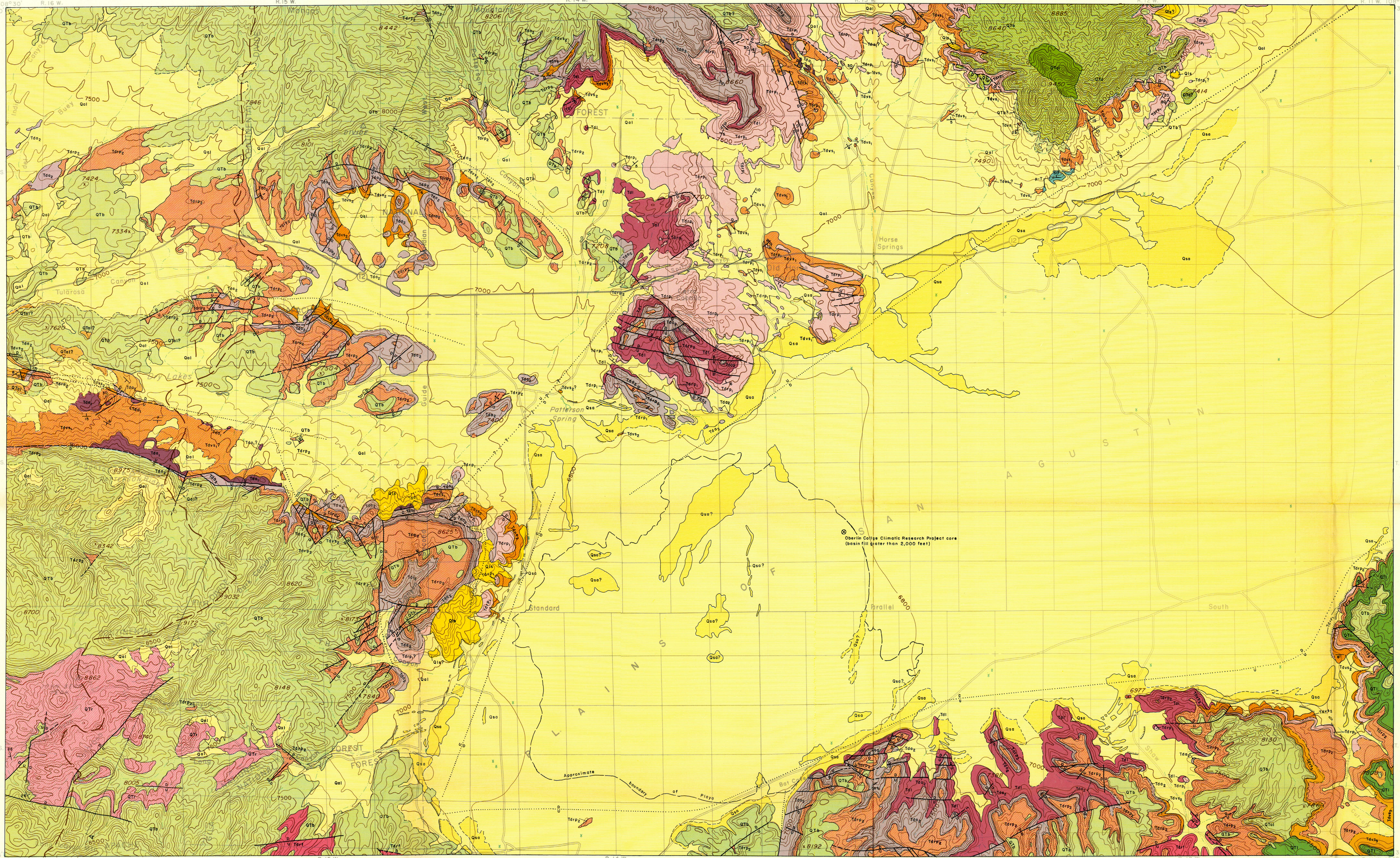


Base map compiled from parts of U. S. Geological Survey Pelona quadrangle and New Mexico State Highway Department Horse Springs quadrangle.

