



The Square Peak volcanic series, northern Quitman Mountains, Hudspeth County, Texas

Thomas M. C. Hobbs and Jerry M. Hoffer
1980, pp. 231-235. <https://doi.org/10.56577/FFC-31.231>

in:
Trans Pecos Region (West Texas), Dickerson, P. W.; Hoffer, J. M.; Callender, J. F.; [eds.], New Mexico Geological Society 31st Annual Fall Field Conference Guidebook, 308 p. <https://doi.org/10.56577/FFC-31>

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THE SQUARE PEAK VOLCANIC SERIES, NORTHERN QUITMAN MOUNTAINS, HUDSPETH COUNTY, TEXAS

THOMAS M. C. HOBBS and JERRY M. HOFFER

Department of Geological Sciences

University of Texas at El Paso

El Paso, Texas 79968

INTRODUCTION

Location and Geologic Setting

A number of Tertiary volcanic centers occur along the Rio Grande in West Texas. This zone of aligned volcanic centers is approximately coincident with the hingeline that separates the Diablo and Coahuila platforms from the Chihuahua Trough (McAnulty, 1976)

The volcanic rocks of the northern Quitman Mountains represent the westernmost volcanic center in West Texas (fig. 1). The igneous complex has been termed a cauldron and is located at the northeastern limit of thrust faults of the Chihuahua Tectonic Belt (McAnulty, 1976). The volcanic rocks of the range crop out in a northerly elongate mass approximately 7.5 km long by 3.5 km wide, just west of the town of Sierra Blanca.

Both extrusive and intrusive igneous rocks constitute the bulk of the northern Quitman Mountains. The Square Peak Volcanic Series, named by Huffington (1943), forms the core of range and occurs as a roughly layered pile with an aggregate thickness exceeding 1000 m. The volcanic units consist of welded tuffs ranging in composition from trachyte to rhyolite. The volcanic units rest with angular unconformity on folded Cretaceous sedimentary rocks and are unconformably overlain by younger colluvium and alluvium.

Intrusive rocks of the Quitman pluton crop out in an almost continuous ovate body surrounding the volcanic rocks. The ring-shaped outcrop is continuous at the surface except on the east side of the range, where it is covered by alluvium (Albritton and Smith, 1965). The Quitman pluton is interpreted as a ring dike (Huffington, 1943).

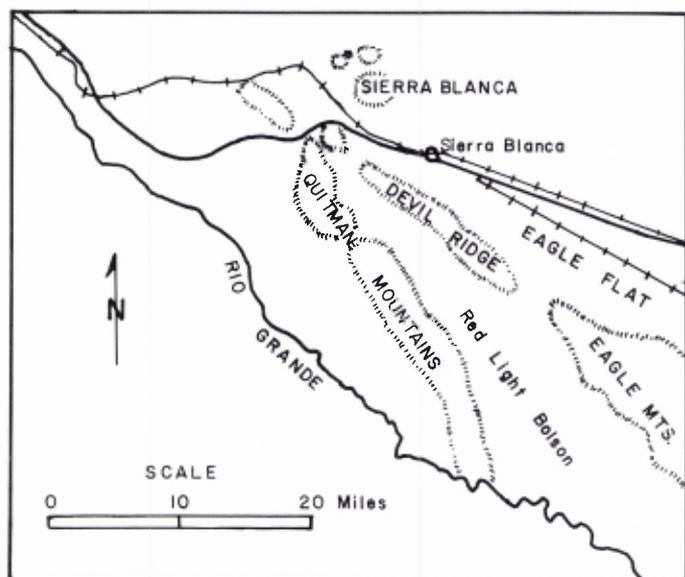


Figure 1. Index map of the Quitman Mountains

Previous Work

The first geological studies in the Quitman Mountains were conducted when Von Streeruwitz (1889, 1890, 1892) and Osann (1892) described the rocks and general geology of the area. Baker (1934) published the first reports on the structural features, igneous rocks and economic geology of the Quitmans.

The first complete study of the northern Quitman Mountains was published by Huffington (1943). Included in Huffington's report are details of the petrography and stratigraphy of the volcanic and plutonic rocks of the range. Information concerning the stratigraphy, structure and geologic history of the region are included in a report by Albritton and Smith (1965). Gieger (1965) and Laux (1969) studied the petrology and mineralization of the quartz monzonite ring dike and intrusion in the northern Quitman Mountains, respectively.

