PETROGRAPHY, NORTHERN DAVIS MOUNTAINS,

TRANS-PECOS TEXAS

APPROVED:

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Dean of the Graduate School

PETROGRAPHY, NORTHERN DAVIS MOUNTAINS,
TRANS-PECOS TEXAS

THESIS

Presented to the Faculty of the Graduate School of
The University of Texas in Partial Fulfillment
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by

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ABSTRACT

The northern Davis Mountains are composed of Tertiary volcanic rocks of the McCutcheon group. This group, resting unconformably on southward dipping Cretaceous strata, contains a basal conglomerate and 1,500-2,000 feet of alternating beds of tuff and lava. Streams have cut steep-walled canyons in the outer margins of the mountains, and differential erosion between the tuffs and lavas has produced a stair-step profile. Landslides occur along the front as Toreva-blocks.

The volcanic units of the McCutcheon group in the northern Davis Mountains are divided into six major mappable units consisting of three dissimilar flows, each underlain by tuff. The lavas are all rhyolites, the lowermost characterized by aegirite; the middle, by riebeckite and chlorite (?); and the upper, by riebeckite. The tuff units are rhyolitic and are classified as lithic, vitric, and crystal tuffs.

The indices of refraction of natural glasses or fused igneous rocks vary inversely with the silica content. A standard silica-index of refraction curve is drawn for rocks from the alkalic province of the nearby Terlingua-Solitario district. Indices of refraction of artificial glasses of the Davis Mountain rocks are referred to this curve to determine their approximate silica percentages.

The igneous rocks of the Davis Mountains are similar in composition to igneous rocks in the Barrilla Mountains, the Big Bend, and the Buck Hill Quadrangle. The similarity of the rocks, indicated by the presence of soda-rich minerals, suggests that they were probably derived from the same parent magma.

CONTENTS

ILLUSTRATIONS

PLATES-- PAGE

FIGURES--

FIGURES-- PAGE

INTRODUCTION

Previous field parties working in this area made no attempt to name and describe the volcanic rocks composing the northern front of the Davis Mountains. The first petrographic work on the northeastern part of the Davis Mountains was by K. O. Dickson (Eifler, 1951) who named and described the volcanic units in the Barrilla Mountains. It is the purpose of this investigation to separate, map, and describe the volcanic units composing the northern front of the Davis Mountains and to determine whether or not they are related to those of the Barrilla Mountains and nearby areas.

These units were separated in the field on the basis of color, texture, and stratigraphic position. Mineral compositions were determined by petrographic examination of thin sections, but many of the specimens were so fine-grained that it was impossible to determine their silica contents so that they could be accurately named.

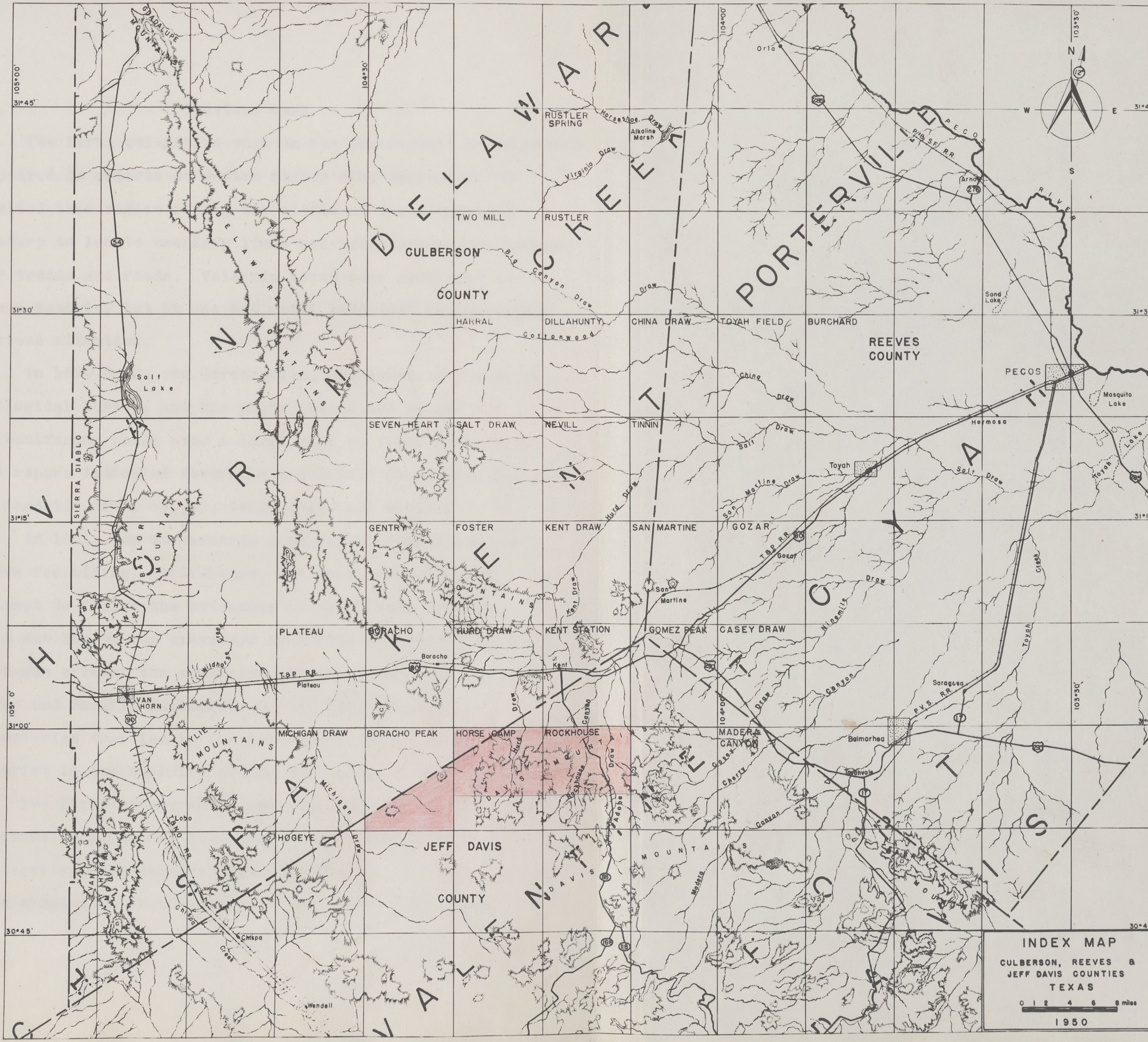
This problem led to the use of a relatively new method for determining the approximate composition of fine-grained igneous rocks. It is based on the relationship that the index of refraction of a natural glass or a fused igneous rock varies inversely with its silica content, and that glassy rocks with similar bulk compositions have similar indices of refraction. Thus, a standard silica-index of refraction curve can be drawn for analyzed samples of a petrographic province and indices of related rocks referred to the curve for approximate silica determinations.

Location

The mapped area, in northern Jeff Davis and south-eastern Culberson counties, is irregular in shape and is best described by geographic coordinates as outlined on the index map (Pl. I).

The town of Kent, about six miles north of the northern boundary of the area, is on the Texas and Pacific Railroad and U. S. Highway 80. Two-tenths of a mile east of Kent, State Highway 118 branches southward from U. S. Highway 80 and passes through the eastern part of the area.

The northern Davis Mountains are served by private ranch roads, some of which are kept in excellent repair. One road parallels the mountain front from the Bar-C Ranch to the B. Wallace Ranch. Other roads lead southward through the canyons and along the draws; and still others, to the tops of the mountains. All permit automobile and truck travel in dry weather, but roads composed of fine alluvial material become impassable during wet weather. The roads on the Bar-C Ranch were graded and crowned during the summer of 1950 and are in excellent condition.


INDEX MAP
CULBERSON, REEVES & JEFF DAVIS COUNTIES
TEXAS
0 1 2 4 6 8 miles
1950
CULBERSON COUNTY
REEVES COUNTY
JEFF DAVIS COUNTY
DELAWARE
KEENA
PORTERVILLE
TOYAH
NOCY
FT. DAVIS
VALENTINE
KENT
CHISPA
GUADALUPE MOUNTAINS
DELAWARE MOUNTAINS
APACHE MOUNTAINS
BAYLOR MOUNTAINS
BEACH MOUNTAINS
SIERRA DIABLO
WYLIE MOUNTAINS
VAN HORN MOUNTAINS
DAVIS MOUNTAINS
PECOS RIVER
RUSTLER SPRING
TWO MILL
RUSTLER
HARRAL
DILLAHUNTY
CHINA DRAW
TOYAH FIELD
BURCHARD
SEVEN HEART
SALT DRAW
NEVILL
TINNIN
GENTRY
FOSTER
KENT DRAW
SAN MARTINE
GOZAR
PLATEAU
BORACHO
HURD DRAW
KENT STATION
GOMEZ PEAK
CASEY DRAW
MICHIGAN DRAW
BORACHO PEAK
HORSE CAMP
ROCKHOUSE
MADERA CANYON
HOGEYE
Orla
Arno
Pecos
Mosquito Lake
Hermosa
Toyah
Toyah Lake
Sand Lake
Salt Lake
Alkaline Marsh
Horseshoe Draw
Virginia Draw
Big Canyon Draw
Cottonwood
China Draw
Salt Draw
San Martine Draw
Hurd Draw
Kent Draw
Ninemile Draw
Toyah Creek
Boracho
Kent
Plateau
Van Horn
San Martine
Gozar
Saragosa
Balmorhea
Toyahvale
Lobo
Chispa
Wendell
Wildhorse Creek
Michigan Draw
Rockhouse Draw
Adobe Draw
Casey Draw
Cherry Canyon
Madera Canyon
T.&P. R.R.
P.&S.F. R.R.
P.V.S. R.R.
T.&N.O. R.R.
31°45'
31°30'
31°15'
31°00'
30°45'
105°00'
104°30'
104°00'
103°30'
N
S
E
W
12°

Previous work

The first scientific work on the Trans-Pecos Texas area appeared in reports of United States Army Engineers, who visited this region during the middle of the nineteenth century to locate boundary lines and transcontinental routes for trains and roads. Volcanic rocks were mentioned in these reports, but it was not until 1890 that they received serious attention.

