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Depositional environments and biostratigraphy of the Lower Triassic Thaynes Formation southwestern Montana

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DEPOSITIONAL ENVIRONMENTS AND BIOSTRATIGRAPHY
OF THE LOWER TRIASSIC THAYNES FORMATION,
SOUTHWESTERN MONTANA

BY

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DEPOSITIONAL ENVIRONMENTS AND BIOSTRATIGRAPHY OF THE LOWER TRIASSIC THAYNES FORMATION, SOUTHWESTERN MONTANA (161 p.)

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The purpose of this study was to determine the depositional history and biologic changes in southwestern Montana during Lower Triassic Thaynes Formation (Smithian - Spathian) deposition. Lithology, biota, sedimentary structures, petrology and diagenesis were described from ten stratigraphic sections in the Tendoy Mountains, Snowcrest Range and Gravelly Range.

In the Tendoys, three stratigraphic members comprise the Thaynes Formation. The lower limestone and middle, calcareous sandstone members record a shallowing-upward carbonate sequence deposited on a complex mixed-carbonate shelf of moderate turbulence, which was periodically affected by storm waves. The sequence terminates with restricted, shallow subtidal to intertidal depositional facies formed during regression of the Triassic sea. The upper unit records transgression of the sea back into the study area and three periods of subtidal, algal-crinoid, mud-mound buildups on the shelf edge. Each period was terminated by storms, or migration of sand and oolite bars over the buildup. Minor channel sandstones plus sand-dominated lithofacies in the upper limestone may record proximity of some sections to terrigenous imput from the craton. Biostratigraphic horizons in the Tendoys include *Meekoceras* and *Pentacrinus* beds. Other biota includes: pelecypods, gastropods, miliolid forams, echinoderms, crinoids, nautiloids, brachiopods (terebratulids, rynchonellids, and *Lingula*), and green and encrusting algae.

The Thaynes Formation in the Snowcrest and Gravelly Ranges consists mainly of 1) a lower, calcareous sandstone, with thin red beds and restricted fauna, and 2) an upper echinoid limestone with stenohaline fauna. The lower sandstone records deposition on a shallow marine shelf dominated by sand bars. Because of the extremely shallow water on this part of the shelf, circulation was at least partially restricted, creating red beds with low-diversity marine fauna in the lower units. As in the Tendoys, the lower units mark a shallowing-upward carbonate sequence that terminates in intertidal to shallow-subtidal deposits. A lithoclast zone above these deposits marks transgression of the sea back into the area. After transgression, circulation was open and carbonate buildups flourished in the normal-marine conditions.

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Pamela G. L. Sikkink

INTRODUCTION

During the Early Triassic, the distribution of marine sediments and invertebrate populations in the western United States was controlled by a deep, elongate, north-trending basin within the Cordilleran miogeosyncline (Carr and Paull, 1983). The basin axis in southeast Idaho was flanked to the north, east and south by shallow, continental shelves. The Lower Triassic (Smithian - Spathian) Thaynes Formation was deposited in this basin and on the shelves during the final regression of the Triassic sea from the miogeosyncline.

Previous geologic studies of the Thaynes Formation have focused on the stratigraphy and paleontology of the deep basin (Kummel, 1954; 1957), the eastern shelf of Wyoming and southeastern Idaho (Picard and others, 1969; Newell and Kummel, 1942; Koch, 1976; and Kummel, 1957; 1954), and the southern shelf of Nevada and southern Wyoming (Bissel, 1970; Picard and others, 1969). The stratigraphy of the northern shelf area in Montana, however, has only been defined in general by Moritz (1951) and Kummel (1957). The stratigraphy, lithofacies, biota and depositional environment(s) of the Thaynes Formation in this area have not been studied in detail. The Thaynes contains three stratigraphic members in the Tendoy Mountains, which were named by Moritz (1951), but detailed sedimentologic characteristics of these members have not been deliniated. Nor have the depositional conditions and history of the northern shelf been deliniated or related to other shelf areas.

Biologically, the northern shelf is thought to possess a fauna of low diversity, including ammonites, brachiopods, pelecypods and Pentacrinus columnals (Kummel, 1954). The scarcity of Lower Triassic fossils has been attributed to both unfavorable environmental conditions (Boyd and Maughan, 1972) and to the severity of extinctions at the end of the Permian (Kummel, 1957). However, environmental conditions on the Montana shelf have not been studied. Similarily, its biostratigraphy has not been examined in detail to ~~to~~ determine the relative abundance of biota on the shelf.

This paper describes the litholgic, sedimentologic, and biologic changes within the Thaynes Formation in the Tendoy Mountains and Snowcrest and Gravelly Ranges of southwest Montana (fig. 1). It describes stratal relationships of the Thaynes with the underlying Woodside Formation and overlying Jurassic rocks (fig. 2). It presents a depositional model for the Thaynes Formation in southwestern Montana and compares this model with depositional models proposed for more southerly shelves. Finally, it describes the diagenetic changes that Thaynes rocks have undergone since their deposition.

The stratigraphy and biota of the Thaynes Formation in southwestern Montana indicate that it was deposited on a shallow shelf, at or above wave base, in the subtidal to intertidal zones. During deposition of the lower Thaynes, the basinward portions of the shelf were dominated by muddy sediments and terrigenous clastics deposited in low-energy conditions. Shoreward, sedimentation was sand-dominated. It includes

Figure 1.--Location of study area and stratigraphic sections.

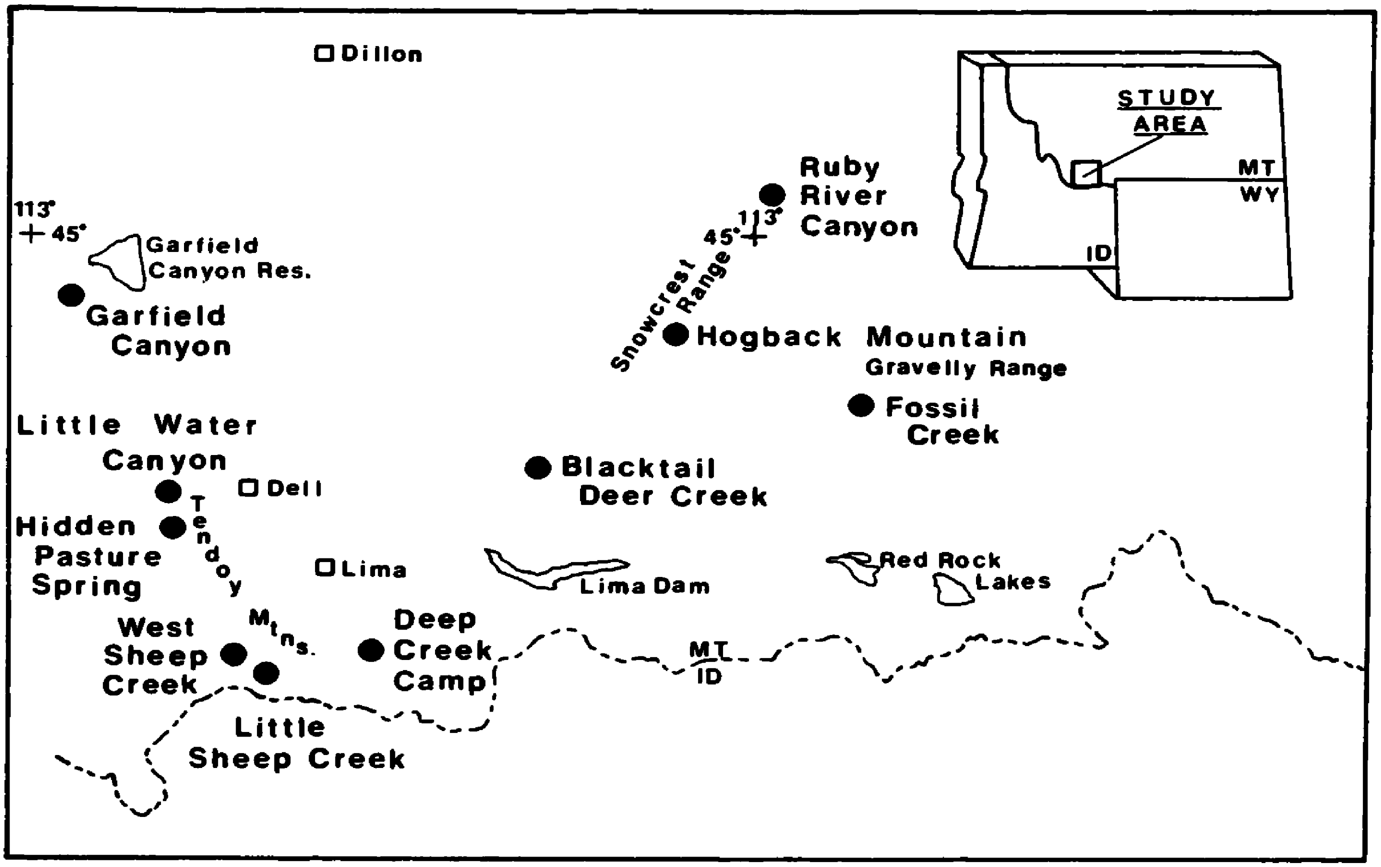

Figure 2 (Opposite page).--Stratigraphic correlations of the lower Triassic Thaynes Formation and related units in Montana, Idaho, Wyoming, Utah and Nevada. Triassic stratigraphy compiled from Kummel, 1954; Reeside and others, 1957; High and Picard, 1967; Collinson and Hasenmueller, 1978; Boyd and Maughan, 1972; Collinson, 1968; and Newell and Kummel, 1942. Jurassic stratigraphy mainly from Imlay, 1980.

* Gr = Griesbachian; Di = Dienerian; Sm= Smithian; and Sp = Spathian.
1 Nugget Ss shown as lower Jurassic in Imlay (1980), Triassic in High & Picard (1967), and Triassic in Reeside and others (1957).
2 Glen Canyon Sandstone of Imlay (1980).

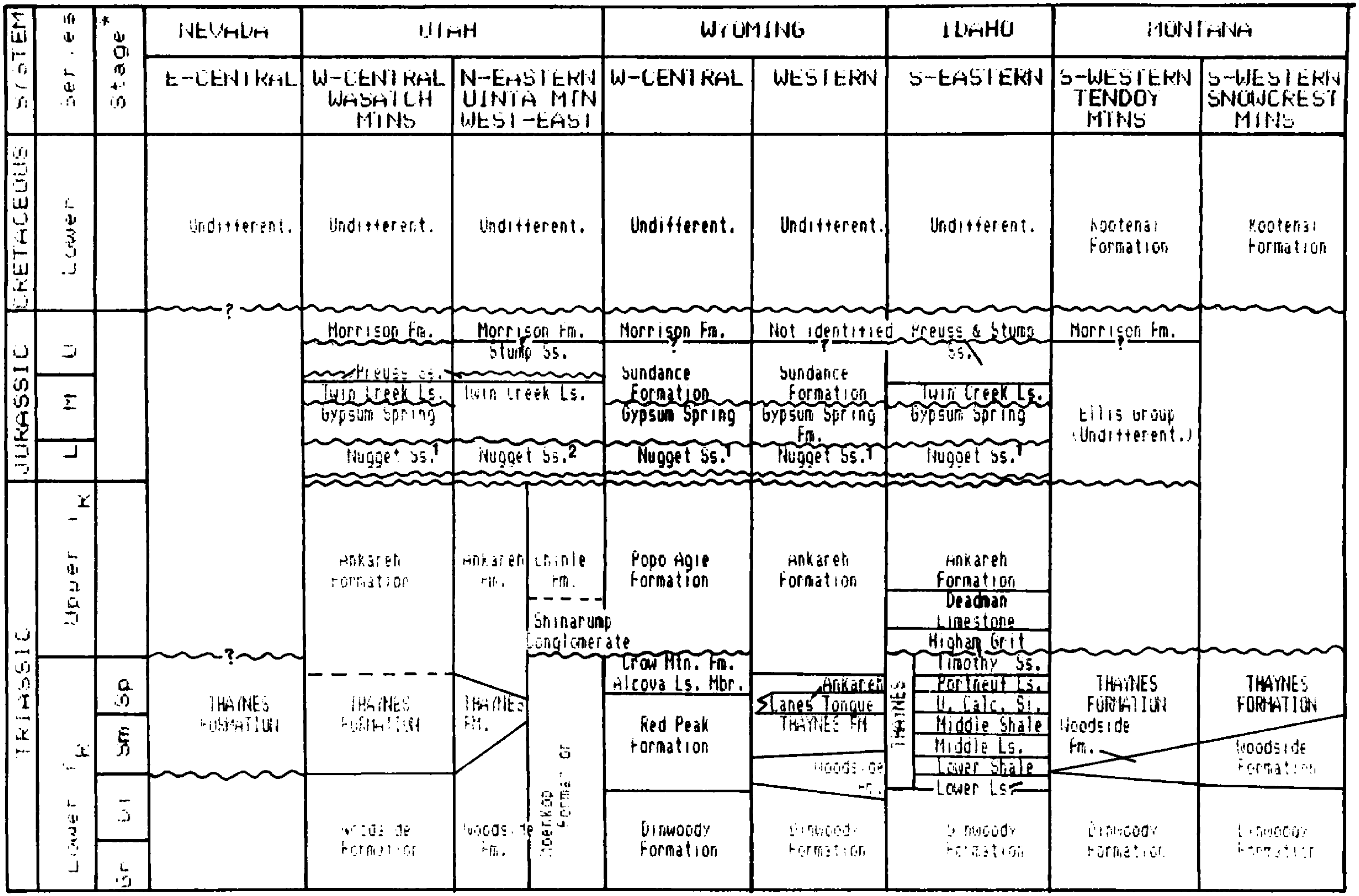

Figure 2.--Stratigraphic correlations of Triassic Thaynes Fm.

both normal-marine sands that formed on carbonate sand bars (shoals) and restricted-marine red beds that formed in areas of very shallow water which restricted circulation. During early sedimentation, some Thaynes sediments were also periodically reworked by storm waves or strong currents. Hardgrounds, marked by intense limonitization of bioclasts and clasts with dissolution textures, formed in shallower areas and been eroded and reworked by these storms.

The lower to middle Thaynes in southwest Montana forms a shallowing-upward carbonate sequence that formed as the Smithian sea gradually regressed from the area. Transgression back into Montana is marked in the upper limestone of the Thaynes Formation by a lithoclast zone and a distinct change from restricted, intertidal and shallow, subtidal depositional facies to normal-marine subtidal depositional facies with open circulation. After the transgression, normal-marine deposition continued throughout southwest Montana. The low- to moderate-wave energy and shallow-water conditions encouraged growth of many stenohaline forms. Algal-crinoid mud mounds and carbonate sand and oolite bars dominated the shelf during this time. During deposition of the upper Thaynes, however, the quiet-water environment was often disturbed by storm waves or strong currents that dominated the southwest Montana coast and shelf. Organisms were disturbed, and bottom sediments were reworked and winnowed during these storms.

Invertebrates living on the northern shelf area at various times during deposition of the Thaynes include a variety of brachiopods, mollusks, echinoids, crinoids and cephalopods. Most of the invertebrate fossils from the Thaynes are highly fragmented and poorly preserved.

Invertebrates that could be identified for this study, and which aided in environmental interpretation, include: Meekoceras, small nautiloids, Lingula, Rhynchonella, terebratulid brachiopods, Pentacrinus, Isocrinus?, monaxon sponge spicules, miliolid forams, and green and encrusting algae. The pelecypods, gastropods, and green algae are largely unidentified. However, the mollusks are similar in size and morphology to Polygyrina, Planospirina, Eumorphotis, Myalina, Pectin, Permophorus, and Unionites, which were identified from similar-age units and environments in Nevada by Bissell (1970).

Several types of diagenesis, including silicification, secondary calcite fillings, neomorphism, and recrystallization have altered Thaynes Fm. sediments since their deposition. Compaction and deformation textures are also evident and form complex textures and diagenetic sequences.

METHODS OF STUDY

Ten stratigraphic sections were measured throughout the Tendoy Mountains and Snowcrest and Gravelly Ranges (fig. 1). Descriptions of these sections provide detailed data on lithology, mineralogy, texture, sedimentary structures, biologic constituents, and porosity (Appendix A).

In addition to field data, analysis of 140 petrographic samples, 25 samples for bulk-fossil content, and three geophysical logs complete the data base. Bulk-fossil samples were dissolved in 10% hydrochloric acid (HCl) and silicified fossils removed from the fine- sand and silt residue with a fine sieve. Separate rock samples were sent to Bruce

Wardlaw, U. S. Geological Survey and Museum of Natural History, for future conodont analysis. Petrographic samples were stained for carbonates using methods described by Friedman (1954) and Hutchison (1974) and examined for lithology, fossils, organic matter and diagenesis with a standard petrographic microscope and a cathode-luminescence microscope (Appendix B).

ACKNOWLEDGEMENTS

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Special thanks go to Gene Hildrith, Art Robinson, and Doug LeBear, who granted access to section locations through their ranches at Little Water Canyon, Deep Creek Cow Camp, and Odell Creek, respectively; and to A. J. Sikkink for field and computer assistance during this project.

PREVIOUS WORK

Condit (1918), Moritz (1951) and Kummel (1954, 1960) comprise the main geologic studies on the Thaynes Formation in southwest Montana.

Condit (1918) conducted the earliest general reconnaissance studies of the Thaynes Formation in this area. Moritz (1951) expanded on Condit's reconnaissance studies by measuring stratigraphic sections of Triassic and Jurassic rocks over a large area in southwestern Montana. Moritz (1951) found that the Thaynes in this area could be divided into an upper limestone member, a middle sandstone member, and a lower limestone member based on his stratigraphic sections at Fossil Creek and Garfield Canyon (fig. 1). He found that these divisions were similar to the Thaynes type section described by Boutwell (1907) in the Park City Mining District of Utah. Boutwell (1907) described the type section as consisting of upper and lower calcareous members, separated by a red shale member. Boutwell described the calcareous members as "mainly dense, homogeneous, blue-gray, calcareous sandstone, which only superficially appears to be a limestone".

Kummel (1954) described the Thaynes Formation of southwestern Montana in conjunction with studies of the Thaynes in southeastern Idaho. In Idaho, he distinquished seven lithologic units within the Thaynes Formation (fig. 2). However, he could not trace these units into Montana. Kummel (1954, 1960) studied stratigraphic sections in Montana at Little Water Canyon, Hogback Mountain, Odell Canyon and Fossil Creek. He described the Thaynes in these areas as "extremely homogeneous" and "composed of siltstone-limestone and limestone-sandstone facies" (Kummel, 1954, p. 442). He did not distinquish more than the three general units of Moritz (1951).

The first interpretations on paleoecology and depositional environments within the Thaynes were published by Kummel (1957) and

Picard and others (1969) for rocks in Idaho and Wyoming. Kummel determined the Thaynes, in general, to be deposited in a shallow marine environment on a relatively stable shelf. Active bottom currents, well-oxygenated and shallow waters supported an abundant, but not diverse, fauna. He suggested that the diversity was low because of Late Paleozoic mass extinctions, not unsuitable Triassic environments. Picard and others (1969) also suggested shallow marine enviroments (less than 60 ft, 18m) composed of shelf edge banks and oolitic shoals in Idaho and an open shelf in Wyoming.

Other environmental interpretations for the Thaynes Formation in Idaho, Utah, Wyoming and Montana are based on conodont analysis. These studies include: Carr (1981), Collinson and Hasenmueller (1978), Paull (1980), Perry and Chatterton (1979), Siberling and Tozer (1968), Solien (1979) , and Sweet and others (1971).

Klecker (1981) first studied the general depositional environment of the Thaynes Formation in southwestern Montana. His interpretations stemmed from general observations made during mapping of the Dixon Mountain-Little Water Canyon area in the Tendoy Range (Klecker, 1980). Klecker interpreted the Thaynes at Little Water Canyon to be deposited on a shallow shelf or a protected shallow lagoon with good circulation and eolian and fluvio-deltaic input. Eolian input occurs in several units of the Thaynes as very- fine terrigenous sand deposited on the shelf by offshore winds. Evidence of periodic shoaling and subaerial exposure suggested subtidal to intertidal environments (Klecker, 1981).

STRUCTURE AND TECTONICS

Laramide Structures

Structurally, the study area is in the Rocky Mountain foreland fold and thrust belt. The main structural elements in this area include: 1) northeast-trending folds; 2) northwest-trending folds; 3) north- to northwest-trending low-angle thrust faults; 4) northwest-trending, high-angle thrust faults; and 5) a number of en echelon normal and tear faults (Scholten and others, 1955). These structures were defined mainly during geologic mapping and topical investigations by Scholten and others (1955), Ryder and Scholten (1975), Perry and others (1981), Skipp and Hait (1977), Mann (1960), Perry and others (1983), Perry and Sando, (1982), and Witkin (1982) (fig. 3).

Most compressional structural elements in this area developed during the Laramide Orogeny (Late Cretaceous-early Tertiary), during three main episodes of deformation (Scholten and others, 1955; Peterson, 1981). These episodes include: Mid-Laramide and Late Laramide folding, and Late Laramide thrust faulting. According to Scholten and others (1955), mid-Laramide deformation in the Lima area began with the formation of northeast-trending folds from northwest-southeast compressive forces. These early folds include the Blacktail-Snowcrest anticline, Little Water syncline, Garfield anticline, and an unnamed anticline north of Lima Reservoir (Scholten and others, 1955). Late Laramide northwest-trending folds, such as Little Water Canyon (superimposed on its northeast-trending fold), Little Sheep Creek, Clark Canyon and Red Rock synclines, and the Lima, Clover Creek, Armstead and

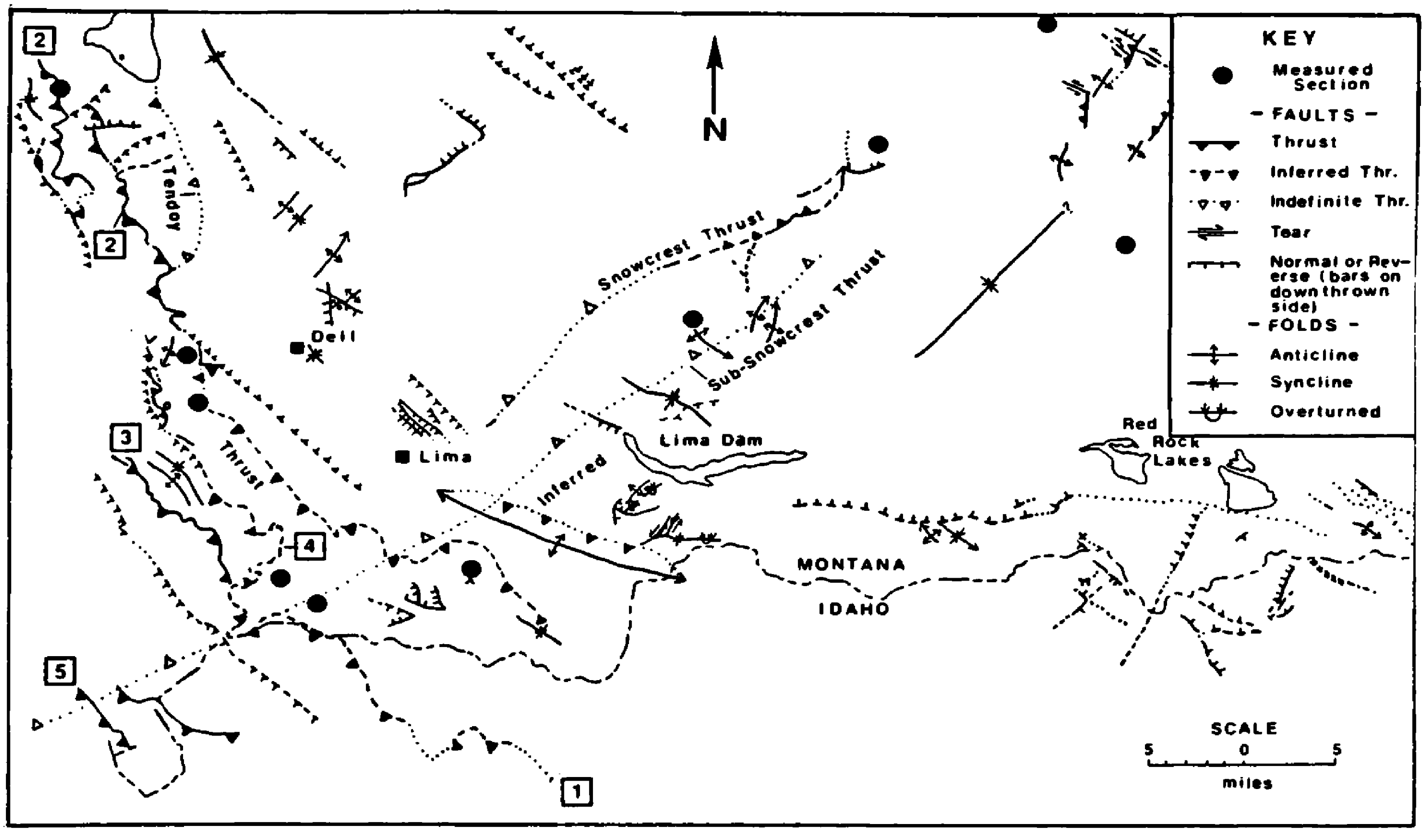


Figure 3.--Laramide structures in study area. Numbers referenced in text. Compiled from Klecker (1980); Perry and others (1981, 1983); Scholten and others (1955); Ryder and Scholten (1973); Klepper (1950); Witkin (1982); Mann (1960); Skipp and others (1983); and Brashner (1950).

"West Armstead" anticlines (Scholten and others, 1955) were created by northeast-southwest compressive forces. These forces deformed the older northeast-trending folds (Scholten and others, 1955). In Little Water Canyon, they formed a heart-shaped depositional basin for Laramide rocks, and exposed Triassic rocks in a horseshoe-shaped outcrop. This episode, according to Scholten and others (1955) and Ryder and Scholten (1973) affects the Beaverhead Conglomerate and, therefore, is Late Paleocene - early Eocene in age.

