Greene

REPORT ON THE 1970 AND 1977 BORINGS

TAKEN BY THE

MARYLAND DEPARTMENT OF TRANSPORTATION

STATE HIGHWAY ADMINISTRATION

IN THE

CATOCTIN FURNACE AREA

IN CONJUNCTION WITH THE

ARCHAEOLOGICAL SURVEY

OF THE

ALIGNMENT 1 CORRIDOR

U.S. ROUTE 15

FROM

PUTNAM ROAD TO MARYLAND ROUTE 77

FREDERICK COUNTY, MARYLAND

Prepared for:
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INTRODUCTION

Continuous sample (GOW) borings and auger borings were taken in the vicinity of present U. S. Route 15 near Catoctin Furnace, Maryland during projects conducted by Maryland Department of Transportation, State Highway Administration (SHA) in 1970 and 1977. The samples from the borings were examined and studied at the State Highway Administration Office, Brooklandville, Maryland on November 18, 1977. Other data including soil boring logs, the Catoctin Pond probings, various maps, and other pertinent materials were provided this consultant through the cooperation and assistance of Mr. David Martin, SHA geologist. Mr. Martin and the SHA Bureau of Soils and Foundations also cooperated by preparing 15 thin sections from portions of several core samples designated by this consultant.

This report not only includes the results of the visual examination and study of the continuous sample (GDW) borings available at Brooklandville, but also attempts to utilize and integrate these data with other available geologic and archaeologic information.

GENERAL EVALUATION

The subsurface data obtained from the 1970 and 1977 borings taken in the area of Catoctin Furnace add appreciably to the knowledge of the type and distribution of the geologic materials which comprise the surficial cover and the bedrock in the vicinity of the proposed Alignment 1 corridor for the dualization of U. S. Route 15.

Seven of the continuous sample (GOW) borings penetrated bedrock, and two auger borings were terminated by "rock refusal". This bedrock information plus other data acquired by geologic field mapping (Fauth, 1977a, 1977b) are plotted on the portion of a 1964 aerial photograph that includes most of the Catoctin Furnace area (Figure 1). The petrographic examination of the rock thin sections is summarized in Table 1.

No iron ore deposit or significant iron-bearing stratum was encountered in the augering or coring programs of 1970 and 1977. Even though "iron oxide" is reported from auger borings A-1 and A-4, it is not believed that "Catoctin iron-ore" was intercepted. However, the lack of details on the nature, distribution, or content of the "iron oxide" encountered in the auger borings leaves this judgement open to some question.

Both the core samples and thin sections reveal no significant ore mineralization in the Catoctin Furnace area, even in the area of the "Silver Mine" (Orr and Orr, 1977, Check 8). Extensive fractures or fragmentation of rock such as might be expected in or about a major fault zone, is absent from core samples recovered from the borings.

SPECIFIC ARCHAEOLOGICAL - GEOLOGICAL PROBLEMS

Nature of the Iron Mine Stratigraphy at Catoctin Furnace: Two auger borings A-1 and A-4 are located on or adjacent to the Charcoal Road leading to Stacks No. 1 and No. 2 at the furnace site (Orr and Orr, 1977, Check 12, Feature 6). Because samples routinely are not

retained from auger borings (D. Martin, personal communication), the only record of the strata encountered in these borings is that compiled in the driller's log by the soil surveyor.

A two-foot zone containing "iron oxide" is reported in auger boring A-1 and A-4 at approximately the same depth from the present land surface (A-1, 8-10 feet; A-4, 6-8 feet). Because the surface elevation of each auger site is not recorded on the logs, the elevation of the "iron oxide" zones is not determinable, and the possible lateral relationships of one zone to the other cannot be evaluated.

Does the "iron oxide" in A-1 and A-4 represent part of the normal iron mine stratigraphy at Catoctin Furnace? Interpretation of the evidence on hand suggests that it is not.

The auger boring logs in both cases report the occurrence of the "iron oxide" at levels where the water content of the "soils" initially exceeds optimum conditions for the material. This suggests that the "iron oxide" horizons noted in A-1 and A-4 probably present day deposits of this mineral material at the position where the subsurface physical and chemical environment change (lower Eh and higher pH) so as to cause the precipitation of the iron oxide. Although the "Catoctin iron ores" may have formed in response to similar geologic conditions, the "iron oxide" intervals penetrated by A-1 and A-4 are not considered to be part of a geologic section associated with the typical iron mine stratigraphy of the Catoctin ore banks.