VOLCANIC STRATIGRAPHY

Introduction

The Square Peak Volcanic Series, based on field relationships and petrographic textures and mineralogy, has been divided into nine chronostratigraphic units (fig. 2), which are discussed in ascending order below. According to Hobbs (1979), four of the units show continuous exposure across the range, but the remaining five are discontinuous due to topographic restrictions during emplacement. The total volume of erupted material exceeds 35 km³.

All the units are nonwelded to densely welded tuffs with airfall tuffs and tuff breccias included. Lack of fossils or radiometric dates of the volcanic rocks precludes precise age determination; a tentative assignment of middle Oligocene age (i.e., 30 to 35 m.y. old) has been made.

Volcanic Units

Unit I (Double Canyon tuff)

This basal ash flow unit is a stretched pumice lapilli, vitric tuff of rhyolite composition; it averages 120 m in thickness. The tuff has a characteristic light color and well-developed eutaxitic texture from stretched pumice lapilli. Most of the original pumice is devitrified and deformed. Lithic fragments of sandstone and limestone are abundant near the base of the tuff.

The Double Canyon tuff is porphyritic with phenocrysts of K-feldspar and quartz. The phenocrysts average 2 mm in length and range from 3 to 19 percent of the rock. Locally, K-feldspar composes as much as 25 percent of the rock. Most of the K-feldspar phenocrysts have been altered to clay and sericite or replaced by calcite, whereas much of the groundmass texture has been obscured by devitrification.

Unit II (Bug Hill tuff)

The Bug Hill tuff is a non-welded trachyte, grading from a basal lithic tuff to a well-sorted airfall vitric tuff. The lithic unit has a max-

