GEOLOGY OF THE CERRO COLORADO MOUNTAINS, PIMA COUNTY, ARIZONA

RUSSELL SMITH

TUCSON, ARIZONA

ABSTRACT

The Cerro Colorado Mountains, 45 miles southwest of Tucson, Arizona, comprise a three-fold sequence of Late Mesozois (?) to Quaternary lava flows and tuffaceous deposits in a wide variety of stratigraphic and structural relationships.

Lavas of intermediate to basic composition emerged from local vents and flowed over a gently arched surface of Cretaceous (?) sedimentary rock. Water laid tuffs overlie the flows from which they were derived. Pumice, tuff, and rhyolite were then emitted to form a complex ash flow sequence showing various degrees of welding. Erosion and redeposition of this material filled depressions and mantled the marginal slopes with aprons of tuffaceous conglomerate. Basalt flows cap the eastern half of the range marking the final episode of igneous activity. At least one local vent is identified for each of the eruptive cycles.

Block faulting, with relative uplift of the west half of the range, led to stripping off of the basalt followed by gravity sliding of tuffaceous rocks down the northwest flank of the uplifted block.

INTRODUCTION

Several features of the Cerro Colorado Mountains make them particularly well suited to illustrate the Tertiary geology of southeastern Arizona. They lie on one of the main belts of orogenic activity in the area; they comprise a wide variety of rock types in complex but generally well exposed stratigraphic and structural relationships; their location, areal extent and topography permit relatively easy access for detailed examination.

The geologic map of Pima and Santa Cruz Counties (Wilson and others, 1960) shows a striking distribution of mountain ranges in north-south trending belts. The Cerro Colorado Range lies on one such belt together with the San Luis Mountains to the south and the Sierrita and Tucson Mountains to the north.

Like most of the smaller ranges in southeastern Arizona, the Cerro Colorado Mountains consist chiefly of volcanic rock. The highest peak (NW¼ sec. 7, T. 20 S., R. 11 E.) stands at 5319 feet, about 1800 feet above the adjacent valley floor. A north trending normal fault divides the range approximately in half (Figs. 1 and 3). The western part is an uplifted mass of tuffaceous beds which have been dissected into sheer cliffs and serrate

ridges (Fig. 2). East of the fault thick basalt flows are weathered to rounded hills and relatively gentle, scree-covered slopes (Fig. 3). The entire complex occupies about 15 sections around the common corner of Tps. 19 and 20 S.; Rs. 10 and 11 E. It may be reached by driving 35 miles south from Tucson on U. S. Highway 89, thence eight to ten miles west from Arivaca Junction (see index map). Several jeep trails lead from Sopori School and the Santa Lucia Ranch to the base of the mountains (Tubac, Arizona 15′ quadrangle, U. S. G. S. 1939).
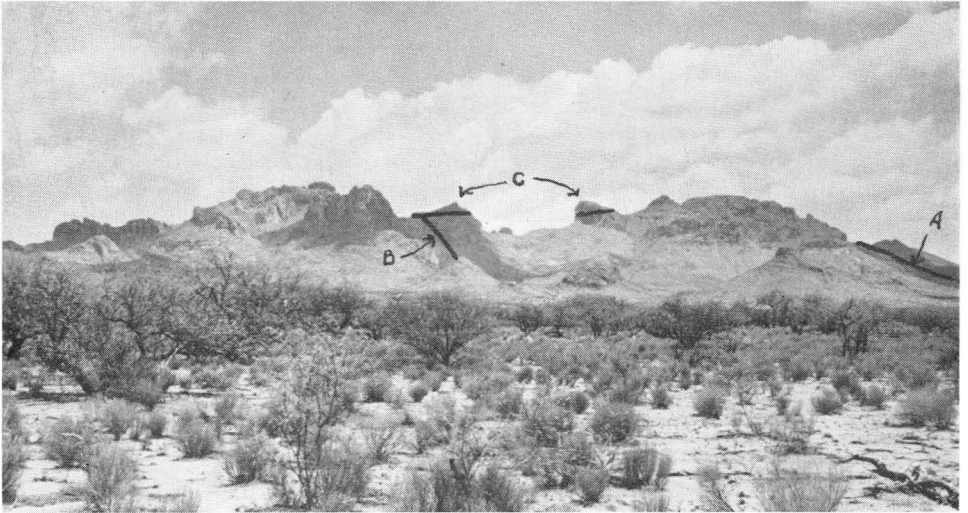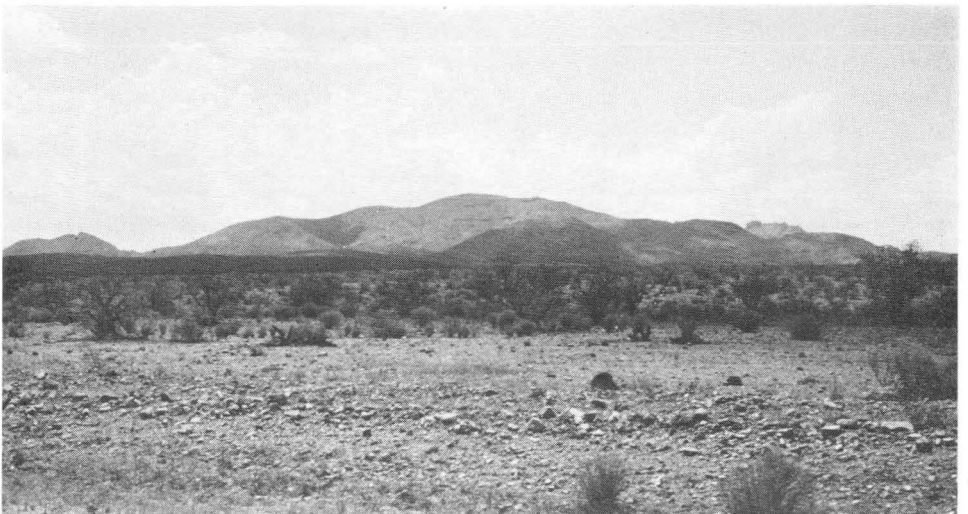

FIGURE 2

FIGURE 3.   Cerro Colorado Range from the east.