The conclusion advanced by Mr. William B. Greene, Chief, Bureau of Soils and Foundations (SHA) in his memorandum of September 8, 1977 that boring A-4 is located in an area not previously mined, and therefore probably can provide a complete geologic section of the original ore pit, is a reasonable one. However, the log for auger boring A-4 indicates "rock refusal" at 31 feet and only the single, shallow, thin zone of "iron oxide" discussed previously.

Furthermore, Mr. Greene's interpretation and suggestion rests on some major suppositions; such as:

(1) The furnace site and the location of the Charcoal Road was selected and developed without any investigatory efforts to determine the possible existence of iron ore at this locality.

(2)The Charcoal Road in its recognized location was more valuable than the iron ore presumed to underlie it to the extent that ore banks over a mile away were developed and exploited in order to supply the active furnaces during the late nineteenth century rather than to relocate or construct a new "charcoal" road.

(3) The ore presumed to be beneath the Charcoal Road was not of appropriate quantity, quality, or economic value to mine after Stack No. 2 (Isabella), the last charcoal burning furnace, was shut down in 1893 and only the "anthracite-coke" furnace (Stack No.3, Deborah) remained.

Consider the alternative hypothesis that no iron ore exists beneath the Charcoal Road identified in the archaeological survey

as Check 12, Feature 6 (Orr and Orr, 1977) - some evidence, though fragmentary and inconclusive, suggests this possibility!

(1) Auger boring A-4 indicates probable bedrock at its base 31 feet below surface level (Doering, 1977). No definite iron ore is identified although iron oxide is reported from an interval 6-8 feet below the surface.

(2) Extensive prospecting for new "ore banks" in the late 1800's and very early 1900's failed to discover any deposits in the vicinity of the furnace site; i.e., between Auburn and the Fitzhugh-Kunkle ore banks (Singewald, 1911, p. 201; Orr and Orr, 1977, p. 41).

(3) The distribution of known ore banks and the historical record of prospecting indicate that the Catoctin iron deposits do not form a continuous belt even where the "supposedly appropriate geologic conditions" exist; namely limestone "faulted" against phyllite or shale. Figure 1 portrays the distribution of limestone and phyllite bedrock as determined by borings, surface excavations, and natural exposures. In addition, Figure 1 also notes the general trend of the rock units in the area of interest.

The rocks that tend to be associated with iron ore in this area do not maintain a linear continuity over a large distance. Instead these rocks define a series of intervals that differ slightly in orientation and apparently are terminated or offset from one another rather abruptly along "east-west" trending boundaries. The termination and reorientation of such belts of rock are commonly the effect of faults, transverse to the trend of the rocks, on which measurable lateral displacement has occurred. This is a possible explanation for the discontinuity of ore banks in this area.

(4) Inspection of the location of known and supposed (probable?) iron ore mines astride existing U. S. Route 15 in the vicinity of Catoctin Hollow Road and the furnace site shows that these ore banks have no continuity, when extended along their length, one into another (see: Planview of Dualization of U. S. Route 15, Catoctin Iron Furnace). This relationship may be the consequence of faulting.

As the above information demonstrates, geologic dislocations (faults) of strata typically associated with Catoctin iron ore deposits may be important in determining where complete geologic stratigraphic) sections of an iron mine may still exist, and should be considered in evaluating potential sties. Such dislocations may explain the possible absence of iron ore in the area of the Charcoal Road and/or the furnace site.

The Ore Banks Behind the Furnace Site: Singewald's description of the location of the ore banks back of the old furnace site (1911, p. 199) is not detailed enough to identify the position of both these workings unequivocally. A consensus opinion exists that the second of the two ore banks described by Singewald (1911) is the Big Pond site or Big Ore Bank identified as Check 13 by Orr and Orr (1977). However, the location of the other mine is questionned. Mentzer (1974, p. 5 in Orr and Orr, 1977) places this ore bank northwest of and en echelon with the Big Ore Bank. Orr and Orr apparently accept Mentzer's interpretation in the light of the 1977 archaeological survey, for they label the site Check 12, Feature 4 and refer to it as an ore bank.

