STRUCTURAL GEOLOGY OF THE SAFFORD PEAK AREA, TUCSON MOUNTAINS, PIMA COUNTY, ARIZONA

by

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STATEMENT BY AUTHOR

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TABLE OF CONTENTS

	Page
INTRODUCTION	1
Location	1
Extent and Access	1
Topography and Drainage	1
Climate and Vegetation	4
Purpose and Method of Study	4
Previous Work	5
Acknowledgments	5
DESCRIPTIVE GEOLOGY	6
Formational Units	6
Introduction	6
Cretaceous Rocks	8
Tertiary Extrusive and Sedimentary Rocks	8
Safford Conglomerate	8
Safford Tuff	14
Contzen Pass Formation	19
Upper Andesite	24
Tertiary Intrusive Rocks	26
Rillito Andesite	26
Marginal Vitrophyre	32
Safford Dacite	32
Structure	36
Cretaceous Structures	36
Tertiary Structures	38

Page

Attitude of Tertiary Rocks 38
Jointing of Tertiary Rocks 38
Faulting of Tertiary Rocks 38
Structure of Tertiary Intrusives 41

GEOLOGIC HISTORY 43

MINERALIZATION 45

REFERENCES CITED 46

LIST OF ILLUSTRATIONS

Figure Page

1. Location map 2

2. Generalized columnar section 7

3. Relationships of thicknesses in selected measured sections 13

Plate Page

1. Geologic map and cross sections .... in pocket

2. Topography of the thesis area 3

3. Upper and lower members of Safford conglomerate and Rillito andesite in northern part of area 10

4. Upper Safford conglomerate and Lower Safford conglomerate 11

5. Contact between the Safford tuff and the Safford conglomerate 15

6. Stratified and intrusive Safford tuff 16

Plate Page

7. Intrusive veins in Safford tuff 18

8. Lower contact of Upper andesite and geomorphology of northwestern part of area 21

9. Weathering characteristics of the Upper andesite 25

10. Flow banding in the Rillito andesite 29

11. Cliff of Rillito andesite north of Safford Peak 30

12. Flow banding in the core of Safford Peak 34

13. Safford dacite and intrusive neck 35

14. Xenoliths of Cretaceous rock in flow rock from intrusive neck 37

15. Faulting and jointing in the Tertiary rocks 39

INTRODUCTION

Location

Extent and Access

The thesis area is about five and one half square miles and includes all or parts of T. 12 S., R. 11 E., section 36; T. 12 S., R. 12 E., sections 29, 30, 31, 32, 33; and T. 13 S., R. 12 E., sections 4, 5, 6 of the Cortaro, Arizona quadrangle (Fig. 1). The area is accessible from Cortaro, Arizona via Cortaro Road, Silverbell Road, Wade Road, Pima Farms Road, and Picture Rocks Road.

Topography and Drainage

The topography of the area mapped is rugged (Pl. 2), with a maximum topographic relief of 1,326 feet. Safford Peak, the most prominent topographic feature, is an east-west-trending elliptical tower with an elevation of 3,576 feet, and is located in the northern part of the area. West of Safford Peak is an eastward-sloping cuesta 3,450 feet in elevation; a spine 2,750 feet in elevation is located 1,000 feet southwest of this. A scarp with 500 to 750 feet of relief extends southeast from the west end of Safford Peak and terminates abruptly about 2,000 feet north of Picture Rocks Road. A dip-slope of about 15 to 20 degrees

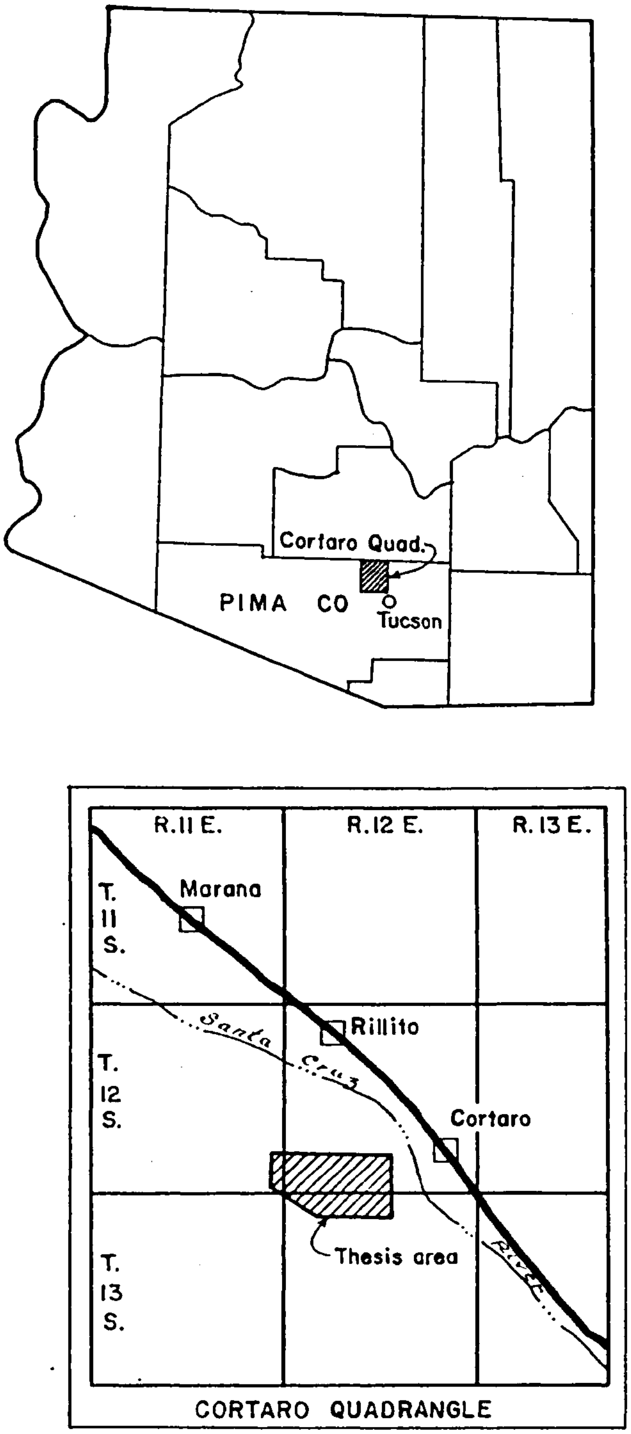


FIGURE 1.

LOCATION MAP

PLATE 2

TOPOGRAPHY OF THE THESIS AREA

Figure 1. Looking west at Safford Peak from Pima Farm Road near Black Arrow Ranch.