In 1890 W. H. von Streeruwitz, geologist of the Texas Geological Survey, and his party traced and mapped the Carboniferous rocks over a large part of Trans-Pecos Texas. His report indicated favorable conditions for mining deposits of magnetic iron, copper, lead, gold, and silver.

In 1891, von Streeruwitz returned to locate reservoir sites for mining, agriculture, and stock requirements. His attempt to follow the extension of the Diablo Mountains into New Mexico was prevented by a lack of water; therefore, he began work on the extensive volcanic rocks south of the Texas and Pacific Railroad. During this time he made discoveries that led to the development of a new mining district in the vicinity of Mt. Ord, south of Alpine, Texas.

The first petrographic study of the rocks of the region was made by A. Osann, Professor of Mineralogy at the University of Heidelberg, Germany, who was appointed Mineralogist and Petrographer of the Texas Geological

Survey. He published a preliminary report on the igneous rocks collected by von Streeruwitz. Later E. C. E. Lord (1900) made petrographic examinations of igneous rocks from the vicinity of San Carlos and Chispa, Texas, and designated them as rhyolite breccia, quartz-pantellerite, and basalt.

Subsequently, J. A. Udden (1907) described the igneous and volcanic rocks of the Shafter Mining District, Presidio County, and of the Chisos Mountains, Brewster County, Texas. Notes on a few thin sections were prepared for him by B. F. Hill.

C. L. Baker and W. F. Bowman (1917) described the general geology of this area, mentioning the volcanic rocks. They stated that chemical analyses of these rocks showed that "all of the rocks of the region are deficient in magnesia, even including some of the more basic rocks. In all but nine analyses soda is in excess of potash . . . ," and cited Osann on the sequence of eruptions: "first, basalt; second, rhyolite; and third, trachytes and phonolites."

Subsequently, C. L. Baker (1927) completed the exploratory work which had been begun some twenty years earlier. The work was initiated under The University of Texas Mineralogical Survey and completed under The University of Texas Bureau of Economic Geology.

J. T. Lonsdale and W. S. Adkins (1927) described orthoclase crystals near Sierra Blanca, Texas, and Lonsdale (1928) described specimens of analcime from an abandoned quicksilver mine in Brewster County, Texas. This is believed to be the first discovery of the mineral in Texas.

In the next decade E. H. Sellards, W. S. Adkins, and F. B. Plummer (1932) described the volcanic rocks in Trans-Pecos Texas, and P. B. King (1935) outlined the structural development of Trans-Pecos Texas. C. C. Albritton, Jr., and Kirk Bryan (1939) studied the Quaternary stratigraphy in the southern Davis Mountains.

Thereafter, J. T. Lonsdale (1940) described the geology and petrography of the rocks south of the Davis Mountains in the Terlingua-Solitario region. He showed that many of the rocks contain analcime and that they constitute another of the remarkable alkalic subprovinces which characterizes the front of the Rocky Mountains.

S. S. Goldich and M. A. Elms (1949) described the stratigraphy and petrology of the Buck Hill Quadrangle, southern Davis Mountains, and G. K. Eifler, Jr., (1951) described the igneous and volcanic rocks of the Barrilla Mountains.

Detailed work on the area just to the north of the Davis Mountains appears in unpublished Master's theses of The University of Texas, prepared on the Kent Quadrangle by Brown (1948) and Williams (1948); on the Hurd Draw

Quadrangle by McCracken (1948) and Hays (1948); on the Boracho Quadrangle by Scholl (1948) and George (1948); and on the Jeff conglomerate by Barnhill (1950) and Zimmerman (1950).

Methods

A two-week reconnaissance indicated that the volcanic rocks of the northern margin of the Davis Mountains can be divided into six large mappable units consisting of three dissimilar flows, each underlain by tuff.

Once the sequence of rocks was determined, the field work consisted of the walking of contacts along 25 miles of the mountain front and sketching them on acetate paper covering aerial photographs mounted on masonite. A portable stereoscope was used as an aid in the interpretation of the aerial photographs. Geologic sections were measured with the handlevel. The aerial photographs were prepared by Muldrow Aerial Surveys, Incorporated, Midland, Texas.

Acknowledgments

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Others who contributed to the interpretation of the data include: Dr. P. T. Flawn and M. E. Dehlinger; F. J. Fuqua and M. Levin; C. V. Winter and W. Lesko; E. A. Humble and G. B. Baker; W. Halamicek, G. Slocum, and V. C. Grasso.

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GEOGRAPHY

Physical features

Trans-Pecos Texas is divided into two physiographic provinces, a southwestern or mountainous province, and a northeastern or plains province. The mountainous province is a part of the great Western Cordillera of the Western Hemisphere which stretches from Alaska to Tierra del Fuego. Along the eastern front of the Cordillera, south of the Texas and Pacific Railroad, the Barrilla and Davis Mountains, composed of Tertiary volcanic rocks, rise abruptly above the plains on the east.

The Davis Mountains are composed of 1,500-2,000 feet of alternating beds of volcanic ash and massive lava flows (Fig. 1) which form steep cliffs on the northern edge of the mountains. They rest unconformably upon southward-dipping Upper Cretaceous rocks. Rising in the central part of the Davis Mountains are two high peaks, Mt. Livermore (8,382 ft.) and Sawtooth Mountain (7,748 ft.). On the northern rim of the mountains are three other prominent peaks, Newman Peak (6,400 ft.) and Gomez Peak (6,325 ft.), southeast of Kent, and Boracho Peak (5,661 ft.), southwest of Kent.

The Davis Mountains may be considered as a large broad mesa of lava with a southwesterly dip. Streams have cut

Fig. 1--Alternating beds of volcanic tuff and lava flows composing the northern front of the Davis Mountains.

steep-walled canyons through the outer margins of the mountains. Along the front of the northern Davis Mountains differential erosion between the resistant lavas and the poorly consolidated tuffs has produced a stair-step profile (Fig. 2). Debris, in the form of talus and sliderock, from the overlying lavas tends to destroy this profile and develop, instead, a smooth slope. Care must be taken when studying the stratigraphic sequence of the volcanic rocks in this area in order not to overlook concealed tuffs which also tend to form smooth slopes.

Toreva-blocks.-The term Toreva-block was proposed by Reiche (1937) in describing landslides near the Indian village of Toreva on the Hopi Indian Reservation in north-eastern Arizona.

> A Toreva-block is a landslide consisting essentially of a single large mass of unjostled material which, during descent, has undergone a backward rotation toward the parent cliff about a horizontal axis which roughly parallels it.

The landslide mechanism is described by Terzaghi (1950, p. 91).

Along the northern front of the Davis Mountains similar landslides are present (Fig. 3). The Toreva-blocks extend northward from the mountain front for a distance of approximately one mile. Those closest to the front are high and angular, whereas those farther from the front are low and well-rounded. Those farthest from the front rise only

Fig. 2--Differential erosion between lavas and tuffs produces stair-step profile.

Fig. 3--Toreva-blocks along the northern front of the Davis Mountains.

15-20 feet above their bases. The blocks roughly parallel the mountain front, and most of them are much longer than wide. Much of the underlying material is obscured by the Toreva-blocks, and it is difficult to determine the relationship of the layers involved in the sliding to those composing the mountain front. In most blocks where color and textural differences were definite enough, fairly accurate correlations were obtained, but the different tuff sections were so similar in places that only in blocks where the sequence of beds was undisturbed was it possible to infer which tuffs were included in the Toreva-blocks.

The numerous Toreva-blocks dip toward the parent cliff, but the amount of dip is not constant. Dips of 50° or 60° are not uncommon at a distance of no more than half a mile from the cliff. Blocks at greater distances from the front are so disintegrated that dip determinations are difficult. It is very probable that the northern front of the Davis Mountains extended several miles farther to the north than at present and that Toreva-blocks existed at one time farther to the north than they do now. Their absence in the more northerly areas is due to erosion, perhaps by pedimentation as suggested by Dehlinger (personal communication, 1951).

Drainage

The area is drained by two large, intermittent streams; Adobe Draw drains the eastern part, and Hurd Draw, the central part. Hurd Draw rises high in the northern part of the mountains, heading between parallels N 30°50' and N 30°55'; Adobe Draw heads somewhat farther south. These two streams are supplied with water during the rainy season by myriads of small dendritic branches which come from the mountains and which dissect the originally flat surfaces of the lava flows. They drain northward into Salt Draw, a western tributary of the Pecos River. West of a divide roughly paralleling meridian 104°19' W. the drainage is westward into the closed Salt Basin. This closed basin was described by Richardson (1914) as

> a depressed trough, the floor of which is an aggraded surface composed of unconsolidated deposits derived from the disintegration of rocks of highlands and deposited under arid conditions . . . [it] exists as a self-enclosed basin without exterior drainage.

The semiarid climate and torrential floods of the thunderstorms produce steep-walled canyons and alluvial fans of debris. This debris, deposited in front of the mountains, produces alluvial terraces which are prominent as digital projections resting upon underlying Cretaceous slopes.

The Cretaceous beds have a southwesterly dip, and drainage on them is to the southwest. Approximately one mile north of the mountain front, the southwesterly drainage of the exposed Cretaceous slopes is captured by the northerly drainage of the mountain streams, and drainage continues from this junction northward through Adobe Draw and Hurd Draw.

Climate

The area has a climate which varies from "the nearly semi-tropical heat of the Rio Grande and Pecos Valleys to the cooler air of the higher mountains" (Baker, 1917, p. 73), and it has a more uniform climate than the areas to the north and east. The climate is considered semiarid, and the very dry air tends to reduce the harmful effects of extreme temperature.