Geology by Charles E. Stearns surveyed 1952–54. Cartography by W. E. Arnold.

EXPLANATION

QUATERNARY

- Qsa — Littoral deposits of Lake San Agustin
- Qls — Landslide debris
- Qal — Alluvium and bolson deposits of San Agustin Plains

UNCONFORMITY

QUATERNARY–TERTIARY

Younger volcanic formation

- QTr — Rhyolite
- QTa / QTai — Andesite (QTa: extrusive; QTai: intrusive)
- QTl — Latite
- QTb — Basalt and andesite-basalt
- QTal — Alluvial deposits

UNCONFORMITY

TERTIARY

Datil Formation

- Tdrp₂ — Upper rhyolite pyroclastic unit
- Tda₂ — Upper andesite unit
- Tdvs₃ — Upper sedimentary unit
- Tdrp₁ — Lower rhyolite pyroclastic unit
- Tda₁ — Lower andesite unit
- Tdvs₂ — Middle sedimentary unit
- Tdrf — Rhyolite flow unit
- Tdl — Latite
- Tdvs₁ — Lower sedimentary unit

UNCONFORMITY

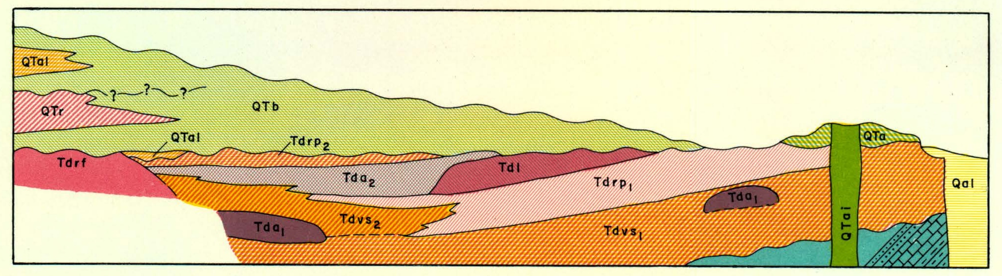
PERMIAN, TRIASSIC

- P-T — Pre-Tertiary rocks

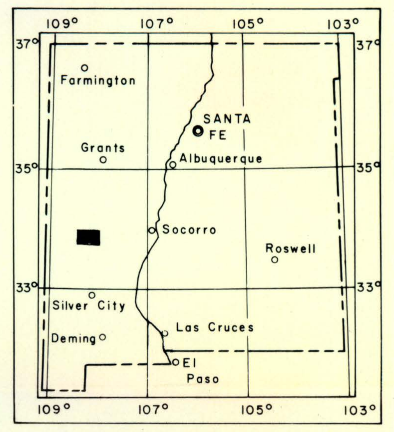
Contact (Dashed where approximately located)

Fault (Dashed where approximately located; dotted where concealed. U, upthrown; D, downthrown)

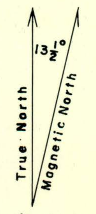
Wave-cut scarp of extinct Lake San Agustin



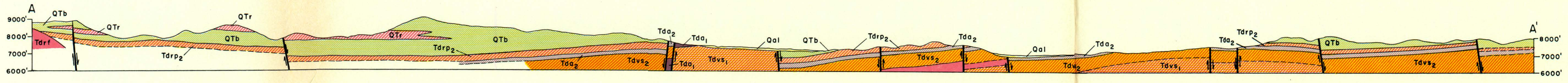
Diagrammatic relationships of mapped lithologic units



Index map showing north half of the Pelona quadrangle



Approximate mean declination 1950



GEOLOGIC MAP NORTH HALF OF PELONA THIRTY-MINUTE QUADRANGLE

Scale 1/63360

1 0 1 2 3 4 5 Miles

Contour interval 100 feet

Datum is mean sea level