Previous geologic work has been concentrated chiefly in the many local mining areas. Chief among these is the Pima District in the Sierrita Mountains, about 14 miles to the north, where recent new discoveries have revealed one of the richest sources of copper in the United States. E. D. Wilson (1950) and J. R. Cooper (1960) are among those who have contributed significantly to our knowledge of the Pima District. R. E. Davis (1955) and R. D. Jones (1957) have written Masters' Theses on the Cerro Colorado District, a small abandoned mining camp to the southwest.

The Southern Arizona Guidebook II (1959), edited by L. A. Heindl, contains several papers on these and other significant localities. Among the contributions in the guidebook which are relevant to the present problem are those by S. R. Titley, E. D. Wilson and R. T. Moore, and P. A. Wood.

Field mapping for this project was done during the summers of 1963-64 on the Tubac and Arivaca 15' quadrangle maps and on aerial photographs at a scale of approximately 1:5400. Petrographic work and writing was done at the University of Nebraska.

STRATIGRAPHY

General Statement

The rocks of the area may be divided into two main groups on the basis of age and their apparent relationship to the present Cerro Colorado Mountains. The older group, which antedates the mountains, consists of Cretaceous (?) limestone and arkosic sandstone resting on a surface of Precambrian (?) granite. Although these beds were derived in part from pre-existing volcanic rocks, their limited exposure offers few clues to the exact nature and location of their source. The sediments are not differentiated on the geologic map (Fig. 1).

The second group is a dominantly volcanic sequence of Tertiary (?) and younger age, which accumulated on the sediments where it was deformed and eroded to become today's range. This series of deposits is subdivided into three cycles of eruptive rocks each of which is overlain by a detrital unit. Successive flows of andesite porphyry, latite porphyry, and

rhyolite were followed by bedded lithic tuff. Next is an ash flow complex consisting of intergradational units of rhyolite vitrophyre, crystal tuff, perlitic glass and welded tuff all overlain by a tuffaceous conglomerate. Basalt flows cap the tuaceous conglomerate and are flanked by conglomerate to which they contributed much of the coarse debric. Many units are locally absent due to erosion, non-deposition, and faulting so that the section is not complete at any one locality.

Pre-Tertiary Rocks

GRANITE

A small horst of Precambrian (?) granite borders the southwest flank of the range (W½ sec. 18, T. 20 S., R. 11 E.). It is grayish-red and medium grained with uniform distribution of minerals. Hand specimens reveal approximately 30 per cent quartz, 35 per cent fresh pink feldspar, 25 per cent pale pink to buff feldspar, and 10 per cent weathered mafic minerals. The light colored feldspar is extensively kaolinized but some grains show plagioclase twinning striations. The mafic minerals are chiefly hornblende with some biotite.

LIMESTONE

Limestone is exposed beneath arkosic sandstone at one locality in the base of the west flank (E½ sec. 1, T. 20 S., R. 10 E.) where it represents the upper eight feet of a unit of unknown thickness. The rock consists of brecciated fragments of lithographic limestone in a matrix of calcareous and siliceous clay. Also included in the matrix are doubly terminated quartz crystals, grains of sanidine, and a few chips of reddish-brown volcanic rock. Within the unit is a lense of dense, yellow, argillaceous limestone containing a few ostracods. Float fragments indicate the presence of limestone in Section 12 but farther south it is downfaulted against the granite horst.

ARKOSIC SANDSTONE

Above the limestone is about 85 feet of arkosic sandstone. Distinct layers of alternating coarse and fine particles characterize the rock. Layers average about one inch in thickness. The color is light gray to pink depending on the amount of feldspar and ferruginous clay matrix.

Grain composition, estimated from thin section, is 20 per cent angular quartz, 30 per cent sanidine, and 10 per cent kaolinized plagioclase. Quartz shows slight strain, numerous bubble trains, and microlites. The plagioclase that is still identifiable is oligoclase. The remaining 40 per cent of the detritus is volcanic rock.

Tertiary(?) Rocks — First Cycle

ANDESITE PORPHYRY

Dark gray to reddish-gray, slightly porphyritic andesite is exposed at several points along the west flank. It is approximately 30 feet thick where

EXPLANATION

QUATERNARY

Qal — Alluvium

TERTIARY (?)

Qc — Conglomerate

Tb — Basalt

Ttc — Tuffaceous conglomerate

Taw / Tag / Tac / Tav — Ash flow complex
Taw, welded tuff; Tag, perlitic glass; Tac, crystal tuff; Tav, rhyolite vitrophyre

CRETACEOUS (?)

Tlt — Lithic tuff

Tr — Rhyolite

Tlp — Latite porphyry

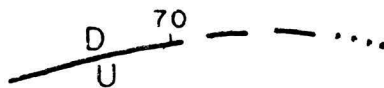Tap — Andesite porphyry

Ks — Sedimentary rock

PRECAMBRIAN (?)