Figure 2. Looking northwest at dip-slope (left) and Safford Peak (right) from east of Picture Rocks on Picture Rocks Road.

extends northeastward from the scarp. A hill 2,700 feet in elevation lies adjacent to and south of the southeast termination of the scarp, and a ridge of the same height as the hill extends for 1,200 feet to the west. Three hills with elevations varying from 2,500 to 2,850 feet are located at Contzen Pass. A ridge with elevations of 2,500 to 2,700 feet extends north from the east end of Safford Peak, and a hill 2,800 feet in elevation lies 1,000 feet northeast of Safford Peak (Pl. 2).

Drainage flows both east and west from the northwest-southeast-trending scarp and is carried northward by major arroyos to the Santa Cruz River.

Climate and Vegetation

The climate is semiarid. Smith (1956) reports an extreme range of temperatures of 6 to 112 degrees and an average annual mean of 67.4 degrees. He also reports an average annual rainfall of 10.36 inches. Vegetation consists primarily of cactus, small trees, and bushes; some grass is on the higher slopes.

Purpose and Method of Study

The purpose of this study is to reveal details of the structure of this complicated area in the northern part of the Tucson Mountains.

Detailed geologic mapping was done on a scale of 800 feet to the inch. An enlarged section of the U. S. G. S. Cortaro, Arizona quadrangle was used as a base map, and aerial photographs were used as a supplementary aid in field mapping.

Previous Work

The area was mapped in general by Brown (1939) in connection with his study of the Tucson Mountains. Kinnison (1958) briefly mentioned features in the extreme southern part of the area. No detailed work has previously been done.

Acknowledgments

I am especially grateful to Professor E. B. Mayo who suggested the problem, spent two days in the field with me, and has provided much helpful criticism. Professor R. L. DuBois, Carl Fries, Jr., J. H. Courtright, and L. A. Heindl, discussed various phases of the problem with me, and I appreciate their thought provoking comments. I want to sincerely thank Dr. and Mrs. B. S. Butler whose generous establishment of the Bert S. Butler scholarship in geology helped to make this work possible.

DESCRIPTIVE GEOLOGY

Formational Units

Introduction

Formation names used herein conform as closely as possible to those established by Brown (1939). Field relationships have demanded certain changes in the original nomenclature, and certain mappable units have been given manuscript names to facilitate discussion. Figure 2 compares the nomenclature previously established with that used in this thesis. Plate 1 shows the distribution of the mappable rock units.

The ages of the rocks are rather indefinite. Brown (1939) established the age of the Safford tuff on the basis of fossil flora described as more apt to belong in the later rather than the earlier half of the Tertiary. He states (1939, p. 732), "On a basis of this determination and the structural features of the occurrence of the rocks, the writer has placed the entire series of volcanics in the Tertiary." Although the Safford tuff, as defined by Brown (1939), rests in places with angular unconformity on a series of highly deformed volcanics, there is no evidence, other than the presence of this unconformity, to assign the series of deformed volcanics to the Cretaceous as Brown has done.

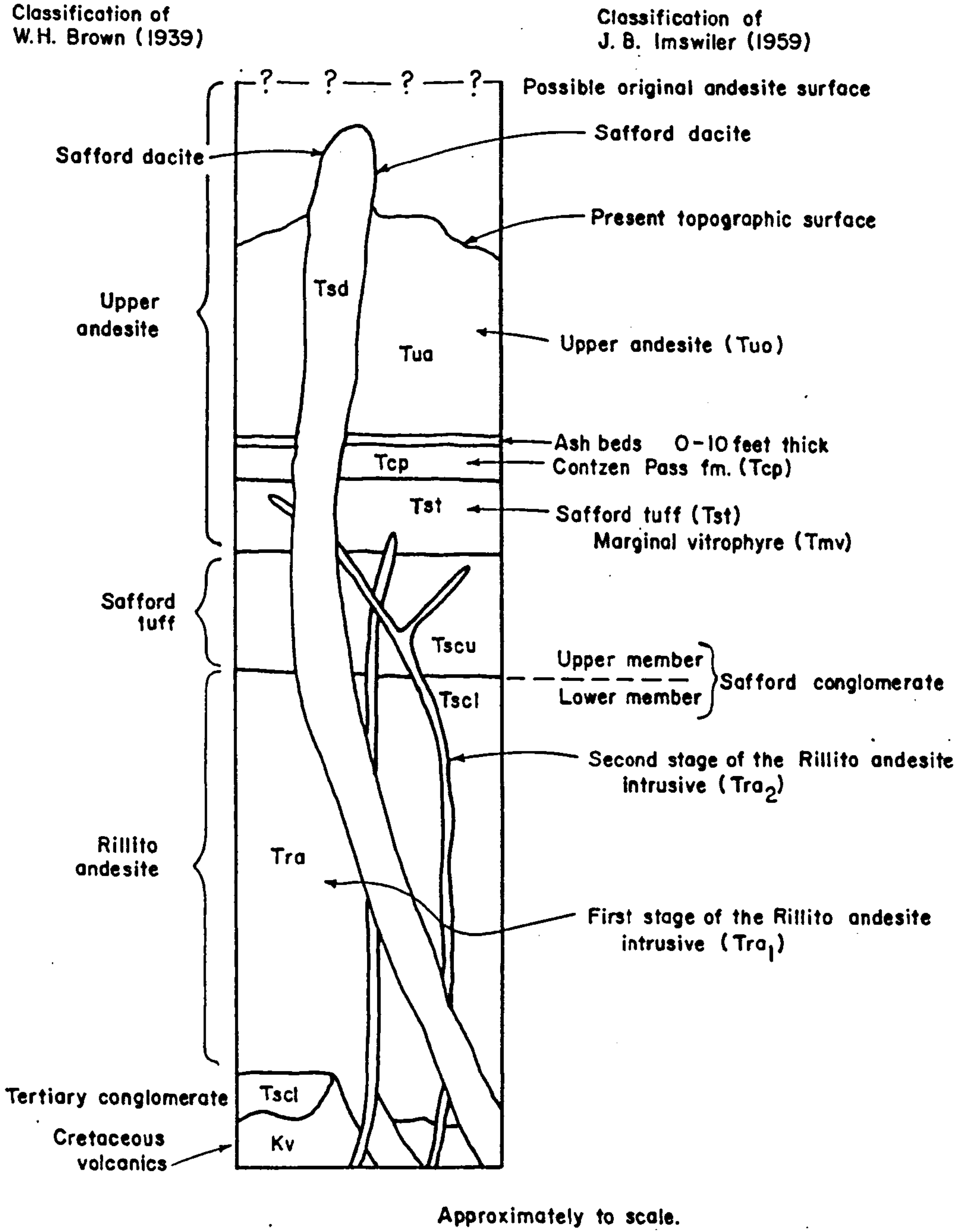


FIGURE 2.

GENERALIZED COLUMNAR SECTION

It is quite possible that this deformed volcanic series is actually of Lower Tertiary age. For lack of any conclusive evidence to the contrary, I will adhere to Brown's (1939) use of Tertiary for the gently tilted series, and Cretaceous for the unconformable underlying deformed series (Fig. 2).