None the less, Singewald (1911, p. 199) describes the two ore banks as being north and south of one another. Thus, Feature 2 of Check 12 (Orr and Orr, 1977) more nearly fits the location of the other mine as noted by Singewald, and should be considered a viable alternative location to the site identified by Mentzer.

Besides the directional aspect between the two mines, Check 12, Feature 2 has the physical dimensions noted by Singewald, and boring B-6 penetrates shale (phyllite?) near its southern end at a depth consistent with that indicated in the Singewald report.

One fact about the location of the mine at Check 12, Feature 2 conflicts with the description given by Singewald: it is almost 200 yards north of the Big Ore Bank and not 100 yards as noted in the 1911 report. However, even Mentzer's location for the mine violates this point; his locality places the ore bank less than 100 yards (about 150-200 feet) from the Big Ore Bank (Check 13).

The importance of properly identifying the location of the first ore "pit" described in Singewald's 1911 report pertains to the fact that exploratory prospect holes "put down" in 1908 were reported by him to have found ore on both the east and west banks, and also in the bottom of the more northerly situated mine. Continuous sample (GOW) borings located appropriately with respect to this ore bank are thus likely to penetrate and recover a typical geologic section associated with and containing "Catoctin" iron ore.

<u>Data from the 30-50 Foot Section of Boring B-3</u>: The description of the geologic section obtained by boring B-3, situated along the eastern edge of the Big Ore Bank (Orr and Orr, 1977, Check 13),

between the 30 and 50-foot depth interval, is compiled from the boring log (Myers, 1977) plus the visual examination by this consultant of the samples recovered and presented in Table 1. No evidence of ore occurs. Although the stratigraphic succession penetrated by the boring may be reasonably similar to that associated with the "Catoctin iron ore" deposits, the absence of any indications of ore in the boring detracts from the credibility of the section as being one representative of a typical ore zone.

Characteristics of the "Filled-in" Iron Mine (Check 12, Feature 2): In large part the aspects of this feature and its possible identity are discussed and evaluated earlier in this report (p. 7).

Mr. Renner identifies this feature as a filled-in iron mine (Orr and Orr, 1977, p. 51), and reports that it probably has been filled in to a depth of 8-10 feet. Whether this depth of fill extends to the bottom of the mine workings or simply represents the overlay due to the route location of existing U. S. 15 is not clear in the reference cited. Regardless, three auger borings (A-2, A-3, and A-5) are located within 30 feet of one another near the southern end of this feature and no more than 30-50 feet north of the existing Catoctin Hollow Road. In addition, the continuous sample (GOW) boring B-6 is located approximately at the site of auger hole A-3.

The boring A-5 is the easternmost auger hole. It penetrates 8 feet of strata and intercepts a recognizable root mat at a depth of 5.5 feet. This mat is interpreted by this investigator as the probable thickness of the overlay related to the construction of existing U. S. Route 15 which covered an existing vegetated surface.

The westernmost of the three auger borings is A-2. The remarks on the soil boring log (Doering, 1977) suggest that fill comprises the total depth of the test; 38 feet below existing ground level.

In the middle auger boring, A-3, "rock refusal" occurred at 24.5 feet (Doering, 1977). However the location of this auger boring is essentially the same as the position of continuous sample (GOW) boring B-6 which penetrated to a depth of 57 feet. In this test, only the final 11 feet (depth interval 46-57 feet) are reported to be in phyllitic bedrock (Stephens, 1977). Based on the number of "blows" to penetrate one foot in the upper 46 feet of the test, the material encountered in this boring consists of loose or soft, unconsolidated material except for two thin intervals that occur between 23.5 - 25 and 41 - 43 feet. Such physical characterists suggests fill to a depth of over 40 feet in the vicinity of A-3 and B-6.

In boring B-6, sample recovery was possible only for the interval between 41 and 57 feet below surface level. The characteristics of this interval follow:

Continuous Sample Boring B-6

Depth (feet)	Description
41 - 43	Moderate brown (5YR 3/4) to dark yellow brown (10YR 4/2) clay containing white, angular fragments of vein(?) quartz up to 10 x 10 mm; associated with small, highly weathered (2 x 4 mm) phyllite particles; limonite or other iron oxide coats some of the rock fragments.
45 - 47	Mottled moderate brown (5YR 3/4) and dark yellowish brown (10YR 4/2), slightly plastic clay with irregular dark yellowish orange (10YR 6/6) patches; observable micaceous material and small (4 mm) phyllite fragments.

