A PETROGRAPHIC AND PETROLOGIC ANALYSIS OF A CAMBRIAN AND DEVONIAN SECTION AT MINGUS MOUNTAIN ARIZONA

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A PETROGRAPHIC AND PETROLOGIC ANALYSIS OF A CAMBRIAN AND DEVONIAN SECTION AT MINGUS MOUNTAIN ARIZONA

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INTRODUCTION

Purpose and Scope of Study

The Devonian and underlying Cambrian(?) sections at Mingus Mountain in central Arizona represent 440 to 550 feet of sediments between the Precambrian rocks and the Mississippian Redwall limestone.

The Devonian section has been ascribed to the Martin limestone by most authors; however, the Jerome formation has also been proposed by A. A. Stoyanow (1936) for a section believed not to be a correlative of the Martin formation. Further, the entire sedimentary sequence beneath the Redwall limestone has been classified as the Martin formation by H. McNair (1951). The basal member of 0 to 100 feet of sandstones and fine clastics has generally been referred to as the Tapeats sandstone, thereby inferring the Cambrian to be represented here.

The writer has communicated orally with Dr. Curt Teichert who has made detailed studies, including paleontological work, on the western side of Mingus Mountain and other Devonian sections of central and northwestern Arizona. The author has measured and described two detailed sections on the eastern slopes of Mingus Mountain to tie in with

Dr. Teichert's sections. Dr. Teichert has expressed interest in this work.

The scope of this investigation is to (1) do sedimentary petrographic and petrologic analyses with considerations concerning sedimentary and environmental implications, (2) to compare the details of the Tapeats with the Martin formation to determine if different source areas are involved, (3) to compare the stratigraphy of these sections with other available sections in the general region giving attention to fossiliferous zones existing within the sections, and (4) to study the implications of special lithologic types such as aphanitic dolomites and bedded nodular chert.

With the completion of this work, it is hoped that some contribution can be made to the knowledge of the stratigraphy of the Devonian and Cambrian of this region regarding source, origin, paleo-environments, and correlation.

History of Work in General Area

The first geologic study of the Jerome area began in 1875 when the Wheeler Survey recognized the Paleozoic beds unconformably overlying the Precambrian rocks.

Pioneer work in the central Arizona region was done by T. A. Jaggar and C. Palache (1905) as recorded in the U.S. Geological Survey Geological Atlas, Bradshaw Mountains quadrangle, Folio 126.

Most of the previous articles since the beginning of the century have been written about the local geology of the copper, iron, silver, and gold ore deposits centering around the Jerome area.

Early stratigraphic studies were carried out by F. L. Ransome (1916). He measured ten Paleozoic sections of Arizona including a generalized stratigraphic section near Jerome. A 500 foot section was assigned to the Martin limestone of Upper Devonian age on the basis of faunal studies.

This assignment was questioned by A. A. Stoyanow (1936) who made a regional correlation study of the Paleozoic rocks of Arizona from several measured sections northwestward across the state including a 505 foot detailed section near Jerome. He proposed that the local Devonian strata be called the Jerome formation.

J. W. Huddle and E. Dobrovolny (1945, 1952) did regional stratigraphic studies from 19 measured sections of southeastern Arizona. Well samples and cores from the northeastern

region were also examined. This work was complemented by H. McNair (1951) who measured 11 sections from Jerome northwestward across Arizona. He considers the basal sandstone of this area as part of the Martin limestone rather than Tapeats of Cambrian age.

A geochemical analysis of the basal sandstone in the Jerome area was made by L. C. Huff (1955).

The general geology of the Jerome area was discussed by C. A. Anderson and S. C. Creasey (1958) in the U. S. Geological Survey Prof. Paper 308 which also contains a large scale geologic map.

E. Lehner (1958) briefly described the Paleozoic rocks in the Jerome area from four sections north of Mingus Mountain.

Regional studies of the Devonian sediments in Arizona have produced differing paleogeographic conclusions by C. Schuchert (1910), W. A. Ver Wiebe (1932), A. A. Stoyanow (1942), E. D. McKee (1951), J. W. Huddle and E. Dobrovolny (1952), and D. V. LeMone (1957).

A detailed regional study of the Devonian rocks of central Arizona is now being prepared by C. Teichert.

Location of Area

The two sections for this thesis were measured along southeast and northeast facing slopes on the east side of Mingus Mountain, southwest of Jerome, in T15N, R2E in the Mingus Mountain quadrangle of eastern Yavapai County, central Arizona (figure 1, Index map of area). Sections 1 and 2 are located along coordinates N. 1,348,500; E. 445,000, and N. 1,347,400; E. 445,000, respectively. The elevation of the areas is between 6,000 and 6,500 feet above sea level.

The most accessible route is an eight mile dirt road leading up the slope southwestward from Cottonwood. Jeep travel to the site is recommended.

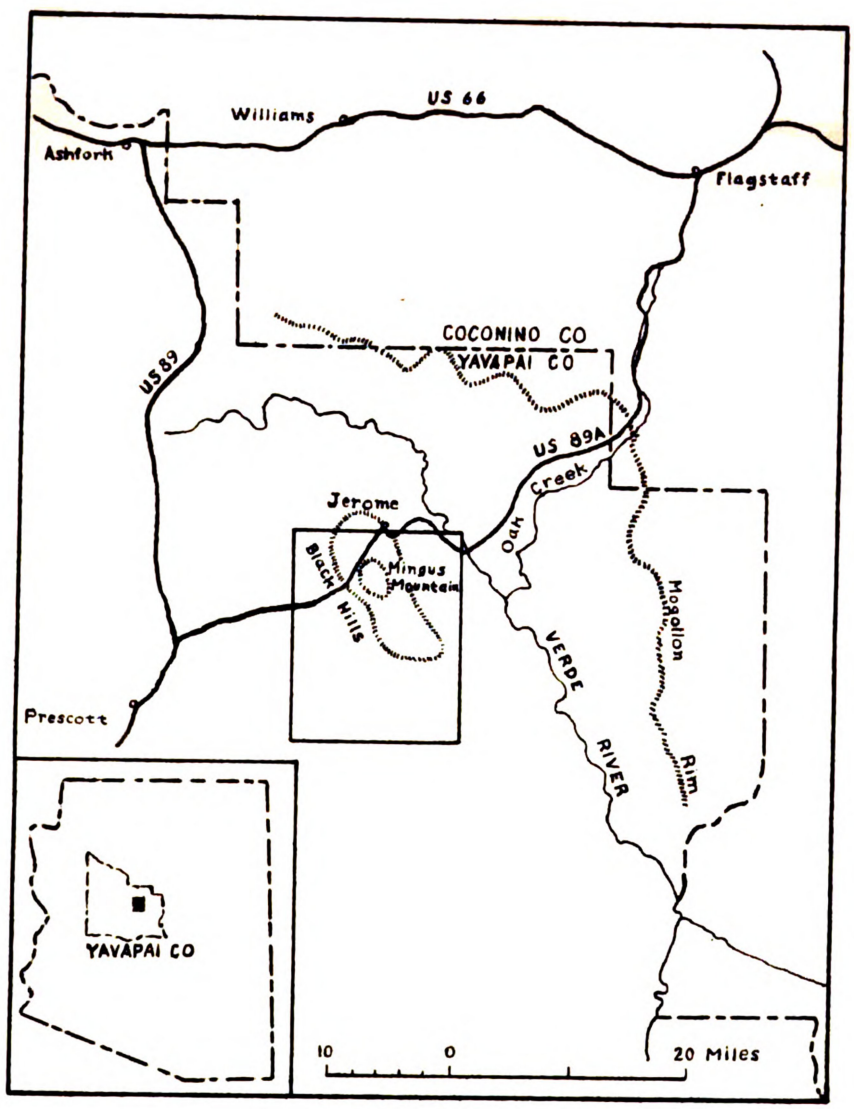

Figure 1. Index map of area.

GENERAL STRATIGRAPHY

The stratigraphic column (figure 2) represents a composite section in the Jerome area which includes the Mingus Mountain quadrangle. Refer also to correlation chart (figure 3).

A prominent unconformity separates the Early Precambrian rocks from the Paleozoic sediments.

It has been generally concluded that the Precambrian Yavapai series is equivalent to the Vishnu schist of the Grand Canyon region. The Yavapai series exhibits intense deformation of beds of sedimentary origin. The folded strata were intruded by igneous rocks including a granitoid batholith.

A long period of erosion followed the orogeny at the close of the Early Precambrian sedimentation. Younger Precambrian beds corresponding to the Grand Canyon series are missing in the Jerome area.

However, southeast of this area near Globe, the younger Precambrian Apache group unconformably overlies the older Pinal schist. The Paleozoic rocks lie disconformably over the Apache group.

The Paleozoic deposits of the Jerome area comprise a total thickness of about 1200 feet. An erosional break is

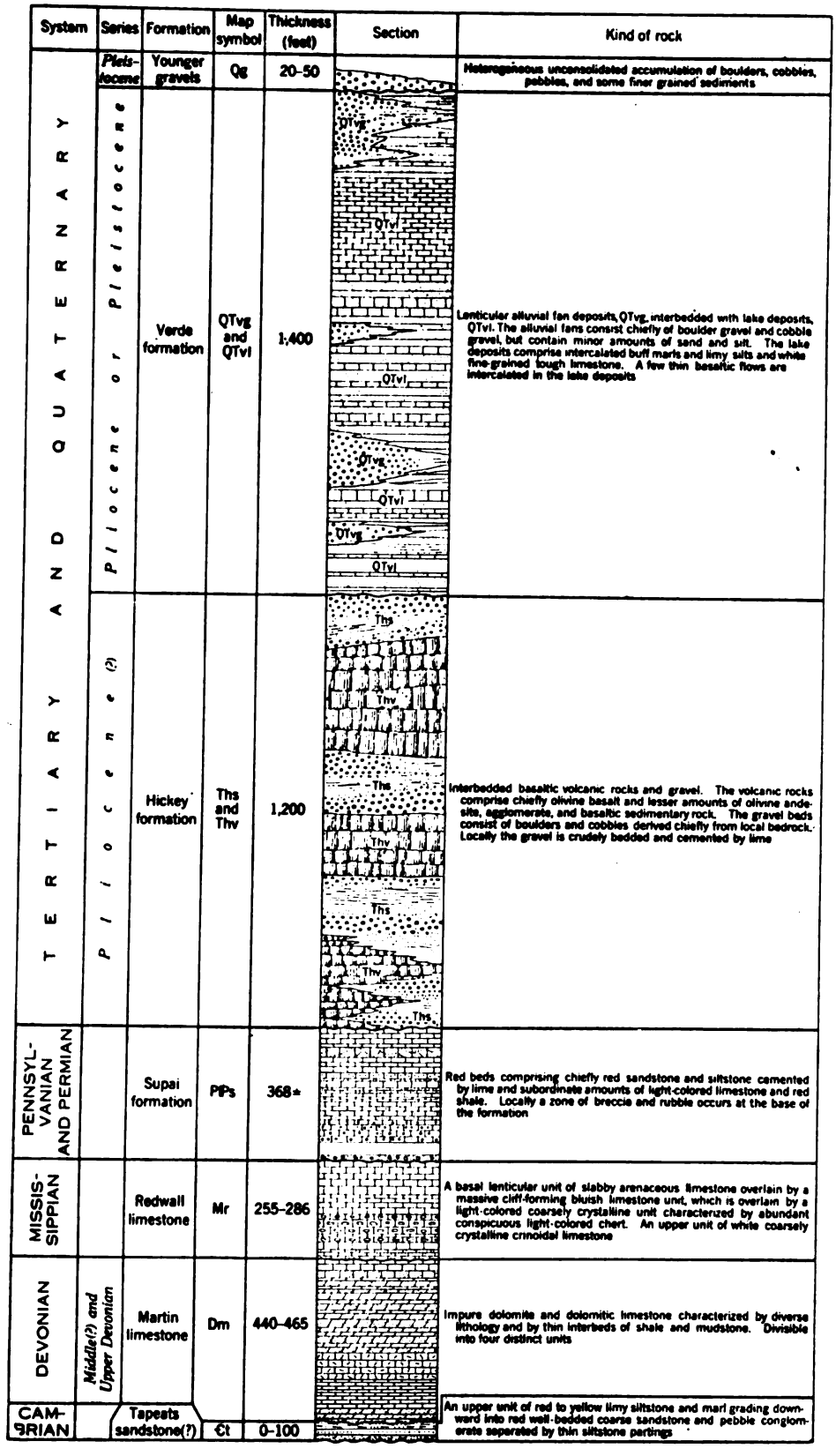

Figure 2. Stratigraphic column of Paleozoic, Tertiary, and Quaternary rocks in the Jerome area. After C. A. Anderson and S. C. Creasey (1958).

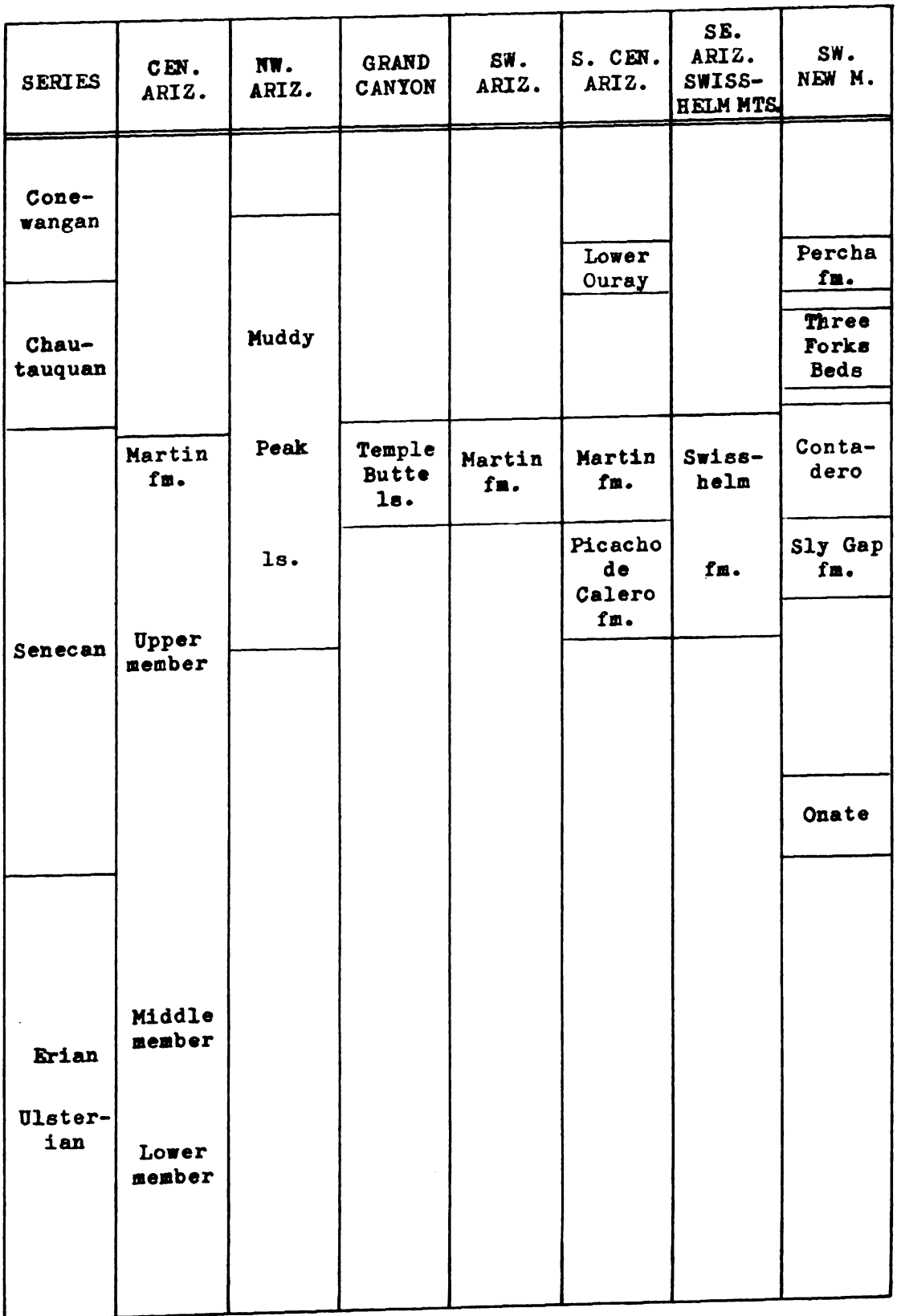

Figure 3. Devonian correlation chart of Arizona and SW. New Mexico.

believed to exist between each of the Paleozoic periods represented.

The oldest Paleozoic formation is considered as Tapeats sandstone of Early Cambrian age. The Ordovician and Silurian rocks are not found in the Jerome area. The overlying Martin formation belongs to the Devonian system. It is in turn overlain by the Mississippian, Redwall limestone. The Supai red beds overlie the youngest Paleozoic rocks of this region and may be either Pennsylvanian or Permian in age. The Supai formation is overlain by Pliocene volcanics which in fact cap Mingus and the adjacent Woodchute Mountains.

Tapeats Sandstone

The Tapeats formation lies unconformably on Early Precambrian rocks and underlies the entire area of Mingus Mountain. It crops out in part as a conspicuous reddish-brown rounded cliff around the periphery of the summit area.

The thickness of the Tapeats ranges from a few inches to about 100 feet, and averages about 50 feet in the Jerome area. The variation in thickness is a consequence of the uneven Precambrian surface. The Tapeats is thickest over

shallow Precambrian depressions and thinnest over low knolls. Locally, Precambrian topographic highs rise over the Tapeats strata into the overlying Martin limestone.

The Tapeats consists of two principal lithologic types. The lower cliff-forming member is characterized by reddish-brown sandstone which comprises about two-thirds of the total thickness. The sandstone, generally medium- to coarse-grained, is loosely cemented with siliceous and ferruginous cement. Poorly-sorted sandstone beds contain granule and pebble size grains. Commonly, sorted as well as poorly-sorted beds exist adjacent to each other, cross-bedding and channeling are widespread features of the Tapeats sandstone. Individual beds range from about 1 inch to 10 feet in thickness.

The mineral grains consist mainly of quartz, chert, jasper, and minor amounts of feldspar. Abnormal copper and zinc concentrations have been noted in local areas above ore deposits near Jerome (L. C. Huff, 1955).

The upper member consists of very thin beds of silt-stones, claystones, and marls. Interbedded thin light cream colored medium- to coarse-grained sandstone beds exist near the top of the member. The exposure forms a receding slope which is generally covered with soil and

rubble. Locally, the claystones have a fissile shaly appearance. The upper member grades upward from reddish colored rocks to lighter yellowish-gray beds. The lighter beds are slightly calcareous.

The age of the basal Paleozoic formation is tentatively correlated with the Early Cambrian Tapeats sandstone of the Grand Canyon region. L. E. Reber (1922), F. L. Ransome (1932), A. A. Stoyanow (1936), E. D. McKee (1951), and C. A. Anderson and S. C. Creasey (1958) suggest this correlation. Other authors disagree with this correlation. A. H. McNair (1951) believes the basal formation to be part of the Devonian Martin formation because of the apparent gradation into and conformity with the Martin formation. He contends that the Early Cambrian Tapeats has been overlapped northwest of the Jerome area. R. E. Lehner (1958) defends the Early Cambrian age for the basal Paleozoic formation in the Clarkdale quadrangle immediately north of the Jerome area. Concerning gradational contact at the base of the Martin formation he writes:

> However, this may be more apparent than real in the light of Krieger's recent investigations (oral communication, 1953) where she has found a possible break above the Tapeats(?) in the Paulden quadrangle, which adjoins the Clarkdale quadrangle on the west. The area of Tapeats(?) which Krieger mapped is only a

> few miles from the Tapeats sandstone at Simmons. . . . McNair (1951) traced the Tapeats from the Grand Canyon south and eastward to Simmons. McKee (written communication, 1953) has found many Cambrian trilobites in the shales overlying the Tapeats at Juniper Mountain (Camp Wood quadrangle) and stated that from there to the Clarkdale quadrangle, exposures are fairly continuous along the north side of Chino Valley.

The difficulty in detecting a break between the Tapeats and Martin formations is accounted for by the slope-forming character of the Upper Tapeats member. In addition to the evidences of a possible break observed by Krieger, and the continuous exposures of the Tapeats from the Grand Canyon to central Arizona, other evidences indicate Cambrian age for the basal strata. The lithologic character of the Tapeats in Mingus Mountain area is similar to the Tapeats of the Grand Canyon where the upper part consists of alternating sandstone and shale beds. In central Arizona, the basal part of the Martin limestone ranges from 10 to 20 feet thick. In contrast, the Tapeats of the Jerome area comprises a maximum thickness of 100 feet. The author has noted a dip of four degrees of the Lower Tapeats member.

The Martin Formation

The Devonian sequence of central Arizona has been correlated with the Martin limestone of southeastern

Arizona as described by F. L. Ransome (1904) where it was named after Mount Martin on Escabrosa ridge in the Bisbee quadrangle. In 1916, he assigned 500 feet of Devonian rocks of the Jerome area to the Martin limestone. Huddle and Dobrovolny (1952) preferred to call the Devonian rocks of central Arizona the "Martin formation" rather than the "Martin limestone" because a high percentage of clastic material was observed in the area.

The Martin formation is well exposed as steplike slopes around the periphery of Mingus Mountain.