Cretaceous Rocks

Cretaceous volcanic rocks (Brown, 1939) crop out along the southern and western borders of the area mapped. These rocks appear megascopically to be a series of interbedded flows, tuffs, and tuffaceous arkoses. Perhaps half a dozen separate units are recognizable in the field, but no attempt has been made to establish their sequence.

Tertiary Extrusive and Sedimentary Rocks

Safford conglomerate. --The formational unit I have designated as the Safford conglomerate is composed of two members. The lower member is equivalent to Brown's (1939) Tertiary conglomerate, and the upper member is equivalent to Brown's (1939) Safford tuff. At certain locations in the northern part of the area the upper and lower members are separated by the Rillito andesite, but at other locations there is a gradation from the lower member to the upper member. This gradation is particularly evident along the southwest slope of the northwest-southeast-trending scarp and in the southern part of the area.

Plate 3 shows the relationship between the upper and lower members of the Safford conglomerate and the Rillito andesite in the northwestern part of the area.

The lower member of the Safford conglomerate rests with angular unconformity on Cretaceous rocks everywhere that the base of the conglomerate is exposed. It is composed essentially of sand- to boulder-sized clasts of Cretaceous and older rocks. These fragments are generally angular, but are locally well rounded. Some silt beds occur within the conglomerate. The conglomerate is poorly and discontinuously bedded (Pl. 4, Fig. 2), poorly indurated, and weathers to moderate slopes. It is characteristically whitish gray in color, but locally it is reddish brown.

The upper member of the Safford conglomerate rests, in most places, either conformably or possibly with slight disconformity on the lower member. In the northern part of the area there are, however, places where it rests nonconformably on the Rillito andesite.

The upper member is composed of 10 to 80 percent clasts of Rillito andesite in addition to the clasts of Cretaceous and older rocks found in the lower member. The fragments range from sand to boulder size, the largest being about two and one half feet on the long axis. They generally have low sphericity and low roundness. The beds range from one or two inches to perhaps four feet in thickness. The sphericity and roundness of the fragments decreases as the thickness of the beds

PLATE 3

UPPER AND LOWER MEMBERS OF SAFFORD CONGLOMERATE AND RILLITO ANDESITE IN NORTHERN PART OF AREA

Figure 1. Looking west from north side of Safford Peak. Kv, Cretaceous volcanics; Tscl, Safford conglomerate, lower member; Tra, Rillito andesite; Tmv, Marginal vitrophyre; Tst, Safford tuff; Tscu, Safford conglomerate, upper member; Tsd, Safford dacite; Qal, Quaternary alluvium. Eastward dipping cuesta on skyline at right.

Figure 2. Looking south at north side of base of east-dipping cuesta (Fig. 1). Stratified rock at base is lower member of Safford conglomerate, overlain by Rillito andesite.


Location of Fig. 2
Qal

PLATE 4

UPPER SAFFORD CONGLOMERATE AND
LOWER SAFFORD CONGLOMERATE

Figure 1. Looking northwest along face of Upper Safford conglomerate cliff at west end of Safford Peak. Well-bedded Upper Safford conglomerate displaying characteristic cliff-forming habit.

Figure 2. Close-up of part of Pl. 3, Fig. 2. Poorly and discontinuously bedded Lower Safford conglomerate underlying Rillito andesite.

increases. The percentage of Rillito andesite clasts is greatest in the thickest beds. The bedding is distinct but lenticular (Pl. 4, Fig. 1). There are a few thin tuffaceous beds near the top. The Upper Safford conglomerate is well indurated, weathers to steep cliffs, and is characteristically reddish brown in color.

The Safford conglomerate thins from about 500 feet in the northwest to 75 feet in the southeast (Fig. 3). Brown (1939, p. 732) states, "About 1-3/4 miles southeast of the point where the coarse Safford tuff wedges out, and 4 miles southeast of Safford Peak, the fine-grained, thin-bedded variety crops out. At this point the tuff lies between the Cat Mountain rhyolite and the Upper andesite." If this correlation is correct, then the Safford conglomerate, the upper member of which is Brown's (1939) Safford tuff, would be younger than Kinnison's (1958) Tucson Mountain chaos. There is, however, no lithologic similarity between the Safford conglomerate and the Safford tuff as the tuff is defined by Brown in other parts of the Tucson Mountains.

In summary, the Safford conglomerate, composed of two distinct members, seems to have filled depressions or valleys in an irregular surface. In all places it lies with angular unconformity on an older deformed series of volcanics and is overlain by a tuff sequence.

The conglomerate is sharply separated from the overlying tuff series except for local occurrences of two- to three-inch tuffaceous beds in the upper five feet of the conglomerate. The upper and lower members