Middle-latitude semiarid and arid regions are not primarily the result of location within particular wind belts. They are due rather to their interior location within large continents, far from large bodies of water which are the chief sources of atmospheric water vapor. In addition, although to a somewhat lesser degree, the rotation of the earth deflects rain-bearing winds from these areas. Meager precipitation in the middle-latitude dry climates may be attributed to two factors: (a) they are either in the deep interior of a large continent or are separated from oceans by large mountain barriers; or (b) there is a well-developed seasonal anticyclone in the area, bringing with it high atmospheric pressures and dry descending winds from above. Accompanying the settling cold air and diverging winds are clear skies and cold weather. Most of the winds are not strong during this season. They become so only with the passing of a cyclone (low pressures and rising warm winds) or during an anticyclonic surge from higher latitudes. In western Texas these cold surges are called "northers".

During the summer months, the heat tends to produce over much of the interior of the continent a seasonal low-pressure area or cyclone, directly related to the severe daily heating of the bare rock surfaces. This "center of action" generates inflowing monsoonal winds. It might be expected that much precipitation would result, but as the inflowing moist air must pass over great distances during its travel inland, it loses much of its moisture as rain before reaching this area.

Trans-Pecos Texas has an annual rainfall average of less than 13 inches according to the U. S. Weather Bureau. The Davis Mountains usually have the slightly higher average of about 17 inches (U. S. Department of Commerce, Weather Bureau, Climatological Data - Texas, 1950). Most of the precipitation occurs between mid-July and mid-September. This season is characterized by fairly strong winds during the day, when convection currents rise over the mountains and produce magnificent cumulonimbus clouds (Fig. 4). Thunderstorms, produced by the formation of these clouds, occur during early afternoon forming quickly and becoming widespread in a short time. They are accompanied by much vertical lightning and very often by hail. Streams may become swollen and devastating during these storms, carrying away anything found in their paths.

Fig. 4--Rain-producing midday cumulonimbus clouds.

Vegetation

The vegetation found in the higher mountains is mesophytic (plants that grow under normal conditions of moisture), and it includes several species of oak, cedar (juniper), and pine (Fig. 5). There are also specimens of pinon, Texas madrono, wild cherry, and mountain sugar maple.

Along the streams and canyons are found cottonwood, willow, walnut, and Spanish buckeye, whereas the flats are covered with fine soil and exhibit such xerophytic plants (those that grow in desert conditions of moisture) as creosote bush, mesquite, sage brush, and catclaw (acacia). The plateaus are covered with deeper soil and have a short grass cover typical of that on the Llano Estacado.

The most abundant vegetation, however, is found on the slopes and foothills of the mountains. Mesophytic varieties of cactus, yucca, and agave are among the more common types encountered (Fig. 6). Included in this flora are sotol, lechuguilla, ocotillo, ephedra, and allthorn.

Economy

Ranching is the predominant occupation in this area, the climate being too arid for farming. Both cattle and sheep are pastured on the high grassy slopes of the mountains. The Cretaceous slopes provide very little grass for grazing due to a lack of water and previous overgrazing. The shortage of water is a constant problem to this area,

Fig. 5--Mesophytic vegetation in the mountains, including several varieties of pine.

Fig. 6--Mesophytic yucca (Spanish Dagger) on foothills and slopes of the mountains.

and the seriousness of the problem has been lessened only slightly by the drilling of wells and the development of earth tanks to catch surface runoff.

During the summer of 1950, a local mining company from Van Horn, Texas, began the mining of a substance referred to as "diatomite" from the lowermost tuff bed, T35, about 100 feet above the base of the Tertiary. This mine is located on the B. Wallace Ranch. The material is used in the production of building blocks. Mr. Paul Evans, partner in the mining company, stated that a microscopic study of this deposit, made at the request of the Texas and Pacific Railroad Company, proved it to be diatomite, but the writer was unable to find diatoms in the specimens he collected. It was stated that test blocks made from this material withstood more than 1,100 lbs. per square inch, whereas ordinary concrete building blocks can withstand pressures only slightly more than 700 lbs. per square inch. Up to December, 1950, one house had been constructed from these blocks; it is on the Evans Ranch.

Ranchers also receive income from the sale of hunting privileges during the deer and antelope season.

STRATIGRAPHY

The stratigraphic sequence of formations within the mapped area is given below in Table I. The emphasis of the study is upon Tertiary volcanic rocks, the location of Cretaceous and Quaternary rocks being recorded. Color designations used for descriptions are from the Rock-Color Chart (Goddard and others, 1948).

Table I

Quaternary	Neville Q7
Tertiary	Lava T60 Tuff T55 Lava T50 Tuff T45 Lava T40 Tuff T35 Jeff conglomerate
Upper Cretaceous	

Cretaceous system

All Cretaceous rocks exposed in the area were grouped together as Upper Cretaceous. No effort was made to divide them into separate formations, for the exposures were few and poor. A more complete treatment of these rocks is to be found in theses by Barnhill (1950) and Zimmerman (1950).

Tertiary system

Tertiary rocks composing the northern Davis Mountains include a basal conglomerate and a sequence of interbedded tuffs and lavas, comprised in the McCutcheon group (Eifler, 1951). The several formations are numbered, and the matter of naming them is left to the future. The survey indicates that the McCutcheon group can be divided into seven major mappable units, to-wit, a basal conglomerate, and three dissimilar flows, each underlain by tuff.

These units were arbitrarily designated as T35, the lowest tuff; T40, the overlying flow; T45, the middle tuff; T50, the middle flow; and T55 and T60, the upper tuff and flow, respectively. The system of numbers was adopted to avoid naming the rocks, perhaps incorrectly, before their composition could be determined in the laboratory, and to allow intervening numbers for units that might be found in other places. In several places small outcrops of basalt and freshwater limestone lentils were observed within the lower part of the basal tuff, but their outcrops are neither continuous nor large enough to merit a separate numerical designation.

Jeff conglomerate.-The Jeff conglomerate, named by Eifler (1951) in the Barrilla Mountains, is composed of well-rounded limestone, sandstone, and quartzite cobbles, resting unconformably on Upper Cretaceous strata. The conglomerate is exposed in patches along the northern front of the Davis Mountains, the highly weathered parts forming cobble terraces.

Tuff T35.-The lowermost part of the volcanic sequence is Tuff T35 which is approximately 300 feet thick and forms smooth steep slopes, covered in part by Toreva-blocks. Within the lower part of the tuff are lentils of freshwater limestone and basalt. The limestone contains a continental molluscan fauna (Barnhill, 1950) composed of many high-spired gastropods that have been replaced by silica. The basalt is hard, black, fine-grained, and exhibits a few large resinous phenocrysts; it is amygdaloidal in places, and the amygdules are filled with secondary calcite, quartz, and chalcedony.

Crystalline fragments, lapilli, pumice, and glass shards compose Tuff T35. A hard baked zone at the top, approximately 15 feet thick, grades from reddish brown (10 R 3/4) at the contact with the flow to grayish orange pink (5 YR 6/2) at the lower limit of the baked area.

Lava T40.-Lava T40 is widespread throughout the area, forming the lowest of vertical cliffs along the front. It is approximately 100 feet thick on the east, but it thins rapidly toward the west. It is grayish blue green (5 BG 5.5/2) at its contact with Tuff T35 and grades vertically into a reddish brown (10 R 4/4) about 10-15 feet above the base. Sanidine (moonstone) is abundant in the lower part of the flow as phenocrysts. Throughout the rest of the flow phenocrysts of other feldspars are imbedded in a glassy groundmass. This lava forms vertical columns along the mountain front.

Tuff T45.-The tuff unit that overlies Lava T40, designated Tuff T45, is widespread throughout the eastern and central parts of the area, but it is concealed in many places along the front by sliderock. It varies in hue, the two dominant colors being greenish gray (5 GY 6/1) and grayish orange pink (5 YR 6/2). In places it is porous, loosely consolidated, and contains fragments of crystals; in other places it is composed of microscopic glass shards and is very friable, whereas at still other places, it is fine-grained and indurated. It has its maximum thickness in the central part of the area.

Lava T50.-Lava T50 is approximately 350 feet thick and forms vertical cliffs along the mountain front. The lower 200 feet is fine-grained, exhibiting few phenocrysts. It is compact and weathers along rather well-spaced fractures to form plates from 2 to 4 inches thick. This platiness seems to be indicative of the basal part of the flow and was used as an aid in identifying Lava T50 in the field. In contrast, the upper part of the flow contains many angular fragments of preexisting lava, some fragments still retaining their original phenocrysts and flow structure. There is no consistent size of the fragments; they range from a few millimeters to several inches in their greatest dimension.

The brecciated part of Lava T50 also is widespread and is most conspicuous in the field. In contrast to the lower part of the flow, it forms large vertical columns and lacks platiness. The top of the flow is irregular and contains a few widely scattered patches of a black porphyritic vitrophyre, containing many colorless feldspar crystals. Occurring also in isolated patches on top of the flow are weathered nodules of agate, chalcedony, chert, and aggregates of quartz crystals.

Tuff T55.-Tuff T55 is approximately 50 feet thick in the central and eastern parts of the area, but thins rapidly to the west and is entirely absent in the extreme western part of the area. It is absent also on inclined Lava T50 surfaces, having been eroded before the arrival of Lava T60. It is a hard, indurated tuff, moderate orange pink (5 YR 8/4) to yellowish gray (5 Y 8/1), and contains very few fragments of recognizable crystals. Color, grain size, and hardness suggest heating as the possible agent of induration. The tuff grades laterally in color, induration, and texture, and is best identified in the field by its stratigraphic position.