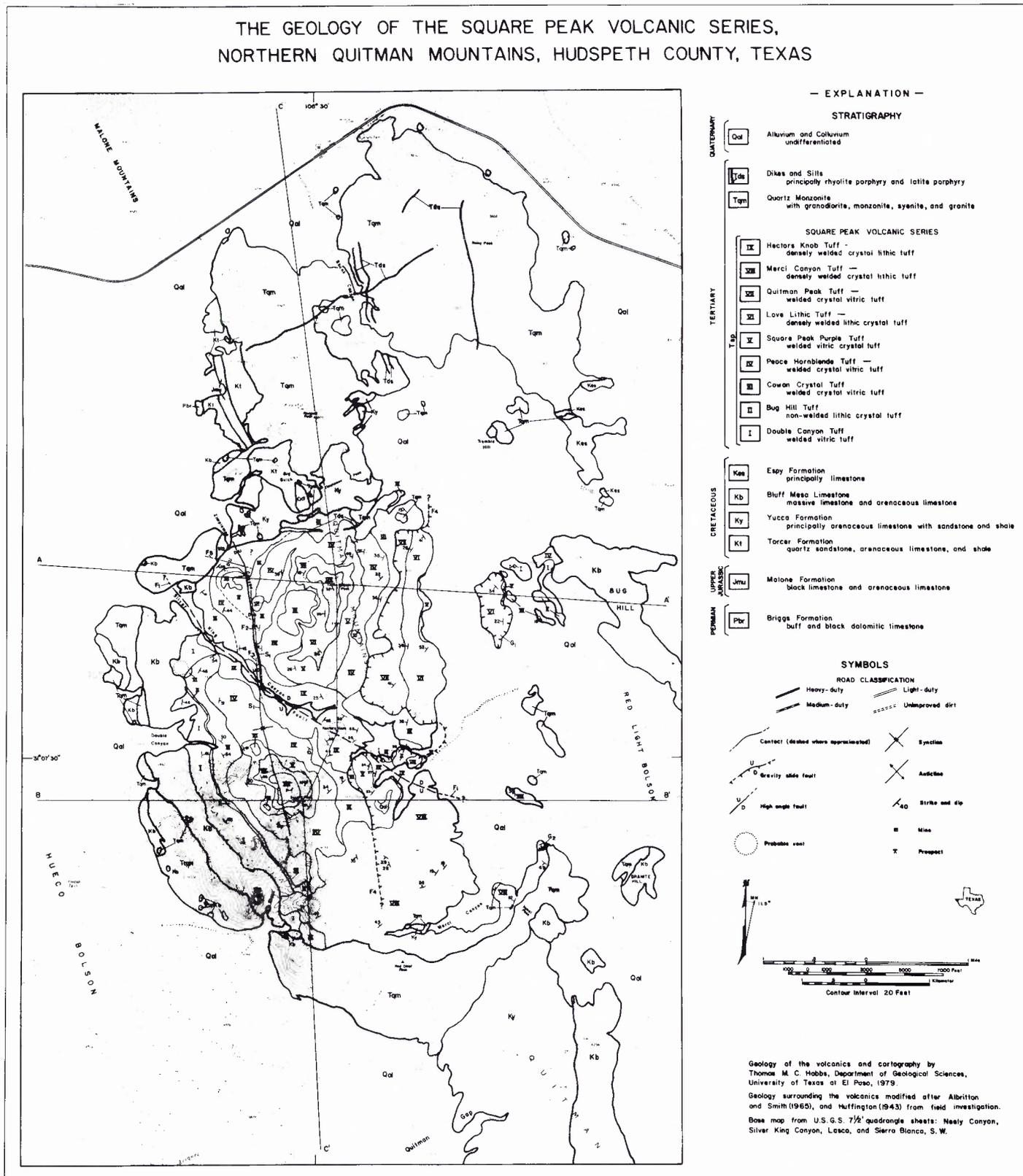


Figure 2. Geologic map of the Square Peak Volcanic Series, northern Quitman Mountains.

imum thickness of 70 m, and the airfall tuff ranges from 7 to 15 m thick.

The basal lithic tuff contains up to 65 percent epiclastic fragments of volcanic and sedimentary rocks. The unit is poorly sorted, but locally all the fines are winnowed out. Bedding laminations and slight grading of materials suggest that at least part of the unit was water-laid. The airfall tuff has well-sorted, and sand-size clasts which have fine laminations of graded bedding.

Petrographically feldspars compose a maximum of 25 percent of the unit. The crystals are small, 0.1 to 1.0 mm in diameter, and are dominated by anhedral K-feldspar. Scattered quartz, hornblende and hypersthene compose less than 5 percent of the rock. Lithic grains are rounded, averaging 0.5 to 2 cm, and composed predominantly of spherulitic fragments from the underlying Double Canyon tuff with lesser amounts of sandstone and limestone clasts.

The groundmass has devitrified to a crystalline matrix of quartz and K-feldspar. Hydrothermal alteration has resulted in sericitization of the feldspar, embayment and saussuritization of the lithic fragments, and general silicification.

Unit III (Cowan tuff)

This unit is a distinctive crystal tuff of trachytic composition. It is well exposed on the flanks of the range, is an excellent marker bed, and has a measured thickness of approximately 150 m.

The tuff is medium bluish-gray with a distinctive porphyritic texture. The phenocrysts are composed of euhedral to subhedral feldspars averaging approximately 4 mm in length. Remnants of ferromagnesian minerals make up approximately 5 percent of the rock; these include skeletal hornblende, lesser amounts of biotite and minor augite. Lithic fragments are rare; where present, they are concentrated in the upper part of the unit and are composed of sandstone and limestone.

The groundmass is almost completely devitrified; in isolated areas remnant welding structures can be recognized. Judging from the degree of compaction and deformation of the glass, the unit is only moderately welded.

Unit IV (Peace hornblende tuff)

The Peace hornblende tuff is trachytic and grades laterally from a lithic crystal tuff to a crystal tuff. The unit has a maximum thickness of about 220 m and is characterized by the great variability in the lithic fragment and crystal content and in the degree of welding.

The basal part of the unit contains abundant lithic grains with a sintered matrix. The lithic fragments, ranging from 0.5 to 1 cm in diameter, are composed of predominantly subrounded volcanic fragments of the underlying three tuffs with local clasts of limestone and sandstone. The unit has a maximum thickness of approximately 110 m.