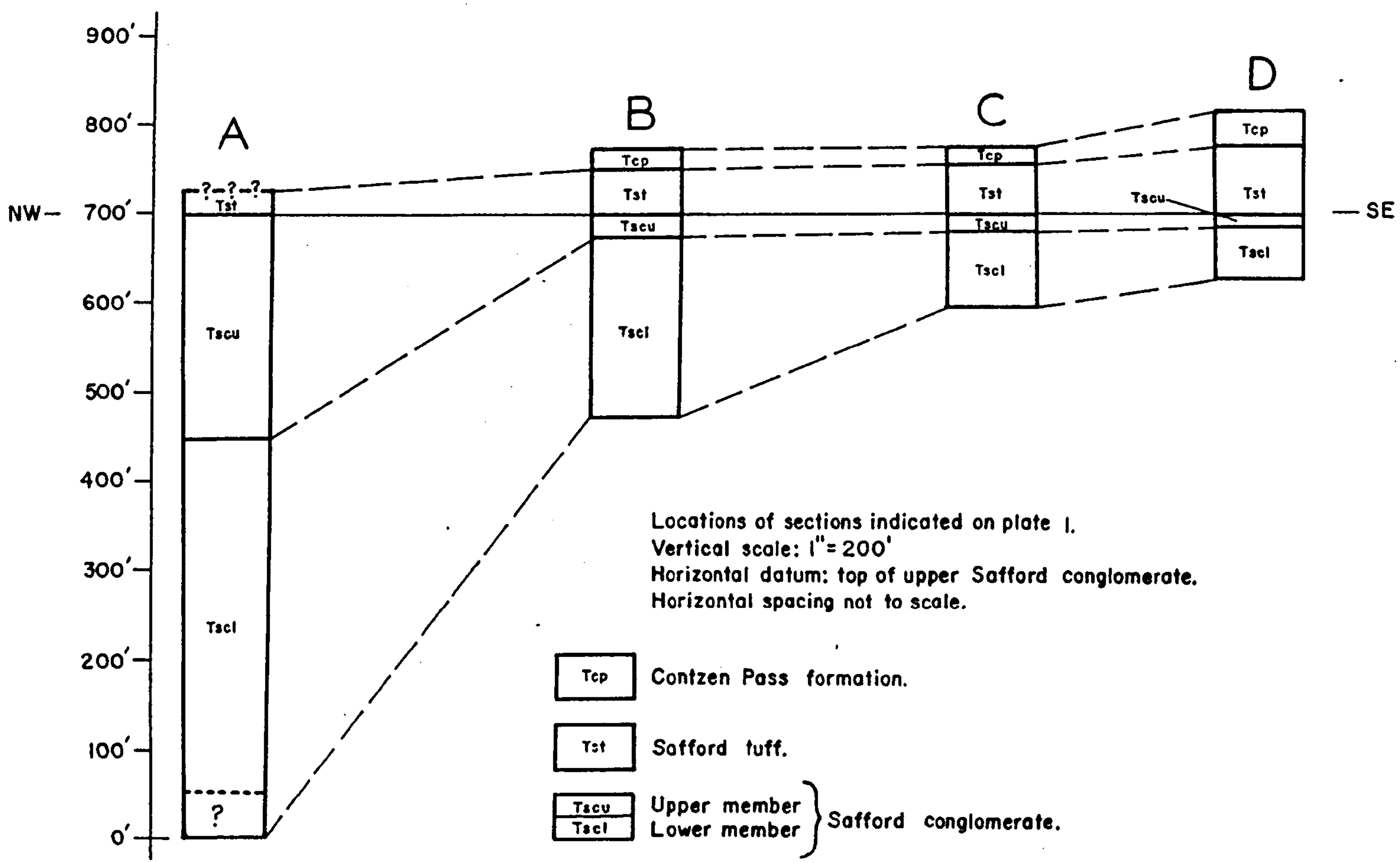


FIGURE 3.

RELATIONSHIPS OF THICKNESSES IN SELECTED MEASURED SECTIONS are conformable at most places, but they are separated in the northern part of the area by the Rillito andesite.

Safford tuff.--The formational unit I have defined as the Safford tuff was considered by Brown (1939) to be the bottom member of the Upper andesite. In describing the Upper andesite he states (1939, p. 737):

> Near the peak the formation consists of three different phases. The lowest bed is tuffaceous and usually more nearly resembles a hydrothermally altered phase of the overlying massive material. However it is locally well stratified, and chalky bedded zones split the more massive chalky material. This tuffaceous facies rests on the Safford tuff (herein called the upper member of the Safford conglomerate) and is overlain in turn by the cliff-forming flows.

I have already established that Brown's (1939) Safford tuff is a conglomerate, and I will later show that the rock unit I choose to call the Safford tuff is a mappable rock unit which is separate and distinct from the Upper andesite.

The Safford tuff (Pl. 5) usually conformably overlies the Safford conglomerate, and is conformably overlain by a rock unit I have called the Contzen Pass formation. However, the Safford tuff appears to be intrusive into the upper member of the Safford conglomerate (Pl. 6, Fig. 2) at the west end of Safford Peak and immediately south of the east end of Safford Peak.

The tuff can be divided into three megascopic units which are fairly uniform, except that the lower unit may contain some interbedded flows in the vicinity of the northeastern end of Safford Peak. The thickness

PLATE 5

CONTACT BETWEEN THE SAFFORD TUFF AND THE SAFFORD CONGLOMERATE

Figure 1. Looking northeast from the top of the conglomerate cliffs at the west end of Safford Peak. Residual weathered boulders of Safford tuff rest on the dip-slope of Upper Safford conglomerate, and scattered patches of tuff are in conformable contact with the underlying conglomerate.

Figure 2. Looking north in southeastern part of the area. Obsequent fault-line scarp exposing contact between the Safford tuff and the Safford conglomerate. Contact slopes 15 degrees from upper left to lower right and touches the top of the hammer handle. North side is down, but south side has been eroded lower.


Tsl
Tsl
Tscu
Tscu


Tsl
Tscu
Slickensides
Tscu

PLATE 6

STRATIFIED AND INTRUSIVE SAFFORD TUFF

Figure 1. Stratified Safford tuff on northeast wall of wash on lower southeast slope of hill which lies 1, 000 feet northeast of Safford Peak.

Figure 2. On south slope of Safford Peak, looking east. Safford tuff (Tst) intrudes Safford conglomerate (Tscu) from below in sill-like fashion.


Tst

of the tuff varies from 20 to 100 feet. All three members are well exposed at Contzen Pass on the south side of the hill which lies south of Picture Rocks Road.

The lower member is a poorly consolidated, stratified, white ashy tuff. It has euhedral phenocrysts of biotite and only locally contains rock fragments. These rock fragments are restricted to intercalated well-consolidated layers which are best developed in the northeastern part of the area (Pl. 6, Fig. 1). The lower member is locally missing.

The middle member is a dirty whitish to yellow, well cemented, highly vesicular, pumiceous tuff which contains much detrital material of coarse sand size. It is this member which is usually well exposed as rounded benches on the slopes.

The upper member is a dense, well-cemented rock containing many fragments of older rocks. The matrix is a mixture of tuffaceous ash and coarse sand, and the fragments range up to one and one-half inches in diameter.

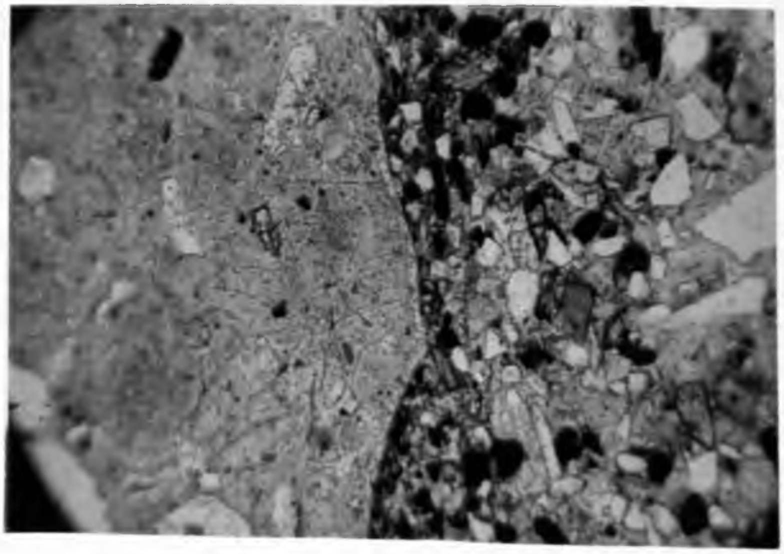
At both locations where the tuff is intrusive, it is itself intruded by a network of granophyre or aplite veins (Pl. 7, Fig. 1). These veins, both in the field and in thin section, appear to be very similar to the nondilational net veins of granophyre shown by Reynolds (1954, Pl. 2) from Slieve Gullion, Northern Ireland. Brown (1939) in describing these intrusive relations south of Safford Peak, notes that the veins are

PLATE 7

INTRUSIVE VEINS IN SAFFORD TUFF

Figure 1. Looking north immediately south of Safford Peak. Exposure of intrusive veins in Safford tuff.