The thickness of the Martin is 465 feet on the western side of Mingus Mountain (1,353,000 N; 413,000 E) according to C. A. Anderson and S. C. Creasey (1958). The two sections measured by the author on the east side of the mountain comprise thicknesses of 395 and 443 feet respectively. Just north of Jerome it is 441 feet thick.

The Martin formation generally overlies the Tapeats and locally the Precambrian topographic highs. The Martin is overlain by the Redwall limestone.

The formation consists of beds of aphanitic to coarse-grained dolomites interbedded with sandstones, dolomitic siltstones, limestones, claystones, quartzites, bedded nodular cherts, and shaly partings. Invertebrate fossils

are locally abundant but dolomitization of the rock has made identification difficult in central Arizona.

The formation comprises three distinct members (J. W. Huddle and E. Dobrovolny, 1952; C. Teichert and J. M. Schopf, 1958). In the Mingus Mountain and Clarkdale quadrangles, four units, A, B, C, and D have been chosen by R. E. Lehner (1958), and C. A. Anderson and S. C. Creasey (1958). This division was used chiefly for structural control surrounding the ore deposits of Jerome and is not recognized over a widespread area in central Arizona. The lower, middle, and upper members are easily distinguished from a distance as a consequence of the light colored middle member.

The lower member comprises a buff gray to dark gray, very thin- to thick-bedded, fine- to coarse-grained dolomitic limestone characterized by a persistent fetid odor. The dolomitic rock is interbedded with siltstones and limestones. The base of the member is the contact between the reddish claystone beds and the lowest overlying fetid dolomitic rocks.

Thicknesses of 26 and 28 feet were measured at sections 1 and 2 respectively. Other measured sections of the region ranged from 20 to 53 feet in thickness.

The member has been identified as far southeastward as Roosevelt Lake and the Superior area (C. Teichert and J. M. Schopf, 1958) and northwestward to Simmons in the upper Verde River area.

The beds comprise thicknesses from a fraction of an inch to 5 feet, thin beds alternating with massive strata. Cross-bedding and channeling are apparent on weathered surfaces. Lenticular chert nodules are located in the uppermost two feet of the unit. The member is spotted with coarsely crystalline calcite "augen." A high content of organic matter accounts for the dark gray color of the dolomite. Fossil plant assemblages have been studied at Flying V Canyon (C. Teichert and J. M. Schopf, 1958).

The middle member disconformably overlies the fetid dolomitic beds. It consists of a light gray aphanitic mottled dolomitic limestone.

Thicknesses of 81 and 92 feet were measured by the author at Sections 1 and 2 respectively. Elsewhere, in the Jerome area, thicknesses of 80 to 90 feet have been recorded.

Beds range from three inches to three feet in thickness to form steplike exposures. Locally, the lower beds are

dark gray. The dolomite does not generally exhibit lamination. Yellow to dark gray and black cherts are relatively abundant as nodules, lenses, and layers parallel to bedding planes. A red dolomitic quartzite band, locally known as the "Red marker" bed, comprises a thickness of one to three feet. It is located about 6 to 10 feet below the top of the member.

The aphanitic beds contain both frosted quartz grains and secondary crystalline quartz often showing etched surfaces. The lateral concentrations of sand grains stand out in sharp relief on weathered surfaces.

The upper member overlies the aphanitic member with a distinct and abrupt lithologic change. It ranges from aphanitic to coarsely crystalline dolomites and dolomitic limestones and contains silty dolomite, sandstone, siltstone, and claystone beds. The upper member includes all the lithologic types represented in the underlying members in alternating sequence. Alternating light and dark colored beds exhibit a heterogeneous appearance.

The member comprises thicknesses of 250 to 350 feet. The writer measured thicknesses of 287 and 319 feet for Sections 1 and 2 respectively.

Beds range from a fraction of one inch to seven feet in thickness. The great number of rock types represented in this member is accounted for by the rapid succession of many thin diverse lithologic types commonly ranging between thicknesses of one-half to three feet. The dolomite is frequently mottled by reddish or purplish colored clay and silt.

Near the middle of the member, the lithologic units comprise clayey and silty beds mottled purple and red. These beds are overlain by massive cliffs. Argillaceous materials are absent from the top 50 feet.

Two distinctive key beds of light olive-gray medium-grained dolomitic limestone contain many inclusions of fine-grained red sandstone masses ranging from less than an inch to about nine inches in diameter. The two foot thick beds occur 40 and 50 feet respectively above the base of the member.

Overlying Beds

The Redwall limestone disconformably overlies the Martin formation. A local irregular erosion surface with a one foot relief was observed at Mingus Mountain. Like the underlying Paleozoic beds, the Redwall crops out in

a peripheral zone in this area. It ranges from 250 to 286 feet in thickness.

The Redwall limestone is of early Mississippian age. It is easily distinguished from the Martin by its massive white vertical cliffs. The Redwall is typically a light gray coarsely crystalline pure limestone. Basal sandy beds appear to consist of reworked Martin formation but they may be identified as Redwall by their high calcium carbonate content.

The Supai formation which generally overlies the Redwall has been stripped by erosion from most of Mingus Mountain. Consequently the volcanics of the Tertiary Hickey formation rest directly on the Redwall and cap Mingus and adjoining Woodchute Mountains.

GENERAL STRUCTURE

The structure of the location area consists essentially of flat-lying outliers. These horizontal beds of Paleozoic age rest unconformably on the irregular erosion surface of folded Early Precambrian rocks. Mingus Mountain is a mesalike feature located in the center of a short south-southeastward-trending range known as the Black Hills. The range is located within the mountain region which extends southeastward between the Basin and Range Province and the Colorado Plateau.

The Black Hills consist of a fault block resulting from three main periods of faulting since the end of Cretaceous time. Along the eastern front, the structure is bounded by normal faults of the Verde fault zone. High angle en échelon faults comprising the multiple Coyote fault, border the Black Hills on the west. Complex Bessie and related faults, bordering on the northeast, display both tensional and compressional forces.

SEDIMENTARY PETROLOGIC AND PETROGRAPHIC ANALYSES

A clear understanding regarding the geology of a geologic section can be gained by pursuing a field as well as a laboratory investigation of the lithologies involved.

A field study is necessary for a megascopic description involving vertical and lateral extents of rock units and beds, characteristic features on weathered surfaces, and the outcrop pattern on the weathered exposure. Locally, an acquaintance of the geographic location is important because local lithologic types differ from other Devonian sections in central Arizona. Local tectonic activity since Precambrian time, having a possible influence on dolomitization and the concentrations of clastic sediments, must be considered.

A petrographic and petrologic study reveals the true nature of the lithologic types, the environmental conditions of deposition, and the diagenetic processes involved.

Procedure

The procedure used in this sedimentary analysis consisted of (1) a field study in the location area in central

Arizona and (2) a series of investigative techniques in the laboratory.

Field Study

The writer chose central Arizona as an area of study of the Devonian sequence. Curt Teichert of the U. S. Geological Survey recommended the eastern side of Mingus Mountain. He considered this a good exposure area of the Devonian rocks, and a favorable location for study intended to assist in his regional work in central Arizona.

The field work was carried out in December, 1960. This phase of the study involved a threefold simultaneous investigation. Data were compiled and samples were taken from measured sections.

Measuring sections.--Two Devonian sections along with the underlying Cambrian beds resting on the early Precambrian diabase were measured along the eastern flank of Mingus Mountain. Section 1 was located along a southeastward facing slope and a northeastward facing slope was chosen for Section 2. A four foot section of a stadia rod scaled to one-tenth of a foot was utilized for measuring the thicknesses of the various lithologic beds. The thicknesses were determined by sighting from the upright

stadia rod to the flat-lying, steplike Paleozoic beds.

Obtaining samples.--Rock samples were selected from each successive lithologic unit or at about 10 foot intervals within a single massive homogeneous unit. The samples were labeled according to formation, location, and stratigraphic position, example: TMA 5a. "T" designates the sample as belonging to the Tapeats formation. "M" signifies its location in the Mingus Mountain quadrangle. "A" is used to further identify its location in Section 1. The number "5" is given to the 5th successive rock sample counting upward from the base as recognized from field observations. The small letter "a" is used to signify an additional sample taken from the same unit as the sample labeled TMA 5.

Compiling data.--An efficient aid for rock description of detailed sections utilized by the Fuels Branch of the U. S. Geological Survey was used for compiling field data. This field technique consisted of (1) a set of the following abbreviations applied to a rubber stamp and stamped on blank paper:

Typ: Col: w f Col Distr: hom-grad-band-mottl
Top Exp: Cl rnd-ver-ir Sl reg-ir-rl Exp: gd-fr-pr-cov
Prdts: rub-sol Jnt: Att: 90-60-30-15-0 Form: tab-wedge-lens-ir Base: sh-grad, ev-ir, par-ang, cov Bed Type:

Bed Thickness. Bed Succ: rhy-nrhy-misc Bed Strct: lam-grad hom-het Lam Type Thickness: Lam Strct: grad-hom-het Gr Size: 256-64-4-2-1-.5-.25-.125-.062 Gr Sh: tab-eq-prol-bed Gr Rnd: ang-sang-srnd-rnd ST: dul-sm-rgh-pol Sort: Com: qtz mica femag $CaCO_3$ cl feld rxfrag C chert misc Cem: fe-si-ca-cl-o Deg of Cem: CT: xln-gran-aph-ph-xbl-col-bio-misc Chert: layrd-nod-lens-ir Chert Col: Concr: cal-fe-si-o Fossils: abd-rare Types: Condition: Fab: SM: Remarks:

(2) the following guide expressing the meaning of the abbreviations:

Typ - Type of sediment, i.e., sandstone, shale, limestone
Col - Color of sediment (refer to color chart and use symbol).
w - weathered f - color fresh
Col Distr - Color distribution (overall color distri-on weathered surface of the unit).
hom - homogeneous band - banded
grad - gradational mottl - mottled
Top Exp - Topographic expression of the unit.
Cl - cliff Sl - slope
rnd - rounded reg - regular
ver - vertical ir - irregular
ir - irregular rl - rolling
Exp - Exposure (qualify of).
gd - good pr - poor
fr - fair cov - covered
Jnt - Jointing (use +, ,/, or - to indicate amount).
Prdts - Products of weathering.
rub - rubble sol - soil
Att - Attitude of the unit (circle general range of dips).
Form - Form of the unit as a whole.
tab - tabular lens - lenticular
wedge - wedge-shaped ir - irregular
Base - Base (character of the base of the unit).
sh - sharp par - parallel
grad - gradational ang - angular
ev - even cov - covered
ir - irregular
Bed Type - Type of bedding.
Bed Thickness - Thickness of the individual beds; may be either the average thickness or the limits.

Bed Succ - Bedding Succession
- rhy - rhythmic
- nrhy - non-rhythmic
- misc - miscellaneous

Bed Strct - Bed structure
- lam - laminated
- grad - gradational
- hom - homogeneous
- het - heterogeneous

Lam type - Lamination type.

Lam Thickness - Lamination thickness.

Lam Strct - Lamination structure.
- grad - gradational
- hom - homogeneous
- het - heterogeneous

Gr size - Size of grains

Gr Sh - Shape of grains (estimated)
- tab - tabular
- eq - equant
- prol - prolate
- bld - bladed

Gr Rnd - Degree of rounding of grains
- ang - angular
- sang - subangular
- srnd - subrounded
- rnd - rounded

St - Surface texture of grains
- dul - dull
- sm - smooth
- rgh - rough
- pol - polished

Sort - Sorting (use +, ,/, or -).

Comp - Detrital components (estimate percentage).
- qtz - quartz
- mica - mica
- femag - ferromagnesians
- $CaCO_3$ - $CaCO_3$
- cl - clay
- feld - feldspar
- rxfrag - rock fragments- indicate type, e.g., ba. basalt).
- C - carbonaceous material
- misc - miscellaneous

(Space is left after each component for a letter to indicate degree of weathering, e.g., feld <u>10%SW</u> or feldspar present to amount of 10% and in a <u>strongly weathered</u> condition).

Cem - Type of cement.
- fe - ferruginous
- si - siliceous
- ca - calcareous
- cl - clay
- o - other

Deg of Cem - Degree of cementation (use +, ,/, or -).

CT - Chemical texture
- xln - crystalline
- gran - granular
- aph - aphanitic
- ph - phaneritic
- xbl - crystalloblastic
- col - colloform
- bio - bioform

Chert - Chert
    layrd - layered lens - lenticular
    nod - nodular ir - irregular
Chert Col - Chert Color
Concr - Concretions.
    cal - calcareous si - siliceous
    fe - ferruginous o - other
Fossils - Fossils.
    abd - abundant rare - rare
Fab - Fabric
SM - Surface markings

(3) rock description recorded on the stamped paper.

Laboratory Techniques

Preparation of thin sections, acetate peels, insoluble residues and stains comprised the necessary laboratory techniques for a petrologic and petrographic analysis of the samples taken from Section 1.

Preparation of thin sections.--Standard procedures were followed in cutting, grinding, and mounting thin sections, (F. Wm. Heinrich, 1956; C. Meyer, 1946; and A. Johannsen, 1918). Eighty-five thin sections were prepared from rock samples representing lithologic units of Section 1. Friable sandstones and dolomites were prepared for cutting and grinding by soaking the samples in hot liquid aroclor for one-half an hour.

Preparation of acetate peels.--The rock samples collected from Section 1 were cut and polished to a smooth surface

resulting from the use of corundum #600 abrasive. The polished surface was etched with dilute HCl. The acid was washed from the rock after 30 seconds. Acetone was applied to the etched rock with an eye dropper. Next, a strip of acetate paper was quickly pressed to the wet surface with a rubber roller. After 20 minutes, the peel was removed from the sample and sandwiched between two micro-slides secured by cellophane tape.

Procedure for insoluble residues.--A small part of each rock sample was crushed into coarse fragments and disaggregated or dissolved in 12 per cent HCl inside 250 milliliter beakers. Disaggregation was completed before the minimum alloted time of five hours.

The fine insolubles were washed inside 400 milliliter beakers by siphoning the solution from the solids. A solution sample, corresponding to each insoluble sample, was retained for observation. The insoluble residue was recovered on a filter paper.

Procedure for staining.--The potassium ferricyanide technique was utilized (E. Steidtmann, 1917). A saturated solution was prepared in a small sealed flask by dissolving several potassium ferricyanide crystals in water. Ten

drops of the prepared solution were added to a glass pan containing 288 cc of five per cent HCl. The carbonate samples were stained by dipping the rocks into the liquid. Dolomite turned blue while calcite was unaffected. Polished surfaces render best results.

Stratigraphy of Measured Sections

The following description is based upon the specific data as recorded in Appendix A, Section 1. Data from Section 2 were incorporated when the necessary information was not available from Section 1, but in such cases reference is made to the use of the second measured section. However, Section 2 is readily correlated with Section 1 since correlative units are designated by similar Roman symbols in Sections 1 and 2.

Tapeats Sandstone

The Tapeats is represented in this area by a lower and upper member comprising a total thickness of 40.9 feet. The lower member forms a conspicuous reddish-brown ledge along the eastern slopes of Mingus Mountain. The basal exposure consists of cross-bedded sandstones interbedded with conglomerates. The upper slope-forming member comprises fine clastics.

Lower member.--The lower member consists of 17 feet of reddish-brown sandstones interbedded with conglomerates. The clastic beds contain ferruginous and siliceous cement. Medium grains predominated, but sizes range from silt to pebbles with a maximum diameter of 40 millimeters. Arkosic beds exist in the upper units. The thick-bedded units weather to conspicuous reddish-brown steplike ledges above the steep Precambrian slope. The beds exhibit concave tabular cross-laminae and graded bedding. Sharply defined alternating reddish-brown and brown tabular bands are displayed four feet above the base. Authigenic quartz is abundant throughout the member. Essential constituents consist of quartz, chert, and some feldspar. Accessory minerals include hematite, ilmenite, limonite, specularite, glauconite, pyrite, and muscovite. The lower member lies unconformably above the Precambrian diabase.

Upper member.--The upper member comprises a thickness of 24 feet of thin-bedded claystone, siltstone, and silty dolomite. The texture is aphanitic with local sandy lenses. The Upper Tapeats member forms an irregular slope. The basal unit comprises six feet of red claystone with thin tabular bands of rounded and frosted sand grains embedded

in clay matrix. The base is concealed. The claystone is succeeded upward by a concealed slope. In Section 2, gray siltstones and pink silty dolomite beds overlie the red claystone strata. This sequence compares with the general stratigraphy of central Arizona.

Martin Formation

The Martin formation constitutes a total thickness of 395.4 feet. It is composed of three members. Medium beds of dark gray dolomite, weathering gray to buff, consisting of microcrystalline textures, and forming steplike ledges, characterize the nature of the Devonian rocks. The lithologic characteristics of the lower and middle members are homogeneous relative to the upper member. Individual units similar in appearance and lithology to the lower and middle members reappear sporadically in the upper member.

Disconformities, displaying a maximum relief of one foot, separate each of the members of the Martin formation and its contact with the overlying Redwall limestone. The disconformities were discovered in both of the two measured sections. No unconformity was discernable at the base of the formation; however, a four degree dip was noted on the resistant Cambrian sandstones. The Devonian beds are

essentially horizontal. The contact with the overlying Redwall limestone is readily distinguishable: (1) the Devonian and Mississippian rocks are separated by a disconformity with a one foot relief (refer to Appendix A, Section 2); (2) the underlying rocks, consisting of impure dark gray dolomite, are overlain by white limestone; (3) the Devonian rocks, forming medium-bedded steplike ledges, are succeeded by massive Mississippian cliffs.

Lower member.--The lower member comprises a total thickness of 26 feet. The dark gray dolomite units, constituting a microcrystalline texture, emit a characteristic fetid odor.

The thin- to thick-bedded units weather to an irregular cliff above the Cambrian slope. The beds possess sharply defined thin laminae. The lower beds contain vugs and small calcite-filled cavities. The upper beds display larger calcite concentrations and some chert nodules.

A local marker bed three feet thick is located 20 feet above the base (Appendix A, correlative unit III). The bed consists of a white to pink limestone with calcite geodes and red clayey lenses one to three feet thick.

Middle member.--The middle member is known as the lithographic member. At a distance, it is readily distinguished from the upper and lower members by its characteristic light gray steplike ledges. It comprises a total thickness of 81.3 feet and overlies disconformably the lower member. A four inch relief was observed in Section 2. The dolomite is typically light to dary gray, weathering light gray. Several beds above the base weather medium gray. Some beds are mottled a deep purple. The characteristic even-grained, lithographic rocks display subconchoidal to conchoidal fractures. The thin- to very thick-beds crop out as steplike ledges. Thin laminae appear only on weathered surfaces in the lower part of the member.

Several units contain irregular bedded chert and brown to black nodular chert zones oriented parallel to bedding planes. Nodular chert zones are located three and six feet respectively above base of member. The chert consists of ellipsoidal nodules.

A one foot thick calcitic ledge contains a dark gray irregular chert bed one to three inches thick. An uneven parting beneath the top of the unit forms a very irregular surface constituting two inch high mounds.

A black ropy chert bed, located 17 feet above the base of member, was used as a local marker bed (Appendix A, correlative unit VIII).

The well known "Red marker bed" consists of 3.3 feet of pink sandy dolomite. The texture is microcrystalline with embedded medium size sand. The rock displays a fragmental structure. A sandpaper-like weathered surface is produced on the irregular cliff exposure.

Upper member.--The upper member comprising a thickness of 288.1 feet consists chiefly of dolomite, but it varies greatly in color, texture, and structure. A few local units of limestone are sandwiched between the dolomite rocks. The dolomite tends to become more calcareous toward the top. Several sandstone and silty dolomite units are located in the lower part of the member. Many silty strata lie beneath the upper cliff-forming beds. The color is typically medium to dary gray. Many units exhibit varying shades of pinkish- to purplish-gray. Several dolomite beds are greenish-gray and reddish-brown. The weathered surfaces appear buff or light to dark gray. Red to purple mottling is a common feature of the upper member.

The lithology is characterized by uneven textures. Microcrystalline rocks predominate; however, grain sizes

range from sublithographic to medium crystalline. The upper 70 feet are more coarsely crystalline than the beds below. Some of the lower units are sublithographic and locally exhibit conchoidal fracture.

The units are mainly medium-bedded, but thicknesses range from very thin- to very thick-bedded. Steplike ledges with many interbedded slopes characterize the outcrop pattern. Numerous beds are thinly laminated. The laminae of some beds are evident only on weathered surfaces. Several units contain small flow roll structures. Calcite-filled cavities exist in most units. Cellular and vuggy weathered surfaces result from solution of the calcite. The cavities commonly range in size from one-tenth to one inch in diameter.

Several dark gray dolomite units emit a fetid odor. Fossils are generally dolomitized. Recrystallized fauna consist of brachiopods, gastropods, colonial corals, and crinoid stems. A basal disconformity separates the upper and middle members. Another disconformity with a one foot relief is exhibited 125 feet above the middle member.

Locally, six feet of sandy dolomite and sandstone beds interbedded with dolomite are concentrated above the base. Brown sandpaper-like horizontal bands appear on weathered

surfaces. Quartz grains stand out in sharp relief in the sandy beds.