P€g — Granite

Contact, dashed where approximately located

D 70 / U — Fault, showing dip; dashed where approximately located; dotted where concealed; U, upthrown side; D, downthrown side

Gravity slide block; barbs on side of slide mass
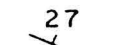
27 — Dip and strike of beds
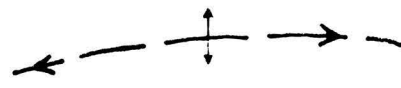
Anticlinal axis, showing direction of plunge

Volcanic vent

Approximate mean declination (1960) 13°
True North

Geology by Russel Smith 1963-4

INDEX MAP OF SOUTHEASTERN ARIZONA

PHOENIX

PIMA COUNTY

TUCSON

U.S. 89

CERRO COLORADO MOUNTAINS

SANTA CRUZ COUNTY

COCHISE COUNTY

NEW MEXICO

Nogales

MEXICO

0 10 20 30
Miles

5000   0   5000
Scale in feet

A — Bends in section — A'

5500'
5000'
4500'
4000'
3500'
3000'
2500'
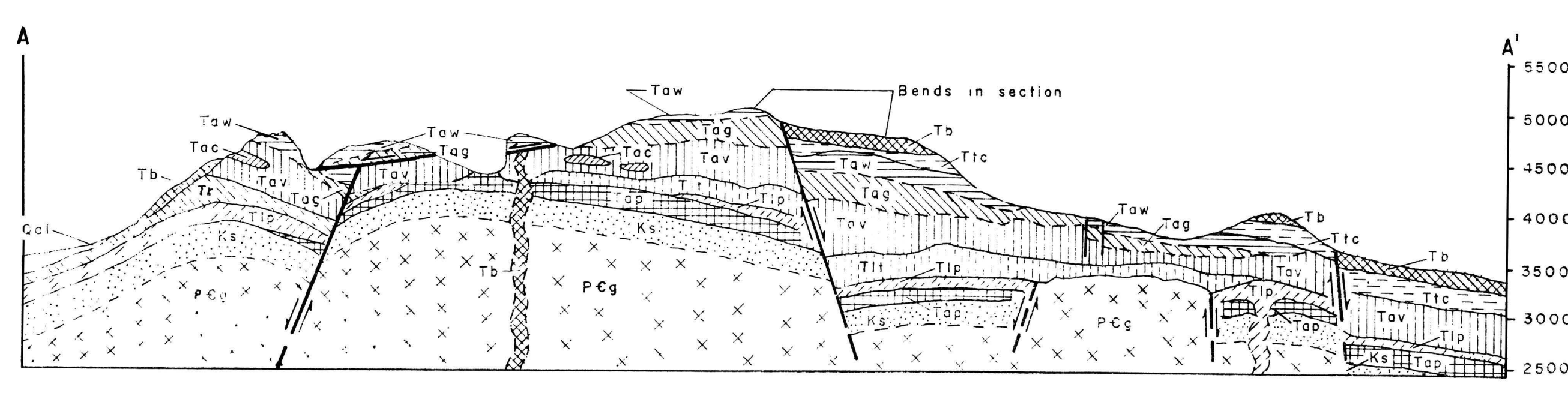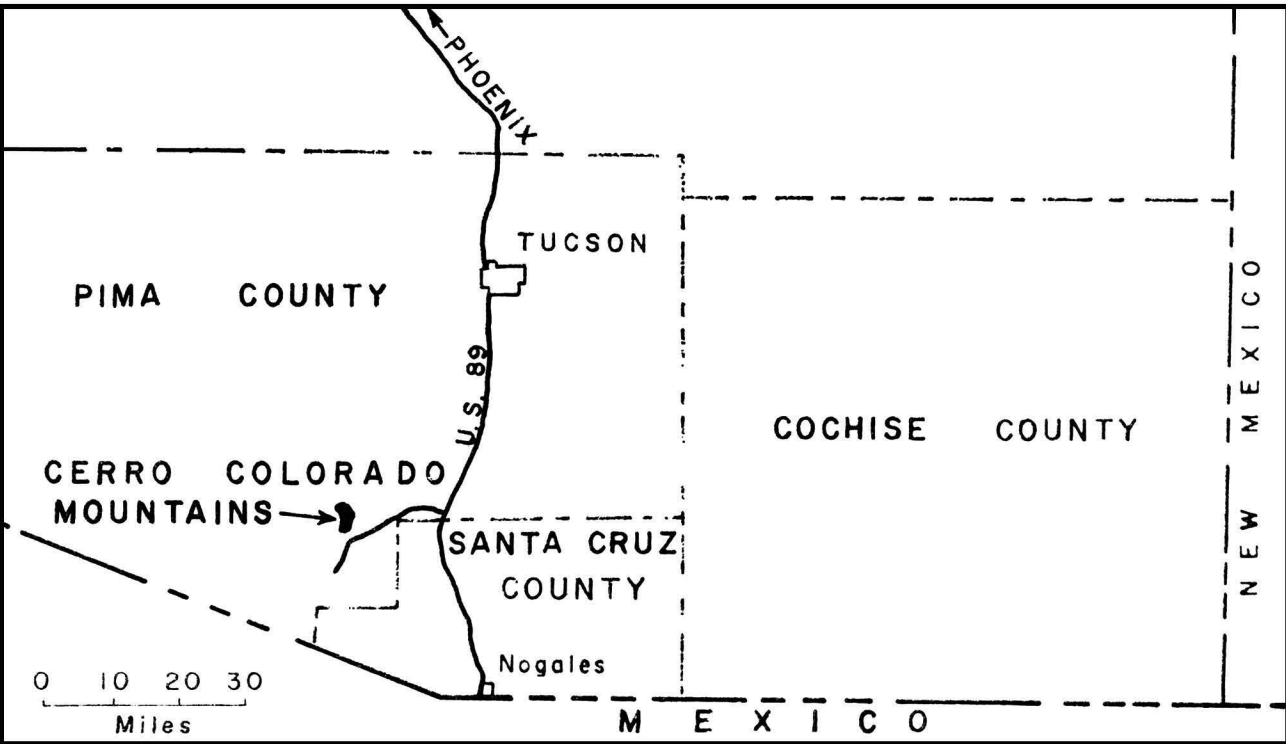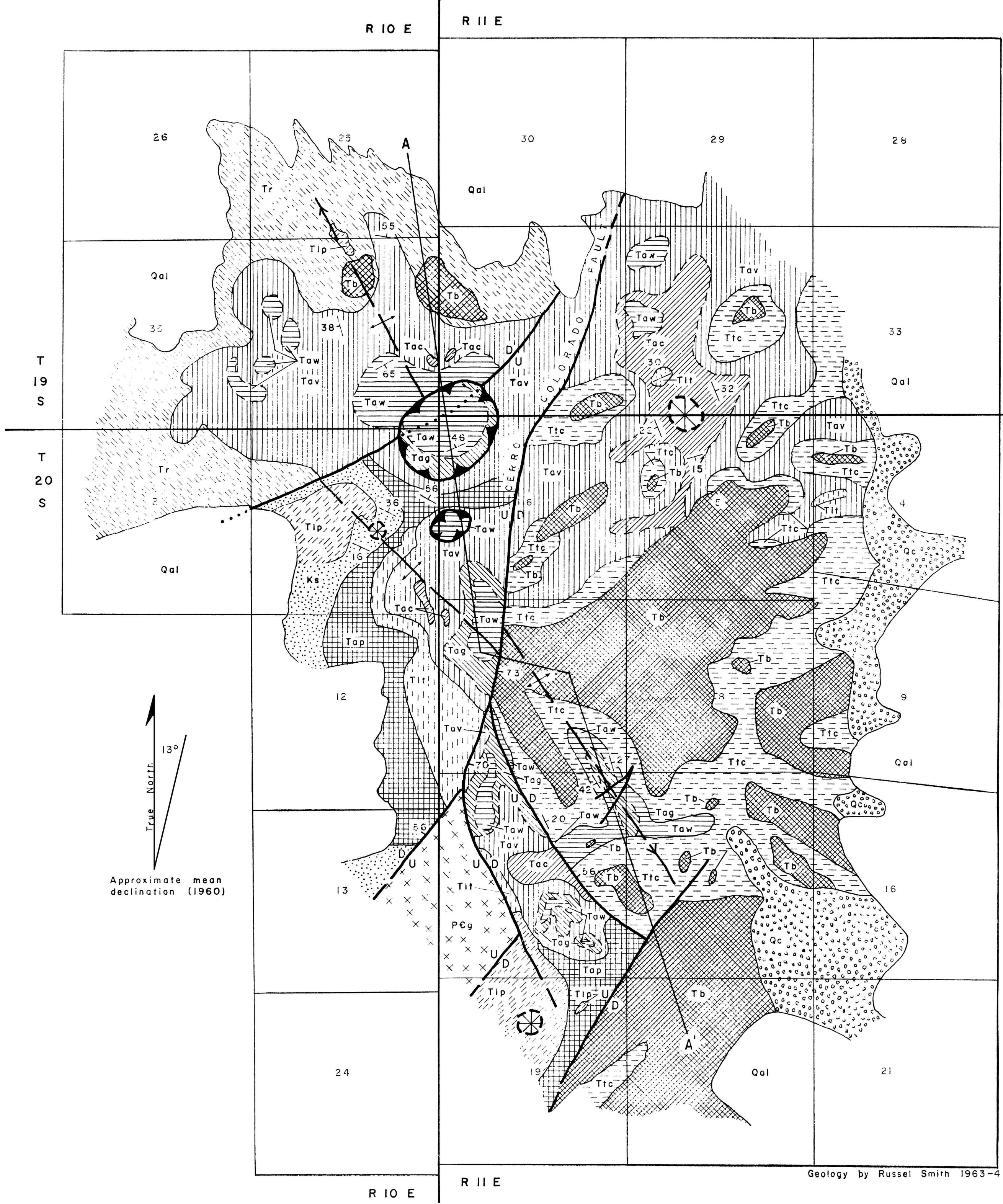
GEOLOGIC MAP OF THE CERRO COLORADO MOUNTAINS
PIMA COUNTY, ARIZONA