Figure 2. Photomicrograph showing fine-grained edge of intrusive vein truncating structures in the tuff. Plane polarized light, X 60.



restricted to the tuff. However, I have seen these same veins intrusive into the Upper Safford conglomerate at the northwest end of Safford Peak.

In hand specimen the vein material from the Safford tuff appears to have primary sedimentary structures, and this suggests that the veins are actually xenoliths of sedimentary rock within the tuff. However, in thin section (Pl. 7, Fig. 2) the veins have fine-grained margins and truncate structures within the tuff. The veins are, therefore, intrusive into the tuff. Reynolds (1954) concludes that the net veins of granophyre at Slieve Gullion were emplaced as fluidized systems. I believe that the veins within the tuff, as well as the tuff itself, were possibly emplaced in the same manner, and that these intrusions may have been concurrent with the emplacement of the Safford dacite.

Contzen Pass formation.--The unit I have called the Contzen Pass formation was considered by Brown (1939) to be part of the Upper andesite. He states (1939, p. 737): "At the base of the flow a chilled vitrophyric zone ranges up to 20 feet in thickness.... The glass is perlitic and has an index of refraction of 1.492."

The Contzen Pass formation rests conformably, but with sharp contact, on the Safford tuff in all parts of the area mapped. This contact is especially well exposed at Contzen Pass on the north side of the hill immediately north of Picture Rocks Road. The top of the Contzen Pass formation is separated from the overlying Upper andesite by a bed of loose unconsolidated ash which ranges from less than one to possibly 10 feet in thickness and is possibly locally missing. This ash bed becomes washed out by water seeping down through the fractures in the Upper andesite, and by its erosion literally undercuts the Upper andesite causing the andesite to slump off and conceal its lower contact with talus. I have found one good exposure (Pl. 8, Fig. 1) where the ash bed can be clearly seen to separate the Contzen Pass formation from the Upper andesite. In two other exposures it clearly separates the two formations but is only several inches thick and is difficult to see. The Contzen Pass formation crosses Picture Rocks Road 100 yards east of the crest of Contzen Pass. Here along the south side of Picture Rocks Road, the ash beds can indistinctly be seen to separate the Contzen Pass formation from the Upper andesite.

The Contzen Pass formation is uniformly 20 to 40 feet thick and is a vitrophyre from bottom to top. It contains phenocrysts of oligoclase, biotite, hornblende, diopside, and apatite. The phenocrysts are for the most part euhedral. Flow banding is continuous around the phenocrysts. Shards are present but not abundant. The formation is characterized by its perlitic matrix. I have determined the index of refraction to be 1.495. This index, as well as that reported by Brown (1939), falls within the range of a rhyolitic obsidian. The color varies from gray to black.

The normally gray to black rock grades from gray to brick red

PLATE 8

LOWER CONTACT OF UPPER ANDESITE AND GEOMORPHOLOGY OF NORTHWESTERN PART OF AREA

Figure 1. Looking north at point about 250 feet below the top of the southeast termination of the northwest-southeast-trending scarp. This location is about 1, 800 feet north of Picture Rocks Road. Note the powdery area around the head of the hammer. Near its top, the ash is stained pink from the Upper andesite (Tua), becomes incorporated in the base of the Upper andesite. Ash lies on Contzen Pass formation (Tcp).

Figure 2. Looking north toward cuesta of Rillito andesite (Tra) (upper left), conglomerate cliffs (Tscu), and scarp formed by Upper andesite (Tua). Rillito andesite can be seen to wedge out in the middle of the photograph. Tsd is Safford dacite.


Tcp
Ash


Tra
TSCU
Tsd
Tsd

at certain locations. This phenomenon is restricted to the top of the formation, and although it has not been observed in actual outcrop, because of the poor exposures, it has been observed in pieces of float picked up along the concealed upper contact.

At the suggestion of Professor R. L. DuBois, a piece of the black rock was put in an oven and held at a temperature of approximately 1100 degrees F. for a period of 20 hours. At the end of this period the rock had lost its perlitic luster and had changed to a brick-red rock with a glassy luster. The results of this experiment may suggest that if a lava flow had covered the top of the Contzen Pass formation, a baked contact having similar characteristics as the rock which was heated in the oven, might exist in places where the ash was locally missing.

Whether an actual erosion surface exists at the top of the Contzen Pass formation or not, the presence of the ash beds, the fact that the greatest amount of weathering is near the top of the formation, and the inferred baked contact all indicate that the Contzen Pass formation is certainly not a part of the Upper andesite.

Flow breccia is present in some exposures of the formation. There are rounded inclusions within the flow which are megascopically identical with the lower part of the overlying Upper andesite. The texture of these inclusions is, however, entirely different microscopically from the texture of the Upper andesite even though the mineralogy is very similar.

Kinnison (1958, p. 64) states:

> Exposed in a cliff face north of the Old Yuma Mine and in a wash to the east is a thin layer of porphyritic andesite which resembles the Ivy May andesite, and which overlies the Safford formation. The association of this andesite with the Safford formation, coupled with its lithology, suggests that this unit is equivalent to the Ivy May andesite.

I have traced the Contzen Pass formation for a mile and a quarter south-east of Contzen Pass, and I believe that this is the unit which Kinnison suggests is equivalent to his (1958) Ivy May andesite. The composition of the Contzen Pass formation, however, does not in the least resemble the petrographic description of the Ivy May andesite given by Kinnison (1958).

The genisis of the Contzen Pass formation is somewhat enig-matic. One possible explanation is that the formation represents the chilled base of a much thicker flow. It is hard to imagine, however, an erosional situation which would remove the upper part of the flow to an almost perfectly plane surface and result in a continuous body of rock having a constant thickness of 20 to 40 feet and an areal distribution of at least six or seven square miles.

Another possibility is that the Contzen Pass formation is a sill which was exposed by weathering and erosion and was then covered by the ash bed and the Upper andesite. However, the relationships at the upper and lower contacts, the lack of alteration of the underlying Safford tuff, and the lack of a definite erosion surface at the top of the formation all oppose this interpretation.

Other possible explanations are that the formation is a thin glassy flow or else an ignimbrite which was formed as the base of a nuée ardente. The scarcity of shards argues against an ignimbrite. The perlitic nature of the glass seemingly argues against both an ignimbrite and a thin glassy flow, because one would normally expect the volatiles to escape, under atmospheric pressure, at the temperatures existing in a molten magma. However, work by Ross and Smith (1955) indicates that some perlites form at the expense of obsidian, the addition of water evidently occurring after emplacement of the original glass. They believe that the water of hydration may have been derived from a distinctly post-magmatic episode, probably the result of rain, snow, or ground water, and they further believe that this reaction could occur during a late cooling stage or at a still later time.