A fossiliferous zone is located between 32 and 37 feet above the base. The lower beds weather to a reddish-brown crumbly slope. The silty rocks contain abundant brachiopods. The upper three feet of dark reddish-brown, finely crystalline, dolomite constitutes a good local marker bed. It is crowded with recrystallized brachiopid valves and fragments. The recrystallized unit weathers to resistant ledges between slope-forming rocks. It correlates with a similar unit in Section 2 (Appendix A, correlative unit IX).

A possible marker bed is located 159 feet above the base. The one foot thick unit consists of a marble-like gray and red banded dolomite. The silty rock is mottled with red clay.

A useful marker, eight feet thick was measured 205 feet above the base (Appendix A, correlative unit XXVIII). The banded dolomite consists of alternating red and gray silty bands exhibiting a marble-like structure. The unit weathers to a slope.

The preceding banded unit is included in a zone of silty beds between 175 and 219 feet above the base of the

upper member. These silty and clayey dolomite units, characteristically gray, pinkish- to purplish-gray, or reddish-brown, exhibit a powdery texture and weather to an irregular slope.

Immediately above the silty slope, a 32 foot thick irregular cliff interrupts the typical steplike outcrop pattern of the Martin formation (Appendix A, correlative unit XXIX). The cliff-forming dolomite units are gray to purplish-gray in color and weathering light gray to buff. Its resemblance to sandstone on weathered surfaces is accounted for by its crystalline texture. The grain size ranges from very finely to medium crystalline. Other surface features include chipped and vuggy to cellular weathered surfaces in the varying medium- to thick-bedded units.

DOLOMITIZATION

Dolomite as a double carbonate molecule is composed of 54.35% $CaCO_3$ and 45.65% $MgCO_3$. Dolomites are more common than calcitic dolomites. Paleozoic dolomites are more common than dolomites of later eras.

Lime-magnesia Ratio in Limestones of Various Ages (after Daly)

	Ca-Mg Ratio	No. of Analyses
Pre-Devonian	3.35 to 1	392
Devonian	6.29 to 1	106
Carboniferous	12.45 to 1	238
Cretaceous	56.32 to 1	77
Tertiary	53.09 to 1	26
Quaternary & Recent	35.00 to 1	26
		865

Magnesium is 28 times more soluble than calcium (F. M. Van Tuyl, 1914). Extensive dolomite deposits are not being formed under present conditions perhaps because a necessary chemical constituent or catalytic agent is lacking in the proper environment requiring a particular temperature, pressure, salinity, and/or chemical relationship.

Petrographic Characteristics of the Devonian Section

The most significant feature regarding the dolomite rocks of the Devonian section at Mingus Mountain and farther to the northwest is the diverse character of the lithologic types which commonly form thin units. The dolomite is interbedded with several limestone, claystone, siltstone, and sandstone units. Many dolomite beds are mottled. Local lateral changes to calcareous rocks were noted. As a formation, the Martin of central Arizona grades laterally from dolomite to limestone rocks. Vertically, the units tend to become more calcareous and coarsely crystalline towards the top of the formation.

The lithographic beds concentrated in the middle member comprise the purest dolomite. Calcite is extremely scarce in the aphanitic beds. Generally the beds do not appear to be laminated.

The lower member of the Martin formation displays an uneven microcrystalline to very finely crystalline texture. Well defined relict aphanitic textures constitute .02 mm size grains superimposed by recrystallized grains ranging from 0.5 to 0.1 mm in diameter. These anhedral grains transect laminae partings. Thin undulating laminae are dotted with small calcite-filled cavities.

The textures of the upper member are microcrystalline to medium crystalline. Relict aphanitic textures showing areas of recrystallization were observed (refer to Plate XII, B). Calcite-filled cavities are abundant. Several fossiliferous beds contain dolomitized fauna.

Significant sedimentary features consist of thin laminae and bands, slump structures, intraclasts, shrinkage cracks, and rare intercrystalline and vuggy porosity. Laminae are frequently evident only on weathered surfaces. Secondary quartz, a common constituent of the Devonian, may surround clastic grains and form secondary overgrowths (refer to Plate XI, B). Small clastic quartz grains occasionally are enclosed in dolomite grains. Quartz sand scattered sporadically throughout the Martin formation is typically rounded and frosted. Some secondary quartz appears to be etched by carbonate corrosion. Dolomite crystals are anhedral against other dolomite crystals but euhedral against calcite. Some well-developed dolomite rhombohedra are zoned. Well-rounded quartz grains are bordered by anhedral dolomite crystals (refer to Plate XII, A). Minerals contained in the carbonate rocks include quartz, chert, chalcedony, hematite, limonite, ilmenite, siderite, glauconite, muscovite, and clay.

Evidences for Replacement

Replacement of loosely consolidated calcite or aragonite sediments was effected on the sea floor penecontemporaneously with deposition. Observed evidences are indicative of replacement: (1) relict aphanitic textures, (2) lateral gradation of dolomite into limestone, (3) dolomitized fossils in dolomite once known to have been calcareous, (4) obliteration of some laminae, (5) dolomite rhombohedra superimposed on laminae partings, (6) finer-grained rocks more dolomitic, (7) automorphic boundaries of dolomite against calcite, (8) inclusions of clastic quartz inside dolomite grains, (9) the association with secondary quartz, limonite, glauconite, siderite, hematite, and bedded chert.

Significant observations were made in the lithographic member and other aphanitic units to determine the sedimentary processes involved. The units are generally thin- to thick-bedded rather than massive. Lamination is evident only on weathered surfaces of many units. Ostracods and crinoid stems frequently occur in the aphanitic dolomites. Clastic quartz grains are rounded and pitted or frosted. A purer grade of dolomite occurs in rocks showing aphanitic textures. Brecciated structures contain rounded dolomite

fragments. The ellipsoidal fragments are surrounded by dolomite exhibiting a coarser texture and containing greater concentrations of clastic quartz. The finer-grained fragments are more dolomitic than the surrounding carbonate material. The initial deposits may have been broken up into fragments and rolled about by bottom currents after partial compaction. Several beds contain an abundance of silica around aphanitic dolomite grains. Chert occurs as irregular beds and bedded nodules oriented parallel to bedding planes. Dolomite grains are enclosed in nodular chert. Rhombohedral pseudomorphs, now consisting of silica, were observed inside a chert nodule. Sponge spicules, radiolaria, and ostracods occur in the nodular cherts. The ostracods inside the chert are silicified. No sponge spicules or radiolaria were observed inside the dolomites. Microcrystalline dolomite rhombohedra penetrate ostracod valves. Dolomite units are interbedded with calcitic dolomites.

Either primary deposition or early replacement may be interpreted from the interbedding of dolomite with calcitic dolomite.

Replacement of the aphanitic rocks is indicated by (1) the obliteration of laminae, (2) the occurrence of ostracods

and crinoid stems, and (3) the penetration of microcrystalline dolomite into ostracod valves.

Penecontemporaneous replacement may be evidenced by rhombohedral pseudomorphs inside the nodular chert and microcrystalline dolomite grains enclosed by zones of siliceous boxwork.

Aphanitic rocks may be more susceptible to dolomitization than coarser texture because smaller lime particles have a greater surface area per unit volume than larger grains. The penetration by magnesium ions is therefore more effective.

PALEOGEOGRAPHIC AND PALEOGEOLOGIC INTERPRETATIONS

Paleogeographic and paleogeologic interpretations are based on studies of the author's two measured sections and the regional studies of J. W. Huddle and E. Dobrovolny, D. V. LeMone, E. D. McKee, A. H. McNair, F. L. Ransome, C. Schuchert, A. A. Stoyanow, and C. Teichert.

Varying conclusions have been drawn concerning the paleogeography of Arizona in early Paleozoic time. C. Schuchert (1910) named Ensenada as a topographic high which was persistent throughout the Paleozoic era. The area trended northeastward from northern Mexico into southwestern Arizona. The existence of a topographic high extending westward into northeastern Arizona is generally accepted in paleogeographic interpretations of the region.

According to A. A. Stoyanow, Mazatzal land, consisting of a land barrier trending southwestward through central Arizona separated the Devonian sediments of northwestern and southeastern Arizona. He contended that Mazatzal land was established already in Late Precambrian time. The positive area moved upward intermittently until Middle Devonian time.

J. W. Huddle and E. Dobrovolny (1952) defended a restricted Mazatzal land in central Arizona. A chain of discontinuous ridges trending northeastward from southwestern Arizona to southwestern Colorado was suggested. The Mogollon sag in the author's area of study connected the two basins of northwestern and southeastern Arizona.

A study concerning the sedimentary basins of Arizona during the Paleozoic era was made by E. D. McKee (1951). He prepared a series of isopach maps of the state from which he defends a southeastward trending basin representing a shelf area which connects the Cordilleran with the Sonoran geosyncline and separates Ensenada from the Defiance positive area of northeastern Arizona. A positive high in central Arizona is not considered.

The paleogeologic conditions of this region are discussed in the following statements.

Local Paleo-environment

A thorough appraisal of the sedimentary environment is limited by the author's two, closely-spaced measured sections.

During the Paleozoic era, Arizona was covered by marine areas. The region constituted a shelf area between

the continental interior and the Cordilleran geosyncline. The Tapeats sandstone overlying unconformably the rough surface of the Precambrian diabase exhibits evidences of rapid erosion of a local rising granitic source area. The lower sandstone member contains many poorly-sorted conglomeratic beds with abundant orthoclase feldspar pebbles. The rapid wearing down of the source rock is accounted for by the rapid change to fine clastics in the Upper Tapeats member.

The Cambrian was followed by a long period of crustal stability as evidenced by the inconspicuous Cambrian-Devonian contact. This period of non-deposition continued through the Ordovician and Silurian. The Ordovician deposits are restricted to the northwestern and southeastern corners of the state. The Silurian is entirely missing in Arizona.

The Martin formation was deposited in a warm shallow marine sea within the neritic zone. Unstable crustal conditions prevailed throughout the Devonian period of deposition. A local source rock of low relief was eroding towards base level.

A marine environment is indicated by the occurrence of invertebrate fauna such as colonial corals, brachiopods,

and crinoids. The recrystallized crinoid stems sporadically located in several beds suggest a shallow sea deposit. The frequent occurrence of shrinkage cracks in relatively thin lithologic units provide further criteria for shallow water deposition. Thin units high in dolomite are indicative of shelf area.

Lithologic features exhibit evidences for conditions of deposition above wave base. Brecciated beds contain angular to ellipsoidal intraclasts. Some fragments are bedded. The fragments were dislodged after incipient cementation. Some were rolled about into elliptical and spherical shapes before being covered by later deposits. Periods of deposition followed periods of submarine erosion during the time of the accumulation of beds in water shallow enough to be subjected to strong wave action. The influence of intermittent bottom currents is further indicated by the concentration of sand grains around some of the aphanitic dolomite intraclasts. Active bottom currents, affected by storm waves and tital currents have caused sorting and size-grading. Oxidized sediments are indicative of the influence of current action.

Unstable tectonic conditions are accounted for by the thin diverse lithologic units. Sediments temporarily

exposed have resulted in the forming of shrinkage cracks and disconformities. Sandy bands, siltstones, and shales sandwiched between dolomite beds also express sharp changes in the depositional environment.

The common occurrence of well-rounded and frosted quartz grains ubiquitous throughout the Devonian sequence along with the existence of the thin interbedded sandstones provides evidences for local sources possibly consisting of wind-blown sand dunes along beaches of an old land surface. The occurrence of coarse clastics in lower beds, succeeded upward by fine clastics, may indicate a gradual lowering of the source area. Sandy units lie beneath a group of silty and clayey beds located higher in the sequence. These beds are succeeded by crystalline carbonates containing less siliceous material.

Relationship to Regional Peleogeographic Features

A topographic high, the Defiance Positive area of central New Mexico and northeastern Arizona existed as a continuous land-mass from Cambrian through Mississippian time. Early Paleozoic deposits thicken northward, westward, and southward from this area. No ridge separated

the Arizona basins, however the beds thin towards Ensenada, a persistent high throughout the Paleozoic era. The existence of Devonian sections in the Harquahala, Growler, and Vekol Mountains of southwestern Arizona rule out an extensive Mazatzal land. The author proposes a restricted Mazatzal area of islands surrounded by an unstable but slowly sinking shelf.

SUMMARY AND CONCLUSIONS

General Summary

The petrographic and petrologic analysis was based upon two measured sections of central Arizona. The author's field studies consisted of measuring sections, sampling and compiling field data. Thin sections, acetate peels, insoluble residues, and stained samples were utilized for laboratory studies of Section 1. Units of Section 2 were correlated with Section 1.

Conclusions regarding sedimentary and environmental implications could be made merely of the limited local area of the two closely spaced sections. However, relationships with the regional paleo-environment were considered.

Conclusions

The basal Paleozoic strata underlying the fetid dolomite member of the Martin formation belong to Cambrian age on the basis of observed evidences of lithologic similarity, stratigraphic position, and attitude of beds. These basal units are correlated with the Tapeats sandstone exposed in the Grand Canyon.

Differing paleo-environments marked the deposition of the Tapeats and Martin formations. The Tapeats received sediments from a rapidly rising and eroding source.

The source area providing sediments for the Martin formation constituted an island or islands of low relief containing dune sand. This small topographic high is here considered a restricted Mazatzal land located on a submarine shelf between the Cordilleran geosyncline and the continental interior.

The depositional environment of the Martin formation comprised a warm shallow marine sea. The lime deposits were laid down above wave base. Alteration to dolomite was effected on the sea floor before deep burial. This process was possibly penecontemporaneous with deposition. The aphanitic dolomites exhibit a more advanced state of dolomitization than the carbonate rocks showing a coarser texture.

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APPENDIX A

Megascopic Description

and

Photographs

of

Sections 1 and 2

Mingus Mountain Area

Section 1

Section 1 is located along coordinates N. 1,348,500; E. 445,000, T15N, R2E on the east flank of Mingus Mountain.

Numbers as "127" refer to thin section or acetate peel in Appendix B. Roman symbols as "XXXIII" refer to correlative unit in Section 2.

	Thickness in feet	
	Unit	To base of member
Devonian:		
Martin formation: (395.4 feet)		
Upper member: (288.1 feet)		
Dolomite, dark gray, weathering gray; finely crystalline; medium-bedded, steplike ledges; spotted with fine calcite-filled cavities (127) (XXXIII)	2.5	288.1
Dolomite, dark gray, weathering gray; mottled pink; finely to medium crystalline; irregular slope, calcite-filled cavities 1/2 inch; mottled area calcareous (125, 126)	6.6	285.1
Dolomite, calcitic, dark gray, weathering buff; finely crystalline; thick-bedded, steplike ledges; calcite-filled cavities 1/2 to 1 inch (124)	7.1	279.0
Dolomite, calcitic, pinkish-gray, weathering light gray, mottled pink; sandy, silty, aphanitic; irregular slope; undulating laminae; calcite-filled cavities 1/4 to 1 inch; uneven fracture (123) (XXXII)	7.0	271.9

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Upper member--Continued		
Dolomite, gray, weathering light gray, mottled purple; microcrystalline; medium-bedded; laminated; slightly vuggy (122) (XXXI)	1.0	264.9
Dolomite, purplish-gray, weathering buff-gray; locally calcareous; very finely to finely crystalline; medium-bedded, 4 inches to 1 foot thick, steplike ledges; vuggy; increasingly calcareous upward (120, 121) (XXX)	13.0	263.9
Cliff-forming beds (XXIX) . . . . . .*		
Dolomite, dark gray, weathering buff-gray, mottled purple; very finely to finely crystalline; thick-bedded; vuggy with some cellular weathered surface (119) . . . . . .*	4.8	250.9
Dolomite, gray, weathering light gray; very finely crystalline; medium-bedded, blocky; undulating laminae alternating between gray bands containing both vugs and rounded quartz grains and non-vuggy, purplish bands (118) . . . . . .*	2.5	246.1
Dolomite, dark purplish-gray, weathering buff-gray, mottled red; finely crystalline; thick-bedded, blocky; cellular weathered surface (117) .*	3.3	243.6

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Upper member--Continued		
Dolomite, reddish-gray, weathers gray, patchy; clayey, medium crystalline; irregularly bedded; fragmental structure (116) . . . . . .*	2.0	240.3
Dolomite, gray, weathering light buff; very finely to finely crystalline; medium-bedded; cavities and joints red clay stained; chipped surface texture; vugs (115) . . . . . .*	2.1	238.3
Dolomite, gray, weathering light buff; medium crystalline; thick-bedded; calcite-filled cavities; red stained joints; thin calcite veins; red silty parting 7.4 feet above base; thinly laminated near base (113, 114) ...*	17.3	236.2
Dolomite, gray, weathering purplish-gray; silty, clayey, aphanitic; medium-bedded, rounded, steplike ledges; shrinkage fractures; powdery texture (112)	4.0	218.9
Concealed	2.0	214.9
Dolomite, banded, alternating marble-like gray and red bands; silty, aphanitic; slope-forming; partly concealed; colorful marker bed (110, 111) (XXVIII)	8.0	212.9

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Upper member--Continued		
Dolomite, pinkish-gray; silty, clayey, aphanitic; partly concealed slope; laminae poorly defined; powdery texture (109)	6.6	204.9
Dolomite, medium gray, mottled purple; silty, clayey, aphanitic; partly concealed slope; deep purple mottled areas; powdery texture (108) . . .	3.0	198.3
Concealed	6.0	195.3
Dolomite, purplish-gray, weathering reddish-brown; silty, aphanitic; very thin-bedded; irregular slope; thinly laminated; dendrite patterns on partings (107)	5.0	189.3
Concealed 30° slope	7.2	184.3
Dolomite, purple-yellow; weathering reddish-brown, mottled yellow; silty, clayey, aphanitic; partly concealed slope (106)	2.5	177.1
Dolomite, dark greenish-gray, weathering green-buff; very finely crystalline; cliff-forming, medium-bedded; channeling; laminated, uneven, graded; rounded quartz grains, lenticular concentrations; silty bed .5 feet thick, 1.5 feet above base, containing quartz grains, laminated, lenticular (103-105)	2.7	174.6

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Upper member--Continued		
Dolomite, dark reddish-gray, weathering dark buff, mottled reddish-brown; finely crystalline; medium-bedded, rounded slope-forming, crumbly; cellular weathered surface; base covered (101, 102)	2.5	171.9
Concealed	10.3	169.4
Dolomite, gray with marble-like red mottled bands; silty, aphanitic; thin-bedded, steplike ledges; stylolitic surface (99, 100) . .	1.2	159.1
Dolomite, interbedded, pinkish-gray, weathers light buff to light pink; aphanitic; thin-bedded, partly concealed slope; irregularly laminated (97, 98)	3.5	157.9
Concealed 20° slope	3.9	154.4
Dolomite, calcitic, interbedded, brown to gray; finely crystalline, locally clayey, medium-bedded, 3 inches to 1 foot thick, rounded steplike ledges; cellular weathered surface, calcite-filled cavities (95, 96)	5.0	150.5

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Upper member--Continued		
Dolomite, calcitic, pale greenish-gray, weathering buff, mottled red; medium crystalline; friable; cliff-forming, thick-bedded, blocky; calcite patches; cellular weathered surface (93, 94) (XXVII)	3.4	145.5
Dolomite, dark purplish-gray, weathering light buff; very finely crystalline; medium-bedded, cliff exposure; calcite-filled cavities (92)	0.6	142.1
Dolomite, calcitic, reddish-gray; very finely crystalline; thin vertical calcite veins (91) (XXVI)	2.8	141.5
Dolomite, dark reddish-gray, weathering dark greenish-buff, mottled purple; very finely crystalline; undulating bedding, banded; calcite-filled cavities (90) (XXV) .	0.3	138.7
Dolomite, dark gray, weathering buff, mottled red; microcrystalline; calcite-filled cavities (89)	0.3	138.4
Dolomite, brownish-gray, weathering gray; microcrystalline, medium-bedded, steplike ledges, blocky; vertical jointing, dendrites on surface (88)	1.7	138.1

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Upper member--Continued		
Dolomite, purplish-gray, mottled purple; silty, aphanitic; slope-forming, crumbly; powdery texture (87) (XXIV)	2.5	136.4
Dolomite, brownish-gray, weathering light buff; microcrystalline; medium-bedded, beds 6 inches thick, steplike ledges; thinly laminated; lies disconformably over underlying unit (86) (XXIII)	2.4	133.9
Dolomite, pinkish-gray, mottled red; silty, aphanitic; slope-forming; red stained joints; small calcite-filled cavities; speckled weathered surface; crumbly; slightly calcareous (85) (XXII)	2.2	131.5
Dolomite, interbedded, brownish-gray to dark gray, weathering light gray; microcrystalline; thin to thick-bedded, beds 1/2 inch to 2 feet thick; thinly laminated; stylolitic surfaces containing red ferruginous material; calcite-filled veins and cavities intersecting vertical joint pattern (83, 84). . .	3.0	129.3
Dolomite, dark greenish-gray, weathering buff; microcrystalline; fetid odor; thick-bedded, massive, cliff exposure; undulating laminae, basal disconformity, 1 foot relief (82). .	1.1	126.3