Lava T60.-Lava T60 caps the northern front of the Davis Mountains, forming steep, well-rounded peaks. It is approximately 300 feet thick. It is a grayish blue (5 PB 6/2), coarse-grained, extrusive rock, with abundant euhedral colorless feldspar crystals. The phenocrysts are imbedded in an aphanitic groundmass that contains many small patches of altered ferromagnesian minerals. Weathered specimens present a rough surface, somewhat lighter in color than the interior. In places the rock is highly colored by lichens. The rock seems to be composed of obscure, small polygonal areas which are approximately 3 to 4 millimeters in their greatest dimension. These areas are pentagonal or hexagonal, and as the rock weathers around them, foreign matter fills the crevices, accentuating the pattern.

A section, located in the SE 1/4 Sec. 12 and the NE 1/4 Sec. 13, Blk. 61, was measured with a handlevel by the writer on December 17, 1950, and is as follows:

Unit		Thickness Feet
T60	Lava, hard, massive, porphyritic, coarse-grained, grayish blue; phenocrysts of anorthoclase and plagioclase (?); mottled surface; altered riebeckite appears as resinous to dark brown sponges	282
T55	Tuff, hard, dense, fine-grained; upper part moderate orange pink, lower part yellowish gray; few crystal fragments present	34
T50	Lava, hard, massive; upper part light brownish gray, flow breccia of angular fragments of previous flow up to several inches in greatest dimension; forms vertical cliffs; local patches of vitrophyre on top	155
	Below is hard, massive lava, grayish brown; fine-grained, few phenocrysts of anorthoclase; weathers in thin plates approximately 2 to 4 inches thick	184

Unit		Thickness Feet
T45	Tuff, induration varies with locality; greenish gray and grayish orange pink; contains many shards and angular crystal fragments; covered in part by slide rock . .	57
T40	Lava, porphyritic, glassy groundmass; grayish blue green at base, grades upward to reddish brown; sanidine phenocrysts present; 10-foot perlite zone developed at base; above this phenocrysts mainly anorthoclase; baked contact with tuff below; thins westward	40
T35	Tuff, loosely consolidated, yellowish gray; upper 15-20 feet dense, baked; contains many angular fragments of feldspar crystals, lapilli, pumice; covered partly by Toreva-blocks; lower part contains local lentils of freshwater limestone and basalt; forms steep slopes	335
	Total measured thickness	1,087

STRUCTURE

The Tertiary rocks within the mapped area rest unconformably upon Cretaceous strata which have a southerly dip of 2° to 5°. Gentle undulations in the flows which rest on these beds may have been caused by the late Tertiary uplift of the Apache Mountains to the north as reported by Levin (1951). Rock House Canyon and Hurd Draw occupy shallow synclinal depressions in the undulating surface of the lava. The thick basal tuff underlying these flows tends to obscure any preexisting structures in the Cretaceous.

Faults within the mapped area are restricted to the western part. They are small step faults trending north-northwest, the down thrown side being on the west. One small graben was mapped in Sec. 3 and Sec. 10, Blk. 62. The throws of the faults are small, each probably less than 50 feet.

These faults are dated as post-Lava T60, as this flow is involved in the faulting. To the east of the mapped area the writer noticed a large syncline trending northwest-southeast, in which the J. Navarette Ranch is located. Large faults in this area also trending northwest-southeast have throws probably well over 300 feet, and Lava T60 is also involved in the faulting and folding here.

A topographic basin within the central part of the mapped area, which is occupied by the R. L. Nunn Ranch, appears to have been formed on a very irregular surface on top of Lava T50. Several high peaks of Lava T50 seemingly acted as steptoes, diverting the advancing Lava T60. It is the opinion of the writer that this central basin area was never covered by Lava T60 but was surrounded by it. Drainage into this relatively low area from the surrounding high rims excavated the basin to its present level. The only outlet of the basin is through Hurd Draw.

Small igneous intrusions are present as stocks along the front of the mountains in the western part of the area. They occur as bulbous masses, breaking and highly arching the overlying lava flows. Small joint patterns in the arched and broken flows align themselves approximately N 48° W.

PETROGRAPHY

General statement

The volcanic rocks of the area are lava flows and tuff beds. There are local igneous intrusions into these units at several places along the front. The flows are all porphyritic soda rhyolites, bearing phenocrysts of alkali feldspars. These feldspar crystals range from sanidine at the base of the lowermost flow to anorthoclase and plagioclase (?) in the uppermost flow, suggesting some differentiation of the magma as volcanic activity progressed. The tuffs are all similar in composition, the lower two being more coarse-grained than the upper. Indices of refraction of fused powder from these rocks, both lavas and tuffs, indicate that they are all related in composition and were probably derived from the same parent source.

Rhyolitic rocks

Aegirite-rhyolite.-Lava T40 contains numerous colorless euhedral feldspar phenocrysts imbedded in an aphanitic groundmass. The lower part of the flow contains euhedral phenocrysts of sanidine, which are optically negative and biaxial. The optic angle is small ($2V = 0 - 10°$). Some of the phenocrysts appear to be etched, so as to give the crystal a rough checkerboard appearance. Higher magnification shows this checkerboard appearance to be due to radial structures of white and black lines resembling a rectangular network of uniaxial interference figures. S. E. Clabaugh suggested (personal communication, 1951) that these radial structures might be zeolites replacing feldspar.

Above the zone bearing sanidine phenocrysts is a zone in which the phenocrysts are intermediate in optical characters between sanidine and anorthoclase. The crystals show simple Carlsbad twins, extinction parallel to the twinning axis (c-axis), and a negative optic angle with a moderate 2V = 20-25°. This angle lies between that of sanidine (2V = 0-10°) and anorthoclase (2V = 32-54°).

Above this intermediate zone most of the phenocrysts are anorthoclase. Included within some of the crystals are subhedral forms of developing crystals, presumably of anorthoclase or a closely related feldspar, which are composed entirely of masses of tiny crystallites (spiculites and longulites) that meet the outlines of the crystals at various angles. The center of one of the crystals is dark, this being caused by an accumulation of incipient crystals. The enclosing crystal has a higher index of refraction than the area containing the crystallites.

Ferromagnesian minerals are present as accessory constituents in the matrix. For the most part they reveal their presence by alteration to iron oxides. Aegirite, the most abundant of the ferromagnesians (Fig. 7), occurs

Fig. 7--(X 50) Aegirite (A) as phenocrysts in Lava T40.

as microscopic grains and also as phenocrysts. It exhibits strong pleochroism from yellow to dark green, length fast crystals, and a small extinction angle (2 - 5°). Aegirite is present in amounts exceeding 5 percent.

Associated with aegirite, but present in amounts less than 5 percent, is riebeckite. It occurs in small angular fragments that are highly pleochroic from light to dark blue. It does not occur in skeletal sponges as it does in later flows. Black angular magnetite and colorless, angular zircon fragments are present in amounts less than 5 percent.

Near the base of the flow there is well-developed flow structure in the aphanitic groundmass resulting from parallel alignment of incipient crystals (spiculites, margerites, and scopulites). This structure is particularly conspicuous where these incipient crystals form flow lines bending around the phenocrysts. The groundmass is glassy and appears to be isotropic, but it is actually composed of many small spherulites and crystallites which are faintly anisotropic in convergent light and exhibit undulatory extinction.

A zone approximately five feet thick at the base of the flow contains excellent perlitic structure (Fig. 8). The curved fractures are dark brown and are lined with opal. Only the brown portions of the fracture lines are anisotropic. Some of the fractures are in the form of concentric rings resembling layers of onion skin, whereas others are straight, parallel rods which join the crystal outlines at various angles.

Fig. 8--(X 50) Perlitic structure developed at base of Lava T40.

This structure is restricted entirely to the matrix, none of the fractures breaking across the phenocrysts.

Fractures are common within the rock. Lenticular fractures, which tend to parallel the direction of flow, are filled with quartz or feathery chalcedony, and lined with isotropic opal (Fig. 9 and Fig. 10). The fractures are further accentuated with brown stain from the alteration of the ferromagnesian minerals. The crystallites of the groundmass tend to project into the opal lining and even into the edges of the phenocrysts, destroying otherwise definite outlines. Some of the opal is nodular and appears to be crystallizing, developing a granular or crystalline surface, and becoming anisotropic.

Riebeckite-rhyolite and flow breccia.-Lava T50 bears euhedral phenocrysts of anorthoclase included within a glassy to fine-grained groundmass. These phenocrysts are biaxial negative with a moderate optic angle ($2V = 42 - 50°$). Simple Carlsbad twins are prominent, and close examination of the crystals reveals an embryonic grid twinning. Lonsdale (personal communication, 1951) called attention to this, stating that previous study on anorthoclase crystals from this alkalic subprovince revealed faint grid twinning as well as Carlsbad twinning. In Lava T50, the number of phenocrysts is markedly less than in Lava T40.

In Lava T50 riebeckite occurs as a dark brown to black almost opaque mineral in spongy patches (Fig. 11). It is

Fig. 9--(X 50) Fracture in Lava T40 lined with isotropic opal.

Fig. 10--(X 50) Same as Fig. 9; under X-Nicols showing feathery chalcedony filling.