Upper andesite.--The Upper andesite as defined by Brown (1939) includes what I have designated as the Safford tuff and the Contzen Pass formation. The Upper andesite, as I have mapped it, is the cliff-forming, massive, dark-red flow-rock which covers most of the area (Pl. 9, Fig. 1).

The Upper andesite is the youngest flow in the area, has the largest area of outcrop, and is perhaps the thickest formation present. The greatest thickness exposed is about 250 feet, but undoubtedly part

PLATE 9

WEATHERING CHARACTERISTICS OF
THE UPPER ANDESITE

Figure 1. Looking south at hill which lies at the east end of Safford Peak. Photograph shows cliff-forming habit of the Upper andesite (Tua).

Figure 2. Top of hill immediately north of Contzen Pass. Flow layers in the Upper andesite resemble bedding.


Tua
Tua

of the flow is missing by erosion.

The formation varies in color from a bright red in the dense glassy chilled base to black on surfaces which have been heavily coated with MnO_2. Where weathered it is usually reddish gray and has a very rough surface. When fresh the great abundance of phenocrysts causes it to have an apparent holocrystalline texture to the naked eye, but the hand lens shows an aphanitic groundmass. Brown (1939) reports the rock to have a cryptocrystalline groundmass containing phenocrysts of oligoclase, biotite, magnetite, and some diopside. Thin sections which I have examined verify his findings.

Above the dense, glassy chilled base is a rather thick zone of flow breccia which grades into andesite with good flow banding. The flow banding weathers in such a manner as to resemble bedding (Pl. 9, Fig. 2).

Tertiary Intrusive Rocks

Rillito andesite.--Brown (1939) named the Rillito andesite and considered it to be an extrusive rock. Field investigation has revealed several intrusive sources for the Rillito andesite (Pl. 1). Evidence strongly suggests that it occurred only locally as flows, and it is possible that some of these were actually shallow sills or laccoliths. At least two and perhaps three ages are indicated for the Rillito andesite.

The Rillito andesite varies widely in color from grayish purple to light reddish tan. It has an aphanitic matrix, but contains abundant phenocrysts of euhedral biotite and feldspar which usually are well oriented to form a distinct foliation. This andesite weathers to a smooth rusty tan surface which is only minutely pocked by preferential weathering of some of the phenocrysts.

The eastward-sloping cuesta located immediately west of Safford Peak is for the most part formed on the Rillito andesite. The relationships between the Rillito andesite and the lower member of the Safford conglomerate at this location have already been discussed and illustrated (Pl. 3).

The contact between the two formations is much different toward the south end of the west-facing cliffs. Here the bottom 15 feet is composed of many clasts of the underlying conglomerate. Angular pieces of Rillito andesite as large as two feet in diameter and some ashy or tuffaceous material are also present. This bottom 15 feet is probably ashy, tuffaceous, rubbly basal flow breccia. Above the heterogeneous basal 15 feet is perhaps 50 to 75 feet of flow breccia composed wholly of pieces of Rillito andesite cemented by the same material. This flow breccia grades into flow with distinct banding. The attitude of the banding is conformable with the local dip.

The Rillito andesite continues southeast of the cuesta, in the form of several smaller hills, and eventually wedges out (Pl. 8). Steep flow structures (Pl. 1) indicate that this wedge is the southeastern termination of an arcuate or wishbone-shaped dike which probably was the source of these northwestern flows.

Another source, which probably erupted contemporaneously with that in the northwest, is located in the northeastern part of the area. The andesite here is porphyritic and contains phenocrysts of oligoclase, biotite, and some diopside in a microcrystalline groundmass. In addition to this, stringers of quartz up to six inches long are present. These quartz stringers are clearly visible megascopically. This andesite is identical to that found in the northwest.

Mapping of the flow structures revealed a dome-like intrusion at the northern edge of Conception Cove (Pl. 1). A dike with well-developed vertical flow structures (Pl. 10, Fig. 1) connects this dome with the ridge which extends north from the east end of Safford Peak. Steep flow structures (Pl. 10, Fig. 2) indicate that at least part of the north-trending ridge is also a dike. The dip of the flow banding in each of these dikes can be traced as it bends around to a less steep attitude. The rocks having this gently dipping flow banding appear to represent flows fed from the dikes. A third dike, which has well-developed flow banding, is located on the north side of the hill which lies 1,000 feet northeast of the east end of Safford Peak. This dike is probably of the same age as the others, but it is in fault contact with the flow rocks.

A cliff of Rillito andesite is located immediately north of Safford Peak (Pl. 11, Fig. 1). The andesite in this cliff is highly brecciated,

PLATE 10

FLOW BANDING IN THE RILLITO ANDESITE

Figure 1. Steeply dipping flow banding in the dike which connects the intrusive dome with the ridge-forming dike, which extends northward from the eastern end of Safford Peak. Looking west.

Figure 2. Steeply dipping flow banding in the ridge-forming dike. Looking north. Contortions in flow layers on crest suggest that present summit of ridge is near original top of dike.

PLATE 11

CLIFF OF RILLITO ANDESITE NORTH OF SAFFORD PEAK

Figure 1. Looking south. Rillito andesite (Tra), Safford tuff (Tst), Safford dacite (Tsd).

Figure 2. Looking east. Note fault contact. Upper conglomerate (Tscu), Rillito andesite (Tra), Safford tuff (Tst), Safford dacite (Tsd).


Ted
Tst
Tra


Tra
Tst
Tst

and it is difficult to determine the contact between it and the upper member of the conglomerate. This andesite is either from the northwest or from one of the northeast sources.

The Rillito andesite forms the hill and ridge which are located at the southeast termination of the northwest-southeast-trending scarp. One hundred feet of the Safford conglomerate appears to overlie the andesite in a gully at the west end of the hill, but clasts of Rillito andesite are found only in the upper 15 feet of the conglomerate. These fragments are well rounded and I believe that they were derived from the northern flows. At the east end of the hill, however, the conglomerate can clearly be seen to underlie the andesite, and fine-grained clastic dikelets of the conglomerate matrix can be seen in the andesite along the contact. The andesite wedges out just north of Picture Rocks Road. The rock of both the hill and the ridge is megascopically different from that found in the northwest and the northeast. However, in thin section only that of the hill differs; it lacks the quartz stringers found in the northern areas. The rock of the ridge contains quartz stringers, but they, as well as the phenocrysts, are highly fractured. I believe this fracturing to be the result of a fault which shows later alteration along its borders, and which runs through the ridge. The evidence indicates that this Rillito andesite is an intrusive body, of the same age as the flows to the north, but which never reached the surface.