[Bound between p. 134 and 135 in original publication]

it rests on arkosic sandstone and beneath the ash flow complex (sec. 1, T. 20 S., R. 10 E.). The other units of the first flow sequence were either not deposited here or they have been eroded.

The andesite porphyry is a dense, tough rock whose chief characteristic in hand specimen is thin concentric rings of iron oxide stain apparently derived from breakdown of the mafic grains. Irregular grains of pyrophyllite are also visible, especially in the southernmost outcrops.

Thin sections disclose 80 to 90 per cent matrix consisting of trachytic microlaths of plagioclase with scattered euhedral magnetite and anhedral olivine. Plagioclase ranging from andesine to oligoclase forms an estimated 60 per cent of the rock including about half of the phenocrysts. Most of the remaining phenocrysts were pyrophyllite, which was lost in grinding. Augite is next in abundance with hornblende and sanidine not more than five per cent each. Mafic crystals are extensively altered to iddingsite, hematite, and limonite; feldspar is sericitized. There is a general coarsening of matrix texture and a slight increase in abundance of phenocrysts to the south.

LATITE PORPHYRY

The latite porphyry lies between andesite porphyry and the ash flow complex at the south end of the range (sec. 18, T. 20 S., R. 11 E.), on arkosic sandstone in the west central part (sec. 1, T. 20 S., R. 10 E.), and beneath rhyolite at the north end (sec. 36, T. 19 S., R. 10 E.). Its maximum thickness is about 60 feet. The color is medium gray with a purplish or bluish cast in some outcrops. Phenocrysts make up nearly half the rock with feldspar predominating but with mafic minerals nearly as abundant in many specimens.