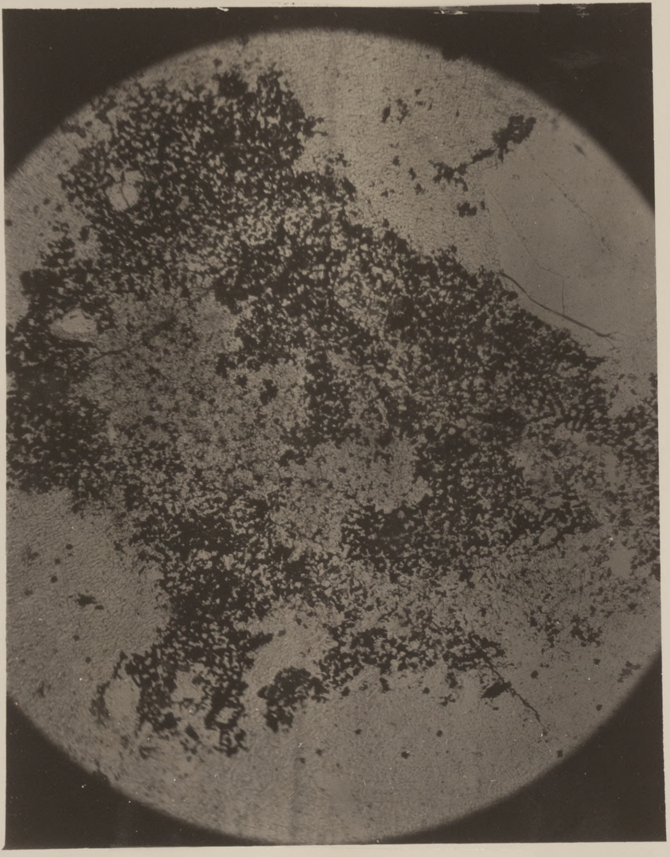

Fig. 11--(X 50) Dark brown to black riebeckite occurring in skeletal patches in groundmass of Lava T50.

present in amounts from 10 to 15 percent. There are no angular fragments as in the lower flow, and thin edges of these spongy patches exhibit faint bluish pleochroism. Leucoxene is also present.

Along with riebeckite is another mineral in spongy patches. It is faintly pleochroic from light yellow green to light green, but it does not occur in large enough crystals to permit identification. Under high magnification these small patches appear to have an undulatory extinction similar to that of fibrous chlorite. This mineral is present in amounts of 10 to 15 percent and merits additional study and description.

The matrix is composed of a microscopic intergrowth of feldspar and quartz, producing patches which have the same orientation and which extinguish at the same time. This patchy extinction, which is an expression of micrographic or granophyric texture (Johannsen, 1939, pp. 42-43), is also observed in Lava T60. The quartz in Lava T50 is in anhedral crystals and grains, and it appears also in stringers throughout the rock and is easily identified as a clear mineral imbedded in a slightly pinkish feldspar. It may also be identified by its flash extinction.

There are a few fractures in the matrix but they are not as common as in the aegirite rhyolite. Flow structure is absent.

Above the riebeckite rhyolite is a thick zone of flow breccia containing many angular inclusions of the lower part of Lava T50 (Fig. 12). Parts of these inclusions exhibit well-developed flow structure and original phenocrysts. The inclusions are imbedded in a matrix that shows no flow structure, and the appearance is therefore distinctive.

A black porphyritic vitrophyre occurs in local patches on top of the flow breccia. The phenocrysts are anorthoclase imbedded in a glassy groundmass. Flow structure (Fig. 13) is prominent, formed by the alignment of incipient crystals. This rock is restricted to the top of the flow breccia.

Riebeckite-rhyolite.-Lava T60 is composed of colorless euhedral phenocrysts of feldspar imbedded in a fine-grained groundmass, more coarsely crystalline than those of the two previous flows. The matrix is composed of laths of feldspar in which are imbedded phenocrysts of anorthoclase and plagioclase (?). These laths of feldspar are intergrown with quartz, as in the middle flow, so as to produce similar patches of identical orientation, which also show patchy extinction (Fig. 14 and Fig. 15).

Riebeckite (10 to 15 percent) occurs in spongy skeletal patches and is altered to dark brown or black material. Unaltered edges are slightly pleochroic. A few zircon crystals also are present, and leucoxene occurs in patches around the riebeckite.

Fig. 12--(X 50) Flow breccia showing inclusions of earlier flow with flow lines and phenocrysts preserved.

Fig. 13--(X 50) Vitrophyre on top of Lava T50 showing anorthoclase phenocryst and flow structure.

Fig. 14--(X 50) Shows fine-grained groundmass; dark patches of riebeckite; gray phenocryst of anorthoclase.

Fig. 15--(X 50) Same as Fig. 14, except under X-Nicols. Granophyric intergrowth of quartz and feldspar produces patchy extinction. Common in both Lava T50 and Lava T60.

In the upper parts of the flow the anorthoclase phenocrysts tend to be zoned, and the outer portions are more sodic than the inner. The elliptical central core of one zoned crystal (Fig. 16 and Fig. 17) has a moderate optic angle (2V = 30-35°) and is biaxial negative. Surrounding it is a zone that is biaxial positive and has a large optic angle (2V = 60-70°). The outer zone has a slightly higher index of refraction than that of the central core.

Tuff T35.-The basal tuff, T35, in this volcanic series may be considered as a mixed lithic, vitric, and crystal tuff. It contains fragments of glass shards and angular fragments of feldspar crystals. Lapilli and pumiceous particles (Fig. 18) are also included within the tuff. The constituents of the tuff range in size from microscopic particles to fragments 2 to 3 inches in their greatest dimension. Most of the crystals are small and are poorly preserved, so that no accurate optical determinations can be made. Indices of refraction indicate that the tuff is essentially rhyolitic and is related to the lavas mineralogically.

Tuff T45.-Tuff T45 is a volcanic unit that varies laterally and vertically throughout the area. In the central part of the area it is essentially a vitric tuff, composed almost entirely of angular glass shards, some as large as 0.95 mm in their greatest dimension (Fig. 19). At other places in the area it is largely a crystal tuff (Fig. 20); and at still other places, a lithic tuff (Fig. 21). It varies in induration, some of the rock being cemented by silica.

Fig. 16--(X 50) Shows zoned feldspar phenocryst with elliptical core; inner core, biaxial negative; outer part, biaxial positive; black material is riebeckite.

Fig. 17--(X 50) Same as Fig. 16, except under X-Nicols.

Fig. 18--(X 50) Pumice and crystal fragments in Tuff T35. Dark circles are air bubbles in slide.

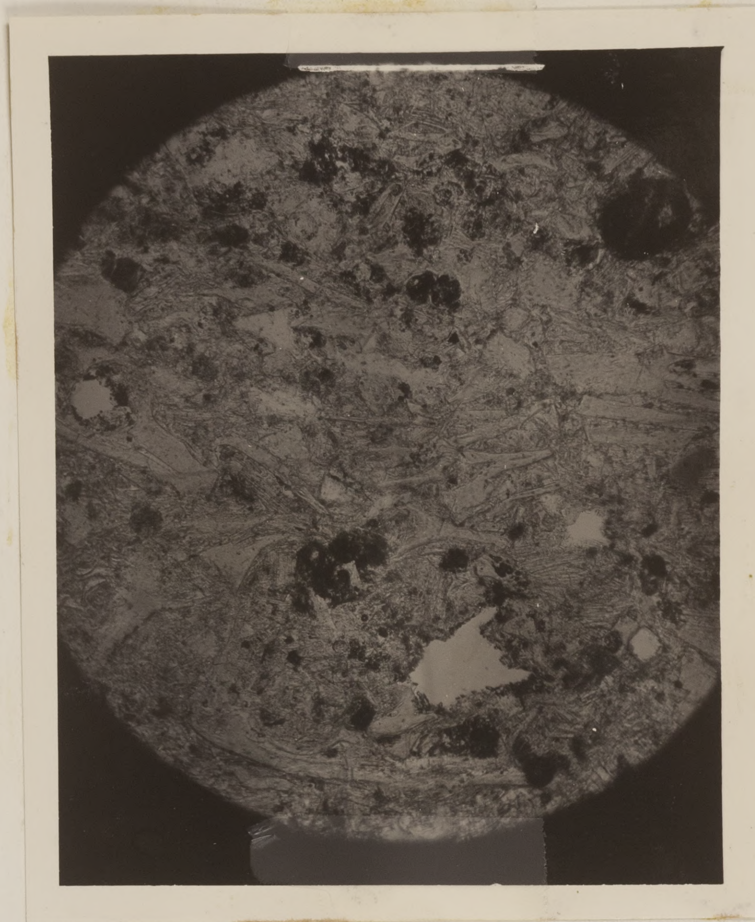

Fig. 19--(X 50) Glass shards in Tuff T45.

Fig. 20--(X 50) Crystal fragments in Tuff T45.

Fig. 21--(X 50) Crystal fragments and fragments of preexisting rock showing phenocrysts and flow structure in Tuff T45.

Tuff T55.-The uppermost tuff, T55, composed of finely divided ash, consolidated into hard rock, is considered to be a crystal tuff. The particles are largely microscopic and are so highly weathered or altered that no microscopic identifications can be made. A few crystal fragments (Fig. 22) occur throughout the tuff, but not as abundantly as in tuffs T35 and T45.

Trachytic rocks

The intrusions along the western margin of the area are trachytes. They are composed of anorthoclase phenocrysts, some of which are zoned and highly altered, imbedded in a groundmass of small laths of feldspar, probably anorthoclase. The inner core of one of the feldspar phenocrysts (Fig. 23) has a higher index of refraction than the outer zone; both zones are biaxial negative, and the optical angle of each zone is moderate (2V = 35-40°). There is a lack of skeletal riebeckite, but dark resinous patches suggest the alteration of ferromagnesian minerals, perhaps riebeckite or even arfvedsonite. Fragments of magnetite, apatite, and leucoxene occur in the groundmass. Quartz is present only as cavity fillings.