Six major Late-Laramide low-angle and high angle thrust faults are present in the Lima area. The low-angle thrusts include the Medicine Lodge overthrust and the Limikin thrust (locs. 1 and 2, respectively, fig. 3), which moved hanging wall rocks to the northeast (Scholten and others, 1955). The high-angle thrusts include Cabin Creek, Four Eyes Canyon and Nichola thrusts (locs. 3-5, respectively, fig. 3) and the Tendoy thrust (fig. 3) (Scholten and others, 1955; Perry and others, 1983). According to Scholten and others (1955), the high-angle thrusts postdate the low-angle thrusts because the Medicine Lodge thrust has been broken, displaced and tilted by the high-angle Nicholia and Tendoy thrusts in the Lima region. Timing of movement on the Tendoy thrust sheet has been constrained by Perry and Sando (1982). Eastward movement occurred after the development of the Four Eyes Canyon thrust and after deposition of part of the Beaverhead Conglomerate. It contains exotic blocks from the Four Eyes Canyon sheet, which contains the westernmost identified rocks of Mississippian Madison Group in southwestern Montana, and overrides part of the Beaverhead Conglomerate.

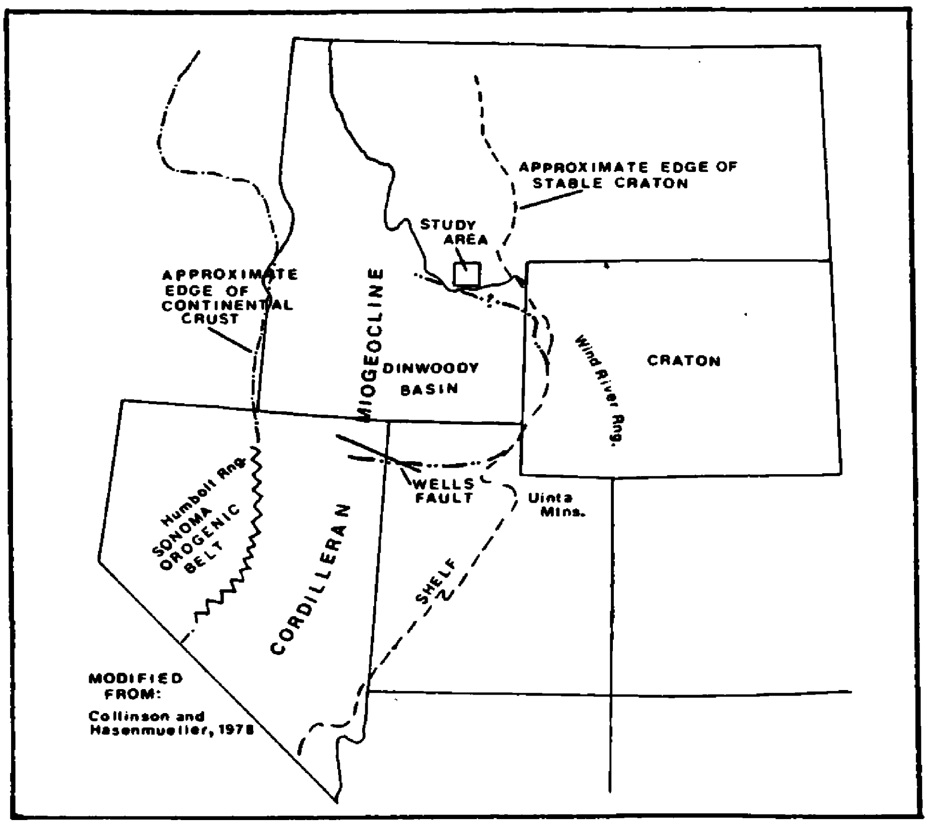
Most pertinent to this study are the Tendoy thrust, its extension, the Limekin thrust, the Snowcrest thrust, and the inferred sub-Snowcrest thrust of Perry and others (1981). All of the stratigraphic sections in this study lie on these thrust sheets. All measured sections on the Tendoy thrust have undergone the same relative movement. Those on the Snowcrest thrust, have probably moved differently than the Tendoy sections. According to Skipp and Hait (1977), total movement on the Tendoy and Medicine Lodge Restricted allochthons (consisting mainly of the Tendoy thrust and Medicine Lodge thrusts) is unknown. They estimate, however, that movements on individual allochthons located from the western edge of the Beaverhead Mountains to the Lima area southwestern Montana are only about 50 km (30 mi). Movement on the Medicine Lodge (Restricted) allochthon is estimated at 50 km (30 mi.). Movement on the Tendoy allochthon is estimated at tens of kilometers, with movement on the Tendoy thrust estimated at 40 km (25 mi.) (Skipp and Hait, 1977). Therefore, the absolute amount of movement on these thrusts does not significantly disrupt the stratigraphic framework on which the interpretations of depositional environments and depositional history emphasized in this study are based.

Pre-Laramide Structures

In contrast to the abundant Laramide folding, faulting and deformation that created present structures in southwest Montana, the Triassic Period was marked by sedimentation in a fairly stable structural environment. Depositional and structural patterns of the area were inherited from at least the late Paleozoic (Collinson and Hasenmueller, 1978), and possibly from the Precambrian (Carr and Paull, 1983).

The major structural element affecting Triassic sedimentation in southwest Montana was a deep, north-trending, elongate basin within the Cordilleran miogeocline (fig. 4). The axis of this basin developed in

Figure 4.--Tectonic framework during Lower Triassic.



southeastern Idaho and persisted throughout Triassic time. The basin was flanked on the north, east and south by shallow shelves (Carr and Paull, 1983). Its southern limit may have been defined by a major easterly-trending, Paleozoic basement growth fault located along the present-day Well's fault in southeastern Nevada (Carr and Paull, 1983). Southwestern Montana was part of a relatively stable shelf from the northeastern edge of this basin to the eastern edge of the miogeocline. The miogeosyncline was flanked on the east by the craton and on the west by the Sonoma orogenic belt (Bissell, 1974). Fine-grained, terrigenous sediments of the Thaynes Formation came from the craton to the east. Little or no sediment reached Montana from the orogenic belt. According to Collinson and Hasenmueller (1978), the eastern shoreline along the cratonic margin also remained relatively stable. The western shoreline, however, shifted from southern and eastern Nevada during the Smithian to central and western Nevada during the Spathian.

DEFINITION

Historically, the Thaynes Formation has been defined as beds between the base of a *Meekoceras*-bearing limestone and the Ankareh Formation (Boutwell, 1907). This paleontologic definition, however, can no longer be applied using rules of the Code of Stratigraphic Nomenclature. The historical definition of the Thaynes, as it was originally conceived, is not regionally consistant throughout the Thaynes depositional area and is particularily inconsistant in the study area of southwest Montana. Three main problems exist. First, *Meekoceras* beds are absent from a number of outcrops that are mapped as Thaynes Formation. Second, the Thaynes is not everywhere overlain by the Ankareh Formation (see fig. 2). Third, the contact of the Thaynes with the underlying Woodside Formation or Dinwoody Formation usually occurs several tens or hundreds of feet below the ammonite zone.

In most areas of the eastern edge of the Triassic miogeocline, the Thaynes Formation transitionally overlies a sequence of interbedded non-marine, calcareous, siltstone and sandstone red beds, and silty, fenestral, marine limestones (Scholten, 1955) belonging to the Woodside Formation (fig. 2). The Woodside forms slopes that are mostly covered by reddish or maroon soil. In the study area, the thickness of the Woodside varies from absent at Garfield Canyon and in the Blacktail Range (fig. 1) to 186 ft (56 m) in the Snowcrest Range (Scholten, 1955) and 800 ft (245 m) in the Centennial Mountains (Witkin, 1982). Its sedimentary structures and depositional characteristics indicate deposition in an arid climate in non-marine and tidal flat or sabkha environments (Klecker, 1981).

The base of the Thaynes overlying the Woodside red-bed sequence was defined by Newell and Kummel (1942) at the base of a Meekoceras zone. Poorly-preserved ammonites are found in the lower, Meekoceras-bearing Thaynes limestone in Idaho, Utah, much of Wyoming, and in outcrops in the Tendoy Range of southwest Montana (Moritz, 1951). At the type section in the Park City Mining District, Utah, however, ammonite fauna is absent from the lower limestone unit (Boutwell, 1907). Ammonoids are also absent from lower limestone units in the Wyoming and Teton Ranges of Wyoming (Kummel, 1954) and the Snowcrest Mountains and Gravelly Range of southwest Montana.

In this study, the base of the Thaynes is defined lithologically and is placed at the lowermost major limestone ledge that outcrops above the red, mudstones and siltstones of the Woodside Formation (see measured sections, Appendix A). In the Tendoy Mountains, the Meekoceras beds are approximately 90 ft (30 m) above this basal limestone. Only at Garfield Canyon, where Woodside is absent, do the Meekoceras beds outcrop approximately 90 ft above a basal thick limestone overlying Dinwoody Formation. In the Snowcrest and Gravelly Ranges, the lower Thaynes consists mainly of fine-grained sandstone and minor limestones, which contain pelecypod and gastropod faunas, but no ammonites. Kummel (1960) reported a single ammonite (<u>Hemipreonites</u> ?) 250 feet above the base of the Thaynes at Hogback Mountain. However, I found no ammonites at Hogback Mountain during this study. The Thaynes - Woodside contact at Hogback Mounain is placed in this study at the color change from red sandstone and shale of the Woodside to green sandstone beds that mark the base of the Thaynes (fig. 5).

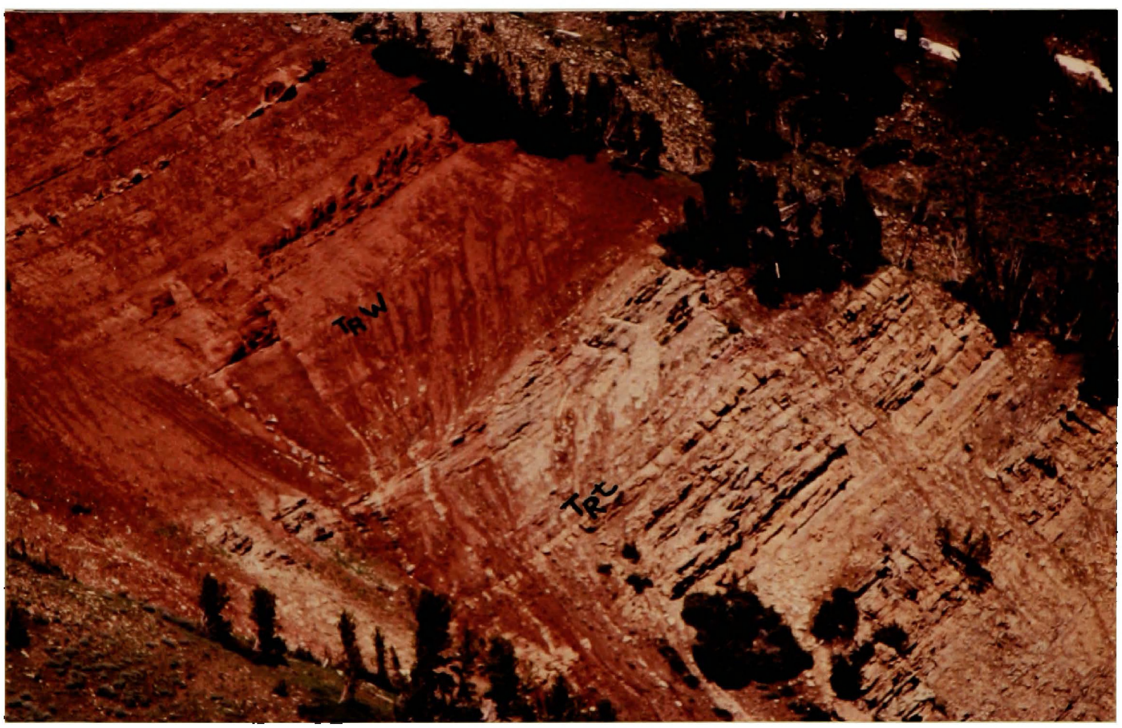


Figure 5.--Contact of Woodside Fm. and Thaynes Fm., Hogback Mountain. Contact is gradational and placed at main color change.

Throughout its depositional extent, the Thaynes is overlain by a variety of rock units (fig. 2). In Wyoming and at the type section, it is overlain by diverse red-beds known collectively as the Ankareh

Formation. In western Wyoming, the Lanes Tongue of the Ankareh separates upper and lower Thaynes Formation. In southeast Idaho, the Timothy Sandstone (considered by Kummel, 1954, as part of the Thaynes Formation), Higham Grit, and Deadman Limestone (Kummel, 1954) overlie the Thaynes Formation.

In southwest Montana, the Thaynes is unconformably overlain by the Jurassic Ellis Group and Cretaceous Kootenai Formation (fig. 2). In the Tendoy Mountains, the unconformity is mostly covered. The upper Thaynes contact is placed at the highest thin limestone bed below a large covered slope of Ellis (see measured sections, Appendix A). Jurassic carbonate beds above this thin limestone ledge reported from other areas contain fauna types and sedimentary characteristics (ie. oolites, Pentacrinus columnals, brachiopods, and other features) similar to the upper part of the Thaynes. In the Snowcrest and Gravelly Ranges, the upper boundary of the Thaynes is sharply defined by the conglomeratic sandstone of the Cretaceous Kootenai Formation.

LITHOFACIES AND SEDIMENTARY PROCESSES

Lithofacies and sedimentary processes of Thaynes Formation rocks in southwest Montana are described from two main geographic areas, namely the Tendoy Mountains and the Snowcrest and Gravelly Ranges. Characteristics from these areas vary greatly in lithofacies and sequence of rocks. They form complex stratigraphic sections that differ in overall proportion of sand, amount of interbedded red sands, quantity and diversity of fossils, and number and thickness of limestone beds. This section describes, compares and correlates the characteristic lithofacies, biota, and sedimentary processes within the Thaynes of each area, and between the two areas.

TENDOY MOUNTAINS

The most complete exposures of Thaynes Formation rocks in southwest Montana outcrop in the Tendoy Mountains on the Tendoy thrust sheet (fig. 3). The six stratigraphic sections measured in this area range up to 680 ft (206 m) and consist of interbedded skeletal limestone, siltstone, sandstone, and mudstone, with minor dolomite.

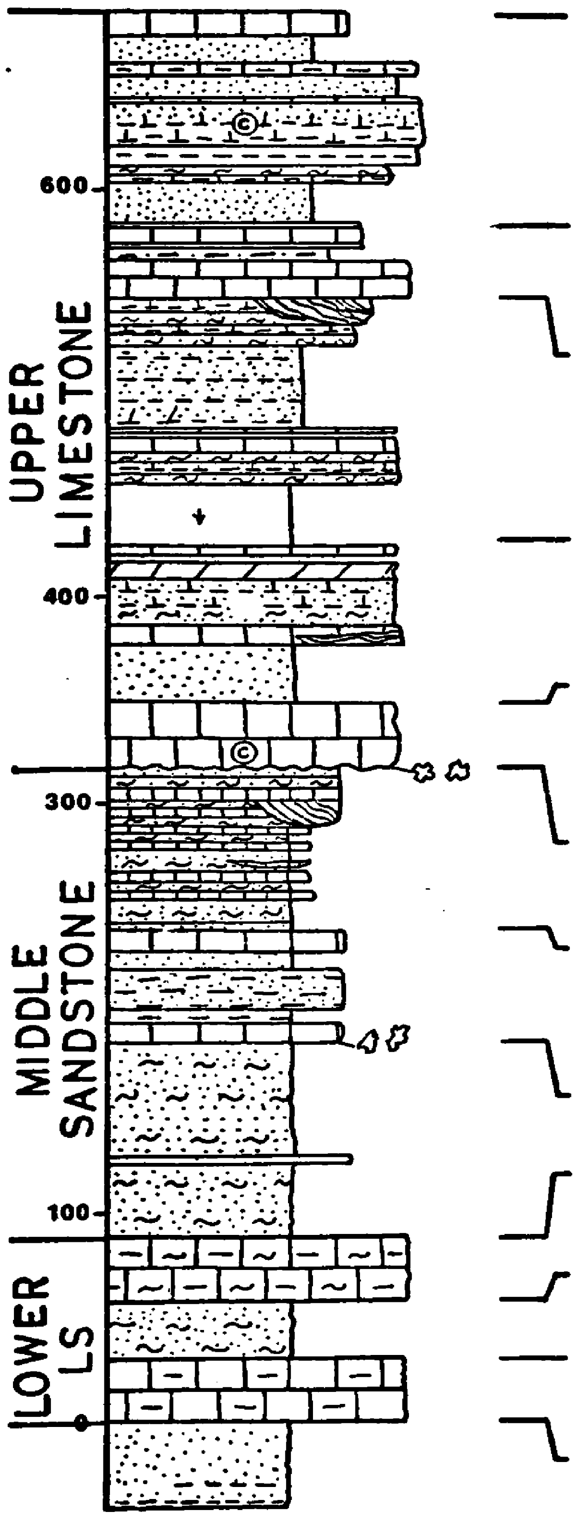
Three distinct units comprise the Thaynes in the Tendoy Mountains. These include: 1) a lower limestone, 2) a middle sandstone, and 3) an upper limestone (Moritz, 1951). In this study, these three units are subdivided into eleven field units (A - K, fig. 6) that correlate easily across the area. Each of these units is comprised of a number of lithofacies that vary laterally to create complex the stratigraphic relationships shown in figure 7.

FIGURE 6

COMPOSITE STRATIGRAPHIC COLUMN

THAYNES FORMATION

TENDOY MOUNTAINS AREA



UNIT K
Mainly mudstone and pelecypod packstone, with interbedded sandstone and siltstone. Wave ripples and cut wave ripples dominate. Coated fragments, peloids, burrows and encrustations common. Abundant chert nodules, layers and lenses(©). Biota (includes trace fossils):

UNIT J
Echinoid wackestone and bindstone (base), and pelecypod packstone (top) with leached, micritized, coated and bored shells. Cyclic deposition on cm scale. Marker bed (field). Biota:

UNIT I
Mainly silty mudstone and bindstone. Also thin echinoid wackestone (middle) and oolitic packstone (top). Ooids, onkoids, bioturbation and micro-crosslamination common. Biota:

UNIT H
Mud- wackestone, with minor dolomite. Rare isolated siltstone and sandstone interbeds. Capped by thin, pelecypod packstone. Abundant bioturbation, burrows, peloids, chert and coated, bored and leached fossil fragments. Minor ooids. Biota:

UNIT G
Echinoid packstone and wackestone; rudstone (of red intraclasts) near base. Abundant coated and bored shell fragments. Peloids, calcispheres and lithoclasts common. Some chert. Cyclic deposition. Marker bed. Biota:

UNIT F
Mudstone and algal-laminated siltstones. Peloids common. Minor thin, v.f. grained, channel-form sandstones. Fenestral and cryptalgal fabrics. Biota:

UNIT E
Wackestone and bindstone. Capped by pelecypod packstone. Red lithoclasts (breccia) at base. Unit only exposed at Deep Creek Cow Camp. Biota:

UNIT D
Siltstone with pellets.

UNIT C
Wackestone with thin bindstone, siltstone, and pelleted mudstone. Marker bed (field). Biota:

UNIT B
Siltstone, v. f. gr., well sorted. Few pellets and bioclasts. Biota:

UNIT A
Wacke - packstone with minor interbedded siltstone. Coated fragments, peloids, bioturbation and micrite or siltstone lithoclasts common. Biota:

WOODSIDE FORMATION / DINWOODY FORMATION

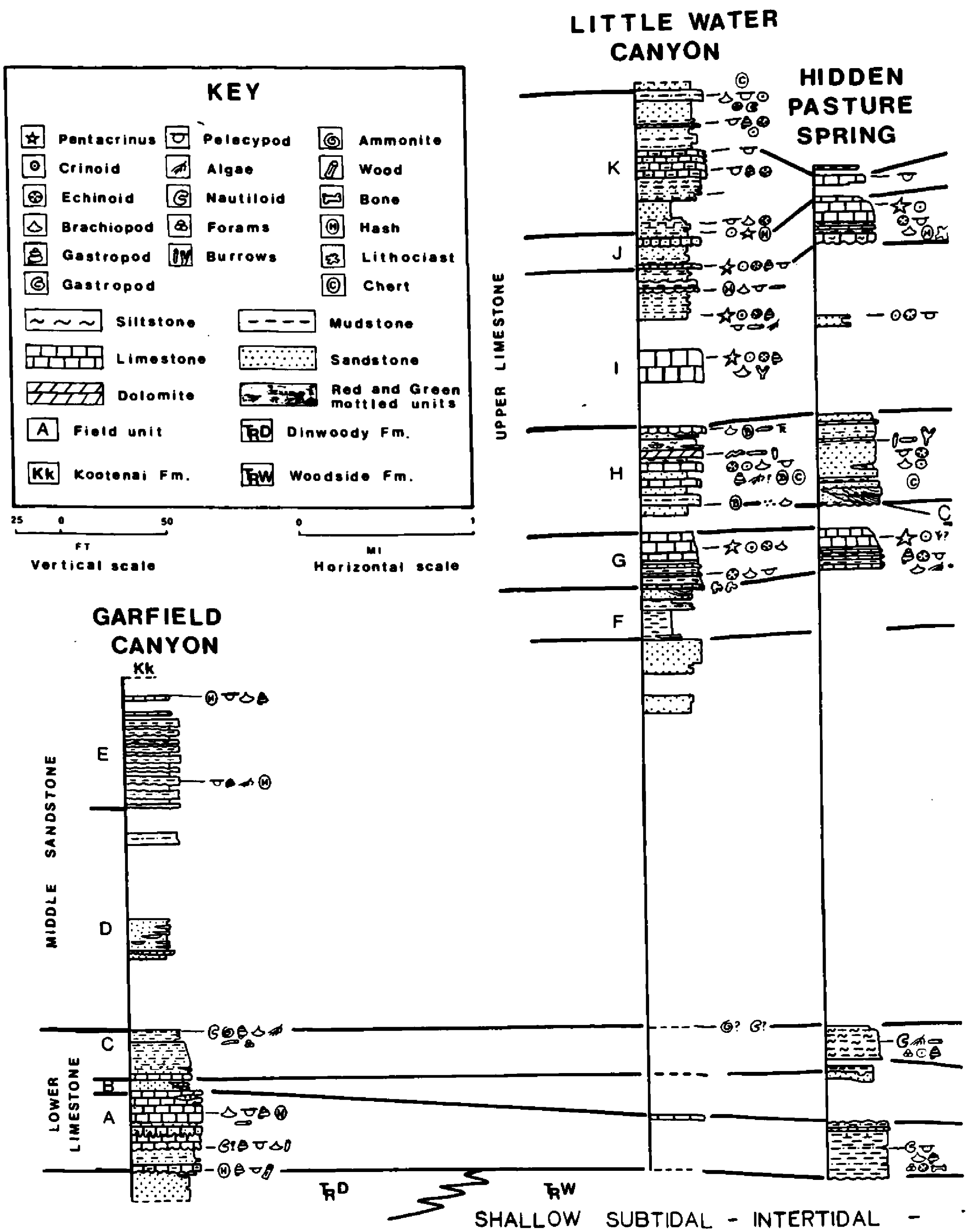
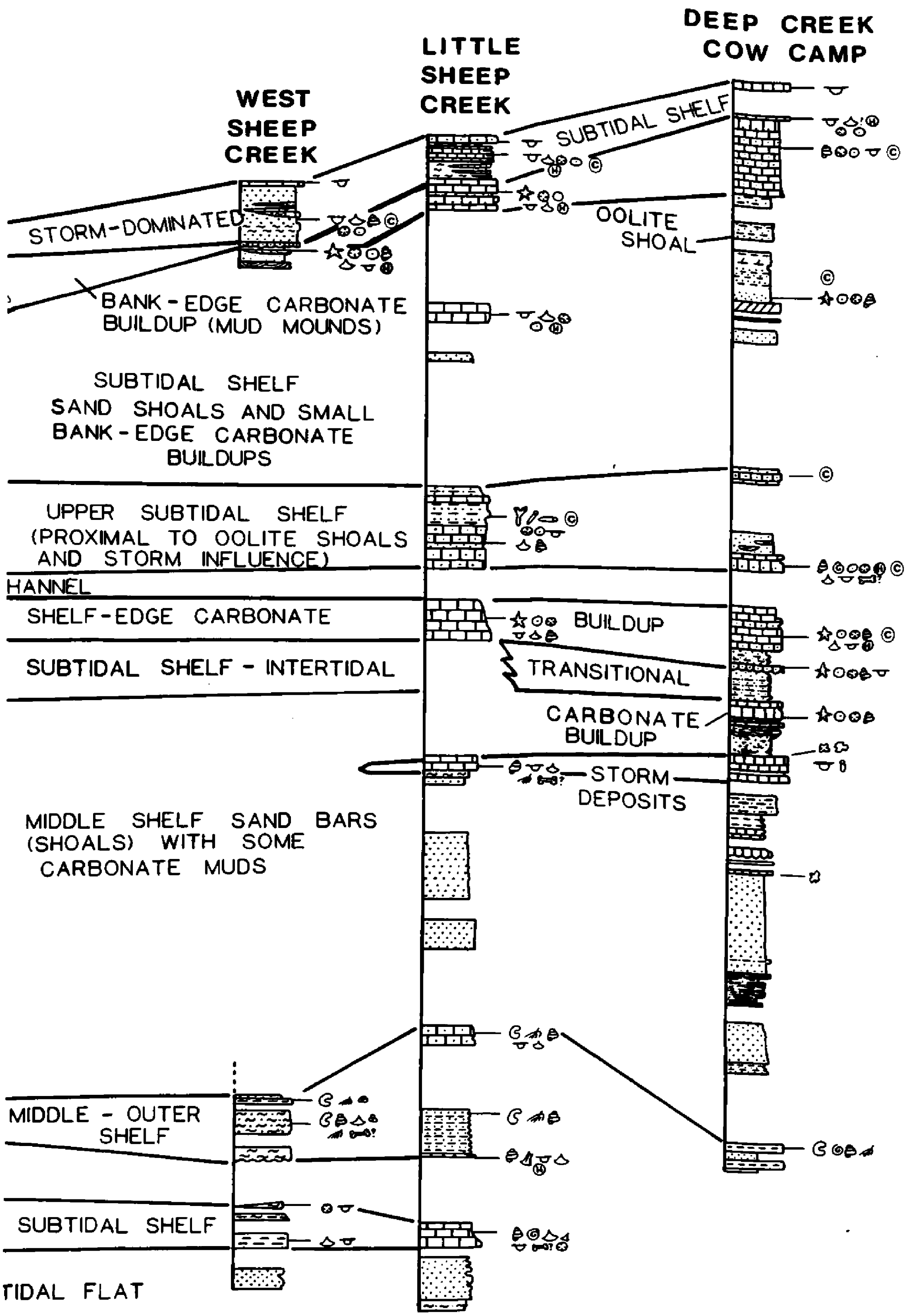


Figure 7. Correlation of lithofacies and environments,



interpretation of depositional

Tendoy Mountains area

"Lower Limestone"

UNITS A - C - The lower limestone consists of dark reddish-brown or reddish-purple mudstone and bioclastic limestone with interbedded siltstone (units a-c, fig. 6). These lithofacies occur in beds with sharp upper and lower contacts. Bedding thicknesses vary irregularily from very-thin to medium. Bedding surfaces in upper Unit C also contain concentrated silicified casts of external molds (steinkerns) of Meekoceras ammonites and small nautiloids (fig. 8). This ammonite horizon makes Unit C a distinct marker bed for correlating stratigraphic sections throughout the Tendoy Mountains.