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Upper member--Continued		
Dolomite,dark gray, weathering gray; microcrystalline to very finely crystalline; medium-bedded, rounded, steplike ledges (81)	2.3	125.2
Dolomite, gray, weathering light gray, mottled red; microcrystalline; steplike ledges; thin calcite veins; stylolitic surfaces (80) (XXI) . . .	1.5	122.9
Siltstone, pinkish-gray, mottled purple; aphanitic; steplike ledges (79)	2.0	121.4
Concealed	1.9	119.4
Dolomite, dark,gray, weathering light gray, mottled purple; microcrystalline; steplike ledges; calcite-filled cavities (78) (XX)	1.5	117.5
Sandstone, dolomitic, pinkish-gray, weathering light brown, mottled purple; silty, medium-grained; rounded quartz grains, poorly sorted (77) (XIX)	0.9	116.0
Concealed slope	2.3	115.1
Dolomite, light purplish-gray, weathering gray, mottled purple; silty, aphanitic; slope-forming, blocky; thinly laminated, wavy; powdery texture; partly concealed (75, 76) (XVIII)	3.7	112.5

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Upper member--Continued		
Dolomite, dark greenish-gray, weathering dark buff; very finely crystalline; fetid odor; massive, cliff exposure; vertical joints; calcite-filled cavities; cellular weathered surface (74) (XVII)	1.0	109.1
Dolomite, gray, weathering light buff-gray; microcrystalline; thin- to medium-bedded, cliff exposure, rubbly, uneven bedding; cellular weathered surface (73) (XVI)	6.2	108.1
Dolomite, gray, weathering light buff; sublithographic; medium-bedded, 4 to 6 inches thick, slope to cliff; thinly laminated, calcite-filled cavities, scattered vugs (72) (XV) .	2.9	101.9
Dolomite, gray, weathering light buff; microcrystalline; massive, cliff exposure; chipped weathered surface texture; slight red staining (71). .	1.7	99.0
Dolomite, pale purplish-gray, weathering gray; very finely crystalline; thin- to medium-bedded, beds 2 inches to 1 foot thick, steplike ledges; vertical jointing (70)	3.4	97.3
Dolomite, dark gray, weathering dark buff; very finely crystalline; cliff-forming, thin- to thick bedded, beds 2 inches to 1.5 feet thick; extremely cellular weathered surface; large calcite-filled cavities (69)	2.2	93.9

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Upper member--Continued		
Dolomite, dark purplish-gray, weathering buff; microcrystalline; receded cliff exposure; laminated, purple wavy bands (68) (XIV)	1.4	91.7
Concealed slope	4.9	90.3
Dolomite, pinkish-gray, weathering light buff-gray, silty, microcrystalline; laminae undulating, lenticular; locally flow roll structure; partly concealed slope (67) (XIII)	3.0	85.4
Dolomite, dark gray, weathering buff; microcrystalline, fetid odor; medium- to thick-bedded, beds 4 inches to 1.5 feet, cliff exposure; locally thinly laminated; vertical jointing (65, 66) (XII)	1.8	82.4
Dolomite, very dary gray, weathering buff; microcrystalline; thick-bedded, massive, cliff exposure, reddish stained patches; small calcite-filled cavities (64) (XI)	1.5	80.6
Sandstone, dolomitic, light pinkish-gray, weathering light buff; medium grained, medium-bedded, cliff exposure; rounded quartz grains, breaking across the grains, sandpaper-like surface; calcite-filled cavities; red staining (63) (X). . .	1.0	79.1

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Upper member--Continued		
Dolomite, gray, weathering light gray; microcrystalline; medium-bedded, steplike ledges, rubbly; laminated near base; locally scattered vugs; rubble comprises uneven angular plates (60-62). . . .	10.4	78.1
Concealed	1.0	67.7
Dolomite, dark purplish-gray, weathering dark gray, mottled purple and reddish-brown; microcrystalline to very finely crystalline; thin-to medium-bedded, 1 inch to 1 foot thick, uneven bedding, steplike ledges thinly laminated, visible on weathered surface; calcite-filled cavities; red ferruginous stained fractures (56-59)	14.5	66.7
Concealed	3.5	52.2
Dolomite, dark gray; clayey, very finely crystalline; irregular slope; shrinkage cracks; small calcite-filled cavities; contains recrystallized crinoid stems (55). .	1.9	48.7
Dolomite, dark gray, mottled red; microcrystalline to finely crystalline; fetid odor; medium-bedded, 4 inches to 1 foot thick beds; rounded steplike slope; calcite-filled cavities; speckled weathered surface (53, 54)	4.6	46.8

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Upper member--Continued		
Concealed	4.6	42.2
Dolomite, dark reddish-brown; finely crystalline; fossiliferous; steplike ledges; red ferruginous staining; crowded with recrystallized brachiopods (51, 52) (IX).	3.0	37.6
Dolomite, reddish-brown; silty; finely crystalline; fossiliferous; slope-forming, crumbly; red ferruginous staining; abundance of brachiopods (49, 50)	2.2	34.6
Dolomite, dark gray, weathering buff, mottled red; mainly aphanitic, recrystallized zones are finely crystalline; thin- to medium-bedded, 1 inch to 1 foot thick, steplike ledges; locally thinly laminated; calcite-filled cavities (46-48). . .	12.7	32.4
Limestone, dark gray; very finely crystalline; slope-forming, uneven bedding; base covered (45)	2.3	19.7
Dolomite, purplish-gray, weathering light buff-gray; microcrystalline; slope-forming (44)	1.0	17.4

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Upper member--Continued		
Dolomite, dark gray, weathering buff, microcrystalline; medium-bedded; steplike ledges; locally laminated; calcite-filled cavities except on cellular weathered surface, cavities 1/4 to 1 inch in diameter; several small crinoid stems (41-43).	5.8	16.4
Dolomite, dark gray, weathering light gray, mottled purple; microcrystalline, subconchoidal fracture; cliff exposure; thinly laminated, visible on weathered surface; irregular pinkish-colored patches (40)	2.2	10.6
Dolomite, dark gray, weathering gray; microcrystalline to very finely crystalline, locally conchoidal fracture; thick-bedded, cliff exposure (38, 39)	2.5	8.4
Sandstone, dolomitic, pinkish-gray, weathering brown; quartzose; medium-grained; medium-bedded, cliff exposure; laminae poorly defined; sandpaper-like surface (37).	0.7	5.9
Dolomite, gray, weathering light gray; microcrystalline, locally sandy; thick-bedded, cliff exposure; sand content increasing upward, exhibiting sandpaper-like surface (36). . .	1.5	5.2

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Upper member--Continued		
Dolomite, gray; sandy, microcrystalline; cliff exposure; fragmental structure; locally sandpaper-like surface (34, 35)	0.5	3.7
Dolomite, pinkish-gray, weathering gray, mottled red; microcrystalline; locally sandy; thick-bedded, cliff exposure; locally thinly laminated, visible on weathered surface; sandpaper-like surface in upper part (32, 33).	2.3	3.2
Dolomite, gray, weathering grayish-brown, mottled purple; sandy, microcrystalline to medium-grained; medium-bedded, cliff exposure; sandpaper-like surface; basal disconformity (31)	0.9	0.9
Devonian--Continued		
Martin formation--Continued		
Middle member: (81.3 feet)		
Dolomite, dark greenish-gray, weathering light gray; lithographic; very thick-bedded, cliff exposure (30). .	4.0	81.3
Dolomite, pink, "Red marker bed"; sandy, microcrystalline to medium-grained; irregular cliff; fragmental structure; sandpaper-like surface (29)	3.3	77.3

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Middle member: (81.3 feet)		
Dolomite, light gray; lithographic, Subconchoidal fracture; steplike ledges (27, 28)	20.0	74.0
Dolomite, purplish-gray, weathering light purplish-gray, mottled purple; lithographic, conchoidal fracture (26)	1.6	54.0
Dolomite, light gray; lithographic, conchoidal fracture; cliff exposure (25)	4.0	52.4
Dolomite, dark gray, weathering light purplish-gray, mottled purple; lithographic, conchoidal fracture; medium-bedded, irregular slope exposure (24)	2.4	48.4
Dolomite, medium to dark gray, weathering light gray; lithographic, conchoidal fracture; medium- to thick-bedded, steplike ledges; three nodular chert zones, at 3, 25 and 28 feet respectively above the base, black ropy chert located 3 feet above the base, other cherty zones contain elongate brown nodules oriented parallel to bedding planes; brown weathered band on surface 4 inches from the top of unit; thinly laminated beds, near base showing on weathered surface (17-23) (VIII). .	32.0	46.0

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Middle member--Continued		
Dolomite, calcitic, very dark gray, weathering light gray; cherty; lithographic, with conchoidal fracture; medium-bedded, cliff exposure; irregular dark gray chert bed 1 to 3 inches thick, parallel to bedding planes; uneven parting 0.8 foot above base containing 2 inch high mounds (16) (VII)	1.0	14.0
Dolomite, dark gray, weathering light gray; lithographic, conchoidal fracture; thin- to medium-bedded, 1 inch to 1 foot thick undulating beds, steplike ledges; nodular chert zones 3 and 6 feet respectively above the base, elongate nodules oriented parallel to bedding planes, lower nodular zone consisting of brown to black chert; thin laminae showing on weathered surfaces (11-15) (VI).	13.0	13.0
Lower member (26.0 feet)		
Limestone, very dark gray, weathering dark brownish-gray; microcrystalline; fetid odor; thin-bedded, undulating, cliff exposure; thinly laminated; scattered lenticular areas contain red clay and calcite; some chert nodules (10) (V).	3.5	26.0

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Lower member--Continued		
Limestone, white to pink, mottled red; microcrystalline; medium-bedded, cliff exposure; thinly laminated; several red clayey lenses 1 to 3 inches thick; calcite geodes (9) (IV)	2.8	22.5
Dolomite, dark gray, weathering gray; microcrystalline; fetid odor; cliff-forming; thinly laminated; minute vugs (8).	16.2	19.7
Dolomite, dark gray; microcrystalline; fetid odor; thin-bedded to massive, steplike ledges; rubbly; thinly laminated, laminae sharply defined; small calcite-filled cavities (6, 7) (III)	3.5	3.5
Cambrian:		
Tapeats sandstone: (40.9 feet)		
Upper member: (24.0 feet)		
Concealed slope	18.0	24.0
Claystone, red; aphanitic, locally sandy, containing thin tabular bands of rounded quartz grains embedded in clay matrix; partly concealed slope (5) (II).	6.0	6.0

	Thickness in feet	
	Unit	To base of member
Cambrian--Continued		
Tapeats sandstone--Continued		
Lower member: (16.9 feet)		
Conglomerate with sandstone, arkosic, reddish-brown; sandstone mainly medium-grained, quartz pebbles maximum diameter of 40 millimeters; ferruginous, friable, rounded step-like ledges; torrential cross-lamination and graded bedding (4) (I)	9.3	16.9
Sandstone, arkosic, reddish-brown; silty, aphanitic to medium-grained; ferruginous, friable, weathering back to form notch in sandstone cliff (3)	1.3	7.6
Sandstone, reddish-brown, banded; fine-grained; quartzose; cliff-forming; thick-bedded; sharply defined laminae alternating between reddish-brown and brown bands; scattered quartz pebbles (2)	2.3	6.3
Sandstone, conglomeratic, reddish-brown; fine-grained to pebble-size; ferruginous, with some siliceous cement; cliff-forming, massive; concave tabular cross-laminae, and locally torrential cross-lamination; graded bedding; laminae 1 to 6 inches thick; lies unconformably over Precambrian rocks (1).	4.0	4.0
Precambrian diabase		

Section 2

Section 2 is located along coordinates N. 1,347,400; E. 445,000, T15N, R2E on the east flank of Mingus Mountain.

Roman symbols as "XXXIII" refer to correlative unit in Section 1.

	Thickness in feet	
	Unit	To base of member
Devonian:		
Martin formation: (443.3 feet)		
Upper member: (319.2 feet)		
Dolomite, dark gray, weathering gray; very finely crystalline; thin- to medium-bedded, irregular cliff; undulating laminae; calcite-filled veins; scattered rounded quartz grains with scattered calcite spots; purple staining; top of unit disconformable with overlying Redwall limestone, irregular erosion surface with 1 foot relief (XXXIII).	1.4	319.2
Concealed, 20° slope except for a 1 foot thick ledge consisting of limestone, pinkish-gray; finely crystalline; crumbly	6.8	317.8
Dolomite, gray, mottled purple; finely crystalline; medium-bedded, 4 inches to 1 foot thick; rounded cliff . . .	2.4	311.0
Dolomite, calcitic, dark pinkish-gray, weathering gray, mottled pink; medium crystalline; slope-forming; large irregular pink mottled patches	1.9	308.6

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Upper member--Continued		
Sandstone, dark reddish-brown; irregular slope-forming.	0.3	306.7
Limestone, pinkish-gray; finely crystalline; medium-bedded, cliff exposure; irregularly banded; 1/4 inch calcite veins at right angles to bedding . .	1.0	306.4
Dolomite, calcitic, pink to dark gray, mottled pink; silty, finely crystalline; irregular crumbly slope; fragmental structure; colonial corals. .	5.7	305.4
Concealed	2.5	299.7
Dolomite, purplish-gray, weathering pinkish-gray; finely crystalline; irregular cliff; thinly laminated; thin calcite-filled veins near right angles to bedding planes; few scattered rounded quartz grains . .	4.0	297.2
Dolomite, gray; cliff exposure	0.5	293.2
Dolomite, calcitic, pinkish-gray, weathering light purplish-gray; sandy, silty, aphanitic; irregular slope-forming; irregularly laminated; calcite patches and thin veins; scattered rounded quartz grains (XXXII)	3.5	292.7

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Upper member--Continued		
Dolomite, gray, weathering light yellowish-brown; finely crystalline; medium-bedded, 4 inches to 1 foot thick, steplike ledges; shrinkage cracks (XXXI).	2.5	289.2
Dolomite, calcitic, purplish-gray; finely crystalline; thick-bedded, rounded cliff; vuggy (XXX)	15.4	286.7
Dolomite, gray, weathering light buff-gray; finely crystalline; medium-bedded, cliff exposure; vuggy and calcite-filled cavities	5.1	271.3
Dolomite, dark gray; very finely crystalline; rounded cliff; coarse cellular structure including interconnected cavities, some containing red clay and calcite . .	1.8	266.2
Cliff-forming beds (XXIX) . . . . . .*		
Dolomite, gray, weathering buff-gray; finely crystalline; cliff-forming, medium- to very thick-bedded; locally poorly defined laminae; cellular weathered surface; calcite-filled cavities . . . . . .*	22.4	264.4
Dolomite, gray; finely crystalline; very thin-bedded . . . . . .*	0.7	242.0

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Upper member--Continued		
Dolomite, dark gray, weathering buff-gray; medium crystalline; very thick-bedded, cliff exposure; red ferruginous staining; cellular weathered surface . . . . . .*	4.5	241.3
Dolomite, dark gray, weathering pinkish-gray; aphanitic; irregularly bedded, blocky, irregular cliff; thinly laminated; 1 inch thick red shale parting at top of unit	4.0	236.8
Concealed slope; loose sample taken 17 feet above base consisting of marble-like red and gray banded silty dolomite (XXVIII).	21.0	232.8
Dolomite, pinkish-gray, mottled red; silty, microcrystalline; slope-forming, thin-bedded, 1 to 4 inches thick . .	1.0	211.8
Concealed	5.5	210.8
Dolomite, dark purplish-gray, weathering reddish-gray, mottled purple; silty, very finely crystalline; slope-forming, very thin-bedded. . .	0.5	205.3
Concealed	1.9	204.8
Dolomite, dark gray, weathering buff, stained red; very finely crystalline; thin-bedded, 1 to 4 inches thick, irregular cliff; irregular patchy ferruginous stained bands; small calcite-filled cavities	1.9	202.9

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Upper member--Continued		
Concealed	2.4	201.0
Dolomite, buff-gray, weathering reddish-gray; silty, very finely crystalline; slope-forming, very thin-bedded, 1/4 to 2 inches thick	1.5	198.6
Concealed 35° slope	5.6	197.1
Dolomite, calcitic, greenish-gray, weathering greenish-buff, mottled red; finely crystalline; thick-bedded, rounded cliff	3.0	191.5
Concealed	3.0	188.5
Limestone, dolomitic, dark gray, weathering buff, mottled purple; aphanitic, medium-bedded, 6 inches to 1 foot thick, rounded steplike ledges; calcite-filled cavities and veins	3.0	185.5
Dolomite, calcitic, dark purplish-gray; weathering buff, mottled purple; finely crystalline; slope-forming, partly concealed; calcite-filled cavities	2.0	182.5
Limestone, dolomitic, interbedded, purplish-gray, mottled yellow; silty, aphanitic to very fine crystalline; thin-bedded, 1 to 4 inches thick, slope, rubbly; powdery surface texture	6.1	180.5

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Upper member--Continued		
Concealed 35° slope	7.0	174.4
Dolomite, gray, weathering light buff-gray; very finely crystalline; irregular cliff; red stained joints	5.0	167.4
Shale, red; aphanitic; fissile; slope-forming; partly concealed	5.0	162.4
Dolomite, pale greenish-gray weathering dark buff-gray, mottled purple; finely crystalline; friable, rounded steplike ledges; calcite-filled cavities (XXVII)	6.7	157.4
Dolomite, reddish-gray, weathering light buff, mottled red; microcrystalline; irregular cliff; stylolitic surface containing red ferruginous material (XXVI)	3.8	150.7
Dolomite, dary grak, weathering dark buff; microcrystalline; undulating beds, banded, irregular cliff (XXV)	1.4	146.9
Dolomite, purplish-gray, weathering pinkish-gray, mottled purple; silty, microcrystalline, and aphanitic; irregular cliff; purple speckled weathered surface, locally powdery texture; thin calcite veins; locally calcareous (XXIV)	12.0	145.5

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Upper member--Continued		
Dolomite, pale brownish-gray, weathering buff; very finely crystalline; medium-bedded, 2 inches to 1.5 feet thick, steplike ledges, blocky; undulating laminae; unit disconformably overlies underlying unit with a relief of about 6 inches (XXIII)	4.0	133.5
Dolomite, pinkish-gray; silty, microcrystalline; thin- to medium-bedded, 7 inches to 1.5 feet thick, cliff exposure; calcite-filled cavities with maximum diameter of 2 inches; basal disconformity (XXII)	0.6	129.5
Dolomite, dark greenish-gray, finely crystalline; fetid odor; medium-bedded, cliff exposure	0.8	128.9
Dolomite, gray, mottled red; microcrystalline; medium-bedded, steplike ledges, blocky; vertical jointing; thinly-laminated; calcite-filled cavities; red stained joints (XXI)	3.3	128.1
Dolomite, dark greenish-gray, weathering buff; microcrystalline; fetid odor; cliff exposure (XX)	0.4	124.8
Dolomite, pinkish-gray, mottled purple, microcrystalline; thin- to medium-bedded, 1 inch to 1 foot thick, steplike ledges; thinly laminated; purple speckled weathered surface; thin calcite veins	6.4	124.4

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Upper member--Continued		
Dolomite, pinkish-gray, weathering gray; sandy, silty, aphanitic to medium-grained; irregular slope-forming; crowded with rounded quartz grains; red shaly parting at top of unit; partly concealed slope (XIX)	1.2	118.0
Dolomite, pale purplish-gray, weathering buff; microcrystalline; step-like ledges; thin undulating laminae; scattered rounded quartz grains (XVIII)	4.8	116.8
Dolomite, calcitic, dark greenish-gray weathering dark buff; microcrystalline; very thick-bedded, rounded cliff; thinly laminated; 1/2 inch diameter, calcite-filled cavities. .	9.5	112.0
Dolomite, gray, weathering buff; very finely crystalline; medium-bedded, 3 inches to 1 foot thick, steplike ledges; vertical jointing	7.0	102.5
Dolomite, dark greenish-gray, weathering dark buff; very finely crystalline; fetid odor; cliff-forming, thick-bedded; cellular weathered surface; calcite-filled cavities (XVII)	2.0	95.5
Dolomite, dark gray, weathering buff, mottled red; microcrystalline; medium-bedded, irregular rounded cliff, blocky; calcite-filled cavities; scattered recrystallized crinoid stems (XVI)	2.3	93.5

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Upper member--Continued		
Dolomite, gray, weathering light buff; microcrystalline; irregular slope; vertical jointing (XV)	3.0	91.2
Dolomite, dark purplish-gray, weathering dark buff; microcrystalline; irregular steplike ledges; laminated, purple bands (XIV)	2.2	88.2
Dolomite, pinkish-gray, weathering light buff; silty, microcrystalline; cliff exposure; undulating laminae, lenticular (XIII)	0.8	86.0
Dolomite, gray, weathering buff; microcrystalline; fetid odor; irregular slope; jointed; scattered rounded quartz grains (XII)	1.0	85.2
Dolomite, very dary gray, weathering buff; microcrystalline; thick-bedded, 1.5 feet thick, cliff exposure; laminae appearing on weathered surface (XI)	3.0	84.2
Dolomite, light pinkish-gray, weathering buff; sandy, microcrystalline to medium-grained; rounded quartz grains; graded laminae; sandpaper-like weathered surface (X)	2.5	81.2
Dolomite, gray; microcrystalline; thin-bedded, beds 2 to 4 inches thick, uneven partings, rubbly; laminae poorly defined on weathered surface; calcite-filled cavities; chipped weathered surface	10.0	78.7