Andesine is the chief plagioclase; most crystals are zoned and a few have sinidine overgrowths; combined albite-carlsbad twinning is common. Green biotite increases from 25 per cent of the phenocrysts in the north to 40 per cent in the south, hornblende does not exceed five per cent, and widely disseminated magnetite and skeletal crystals of ilmenite are also present. Both feldspar and biotite grains range through all sizes from coarse to cryptocrystalline so that there is no sharp distinction between phenocrysts and matrix.

RHYOLITE

The rhyolite is a grayish pink, thinly laminated rock with pinkishwhite streaks and a few megascopic feldspar grains of the same color. It is most abundant on the north and northwest flanks as well as in many of the low hills to the west.

The matrix, which forms 80 per cent of the flow, is glassy and eutaxitic with microsrystalline quartz, sanidine, biotite, and microlites. Phenocrysts are oligoclase slightly in excess of sanidine, brown biotite, and silica minerals including quartz, chalcedony, opal and tridymite. Most of the quartz occurs in opal lined cavities between the laminae and as minute fracture fillings.

LITHIC TUFF

The lithic tuff rests on andesite porphyry and latite porphyry along the west flank, is downfaulted against granite to the south and outcrops at two places in the northeast part of the range (SW¼ sec. 32, T. 19 S., R. 11 E. and W½ sec. 4, T. 20 S., R. 11 E.). This unit is a hybrid tuff consisting of fragments of rhyolite, latite porphyry, and andesite porphyry in a matrix of arenaceous ash. Sorting ranges from poor near the base, where some fragments are 18 inches across, to fairly uniform sand and gravel at the top. Although the smaller particles are more rounded than the larger ones, none of them show any effect of heat or chemical alteration. Stratification in beds a foot or two thick is well developed except in the coarse basal zone. The total thickness ranges from 100 to 300 feet.

		Generalized from Richard and Courtright (1960)		This Report	
Quaternary		Alluvium	?	Alluvium	
		Andesite and basalt flows		Conglomerate	
Tertiary (?)				Basalt	
		Conglomerate		Tuffaceous Conglomerate	
		Acid pyroclastics including Cat Mountain Rhyolite and Safford Tuff of Tucson Mountains		Welded tuff	
				Perlitic glass	
				Rhyolite vitrophyre including crystal tuff and pumice	
		Silver Bell Conglomerate including Tucson Mt. Chaos		Lithic Tuff	
Cretaceous and Older		Amole Arkose	?	Latite porphyry	
				Andesite porphyry	
				Arkosic Sandstone	
		Granite		Limestone	
				Granite	

FIGURE 4.   Suggested correlation of stratigraphic units in the Cerro Colorado Mountains with generalized section for southeastern Arizona.

Tertiary(?) Rocks — Second Cycle

ASH FLOW COMPLEX

The second eruptive cycle produced a mass of tuffaceous rock which forms three-fourths of the range. All of the steep cliffs and rugged peaks of the northern and western part of the area are carved from this resistant series of diversely colored, fine grained volcanics. Compositional differences are minor, contacts are gradational, and the several variants appear to have had a common origin.

The oldest and most abundant type is a buff to pinkish, brown-weathering rhyolite vitrophyre. Enclosed within the rhyolite vitrophyre are irregularly shaped bodies of white crystal tuff ranging from a few tens of feet to more than a mile long. The crystal tuff contains smaller masses of collapsed pumice which looks like a phase of the rhyolite vitrophyre. The pumice was not mapped separately. This portion of the ash flow complex is from 200 to 500 feet thick and rests on lithic tuff and older rock (Fig. 4).

Dark gray to pinkish-gray stringers of perlitic glass occur in increasing abundance in the upper part of the rhyolite vitrophyre until they form a continuous layer from 100 to 200 feet thick in most of the higher cliffs and ridges. The topmost member of the complex is a pinkish-brown, thinly laminated welded tuff as much as 200 feet thick which caps the highest peaks.

Thin sections of these units reveal a hypocrystalline texture with 60 to 80 per cent glass. The glass in the perlite is fresh except for slight alteration along perlitic cracks and contains abundant trichites but no trace of shards or flow texture. The collapsed pumice in the crystal tuff is made up entirely of shards. In all other units the glass is largely devitrified and eutaxitic with prominent trachytic microlites. Shard outlines are rarely distinguishable but this appears to be due more to the extensive alteration and recrystallization than to advanced welding.

Quartz forms 20 per cent of the phenocrysts in all units of the complex with an additional 10 per cent interstitial in the rhyolite vitrophyre. In the crystal tuff silica also takes the form of opal and chalcedony which more or less fills numerous tiny vesicles. Sanidine makes up about 40 per cent of the crystals and calcic oligoclase 25 to 30 per cent. Brown biotite is the dominant mafic mineral except in some of the welded tuff where it is subordinate to altered hornblende and in the crystal tuff which contains no mafics other than scattered magnetite. Magnetite and sphene are accessory in all units.

TUFFACEOUS CONGLOMERATE

Poorly indurated tuffaceous conglomerate rests on welded tuff and underlies basalt in the rounded slopes of the southeast part of the area. When viewed from a distance, this rock has a yellowish or greenish cast caused by lichen on its surface. It resembles the lithic tuff except that it is much more friable and the inclusions are deeply weathered. A 580 foot

section was measured near the center of sec. 17, T. 20 S., R. 11 E. The lower 140 feet consists of massive to crudely bedded, coarsely pitted conglomerate of rhyolite and andesite fragments as much as six inches in diameter. The next 106 feet is massive and better sorted with most of the grains less than one inch across. Above the massive zone is 124 feet of somewhat coarser conglomerate in beds one to two feet thick. The top 210 feet is massive and fine grained but shows a pitted surface due to the weathering out of less resistant grains. The base of the unit is not exposed at the measured section but the total thickness is not much greater where the underlying welded tuff is exposed in the main canyon to the north.