Depth (feet)	Description
47 - 50	Weathered and pitted medium gray (N5) phyllite; weathered color very light gray (N8) - abrupt transition to greenish gray (5GY 6/1) to medium greenish gray (5GY 5/1) weathering, finely laminated, medium dark gray phyllite.
50 - 53.5	Light gray (N7) to very light gray (N8) phyllite weathering light greenish gray (5G 8/1).
53.5 - 56.0	Medium light gray (N6) to light gray (N7) weathering, light gray (N7), finely crinkled phyllite.
56 - 57	Medium light gray crinkled phyllite.

The 16 foot interval described is similar lithologically to portions of the Harpers formation, other parts of which crop out along the south side of Catoctin Hollow Road just west of existing Route 15.

In the vicinity of the auger borings A-2, A-3, A-5, and continuous sample (GOW) boring B-6 at the southern end of Check 12, Feature 2, the evidence seems to point to thick fill; perhaps, the result of a succession of overlays at different times. If this feature is the "other" ore bank described by Singewald (1911), some of the material had accumulated by natural processes by the time of that study.

The geologic relationship suggested to exist at this site by W. B. Greene (1977a) on the basis of the continuous sample (GOW) borings is doubtful. Based on a study of the boring samples (B-4 and B-6), thin sections of rock samples studied under the petrographic microscope, and the results of my geologic field work in the area (Fauth, 1977, enclosure) does not support nor require a fault to exist between the phyllite and limestone exposed in the two cores. The existence of a fault between the phyllite (Harpers formation) and limestone

(Frederick formation) is predicated purely on the basis of the Stoses' report on the geology of the area as described in their Carroll and Frederick counties report (1946). There the phyllites are assigned to the Loudoun formation, and if this were indeed true, a fault would be necessary. However both the more recent work of Whitaker (1955) and this consultant (1977) demonstrate that the normal stratigraphic succession of Harpers formation overlain by Frederick formation occurs along much of the eastern foot of Catoctin Mountain; specifically in the vicinity of the Catoctin Furnace site.

The"Silver Mine" borings: Four continuous sample (GOW) borings sited in and about the supposed "silver mine" located at Check 8 (Orr and Orr, 1977) encountered bedrock at depths of either 7-8 feet (B-9, B-10) or 14-16 feet (B-7, B-8). The bedrock is limestone that occurs in the Frederick formation with the singular exception of the uppermost part of the B-7 core. In this boring, a rock section taken at a depth of four feet consists of a phyllite containing a few, attenuated lenses of micro-crystalline quartz, and a few pseudomorphs of hematite(?) after pyrite. Local iron-stained patches also occur (Slide 37-4-70). At the five foot level, microcrystalline limestone comprises the bedrock (Slide 37-5-70). This sample contains some very fine-grained quartz and chlorite(?). Although complex and intersecting cleavages occur in the phyllite, neither this rock or the limestone interval beneath show any discernable evidence indicative of faulting. The phyllite unit may be part of the Harpers formation or an altered argillaceous (clayey) zone within the Frederick formation.

If the former is correct, then the geologic (stratigraphic) section at the locality is inverted, probably owing to strong folding.

Nearly complete core recovery particularly from a depth of 17-20 feet to 40 feet in these borings, clearly is inconsistent with the existence of the "silver mine" story, or any significant mining or deep exploratory excavation at this locality. The loss of drilling water at 21'6" in B-10, and the lack of core recovery between 7.5-15.5 feet depth in B-8 suggests that some solution channels and weathered zones may exist within the limestone bedrock. These may be restricted to or localized by major fracture zones (joints?) in the limestone.

Perhaps it is appropriate to note at this point the occurrence and identification of galena (lead sulfide, PbS) in portions of the core recovered from boring B-6 at Check 12, Feature 2 (Greene, 1977b). The existence of this silvery mineral in the core, confirmed by petrographic examination of rock sections in reflected light, may be related to the "silver ore" story associated with the feature at Check 8.