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Upper member--Continued		
Dolomite, gray, weathering light buff, mottled purple; microcrystalline; thick-bedded, rounded steplike ledges; scattered irregular purple areas	7.5	68.7
Dolomite, gray, weathering light buff, mottled red and purple; microcrystalline; fetid odor; thin- to thick-bedded; locally laminated visible on weathered surface; calcite-filled cavities	14.0	61.2
Dolomite, calcitic, reddish-brown, mottled reddish-brown and dark gray; finely crystalline; irregular cliff	0.5	47.2
Dolomite, dark gray, weathering buff, mottled dark gray; microcrystalline to very finely crystalline; fetid odor; medium-bedded, 4 inches thick, steplike ledges; large calcite-filled cavities	7.8	46.7
Dolomite, reddish-brown, weathering dark gray, mottled red; very finely crystalline; irregular slope; calcite-filled cavities; patchy weathered surface; a 1 inch thick calcareous fissile shale parting 1.5 feet above base	9.0	38.9

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Upper member--Continued		
Dolomite, yellowish- to reddish-brown; silty, very fine-grained; thin- to medium-bedded, 1 to 6 inches thick, uneven bedding, irregular crumbly slope; red ferruginous staining	2.0	29.9
Dolomite, dark gray, weathering reddish-brown, mottled red; very finely crystalline; irregular crumbly slope, uneven bedding; recrystallized fossils, possibly brachiopods; calcite-filled cavities	4.7	27.9
Dolomite, dark reddish-brown, mottled purple; fossiliferous; medium crystalline; medium-bedded, rounded cliff; speckled weathered surface; crowded with recrystallized brachiopods sharply defined on weathered surface, small scattered crinoid stems, fossils commonly recrystallized to dolomite, but locally calcite (IX)	0.8	23.2
Dolomite, gray, weathering buff, mottled purple; microcrystalline; slope-forming, partly concealed . .	6.0	22.4
Dolomite, dark gray, weathering buff; microcrystalline; irregular cliff, blocky; thin laminae appearing on weathered surface	4.5	16.4

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Upper member--Continued		
Dolomite, dark purplish-gray, weathering buff; fossiliferous; very finely crystalline; very thin- to medium-bedded, irregular slope, uneven bedding; recrystallized gastropods in sharp relief on weathered surfaces, possibly some brachiopods; several calcite zones	2.8	11.9
Dolomite, gray, mottled purple; microcrystalline; medium-bedded, rounded cliff; laminated, containing purple colored bands; calcite-filled cavities	2.2	9.1
Dolomite, dark gray, weathering buff, mottled purple; microcrystalline; cliff-forming; thin- to thick-bedded, 1 inch to 1.5 feet thick beds, uneven bedding; cellular surface, 3/4 inch diameter cavities, some are calcite-filled	6.9	6.9
Middle member: (96.2 feet)		
Dolomite, pinkish-gray, mottled red; microcrystalline, subconchoidal fracture; medium-bedded, cliff exposure; laminated	1.0	96.2

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Upper member--Continued		
Dolomite, gray, weathering light gray, mottled red; lithographic, sub-conchoidal fracture; medium- to thick-bedded, steplike ledges; undulating laminae; chert lens 10 feet above base of unit; two red dolomite bands, 3 and 6 inches thick respectively, at 1 and 6 feet above the base, exhibit microcrystalline textures; an arenaceous band, 3 inches thick, 2 feet above base of unit may represent "Red marker bed," the band exhibits sandpaper-like surface	13.7	95.2
Dolomite, light gray, mottled purple; lithographic, locally conchoidal fracture; steplike ledges; locally shrinkage cracks	21.4	81.5
Dolomite, light gray, mottled dark purple; lithographic, conchoidal fracture; commonly medium-bedded, steplike ledges; four tabular, purple mottled bands 2 to 3 inches thick at 9, 13, 16 and 17 feet respectively above the base; gray dolomite exhibits conchoidal fracture, mottled rock appears coarser grained	18.5	60.1

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Middle member--Continued		
Dolomite, gray; lithographic; thick-bedded, 2 feet thick beds, steplike ledges; brown nodular chert zone 2 feet above base of the unit. . . .	4.1	41.6
Dolomite, medium to dark gray, weathering light gray; lithographic, conchoidal fracture; thick-bedded, commonly 1.5 feet thick, steplike ledges; black chert zones at 3 and 6 feet respectively above the base, brown nodular chert zones at 2.5, 10, 11 and 19 feet respectively above base, nodules are elongate parallel to bedding planes; minute siliceous box-work appearing on weathered surface at 16 feet above base (VIII)	24.5	37.5
Dolomite, gray; medium-bedded, 1 foot thick, steplike ledges	2.0	13.0
Dolomite, calcitic, very dark gray, weathering gray; cherty; lithographic, conchoidal fracture; medium-bedded, cliff exposure; yellowish-gray chert nodules and locally green chert bed 1 1/2 inches thick at top of unit (VII)	0.7	11.0

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Middle member--Continued		
Dolomite, dark gray, weathering gray; lithographic, with conchoidal fracture; undulating bedding, steplike ledges; brown to black nodular chert zones at 4 and 8 feet respectively above the base, elongate nodules oriented parallel to bedding planes (VI)	10.0	10.3
Dolomite, dark gray; lithographic; cliff exposure; basal disconformity, with a relief of about 4 inches . .	0.3	0.3
Lower member: (27.9 feet)		
Limestone, gray, weathering brownish-gray; finely crystalline; fetid odor; cliff exposure; thinly laminated (V)	1.8	27.9
Dolomite, dark gray, weathering buff; microcrystalline; fetid odor; thin-bedded, 2 inches thick, cliff exposure; thinly laminated; calcite bands	2.3	26.1
Limestone, white to red, mottled red; finely crystalline; thick-bedded, rounded slope; calcite-filled cavities (IV)	2.1	23.8

	Thickness in feet	
	Unit	To base of member
Devonian--Continued		
Martin formation--Continued		
Lower member--Continued		
Dolomite, gray, weathering dark gray; finely crystalline; fetid odor; cliff-forming, medium-bedded, undulating bedding; thin laminae exhibited on weathered surface; vugs	3.2	21.7
Dolomite, calcitic, red; very finely crystalline; local lens	0.2	18.5
Dolomite, calcitic, gray, weathering light buff, mottled pink; very finely crystalline; fetid odor; thick-bedded, cliff exposure	2.8	18.3
Dolomite, dark gray, microcrystalline; fetid odor; medium- to thick-bedded, 6 inches to 2 feet thick, steplike ledges; vugs, some calcite-filled cavities	10.0	15.5
Dolomite, dark gray, weathering buff; microcrystalline; fetid odor; medium to very thin beds upward, 1/4 inch to 1 foot thick, rubbly, cliff exposure; thinly laminated, laminae sharply defined (III)	5.5	5.5

Cambrian:

Tapeats sandstone: (48.6 feet)

Upper member: (21.6 feet)

Claystone, dolomitic, pink; aphanitic; very thin- to thin-bedded, beds 1/4 to 2 inches thick, rubbly, irregular slope-forming; dendrites common on partings	4.0	21.6
Concealed	2.0	17.6
Siltstone, greenish-gray, weathering buff; clayey to sandy; irregular slope-forming; contains scattered quartz grains	1.1	15.6
Concealed	5.5	14.5
Siltstone, dolomitic, dark gray, mottled red; aphanitic; irregular slope; partly concealed	1.4	9.0
Claystone, red, aphanitic, locally sandy; thin tabular bands of embedded quartz grains; crumbly slope (II)	7.6	7.6

Lower member: (27.0 feet)

Sandstone, grading upward to conglomerate, reddish-brown; sandy; mainly quartzose with locally ferruginous cement; medium-bedded, rounded steplike ledges; tabular laminae, subangular to subrounded and frosted quartz pebbles (I)	1.1	27.0

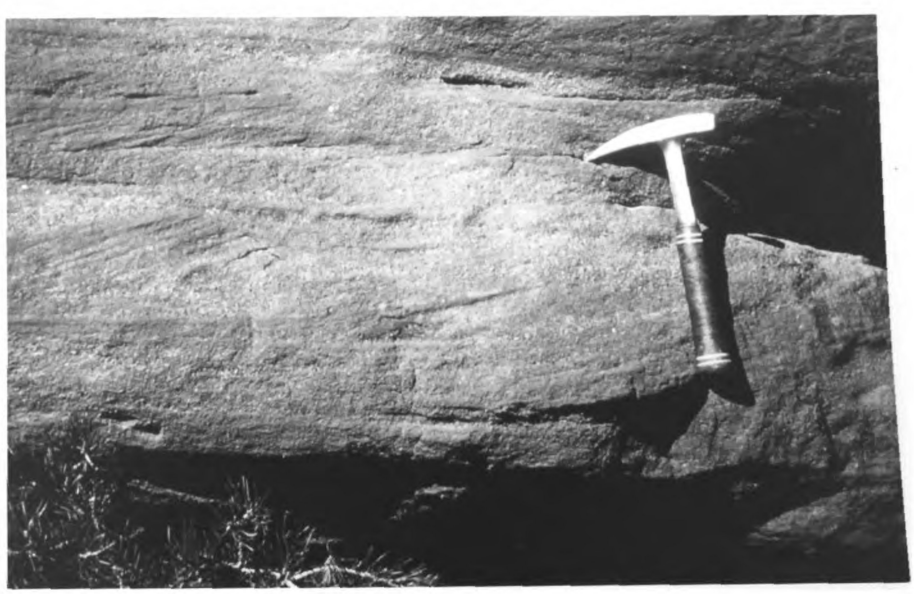
	Thickness in feet	
	Unit	To base of member
Cambrian--Continued		
Tapeats sandstone--Continued		
Lower member--Continued		
Conglomerate, arkosaic, reddish-brown; sandy, uneven-grained; mainly quartzose, with some ferruginous cement; very thick-bedded, rounded cliff; torrential cross-laminae, tabular laminae, graded bedding 2 inches thick; maximum size of quartz pebbles 10 millimeters, subrounded and frosted quartz with scattered feldspar grains (I).	9.1	25.9
Sandstone, reddish-brown; silty, aphanitic to coarse-grained; friable, thick-bedded, steplike ledges; tabular laminae	4.0	16.8
Arkose, conglomeratic, reddish-brown; very fine-grained to pebbly; ferruginous; cliff-forming, thick-bedded; torrential cross-laminae, 1/2 inch thick; abundance of varying grain size orthoclase feldspar	6.0	12.8
Sandstone, reddish-brown; fine-grained; quartzose; cliff-forming, massive, blocky; ferruginous stained; ironstone at base; base of member is covered	6.8	6.8
Precambrian diabase		

A. Mingus Mountain, Precambrian to Pliocene.

B. Exposure of Precambrian to Middle Martin.

Plate I

A. Exposure of Lower, Middle, and Upper Martin.



B. Cross-lamination at base of Tapeats.

Plate II

A. Banded sandstone in lower member of Tapeats.

B. Bedded chert in lithographic dolomite.

Plate III

A. Nodular chert in lithographic dolomite.

B. Sandpaper-like weathered surface.

Plate IV

A. Disconformity in Upper Martin member.

B. Disconformity between Martin and Redwall.

Plate V

APPENDIX B

Microscopic Description

and

Photomicrographs

of

Section 1

Mingus Mountain Area

Section 1

127 Thin section: Equigranular aphanitic texture, average grain size .01 mm; rock is spotted with 0.5 mm well-rounded quartz grains and 1 mm calcite-filled cavities, scattered carbonate rhombohedra ranging in size from .04 to 0.2 mm inside the calcite, contains ferruginous staining; single calcite crystals fill irregular, ellipsoidal, and crescent-shaped areas and narrow fractures.

Insol. residue: Less than 1 per cent residue; consists of quartz grains, subangular to rounded and pitted silt; several grains of ilmenite and glauconite; minor amount of gray clay.

126 Thin section: Equigranular subhedral mosiac, average grain size .07 mm; numerous zoned rhombohedra scattered throughout mosiac; few grains of microcrystalline quartz, .02 mm size, euhedral relative to dolomite; contains calcite.

Insol. residue: Silt content slight; hematite grains; pale red clay.

125 Thin section: Inequigranular anhedral mosaic, grain size commonly 0.15 mm, ranging from .04 to 0.3 mm; several zoned rhombohedra of varying sizes with maximum diameter of 0.3 mm; scattered well-rounded quartz grains, an embedded spherical quartz grain, 0.4 mm in diameter is idiomorphic against surrounding anhedral crystalline dolomite; a lenticular area of relict microcrystalline texture with a grain size of .02 mm exhibits irregular, partly recrystallized edges consisting of 0.1 mm diameter rhombohedra; scattered quartz prisms with a diameter of .02 mm are euhedral relative to dolomite; refer to Plate XII.

Insol. residue: Abundant frosted and commonly well-rounded with some subangular quartz grains ranging from silt size to 1 mm diameter; several ilmenite and glauconite grains; brownish-gray clay; some quartz grains coated with iron oxide.

124 Thin section: Inequigranular anhedral mosaic, average crystal size .15 mm, ranging from .04 to 0.3 mm; scattered rhombohedra, some are zoned; few quartz chips and prisms idiomorphic against dolomite.

Insol. residue: Less than 10 per cent; minor amount of angular to rounded and frosted silt size quartz, with several 0.3 mm size grains; few glauconite specks.

123 Thin section: Equigranular microcrystalline texture, grain size is .005 mm; calcite-filled cavity contains 4.0 mm crystal, twinning present; scattered quartz prisms, .04 to 0.1 mm diameter embedded in calcite; lenticular zones contain concentrations of silt size quartz; red iron oxide abundant.

Insol. residue: Fine quartz silt abundant; few scattered well-rounded and frosted quartz grains commonly 0.5 mm diameter; contains pink clay; well developed prisms of secondary overgrowths surround spherical frosted quartz grains; refer to Plate XI, B.

122 Thin section: Tabular laminated structure; equigranular microcrystalline texture, grain size .005 mm, but one millimeter thick horizontal band of coarser grained texture with silt size quartz concentrations, maximum diameter of dolomite and quartz grains 0.1 mm size, average size about .02 mm.

122 (Continued)
Insol. residue: Abundant fine silt size quartz with several scattered well-rounded and frosted quartz grains, largest is 0.4 mm diameter; few glauconite and ilmenite grains; contains very pale gray clay.

121 Acetate peel: Vuggy structure; inequigranular anhedral mosaic, commonly 0.2 mm size crystals; rhombohedra having a maximum diameter of 0.6 mm.

Insol. residue: Less than 5 per cent residue; principal constituent is fine silt size frosted quartz grains and prisms with several larger well-rounded and frosted quartz with a maximum diameter of 0.5 mm; few ilmenite grains; slight amount of pale purple clay.

120 Thin section: Inequigranular, anhedral mosaic, locally porous, grain sizes range from .02 to about 0.2 mm; rhombohedra poorly developed, some are zoned; calcite areas 1 to 2 mm in length, some are elliposidal containing anhedral calcite with maximum diameter of 0.4 mm; quartz prisms embedded in calcite; rounded quartz grains are idiomorphic against ahedral dolomite; red iron oxide staining concentrated in calcite areas.

Insol. residue: Relative abundance of angular to rounded fine silt size quartz prisms and chips, some are pitted; few ilmenite, hematite, and glauconite grains.

119 Thin section: Inequigranular anhedral mosaic, grain size ranges from .04 to 0.4 mm; irregular areas contain anhedral calcite and dolomite about 0.2 to 0.4 mm diameter; many zoned rhombohedra; few quartz prisms .02 mm diameter embedded in dolomite; several twinned grains; red iron oxide concentrated in calcite areas.

119 (Continued)
Insol. residue: Residue less than 1 per cent; fine silt size quartz grains and prisms; several well-rounded grains about 0.3 mm diameter; few ilmenite, hematite, and glauconite grains.

118 Thin section: Laminated and vuggy structure; equigranular aphanitic texture, average grain size .02 mm; laminae consist of alternating porous and non-porous bands about 3.0 mm thick; the coarser-grained vuggy bands contain concentrations of well-rounded quartz grains with a maximum diameter of 0.6 mm along with silt and clay size particles, grain size of carbonate matrix is about .03 mm, automorphic rhombohedra and quartz prisms concentrated along borders of vugs; average size of non-porous bands is .01 mm; refer to Plate XI, A.

Insol. residue: Residue less than 1 per cent; angular to rounded silt size quartz, varying sizes of colorless and wine-colored quartz prisms; several well-rounded and frosted quartz grains, also ilmenite and glauconite.

117 Thin section: Loosely interlocking, inequigranular anhedral mosaic, average grain size .12 mm; interstitial spaces are filled with red ferruginous staining; many well-developed rhombohedra, some are zoned; angular quartz .02 to .04 mm, idiomorphic against dolomite.

Insol. residue: Less than 5 per cent residue; angular to subrounded and pitted silt size quartz; hematite with several ilmenite grains; abundant red clay.

116 Acetate peel: Fragmental structure; loosely interlocking, inequigranular anhedral mosaic surrounding the fragments with aphanitic textures, anhedral crystals commonly 0.2 mm size, aphanitic grain size about .02 mm; red ferruginous staining around coarse grains; sharp contact around fragments.

Insol. residue: Small amount; subangular pitted silt size quartz, also silt size colorless and wine-colored quartz prisms; hematite with few ilmenite grains; abundant reddish-brown clay.

115 Thin section: Equigranular anhedral mosaic, average grain size 0.1 mm; containing several anhedral chert grains 0.8 mm diameter; zoned dolomite rhombohedra 0.5 mm, in recrystallized areas.

Insol. residue: Residue less than 1 per cent; very small amount of angular silt size quartz, several well-rounded and frosted quartz grains with maximum diameter of 0.4 mm; several muscovite, hematite, and glauconite grains; contains red clay.

114 Insol. residue: Abundant angular to rounded silt size quartz .05 mm; few grains of ilmenite and glauconite; abundance of purple clay.

113 Thin section: Tightly interlocking, inequigranular anhedral to subhedral mosaic, average crystal size .25 mm, ranging from .04 to 0.5 mm; several rhombohedra, some are zoned, dolomite idiomorphic against possibly calcite crystals; sparsely scattered quartz prisms enclosed in dolomite; few chert grains.

Insol. residue: Less than 5 per cent residue; silt size quart prisms; several glauconite grains; minor amount of brown clay.

112 Thin section: Equigranular aphanitic texture, average grain size .015 mm; scattered angular quartz grains of equal size.

Insol. residue: Abundance of fine angular, slightly etched, silt size quartz grains and prisms, uniform texture, several sand grains with a maximum diameter of 0.2 mm; many hematite with a few glauconite grains; abundance of purple clay.

111 Acetate peel: Marble-like banded structure; equigranular aphanitic texture, average grain size .01 mm, largest grains .05 mm; colorful marble-like structure of wavy red bands inside gray material.

Insol. residue: Abundance of fine silt size angular quartz grains of uniform texture appear to be slightly pitted; many fine hematite grains of equal size; few glauconite grains; much pink clay.

110 Thin section: Marble-like banded structure; equigranular aphanitic texture, average grain size .02 mm; largest dolomite grains .07 mm; colorful marble-like structure of red and gray bands; scattered quartz grains of equal size; refer to Plate X, B.

Insol. residue: Abundance of fine silt size angular quartz grains, uniform size, slightly etched; many hematite grains of equal size; few glauconite grains; contains bright red clay.

109 Acetate peel: Equigranular aphanitic texture, average grain size is .015 mm; local red staining.

Insol. residue: Abundant residue, fine angular silt size quartz; grain size is uniform; quartz appears to be slightly etched; many fine hematite grains; much purplish-gray clay.

108 Thin section: Loosely interlocking, inequigranular aphanitic texture, average grain size about .02 mm, maximum grain size 0.1 mm; scattered angular quartz silt of equal size; red stained.

Insol. residue: Abundant insoluble material; fine silt size quartz with fine hematite grains; much purplish-gray clay.

107 Thin section: Tabular laminated structure; inequigranular aphanitic texture, average grain size .02 mm, maximum size .06 mm, dolomite and angular quartz grains; laminae consist of reddish-brown and yellowish-brown bands 0.2 to 2 mm thick, moderately defined.

Insol. residue: Incomplete disintegration; many rock fragments; abundant residue; containing fine angular silt size quartz; hematite, and several rounded and pitted quartz grains; purplish-gray clay.

106 Thin section: Inequigranular aphanitic texture, average grain size .02 mm; about 20 per cent angular quartz grains, average size about .04 mm; lenticular concentrations.

Insol. residue: Abundant silt size quartz residue, grains angular to subrounded and pitted; several ilmenite and glauconite grains; buff colored clay.

105 Acetate peel: Inequigranular, very fine-grained texture, average grain size about .07 mm; crowded with quartz grains, maximum diameter of well-rounded grains 0.5 mm.

Insol. residue: Residue essentially consisting of rounded and pitted silt size quartz; some large well-rounded and pitted grains, maximum diameter of 0.5 mm; several ilmenite, hematite, and glauconite grains; some quartz grains coated with red stain.

104 Thin section: Irregular, lenticular, laminated structure; inequigranular aphanitic texture, average grain size .005 mm; some laminae contain concentrations of angular silt size quartz with a few large subangular to well-rounded quartz grains 0.1 to 0.7 mm diameter, and patches of recrystallized microfossils, several dolomite rhombohedra and quartz prisms included in recrystallized areas.

Insol. residue: Abundance of subangular to subrounded and pitted silt size quartz; large quartz grains are well-rounded and pitted to frosted.

103 Acetate peel: Lenticular laminated structure; inequigranular aphanitic to fine-grained texture; grain sizes range from .02 to 0.4 mm; large well-rounded quartz grains concentrated in some of the moderately defined laminae; laminae 0.5 to 4 mm thick.