The basal lithic unit grades upward into a densely welded crystal tuff, the thickness of which averages approximately 20 m. The crystal tuff is porphyritic with phenocrysts predominantly of K-feldspar and minor sodic plagioclase.

The most distinctive feature of the Peace hornblende tuff is the presence of hornblende which averages approximately 10 percent of the lower lithic unit and 5 percent in the upper crystal-rich portion.

The matrix of the lower tuff is dominated by partially compacted and draped pumice lapilli set in glass. The upper tuff has a well-developed dense eutaxitic texture, with almost equal amounts of small glass shards and pumice lapilli which have collapsed around the phenocrysts and lithic fragments. The feldspars have been sericitized and the ferromagnesian minerals have been replaced by iron oxides.

Unit V (Square Peak purple tuff)

The Square Peak unit is a vitric crystal tuff of trachyte composition. It is moderately welded and forms a concentric layer around Square Peak; maximum thickness is approximately 105 m. The basal portion contains lithic fragments; it grades upward into a nonwelded, well-sorted, airfall tuff.

K-feldspar is the most common mineral with lesser amounts of sodic plagioclase. Most crystals are subhedral, 0.3 to 1.5 mm in length and fractured. Hornblende and biotite make up less than 7 percent of the rock. Lithic fragments, forming up to 10 percent of the rock, are composed of volcanic material of underlying units II, III and IV. Most of the matrix is composed of streaked, long-tube pumice; the remainder consists of poorly sorted, highly sintered glass shards draped and compacted during welding.

Secondary alteration products are common throughout the unit and consist of iron oxides, epidote, calcite and chlorite.

Unit VI (Love lithic tuff)

This unit is a densely welded tuff characterized by an abundance of lithic fragments. Lithic fragments consist of welded tuff, airfall tuffs, limestone and sandstone which average approximately 40 percent of the rock. Lithic fragments average 2 cm in diameter, but many exceed 1 m in exposures at Square Peak. The thickness of the unit near Square Peak ranges from 70 to 90 m, but exceeds 200 m along the base of Quitman Peak.

The Love tuff is rhyolitic to trachytic in composition. Sodic plagioclase and K-feldspar phenocrysts range in size from 0.5 to 2 mm and together compose approximately 25 percent of the rock. Ferromagnesian minerals make up approximately 5 percent of the unit; hornblende is most abundant with lesser amounts of biotite and augite. Quartz averages 2 percent of the rock.

The matrix has been intensely deformed, is densely welded and displays a well-developed eutaxitic texture. Pumice has devitrified to axiolites, whereas the glass shards form aggregates of spherulites. Most of the remaining groundmass is devitrified. Most of the feldspar crystals have been sericitized, as the ferromagnesian minerals have been converted to iron oxides.

Unit VII (Quitman Peak tuff)

The Quitman Peak tuff is a densely welded crystal tuff of rhyolitic to trachytic composition which caps Quitman and Square Peaks; maximum thickness of the unit is approximately 85 m. The tuff is massive, but locally it displays a strong eutaxitic texture. Lithic fragments, which constitute less than 5 percent of the unit, are composed of limestone clasts measuring less than 1 cm in diameter.

The tuff is porphyritic with small phenocrysts of sodic plagioclase and K-feldspar which average less than 1 mm in length; the feldspars constitute about 25 percent of the rock. Ferromagnesian minerals include hornblende, augite and lesser amounts of biotite.

The densely welded matrix is composed of well-sorted ash with abundant pumice lapilli draped, compacted and streaked around the phenocrysts and lithic grains.

Most of the phenocrysts have been altered and replaced. Feldspar crystals have been sericitized or replaced by calcite, whereas the mafic minerals were "burned" and later replaced or altered to iron oxides or chlorite and epidote.

Unit VIII (Merci Canyon tuff)

The Merci Canyon tuff is densely welded and grades from a lithic crystal tuff to a crystal tuff. The basal part of the tuff is moderately welded, has a coarse texture, and contains a high percentage of

lithic fragments and phenocrysts. The upper part has fewer lithic fragments and phenocrysts, is more densely welded and displays a well-developed eutaxitic texture. The maximum thickness of the tuff is approximately 70 m in Merci Canyon.