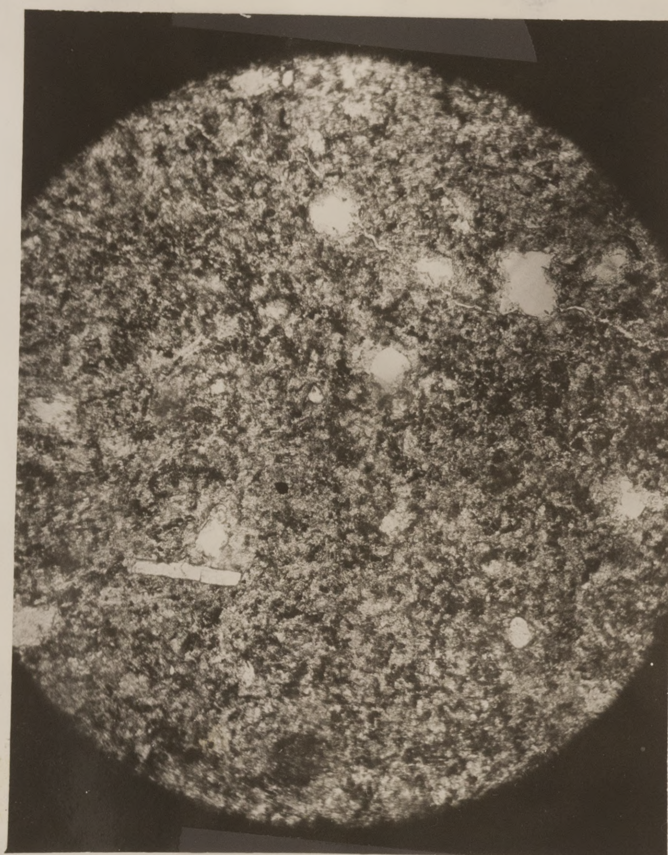

Fig. 22--(X 50) Finely divided ash and crystal fragments in Tuff T55.

Fig. 23--(X 50) Armored feldspar crystal imbedded in groundmass of feldspar laths. Trachytic intrusion. X-Nicols.

DETERMINATION OF THE SiO_2 CONTENT

The rocks described in this paper are very fine-grained and glassy volcanic rocks, in which detailed microscopic identification of the minerals and determination of the chemical composition is almost impossible. It is therefore difficult to estimate the percentage of SiO_2 in the rocks and to establish their classification. At the suggestion of S. E. Clabaugh, the writer studied a paper by W. H. Mathews (1951, pp. 92-101) which described a method for the determination of the approximate composition of fine-grained igneous rocks by thermally converting a powdered sample of a rock to a glass and measuring its refractive index.

Rocks rich in silica have low indices of refraction in contrast to rocks deficient in silica which have relatively higher indices of refraction. Michael Stark (1904) and W. O. George (1924) used this principle in their work with artificial glasses and found in addition that all the constituents of a rock contribute to the index of refraction of its glass in the order of their abundance and according to their specific properties. Effects of alumina, ferric and ferrous oxides, and titanium oxide upon the index of refraction are shown by the graph in Fig. 24. Harker (1909, pp. 118-125) used variation diagrams to show that within groups of igneous rocks of one locality and age,

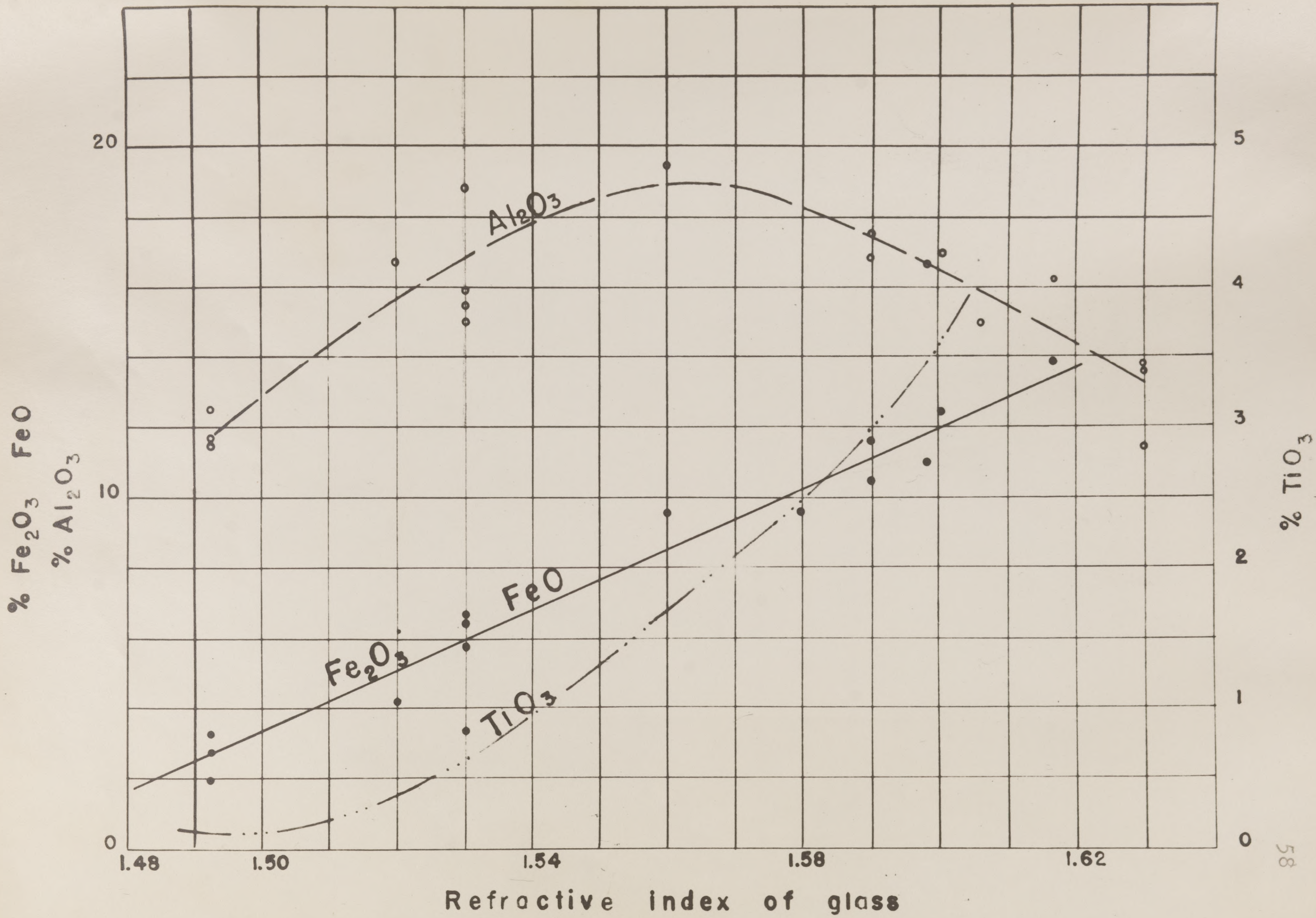

Fig. 24. Variation of refractive index with iron, aluminum, and titanium oxides.

"two rocks with similar contents have similar bulk compositions and, if glassy, can be expected to have similar refractive indices" (Mathews, p. 92).

On this basis Mathews and others proposed that a standard curve could be drawn for rocks of a petrographic province, plotting the index of refraction against the SiO_2 content. This curve could then be used for approximate SiO_2 determinations of rocks from the same or similar provinces for which no chemical analyses were available, but on which index of refraction information could be obtained. With the indices of refraction thus determined, the curve would serve to determine the approximate SiO_2 percentage.

It was found that this theory could be applied to artificially melted rock as well as to natural glasses. In order to obtain artificial glasses from fine-grained igneous rocks they must be fused without appreciable change of composition. Artificial melting of rocks very often changes the composition significantly by driving off the volatile constituents and changing the state of oxidation of the iron. Tilley (1922) showed that a loss of water vapor could change appreciably the index of refraction. It is at once obvious that a source of instant intense heat, such as that produced by a carbon arc, is required so that these volatile constituents will not be lost.

The equipment used by the writer in producing these artificial glasses consists of an ordinary carbon arc projection lantern, employing two carbon sticks, each about 7 mm in diameter. One of the sticks is vertical; the other, horizontal. A shallow crater was hollowed into the upper end of the vertical stick for the purpose of holding the powdered material to be fused. The carbon sticks were then brought together so that the pointed end of the horizontal stick was at the level of the base of the crater in the vertical stick. The carbon arc thus produced instantly fused the powdered rock into a glowing glass bead. The inert carbon did not react with the material being fused. The glass bead was then crushed into small fragments, and the index of refraction determined by immersion methods.

As chemical analyses were not available for the Davis Mountain rocks, this technique was used to determine their SiO_2 percentages. A standard curve was drawn for rocks from the nearby related alkalic province in the Big Bend, for which chemical analyses are available (Lonsdale, 1949, pp. 21-24). Lonsdale kindly furnished samples of these rocks for the tests.