A thin section of the uppermost massive zone reveals about 50 per cent disintegrated rock fragments or cavities left thereby, 25 per cent mineral grains, and 25 per cent matrix. Some of the rock particles are tentatively identifiable as rhyolite, pumice and andesite. Minerals, in decreasing order of abundance include kaolinized feldspar, chiefly plagioclase, biotite, hornblende, quartz, and opaque grains. A little interstitial calcite is also present. The matrix consists of cloudy glass with microlites and relict shards. The entire slide is stained yellowish brown by iron oxide.

Tertiary(?) Rocks — Third Cycle
BASALT

A sequence of basalt flows totaling 650 feet in maximum thickness caps all of the high surfaces east of the Cerro Colorado Fault and forms two small patches near the north end of the range. It rests chiefly on tuffaceous conglomerate but overlaps onto older units at a few localities. The basalt is a dark brown, vesicular rock showing widely scattered dark glassy grains some of which are altered to a rust color. Microscopic examination discloses 10 per cent phenocrysts consisting mainly of iddingsite with olivine cores. The matrix is about 60 per cent feldspar laths and the rest altered augite and olivine. Scattered euhedral magnetite, a few grains of augite, and rare biotite flakes are also present. The texture is strongly pilotaxitic.

Quaternary Formations
CONGLOMERATE

A massive, well indurated conglomerate of rounded boulders in a dense, grayish white matrix is exposed in stream beds and low hills flanking the south and east sides of the mountains. Although many lithologies are represented by the boulders, basalt is by far the most common. The matrix is best described as a calcareous claystone.

ALLUVIUM

Basalt fragments are the dominant rock type in the alluvium. Some are rounded and have obviously been weathered out of the underlying conglomerate. Others are more angular indicating revent gravity transport from the high lava slopes.

Problems of Correlation and Age

Precambrian, Paleozoic, Cretaceous, and Tertiary rocks have all been identified with various degrees of certainty in nearby areas. The basement comprises granite and schist; Paleozoic deposits are almost entirely carbonates except for the Cambrian Bolsa Quartzite; the Cretaceous system includes volcanics, clastics, and thin limestones; Tertiary rocks are chiefly extrusive. Acid plutons of Cretaceous age and younger have been reported by many workers.

Wilson (1950, p. 42) describes granite invading Cretaceous sediments in the Pima District although Cooper (1960, p. 67) believes the younger plutons are chiefly granodiorite. Cretaceous rocks are cut by both granite and quartz monzonite in the Tucson Mountains (Brown, 1939, p. 721). Jones (1957, p. 29) mentions a granodiorite of probable Tertiary age in the Cerro Colorado Mining District.

Cooper (1960, p. 69) refers to an arkose containing a lense of ostracode-bearing limestone in the southern Sierrita Mountains. He tentatively correlates these beds with the Amole Arkose, a Cretaceous formation in the Tucson Mountains (Brown, 1939, p. 716), on the basis of general lithology and the ostracodes. The oldest strata in the Cerro Colorado Mining District consist of thin-bedded arkosic sandstone in which feldspar increases northward to more than 25 per cent (Jones, 1957, p. 11). Limestone was also seen there (Davis, 1955, p. 29) but no description of it is available.

In the absence of conclusive evidence the granite will be considered Precambrian(?) and the limestone and arkosic sandstone Cretaceous(?).

Fossils are rare to absent in the volcanic rocks of southeastern Arizona and even where found they have not been of the type or quality required for accurate dating. None at all were seen above the ostracodal limestone in the Cerro Colorado Range. Radiometric studies seem to offer the best hope of eventual age determination. In fact Evernden and James (1964, p. 953) believe that, where discrepancies are found between radiometric and paleontologic dates, a reevaluation of the paleontologic evidence is advisable. All workers stress, however, that only unaltered and uncontaminated tuffs are satisfactory for analysis. Pending the eventual application of radiometric methods, correlation of sections among the many separate ranges of southeastern Arizona must continue to be based precariously on lithologiic and sequential similarity. Indeed, even when all possible data are assembled, questions will probably remain. Deposits of equivalent age certainly exist but their lenticular nature and the fact that much of the material came from local vents make it likely that specific units never had much greater areal extent than they do now to say nothing of their having been continuous from range to range.

A generalized section of Tertiary(?) and younger rocks in the region is 500 to 5000 feet thick and rests on eroded rocks ranging in age from Precambrian to Cretaceous. Richard and Courtright (1954, 1960) describe the

sequence as consisting of andesite and dacite flows and intrusives overlain by coarse conglomerate mixed with flows and pyroclastics. Above the conglomerate in ascending order is a series of "acid pyroclastics," a second conglomerate, and flows of andesite and basalt. The lower conglomerate, which may be Paleocene or older, is designated as "Silver Bell type" and tentatively correlated with the Tucson Mountain Chaos of Kinnison (1958, p. 50). The "acid pyroclastics" may be in part equivalent to the Cat Mountain Rhyolite of the Tucson Mountains. The upper conglomerate resembles that known in many areas as the Gila Conglomerate. In the type area the Gila was formerly considered to be Plio-Pleistocene in age and includes sheets of basalt and "trass" (Gilbert, 1875, p. 540). Its age is currently a problem whose solution is beyond the scope of this paper.

Cooper (1960, p. 77-89) describes a sequence of deposits in the Pima Mining District that could include the entire Tertiary section in the Cerro Colorado area. It is called the Helmet Fanglomerate and consists primarily of conglomerate with andesite flows in the lower part and rhyolite tuffs and tuffaceous sediments dispersed higher in the formation. The total thickness of these beds is 10,500 feet.