Although Units A - C extend laterally for large distances in the Tendoy Mountains (fig. 7), proportions of carbonate sandstone and mudstone within them vary within short distances. Carbonate lithofacies dominate at Garfield Canyon; mudstones and siltstones between Little Water Canyon and West Sheep Creek; and sandstones and mudstones at Little Sheep Creek and Deep Creek Camp (fig. 7).

Sedimentary structures in Units A - C are listed in Table 1. Most prominent are ripple laminations, which occur at the tops and bases of the beds; algal laminations; thinly lamininated, often graded, calcisiltite and bioclastic layers with some wavy bedding; burrows and burrow- escape structures; and convolute bedding (Appendix A).

Petrographically, the limestones consist dominantly of laminated silty mudstone and calcisiltite with minor wackestone and silty algal bindstone. Silt grains (less than 5 microns in diameter) of quartz, feldspar and mica occur both segregated in distinct laminae and

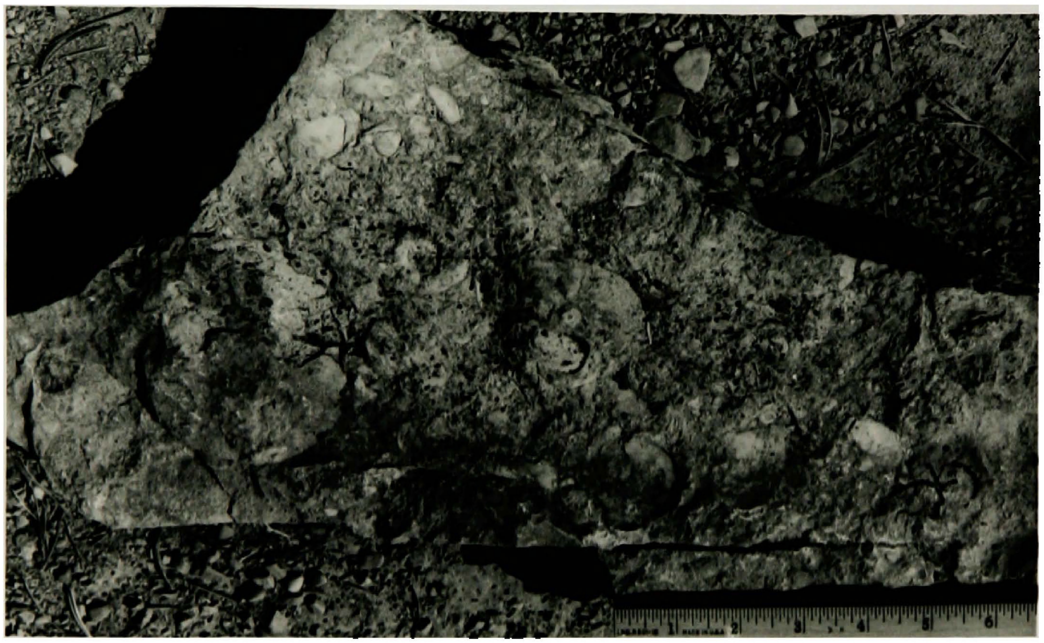


Figure 8. -- Meekoceras and small nautiloids on bedding surface, Lower Limestone (Marker bed, Unit C), Garfield Canyon.

Table 1.--Sedimentary structures and limestone particles in the Triassic Thaynes Formation, Tendoy Mountains.

		LOWER LIMESTONE			MIDDLE SANDSTONE			UPPER LIMESTONE				
		UNIT A	UNIT B	UNIT C	UNIT D	UNIT E	UNIT F	UNIT G	UNIT H	UNIT I	UNIT J	UNIT K
ALGAL	BALLS/LUMPS							---?--				
	LAMINATIONS	-----	-----	-----			-----		-----			-----
BIDIRECTION RIPPLE/XBEDS					----							
BIOTURBATION		-----		-----	-----		-----		-----	-----		-----
BURROWS	ANASTOMOSING											
	BRANCHING											-----
	HORIZONTAL	-----		-----	-----	-----			-----	-----		-----
	VERT/INCLINE	-----				-----	-----		-----	-----		-----
CHERT	LAYERS											-----
	LENSES	-----				-----						
	NODULES	-----					-----	-----	-----	-----		-----
CLIMBING	RIPPLE LAMS	-----	-----		-----		-----		-----			-----
CONTORTED	BEDS	-----		-----			-----		---?---			-----
DISSOLUTION		--?---										
FE NODULES			-----	-----								
FLASER BEDS							-----					
GRADED BEDS							-----	-----	-----		-----	-----
LS PARTICLE	AGGREGATE GR			-----								
	CALCISPHERES			-----					-----			
	CORTOIDS	-----		-----				-----	-----		-----	-----
	ONKOIDS										-----	
	OOIDS								-----	-----		
	PELOIDS	-----	-?-	-----		-----	-----	-----	-----	-----	-----	-----
LITHOCLASTS (RIPUPS)		-----		-----		-----		-----	-----	-----	-----	-----
LOAD CASTS												
MICRO X-LAM									-----			
MOLD & CAST		-----		-----	-----	-----						
MUD DRAPES											-----	-----
OPEN SPACE							---?---	-----	-----	-----	---?---	-----
RIPPLE LAMS NON-CLIMBING		-----		-----			-----		-----	-----		-----
ROOT CASTS		-?-										
SHELL BORE +-ALTERATION		-----		-----		-----		-----	-----	-----	-----	-----
SKELETAL	DEBRIS	-----		-----	- - - - -	-----	-----	-----	-----	-----	-----	-----
STROMATOLITE												
TRAILS +/- FEED TRACE									-----			-----
TROUGH X-BED				-----		-----	-----		-----			-----
WAVY RIPPLE LAMINATIONS		-----	---?---	-----	-----	-----	-----		-----		-----	-----
WAVE RIPPLE LARGE SCALE		-----		---?---		-----	-----		-----			-----

KEY: Unit A - Field unit (see fig. 5)
===== - Very abundant in thin section or field samples
----- - Present to abundant
-?-?- - Identification uncertain
[empty box] - Not identified
[box with dashes at center] - Identified only from center of field unit
[box with dashes at right] - Identified only from upper portion

scattered within the micrite matrix. The limestones also contain green algae, peloids, coated and bored bioclasts, limonitized echinoid fragments, and minor rounded siltstone or mudstone lithoclasts alligned along scour surfaces and scattered in the matrix. Examples of lower limestone composition are shown in Plate 1 (figs. 1 and 2). The petrographic samples from the lower limestone are classified into standard microfacies (SMF) types 3, 9, 10, 14 and 20, using terminology of Wilson (1975). Where no SMF classification could be assigned, as in the calcareous siltstones (or calcisiltites), a SMF of "0" is assigned (see Appendix B).

Biota in the lower limestone are listed in Table 2. Molds of Meekoceras and small nautiloids are distinctive. Small, dark brown, upward-coiling gastropods, benthonic forams (miliolids), punctate brachiopods and terebratulids (whole fossil) are also common but not exclusive to these units. Pelagic pelecypods (?) were tentatively identified; however, few pelagic microfossils, characteristic of basinal fauna, occur in these units.

The sedimentary characteristics of the lower limestone and the sedimentary processes interpreted to have formed them are listed in Table 3. These characteristics indicate that the lower limestone formed in the subtidal zone of a mixed carbonate shelf. Deposition probably occurred in the deeper-water of the outer to middle shelf under fairweather, low- to moderate-wave energy conditions. However, the shelf was also affected by periodic high-energy waves. The irregular bedding thickness, large lateral extent of individual units, fine grain size and muddy textures, and the stenohaline fauna present in these units (Table

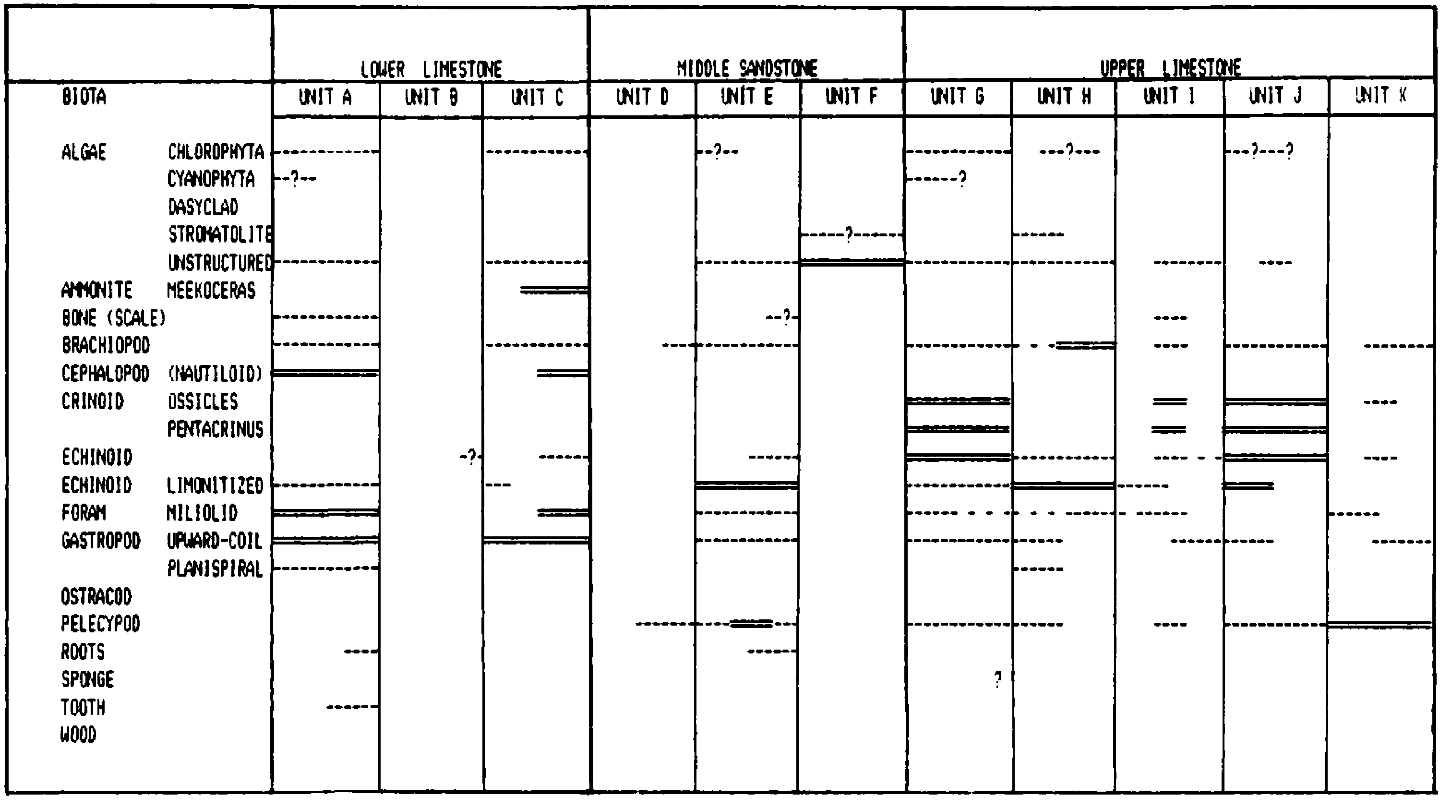


Table 2.--Stratigraphic distribution of biota in the

Triassic Thaynes Formation, Tendoy Mountains.

TABLE 3.--Sedimentary structures, sedimentary processes, and interpretation of depositional environment of Lower Limestone (Units A-C), Tendoy Mountains area.

SEDIMENTARY CHARACTERISTIC	INFERRED SEDIMENTARY PROCESS	ENVIRONMENT OF DEPOSITION
Coarse-grained, bioclastic layers interbedded with sandstone, siltstone and micrite (normally graded)	Variable wave energy and suspension sedimentation. Intermittent strong wave action and abating currents with suspension sedimentation	Subtidal shelf within storm wave base with varying current and wave energy, open circulation, and normal-marine conditions
Wavy & ripple beds (macroscopic)	Deposition within wave base, with waning currents; traction movement of particles along shelf floor	
Algal laminations (macro & microscopic)	Photic zone deposition within quiet water	
Sharp bases on beds; microscours in thin section	Erosion by higher-energy currents and/or waves	
Upper bedding surfaces gradational	Suspension sedimentation during low-energy periods, plus bioturbation	
Irregular bedding thicknesses	Variable sedimentation rates	
Siltstone and mudstone lithoclasts (up to 4mm) with microfossils in micrite matrix; some forams, ooids & bioclasts; located along scour surfaces & intermixed with sediments	Ripups from various areas on shelf floor during high-energy periods. All lithoclasts intrabasinal from both high- and low-energy environments. Waves of sufficient energy to transport or roll large clasts	
Contorted bedding (ball & pillow structures)	Periods of rapid sedimentation over unlithified sediments on shelf floor	
Layers of crossbedded silt and small peloids	Traction movement of particles by currents plus bioturbation	
Coated and uncoated bioclasts in micrite	Zone of winnowing	
Limonitized echinoid fragments	Ripups from areas of non-deposition, concentrations of iron and possible subaerial exposure (hardgrounds?)	
Stenohaline fauna	Little salinity fluctuation	

Table 3 (Continued)

SEDIMENTARY CHARACTERISTIC	INFERRED SEDIMENTARY PROCESS	ENVIRONMENT OF DEPOSITION
Escape burrows; <u>Planolites</u> traces	Reaction of biota to rapid sedimentation Grazing & feeding traces formed by colonization during low turbudence	Habitation of environment by organisms
Miliolid forams	Low-energy shelf to back reef environments	
Dark-colored sediments	Usually found in deeper water or more reducing environments	Outer- to middle shelf
Poorly-preserved ammonites and nautiloids, mainly in single layer	Storm concentrations on deeper shelf; moderate- to high- energy	

3) are characteristic of the fairweather shelf environment (Wilson and Jordan, 1983). Deeper-water deposition is indicated by the ammonite and nautiloid fauna and the abundant dark-colored micrite in these units. Even in the deeper part of the shelf, however, deposition was well within the photic zone to mix green algae with the deep-water fauna (Table 3). During fairweather, low-turbulent periods, algae and "cruising feeders" established themselves on the shelf floor (Kriesa, 1981). These organisms bound, disturbed and added peloids to the fine-grained layers resulting in highly bioturbated and burrowed layers. Green algae today grow in shallow seas with low-water energy, between the low tidal zone and 100 m of water (Flugel, 1982; 1977). Therefore, by comparison, even the deeper areas of the Thaynes shelf must have been shallow and within this depth. Portions of the deeper shelf also appear to have had more terrigenous influence than others. Sand-dominated lithofacies with quartz, feldspar, and mica grains are concentrated in the southern outcrop area. Carbonate- dominated lithofacies occur in the northern outcrop area.

In the lower limestone, evidence of periodic storms on the Triassic shelf is indicated by fossil lag deposits, large-scale convolute bedding, and escape burrows overlain by laminated, fine-grained, burrowed muds or sands. Mixing of deep-water fauna and limonitized echinoderm fragments may represent storm reworking of sediments from hardgrounds or solution surfaces in shallower, possibly exposed, areas of the shelf (Kriesa, 1981, Flugel, 1982). Lithoclasts (intraclasts) within limestones of the Thaynes are from mixed deep- water shelf and shallow-water shoals (Table 3). They are also typical of modern storm-generated, subtidal deposits (Kriesa, 1981). Transport of lithoclasts and sand seaward during storms on modern coasts occur by processes that are not well understood (Kreisa, 1981). Explanations for transport include: 1) storm-surge ebb processes that generate a turbidity current; 2) diffuse fluid gravity flows; or 3) intense rip currents with a "downwelling coastal jet" (Kreisa, 1981).

"Middle Sandstone"

The middle sandstone is composed dominantly of light-colored, very-fine grained, calcareous, muddy siltstone to silty mudstone, with minor interbedded very-fine grained sandstone, skeletal limestone and algal mudstone beds. Across the Tendoy area, the middle sandstone unit forms a covered slope, which is approximately 225 ft (70m) thick. Because of its poor exposure, the middle sandstone is correlated in the field by its position between two distinct marker beds; namely, the *Meekoceras* -bearing bed below it, and the *Pentacrinus* - bearing bed above it.

Based on scattered outcrops, the middle sandstone is divided into three units in this study (fig. 6). Each unit is composed of several lithofacies. The lower portion of the middle sandstone is designated as Unit D; the middle limestone beds, Unit E; and the upper, Unit F (fig. 6).

UNIT D - Unit D consists of yellow-brown to reddish-brown, very-fine grained, pelleted, clayey sandstone and siltstone lithofacies. The grains are well sorted and subround to round. Bedding is wavy with fine laminations. Very thin, irregular outcrops of lenticular, calcareous mudstones, small scale ripples, and small- scale trough crossbeds also occur.

UNIT E - Unit E is a carbonate-dominated lithofacies composed of medium- to thick limestone beds. The limestones are well exposed only at Deep Creek Cow Camp, Little Sheep Creek, and Garfield Canyon (fig. 1) in prominant ridges in the covered slope. They consist of pale yellowish-brown, yellowish-gray, light olive-gray and grayish-red wackestones and bindstones similar to the limestone units of the lower limestone (see above). The base of Unit E is erosional and is marked by red, rounded, algally- encrusted lithoclasts, up to 4.5 cm in diameter (fig. 9). Accumulations of brachiopods, pelecypods, gastropods and forams in the middle sandstone are confined to Unit E (Table 3). Many of the shells are encrusted, bored, leached or micritized (SMF 14). A pelecypod coquina outcrops at the top of Unit E at Deep Creek Camp (Plate 1, fig. 3). Its shells are disarticulated and alligned convex-upward with little micrite in the matrix.

Sedimentary structures within Units D - E of the middle sandstone are less varied than in units above or below it (Table 1). Wavy ripples, climbing ripple laminations, horizontal burrows, and molds and casts of mollusks or brachiopods are the most commonly observed structures.

The sedimentary characteristics and stenohaline biota of Units D and E indicate that they were also deposited in a subtidal, normal

Figure 9. -- Breccia of algally-laminated lithoclasts, Middle Sandstone (base, Unit E), Deep Creek Camp. Pencil points to top of unit.

marine, shallow shelf environment. Overall, their light sediment color and lack of deeper-water ammonoids and nautiloids indicate that they were deposited in slightly shallower water than the lower limestone, probably on the middle to inner shelf. The very-fine grained, thick sandstone units were deposited by low- to moderate-energy waves or currents. They have some of the features of shelf sheet sandstones, including few sedimentary structures, abundant fossils, calcareous, very-fine to fine-grained sediments, and sharp contacts (Kiteley, 1983). They have ripples and megaripples characteristic of elongate sand ridges found on the Middle Atlantic shelf today (Bouma and others, 1981). They also exhibit features of sand bars (shoals) on the shallow shelf in the North Sea (Reineck and Singh, 1980). These include: 1) abundant small-scale ripple bedding, produced by lower current velocities and fine grain size; and 2) evenly laminated sands, which form during sedimentation from suspension clouds after shoaling waves take sand into suspension (Reineck and Singh, 1980). The bars (shoals) may also be highly bioturbated (Reineck and Singh, 1980). Therefore, the sands of the middle sandstone in this area are interpretted to form as sand bars (shoals) on the shallow shelf. These bars dominated the shelf area, although some areas still accumulated more mud and carbonate (fig. 7). Sediment for the shoals or bars was supplied from distant terrigenous sources containing quartz, feldspar and mica, as well as erosion of bioclastic debris. Klecker (1981) also suggests that the origin of some of the fine sand on the shelf may be eolian.

Storm deposition in the middle sandstone is indicated by concentration of winnowed fossils in thin hash layers, some with whole fossils in convex-upward allignment (Unit E), and mixed layers of coarse sediments and fine sediments identical to the lower limestone indicate storm deposits (Flugel, 1982). The breccia at the base of Unit E may represent erosion and redeposition of shoreward, intertidal, restricted sediments during one of these storms.

UNIT F - Unit F consists of red and green mottled and light brown or gray, wavy, rippled, very thin- planar to flaser-bedded sandstones and lenticular mudstones with bioclasts (Appendix A). Bedding within the unit thickens slightly upward. Rare, small lenses of sandstone also cut the mudstone beds. Algal laminations and climbing ripple drift crossbeds are common. At Deep Creek Camp, Unit F contains lithofacies that are transitional between Unit E and Unit G. Thin Pentacrinus - bearing limestones are interbedded with light gray, yellow brown, and red and green mottled sandstones and lenticular, clayey mudstones (Fig. 7). Petrographically, Unit F consists mainly of unfossiliferous, algal-laminated, mudstone and calcisiltite, with fenestral fabric and some dolomite rhombs (Plate 1, fig. 4). Using Wilson's (1975) microfacies types (Appendix B), it is classified as SMF 20.

The upper, muddy lithofacies of the middle sandstone (Unit F) represents a period of dominantly low-turbulence sedimentation. Its lack of fossils, except for algae, and red color (at Deep Creek Camp and Little Water Canyon) indicate that it might have been deposited in a partially restricted, shallow-marine environment. Fenestral structures indicate intertidal or subtidal environments (Flugel, 1982). However, there are no dessication features, evaporites, or bird's eye structures characteristic of intertidal or supratidal deposition (Shinn, 1983). Therefore, these sediments are interpretted to have been deposited in the quiet, shallow, subtidal to lower-intertidal zone.

"Upper Limestone"

The upper limestone consists of five distinct units (Units G - K, fig. 6). These units represent at least three large-scale, rhythmic cycles of deposition, many smaller-scale (cm) cycles of deposition, and carbonate buildup on the Triassic shelf. Each large-scale cycle begins with a basal echinoid wackestone or packstone, representing carbonate buildup, and and is overlain by lithofacies with varying amounts of sandstone, mudstone, bindstone, and pelecypod packstone.

UNIT G - The first depositional cycle commenses with an echinoid wackestone to packstone (Unit G, fig. 6). The basal beds of this unit are composed mainly of layered micrite and bioclastic debris. The bioclastic layers pinch out along the outcrop (within tens of meters) in several places. In these areas, the interval of bioclastic layers is replaced by unlayered wackestone. In some areas, the bioclastic layers pinch out over other bioclastic layers. The bioclastic layers are overlain by a thick sequence of echinoid-crinoid wackestone to packstone, that has topographic relief along the outcrop (fig. 10). Beds within Unit G dip very slightly along the outcrop at Hidden Pasture Spring. In other areas, the amount of covered slope, combined with the very low dip, make distinquishing dip difficult. The topographic relief, lensoid-shaped basal beds, and slightly dipping beds displayed by Unit G are characteristic of carbonate buildups (Wilson, 1975).