Indices of refraction of the Davis Mountain rocks were then determined and referred to the standard curve (Fig. 25). They were found to represent rocks containing an approximate SiO_2 content ranging between 66.0 and 75.5%, with corresponding indices of refraction ranging from 1.5098 to 1.4853. This content was high enough that the rocks are considered to be rhyolites. In one rock there is a marked decrease in

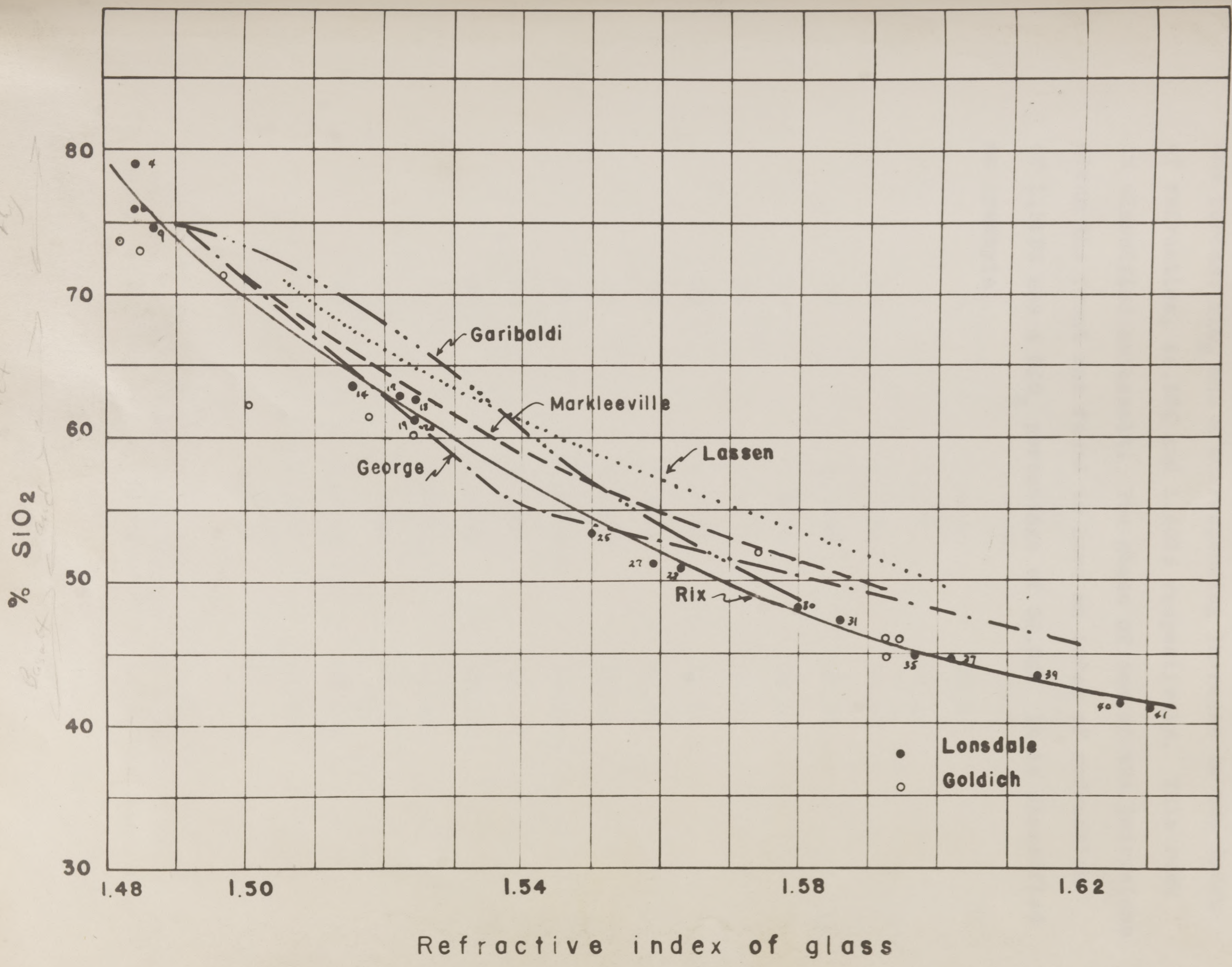

Fig. 25. Four composition-refractive index curves superimposed with curve of rocks from the Terlingua-Solitario district.

the percent SiO_2 and a corresponding increase in the index of refraction, 44.35% and 1.6026 respectively. This rock is classified as basalt. The glass of one of the intrusions along the front was found to have an index of refraction of 1.5135 and a SiO_2 percentage of 64.5%. It is classified as trachyte.

Table II

A. Specimens from the Terlingua-Solitario district.

Number*	Index	% SiO_2
4	1.4842	75.90
6	1.4842	75.39
9	1.4871	74.64
14	1.5156	63.63
17	1.5222	62.84
18	1.5222	62.80
19	1.5243	62.76
20	1.5243	61.28
25	1.5501	53.34
27	1.5590	51.31
28	1.5629	50.96
30	1.5807	46.10
31	1.5860	47.45
35	1.5971	44.99
37	1.6021	44.73
39	1.6144	43.26
40	1.6267	41.55
41	1.6303	41.29

*Numbers refer to specimens listed in tabulated chemical analyses found in West Texas Geological Society Guidebook, Field Trip No. 1, November 6-9, 1949, pp. 21-26.

Table II (cont'd).

B. Specimens from the northern Davis Mountains.

Number*	Index	% SiO_2
35 white	1.4958	71.10
35 yellow	1.4958	71.10
40.1	1.4958	71.10
40.3a	1.4958	71.10
40.3b	1.5140	64.50
45 pink	1.4853	75.50
45 orange	1.4958	71.10
45 green	1.5053	67.50
50.1	1.4958	71.10
50.3	1.4958	71.10
50.4	1.4958	71.10
50 (top)	1.4958	71.10
55 pink	1.4958	71.10
55 white	1.4958	71.10
60.2	1.5098	66.00
60.3	1.4958	71.10
Basalt	1.6026	44.35
Trachyte	1.5135	64.50

*Numbers and color designations refer to labeled specimens from which thin sections were made and for which descriptions appear in this thesis.

Table II (cont'd).

C. Specimens from Hogeye and Michigan Draw quadrangles.

Number*	Index	% SiO_2
E 20 (basalt)	1.6134	42.80
E 20 (trachyte)	1.5738	49.00
E 30 (brown)	1.5140	64.50
E 30	1.5140	64.50
E 40	1.4958	71.10
E 50A	1.4958	71.10
E 50B	1.5098	66.00
E Sil. Tuff?	1.5140	64.50
E Cat Mtn. syen.	1.5235	61.75
E Cat Mtn. gl.	1.4958	71.10

*Numbers and color designations refer to labeled specimens from which thin sections were made and for which descriptions appear in a Master's thesis by E. A. Humble (1951).

Table II (cont'd).

D. Specimens from the Buck Hill quadrangle.

Number*	Index	% SiO_2
R 1646	1.4815	73.85
R 1645	1.4853	73.10
# 868	1.4973	71.17
R 1647	1.5067	62.35
# 812	1.5179	61.46
R 1639	1.5243	60.10
R 1638	1.5736	52.06
R 1648	1.5923	45.98
R 1641	1.5943	45.86
# 841	1.5923	44.33

*S. S. Goldich kindly supplied the writer with powdered samples of analyzed igneous rocks from the Buck Hill quadrangle (#), described by Goldich and Elms (1949), and from the Tascotal Mesa quadrangle (R), described by R. L. Erickson, the results of which have not yet been published.

PETROLOGY

The extensive rocks composing the northern front of the Davis Mountains are soda rhyolite lavas and tuffs. The lowermost of these units, Tuff T35, contains freshwater limestone and basalt lentils at its base. Barnhill (1950) stated that the continental molluscan fauna found silicified within this limestone is approximately Oligocene in age. The volcanic activity in this area, therefore, may be dated as Oligocene or younger.

These soda rhyolites contain phenocrysts of anorthoclase feldspar and such accessory minerals as aegirite and riebeckite. That these rocks are genetically related to each other is proved by the very small range of the indices of refraction of glasses of all the tuffs and lavas within the area. Referring to Table II, Part B, it will be seen that with the exception of three specimens examined, whose indices deviate from the average by no more than 0.018, all specimens have approximately the same index of refraction. This uniformity in the SiO_2 content, in addition to the related mineral content of the rocks, indicates to the writer that they were derived from the same parent source.

Correlation of these rocks with those of the Barrilla Mountains, described by Eifler (1951), seems probable. The lower part of the McCutcheon group, the Huelster formation,

> [is] almost entirely tuff, contains thin layers of sandstone and conglomerate, lenses of freshwater limestone, and of trachy-doleritic lava. At the type locality it is approximately 400 feet thick, but it thins eastward. (p. 343)

The similarity between the Huelster formation in the Barrilla Mountains and Tuff T35 in the northern Davis Mountains described above suggests that the two tuff units may be equivalents.

Correlation of the lavas of the two areas is somewhat more difficult. Both of Eifler's formations, the Star Mountain rhyolite and the Seven Springs formation, could possibly be equivalents of the lavas found in the northern Davis Mountains. The Star Mountain rhyolite is composed of riebeckite soda rhyolite porphyry, in which the chief feldspar is anorthoclase. Quartz occurs as an intergrowth with feldspar and produces a micrographic texture. Sponges of riebeckite have altered to an opaque black mineral and hematite. The Seven Springs formation, composed of four lava members, is also similar to lavas found in the northern Davis Mountains. Anorthoclase and riebeckite occur much as they do in the Star Mountain rhyolite. Eifler mentions the presence of microlites of aegirite in lava members No. 3 and No. 4 of the Seven Springs formation. This occurrence is similar to that of aegirite at the base of lava T40. He also mentions a black vitrophyre at the base of lava No. 1 member of the Seven Springs formation. A black vitrophyre occurs on top of lava T50. Granophyric textures are also present in the lavas of the Seven Springs formation, which compare favorably to those in lavas T50 and T60. In addition, intrusives in both the Barrilla Mountains and the northern Davis Mountains are soda trachytes.

While definite correlation cannot be established between these two areas at present, the lavas of the northern Davis Mountains seem to correlate better with the lava members of the Seven Springs formation than with those of the Star Mountain rhyolite.

As no large vents were found in the northern Davis Mountains, it is thought that extrusion was probably through fissures which have subsequently been covered by the lavas. Eifler suggests this as a possible origin for lavas in the Barrilla Mountains. He adds that extrusion of all volcanic units probably occurred within a short time, as there is no evidence of channeling in the tuffs or lavas. This seems to be true of the period of extrusion in the northern Davis Mountains also. Not only is there an absence of channeling, but the extreme similarity of compositions of all the tuffs and lavas as indicated by indices of refraction suggests that these materials were extruded while the source remained essentially the same in composition.