In the northern part of the area, a dike of Rillito andesite cuts through the saddle which separates Safford Peak from the hill which lies 1,000 feet to the northeast. This dike intrudes the upper member of the Safford conglomerate and is definitely a younger intrusion than those previously described. The Safford tuff has been intruded at this same location, but the tuff, where intruded, is in fault contact with the conglomerate. It is not possible therefore, to determine whether this represents the same or a later intrusion than that which cuts the upper member of the conglomerate.

Marginal vitrophyre.--A felsitic vitrophyre containing phenocrysts of oligoclase and some biotite is exposed north and west of Safford Peak. On the north side it occurs along a fault contact between the Rillito andesite and the Safford tuff. On the west it separates the Rillito andesite from the Safford conglomerate. It appears to form an arcuate dike around the northwestern end of Safford Peak, and was probably emplaced either at the time of, or after the intrusion of the Safford dacite.

Safford dacite.--The rock comprising the intrusive core of Safford Peak has been described by Brown (1939) as a dacite on the basis of the phenocrysts, but he states that the glass of the groundmass has the index of refraction of a rhyolite. I have found the rock to contain phenocrysts of oligoclase and biotite in a cryptocrystalline groundmass. Megascopically the rock is dark reddish brown on fresh surfaces, has a dense aphanitic groundmass, and is finely and sparsely porphyritic.

Flow banding within the core of Safford Peak is well developed with an average east-west strike and vertical or nearly vertical dips (Pl. 12, Fig. 1; Pl. 13, Fig. 1). Along the margins the attitude of the flow banding deviates from that of the central part and conforms to the shape and direction of local irregularities in the outline of the body.

The flow banding is discordant at the eastern end of Safford Peak (Pl. 1; Pl. 12, Fig. 2). I interpret the gently dipping flow structures at the eastern end to represent doming as described in small stocks and volcanic plugs by Balk (1937). The discordance is extremely abrupt, and takes place in a zone which is two to three feet wide, and in which the flow structures disappear. The actual contact is impossible to detect even with the aid of a hand lens. No shearing or jointing is associated with this discordance. I interpret the discordance to represent a later upward surge of magma, having an east-west-trending dike-like form, occurring at a time when the original dome was very viscous but had not yet solidified.

There have been no flow rocks found in the area by me or reported in the vicinity by any one else which would correspond to the Safford dacite. This, plus the configuration of the flow structure, particularly at the eastern end of Safford Peak, leads me to believe that the Safford dacite never reached the surface, and therefore was wholly intrusive.

PLATE 12

FLOW BANDING IN THE CORE OF SAFFORD PEAK

Figure 1. Looking east along the summit of Safford Peak. Flow banding is essentially vertical and perpendicular to the plane of the photograph.

Figure 2. Looking north on the eastern summit of Safford Peak. Picture shows discordant flow banding in the Safford dacite. Flow banding in right foreground is parallel to plane of picture; that in lower center dips gently to the east.

PLATE 13

SAFFORD DACITE AND INTRUSIVE NECK

Figure 1. Looking west along ridge of Safford Peak. Note vertical flow banding. Small intrusive neck can be seen in left background.

Figure 2. Looking northwest toward intrusive neck, Rillito cuesta, and conglomerate cliffs.

A small intrusive neck forms the spine which is located 3,600 feet southwest of Safford Peak (Pl. 13). The rock is composed of the same material as the intrusive core of the peak. This small neck has, along its edges, many partially digested xenoliths of the surrounding Cretaceous rocks (Pl. 14). Flow banding in this small neck dips about 60 degrees to the west. A dike of the same material trends northeastward away from the small neck, and several other small dikes are located adjacent to Safford Peak (Pl. 1).

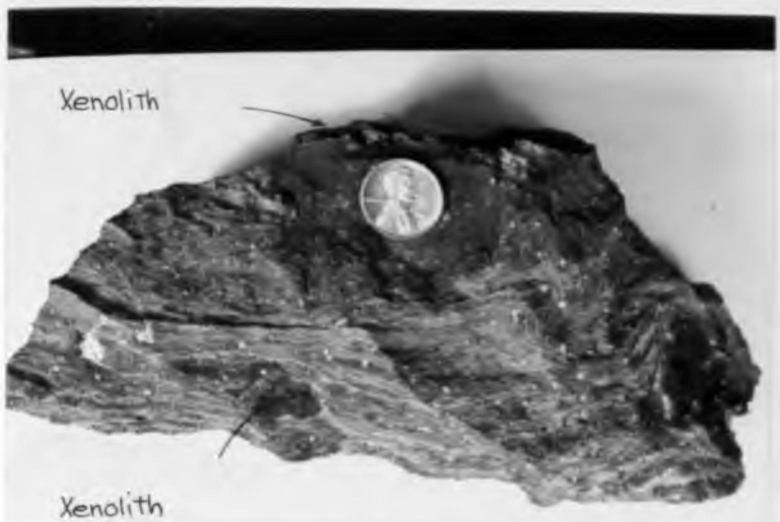
Structure

Cretaceous Structures

Cretaceous rocks generally have east-west strikes and steep northerly dips. Four or five distinct lithologic types which strike north 80 degrees east and dip 60 degrees northward are present on the south slope of the ridge which is 1,700 feet north of Picture Rocks Road. Cretaceous rocks are all highly fractured. One set of closely spaced fractures parallels bedding and is cut by a distinct set of oblique fractures which strikes north 60 degrees west and has a nearly vertical dip. Repetition of beds dipping consistently northward suggests either faulting or folds which were overturned to the south and later truncated. No faults restricted to Cretaceous rocks were mapped.

PLATE 14

XENOLITHS OF CRETACEOUS ROCK IN FLOW ROCK FROM TERTIARY INTRUSIVE NECK


Xenolith
Xenolith

Tertiary Structures

Attitude of Tertiary rocks.--The Tertiary rocks in the area mapped have a local strike of N. 55 W., and a general dip of about 15-20 degrees to the northeast. The attitude varies locally and of course is different where the rocks have been disturbed by faulting.

Jointing of Tertiary rocks.--The Tertiary flow rocks are closely fractured. The attitudes of these fractures vary widely, and I suspect that many of them are actually cooling cracks. The main reason I believe this is because the well-indurated upper member of the Safford conglomerate does not show any jointing in the southern part of the area, and the well-consolidated members of the Safford tuff do not show prominent jointing anywhere. One exception is noted in the conglomerate cliffs at the west end of Safford Peak (Pl. 15, Fig. 1). Here two sets of joints, one striking north 80 degrees west and dipping 75 degrees southwest and one striking north 20 east and dipping 80 degrees northwest, are very well developed in the upper member of the conglomerate.