Detailed stratigraphic layers within Unit G, from the base upward, include the following (fig. 11): 1) Rudstone with red, micrite lithoclasts (Plate 1, fig. 5); 2) calcareous, fetid mudstone with few fossils and chert nodules alligned along bedding; 3) repeated, small-

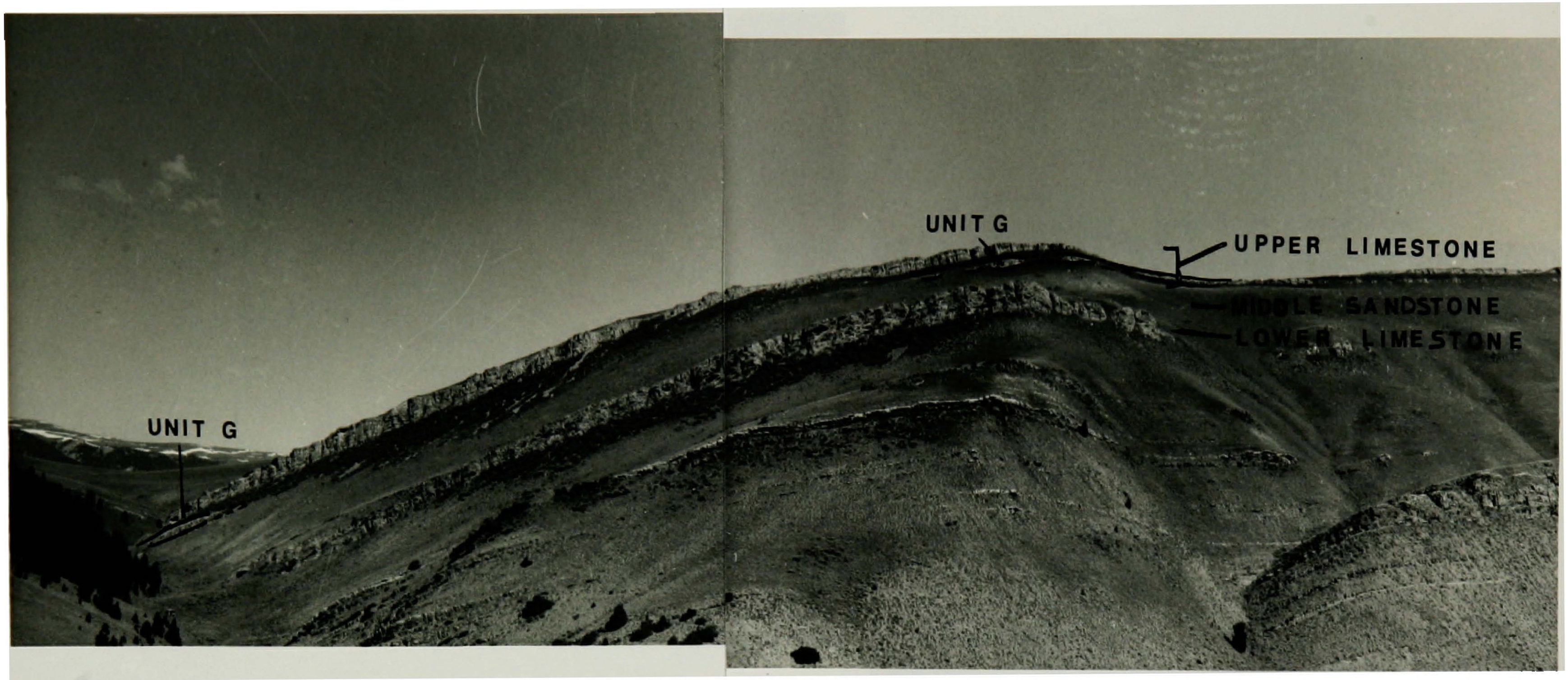
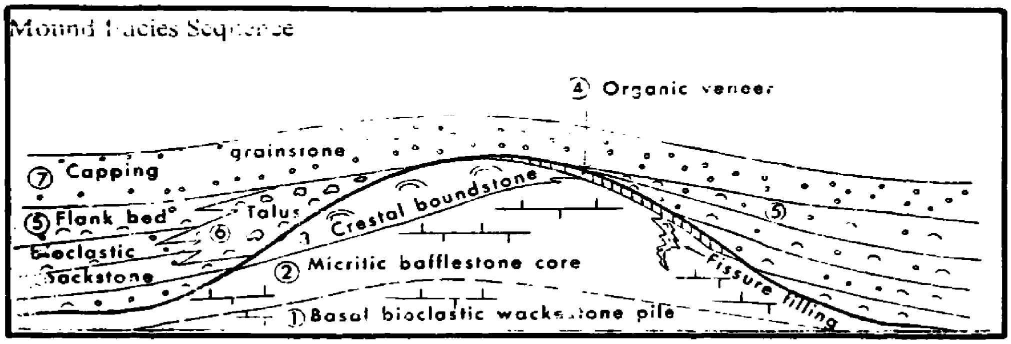
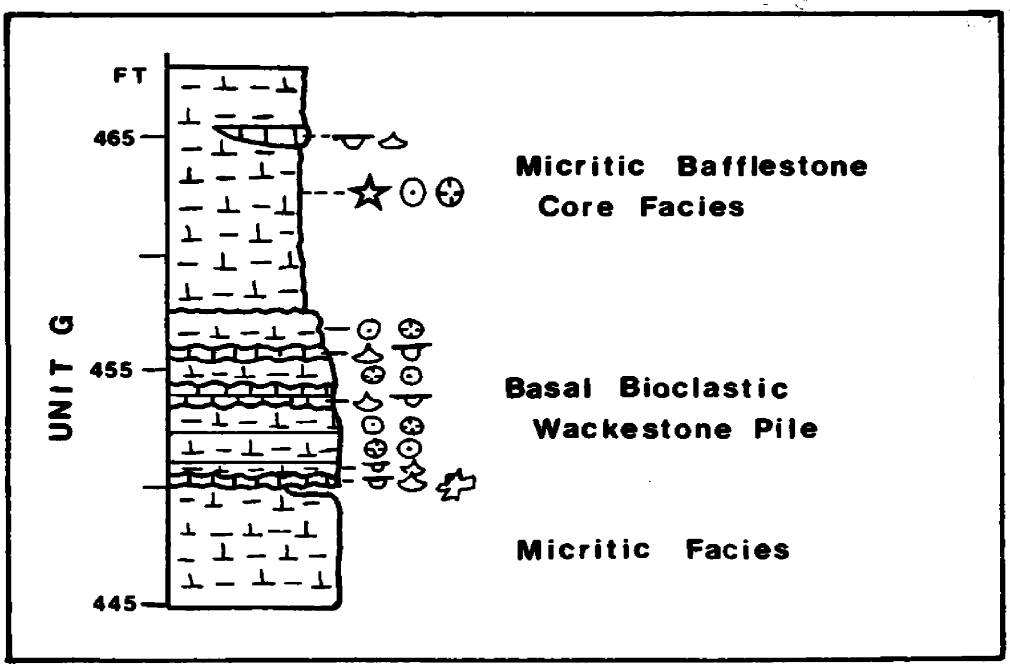


Figure 10.--Carbonate buildup (Unit G) in Hidden Pasture Spring area, showing topographic relief and dipping beds.



A



B

Figure 11.--Stratigraphy of Thaynes carbonate buildup (Upper Limestone, Unit G) compared to mud-mound facies. A. Ideal carbonate mound with seven commonly developed facies (from Wilson, 1975, p. 367). B. Stratigraphy and interpretted carbonate lithofacies of Unit G.

scale cyclic layers, consisting of packstone with shell hash, echinoid wackestone (mainly spines, plates, and ossicles), and cherty, calcareous, bioturbated mudstone (fig. 12); and 4) a thick (10-20 ft) wackestone dominated by Pentacrinus, with isolated patches of brachiopod and pelecypod shells (fig. 11).

The biota of Unit G is the most diverse in the Thaynes Formation in either the Tendoy or the Snowcrest and Gravelly areas (Table 2). It includes crinoids, echinoderms, pelecypods, brachiopods, gastropods, miliolid forams, and green algae. Many of the bioclasts are limonitized, coated with algae or bored and replaced with chert; some are leached. A few well preserved specimens of Rhychonella triassicus?, like those described by Perry and Chatterton (1979) from the Thaynes Formation in southeastern Idaho, were collected from the small-scale cyclic layers (3) described above (fig. 13).

Sedimentary structures, characteristics, and processes in Unit G are listed in Tables 1 & 4. Standard microfacies types represented in this unit include 9, 12, 14, 23, and 24 (Appendix B). The dominant microfacies is SMF 12, a bioclastic echinoid packstone with a micrite or silty matrix (Plate 1, fig. 6).

Compositionally, the carbonate buildups of Unit G may represent both lime mud mounds (or accummulations) and organic bank deposits. The basal layers of calcaraeous mudstone with numerous, interbedded, small-scale cyclic deposits (2-4 above) exibit characteristics of mainly mechanical accummulation with some in situ organic production that is typical of lime mud mounds, or accummulations (Wilson, 1975). These characteristics include: a basal bioclastic wackestone pile of

Figure 12.--Second small-scale depositional cycle in Unit G (Upper Limestone). Cycle consists of bioclastic layer (base); micrite with ecinoids, crinoids, and layers of brachiopods and pelecypods (middle); and crinoid- and echinoderm-dominated lithofacies with chert nodules and bioturbation (top). Small-scale, cyclic units are capped by thick crinoid-echinoid accumulations. Hidden Pasture Spring section.

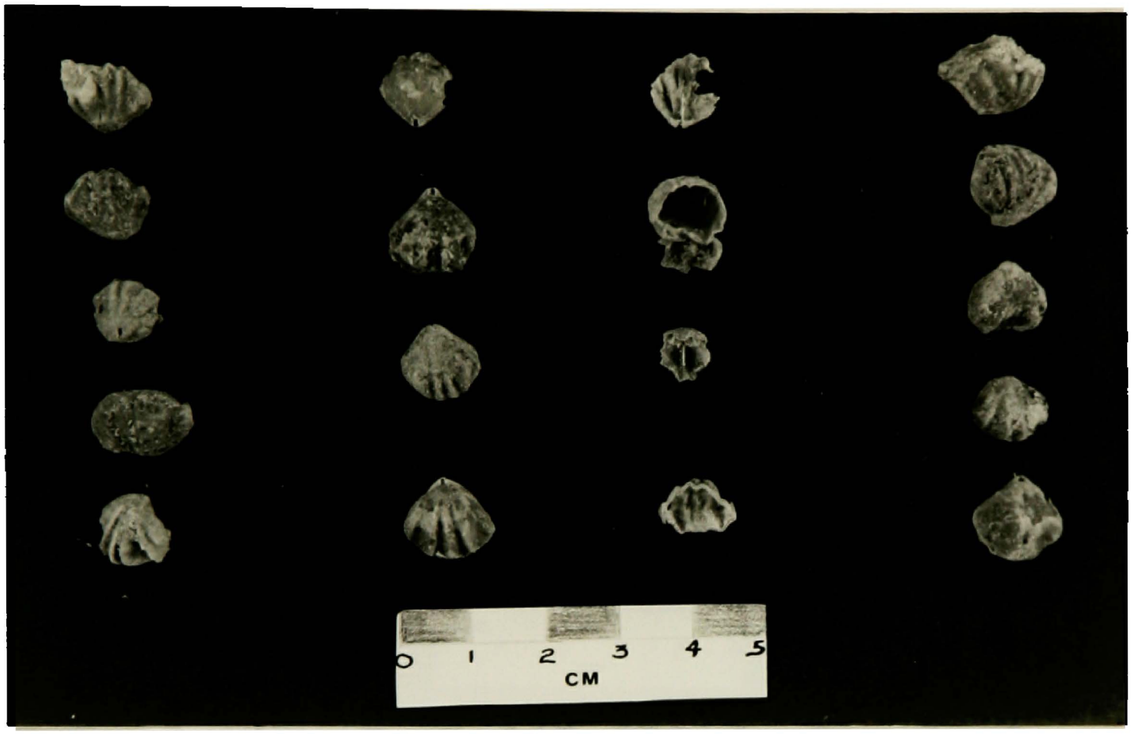


Figure 13.--Rynchonella triassicus? brachiopods from the lower Upper Limestone (Unit G), Little Water Canyon.

TABLE 4.--Sedimentary structures, sedimentary processes, and interpretation of depositional environment of Unit G (Upper Limestone), Tendoy Mountains area.

SEDIMENTARY CHARACTERISTIC	INFERRED SEDIMENTARY PROCESS	ENVIRONMENT OF DEPOSITION
Large, red intraclasts (up to 2 mm) at base	Erosion surface formed during sea level fluctuation or high-turbulence	Erosion surface formed during transgression
Pack- to wackestone, slightly dipping beds, thin laterally	Mechanical accummulation of shells by waves or currents; or bioclastic flank beds off mud mounds with beginning carbonate buildups	Carbonate-dominated shelf within wave base
Clastics rare or patchy	Sporatic current energy or influx from terrestrial source	
Thick upper layer of crinoid-echinoid wackestone with lenses of rynchonellid brachiopods and gastropods	Dominance phase of carbonate buildup (mud mound) - ie. micrite bafflestone core. Algal binders; crinoid bafflers; brachiopod, pelecypod and gastropod grazers comprise community	Crinoid-algal mud mound on shallow, normal-marine shelf with open circulation. Warm climate; water at or below wave base. Bank-edge shelf carbonate
Poor- to moderate sorting of bioclasts in micrite matrix; some limonitic bioclasts	In situ accummulation of bioclastic debris with some reworked during high-energy periods (zone of winnowing)	
Algae and forams	Low- to moderate energy wave/current in shallow water	Deposition within photic zone on low-energy shelf;
Abundant coatings, encrustations, and bored bioclasts	Algal growth in low-energy currents. Grains moved occasionally to coat all sides	possibly protected shelf with intense biologic activity
Contorted bedding at tops of beds	Burrowing & bioturbation by colonizing organisms	
Micrite & microspar in matrix	Cementation in low-energy currents or waves	Low-energy shelf/Diagenetic
Abundant layered chert	?	Sponge spicule dissolution?
Silica replacement of bioclasts	Late-stage diagenesis	---------
Styolites	Pressure solution on compacted sediments	---------

alternating mollusk shells, echinoids and mud formed by currents and waves; and an upper micritic, bafflestone core facies, that forms during baffling of currents and trapping of sediment by algae, crinoids, and echinoids (fig. 11). They are also typical of bank-edge, algal-crinoid mud mounds (Halley and others, 1983) that form in low- to moderate- wave energy, at or slightly below fairweather wave base, in the normal marine, subtidal environment. The upper, massive echinoid-crinoid wackestone or packstone with abundant micrite matrix is dominated by in situ detrital organic accummulation during baffling and trapping, with minor mechanical accummulation characteristic of the mound core facies (fig. 11) or of organic banks (Wilson, 1975).

Initially, the Thaynes carbonate buildups probably formed as lime mud mounds on mechanical accumulations of debris on the shelf floor. However, their buildup was curtailed by each new influx of high energy sediments brought in by waves or currents (ie. the basal cyclic units). During more quiet conditions, crinoids and algae colonized the the bioclastic debris, trapped and baffled sediments, and gradually became the dominant species of the buildup. The mud mound probaby grew together, or coalesced, to dominate the shelf floor during the quiet conditions. Their growth was terminated abruptly, however, by rapid sand influx and accumulation during deposition of overlying Unit H. No evidence of restricted lagoon or restricted shelf deposition was identified in Unit G to cause termination of the carbonate buildups. All biota are stenohaline forms. Limonitized bioclasts within the unit, however, indicate hardground surfaces of non-deposition were present during their growth.

Unit G is an important lithofacies in the Tendoys because it represents a distinct change in both biota and depositional conditions from units below it. The biotic change from impoverished species of Unit F to low-energy, normal marine organisms of Unit G (ie. echinoderms and crinoids) provides a baseline to correlate stratigraphic sections across the Tendoy thrust sheet (fig. 7). Second, depositional conditions change from shallow, subtidal-intertidal, partially-restricted environments with terrigenous input of Unit F to low- or moderate-energy, subtidal, normal-marine environments with open circulation and little terrigenous input of Unit G. Therefore, the transition from Unit F to Unit G records distinct changes on the shelf between the deposition of these two units.

The sequence of lithofacies from Unit F to Unit G indicate that the changes produced on the shelf represent two important depositional episodes and one erosional episode caused by fluctuations in sea level. First, Unit F represents regression of the Early Triassic sea from the area. Second, transgression of the sea back into the area is represented by the lithoclast zone (base of Unit G). Third, deposition on algal-crinoid carbonate buildups on the shallow shelf is represented by Unit G. The ripups at the base of Unit G, along with a similar ripup zone in Thaynes rocks of the Snowcrest and Gravelly Ranges, indicate that the readvance of the Triassic sea formed a widespread, erosional surface on top of Unit F. After the transgression, carbonate mud mounds flourished in the deeper water of the shelf or bank edge until the deposition of Unit H.

Depositional cycle 1 continues from Unit G into the lower portion of Unit I. It contains a calcisiltite (base, Unit H); a mud- to wackestone; a pelecypod packstone; and a thin-bedded, muddy sandstone, silty mudstone, and bindstone (lower Unit I, fig. 5).

UNIT H - Although variable, Unit H is composed mostly of a basal calcisiltite bed and a resistant main ledge of up to 55 ft (17 m) of sandstone and varying proportions of carbonate. At Little Water Canyon and Little Sheep Creek, the resistant ledge is mostly sandy carbonate (fig. 7). At Deep Creek Camp and Hidden Pasture Spring, it is a calcareous quartz sandstone and limestone is confined to thin layers or lenses. In all areas, the main ledge contains abundant chert layers and lenses along bedding surfaces, numerous *Planolites* and *Skolithos?* burrows, algal laminations, and sparcer marine fauna than in Unit G below. The chert often contains dolomite rhombs in thin section (see HPS-16A, Appendix B). In some areas, chert fills burrows (Little Sheep Creek, Appendix A).

In detail, Unit H is highly varied at each location. Little Water Canyon contains basal hummocky bedding, dolomite, dissolution (?) structures (leached grains with micrite envelopes and algal encrustation), feeding traces and a pelecypod packstone in its upper half. Hidden Pasture Spring contains a basal, trough-crossbedded, channel deposit that cuts a mottled silty mudstone (fig. 14). The channel lacks bimodal crossbeds, but it cannot be traced laterally to determine its geometry for deltaic vs. tidal origin. It contains coarse sand and scattered pebbles, highly fragmented bioclasts, small, unidentified whole brachiopods, and ooids. Minor hummocky bedding and

Figure 14.--Unit H, Hidden Pasture Spring, with thick, coarse-grained, trough-crossbedded unit. Hammer for scale.

complex ripple laminations also mark this base. Petrographically, it contains lithoclasts of gray mudstone with very small forams characteristic of deeper, basinal deposits. Two gypsum beds outcrop in the middle of Unit H at Hidden Pasture Spring. They are less than 4 in. (10 cm) thick and extend laterally for tens of meters between bedding surfaces. They are believed to be secondary deposits because of their composition, limited exposure, and the lack of other evidence of evaporites or subariael exposure in this unit. The upper portion of Unit

H at Hidden Pasture Spring is mainly finely laminated, very-fine grained, cherty or dolomitic, quartz sandstone with rare layers of limestone and a pelecypod packstone containing ooids. Unit H at Little Sheep Creek is dominantly a sandy limestone, which grades upward into a highly burrowed and bioturbated mudstone and sandstone lithofacies. At Deep Creek Camp, Unit H consists of a basal, bioclastic, fossil-lag layer that includes both upward-coiled and planispiral snails. The middle and upper portions consist of sandstone with little fauna.

Petrographic samples from Unit H contain ooids, and limonitized and coated bioclasts, dolomite, micrite, and lithoclasts. The matrix is totally or partially replaced by silica in many samples. Open space is also present.

The very-fine grained, carbonate- to quartz sandstone- dominated lithofacies with stenohaline fauna of Unit H formed under low- to moderate- wave energy in the shallow subtidal zone of a highly-mixed carbonate shelf with open circulation. The abundant very-fine grained sand in these rocks indicates proximity to a terrigenous source. The coarse-grained, trough-crossbedded channel sandstone at Hidden Pasture Spring, interpretted as a tidal or deltaic channel, also suggests a nearby terrigenous source. Hidden Pasture Spring may have been nearer a terrigenous source than other sections throughout its deposition because of the dominance of sand in its stratigraphic section. Ripple- and wave- laminated sands and muds at all locations indicate varying current and low wave energy during deposition. Muds settled during suspension sedimentation as wave/current velocity decreased (Reineck and Singh, 1980). Dissolution surfaces (?) may indicate intertidal deposition of

Unit H; however, according to Flugel (1982), they can form in intertidal to deep sea rocks.

The ooids both at the base of Hidden Pasture Spring in the channel sandstone and at the top of the unit indicate proximity to an oolitic shoal (Flugel, 1982) or an increase in current velocity at this location. Because these ooids are rare in Unit H, the shoals were not very close to Hidden Pasture Spring, but were probaby forming closer to shore. Ooids were carried seaward either in channels and/or across the shallow bottom by waves or currents during storms.

Some beds in Unit H contain sedimentary structures characteristic of modern subtidal storm deposits. The fossil packstones at the top of Little Water Canyon and Hidden Pasture Spring are similar to the bioclastic packstone/sandstone couplets proposed by Kreisa (1981) for subtidal storm deposits. They are high wave-energy deposits of shells oriented convex upward and parallel to bedding. According to Flugel (1982, p. 459) such "mass concentrations" of pelecypod shells are best explained by storms, rather than by tidal currents or waves produced by wind. Both modern and Early Triassic shell accummulations are infiltrated with mud and sand during waning storm currents. Hummocky, or wave-cut, bedding, present at Little Water Canyon and Hidden Pasture Spring, are proposed to form by storms in the subtidal zone (Kreisa, 1981; Swift and others, 1983). According to Swift and others (1983), hummocky, or wave-cut, bedding commonly forms in response to combined-flow currents on the shelf in areas where currents decrease in velocity downstream and sediment deposition during a storm. Lithoclasts from deeper deposits, at Hidden Pasture Spring, may have been carried shoreward by storm currents that scoured deeper shelf sediments than normal waves. Limonitized bioclasts may be reworked and transported from shallower hardgrounds. In addition, the upper sandstone or mudstone surfaces contain burrows, bioturbation, and feeding traces of organisms common in modern, late-stage subtidal storm deposits (Kreisa, 1981). These features indicate that Unit H formed in a mixed, normal marine, subtidal environment on the continental shelf with varying wave and current energy. Sand bars and oolite bars formed shoreward and terrigenous sediments came from the craton. Storm currents or waves periodically concentrated, disturbed and reworked shells and the bottom sediments. Suspension sedimentation, algal growth, and colonization by sediment grazers occurred between storms.

UNIT I - Unit I consist of two main lithofacies. One is an echinoid wackestone, similar to basal beds of Unit G (see above). The second is oolitic packstone. The echinoid wackestone begins the second period of carbonate buildup on the shelf. Compared to buildups of Unit G, these buildups were patchy and thin (fig. 7). Their growth and extent may have been limited by 1) incursion by overlying oolitic shoals, or 2) fluctuating sea level, as suggested by the impoverished fauna, fenestral structure, leached grains and micrite envelopes, and bioclasts eroded from hard grounds above the echinoid wackestone at Deep Creek Camp (fig. 7). The dolomitized samples indicate that these rocks were deposited in an high-porosity, low-energy environment, possibly in water with fluctuating salinity, from high magnesium to low magnesium concentration. Salinity may have varied during sea level fluctuation which created more restricted circulation on the shallow shelf. Plate 1 (fig. 7) clearly shows the sequence of diagenesis in these rocks: 1)

Dissolution of echinoderm fragments; 2) dolomitization during periods of high Mg+ concentration in the water; 3) calcite pore filling in low Mg+ concentration water; and 4) small fracture fillings in the calcite pore fillings with quartz. Limitation of growth by oolitic shoals is also indicated at Deep Creek Camp and Little Water Canyon where oolitic packstones represent proximity to oolitic shoals. Interbedded crossbedded oolites, siltstones and micrites (Plate 1, figs. 8 - 9) indicate periodic fluctuations from moderate-wave energy to low-wave energy and suspension sedimentation. Micrites may have also formed in less turbulent portions of the shoal, like shallow depressions between megaripples (Flugel, 1982).

Like the units below, storms may also have affected at least parts of Unit I. As in units below, the pelecypod and brachiopod packstone at Little Water Canyon (fig. 7) represents a storm deposit. Reworked, limonitized echinoid fragments (LSC-12, DCC-05, Appendix B) also indicate erosion of a hardground.

UNIT J - Unit J represents the third and final period of carbonate buildup in the Thaynes Fm. Like Unit I, carbonate buildups in Unit J vary in thickness and lithology across the outcrop area from dominantly sandstone to dominantly cherty limestone. At Little Water Canyon and West Sheep Creek, its lithofacies are mostly cherty sandstone with thin hash layers and reworked, limonitic bioclasts. At Hidden Pasture Spring, Little Sheep Creek and Deep Creek Camp, it is mostly cherty carbonate in cyclic layers that have topographic relief and slightly dipping beds like Unit G. Unit J formed as low- to moderate energy, normal marine bank-edge or shelf carbonate buildups, like Unit G, with moderate reworking and redeposition from storm waves.

UNIT K - Unit K is composed of interbedded sandstone, siltstone, mudstone and carbonate lithofacies, in varying proportions across the Tendoy Mountains (fig. 7). It is distinquished by abundant, thin, bioclastic layers; brachiopod, pelecypod and mollusk coquinas; and chert, which is interbedded with all lithologies to form laminated outcrops (fig. 15). Bases of the layers are sharp and wavy. Tops are bioturbated and more gradational. The thin bioclastic layers overlain by micrite are shown in fig. 16. Unlike Unit G below, terebratulid brachiopods dominate Unit K. Bioclasts in the same petrographic sample are often both coated and uncoated with algae, and altered and unaltered with limonite or other iron minerals (Appendix B).

The sedimentary structures in Unit K are listed in Table 1 and best exposed at Little Water Canyon and West Sheep Creek. Giant symmetrical ripples with meter wavelengths and smaller scale ripples on their surfaces make up the interbedded sandstone and mudstone unit below the upper nodular limestone bed (fig. 17). Bedding thickens upward in several cycles. Complex wave ripples and wave-cut ripples (hummocky bedding) comprise some sandstone units (fig. 18). Planolites, Skolithos?, anastomosing burrows, bioturbation and contorted bedding are abundant. Less than 2 in. thick storm layers, consisting mainly of highly fragmented, algally-coated mollusk and brachiopod debris separates mudstone, sandstone, and pelecypod coquinas.

The lithofacies and fauna of Unit K are interpreted to have been deposited in a dominately moderately- to highly turbulent, subtidal, normal marine environment well within storm wave base. Like lower units, many characteristics of Unit K point to a storm-dominated shelf. Couplets of coarse hash layers, and fine-grained mudstone and siltstone prevail along with wavy, hummocky, and contorted bedding. Winnowing and reworking of subtidal, bottom sediments and shallow-water, solution hardgrounds by the storm waves or currents concentrated quiet-water faunal fragments (echinoderm and crinoid) with limonitized bioclasts and whole fossil fossil mollusks in these rocks.