Insol. residue: Residue consists of silt size quartz to well-rounded and pitted to frosted quartz sand 0.5 mm diameter; some shell fragments; few ilmenite, hematite, glauconite, and pyrite grains.

102 Thin section: Loosely interlocking, inequigranular anhedral mosaic, average grain size about 0.1 mm, ranging from .05 to 0.3 mm; scattered zoned rhombohedra; red ferruginous staining in recrystallized areas and around dolomite grains; quartz prisms .02 mm diameter idiomorphic against dolomite.

Insol. residue: Residue less than 1 per cent; contains fine angular silt size quartz and hematite; a few grains of ilmenite and glauconite; purple clay.

101 Acetate peel: Loosely interlocking, inequigranular anhedral mosaic, average grain size about 0.1 mm; several zoned rhombohedra with grain sizes of 0.1 to 0.2 mm; red stained areas.

Insol. residue: Abundant insoluble material including incompletely disintegrated fragments; content contains hematite; minor amount of angular silt size quartz, several are slightly etched; maximum diameter of angular quartz grain is 0.2 mm; few ilmenite grains.

100 Thin section: Marble-like red and gray banded structure; equigranular aphanitic texture, average grain size .005 mm; scattered angular silt size quartz .02 mm diameter contrasted by several large well-rounded quartz 0.2 mm size grains; ferruginous stained recrystallized vein 0.2 mm thick.

Acetate peel: Recrystallized stylolitic surface 0.2 mm thick.

Insol. residue: Consists of abundance of subangular fine silt size quartz grains, slightly pitted; several hematite and ilmenite grains.

99 Acetate peel: Inequigranular aphanitic texture, average grain size about .01 mm.

Insol. residue: Abundance of subangular to rounded fine silt size quartz, several large well-rounded and pitted to frosted grains, maximum size 0.2 mm; several hematite and glauconite grains; reddish-purple clay.

98 Acetate peel: Sharply defined, tabular laminated structure, bands range from 0.5 to 5 mm thick; equigranular aphanitic texture, average grain size .005 mm; large well-rounded quartz grains 0.1 to 0.6 mm diameter scattered among fine-grained material, concentrated in certain laminae.

98 (Continued)
Insol. residue: Consists of quartz grains, commonly well-rounded and frosted ranging from silt size to 0.5 mm diameter; few hematite and ilmenite grains; pinkish-gray clay.

97 Acetate peel: Equigranular aphanitic texture, average grain size about .005 mm.

Insol. residue: Minor amount of fine angular silt size grains and prisms; several hematite and glauconite grains; reddish-brown clay.

96 Acetate peel: Inequigranular anhedral mosaic, average size about 0.2 mm, largest grains 0.5 mm; recrystallized areas contain anhedral crystals with maximum diameter of 1 mm.

Insol. residue: Angular silt size quartz grains with well-developed quartz prisms; several hematite, ilmenite, and glauconite grains; reddish-brown clay.

95 Thin section: Loosely interlocking, porous, inequigranular anhedral mosaic, average grain size about 0.1 mm, ranging from .02 to .4 mm; zoned rhombohedra; red staining surrounds grains.

Insol. residue: Scattered angular silt size quartz; several glauconite grains; red clay.

94 Acetate peel: Inequigranular subhedral mosaic, average grain size about 0.3 mm, ranging from .04 to 0.8 mm; broad interstitial spaces, commonly calcite-filled; dolomite idiomorphic against calcite; many rhombohedra of varying sizes.

Insol. residue: Residue less than 1 per cent; essentially very fine silt size quartz prisms; several hematite and ilmenite grains.

93 Thin section: Inequigranular, anhedral mosaic; locally tightly interlocking, average grain size 0.2 mm, ranging from .02 to 0.5 mm; some zoned thombohedra; scattered .01 mm size angular quartz grains.

Insol. residue: Less than 1 per cent residue; scattered pitted silt size quartz prisms, several grains of hematite, ilmenite, and glauconite; pale red clay.

92 Thin section: Tightly interlocking, inequigranular anhedral mosaic, average grain size .07 mm, ranging from .02 to .25 mm; ellipsoidal, light colored recrystallized areas parallel to bedding planes, possibly calcite with zoned rhombohedra containing siderite, ferrugionous material concentrated in recrystallized areas; crystalline quartz, .02 mm diameter, euhedral against carbonates.

Insol. residue: Very little residue, less than 1 per cent; consisting of pitted silt size quartz prisms with hematite; several ilmenite and glauconite grains; pink clay.

91 Thin section: Inequigranular anhedral mosaic, average grain size .07 mm, ranging from .02 to 0.2 mm; many irregular areas of light colored recrystallized carbonate, possibly calcite, crystallization appears to originate along interstices, maximum size of crystals 0.5 mm, rhombohedra, embedded in calcite, zoned and stained with red ferruginous material, some calcite areas are stained; angular silt size quartz idiomorphic against carbonates; vein calcite crystal 2 mm in length; faintly defined, relict aphanitic texture, grain size .02 mm.

Insol. residue: Residue less than 1 per cent, consists of fine angular silt size quartz grains and prisms; several ilmenite grains; pale red clay.

90 Thin section: Tightly interlocking, inequigranular anhedral mosaic, average grain size about .09 mm, ranging from .02 to 0.3 mm; irregular calcite-filled veins and areas, commonly 0.5 mm size calcite crystals; carbonates idiomorphic against quartz, scattered secondary quartz masses ranging from .02 to 0.2 mm; refer to Plate X, A.

Insol. residue: Residue less than 1 per cent; containing angular, clear to pitted, silt size quartz grains and prisms; several hematite, ilmenite, and glauconite grains; reddish-brown clay.

89 Acetate peel: Equigranular aphanitic texture, grain size about .01 mm, several scattered quartz grains .02 mm diameter.

Insol. residue: Very little residue, less than 1 per cent; consisting of several subangular to subrounded, slightly pitted, silt size quartz with ilmenite and glauconite grains.

88 Thin section: Essentially, equigranular aphanitic texture with many irregular, light colored, recrystallized areas; aphanitic grains average about .015 mm; recrystallized zones consist of calcite, dolomite, and quartz, crystal sizes range from .03 to 2 mm, well-developed, 0.1 mm size dolomite rhombohedra are idiomorphic against calcite and quartz; crystalline zones include oval- and ring-shaped recrystallized microfossils; refer to Plate IX, B.

Insol. residue: Very little residue, less than 1 per cent; several grains of silt size quartz masses and prisms with ilmenite and hematite grains.

87 Thin section: Equigranular aphanitic anhedral mosaic, average grain size .02 mm; scattered angular quartz grains ranging in size from .01 to .02 mm.

Insol. residue: Very little residue, less than 1 per cent; several fine angular silt size quartz, rounded and pitted quartz grains .15 mm diameter with hematite.

86 Thin section: Laminated structure; equigranular aphanitic texture; laminae consist of alternating light brown and dark brown irregular wavy bands 0.1 to 1 mm thick; average grain size about .015 mm; several scattered quartz crystals ranging from .01 to .04 mm.

Insol. residue: Residue less than 1 per cent; essentially fine angular silt size quartz grains; several hematite, ilmenite, and glauconite grains.

85 Acetate peel: Crumbly patchy structure; essentially equigranular aphanitic texture, grain size about .02 mm diameter; contains contrasting large well-rounded embedded quartz grains 0.1 to 0.6 mm; enclosed patches consist of subhedral mosaics, average grain size 0.1 mm, sharply defined rhombohedra idiomorphic against possibly calcite.

Insol. residue: Principal constituent, subangular silt size to many well-rounded and frosted, 0.7 mm diameter, quartz grains with hematite.

84 Acetate peel: Equigranular aphanitic texture, average grain size about .01 mm.

Insol. residue: Very little residue, less than 1 per cent; essentially angular to well-rounded and pitted quartz grains, some coated with red stain; several hematite and ilmenite grains.

83 Thin section: Laminated structure, inequigranular aphanitic texture; average grain size about .02 mm; red ferruginous stained stylolitic surface separates section, stained front appears to move upward from below, lower fabric darker, angular quartz as large as 0.1 mm inside stylolite lobe, lower area contains many irregular and small oval-shaped light-colored crystallized zones some calcite-filled, some possibly recrystallized microfossils; grain size increasing downward to 0.1 mm grains with zoned rhombohedra; rounded quartz grain .15 mm.

Insol. residue: Less than 1 per cent residue; angular silt to 0.5 mm size quartz, several rounded and pitted grains; also hematite, ilmenite, and limonite.

82 Thin section: Irregular, laminated structure; inequigranular aphanitic texture; grain sizes vary with laminae; lenticular laminated bands poorly defined; grain sizes commonly range from .02 to .04 mm; irregular light-colored calcite-filled zones, bordering rhombohedra and silt size quartz idiomorphic against calcite; silt size quartz scattered throughout mosiac.

Insol. residue: Scattered fine angular silt size quartz; several hematite and ilmenite grains.

81 Acetate peel: Irregularly laminated structure; inequigranular texture; enclosed fragments possess aphanitic texture, grain size about .02 mm; grain size of surrounding material averages about 0.1 mm; cavity filling commonly saw-toothed pattern of zoned carbonates possibly both calcite and dolomite.

Insol. residue: Residue less than 5 per cent; angular to well-rounded, pitted to frosted silt size to 0.3 mm quartz grains with hematite; several grains of ilmenite and limonite.

80 Thin section: Equigranular aphanitic texture, average grain size .01 mm; irregular linear and circular zones of light-colored coarser-grained carbonates; maximum diameter of rhombohedra 0.1 mm; circular areas possibly crinoid stems; scattered angular quartz; stylolitic surfaces.

Insol. residue: Disaggregation incomplete, large subangular fragments, major amount of dolomite rock material retained; scattered hematite and glauconite grains.

79 Acetate peel: Laminated structure poorly defined, graded laminae; inequigranular texture, grain size of quartz ranging from .01 to 0.7 mm, average size of well-rounded quartz grains about 0.3 mm, some large grains embedded in fine silt; locally red ferruginous staining.

Insol. residue: Abundant subrounded to well-rounded and frosted silt size quartz, scattered well-rounded and frosted sand with a maximum diameter of 0.7 mm, glauconite grains; contains pink clay.

78 Thin section: Equigranular aphanitic texture, average grain size .01 mm; circular calcite-filled cavity, largest contained crystal 0.5 mm diameter, concentrations of angular quartz grains with sizes commonly ranging from .02 to .04 mm, quartz idiomorphic against calcite, red ferruginous staining concentrated in cavity; several small rounded areas may represent recrystallized crinoid stems.

Insol. residue: Very little residue; consisting essentially of angular to rounded silt size quartz with some rounded and pitted quartz grains; several hematite and glauconite grains.

77 Thin section: Laminated structure, faintly defined graded laminae; inequigranular texture, grain size ranges from .01 to 0.7 mm, well-rounded quartz grains are embedded in fine angular 01. to .04 mm size silt; pressure solution between well-rounded quartz grains; linear red ferruginous staining.

Insol. residue: Disaggregation incomplete, several rock fragments, major rock material retained; residue consists essentially of subrounded to rounded and frosted silt size quartz and scattered large well-rounded, frosted grains; scattered hematite grains; several red iron oxide coated grains.

76 Thin section: Equigranular aphanitic texture, average grain size about .02 mm, scattered irregular areas of light-colored carbonate average grain size .06 mm.

Insol. residue: Residue less than 5 per cent; very fine silt size quartz; several hematite and ilemite grains.

75 Acetate peel: Irregular laminated structure, ferruginous stained bands .5 to 5 mm thick; equigranular texture, average size about .01 mm.

Insol. residue: Very little amount of residue, less than 1 per cent; principal constituent is hematite; several pitted quartz, ilmenite, and glauconite grains; some very fine silt size quartz; containing purple clay.

74 Thin section: Equigranular anhedral mosaic, dark gray, average grain size 0.1 mm; scattered irregular zones of light-colored recrystallized carbonate; scattered angular quartz grains .02 to .04 mm size idiomorphic against carbonates.

74 (Continued)
Insol. residue: Very little amount, less than 1 per cent residue; grains of angular silt size quartz and ilmenite; slight organic content.

73 Thin section: Equigranular aphanitic texture, average grain size .02 mm; scattered angular quartz grains, .02 to .04 mm, idiomorphic against dolomite; scattered small ellipsoidal light-colored areas may represent recrystallized microfossils; recrystallization noted by larger faintly defined, anhedral crystal outlines superimposed on finer-grained mosaic.

Insol. residue: Residue less than 1 per cent; several grains of angular silt size quartz and hematite.

72 Thin section: Tabular laminated structure 0.1 to 1 mm alternating light and dark pink bands; equigranular aphanitic texture, average grain size .005 mm; scattered angular silt size quartz .01 to .04 mm; ellipsoidal areas 0.6 mm in length, coarser-grained, .05 mm rhombohedra, these areas may represent recrystallized ostracods; refer to Plate IX, A.

Insol. residue: Residue less than 5 per cent; consisting of very fine angular silt size quartz.

71 Thin section: Equigranular anhedral mosaic, average grain size .05 mm with maximum size of 0.1 mm; scattered angular quartz grains, .02 to .04 mm; also calcite crystals; relict aphanitic texture appears faintly visible with average grain size of .02 mm.

Insol. residue: Very little amount, less than 1 per cent residue; essentially very fine angular silt size quartz with several larger silt grains.

70 Thin section: Inequigranular anhedral mosaic, average grain size .06 mm, possibly scattered calcite crystals .1 mm diameter; .02 to .08 mm size angular quartz idiomorphic against carbonates.

Insol. residue: Less than 1 per cent; very fine angular silt with scattered subrounded and pitted 0.2 mm size quartz hematite and glauconite grains.

69 Thin section: Inequigranular anhedral mosaic, dark gray, average grain size .07 mm; scattered light-colored ellipsoidal and circular zones appear as outlines of recrystallized ostracods and crinoid stems respectively; ellipsoidal, circular, and elongate areas consist of calcite and dolomite, maximum diameter of calcite 0.6 mm, several zoned rhombohedra; chert mass, 0.6 mm; rhombohedral grain euhedral relative to the chert; locally red staining.

Insol. residue: Very little amount, less than 1 per cent; main constituent is fine silt size crystalline quartz; several hematite and glauconite grains; some organic material.

68 Thin section: Equigranular aphanitic anhedral mosaic, average grain size .03 mm, several spherical light-colored crystallized areas.

Insol. residue: Very little amount, less than 1 per cent residue; fine angular silt to sand size quartz with several rounded and pitted quartz grains; also hematite, ilmenite and glauconite; abundance of red clay.

67 Thin section: Irregularly laminated, flow roll structure; inequigranular aphanitic texture, grain sizes range from .005 to .06 mm commonly .015 mm; several poorly defined zoned rhombohedral grains 0.1 mm; ellipsoidal fragments and narrow to broad lenticular bands are finer-grained, may contain organic material; carbonate with quartz veins, quartz euhedral against carbonate; spherical, ellipsoidal, and crescent-shaped areas probably represent recrystallized ostracod valves and crinoid stems; laminae accordant with recrystallized fossils; scattered red stained patches.

Insol. residue: Very little, less than 1 per cent residue; essential constituent is fine angular silt size quartz; accessory constituents consist of 0.2 mm size subrounded pitted quartz with hematite and glauconite grains.

66 Acetate peel: Texture poorly defined, possibly anhedral mosaic, grain size 0.1 mm.

Insol. residue: Very little residue, less than 1 per cent; several rounded and pitted quartz with hematite and glauconite grains.

65 Thin section: Irregularly laminated structure, bands range in thickness from 0.2 to 3 mm; inequigranular poorly defined anhedral mosaic, locally distinct relict aphanitic texture, average grain size .02 mm; gradual change to 0.1 mm size loosely interlocking anhedral mosaic, contact is irregular and discordant with bedding planes; light-colored carbonate, possibly calcite veins and .1 to .3 mm irregular areas; red staining between anhedral grains; scattered angular quartz grains.

65 (Continued)
Insol. residue: Less than 1 per cent residue; essentially consisting of subangular to rounded and pitted quartz grains; several ilmenite and glauconite grains.

64 Acetate peel: Poorly defined, aphanitic texture average grain size about .02 mm; irregular light-colored recrystallized areas, maximum diameter of crystals 1 mm.

Insol. residue: Very little amount, less than 1 per cent residue; several subangular silt size quartz, ilmenite, and glauconite grains.

63 Thin section: Inequigranular texture, average grain size 0.2 mm, commonly ranging from 01. to 0.7 mm; essentially well-rounded quartz grains surrounded by finer angular grains, secondary overgrowths, siliceous cement and some calcareous cement; possibly pressure solution between quartz grains; red staining; refer to Plate VIII, B.

Insol. residue: Disaggregation incomplete, small rock fragments, major amount of rock retained in residue; consists of varying sizes of quartz particles; well-developed prisms of secondary overgrowths surround hematite stained quartz grains; largest well-rounded quartz grains 0.9 mm diameter.

62 Thin section: Equigranular aphanitic texture, average grain size .015 mm; scattered ellipsoidal light-colored crystallized areas, one measuring 0.5 by 1 mm, may represent an ostracod valve.

Insol. residue: An abundance of fine silt size quartz prisms with several rounded and pitted quartz, hematite, and glauconite grains.

61 Thin section: Sharply defined tabular laminated structure, alternating laminae 3 and 8 mm thick; inequigranular within laminae, grain sizes of alternating bands average .02 and .04 mm respectively; red ferruginous stained partings between laminae, scattered quartz grains.

Insol. residue: Very little residue, less than 1 per cent; consisting of several fine silt size angular quartz grains.

60 Acetate peel: Equigranular aphanitic texture, average grain size .03 mm.

Insol. residue: Disaggregation incomplete, abundant residue consisting essentially of dolomite fragments and rhombohedral grains; some fine silt size quartz and several grains of ilmenite.

59 Acetate peel: Irregularly laminated and mottled structure; inequigranular aphanitic to very finely crystalline texture, average grain size is commonly .02 mm, average grain size of local mottled zones about .08 mm.

Insol. residue: An abundance of fine silt size angular quartz grains, several hematite grains; containing red clay.

58 Acetate peel: Mottled structure; inequigranular texture, average grain size 0.1 mm, ranging from .05 to .2 mm, rhombohedral grains.

Insol. residue: Residue less than 5 per cent; fine silt size angular quartz grains and prisms mixed with hematite and a few 0.2 mm size rounded and pitted quartz grains, some are coated with hematite; several glauconite grains.

57 Acetate peel: Mottled structure; inequigranular texture grain size ranges from .02 to 0.1 mm; except crystal of 0.5 mm size in calcite veins, veins stained with red ferruginous material.

Insol. residue: An abundance of angular silt size quartz grains mixed with hematite; several glauconite grains.

56 Thin section: Inequigranular aphanitic texture, grain sizes ranging from .02 to 0.1 mm, commonly .02 mm size; relict aphanitic grains; mottled zones are recrystallized; hematitic crinoid stems; scattered quartz grains; ellipsoidal area appears as recrystallized ostracod.

Insol. residue: Angular silt size to 1 mm quartz, well-developed quartz prism; 1 mm quartz grains appear etched perhaps by dolomite; quartz mixed with hematite.

55 Thin section: Inequigranular aphanitic texture, average grain size about .04 mm, ranging from .02 to 0.1 mm; large recrystallized calcite rhombohedra 0.3 mm; scattered light-colored recrystallized areas contain calcite and quartz; dolomite and quartz idiomorphic against calcite.

Insol. residue: Disaggregation incomplete; abundance of microcrystalline dolomite rhombohedral grains; several quartz prisms and hematite grains; containing pink clay.

54 Thin section: Lenticular laminated structure, poorly defined undulating laminae; inequigranular aphanitic texture, average grain size about .05 mm, ranging from .02 to 0.2 mm; dark bands, possibly containing higher organic concentrations, are finer-grained than lighter material; ellipsoidal light-colored recrystallized areas possibly represent ostracod valves; many subangular to rounded quartz grains .02 to 0.1 mm size idiomorphic against dolomite, several rhombohedra, some are zoned.

Insol. residue: Disaggregation incomplete; dolomite mixed with subangular to rounded and clear to frosted quartz; several ilmenite grains.

53 Acetate peel: Brecciated structure; inequigranular texture, grain sizes range from .02 to 0.2 mm; scattered ellipsoidal crystalline areas are possibly recrystallized ostracod valves, surrounding rhombohedra penetrate valve outline, possibly authigenic dolomite.

Insol. residue: Abundance of angular to rounded silt size quartz, clear prisms mixed with pitted grains.

52 Insol. residue: Quartz is mixed with hematite; quartz consists of fine angular silt to 0.2 mm size grains and prisms.

51 Thin section: Brecciated structure; inequigranular anhedral to subhedral mosaic, sizes range from .02 to 0.4 mm; scattered crystalline quartz; dolomite rhombohedra euhedral against quartz and calcite, quartz idiomorphic against calcite, ferruginous staining in interstices; locally, calcite ground mass, dolomite to dolomite contact is anhedral, otherwise euhedral; refer to Plate VIII, A.

Insol. residue: Minor amounts of crystalline quartz and hematite.