As mentioned previously, the northern Davis Mountains are related to the Big Bend "as another of the alkaline subprovinces at the front of the Rocky Mountains thus extended still farther southward" (Lonsdale, 1940, p. 1619). Lonsdale described volcanic rocks in the Big Bend that are similar to those in the northern Davis Mountains. He stated that the soda rhyolites are "aphanitic with feldspar phenocrysts and the presence of the greenish mafic minerals imparts a grayish-green color to the rocks." He went further to add that anorthoclase is more common in the soda rhyolites than in the non-sodic rhyolites, but that the soda pyroxenes and amphiboles give the rocks a distinctive composition. He reported that rocks from the Agua Fria and Adobe Walls Mountain regions possess a granophyric texture (intergrowth of quartz and feldspar, as in lava T50 and lava T60) and include riebeckite occurring "as spongelike crystals with poikilitic relations to quartz and feldspar." Aegirite is also reported in abundance in marginal facies in the Agua Fria and Adobe Walls Mountain areas. Similar rocks are reported by Goldich and Elms in the Buck Hill region although they do mention some rocks not found farther south in the Big Bend.

Lonsdale suggested that the igneous rocks found in the Terlingua-Solitario region were probably derived from a regional batholith and that the variations in the rocks in the area are probably due to the separation of the parent magma into smaller laccolithic chambers on top of the batholith. He suggested that "a slight difference in composition of the magma in the laccoliths and other bodies above the roof of the batholith would account for the various analcite-bearing rocks." Even though the rocks of one area may differ from those of another, he nevertheless believed that their kinship is revealed through the presence of special minerals such as anorthoclase.

As to the composition of this parent magma, Lonsdale suggested that "in a period early in the emplacement of a regional batholith of intermediate composition, differentiation produced varieties ranging through syenodiorite, soda trachyte, soda rhyolite, to rhyolite," and postulated that the differentiation of this magma was probably controlled by tectonic movements associated with the sinking of the large graben now occupied by the lava fields.

In the light of the foregoing arguments, the igneous rocks from each of the igneous rock-bearing localities in Trans-Pecos Texas are related to each other, the consanguinity always being shown by the presence of anorthoclase and other soda-rich minerals. This consanguinity suggests, therefore, that these rocks were probably derived from a parent magma. However, whether there was one large batholith underlying all of Trans-Pecos Texas as in California or British Columbia, or whether there were several batholiths of similar composition underlying Trans-Pecos Texas and contributing to these various areas is not known. Lonsdale postulated a regional batholith for the Big Bend area with smaller laccolithic differentiating chambers to account for the various igneous rocks found in the area, but no definite evidence is available.

It may very well be that when more work is done on the volcanic rocks in this area, especially on Gomez Peak, which appears to be a volcanic neck between the mapped area and the Barrilla Mountains, more definite information concerning the source and mechanics of extrusion of these volcanic units will be forthcoming.

REFERENCES

ALBRITTON, C. C., Jr. and BRYAN, KIRK (1939) Quaternary stratigraphy in the Davis Mountains, Trans-Pecos Texas: Bull. Geol. Soc. Amer., vol. 50, pp. 1423-1474.

BAKER, C. L. (1927) Exploratory geology of a part of Southwestern Trans-Pecos Texas: Univ. Texas Bull. 2745.

____________, and BOWMAN, W. F. (1917) Geologic exploration of the Southeastern Front Range of Trans-Pecos Texas: Univ. Texas Bull. 1753.

BARNHILL, W. B. (1950) Jeff conglomerate, Northern Davis Mountains, Texas: Univ. Texas thesis.

BOWEN, W. B. (1928) The Evolution of the Igneous Rocks: Princeton University Press, Princeton.

BROWN, J. R. (1948) The geology of the Kent area, Culberson and Jeff Davis counties, Texas: Univ. Texas thesis.

DUMBLE, E. T. (1891) Texas Geol. Survey, 3rd Ann. Rept., pp. xxix-xxxi.

EIFLER, G. K., Jr. (1943) Geology of the Santiago Peak quadrangle, Texas: Bull. Geol. Soc. Amer., vol. 54, no. 10, pp. 1613-1644 (1941).

__________________ (1951) Geology of the Barrilla Mountains, Texas: Bull. Geol. Soc. Amer., vol. 62, no. 4, pp. 339-354 (~~1949~~).

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GEORGE, C. E. (1948) The geology of the Boracho area, Culberson and Jeff Davis counties, Texas: Univ. Texas thesis.

GEORGE, W. O. (1924) The relation of the physical properties of natural glasses to their chemical composition: Jour. Geol., vol. 32, pp. 353-372.

GODDARD, E. N., TRASK, P. D., DeFORD, R. K., ROVE, O. N., SINGEWALD, J. T., Jr., and OVERBECK, R. M. (1948) Rock-color chart: National Research Council, Washington, D. C.

GOLDICH, S. S., and ELMS, M. A. (1949) Stratigraphy and petrology of Buck Hill Quadrangle, Texas: Bull. Geol. Soc. Amer., vol. 60, no. 7, pp. 1133-1182 (1947).

HARKER, A. (1909) The natural history of igneous rocks: The Macmillan Co., New York.

HAYS, N. A. (1948) Geology of Hurds Draw, Culberson and Jeff Davis counties, Texas: Univ. Texas thesis.

HUMBLE, E. A. (1951) Cenozoic history of northeastern Chispa Quadrangle, Trans-Pecos Texas: Univ. Texas thesis.

JOHANNSEN, A. (1931) A descriptive petrography of the igneous rocks, vol. 1: The University of Chicago Press, Chicago, Ill.

KING, P. B. (1935) Outline of structural development of Trans-Pecos Texas: Bull. Amer. Assoc. Petr. Geol., vol. 19, no. 2, pp. 221-261 (1934)

LEVIN, MAX (1951) Geologic structure of part of Hurd Draw Quadrangle, Culberson County, Texas: Univ. Texas thesis.

LONSDALE, J. T. (1928) Analcite from Brewster County, Texas: Amer. Mineral., vol. 13, no. 8, pp. 449-450.

_______________ (1940) Igneous rocks of the Terlingua-Solitario region, Texas: Bull. Geol. Soc. Amer., vol. 51, no. 10, pp. 1539-1626 (1939)

_______________, MAXWELL, R. A., and DICKSON, K. O. (1949) The Big Bend region, Road Log of West Texas Geological Society Field Trip, November 6-9, 1949, pp. 21-26.

_______________, and ADKINS, W. S. (1927) Euhedral orthoclase crystals from Sierra Blanca, Texas: Amer. Mineral., vol. 12, no. 6, pp. 256-259.

McCRACKEN, W. W., Jr. (1948) Geology of Hurds Draw area near Kent, Culberson and Jeff Davis counties, Texas: Univ. Texas thesis.

MATHEWS, W. H. (1951) A useful method for determining approximate composition of fine grained igneous rocks: Amer. Mineral., vol. 36, nos. 1 & 2, pp. 92-101 (1950).

OSANN, A. (1892) report of the rocks of Trans-Pecos Texas: Texas Geol. Survey, 4th Ann. Rept., pp. 123-138.

REICHE, P. (1937) The Toreva-block - a distinctive landslide type: Jour. Geol., vol. XLV, no. 5, pp. 538-548.

ROGERS, A. F., and KERR, P. F. (1942) Optical Mineralogy, 2d ed.: McGraw-Hill Book Co., Inc., New York.

SCHOLL, M. R., Jr. (1948) The geology of the Boracho Quadrangle, Culberson and Jeff Davis counties, Texas: Univ. Texas thesis.

SELLARDS, E. H., ADKINS, W. S., and PLUMMER, F. B. (1932): The geology of Texas, vol. 1: Univ. Texas Bull. 3232.

STARK, M. (1904) Zusammenhand des Brechungsexponenten nätürlicher Gläser mit ihrem Chemismus: Tsch. min. i. petr. Mitt., Neue Folge, 23, pp. 536-552.

STREERUWITZ, W. H. von (1890) Geology of Trans-Pecos Texas: Texas Geol. Survey, 1st Ann. Rept., pp. 217-235.

TERZAGHI, KARL (1950) Mechanism of landslides: Geol. Soc. Amer., Application of geology to Engineering practice, Berkey Volume, pp. 84-123.

TILLEY, C. E. (1922) Density, refractivity, and composition relations of some natural glasses: Min. Mag., vol. 19, pp. 275-294.

TREWARTHA, G. T. (1937) An introduction to weather and climate: McGraw-Hill Book Co., Inc., New York, pp. 244-246.

TYRRELL, G. W. (1948) The principles of petrology, 9th ed.: Methuen and Co., Ltd., 36 Essex St. W.C., London.

UDDEN, J. A. (1907) A sketch of the geology of the Chisos country, Brewster County, Texas: Univ. Texas Bull. 93 (Sci. ser., Bull. 11).

WAHLSTROM, E. E. (1948) Igneous minerals and rocks: John Wiley and Sons, Inc., New York.

_______________ (1950) Introduction to Theoretical Igneous Petrology: John Wiley and Sons, Inc., New York.

WILLIAMS, H. F. (1948) Geology of the Kent area, Culberson County, Texas: Univ. Texas thesis.

ZIMMERMAN, J. B. (1950) Jeff conglomerate, northeastern Davis Mountains, Texas: Univ. Texas thesis.

Windmills and Water wells

No.	Name	Depth(ft)	Sec.	Blk.	T
1	Duncan	30	16	60	9
2	New Well	30	15	60	9
3	New Well Reservoir		10	60	9
4	Holding Pasture Reservoir		2	60	9
5	Ash Spring Reservoir		13	60	9
6	Gilson	1946	24	60	9
7	Horse Pasture	115	19	59	9
8	Lower Rock House	600	30	59	9
9	Campbell	100	36	60	9
10	Canyon	620	32	59	9
18	Marshall	400	38	60	9
19	Redford Horse Pasture	400	39	60	9

Tanks, earthen

No.	Name	Sec.	Blk.	T
1	Duncan	9	60	9
2	Medley	14	60	9
3	Headquarters Lake	24	60	9
4	Lower Rock House	31	59	9
14	Eagle	41	60	9
23	Three Mile	38	61	9
24	Levy	39	61	9
26	Stripling	40	61	9