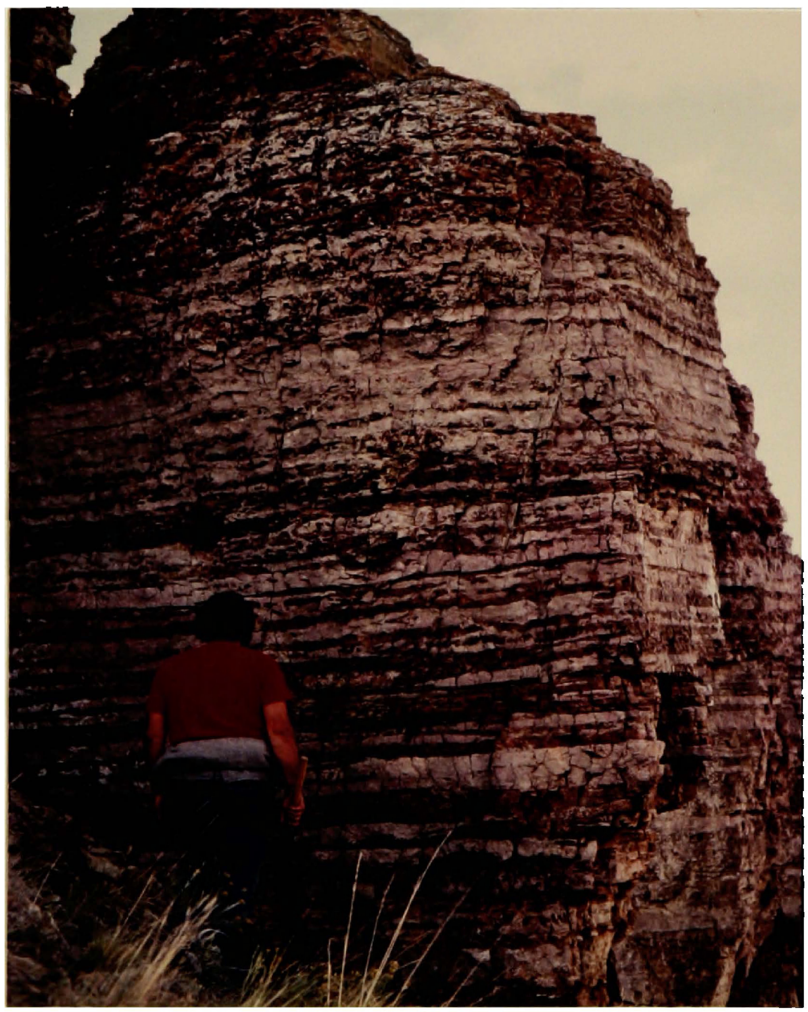


Figure 15.--Upper Limestone (Unit K), West Sheep Creek. Laminated outcrop formed by interbedded mudstone, sandstone, bioclastic limestone, and chert. Dark laminations are the cherty layers.

Figure 16.-- Storm layers in Upper Limestone (Unit K), West Sheep Creek. Layers consist of bioclastic layers (darker layers) and mudstones (lighter layers). Interval shown contains five bioclastic-mudstone couplets.

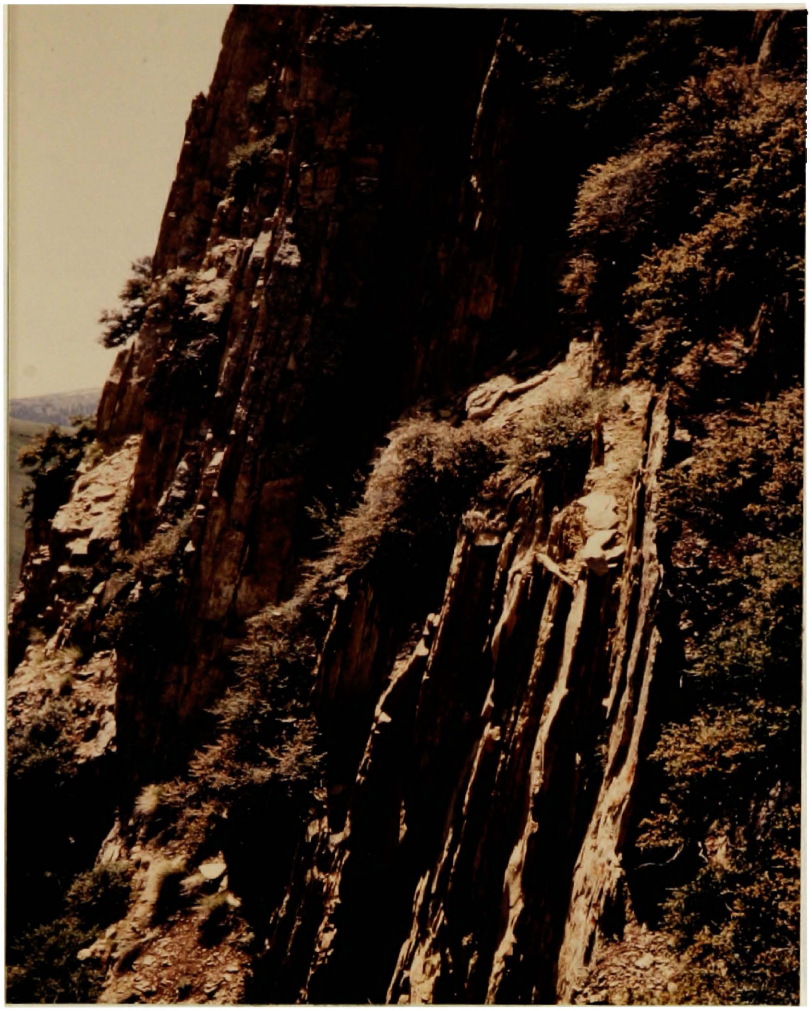


Figure 17.--Large-scale, symmetrical wave ripples in interbedded sandstone and limestone unit, Upper Limestone (Unit K), Little Water Canyon. Top of section to left.

Figure 18.--Wave ripples and cut-wave ripples (hummocky bedding), Upper Limestone (Unit K), Little Water Canyon. Pencil points to top of section.

SNOWCREST AND GRAVELLY RANGE, FOSSIL CREEK AND RUBY RIVER CANYON

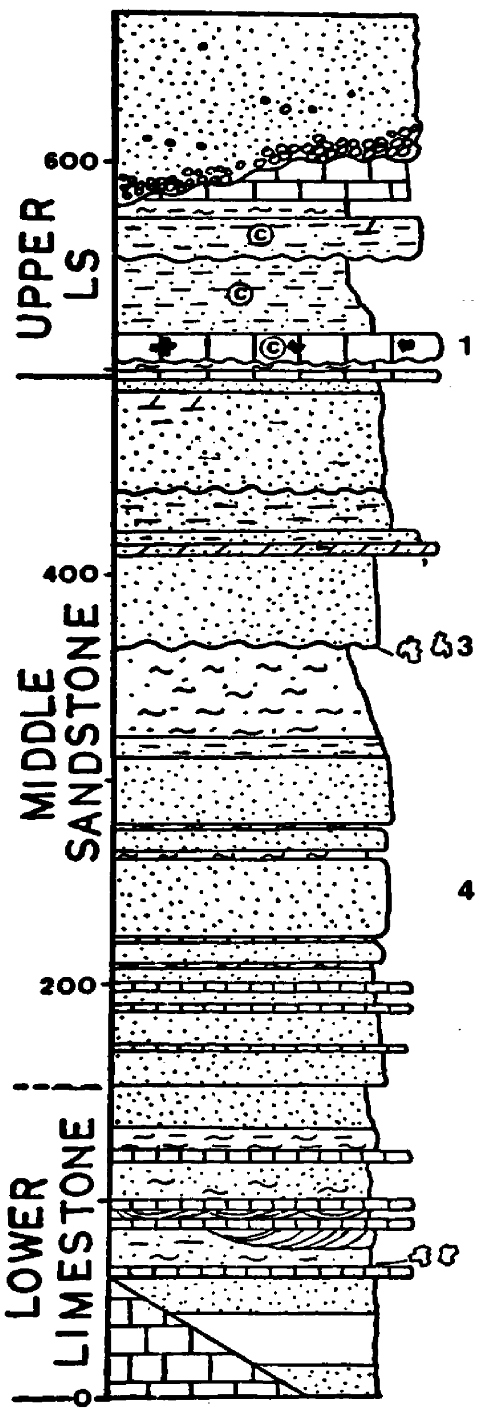
The northeastern stratigraphic sections in the Snowcrest and Gravelly Ranges and at Fossil Creek and Ruby River Canyon cannot be separated into "lower limestone", "middle sandstone", and "upper limestone" as easily as in the Tendoys. Only at Blacktail Deer Creek, is this division possible. Hogback Mountain lacks a thick lower limestone; therefore, the lower limestone-middle sandstone boundary is arbitrarily placed at a change in depositional conditions marked by the last major outcrop of red sandstone. At Fossil Creek and Ruby River Canyon, the major divisions cannot be identified. The Thaynes is very thin and contains few distinctive beds in these areas. Figure 19 summarizes stratigraphic characteristics from these four measured sections. Figure 20 correlates lithofacies between the Snowcrest and Gravelly areas.

"Lower Limestone"

Blacktail Deer Creek - At Blacktail Deer Creek, the lower limestone forms a prominant ridge above red, shale and siltstone of the Woodside Fm. (see measured section, Appendix A). Like the lower limestone in the Tendoy's, it consists of gastropods, forams, echinoids, pelecypods or brachiopods in a wacke- to packstone with a micrite matrix. It does not, however, contain ammonite or nautiloid molds or crinoid fragments (Table 5). Reworked, limonitic bioclasts, peloids, coated grains, and siltstone lithoclasts are common (Appendix B).

FIGURE 19

COMPOSITE STRATIGRAPHIC COLUMN
THAYNES FORMATION
SNOWCREST AND GRAVELLY RANGES



KOOTENAI FORMATION

UPPER LIMESTONE

Echinoid wackestone, mudstone, and bindstone. Coated fragments, some onkoids and abundant calcispheres. Dissolution surfaces?. Limestone breccia in lower portion at Hogback Mountain (clast diameter < 2 in.). Mudstones contain lams, red & green mudstone ripups, siltstone, fenestral fabric, bioturbation and sm. scale ripples. (## ft, ## m). Biota in upper unit (including trace fossils):

MIDDLE SANDSTONE

Mainly siltstone and v. f. grained sandstone; lt brown (at Blacktail Deer Creek (BDC)) to red, green and brown (at Hogback Mountain (HM)). Grains very well sorted, rounded to subangular quartz, minor feldspar and muscovite grains. Abundant lg. scale wave ripples; flattened, assym. & sym. ripples; and ripples at 45° to wave ripples. Shell molds, horizontal burrows, fossil hash and peloids abundant. Contact with lower unit is gradational at HM. Biota:

1 Location of limestone breccia (HM) or silicified zone (BDC).

2 Loc. of floatstone (oomicrite) with coated grains, ooids, and onkoids.

3 Green ripups in red sandstone above scour base (HM) or channel-form sandstone (BDC).

4 Approx. loc. of ammonite (Hemiprionites) of Kummel (1968).

LOWER LIMESTONE

Wacke-packstone (BDC) or interbedded red and green siltstone, sandy mudstone, and thin wackestone (HM). Wackestones contain abundant coated grains, calcispheres and peloids. Micro x-bedding, laminations, and bioturbation common. Some trough x-bedded sandstones near base at HM.

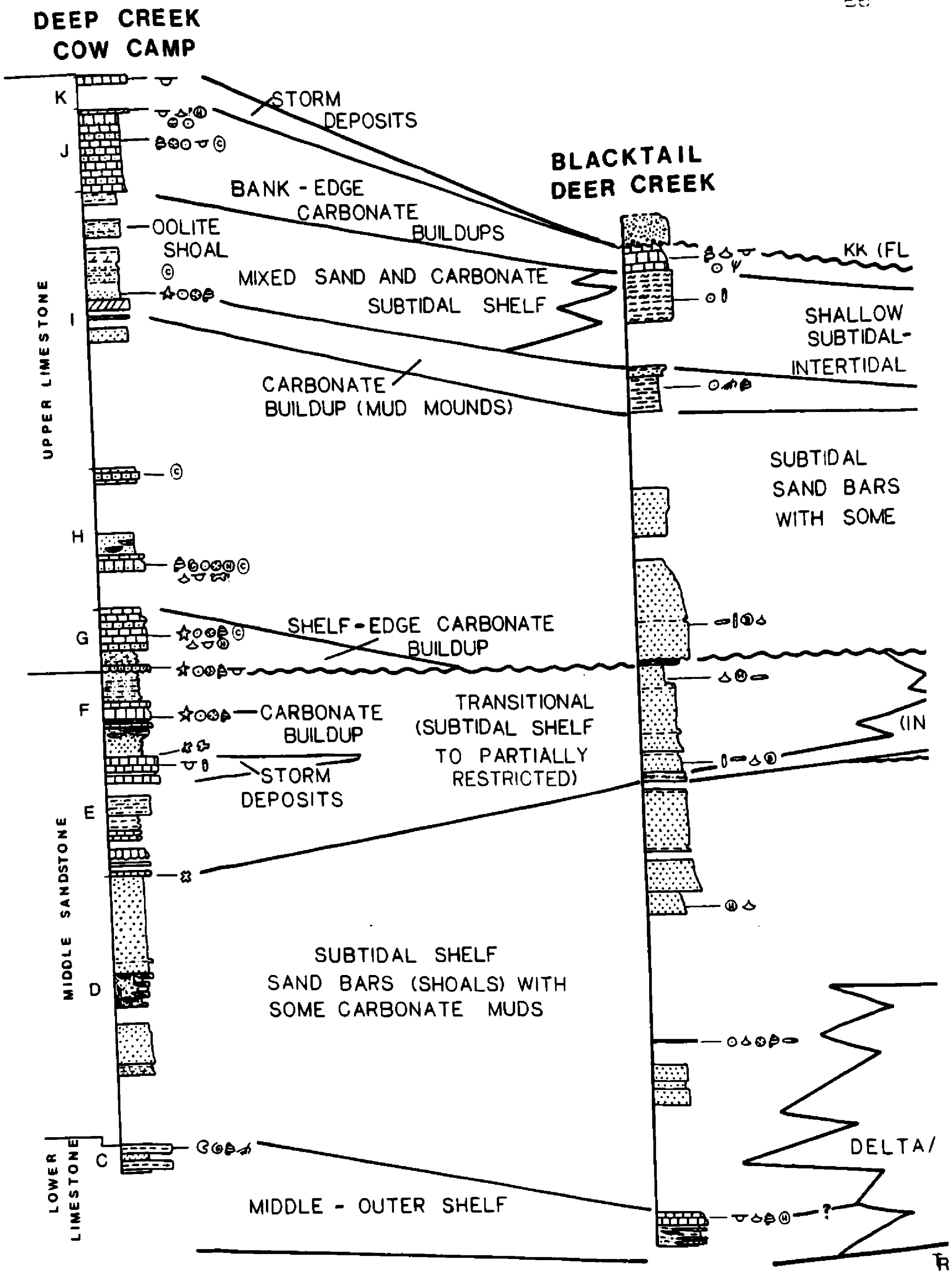
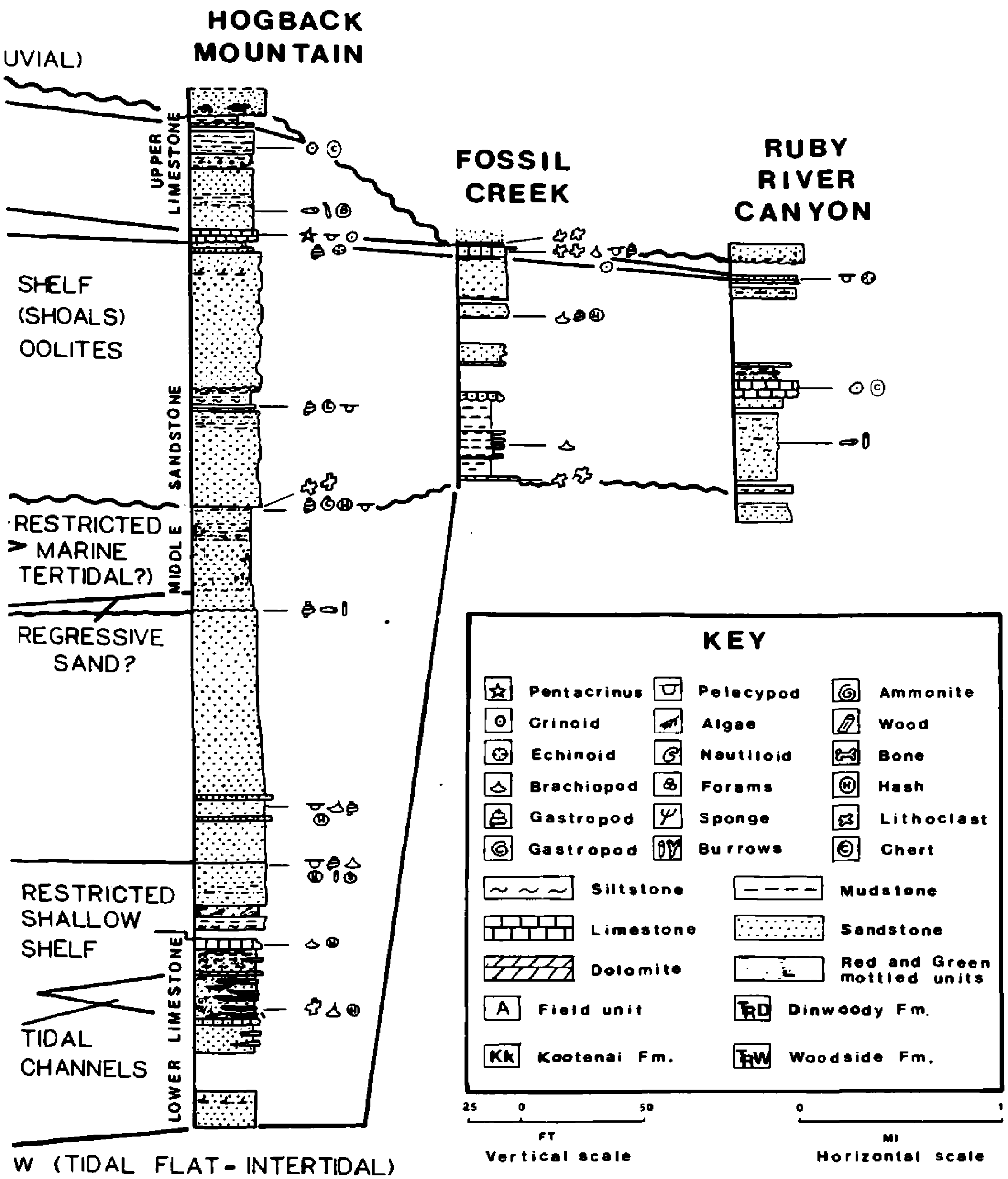


Figure 20. Correlation of lithofacies and environments, Tendoy Mtns. Gravelly Range areas.



interpretation of depositional
to Snowcrest Mtns. and

Table 5.--Stratigraphic distribution of biota in the Triassic Thaynes Formation, Snowcrest and Gravelly Ranges.

BIOTA		LOWER UNITS	MIDDLE SANDSTONE	UPPER LIMESTONE
ALGAE	CHLOROPHYTA	-----?-----		
	CYANOPHYTA			
	CHAROPHYTA	-----?-----		
	DASYCLAD	-----?-----		
ALGAE	STROMATOLITE	---?--		------
	UNSTRUCTURED			
AMMONITE	MEEKOCERAS			
BONE OR SCALE				
BRACHIOPOD		-----	--------- ------	------------------
CEPHALOPOD	(NAUTILOID)			
CRINOID	OSSICLES		------	----------------------
	PENTACRINUS			
ECHINOID		-----	-------- - - - - ----- - - - -------	----------------------
ECHINOID	LIMONITIZED		------- - - - - - - ---- - - - ----	----------------------
FORAM	MILIOLID	------	---?--	----------------------
GASTROPOD	UPWARD COIL	------------------------------------	------------------------------------	------------------
	PLANISPIRAL		-----------	
OSTRACOD				
PELECYPOD		------------------------------------	------------------------------------	
ROOT STRUCTURES				
SPONGE				----------
TOOTH				
WOOD				

The abundant normal marine fauna, which lacks ammonites and nautiloids, indicates that this unit was deposited on the shelf in shallower-water than the lower limestone in the Tendoys. It was deposited in water with dominantly moderate- to low- wave energies, probably on the middle to inner shelf as a carbonate buildup of mud mounds or accummulations. Periodically, bottom sediments and some subtidal dissolution surfaces were scoured by storm waves or currents, which redistributed shallow-water faunal fragments (echinoids) and limonitic bioclasts with unaltered, normal marine bioclasts.

Hogback Mountain - The "lower limestone", at Hogback Mountain, consists mainly of very fine-grained quartz sandstone and siltstone beds with thin bioclastic limestone ledges less than 5 ft. (1.5 m) thick. The sandstone is red, or red and green mottled. It is wavy and ripple bedded with some thin, normally-graded trough crossbeds. Abundant bioclastic debris, of echinoids, gastropods, pelecypods, and rare brachiopods, is concentrated along crossbed sets. Mollusk molds are common in the sandstone. The limestone ledges consist of gastropod and pelecypod hash, miliolid forams and algae, and cortoids. Similar lithologies and coloration continue up into the middle sandstone units at this location.

The abundant red beds, and low-diversity, exclusively-marine fauna of the "lower limestone" at Hogback Mountain indicate that it was deposited marine environment with low- to moderate-wave energy and restricted circulation (Enos, 1983; Picard and others, 1969). Circulation may have been restricted by extremely shallow waters bordered seaward by sand bars and mud mounds built seaward of it (such as at Blacktail Deer Creek), or a combination of these two (Enos, 1983). Absence of mudcracks or evaporites indicates dominantly subtidal deposition.

The interbedded trough crossbeds with fossil hash from mixed normal-marine and restricted-marine environments may be interpretted as deltaic channels affected by storms or as tidal channels. Distinction between tidal and deltaic origins is difficult in Thaynes rocks because exposure is extremely limited, the channels cannot be traced in three dimensions, and typical characteristics of modern tidal or deltaic environments, discussed by Reineck and Singh (1980), Walker (1980) and Shinn (1983), do not apply to Thaynes deposits because of the extremely low slope (less than 0.2 ft/mi) on the Triassic shelf (Picard and others, 1969) and the dry climate. Terrigenous grains of quartz, feldspar, and mica, comprising the more sandy deposits of the Snowcrests and Gravellys and the Tendoy Mountains, may indicate proximity to deltaic input from fluvial sources on the craton.

Therefore, the red beds of the lower limestone are interpreted to have formed in a subtidal, shallow marine environment, with restricted circulation. They formed in depths and environments transitional between the underlying, tidal-flat Woodside deposits at Hogback Mountain and the deeper-water, shelf carbonates of the lower limestone in the Tendoys. They may have recieved terrigenous sediments via tidal or fluvial channels. Rapid sedimentation is indicated in this environment because of the abundant shell molds, and escape burrows in these deposits.

"Middle Sandstone"

As in the Tendoy Mountains, the middle Thaynes at Hogback Mountain and Blacktail Deer Creek consists mainly of quartz sandstone, which is very fine grained, calcareous, and micritic. Grains are well sorted and subrounded to subangular. Thin, lenticular layers of shells are scattered throughout the sandstone. Dominant sedimentary structures include: tabular, wavy and ripple-laminated crossbedding, brachiopod and pelecypod molds on bedding surfaces, and vertical and horizontal burrows (Table 6). Ripples occur mainly as small scale asymmetrical, symmetrical, and flattened symmetrical ripples on larger scale symmetrical wave-ripple beds up to a meter in wavelength. Some occur at 45 degrees to main wavy bed surfaces (see Hogback Mountain, Appendix A). Nodular iron concretions are also abundant in the sandstone.

Fossil abundance and diversity is low in the middle sandstone (Table 5). Most fossils occur in thin wacke- to packstone layers less than a meter thick along bedding surfaces or, as previously mentioned, as whole-fossil molds in the sandstone. Pelecypod debris and small gastropods are most common, but rare echinoid, crinoid and brachiopod bioclasts also occur along with siltstone lithoclasts in some layers (see BDC-04, Appendix B).

The middle portion of the middle sandstone is also marked by a siltstone and mudstone bed that correlates with Unit F in the Tendoy Mountains (fig. 20). This bed is characterized by red and green mottled, very-thin to flaser, ripple and wavy beds with fenestral fabric, rare mudcracks (?) and dolomite. Like Unit F in the Tendoys, it marks a

Table 6.--Sedimentary structures and limestone particles in the Triassic Thaynes Formation, Snowcrest and Gravelly Ranges.

STRUCTURE		LOWER UNITS	MIDDLE SANDSTONE	UPPER LIMESTONE
ALGAL BALLS				
ALGAL LAMINATIONS				
BIDIRECTIONAL RIP/XBEDS				
BIOTURBATION		———	———	—?—?—
BURROWS	ANASTOMOSING			
	BRANCHING			
	HORIZONTAL		———	———
	VERT./INCLIN		———	
CHERT	LAYERS			———
	LENSES			
	NODULES			———
CLIMB RIPPLE LAMS		———	———	
CONTORT BEDS			———	———
DISSOLUTION			———	———
FE NODULES			———	
FLASER			——— ———	
GRADED BEDS		———	———	———
LS PARTICLES	AGGREGATE GR		———	
	CALCISPHERES	———	———	———
	CORTOIDS	———	———	———
	ONKOIDS		———	———
	OOIDS		———	
	PELOIDS	———	———	———
LITHOCLAST	(RIPUP)	———	———	
LOAD CASTS				
MICRO X-LAMS		——— ———		
MOLDS & CASTS (BIOTA)		———	———	———
MUD CRACKS			—?—	
MUD DRAPES				
OPEN SPACE		———	———	———
RIPPLE LAMS (UNDIFFEREN)				
ROOT CASTS				
SHELL-COATS + BORING				
SKELETAL GRAINS		———	——— ———	———
STROMATOLITE				
TRAIL/FEED. TRACE				———
TROUGH X-BED		———		
WAVY RIPPLE LAMS		———	———	———
WAVE RIPPLES(LG. SCALE)			———	———

distinct change in depositional energy from shallow subtidal deposits with interbedded red beds to more normal-marine, subtidal, sand shoals.