The correlation chart (Fig. 4) presents the suggested relationship of the units in the Cerro Colorado Range to those of the composite section generalized from Richard and Courtright (1960, Fig. 2). It is based solely on lithologic similarity and no evidence was found to justify specific age determinations.

STRUCTURE

General Statement

The gross structure of the range is that of a doubly plunging anticline that trends approximately N. 40° W. Two high angle normal faults transect the anticline and form a horst between them. The east boundary of the horst is the most prominent structural feature of the range and will be referred to as the Cerro Colorado Fault. The south end of the anticline is sliced by branches of the Cerro Colorado fault and by other steep transverse faults. Large blocks of the upper ash flow complex broke away from the highest part of the range and slid north along a low angle gravity fault.

Anticline

Details of the main anticlinal structure are obscured by faulting and plastic flow which have produced countless anomalous attitudes especially in the ash flow complex that makes up so much of the range. However, the axis is indicated at three places, one in each of the main fault blocks. Near the mouth of a deep canyon to the south (SE¼ sec. 7, T. 20 S., R. 11 E.) thin-bedded welded tuff dips 27° NE. in the east wall and 42° SW. in the west wall. Strikes average N. 38° W. Cretaceous(?) sediments in the horst block (sec. 1, T. 20 S., R. 10 E.) also show reversal of dip from 36° NE. to

16° SW. The strike is N. 70° W. North of the horst the axis is indicated by the patch of latite porphyry in sec. 36, T. 19 S., R. 10 E., and by opposing dips in the rhyolite vitrophyre on either side. The axial trend here is questionable but it appears to be nearly aligned with that south of the horst. Shifting of the axial trace in the horst may be due partly to differential movement along the faults and partly to erosion. West of the Cerro Colorado Fault the axial plane dips southwest. Erosion of the upthrown block thus caused the trace to migrate westward. Southeast of the Cerro Colorado Fault the axial plane dips northeast. Such a reversal in assymmetry could be produced by a scissors type of movement on the fault with downthrow of the east block increasing to the south.

Faults

The Cerro Colorado Fault is best seen in the W½ of sec. 7, T. 20 S., R. 11 E. where basalt and tuffaceous conglomerate are dropped down to the east against the ash flow complex in the horst block to the west (Fig. 5). The fault plane strikes N. 5° E. and dips 73° E. at this locality; throw is approximately 600 feet. To the north the fault lies mainly in ash flow but patches of basalt and tuffaceous conglomerate are preserved on the east side and absent to the west. Southward it bifurcates and the two branches
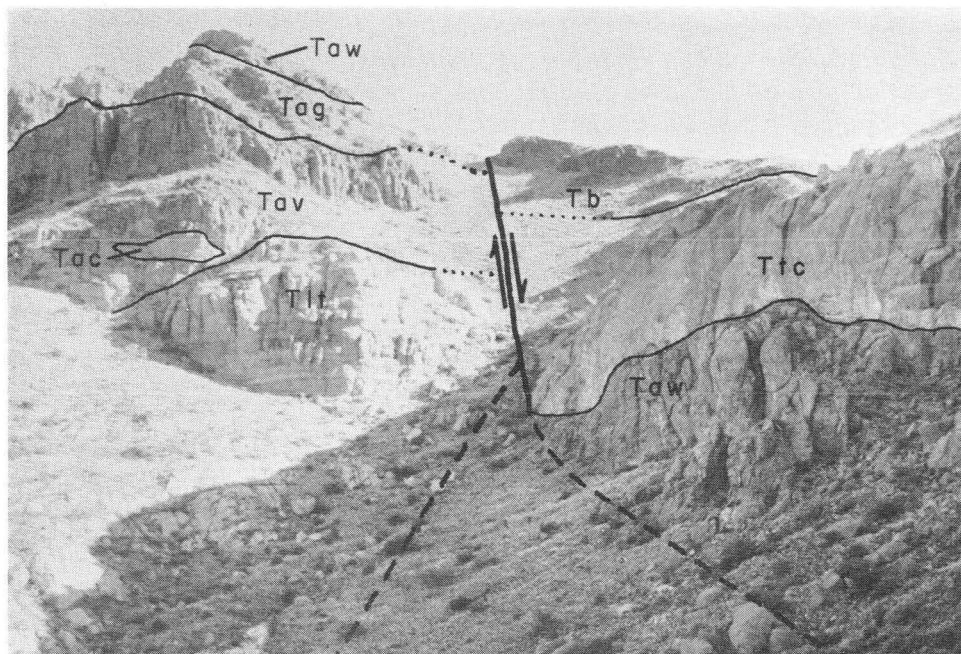

FIGURE 5.   Cerro Colorado Fault in the west half of sec. 7, T. 20 S., R. 11 E.; view from the south. Tlt, lithic tuff; Tav, rhyolite vitrophyre; Tac, crystal tuff; Tag, perlitic glass; Taw, welded tuff; Ttc, tuffaceous conglomerate; Tb, basalt. The rhyolite vitrophyre is about 200 feet thick at this locality.

curve southeast to a strike of about N. 30° W. Both branches are down-thrown to the east with dips of 70° E. on the west branch and 56° E. on the east branch.

A northeast striking high angle fault bounds the south end of the range and truncates the east branch of the Cerro Colorado fault. Basalt is dropped along the southeast side to abut on tuffaceous conglomerate and andesite porphyry.

Two other steep faults strike northeast into the west branch of the Cerro Colorado Fault forming a small horst in granite flanked by andesite porphyry on the northwest and latite porphyry on the southeast. The down-dropped northeast end of the granite horst is interpreted as extending beneath younger deposits in the subsurface of the cross section (Fig. 5). Jones (1957, p. 38) mapped several high angle, northeast trending faults in the Cerro Colorado Mining District which are probably related to those here described.