Examination of all 1970 and 1977 boring samples failed to disclose any evidence of significant mineralization in the rocks encountered and recovered in the two boring projects.

<u>The Origin of the Iron Ore at "Catoctin"</u>: Data acquired through the continuous sample (GOW) boring projects and the auger boring do not add significantly to the understanding of ore formation at Catoctin Furnace and vicinity primarily because no ore zone was breached by the borings. However these data do support strongly the

contention that any major continuous fault between juxtaposed phyllite and limestone rock bodies is absent at the base of the eastern flank of Catoctin Mountain. Core borings (B-4, B-6) are sited with 60 feet, yet they exhibit no physical or geologic evidence of a fault contact between the phyllite and limestone formations. In addition, the topographic and stratigraphic position of the two rock units exhibit a normal relationship to one another. If these core borings are located either within or astride a "filled" ore bank, they reinforce the interpretation that the formation and occurrence of the iron ores that comprise the "Catoctin deposits" primarily reflect a sub surface physical-chemical environment controlled by a post-Triassic(?) geomorphic, sedimentologic, and stratigraphic conditions moreso than the geologic structure (faulting) of the area.

Petrographic examination of rock sections: The preliminary study of a selected suite of 15 thin sections from various core samples reaffirms the following conclusions that have been drawn previously on the basis of other data:

(a) The bedrock associated with the Catoctin iron deposits includes phyllites of the Harpers formation and limestones in the Frederick formation.

(b) Although some rock sections exhibit complex microstructures, no direct evidence of faulting is present in any samples.

(c) The nature and amount of insoluble minerals present in most of the limestone samples indicates that these limestones have insufficient purity to use as a flux.

(d) No silver mineralization occurs in the samples sited in and about "Silver Mine" (Check 8), or in any other locality.

(e) Several iron-bearing minerals occur as accessory minerals in both the Harpers and Frederick formations; concentration of iron derived from such minerals may have contributed to the formation of the Catoctin iron deposits.

Table 2 presents a summary of this preliminary examination of the suite of rock sections.

6-30-64

DISTRIBUTION OF ROCK UNITS RELATED TO THE CATOCTIN ORE DEPOSITS

SOURCE OF DATA

Rock Unit	Quarry, Pit, Excavation	Natural Outcrop	Core or Auger Boring
Harpers Formation	□	△	○
Frederick Formation	□	△	○