Three other intervals of importance in correlating between the Tendoy Mountains and Snowcrest and Gravelly Ranges occur in the middle sandstone. First is a thin floatstone (or oomicrite), where ooids and onkoids are very abundant and well sorted (loc. 2, Fig. 19). This interval is located at Hogback Mountain, Fossil Creek and Ruby River Canyon. Second is a zone of green lithoclasts in red sandstone (loc. 3, fig. 19) located above the middle siltstone-mudstone lithofacies. The lithoclasts are up to 1 cm in diameter, micritic, rounded and some are broken. This zone, or an equivalent scour surface, occurs in all four Snowcrest sections (fig. 20). Third is the approximate location of (Hemiprionites), an ammonite reported by Kummel (1960) (loc. 4, fig. 19).

The lithofacies of the middle sandstone in the Snowcrest and Gravelly Ranges indicate three distinct types of sedimentation. Each type was deposited under different wave energies on the shelf. The thick, wavy bedded, very-fine grained sandstone lithofacies with thin, interbedded, lenticular hash layers was deposited by waves of moderate-to high energy. It is interpretted as sand shoals or bars that built within wave base. The absence of fossils may reflect a highly unstable substrate of sand moving shoals. The abundant whole-fossil molds indicate that sedimentation was often more rapid than organisms could adapt to unless they fed on the surface and could moved quickly to adapt to the mobile substrate. The rare fragments of deeper-water, normal marine fauna (ie. echinoderms and crinoids) mixed in the hash layers with fauna also found in the sandstone lithofacies (ie. pelecypods and gastropods) may represent organisms carried shoreward by storm waves or other strong, periodic, high-energy waves and deposited on the sand shoals or bars. The Hemiprionites specimen (loc. 4, fig. 19) of Kummel (1960) may have been deposited in the middle sandstone during a storm, or have floated in after death under less turbulent conditions from deeper water to be deposited in the sandstone lithofacies.

The sedimentary structures and fauna of the red, and red and green mottled, siltstone and mudstone lithofacies indicate that it was formed in a shallow-water, low-energy environment with restricted circulation and possible subaerial exposure. It is interpretted to be deposited in the intertidal zone during regression of the Triassic sea from southwest Montana. Similar deposits are found in the laterally equivalent, restricted-marine deposits in Wyoming (Picard and others, 1969). The lithoclast zone (loc. 3, fig. 19) above the intertidal deposits represents transgression of the Triassic sea, back into the study area.

The third distinct lithofacies of the middle sandstone is the oolitic lithofacies (loc. 1, fig. 19). As described in the Tendoys, it forms in high-energy currents or waves on shallow marine, oolitic shoals (Flugel, 1982). Portions of the shoals in this area may only be affected by low-energy currents or waves because the oolites are in thin, flaser and ripple beds (fig. 21). Oolite shoals have also been reported from equivalent-age shelf deposits in Nevada (Bissell, 1970) and Wyoming (Picard and others, 1969). They restrict water circulation shoreward in these areas (Picard and others, 1969).

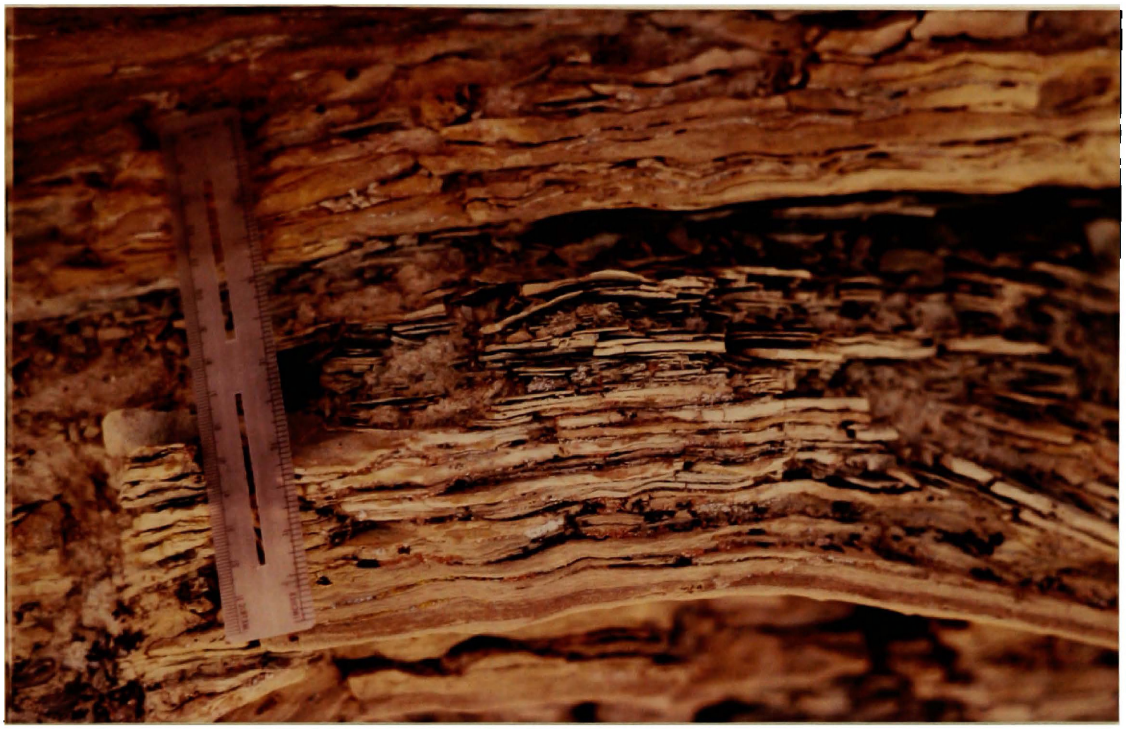


Figure 21.--Flaser and ripple bedding (above oolite zone), Hogback Mountain.

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"Upper Limestone"

The upper limestone consists of four lithofacies (fig. 19). They include (from base to top): wackestone; muddy, calcareous, quartz sandstone; cherty mudstone with bindstone; and echinoid wackestone. These units correlate well between Blacktail Deer Creek and Hogback Mountain, but are only tentatively traced to Ruby River Canyon or Fossil Creek. Their lithologies and biota are the same as part of the upper limestone of the Tendoy Mountains.

Like the Thaynes Fm. in the Tendoys, echinoid and crinoid remains first dominate sediments in the upper limestone of the Snowcrest and Gravelly Ranges. They contain coated bioclasts of normal marine fauna, including Pentacrinus, echinoderms, forams, gastropods, and a few brachiopods or pelecypods in a silicified or micritic matrix (Table 5). They also contain limonitized echinoderm fragments reworked from dissolution surfaces or hard grounds (Appendix B). At Blacktail Deer Creek, the lower wackestone is completely silicified. At Hogback Mountain, it contains abundant, irregular limestone patches (breccia?) (fig. 22). Despite these differences, correlation can be made between

- -

Figure 22.--Limestone breccia, lower Upper Limestone, Hogback Mountain. Limestone patches less than 3 in. in diameter. Notebook for scale. Up to upper right of photo.

- -

these two units based on petrography. Both units contain echinoid or crinoid fragments in a completely or partially silicified matrix with similar, abundant, unidentified calcispheres (Appendix B). The calcispheres are rare in other petrographic samples.

The calcareous sandstone contains the same trace-fossil assemblege as in the sandstones of the middle sandstone unit, including Planolites, Skolithos? and Asteriacites?.

The cherty mudstone beds contain abundant algae, chert nodules, ripple or flaser bedding, bioturbation, bird's eye structures and unidentified calcispheres. Discontinuity surfaces, dolomite, and possible desiccation cracks were also distinquished in thin section. Only one identifiable fossil, a diagenetically altered, silicious sponge, was found at the base of this lithofacies at Blacktail Deer Creek. Monaxon spicules in various orientations around a number of central points in a single layer indicate that these sponges degraded in place (Plate 1, fig. 11). This is the only positive evidence of such organisms in the Thaynes of southwest Montana. Other sponge remains have been found in Thaynes Formation rocks in Utah and Nevada (Rigby and Gosney, 1983).

Characteristics of the upper echinoid wackestone are the same as in the Tendoys. It contains fenestral fabric, onkoids and limonitic bioclasts.

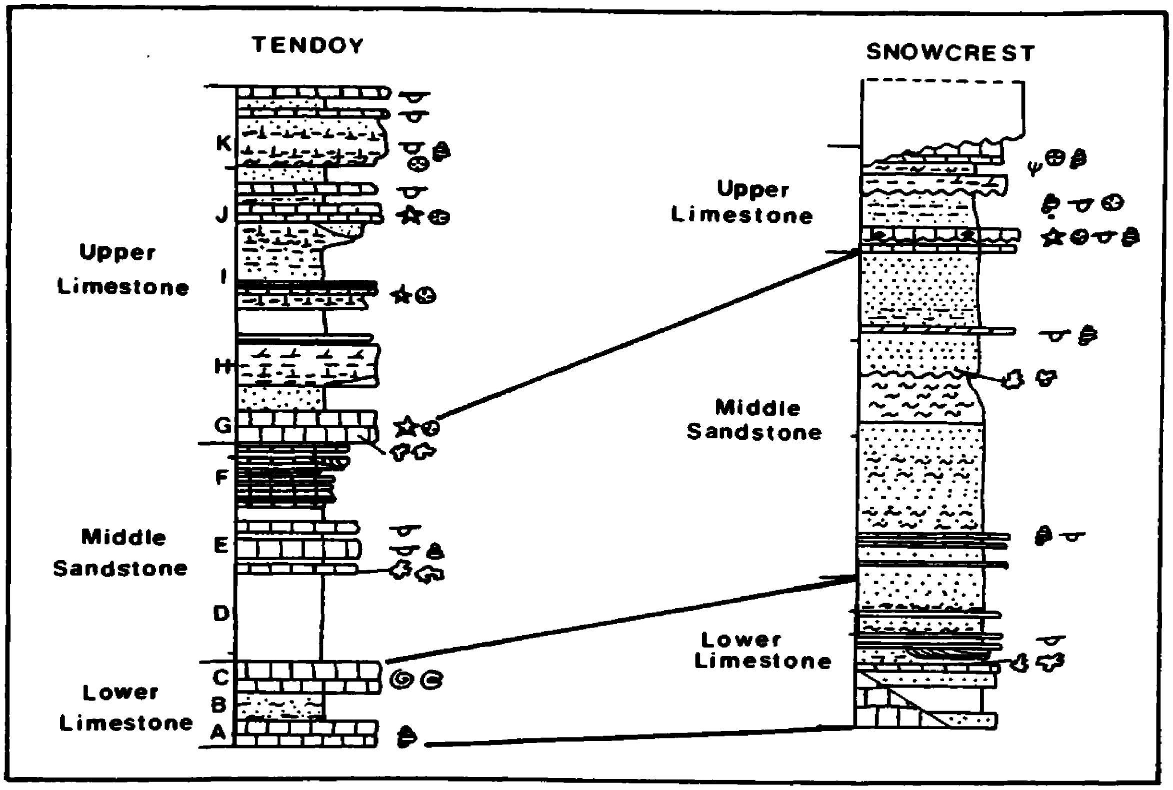
Conditions for the formation of the upper limestone in this area are similar to those discussed for the upper limestone in the Tendoys. The lower and upper echinoid wackestone (with sponge remains) formed in shallow, normal marine water, with low- to moderate wave energy as lime mud mounds or accummulations in the subtidal zone. They possess topographic relief, as well as minor breccia on flank beds. The sandstones formed in moderately-turbulent environments as sand bars like those described in the middle sandstone. The silty mudstones formed in very shallow, subtidal to interidal marine water with low turbulence. Evidence for intertidal deposition includes the bird's-eye structure, discontinuity structures (ie. interruptions in sedimentation or periods of non-deposition), desiccation cracks (?) and dolomite. Discontinuities are marked in petrographic samples mainly by distinct changes in sediment type on either side of an algally- coated or stained surface, by leached and coated grains on a discontinuity plane, or micrites which penetrate deep into the microrelief of the substrate (Appendix B). Depositional conditions may have been somewhat restricted by sand bars/shoals, or oolitic shoals to the south in the Tendoys (Unit I).

CORRELATION OF LITHOFACIES IN THE TENDOY MOUNTAINS AND SNOWCREST AND GRAVELLY RANGES

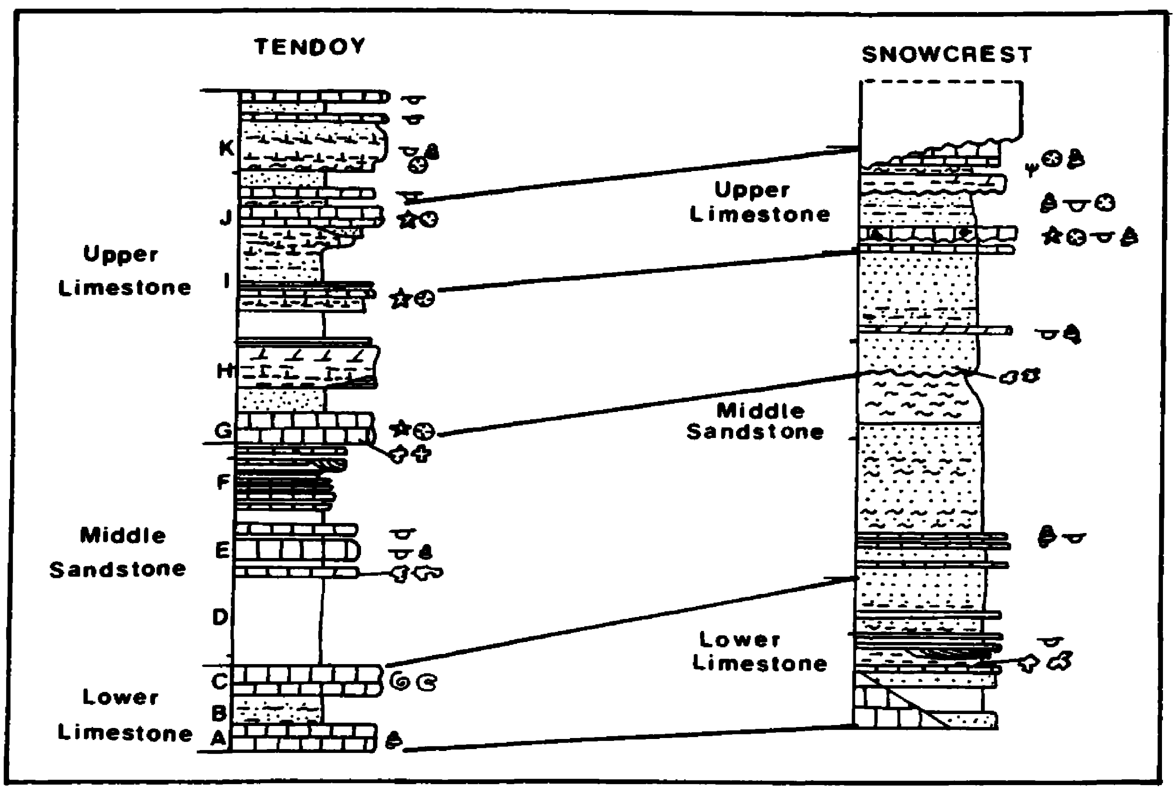
All units of the Thaynes correlate well across the Tendoy Mountains; however, it is difficult to separate Units J and K of the upper limestone in areas of good exposure (see sections Little Water Canyon and Hidden Pasture Spring, fig. 7). Although great variation in lithofacies exists laterally due to a mixed-carbonate environment and terrigenous influence, the general field units can be traced laterally for large distances (fig. 7). Lateral continuity is probably caused by mixed-sediment deposition parallel to the coastline in similar water depths on the shelf. Individual units thicken only slightly southward from Little Water Canyon to Deep Creek Cow Camp (see fig. 7). Therefore, the shelf at Deep Creek Camp may have varied a little in depth and subsidence or in elevation on the shelf floor to accumulate more sediments.

Stratigraphic sections at Blacktail Deer Creek and Hogback Mountain correlate well among themselves, except for the thickness of the middle sandstone at Blacktail Deer Creek (fig. 20). Thickness differences are probably due to the abundance of covered interval and the structural complexity at Blacktail Deer Creek, as well as depositional variations. Correlation of Blacktail Deer Creek and Hogback Mountain with Fossil Creek and Ruby River Canyon can only be tentatively made because the stratigraphic sections at Fossil Creek and Ruby River Canyon lack distinctive lithologic units. Correlations of Fossil Creek and Ruby River Canyon with Blacktail Deer Creek and Hogback Mountain for this study are tentatively based on 1) the basal contact, which contains green lithoclasts similar to Blacktail Deer Creek and Hogback Mountain; 2) the oolitic zones, which occur only above the ripup zone in the Tendoys, Snowcrests and Gravelly Ranges; and 3) the upper, Kootenai contact (fig. 20). Because the basal contact is indistinct, the upper contact is errosional, and ooids occur in a number of Thaynes units and different depositional facies, these correlations are very tentative and should be used with caution. These sections represent both thinning of the Thaynes depositional facies northward toward the craton and extensive erosion by the Kootenai sediments.

Correlation of stratigraphic units between Hogback Mountain, Blacktail Deer Creek, and the Tendoy Mountains area can be made in two main ways. One correlation is based on the lowest dominant occurrence of crinoid and echinoids in both areas (fig. 23a). In addition to the obvious change in dominant biota at this point, other features of the deposits support this correlation. First, the general sequence of lithologies is the same. In both areas, the base is generally muddy limestones; the middle, calcareous siltstone and sandstone with muddy limestone; the top, echinoid-bearing limestones. Thickness differences in the lower limestone may be due to variable lateral deposition, as well as a variable transition-zone thickness at the lower, Woodside contact. Second, the sequence of units in the upper limestone correlate fairly well with the sequence of units in cycle 1 in the Tendoy Mountains, except that the upper pelecypod packstone (of Unit I), which may have been removed pre- Cretaceous erosion, is missing and thicknesses of units differ (fig. 23a). This interpretation would make Cretaceous erosion very deep in the northeastern area, with more than 250 ft (79 m) downcutting if all Tendoy units were deposited laterally. However, this is also approximately the amount of material also removed from Garfield Canyon, the northernmost exposure of Thaynes Fm. in the Tendoy Mtns. Third, erosional surfaces with large lithoclasts in the middle sandstone correlate laterally across both areas, suggesting an erosional surface and possibly a large-scale regression during deposition of the Thaynes. Transgressive and regressive episodes during deposition of the Thaynes have been previously proposed for other areas



A



B

Figure 23.--Correlations possible between Tendoy Mtn.& Snowcrest-Gravelly Rng. lithofacies

by Carr and Paull (1983), Collinson and Hasenmueller (1978), and Bissell (1970). Lithoclasts, however, are common in these rocks and occur in a number of intervals throughout the stratigraphic sections of Thaynes rocks.

The cyclic nature of the Thaynes Formation in the Tendoy's requires that a second correlation be proposed between the Tendoy Mountains and Snowcrest and Gravelly Ranges (fig. 23b). Like correlation A, the general sequence of rock lithologies correspond in correlation B. This correlation, however, is based on two important criteria. First, and most important, is the change in depositional energy and conditions (marked by lithoclasts at its upper surface) that occurs in the middle of Thaynes deposits in both areas (ie. Unit F in the Tendoys and the siltstone lithofacies within the middle sandstone in the Snowcrest and Gravelly Ranges). The change from dominantly shallow, low-energy, marine conditions with restricted fauna to more open-marine, subtidal, low- to moderate-energy marine conditions with open circulation at this horizon is very distinct in both areas. Second, the rock types, thicknesses, rock sequences and stratigraphic details within the sequences correspond more closely in correlation B than correlation A. In all ten stratigraphic sections, the lowest oolitic zones and the echinoid-bearing units outcrop only above this change in depositional energy. Unlike correlation A, this correlation requires erosion or non-deposition of the first echinoid wackestone at Hogback Mountain and Blacktail Deer Creek (fig. 23b). Second, the sequence of lithofacies and their thicknesses in cycle 2 of the Tendoys (Units I - J) correspond more closely to the lithofacies in the upper limestone in the Snowcrests and Gravelly's. Third, dolomitic units correspond more closely in correlation B (fig. 23b), and the ammonite zone of Kummel (1960) may correspond to packstone layers in the Tendoys interpretted as storm layers. Finally, the lateral relationships from deeper, basinward depositional facies in the Tendoys to shallower, shoreward depositional facies in the Snowcrests and Gravelly Range correlate better using correlation B. Therefore, correlation B is proposed in this study to best explain the lithofacies relationships of the Thaynes Fm. in southwest Montana. It is the basis for interpretation and summary of depositional environments and history of the Montana Triassic shelf proposed later in this paper.

DIAGENESIS

Diagenetic changes, which are very pervasive in the Thaynes Formation, have not been examined in detail for this study. In general, they include both isochemical and allochemical changes. Isochemical changes include marine cementation and neomorphism. Allochemical changes include dolomitization, dissolution and silicification (Flugel, 1982). Other changes include compaction, styolitization and fracturing.

Thaynes Formation rocks exhibit several cement types and neomorphic changes. Micrite, formed in marine environments, is the most abundant cement (Plate 1, figs. 1 and 6). Rim, dogtooth, fibrous and blocky (or granular) sparry cements also occur (Appendix B). Most sparite is microsparite (between 4 and 10 microns in diameter), which usually originates from the recrystallization of micritic calcite (Flugel, 1982, p. 84). Many bioclasts are neomorphosed to sparry calcite or replace by silica (Plate 2, fig. 1). Burrows are also filled with sparry calcite or silica (Appendix B). In addition, evidence of shallow-marine diagenesis in areas of non-deposition (ie. hardgrounds) is found in most Thaynes units. This evidence includes shallow-water biclasts with concentrations of limonite and other iron minerals (Plate 1, figs. 1 and 11). Leaching (dissolution) of bioclasts and micrite envelopes occur (Plate 2, fig. 2), and surfaces with deeply penetrating microrelief of the substrate that are filled with micrites or coated.

Silicification is the most abundant allochemical change in the Thaynes Formation. Bioclasts are partially or totally replaced by various silica crystal types (ie. blocky, rim, dogtooth, etc.), that probably replaced sparite or pseudosparite crystals (Plate 2, fig. 3). Replacement by chert and chalcedony is also common. Much of the silicication probably occurred after burial of the Thaynes rocks in the Mesozoic.

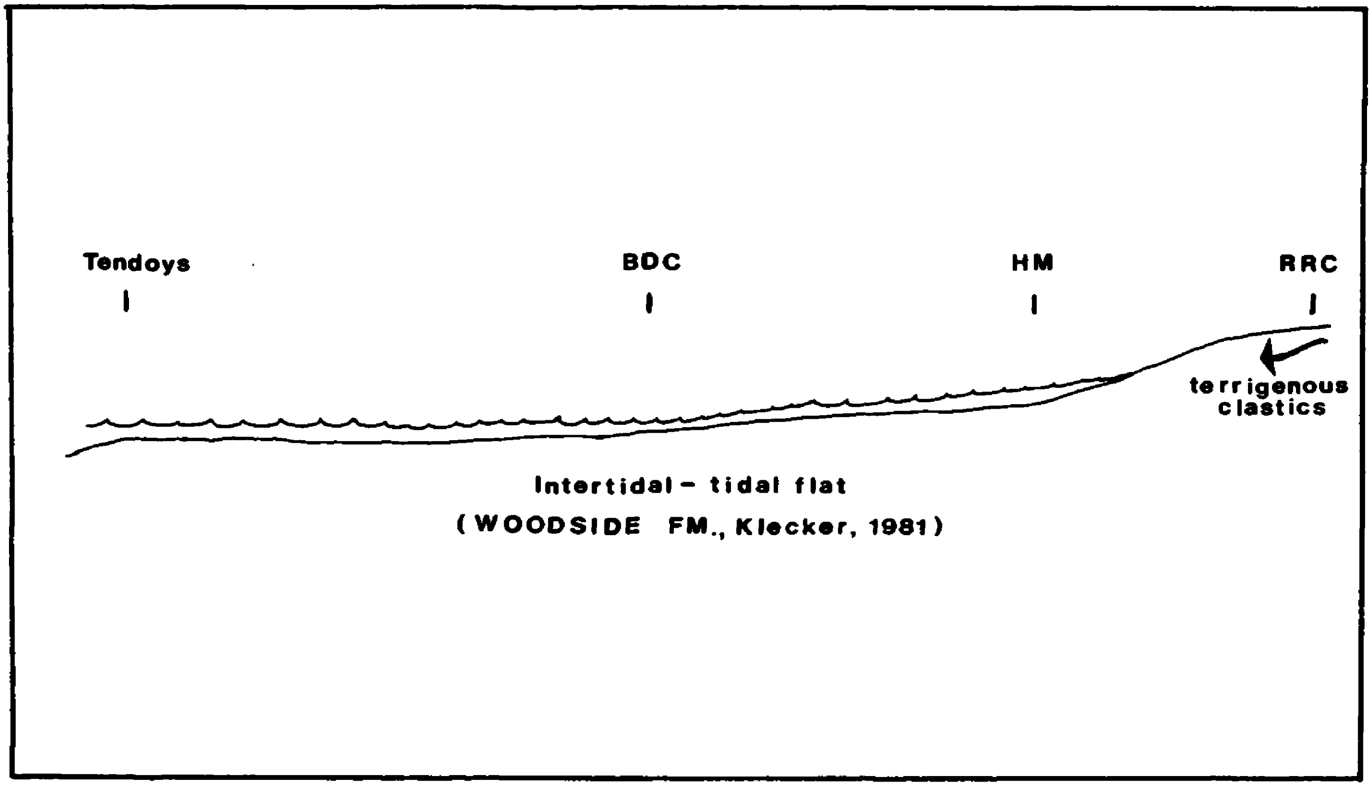
Early dolomitization of Thaynes rocks has been discussed previously (Unit I, Tendoy Mountains). Dolomitization probably occurred in rocks with high porosity, more restricted circulation and possibly evaporation to concentrate Mg+ ions in the pore waters. This process was followed by calcite pore filling and, finally, quartz fracture filling (Plate 1, fig. 8).