The Merci Canyon tuff is a trachyte. It is porphyritic, composed of small euhedral to subhedral K-feldspar crystals (20%) and minor quartz (2%). Mafic minerals, averaging about 5 percent of the rock, consist of augite and lesser amounts of hornblende and biotite.

Lithic fragments near the base of the unit consist of limestone, sandstone and volcanic clasts from the Double Canyon, Bug Hill and Love tuffs. Pumice is rare in this part of the tuff but exceeds 40 percent in the upper part, where it has devitrified and displays an axiolitic texture.

Alteration has produced clay, sericite and calcite from the feldspars, whereas the mafic minerals have been "burned" or replaced with iron oxides and chlorite.

Unit IX (*Hectors Knob tuff*)

This is a densely welded crystal lithic tuff of rhyolite composition. The outcrops of this ash flow are restricted to the valley walls of Silver King Canyon, where the ash lies on top of the older volcanic units; its thickness exceeds 100 m. The tuff contains 15 to 30 percent pumice lapilli which exhibit compaction and draping around large phenocrysts and lithic fragments. Lithic fragments make up 10 to 30 percent of the tuff and consist of limestone, sandstone and lesser amounts of volcanic fragments.

The tuff is porphyritic with phenocrysts of K-feldspar, quartz and lesser amounts of sodic plagioclase and minor crystals of hornblende and augite. The phenocrysts are euhedral to subhedral, average 2 mm in length, and constitute from 10 to 25 percent of the rock. The groundmass is composed primarily of devitrified glass.

Sericite and clay are common alteration products of the feldspars whereas the minor mafic minerals have been replaced by iron oxides.

GEOCHEMISTRY

Introduction

A total of 22 representative rock samples from measured volcanic sections were analyzed for major oxides. The chemical anal-

yses were performed with an ORTEC 6110 Tefa system, and results are reported in Table 1.

Results

All the volcanic rocks analyzed from the Square Peak Volcanic Series are silicic and contain greater than 64 percent SiO₂. Also characteristic of the rocks is high alkali content averaging 9.83 percent; the rocks are chemically metaluminous to alkalic.

These preliminary results suggest that volcanic units were emplaced during three eruptive cycles. The first phase of activity produced a silica-rich tuff (Unit I) followed by tuffs displaying successively lower silica content (Units II, III, IV and V). The second cycle began with eruption of high silica tuff (Unit VI) and was followed by emplacement of Units VII and VIII which contained successively less silica. The final phase of eruption ended with the deposition of high-silica tuff (Unit IX).

VOLCANIC EVENTS

The northern Quitman Mountains have been referred to as a resurgent cauldron (McAnulty, 1976). Hobbs (1979) concluded from his field studies that the igneous complex is, indeed, a resurgent cauldron and has described its formation by the model of Smith and Bailey (1968). As outlined by Hobbs (1979) the stages in the formation of the cauldron are described below.

Stage I. By mid-Oligocene time a magma chamber had risen near the surface of the Quitman block causing regional tumescence and the formation of an elliptical ring fracture, as evidenced by the ring dike circumscribing the central block of the volcanic rocks.

Stage II. Cauldron-forming volcanism began by eruption of ash flows and pyroclastic breccias of units I to VII. The first eruptions were the explosive ash flows of unit I, followed by a period of erosion and then the emplacement of unit II which contains epiclastic fragments of unit I.

A period of erosion was followed by the emplacement of crystal-rich unit III, which covered a well-developed erosional surface. Units IV, V, VI and VII followed in succession, ending the first phase of volcanism.

Stage III. The period of volcanism was followed by caldera

Table 1. Average chemical compositions of volcanic units, northern Quitman Mountains (for description of the units see text).