Dip and strike of the northwest border fault of the main horst are not measurable; its trace is mapped on the basis of topography and structural discontinuity. Northwest striking beds in the horst are truncated by others that strike northeast and dip steeply southeast due to slumping along the fault. Displacement is inferred to be less than that on the Cerro Colorado Fault chiefly because the basalt flows have been almost completely stripped away instead of remaining widely preserved to dominate the physiographic evolution as they do on the eastern block.

A prominent saddle in the horst (Fig. 2) is flanked by two peaks composed of welded tuff and perlitic glass underlain by rhyolite vitrophyre. The sequence is normal but the contact in each peak is a zone of red crushed rock dipping north at a low angle. In the overhanging cliff south of the saddle the contact shows slickensides plunging north. The two peaks appear to be erosional remnants of a slab of rock which became detached from the crest of the upthrown block and slid northward, partly overriding the north border fault.

Volcanic Vents

The eruptive rocks undoubtedly came from many local vents most of whose locations are indeterminate. However, field evidence indicates at least three in the map area. Near the south end of the range (sec. 19, T. 20 S., R. 11 E.), is an irregularly shaped mound of latite porphyry as much as 100 feet across. The rock is a jumble of angular fragments in a structureless matrix of the same material. Several ridges of similarly textured latite porphyry radiate from the mount but elsewhere the rock is megascopically dense and massive. Fragmentation of the latite porphyry could have been caused by movement on the west branch of the Cerro Colorado Fault but the circumscribed area of the jumbled mass is more suggestive of a vent breccia.

Quaquaversal dips surround a hill of chaotic ash flow material in the northeast part of the range (SW¼ sec. 32, T. 19 S., R. 11 E. and NW¼ sec. 5, T. 20 S., R. 11 E.). Structure in the center of the area is impossible to decipher but the appearance suggests an upwelling of molten rock which then spread outward. If this cone does mark a vent for the ash flow it is probably not the only one; the total volume is far too great to be accounted for by a single source.

An isolated mound of basalt at the base of the steep west flank of the range (W½ sec. 1, T. 20 S., R. 10 E.) is the probable site of a third vent. This mound is roughly circular and is sharply circumscribed by sandstone dipping away in all directions at the contact. There is no other basalt on the horst; in the mound it is riven with cracks and shows no evidence of stratification or flowage; north of the horst it dips north as though originating from a source to the south. All of these factors indicate that the mound marks the throat up through which the lava rose but the original mouth has been eroded away. Although the cross section (Fig. 1) does not cut any known vents, those of the latite porphyry and basalt are projected onto it in order to indicate the inferred structural and stratigraphic relationships of these features.

GEOLOGIC HISTORY

Pre-Tertiary (?) events in the report area can only be tentatively sketched to include deposition of igneous and volcanic detritus, presumably on a granite surface. The source of the debris is indeterminate but coarseness and composition indicate a short haul. The environment was marine.

Tertiary (?) history began with the extrusion of andesite porphyry along the west side of the area. Latite porphyry was then erupted from a vent to the southeast although others may have contributed to the supply. Evidence of vents near the anticlinal axis points to the likelihood that the anticline was beginning to rise at this time, possibly due to the accumulation of magma below. The rhyolite is most abundant around the northwest end of the range suggesting a source in that direction but no direct evidence was found.

Reelevation of the anticline, particularly in the central and northern part, preceded the next extensive cycle and led to erosion of the flows and the spreading of debris from them as hybrid lithic tuff to the south.

A second period of vulcanism opened with the outpouring of copious quantities of rhyolitic tuff, probably from several local conduits. Abundant signs of plastic deformation and various degrees of welding from slight to complete identify this complex as an ash flow. Its lower contact is sharp, especially at the south end of the range where it penetrates cracks in underlying andesite porphyry and contains fragments of porphyry in its basal part.

Upward transition is from massive, slightly welded and devitrified tuff through completely welded perlitic glass to moderately welded and thinly laminated tuff. This sequence resembles the "composite ash flow sheet" of R. L. Smith (1960, p. 151) except for the fact that the lower zone is excessively thick and there is no top layer of unwelded tuff. The first phase of the eruption may have been at too low a temperature to produce fusion of the shards whereas any overlying unwelded material could have been easily eroded away. Smith states (1960, p. 155) that he has never seen complete obliteration of shard structure to pure glass but it certainly occurred here.

Erosion removed nearly all of the welded tuff from the northeast part of the range before deposition of the tuffaceous conglomerate which was then spread with irregular thickness over the eastern slopes.

The basalt that marks the final igneous episode caps tuffaceous conglomerate in most places but overlaps locally onto ash flow. Its greater abundance east of the Cerro Colorado Fault is attributed to the fact that it was preserved from erosion by the downfaulting of that area. That it never was as abundant north of the horst is indicated by the absence of lava boulder conglomerate there suggesting that the basalt was never very thick or widespread in that area.

Dips in all units express the main anticlinal structure in a general way. However, it is impossible to be sure how much of this expression is due to continued folding and how much to flowage over a previously arched surface.

Tension faulting followed eruption of the basalt. The actual movement seems to have consisted of slumping of the northwest nose of the anticline against the horst block and tilting toward the south along the east side of the Cerro Colorado Fault. Gravity sliding carried slabs of welded tuff northward across the horst and down into the slump area. Truncation of faults at the south end of the range indicates uplift of a small wedge of granite prior to the main period of faulting and further dropping of basalt at a later time.

There is no evidence of mineralization anywhere in the Cerro Colorado Mountains.

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