Other diagenetic changes prevalent in these rocks include compaction, styolitization and small-scale fractures. Compaction before lithification is very evident in samples with ooids or onkoids, broken lithoclasts, and bioclasts with fitted-grain boundaries (Plate 2, fig. 4). Styolites, which generally form as pressure-solution structures (Bathurst, 1975), are also present in Thaynes rocks (Plate 2, fig. 5).

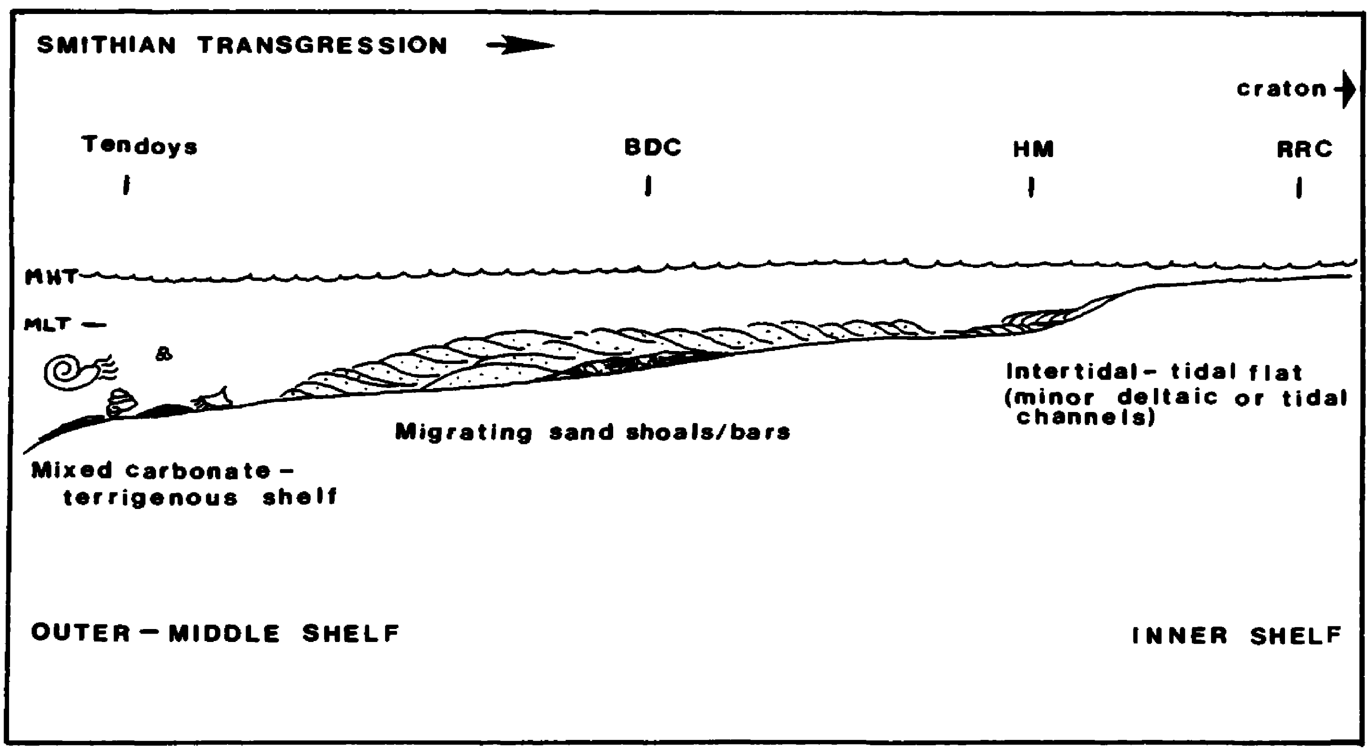
SUMMARY OF THAYNES FORMATION DEPOSITIONAL HISTORY IN SOUTHWEST MONTANA

Prior to deposition of the Thaynes Fm., southwest Montana was covered by a large tidal flat (fig. 24a), which accumulated red-bed sediments of the Woodside Fm (Klecker, 1981). As gradual transgression of the Smithian sea continued into the area, tidal flat deposition gave way to deeper, subtidal, marine deposition on a broad, shallow shelf. The upper Woodside and lowermost Thaynes Fm. were deposited on this low-sloping, shallow-marine shelf. Continued transgression resulted in the deepest shelf sediments of the Thaynes, namely Units A and C in the Tendoy Mountains (fig. 24b). These sediments accumulated in low- to moderate-energy, mixed terrigenous and carbonate environments, with varying amounts of reworking by storm waves and currents. They also supported a moderately diverse fauna of cephalopods, nautiloids, mollusks and terebratulid brachiopods (fig. 24b). Shoreward from the ammonite-bearing sediments, shallow-water, carbonate- to mud accumulations, sand shoals or bars, and restricted red-bed sediments accumulated in low- to moderately- turbulent water on the shelf in the present-day Snowcrest and Gravelly Ranges (fig. 24b). The red beds of the lower limestone in this area are transitional depositional facies with the underlying Woodside, and represent a gradual deepening in the shoreward areas with continued restriction of water circulation. Shoaling of water over the sand flats in this area probably slowed waves and/or currents over this portion of the shelf to restrict circulation. These conditions supported mainly pelecypod and gastropod fauna that probably grazed on algae in these sediments. Thin, trough-crossbedded

Figure 24. -- Depositional history of the Triassic Thaynes Fm. in southwest Montana. Tendoys, BDC, HM, and RRC denote study areas.