Unit	1	2	3	4	5	6	7	8	9
Samples	2	3	3	3	1	3	2	3	2
SiO ₂	71.91	65.26	64.57	64.65	66.34	70.16	68.29	65.60	70.47
TiO ₂	0.12	0.69	0.93	0.98	0.64	0.36	0.33	0.69	0.34
Al ₂ O ₃	13.26	15.75	17.14	17.22	16.60	15.33	17.10	16.32	15.38
Fe ₂ O ₃ *	2.97	5.02	4.89	4.48	4.02	2.71	2.88	4.32	2.84
MnO	0.09	0.08	0.09	0.06	0.11	0.08	0.05	0.09	0.07
MgO	0.41	0.88	1.14	0.89	1.06	0.55	0.26	0.60	0.30
CaO	1.80	1.73	2.10	2.65	2.15	1.44	0.45	1.04	0.51
Na ₂ O	4.91	5.02	5.18	4.42	4.85	5.15	5.49	6.07	4.96
K ₂ O	3.91	5.32	4.26	4.43	4.28	4.56	4.93	5.34	5.27
P ₂ O ₅	0.05	0.32	0.35	0.24	0.06	0.06	0.06	0.20	0.05
Total	99.43	100.07	100.65	100.02	100.11	100.40	99.84	100.27	100.19

*total iron reported as Fe₂O₃; chemical analyses by J. M. Hoffer

collapse that produced the north-striking syncline which dominates the structure of the caldera block. Huffington (1943) states that the caldera block collapsed a minimum of 1270 m. The volcanic units all dip inward as much as 90 degrees near the ring fracture zone.

Stage IV. A period of uplift followed collapse, producing two significant faults in the cauldron block. A north-striking fault, the East Side fault, developed along the east side of the block. As the central core was uplifted, the eastern block slid down the fault plane and came to rest against the ring fracture zone; displacement along this fault exceeds 400 m. The second fault, the West Side fault, was superimposed on the synclinal axis with a steep eastward dip; displacement on this fault exceeds 100 m.

Stage V. Volcanic activity again was renewed with the eruption of unit VIII. This was followed by eruption of unit IX and the emplacement of the large quartz monzonite ring dike and stock at the north end of the range.

The ring dike and stock were emplaced in five major pulses and are differentiated into diorite, monzonite, quartz monzonite, syenite and quartz-rich granite (Gieger, 1956).

A second period of collapse has been noted in the caldera block. Volcanic unit IX has been broken by an east-dipping normal fault which is superimposed on the older structures along the syncline axis. Displacement on this fault is probably less than 20 m; it suggests subsidence of the block as a result of release of magmatic pressure during emplacement of the intrusives.

Stage VI. Intense hydrothermal alteration by magmatic fluids has silicified, sericitized, saussuritized and albitized most of the volcanic rocks. In addition, limestone has been locally replaced by magnetite and hematite and also recrystallized to marble. Laux (1965) has described eleven areas

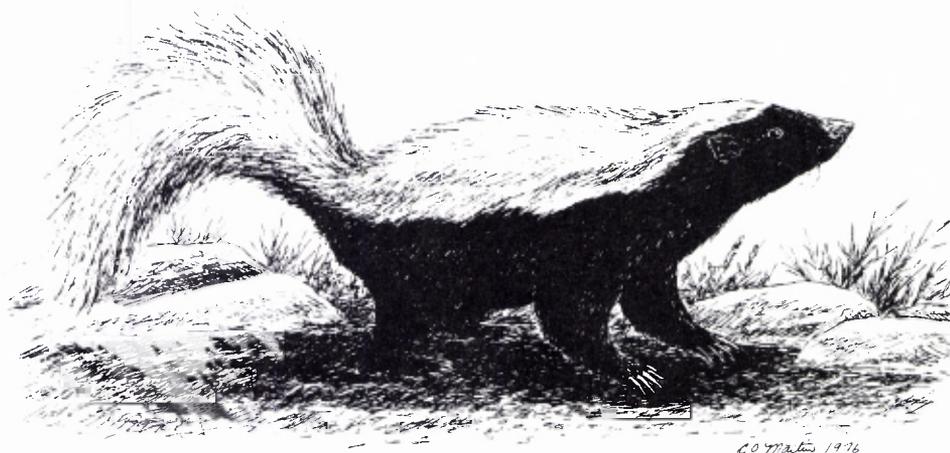
within the cauldron complex containing significant mineralization (including lead, zinc, silver, gold, cadmium and copper).

ACKNOWLEDGMENTS

Funds for this project were provided through a Geothermal Grant to the University of Texas by the State of Texas.

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Hog-nosed skunk, *Conepatus mesoleucus*.



Reverchon bristlegrass plant and spikelet, *Setaria reverchonii*.