50	Thin section:	Lenticular patchy structure; loosely interlocking, inequigranular anhedral to subhedral mosaic, grain sizes ranging from .02 to 0.4 mm; scattered crystalline quartz .02 to 0.2 mm; dolomite rhombohedra idiomorphic against quartz, quartz idiomorphic against calcite; crescent-shaped calcite veins may be cross section of recrystallized brachiopod valves; hematite and limonite staining.
	Insol. residue:	Many grains of crystalline quartz; several hematite and limonite grains.
49	Acetate peel:	Inequigranular texture, grain sizes range from .02 to 0.3 mm; ellipsoidal recrystallized areas.
	Insol. residue:	Major amount of rock retained in residue; crystalline quartz with several hematite grains.
48	Thin section:	Mottled structure; equigranular texture, grain sizes range from .02 to 0.2 mm, relict areas finer-grained, generally aphanitic; mottled areas, partly recrystallized, containing poorly developed rhombohedra; scattered quartz grains, average grain size .03 mm, idiomorphic against dolomite rhombohedra.
	Insol. residue:	Abundance of residue; essentially consisting of pitted and subrounded silt size quartz prisms; several well-rounded and frosted sand size quartz grains; a few hematite and limonite specks; containing red clay; recrystallized crinoid stem.
47	Acetate peel:	Lenticular laminated structure, laminae about 0.5 to 2 mm thick; inequigranular texture, grain sizes range from .02 to 0.2 mm.

47 (Continued)

Insol. residue: Incomplete disaggregation, major amount of rock retained as rock fragments; microcrystalline rhombohedral grains mixed with scattered pitted microcrystalline quartz; several ilmenite and hematite grains; containing red clay.

46 Acetate peel: Mottled structure; inequigranular texture; average grain size about .06 mm, ranging from .02 to 0.2 mm; scattered angular silt size quartz grains.

45 Acetate peel: Mottled structure; inequigranular texture, grain size of .02 to 0.3 mm.

Insol. residue: Abundance of residue; consisting of pitted microcrystalline quartz prisms; several grains of limonite.

44 Thin section: Equigranular aphanitic texture, average grain size .01 mm; scattered ellipsoidal recrystallized areas, measuring 0.5 by 1 mm, may represent ostracod valves, areas contain 01. mm rhombohedral grains.

Insol. residue: Very little amount, less than 1 per cent residue; consisting of several grains of ilmenite; pink clay.

43 Acetate peel: Inequigranular mosaic, sizes range from about .02 to 0.2 mm; calcite fillings.

Insol. residue: Disaggregation incomplete, major amount of residue retained, includes dolomite fragments; several rounded and frosted quartz grains and microcrystalline quartz; recrystalized crinoid stems and possibly ostracods.

42	Thin section:	Inequigranular spotted structure; relict aphanitic texture, grain size average about .02 mm; scattered recrystallized areas contain 0.1 to 0.2 mm size grains, ellipsoidal areas may represent recrystallized ostracods; crystalline quartz present.
	Insol. residue:	Less than 5 per cent residue; particles of crystalline quartz; several hematite grains.
41	Acetate peel:	Mottled structure; inequigranular texture, grain sizes range from .02 to 0.2 mm.
	Insol. residue:	Very little amount, less than 1 per cent residue; subrounded and pitted silt size quartz prisms mixed with hematite particles; several ilmenite grains.
40	Thin section:	Flow roll structure; inequigranular aphanitic texture, varying grain sizes about .005, .01, and .03 mm; light-colored areas finer-grained, chert-like texture, may contain chert, hardness is 5; calcite veins.
	Insol. residue:	Very little amount, less than 1 per cent residue; several particles of silt size crystalline quartz.
39	Acetate peel:	Mottled structure; inequigranular, commonly aphanitic texture, grain size about .02 mm; locally recrystallized mosaic containing 0.1 to 0.2 mm grains.

39 (Continued)

Insol. residue: Less than 1 per cent residue; essentially consisting of pitted silt size quartz crystals; several grains of hematite, glauconite, and pyrite.

38 Thin section: Equigranular aphanitic texture, grain size smaller than .005 mm; irregularly recrystallized calcite areas, maximum grain size is 0.5 mm.

Insol. residue: Less than 1 per cent; several rounded and pitted silt with ilmenite grains; organic matter.

37 Acetate peel: Inequigranular grainy texture, grain sizes range from .01 to 0.5 mm; well-rounded quartz grains are surrounded by angular quartz and aphanitic dolomite; quartz comprises about 70 per cent of volume, grains smaller than 0.1 mm tend to be angular, larger grains are rounded.

Insol. residue: Disaggregation incomplete, major amount of rock retained as fragments and quartz grains; smaller grains are angular, larger grains are well-rounded and pitted to frosted.

36 Thin section: Lenticular flow roll structure; inequigranular aphanitic texture, grain size commonly .005 mm; concentration of .04 mm size subangular quartz in coarser-grained dolomite surrounding lenticular patches; larger well-rounded quartz grains 0.1 to 0.3 mm, embedded in dark finer grained dolomite.

Insol. residue: Abundance of varying size quartz; silt size grains commonly subangular and pitted to frosted, larger grains to 0.5 mm size are well-rounded and frosted.

35 Acetate peel: Brecciated structure; inequigranular grainy texture; grain size of laminated fragments are aphanitic, less than .005 mm size, contain sparsely scattered silt to sand size quartz grains, fragments are angular to rounded; greater quartz concentrations in surrounding dolomite, ranging from fine angular quartz of .02 to 0.5 mm size well-rounded grains; quartz occupies about 40 per cent of volume.

Insol. residue: Disaggregation incomplete, major amount of rock retained, many aphanitic dolomite fragments; abundance of angular and frosted silt to 0.5 mm size well-rounded quartz grains; several ilmenite grains.

34 Thin section: Brecciated structure; inequigranular grainy texture, quartz grains embedded in aphanitic dolomite, grain size of dolomite less than .005 mm, grain sizes of embedded quartz ranges from .02 mm 0.5 mm, finer-grained quartz tends to be angular, larger than 0.1 mm grains are generally rounded to well-rounded; quartz sand is concentrated around fragments; pressure solution of quartz; fragments more dolomitic.

Insol. residue: Disaggregation incomplete, aphanitic dolomite fragments retained; abundance of varying sizes of frosted quartz grains with a maximum diameter of 0.7 mm; several glauconite grains; little amount of red clay.

33 Acetate peel: Inequigranular grainy texture, grain sizes ranging from .005 to 0.2 mm; aphanitic dolomite surrounds subangular quartz grains; quartz commonly 0.1 mm diameter, occupies about 80 per cent of volume; locally red staining.

33 (Continued)
Insol. residue: Disaggregation incomplete, major amount of rock retained in residue, many rock fragments; essential constituent is subangular crystalline quartz, commonly 0.1 mm, some pitted grains.

32 Thin section: Laminated structure; equigranular aphanitic texture, average grain size .005 mm; contains varying concentrations of angular quartz, average size about .04 mm; some 0.2 mm well-rounded quartz grains; small recrystallized areas.

Insol. residue: Residue less than 5 per cent; essentially consisting of angular, pitted, uniform silt size quartz; several ilmenite and glauconite grains.

31 Thin section: Inequigranular grainy texture; grains of dolomite ground mass average less than .005 mm diameter; embedded quartz grains occupy about 30 per cent of total volume; quartz particles range from .02 to 0.6 mm, silt size grains tend to be angular, sand grains are well-rounded; scattered concentrations of secondary overgrowths; some recrystallized areas of calcite.

Insol. residue: Abundance of silt to sand size quartz, maximum size of well-rounded and frosted grains 0.7 mm, several grains are coated with hematite.

30 Acetate peel: Equigranular aphanitic texture, average grain size about .005 mm; scattered angular silt size quartz; several embedded well-rounded quartz grains, commonly 0.2 mm diameter.

30 (Continued)
Insol. residue: Very little residue, less than 1 per cent; consisting of angular to well-rounded quartz grains, surfaces are pitted to frosted; several hematite grains.

29 Thin section: Brecciated structure; inequigranular aphanitic to grainy texture, aphanitic dolomite crowded with sand grains and small subangular to rounded dolomite fragments; fragments entirely aphanitic less than .005 mm size; embedded quartz grains occupy about 40 per cent of total volume, grain sizes range from .02 to 0.8 mm, particles less than 0.1 mm tend to be angular, larger grains are rounded to well-rounded; red staining surrounds grains; scattered calcite areas.

Insol. residue: Disaggregation incomplete; many rock fragments; abundance of frosted silt and sand size quartz grains.

28 Thin section: Inequigranular aphanitic texture, grain sizes range from smaller than .005 to .04 mm; ellipsoidal zones are finest-grained; sharp to poorly defined contact between varying size textures; coarser dolomite contains 0.4 mm angular quartz grains; scattered irregular recrystallized zones of calcite, dolomite, and quartz, 0.1 mm size crystals.

Insol. residue: Less than 5 per cent residue; essentially consisting of fine equigranular silt size clear to pitted quartz crystals; several hematite and glauconite grains.

27 Thin section: Equigranular aphanitic texture, average grain size less than .005 mm; euhedral quartz prisms embedded in carbonate veins.

Insol. residue: Residue less than 1 per cent; consist of angular to rounded quartz grains, average grain size about .01 mm.

26	Thin section:	Ellipsoidal spotted structure; equigranular aphanitic texture, average grain size less than .005 mm; sparsely scattered quartz grains, maximum size .04 mm.
	Insol. residue:	Residue less than 5 per cent; consists of silt size angular to rounded quartz, grains are pitted; contains pink clay.
25	Thin section:	Equigranular aphanitic texture, grain sizes average smaller than .005 mm.
	Insol. residue:	Residue less than 1 per cent; silt size angular to rounded and pitted quartz; several glauconite grains; pink clay; traces of organic content.
24	Thin section:	Equigranular aphanitic texture, average grain size smaller than .005 mm; sparsely scattered angular quartz, maximum grain size .04 mm.
	Insol. residue:	Very little residue, less than 1 per cent; several pitted, silt size quartz grains; pinkish-purple clay.
23	Acetate peel:	Locally fine speckled structure, resulting from siliceous material around grains; equigranular aphanitic texture, grain size smaller than .005 mm; dolomite fragments subrounded.
	Insol. residue:	Abundance of fragments and very fine silt size grains of siliceous material; several grains of clear quartz crystals.
22	Thin section:	Nodular chert structure; equigranular aphanitic texture of dolomite; chert is cryptocrystalline; rhombohedral pseudomorphs consisting of chert inside nodule; scattered angular quartz areas inside chert; chalcedony; possibly radiolaria and sponge spicules.

22 (Continued)
Insol. residue: Disaggregation incomplete; residue consisting of chert fragments and some silt size quartz.

21 Insol. residue: Less than 1 per cent residue; fine silt size quartz with ilmenite grains.

20 Thin section: Nodular chert structure; aphanitic texture of dolomite, average grain size smaller than .005 mm; cryptocrystalline chert; sharply defined contact between dolomite and chert; a spot of crystalline carbonate between chert and dolomite; small recrystallized areas inside dolomite; zones of chalcedony inside chert; scattered spine-like outlines inside chert, possibly sponge spicules, lengths 0.5 to 3 mm; microcrystalline quartz euhedral against carbonates; dolomite grains inside chert; refer to Plate VII, B.

Insol. residue: Disaggregation incomplete; abundance of chert fragments; some contain chalcedony.

19 Acetate peel: Equigranular aphanitic texture; average grain size less than .005 mm.

Insol. residue: Disaggregation incomplete; many dolomite rock fragments with very fine silt size quartz and ilmenite grains.

18 Thin section: Lenticular laminated structure; equigranular aphanitic texture, average grain size smaller than .005 mm; scattered irregular areas of recrystallized dolomite with some chert and quartz, maximum size of crystals 0.5 mm, outside borders of areas contain microcrystalline quartz euhedral against dolomite.

18 (Continued)
Insol. residue: Disaggregation incomplete, dolomite rock fragments are mixed with fragments of fine siliceous cement and silt grains; many grains of ilmenite and crystalline quartz.

17 Thin section: Lenticular nodular chert structure; inequigranular microcrystalline and cryptocrystalline texture; small scattered particles of dolomite; crystalline quartz veins; silicified ostracods.

Insol. residue: Disaggregation incomplete, major amount of residue retained; consisting of dark gray chert fragments.

16 Thin section: Irregularly bedded chert structure; equigranular aphanitic texture of dolomite with cryptocrystalline chert; fractures in dolomite lined with microcrystalline quartz; chert contains irregular zones of chalcedony.

Insol. residue: Disaggregation incomplete; consists of chert fragments.

15 Acetate peel: Tabular laminated structure, laminae 0.2 to 2 mm thick; equigranular aphanitic texture, grain size smaller than .005 mm.

Insol. residue: Abundance of very fine silt size quartz; carbonate fragments; contains organic matter.

14 Acetate peel: Equigranular aphanitic texture; grain size smaller than .005 mm.

Insol. residue: Abundance of very fine silt size quartz; some fragments of chert; several grains of crystalline quartz, glauconite, and ilmenite.

13 Thin section: Equigranular aphanitic texture consisting of dolomitic chert; crystalline quartz-filled veins.

13 (Continued)
Insol. residue: Disaggregation incomplete, major amount of rock retained in residue; consisting of chert and dolomitic chert fragments.

12 Acetate peel: Bedded chert structure; equigranular aphanitic texture; grain size averages smaller than .005 mm; contains discontinuous chert bed 0.5 mm thick; sharp to blended border between dolomite and chert.

Insol. residue: Disaggregation incomplete, abundance of fragments of chert and cherty dolomite; several grains of ilmenite and glauconite; contains organic matter.

11 Thin section: Equigranular aphanitic dolomite, grain size smaller than .005 mm; sparsely scattered crystalline quartz, a .14 mm diameter quartz prism parallel to bedding plane; a .04 mm chalcedony-filled cavity; refer to Plate VII, A.

Insol. residue: Chert fragments containing chalcedony; pitted microcrystalline to crystalline quartz; ilmenite and glauconite grains; quartz, chalcedony, and calcite are intergrown within the same vein; quartz is idiomorphic against dolomite and calcite; quartz, chalcedony, and calcite border fracture walls; etching of quartz where it borders dolomite but not where it is intergrown with calcite.

10 Thin section: Uneven tabular laminated structure, laminae range from 0.1 to 8 mm thick; dark, inequigranular aphanitic texture, average grain size less than .005 to .01 mm; calcite-filled partings; recrystallized areas possibly represent ostracod valves oriented at right angles to bedding planes.

10 (Continued)
Insol. residue: Less than 1 per cent residue, essentially light brown and colorless, pitted microcrystalline quartz, several grains of hematite and limonite.

9 Thin section: Crumbly patchy structure inequigranular mosaic; relict microcrystalline texture, average grain size .015 mm, partly recrystallized by irregular patches of calcite, maximum diameter of crystal is 0.5 mm superimposed on fine-grained calcite; several irregular to ellipsoidal 0.2 mm size possibly pseudomorphs of chalcedony in recrystallized areas; zones of red ferruginous staining; several .02 mm size quartz crystals idiomorphic against calcite.

Insol. residue: Chief constituents are large subrounded to rounded crystalline dolomite granules and chalcedony fragments; some hematite; organic matter; possibly recrystallized echinoderm spines.

8 Thin section: Undulating laminated structure; laminae mosaic, average grain size about .06 mm, ranging from .02 to 0.1 mm; possibly relict aphanitic texture with grain size about .02 mm, recrystallized grains transect faintly defined relict laminae; scattered quartz; refer to Plate VI, B.

Insol. residue: Very little amount, less than 1 per cent residue; consisting of clear microcrystalline quartz prisms; several hematite and crystalline quartz grains.

7 Thin section: Cellular tabular laminated structure; laminae .05 to 2 mm thick; inequigranular aphanitic texture, average grain size about .03 mm, ranging from .01 to 0.1 mm; dolomite crystals transect relict laminae partings; grain sizes generally vary with laminae; lenticular calcite-filled cavities .4 mm in length; scattered microcrystalline quartz.

Insol. residue: Less than 1 per cent residue; several fragments of chert, microcrystalline and crystalline quartz; several ilmenite grains.

6 Thin section: Tabular laminated structure, laminae .05 to 2 mm thick; inequigranular aphanitic texture; average grain size about .03 mm, ranging from .005 to 0.1 mm, grain sizes generally vary with laminae; narrow calcite vein; several brown stained stylolites; rhombohedral grains transect laminae partings.

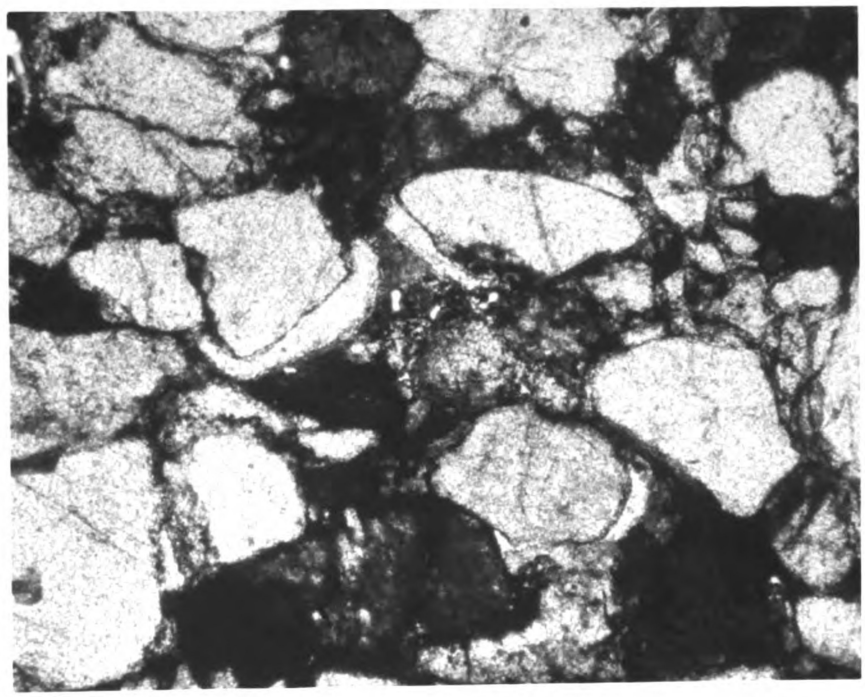
Insol. residue: Less than 1 per cent residue; microcrystalline and crystalline quartz; several grains of hematite, ilmenite, glauconite, and calcopyrite.

5 Thin section: Banded structure; aphanitic texture, comprising red clay with irregular horizontal bands consisting of concentrations of 0.2 to 1 mm size well-rounded to subangular quartz grains surrounded by .01 to 0.2 mm size quartz chips and clay material; a few rounded chert grains and subangular feldspar fragments scattered among the quartz; pressure solution along vertical contacts of quartz grains.

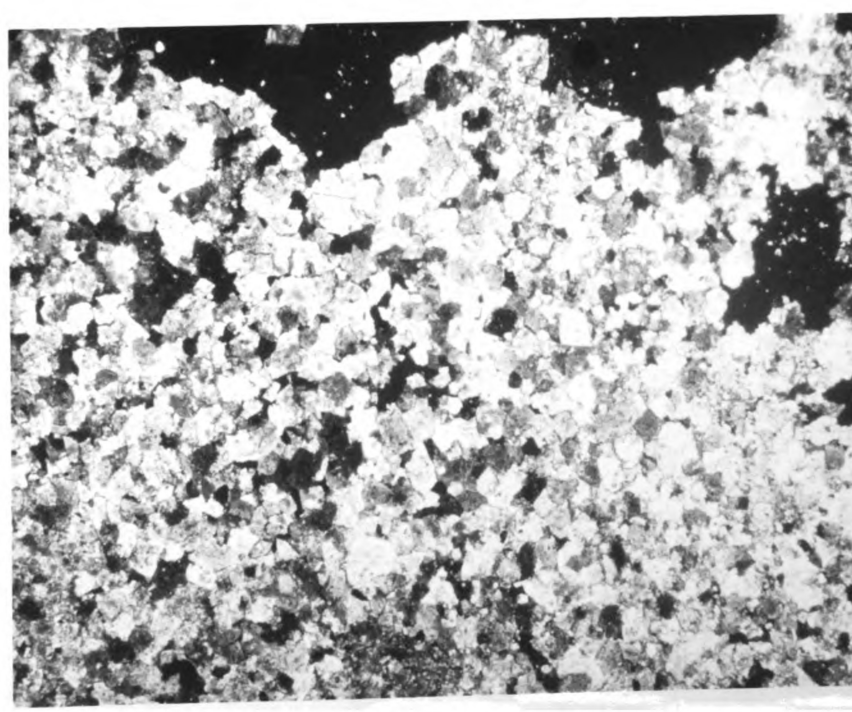
Insol. residue: Quartz grains, frosted.

4	Thin section:	Laminated structure; grainy texture; quartz grains, subangular to subrounded with minute quartz chips comprise about 60 per cent of volume; feldspar, commonly orthoclase; subrounded quartz grains average about .4 mm diameter; cement is chiefly ferruginous, locally siliceous; contains chert; refer to Plate VI, A.
	Insol. residue:	Pitted quartz grains and prisms; abundance of authigenic quartz; ferruginous cement consists of ilmenite and limonite; other minerals include chert, muscovite, and glauconite.
3	Insol. residue:	Subangular to subrounded and pitted grains of quartz, feldspar, and chert; abundance of silt size quartz chips; ilmenite cement; feldspar, commonly orthoclase, comprise about 20 per cent of total volume; contains mica flakes.
2	Thin section:	Tabular laminated structure; tightly interlocking, grainy texture, subangular quartz grains average size is .15 mm; siliceous cement and locally ferruginous; iron oxide coating around grains; ilmenite pellets enclosed in crystalline quartz; few feldspar grains idiomorphic against quartz.
	Insol. residue:	Quartz grains generally surrounded by authigenic quartz; wine-colored ferruginous quartz grains more numerous than colorless grains; glauconite grains are rare; few grains coated by limonite; also silt size fragments and crystals.