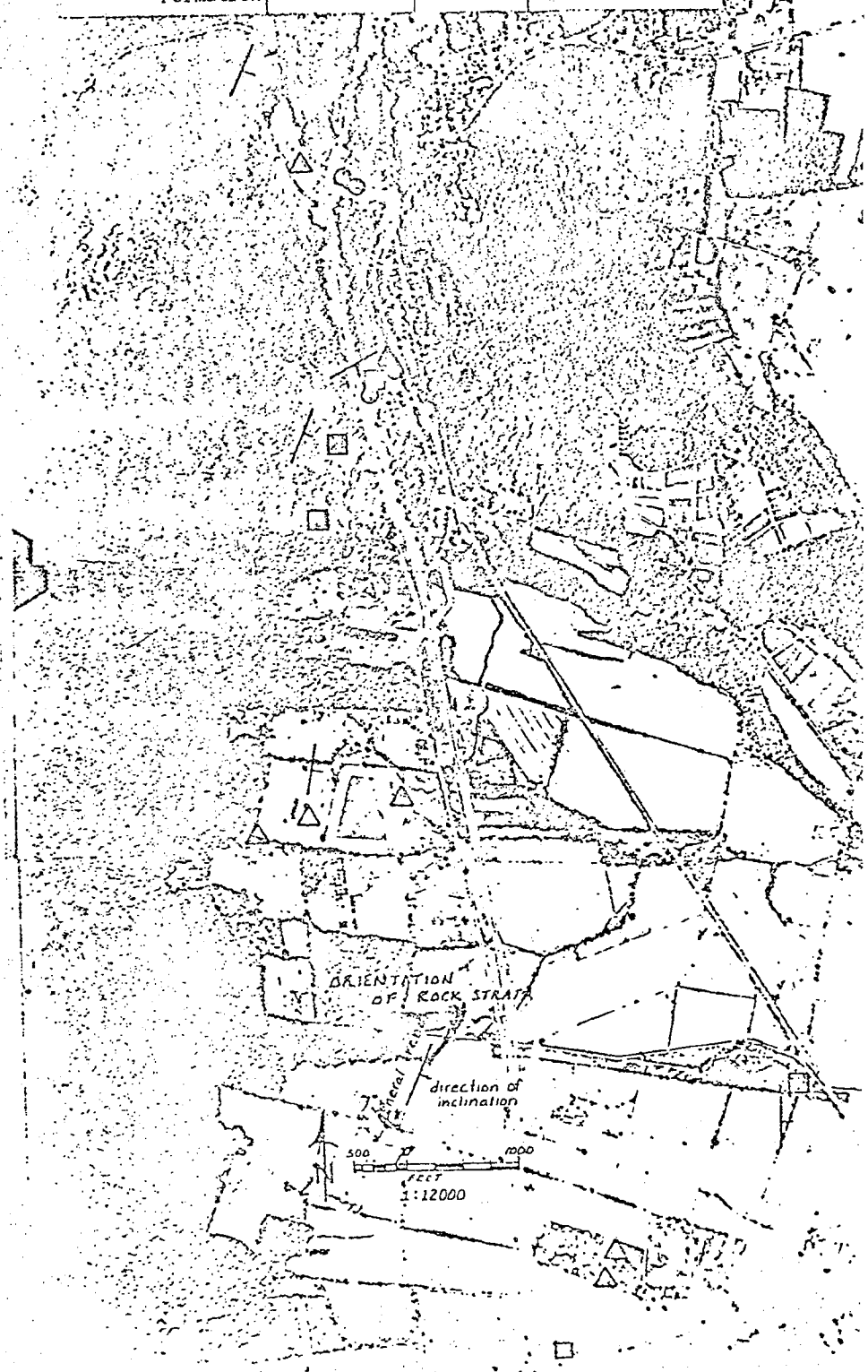

FIGURE 1

TABLE 1

LOG 30-50 FOOT INTERVAL BORING (GOW) B-3, 1977

INTERVAL pth in feet)	ELEVATION (feet)	MATERIAL CLASSIFICATION (1)	RELATIVE STRENGTH (1)
32	456.8-454.8	$A4^7$; Silty clay with sand rock fragments	Very stiff to very hard
35.5	454.8-451.3	$A4^7$; Silty clay with sand and rock fragments	Very stiff to very hard
5-38	451.3-448.8	$A4^7$; Silty clay with sand and rock fragments	Very stiff
.40	448.8-446.8	$A4^7$; silty clay	Very stiff to hard
.42	446.8-444.8	$A4^7$; silty clay	Very stiff to hard
-47	444.8-439.8	$A7^2$; sandy clay	Very stiff
-48	439.8-438.8	$A7^2$; sandy clay	Very stiff
-50	438.8-436.8	$A7^2$; sandy clay	Very stiff to very hard

(1) Driller's log

(2) Goddard, et al - Rock color chart

TABLE 2

PRELIMINARY EXAMINATION OF ROCK SECTIONS
FROM 1970 AND 1977 CORE BORINGS
CATOCTIN FURNACE AND VICINITY

mple No.	Identification (Boring No.-Depth-Yr.)	Description
1	B2-41-77	Calcareous siltstone. Alternating laminae of silt-size quartz and microcrystalline calcite 0.5 - 1.5 mm. thick. Minor amounts of highly disseminated pyrite with "brassy" color in reflected light and square to rectangular form - locally concentrated around periphery of irregular patches consisting of very fine grain, anhedral quartz; some calcite spar near areas of quartz concentration. Frederick formation(?)
2	B4-6-77	Impure limestone. Consists of very fine grain anhedral calcite with some thin laminations or seams of subrounded quartz about 0.1 mm. in diameter, narrow, discontinuous zones of chlorite(?) and fibrous to lath-like grains of bleached biotite(?) locally; very low content of heavy minerals; in places, some patches or lenses composed of calcite spar 0.8-1.0 mm. in diameter; aggregates of quartz show evidence of recrystallizaton (fusion). Frederick formation.
3	B4-6-77	Limestone. Extremely fine-grained limestone consisting of anhedral calcite about 0.1 mm. in diameter; thin zones containing sheaves of chlorite plus some altered biotite locally; few accessory minerals. Quartz (0.2-0.5 mm.) occurs as vein or fracture filling; shows some evidence of recrystallization. Frederick formation.
4	B4-11-77	Limestone. Crystalline mosaic of anhedral to subhedral calcite up to 2.0 mm. diameter; inter bands of micrite (0.1 mm.), boundary irregular; isolated patches and discontinuous thin lenses of very fine-grained anhedral quartz; locally, altered biotite. No significant heavy, metallic minerals.