Faulting of Tertiary rocks.--The dominant direction of faulting in Tertiary rocks is east-west. Examples are the large east-west fault just north of Picture Rocks Road, two major faults on the south side of Safford Peak and the fault along the north side of Safford Peak, the fault extending east from Safford Peak, and the fault along the north

PLATE 15

FAULTING AND JOINTING IN THE TERTIARY ROCKS

Figure 1. Looking east toward conglomerate cliffs. Two prominent directions of jointing can be seen both on the cliffs and in the large blocks. Fault cuts between Safford tuff (Tst) and conglomerate (Tscu). The tuff appears to be intrusive along the fault.

Figure 2. Looking southeast; Box Canyon at left, Picture Rocks Road in lower right. Block to left of fault is downthrown. Upper andesite (Tua), Contzen Pass formation (Tcp), Safford tuff (Tst).


Tscu
Tst


Tua
Tua
Tcp
Tst
Tst

side of the hill which lies 1,000 feet northeast of Safford Peak. The second prominent direction of faulting is nearly north-south, as is shown by faults immediately east of Safford Peak. Plate 11, Figure 2 and Plate 15 illustrate some of these faults.

The east-west fault located 1,000 feet south of Safford Peak is definitely a right-lateral strike-slip-fault, as shown by horizontal slickensides and a right-lateral displacement of beds. The net slip is 200 feet and is horizontal. The large fault which is located about 1,700 feet north of Picture Rocks Road shows strike-slip-movement along its western end, as indicated by slickensides which plunge 13 degrees to the east, but appears to be a normal fault at its eastern end (Pl. 15, Fig. 2). The faults immediately adjacent to Safford Peak are high-angle faults but it is impossible to determine whether they are normal or reverse. Both possibilities are illustrated in the cross sections shown on Plate 1. In either case, it appears that the Safford dacite has dragged upward arcuate blocks of its walls. The northeast- and northwest-trending faults located just north of Contzen Pass appear to be normal faults. Verification of this is impossible since, as in the case of the faults adjacent to Safford Peak, the southeast fractures are mapped on the basis of the outcrop pattern of the various formations, and the dip of the fault planes cannot be determined.

The major faults appear to have originated contemporaneously with regional tilting, but later adjustment is evidenced by multiple slickensides on some of them. I believe it is significant that both the east-west faults and the intrusive Safford dacite closely parallel the strike of the Cretaceous rocks. The relative elevations of the Rillito andesite flows in the northeastern part of the area indicate that the younger north-trending dike of Rillito andesite followed an older zone of structural weakness within which faulting had already displaced the flows. Earlier movement, having an opposite displacement from that last recorded, is also indicated along the large north-south-trending fault which is located northeast of Safford Peak.

Mayo (1958) has pointed out prominent zones of east-west and north-south-trending structures. He states (1958, p. 1172), "The north-south set is usually orientated somewhat east of north, and the east-west set somewhat north of west." The pattern of the major faults which I have mapped roughly conforms to this. He believes the east-west structures to be related to the Texas lineament which he notes may be more than 150 miles wide in southern Arizona. Lutton (1958) stated that strike-slip-movement along these east-west structures is usually left-lateral. The prominent east-west strike-slip fault which I have mapped seems to be an exception.

Structure of Tertiary Intrusives.--The flow structures of Safford Peak have been covered in the discussion of the Safford dacite. As was already mentioned, the flow banding mostly strikes east-west and is essentially vertical. Where it follows irregularities along the edges, however, the banding appears to dip steeply to the west. The flow banding in the small intrusive neck which lies southwest of Safford Peak dips 60 degrees to the west. Jointing which strikes north 70 degrees west and dips 70 degrees northeast is extremely well developed in this neck, and from a distance obscures the flow banding.

The intrusions of Rillito andesite follow known major fault directions. I believe that at least the east-west intrusions follow older Cretaceous structural trends. The east-west elliptical shape of the Safford dacite neck suggests that it too might have been controlled by the Cretaceous structural trends. As mentioned before, the north-south Rillito andesite dike in the northeastern part of the area appears to follow an older zone of structural weakness. The marginal vitrophyre definitely intrudes along a steep contact.

GEOLOGIC HISTORY

The deformation of the Cretaceous rocks was probably of Laramide age. The lower member of the Safford conglomerate appears to have been deposited on an irregular erosion surface that truncated these highly deformed Cretaceous volcanic rocks. Numerous clasts of limestones, sandstones, arkoses, and other rock types indicate that there were nearby highlands of older rocks to supply material for the conglomerate.

I believe that at the time of deposition of the conglomerate a topographic high existed between the northern and southern parts of the area. This high area is suggested by the thick Rillito andesite flows which are confined to the northern part of the area, and by the fact that these flows separate the upper and lower members of the conglomerate in the north while no Rillito andesite shows up in the conglomerate until near its top in the south.

Near the top of the conglomerate several thin ash beds indicate the beginning of the period of pyroclastic activity which resulted in the deposition of the Safford tuff. The Safford tuff seems to have been deposited under water throughout. The coarse fragments found in the upper member suggest that the body of water was retreating from the area and that these coarse fragments were deposited near shore.

The intrusions of the Rillito andesite appear to have been emplaced intermittently from the time of deposition of the Lower Safford conglomerate until the end of deposition of the Safford tuff.

The Contzen Pass formation must have covered a large fairly flat surface on the Safford tuff. This is suggested by the wide distribution and the nearly uniform thickness of about 20-40 feet. Inclusions in the formation suggest that it originated somewhere outside of this area at a place where rock like the Upper andesite already existed. The ash beds between the Contzen Pass formation and the Upper andesite indicate that a brief period of pyroclastic activity intervened between the flows.

Following the Upper andesite flows, the whole sequence was apparently intruded by the Safford dacite. It is possible that some flows accompanied these intrusions, but if such flows ever existed they have since been removed by erosion. As stated before, I believe that the Safford dacite never reached the surface..

Minor local faulting accompanied these last intrusions, but the major faulting seems to have been developed by a large-scale regional tilting toward the northeast which followed the intrusions.

MINERALIZATION

There has been some mineralization in the Cretaceous volcanic rocks along the western margin of the area. Copper oxides and sulphides have been found on the dumps of several small mine shafts and prospect pits. There is also a fairly wide band of alteration which runs along the western part of the large east-west fault in the southwestern part of the area. The age of the copper mineralization is not known, but it is believed that the alteration along the fault is post-faulting, which would make it post-tilting.

Many of the fractures in the Upper andesite contain agate, chalcedony, and jasper. This mineralization might have been associated with the intrusion of the Safford dacite neck, but I believe that it is a much later feature.

There is no direct evidence to indicate that any economic mineral deposits occur in the area. This is emphasized by the abandonment of all of the old mines in the vicinity, including the Old Yuma Mine to the south.

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PLATE 1

GEOLOGIC MAP AND SECTIONS OF

THE SAFFORD PEAK AREA, TUCSON MOUNTAINS, PIMA COUNTY, ARIZONA