1 Insol. residue: Subangular to subrounded and pitted quartz chips and grains varying in size from 0.1 to 3.5 mm, principal rock constituent, mainly ferruginous, with some siliceous cement; specularite, ilmenite, feldspar, and chert abundant; accessory constituents, muscovite, pyrite; some subrounded quartz prisms; grains stained with iron oxide; specularite enclosed in quartz.

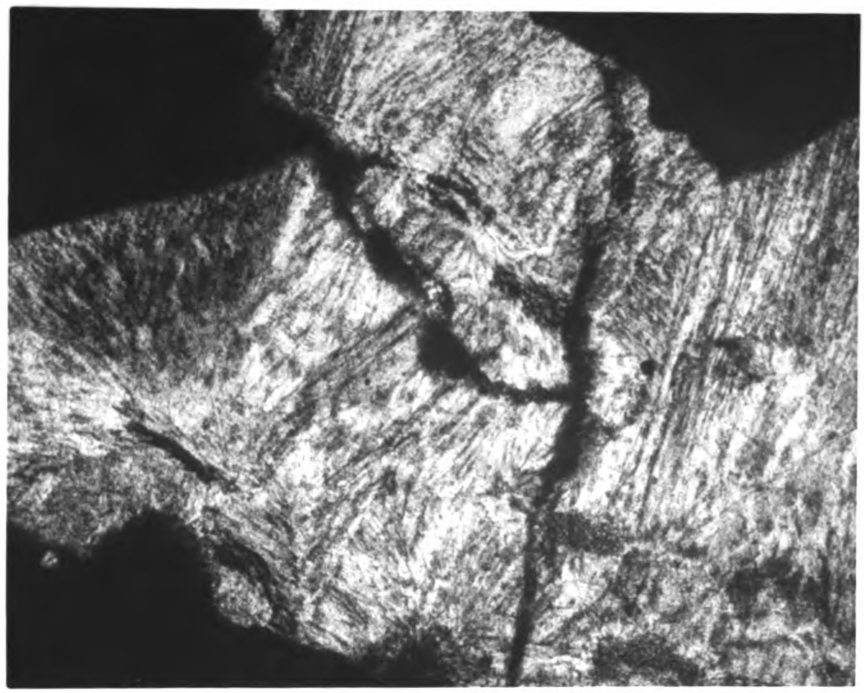


A. Thin section 4, ordinary light, X 60.



B. Thin section 8, polarized light, X 60.

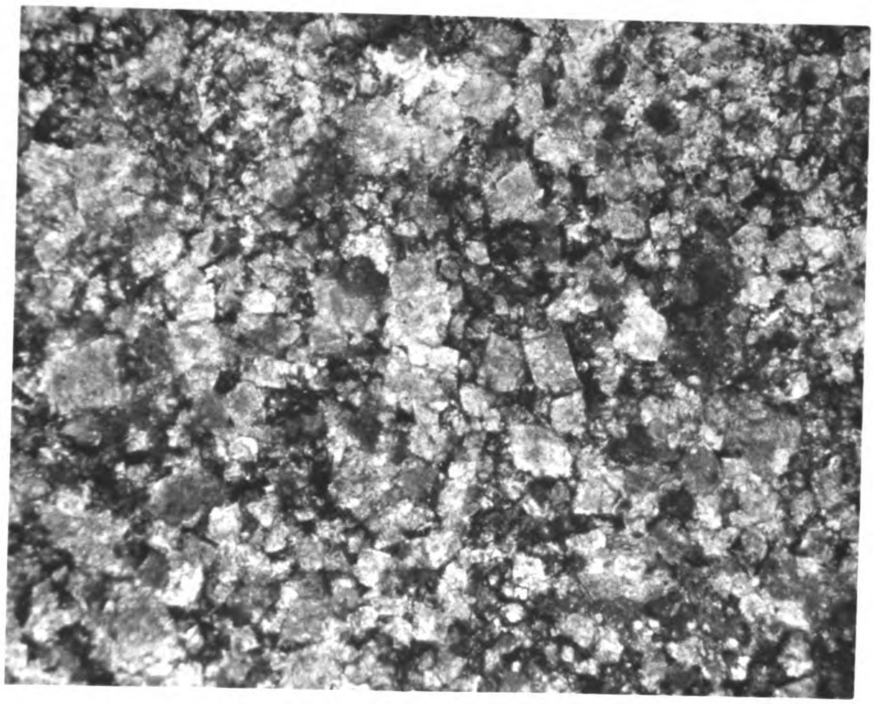
Plate VI



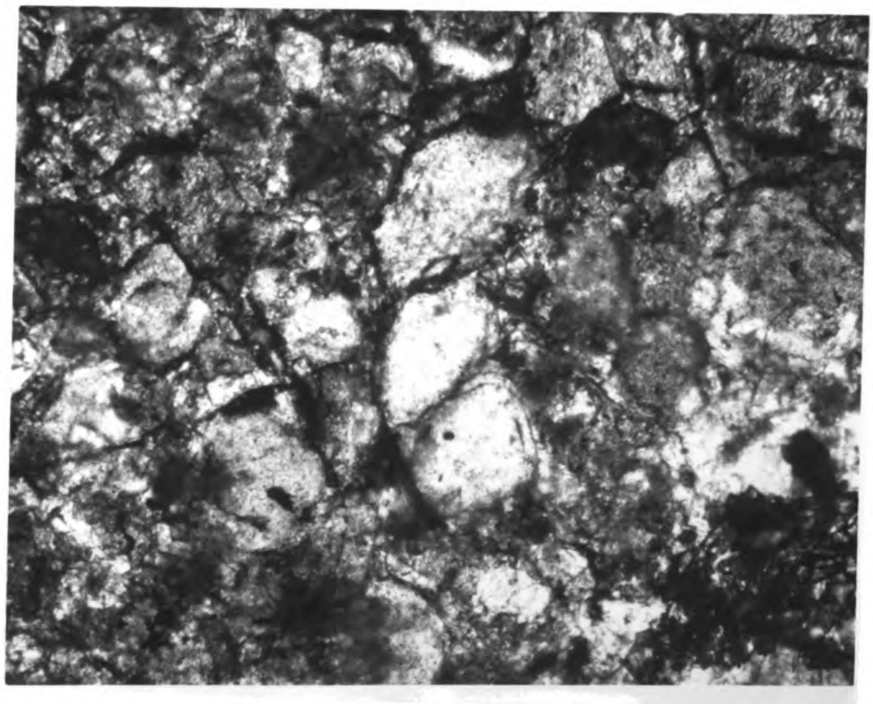
A. Thin section 11, polarized light, X 60.

B. Thin section 20, polarized light, X 60.

Plate VII

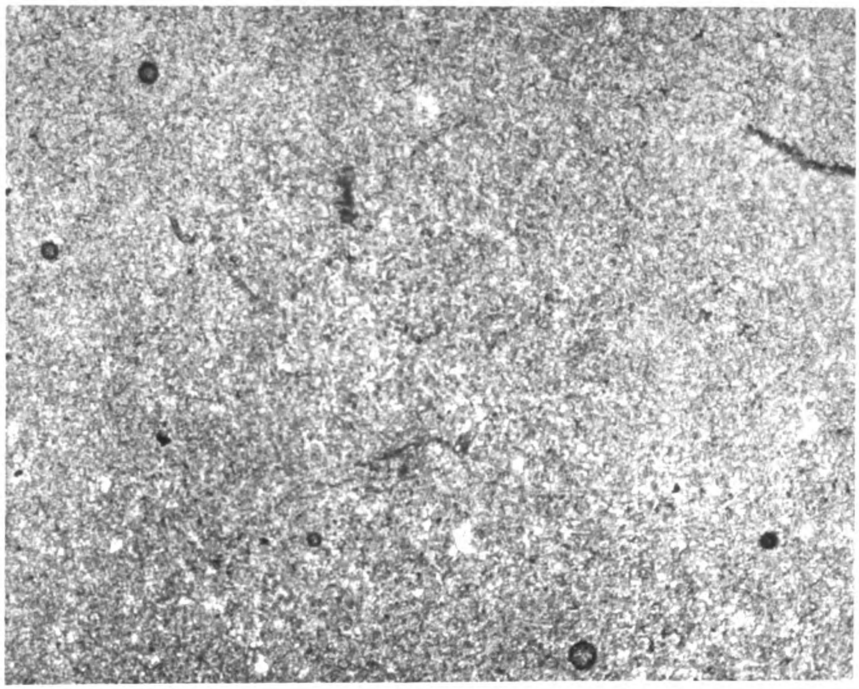


A. Thin section 51, polarized light, X 60.

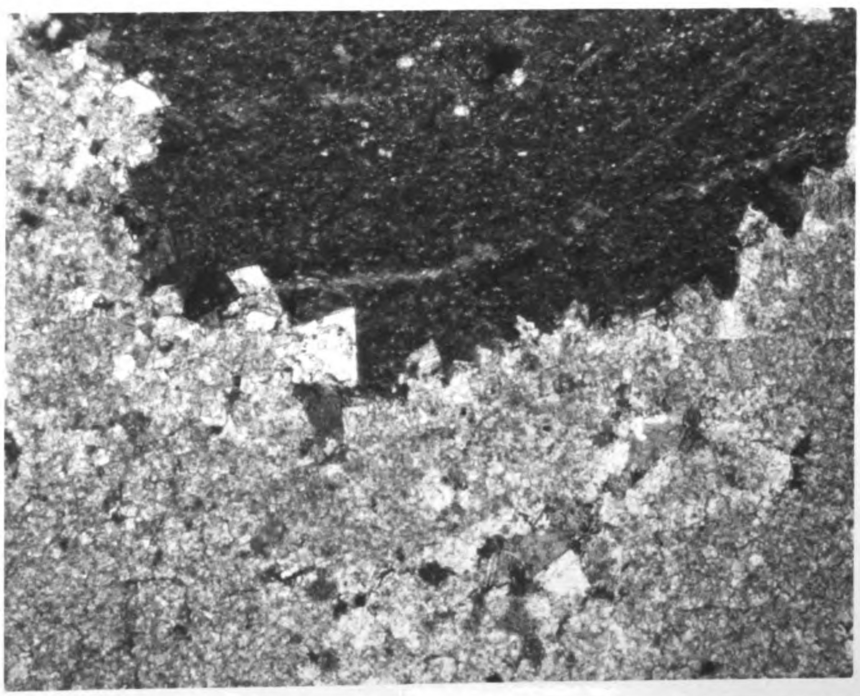


B. Thin section 63, polarized light, X 60.

Plate VIII

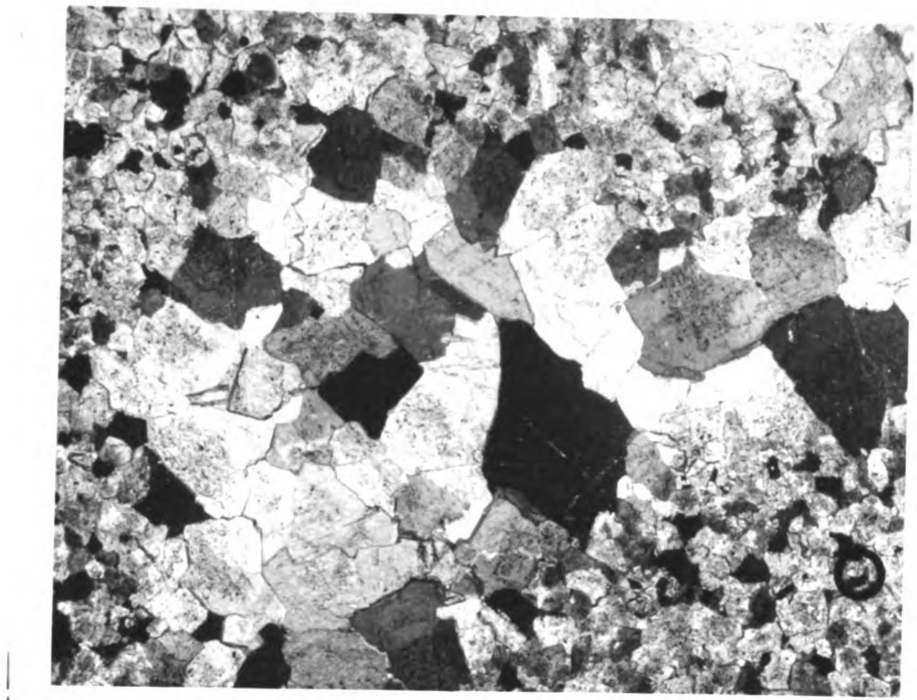


A. Thin section 72, polarized light, X 60.

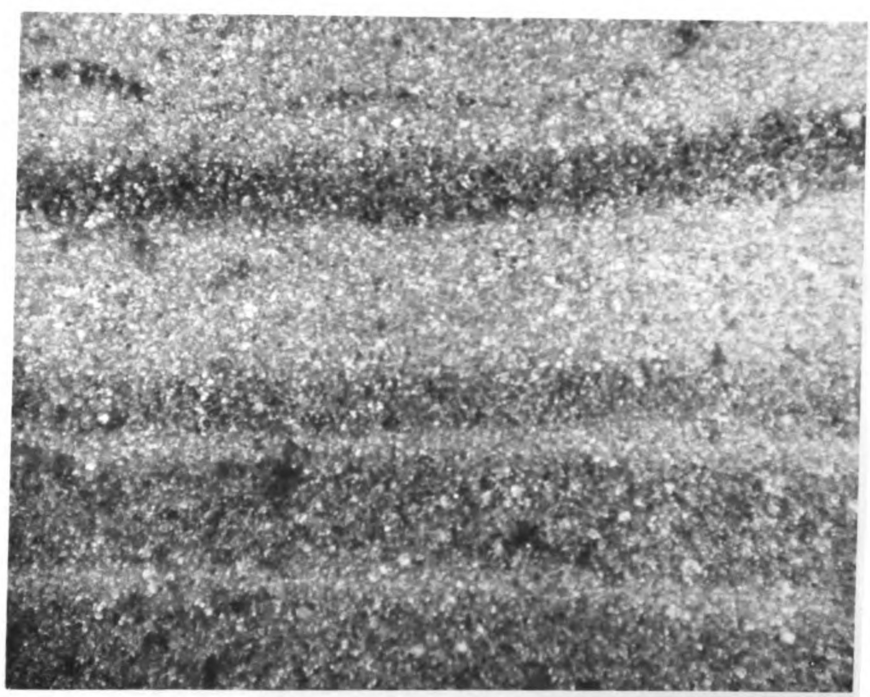


B. Thin section 88, polarized light, X 60.

Plate IX

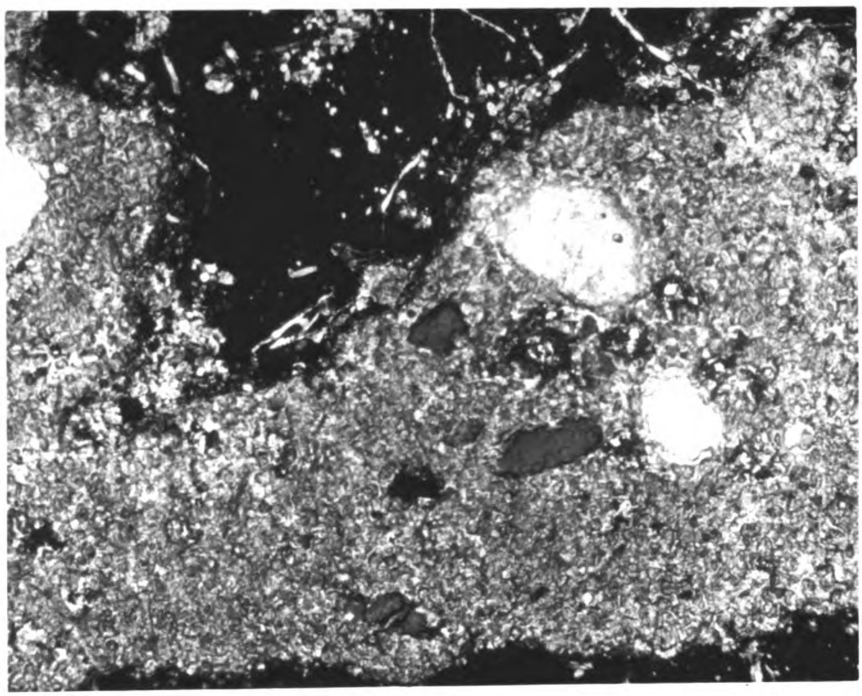


A. Thin section 90, polarized light, X 60.

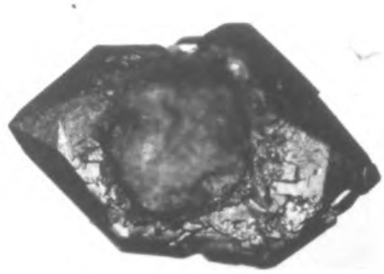


B. Thin section 110, ordinary light, X 30.

Plate X

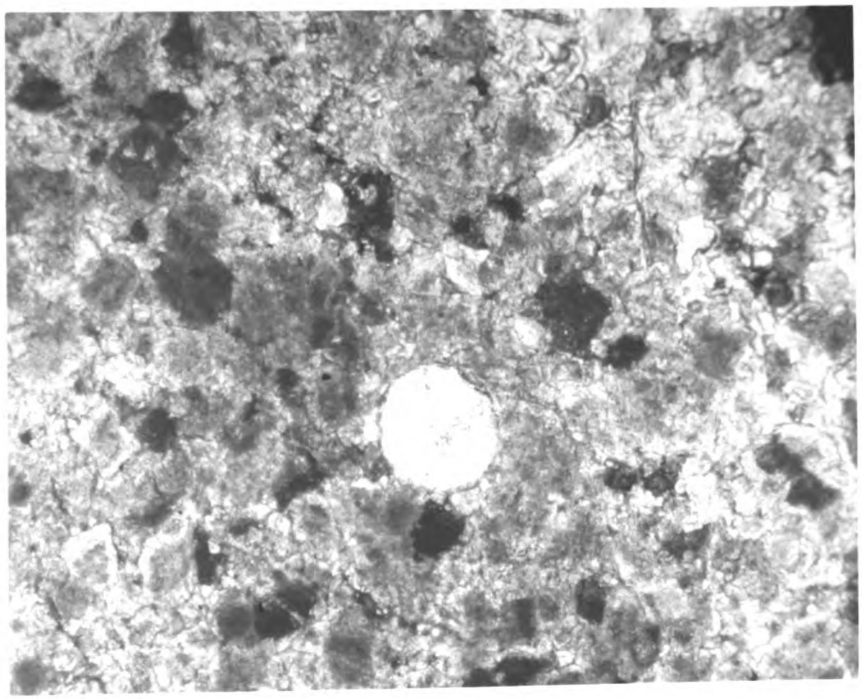


A. Thin section 118, polarized light, X 60.

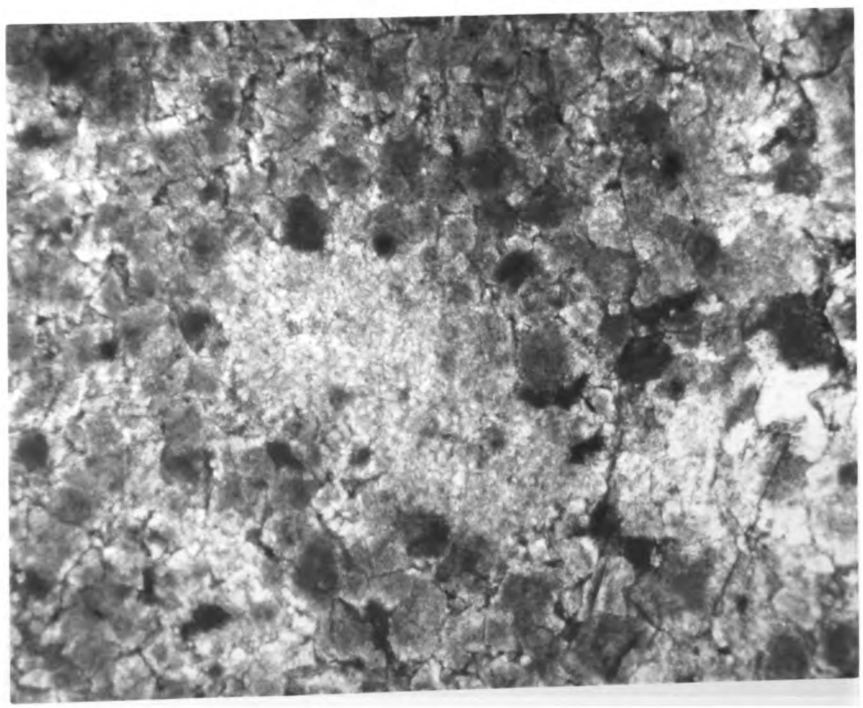


B. Insol. residue 123, ordinary light, X 60.

Plate XI



A. Thin section 125, polarized light, X 60.



B. Thin section 125, polarized light, X 60.

Plate XII