TABLE 2 (Cont'd)

5	B4-26-77	Limestone. Uniformly, very fine-grained limestone with anhedral calcite crystals dimensionally aligned; well-developed, conjugate crenulation cleavage transects dimensional fabric; individual, small, anhedral quartz grains or isolated patches of crystalline quartz. Frederick formation.
6	B4-38-77	Limestone. Fairly uniform, medium-grained (0.25-0.5 mm.), anhedral calcite with some widely dispersed, very fine-grained (0.1-0.2 mm.) quartz grains. Contains disseminate grains or local concentrations of galena (PbS some unidentified black opaque mineral, epidote(?). Frederick formation.
7	B6-50-77	Argillaceous sandstone. Fair to poorly sorted, very fine grained, angular to sub-angular quartz; associated mica (altered biotite?) and clay; finely laminated, spacing 1.0 - 2.0 mm; quartz grains subequant to equant, exhibit poorly developed dimensional alignment. Harpers formation.
8	B6-55-77	Quartz phyllite. Lens-shaped mosaics of 0.1-0.2 mm. long, anhedral quartz grains that extend up to 0.5-1.0 mm. in length; micaceous minerals envelop or "wrap" quartz patches; some fine-grained magnetite granules rock exhibits well-developed cleavage. Harpers formation.
9	B7-4-70	Phyllite. Yellow to red-brown stained mica with some fine-grained quartz as individual grains or lenticular crystalline aggregates 0.5-1.5 mm. long. Small anhedral grains of hematite, deep to bright red on translucent edges; few hematite crystals probably pseudomorphic after pyrite. Harpers formatic

TABLE 2 (Cont'd)

10	B7-5-70	Impure limestone. Anhedral calcite, 0.5-1.0 mm. diameter, and associated fine-grained quartz and altered biotite(?); some areas of euhedral, rhombic crystals (dolomite?); in places, irregular laminations, zones or lenses prominently iron-stained, may also outline crystal borders or occur within crystal along crystallographic or twin planes. Frederick formation
11	B7-30-70	Impure limestone. Anhedral, 0.75-1.0 mm. calcite crystals associated with widely scattered, individual quartz grains (0.1-0.2 mm.) and small quartz mosaics; prominent pyrite as euhedral, rectangular or triangula shaped, metallic crystals; few fibrous laths or matted aggregates of altered biotite(?); local seams and patches of argillaceous material generally stained yellow to orange-brown. Frederick formation.
12	B8-5-70	Limestone. Fine-grained rock containing calcite, locally euhedral and outlined by prominent brown stain; about three percent anhedral quartz (0.15 - 0.3 mm. in diameter) with embayed or corroded boundaries common; approximately 2-3 percent hematite; local, discontinuous seams of argillaceous material Frederick formation.
13	B8-30-70	Limestone. Consists of anhedral calcite grains 0.25-0.3 mm. in size; very fine-grain quartz (0.1 mm.), and local concentrations of dark, opaque, metallic mineral (magnetite?); some red-brown hematite stain. Frederick formation.
14	B10-23-70	Impure limestone. Very fine to fine-grained crystalline aggregate of anhedral calcite; quartz is common as individual anhedral grains 0.1-0.2 mm. in diameter; abundant, very fine-grained argillaceous material; locally, altered biotite. Frederick formati
15	B10-40-70	Calcareous siltstone. Abundant anhedral quartz grains 0.15-0.2 mm. in length associated with aligned chlorite, altered biotite, and other very-fine argillaceous material; prominent crenulation cleavage disrupts dimensional alignment of inequant grains locally. Harpers formation(?) or basal Frederick formation.

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