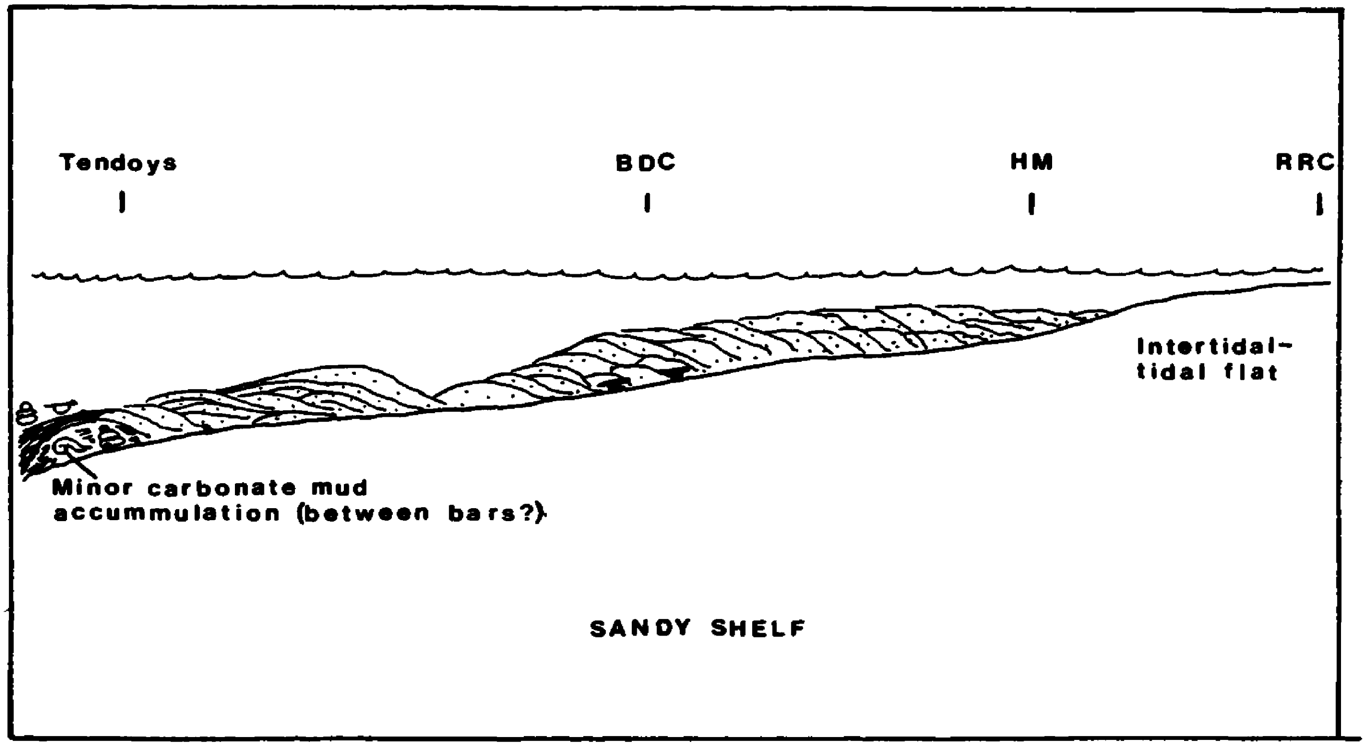


A. PRE-THAYNES DEPOSITIONAL SURFACE (WOODSIDE FM.).

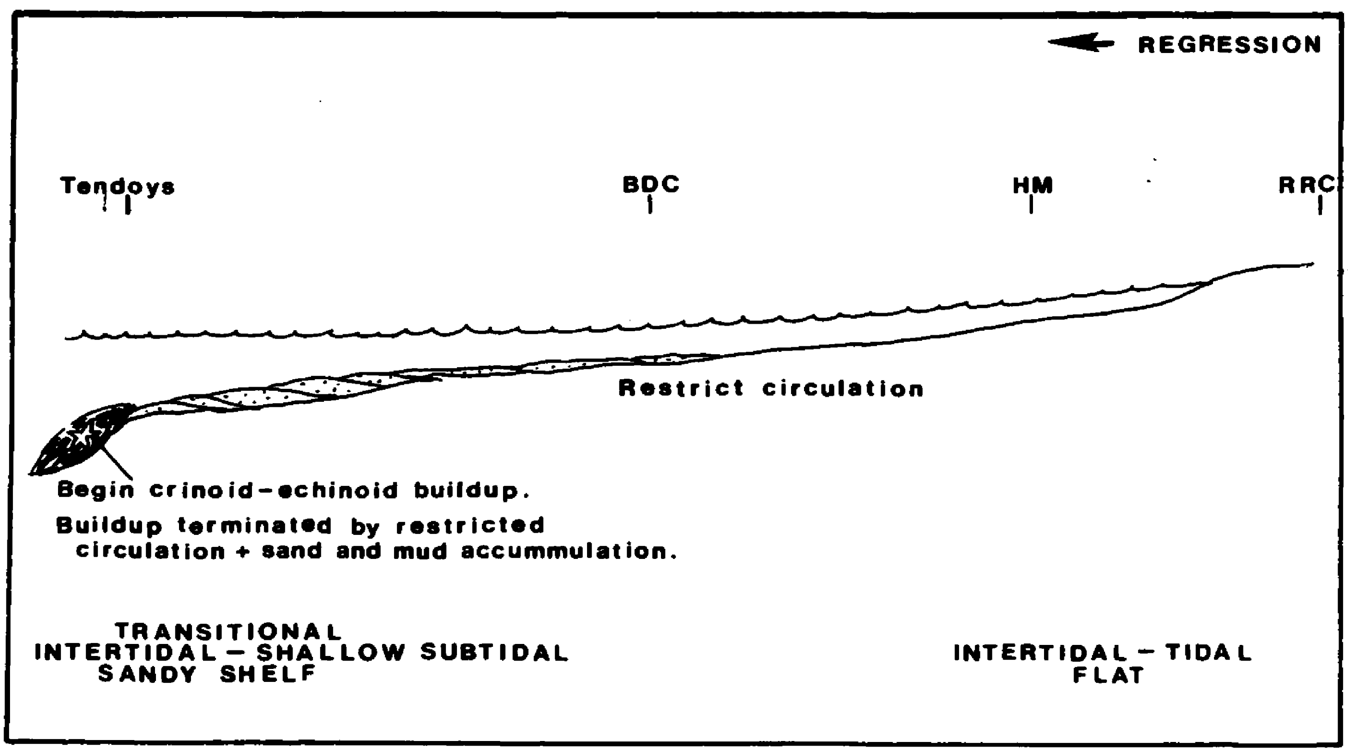


B. LOWER LIMESTONE DEPOSITION.

FIGURE 24

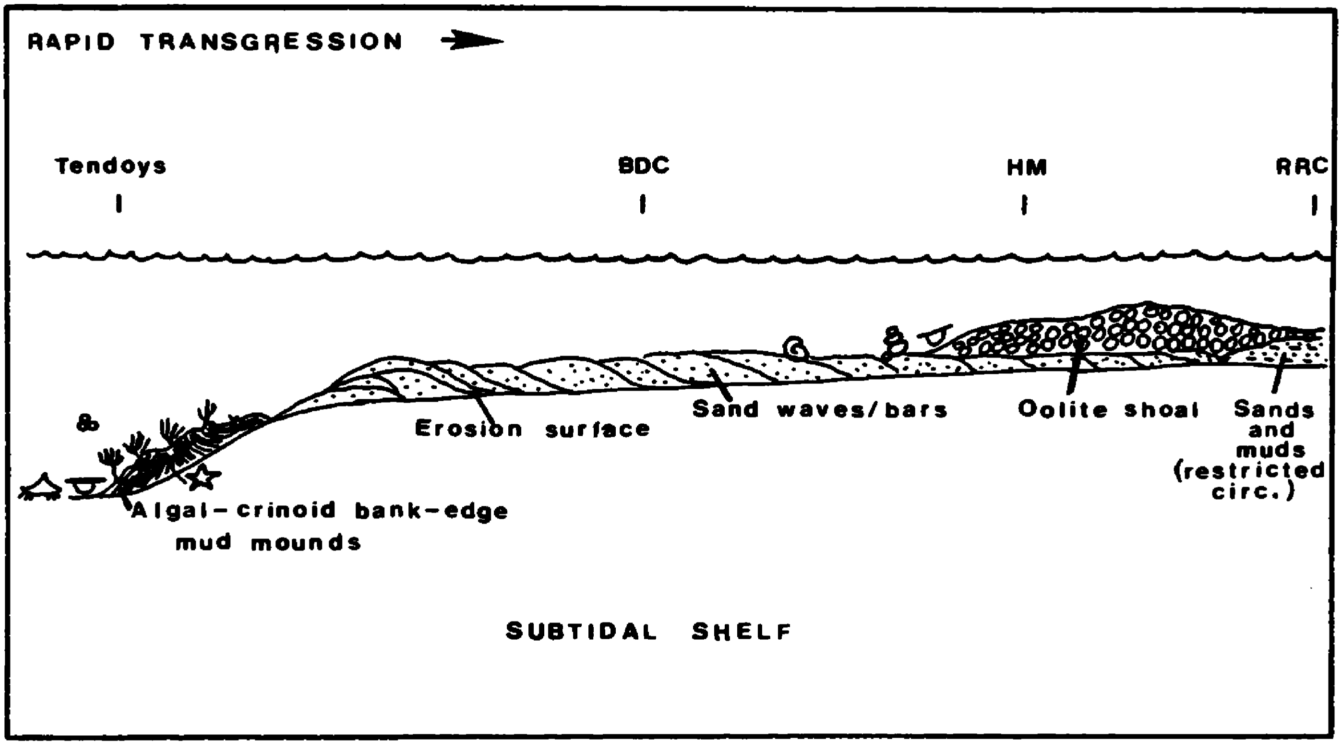


C. LOWER–MIDDLE MIDDLE SANDSTONE DEPOSITION.

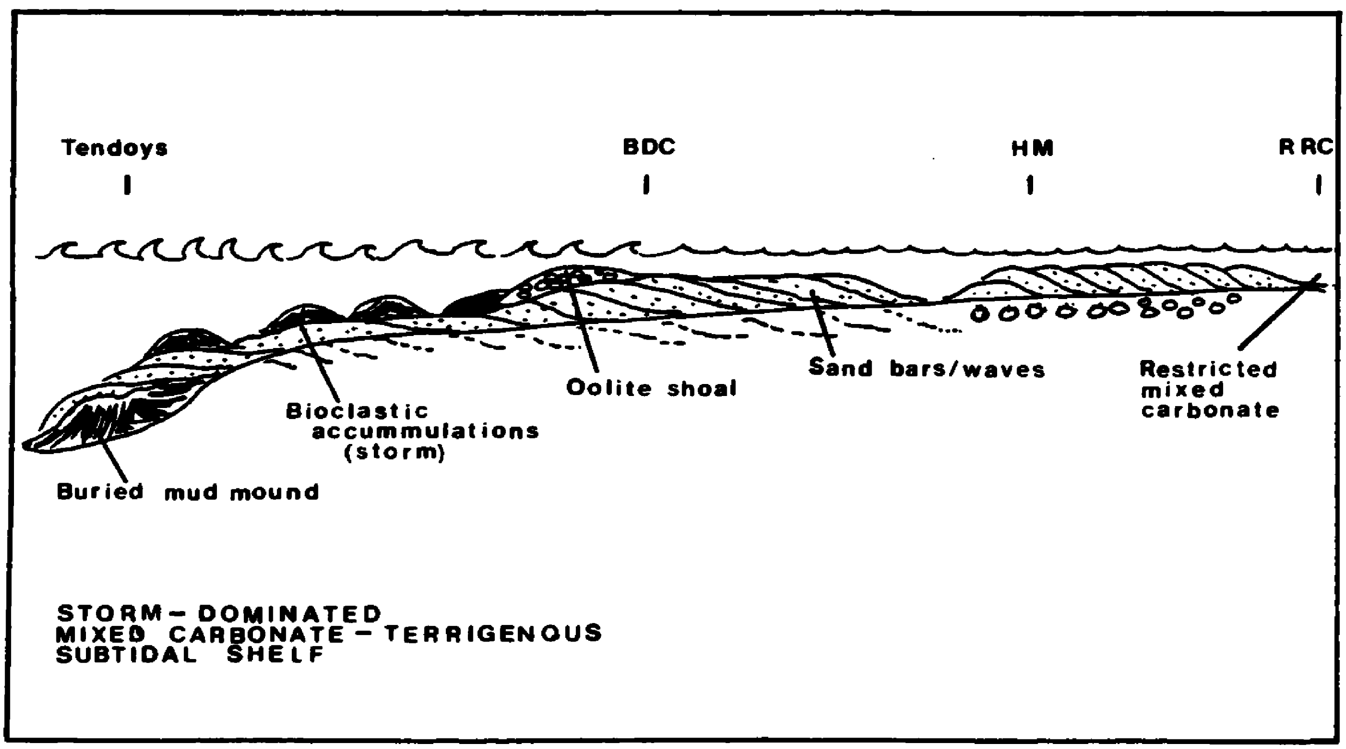


D. UNIT F (TENDOYS) AND MOTTLED LITHOFACIES (MIDDLE MIDDLE SANDSTONE, SNOWCRESTS).

FIGURE 24

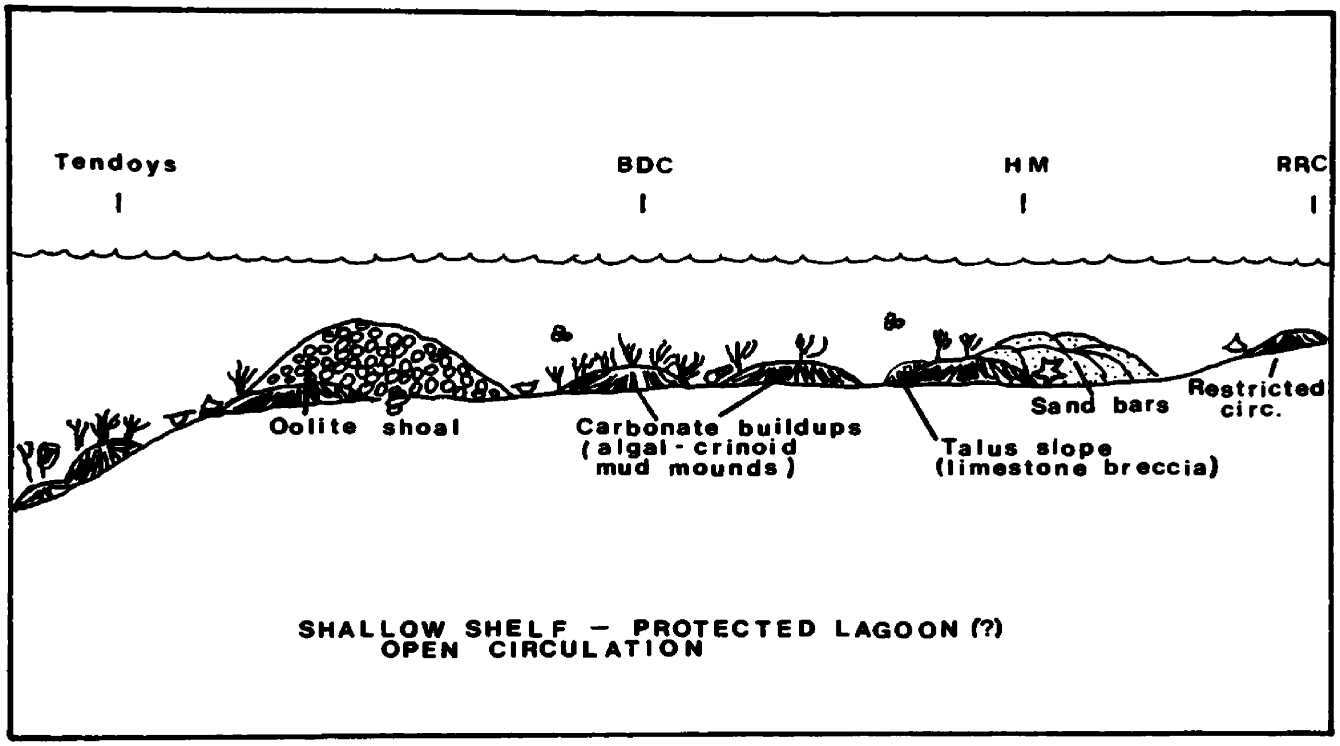


E. UNIT G (TENDOYS) AND UPPER MIDDLE SANDSTONE (SNOWCRESTS).

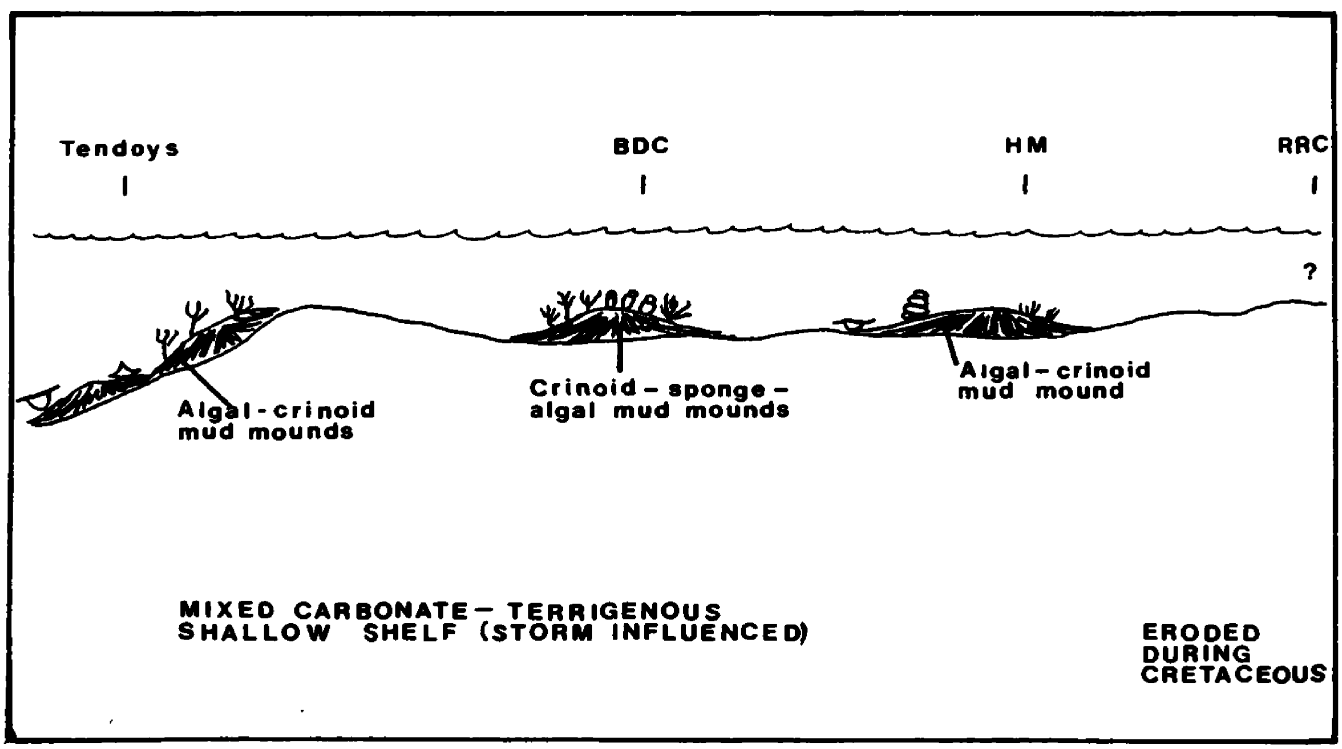


F. UNIT H (TENDOYS) AND UPPER MIDDLE SANDSTONE (SNOWCRESTS).

FIGURE 24

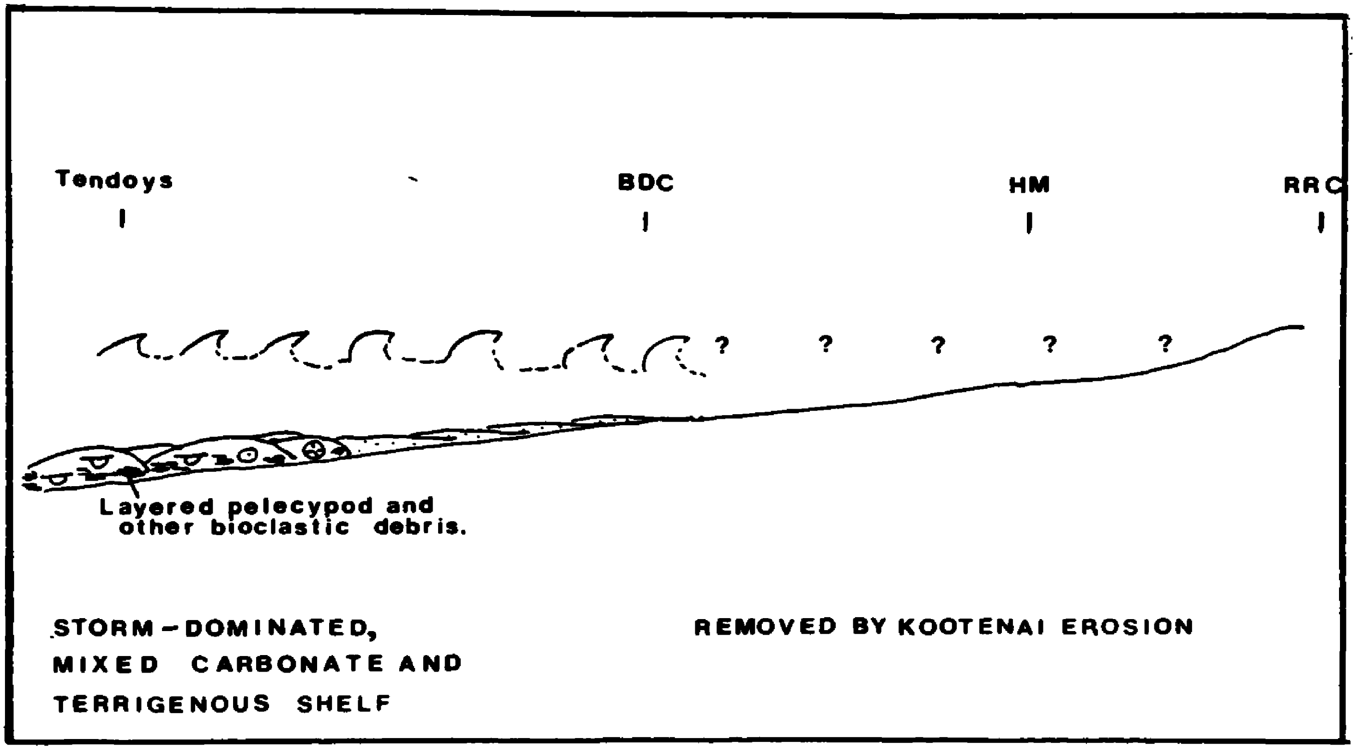


G. UNIT I (TENDOYS) AND LOWER UPPER LIMESTONE (SNOWCRESTS).



H. UNIT J (TENDOYS) AND UPPER UPPER LIMESTONE (SNOWCRESTS).

FIGURE 24



I. UNIT K (TENDOYS).

sandstones in the restricted-circulation areas may have come from the craton in either tidal or deltaic channels (fig. 24b). Because of the low slope on this portion of the shelf, very slight changes in sea level during deposition would have greatly affected the morphology and sedimentation of these channels and the more northerly coastal areas. Climate would also have affected coastal morphology. During the Early Triassic, climatic and paleomagnetic evidence indicates that southwest Montana would have been in a near-equitorial position within the trade wind belt and affected by almost constant northeasterly winds (Peterson, 1978). The prevailing wind direction may have brought airborne silt from arid, inland red beds into the coastal environment and onto the shelf (Klecker, 1981).

Maximum transgression of the Smithian sea probably occurred early during deposition of the middle sandstone member (fig. 24c). Because this interval is mostly covered in the Tendoys, its location in the stratigraphic sections is hard to pinpoint. At Deep Creek Camp, it may be just below the red sandstone breccia (fig. 7). In the Snowcrests and Gravellys, it may be marked by a coarser-grained sandstone located just below the low- to moderate-energy, subtidal to intertidal deposits (approximately 300 ft, fig. 19). Sand bars (shoals) continued to dominate most of the shelf during this time. Carbonate mud accumulations were extensive only at GC (fig. 24c). Biota remained restricted to mainly pelecypods and gastropods. Many organisms were rapidly buried in the unstable substrate, leaving only molds preserved.

Lowering of Triassic sea level in the area is marked by the red and red and green mottled shallow subtidal to restricted (?) intertidal facies of the upper middle sandstone in the Snowcrests and Gravelly Ranges. In the Tendoy's, this zone is transitional. It is interrupted by a small, subtidal, normal marine carbonate mud mound of algae, crinoids and echinoderms (Deep Creek Camp) that may represent further sea level fluctuation during regression (fig. 24d). Generally, the shallow, low-energy, restricted water supported only algae and rare mollusks (fig. 24d). Periodic storms concentrated shells and hash from both deep water and shallow water colonies on the shallow and deeper shelf bottom and disturbed the normal wavy bedding.

Transgression of the sea back into the study area is marked by a lithoclast zone of red or green ripups and a change in depositional facies from the low-energy restricted facies below to normal marine, subtidal facies that occurs at the base of Unit G. This change is seen in even the first Thaynes deposits in the northernmost areas of Ruby River Canyon and Fossil Creek (fig. 20). Therefore, the second Thaynes transgression may have been more extensive and more rapid than the previous one responsible for the Woodside and lower Thaynes.

After transgression, carbonate mud mounds built up to dominate the deeper shelf and/or shelf edge (fig. 24e). They may have been localized by wave and current accumulation of shell debris on the shelf (Wilson, 1975). After initiation, crinoids and algae baffled the currents and bound the sediment and fossil debris until crinoids became the dominant colonizers (fig. 24e). Grazers and scavengers included gastropods, pelecypods and rynchonellid brachiopods. Shoreward from the mud mounds, the shelf was entirely sand dominated. Sand accummulated on shoals or bars in moderate- to high- energy currents (fig. 24e). The shoals supported little fauna, except pelecypods and gastropods, because of the mobile substrate, which prevented colonization, and the restricted circulation caused by very shallow water.

Growth of the algal-crinoid mud mounds may have been interrupted by a number of factors. Storm waves may have destroyed the colonies and reworked the bioclasts. An influx of sand to this area of the shelf from terrigenous sources and/or migration of the sand waves may have created an inhospitable environment for the delicate crinoids and echinoids that colonized the mud mound (fig. 24f). Evidence for storm activity during their growth includes abundant thin hash layers of mollusk debris, abundant reworked, limonitized echinoid fragments from dissolution surfaces or hard grounds in more quiet-water environments, and transported ooliths (upper Unit H, Hidden Pasture Spring) from shallower areas. Evidence for sand influx includes thick overlying sandstones, d possible deltaic or tidal channels (at Hidden Pasture Spring) that may have brought sediment from terrigenous sources to the shelf. Shoreward of the carbonate buildups, thick deposits of sand accummulated (fig. 24e). The sand bars (shoals) are interrupted at Hogback Mountain, Ruby River Canyon and Fossil Creek only by thin oolite layers, indicating oolitic shoals began to form at this time (fig. 24e). Biota was still restricted on this portion of the shelf, probably because of the higher-energy environments and unstable substrates rather than restricted circulation.

Another period of algal-crinoid buildups followed the episode of shoaling and sand influx. The new buildups were more patchy on the shelf edge and extended further north (shoreward) on the shelf (into

Blacktail Deer Creek and Hogback Mountain) than previous carbonate buildups 24g). Some may also have built up in the quiet water ben the shoals and sand bars or in a protected lagoon with open circulation. The biota inhabiting these buildups were algae (binders); crinoids and echinoids (bafflers); and mollusks and brachiopods (grazers and scavengers). Buildup growth was again terminated by incursion of oolitic shoals (Little Water Canyon), migrating sand waves/bars (Blacktail Deer Creek, Hogback Mountain), and possibly terrigenous sand input (channel at West Sheep Creek) from the craton that quickly buried most organisms (fig. 24g).

A possible period of regression or still stand is postulated after the second buildup. The low-energy, intertidal deposits between limestone ledges of the upper limestone in the Snowcrests and Gravellys may have formed during this quiet period. At Blacktail Deer Creek, desiccation cracks, dissolution surfaces and olomite may indicate a shoaling during this period. These features may also, however, have formed on the surface of shallow water bars or shoals (Walker, 1980).

The final major carbonate building episode occurred in mixed-carbonate environments after the influx of sand and oolites by wave or currents (fig. 24h). Wave and current energy was low enough to again encourage the patchy growth of crinoids and the lowest observed sponge. Periodic storms still affected the entire shelf; and sandier areas may have limited favorable growth sites for biota in this area.

The upper units of the Thaynes Fm. (Unit K) were formed in the subtidal zone of a moderate- to high- energy, normal-marine shelf (fig. 24i). They are dominated by high-energy storm layers of bioclastic debris or pelecypod coquinas, formed by winnowing currents or waves, and low-energy micrites, formed during waning currents and suspension sedimentation. In shallower water, at Blacktail Deer Creek and Hogback Mountain, depositional facies formed during this period are unknown because of Cretaceous erosion (fig. 24i).

No modern or ancient examples of shelf deposits are equivalent to the Thaynes rocks in southwest Montana. There are no large, modern cratonic seas, except for Hudson's Bay, which is not affected by the same climatic, hydrodynamic, or biologic conditions as during the Early Triassic in southwest Montana. Studies of ancient shelf deposits have not focused the particular combination of mixed-carbonate, storm-dominated shelf environments, with low depositional slopes and terrigenous input distinquished in the Thaynes.

The general stratigraphic characteristics of the Thaynes Fm. that are presented in this study have been recognized in other Triassic shelf areas. Picard and others (1969) have described shallow-water fauna, oolite shoals and restricted circulation behind the shoals in Thaynes Fm. and Red Peak sediments of Wyoming and southeastern Idaho. Bissell (1970) describes similar faunas, mud mounds, oolites, sand- and silt-dominated lithologies, and depositional facies in the Lower Triassic shelf deposits of the Virgin Member of the Moenkopi Formation in southern Nevada. Similar faunas and lithofacies have also been described from inner and outer shelf deposits of the earlier Dinwoody Formation in southwest Montana (Carr and Paull, 1983). Therefore, the depositional conditions on the Triassic shelf remained fairly constant throughout the Triassic. Tectonically, the shelf on the eastern edge of the Triassic depositional basin was stable and sediments accumulated during transgressions and regressions with great lateral continuity. Salinities, water temperatures, nutrients and water circulation remained similar across most of the shelf to support similar faunas in Triassic deposits from Nevada to Montana. Although the shelf fauna is not abundant, it does include most invertebrate groups by late Spathian time. In Montana, the storm-dominated shelf and coastline and an unstable substrate on the shelf may have affected the growth and diversity of these organisms more than lack of nutrients or hypersaline waters.

After deposition, the Thaynes Formation underwent extensive diagenesis. Cementation, abundant silicification and neomorphism affected the sediments. Fossil fragments were leached and replaced with silica and/or calcite. Compaction and pressure solution of some units created styolites and fractures.

PLATE 1

Petrographic characteristics of the Thaynes Formation, southwestern Montana. Magnified 10X unless otherwise noted.

Figure 1. Wackestone with gastropods, miliolid forams, pelecypods, and limonitized echinoid fragments in micrite matrix. Lower Limestone, Garfield Canyon.

2. Miliolid forams in calcite matrix. Lower Limestone, West Sheep Creek. Magnified 40X.

3. Pelecypod coquina with abundant quartz replacement (storm layer), Middle Sandstone (Unit E), Deep Creek Cow Camp.

4. Algally-laminated mudstone and calcisiltites with dolomite rhombs and open space, Middle Sandstone (Unit F), Little Water Canyon.

5. Rudstone with red, rounded and broken intraclasts. Erosion surface at base of Upper Limestone (Unit G), Little Water Canyon.

6. Pentacrinus, rounded columnals (Isocrinus?), echinoid spines and minor brachiopod and pelecypod bioclasts in silty, micrite matrix. Fragments are both uncoated and limonitized, and partially silicified with chert.

7. Dolomitized layer in Unit I. Sequence of diagenesis shows dissolution of echinoid fragments (left), dolomitization, secondary calcite filling of pore space and quartz filling of tiny fractures in calcite (tiny white fractures in pore space), Deep Creek Camp.

8. Remnant oolitic textures in dolomitized layer, Unit I. Secondary calcite pore filling stained red with Alizarin Red S. Deep Creek Camp.

9. Crossbedded ooids, siltstone and interbedded micrites. Ooids show compaction and grading in unit. Oolitic layer, Unit I, Little Water Canyon.

10. Peloids, coated grains, and limonitized echinoid bioclasts in micrite matrix. Limonitized fragments eroded from shallow, marine hardground (?) during storms. Unit K, West Sheep Creek.

11. Monaxon sponge spicules, Upper Limestone, Blacktail Deer Creek.

PLATE 1

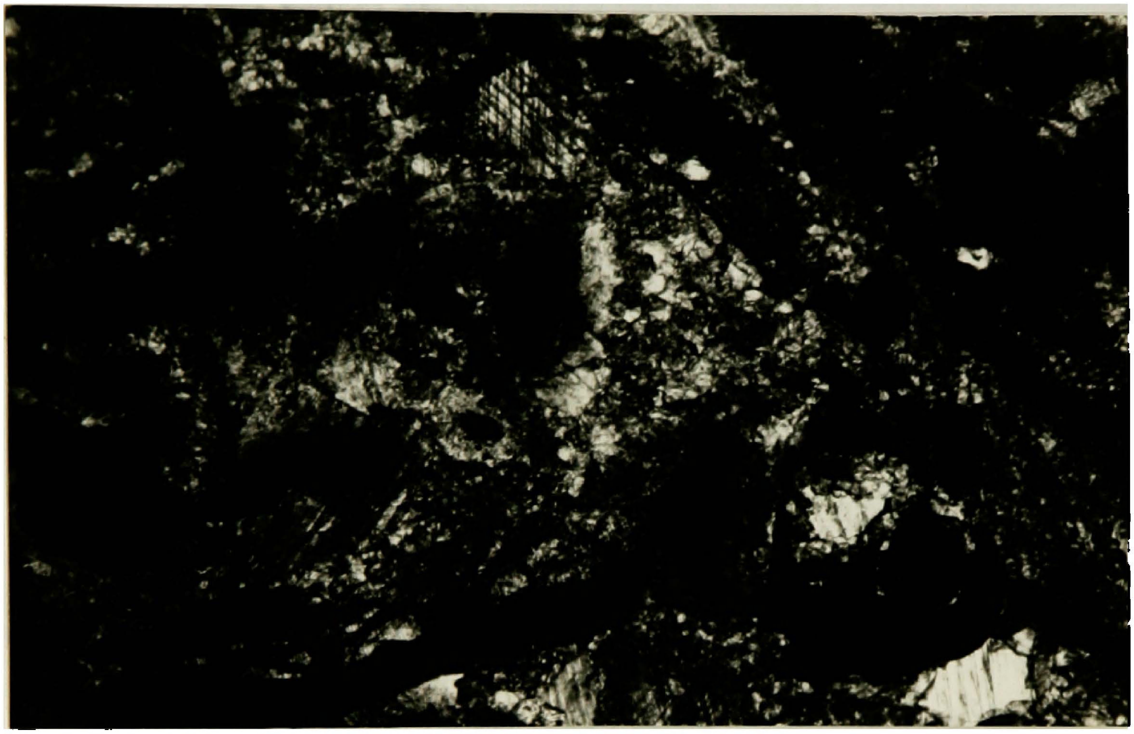


Figure 1

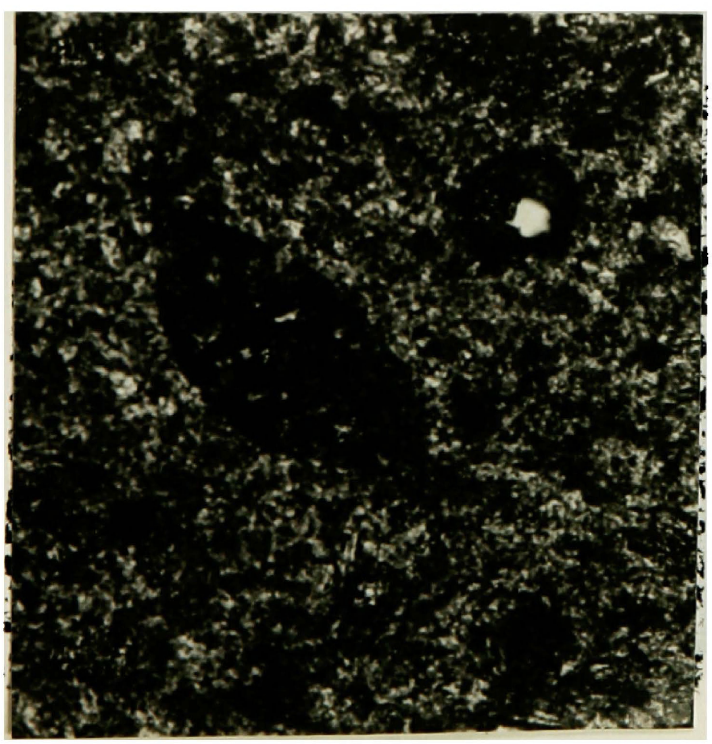


Figure 2

PLATE 1

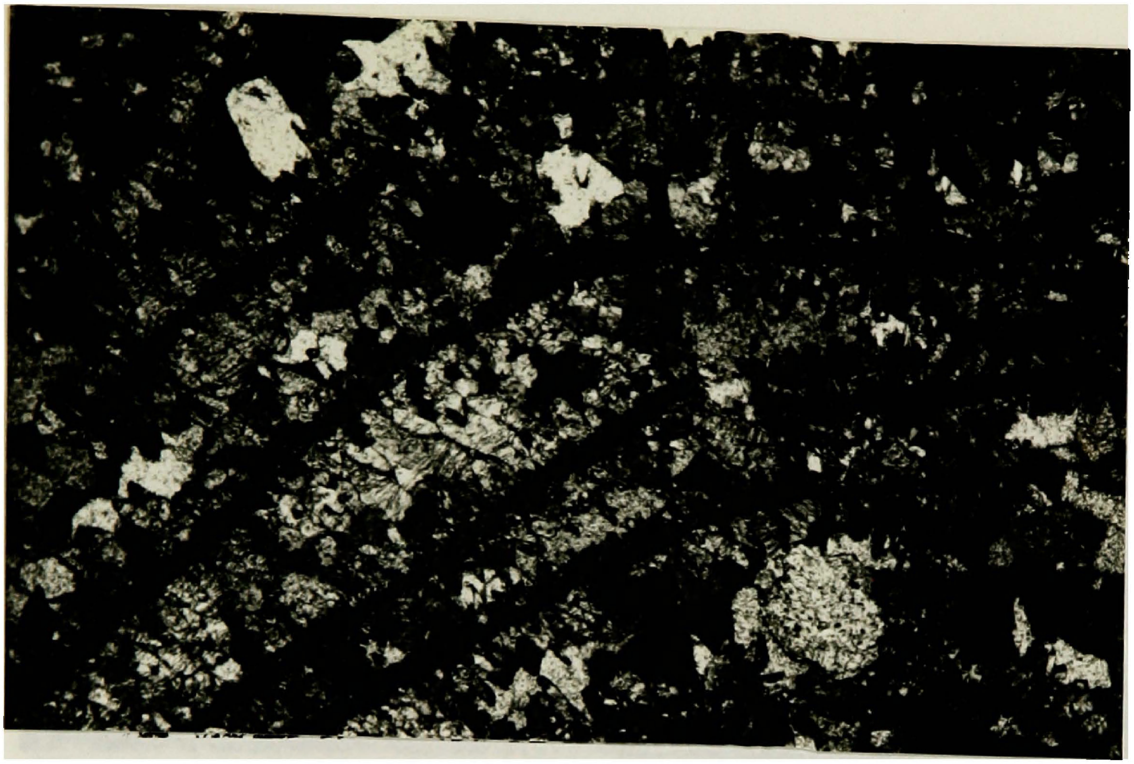


Figure 3

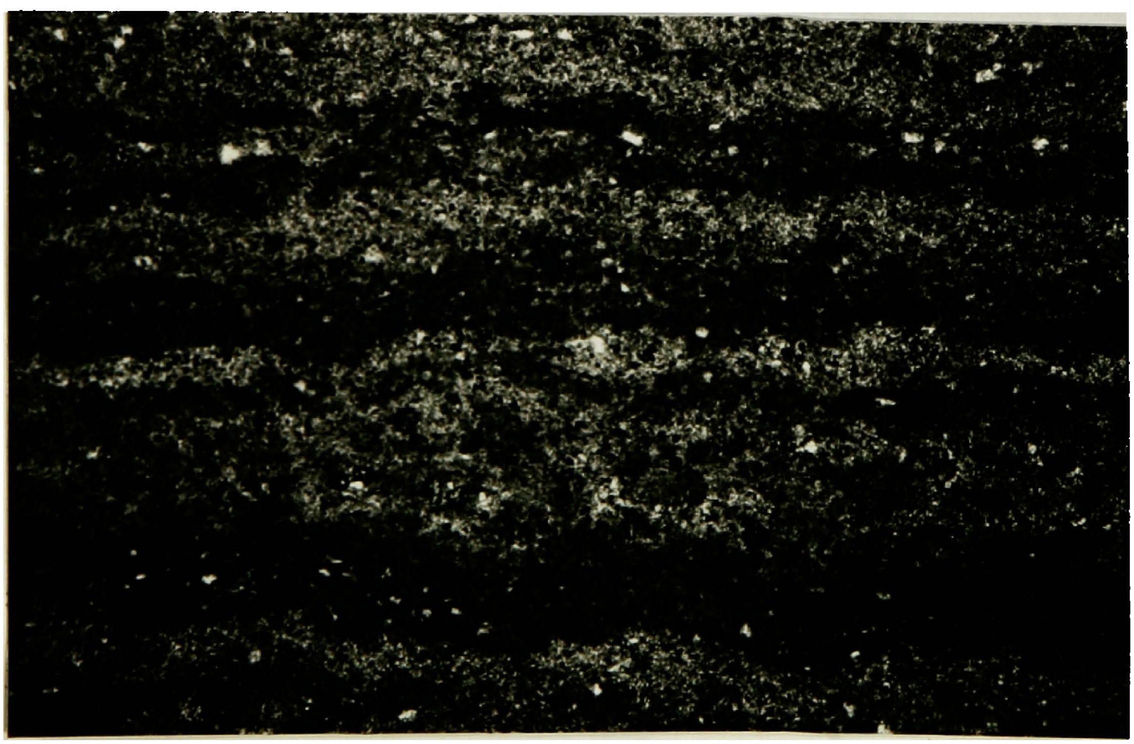


Figure 4

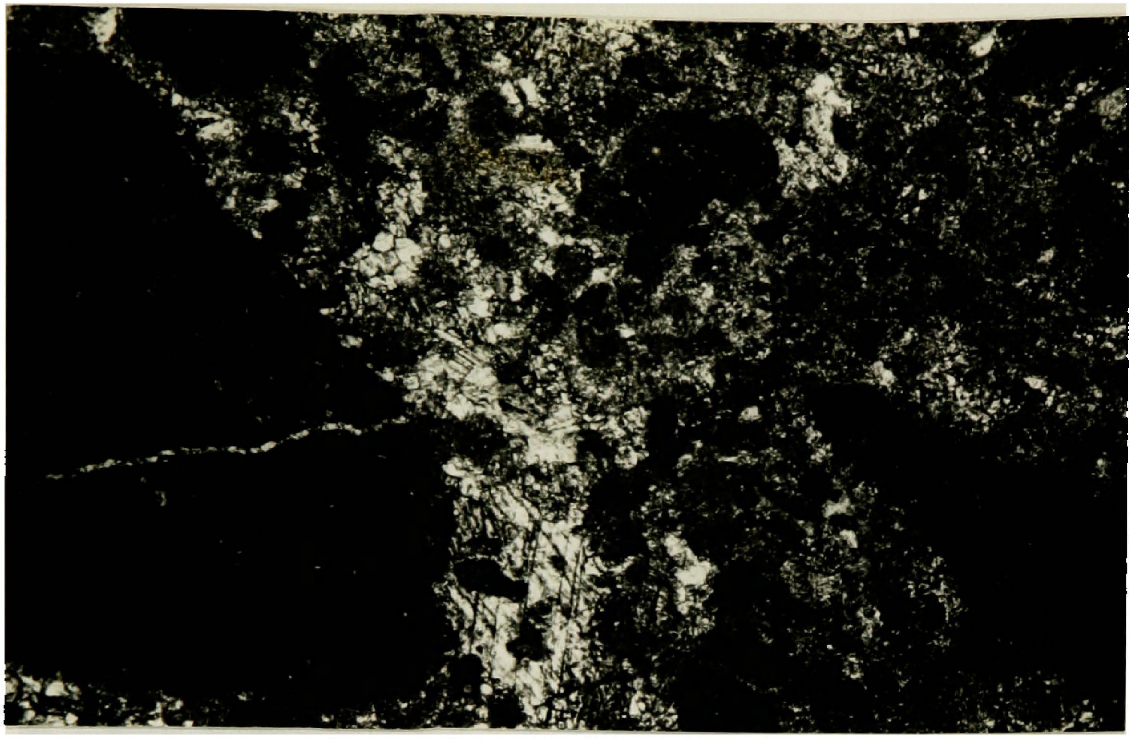


Figure 5

Figure 6

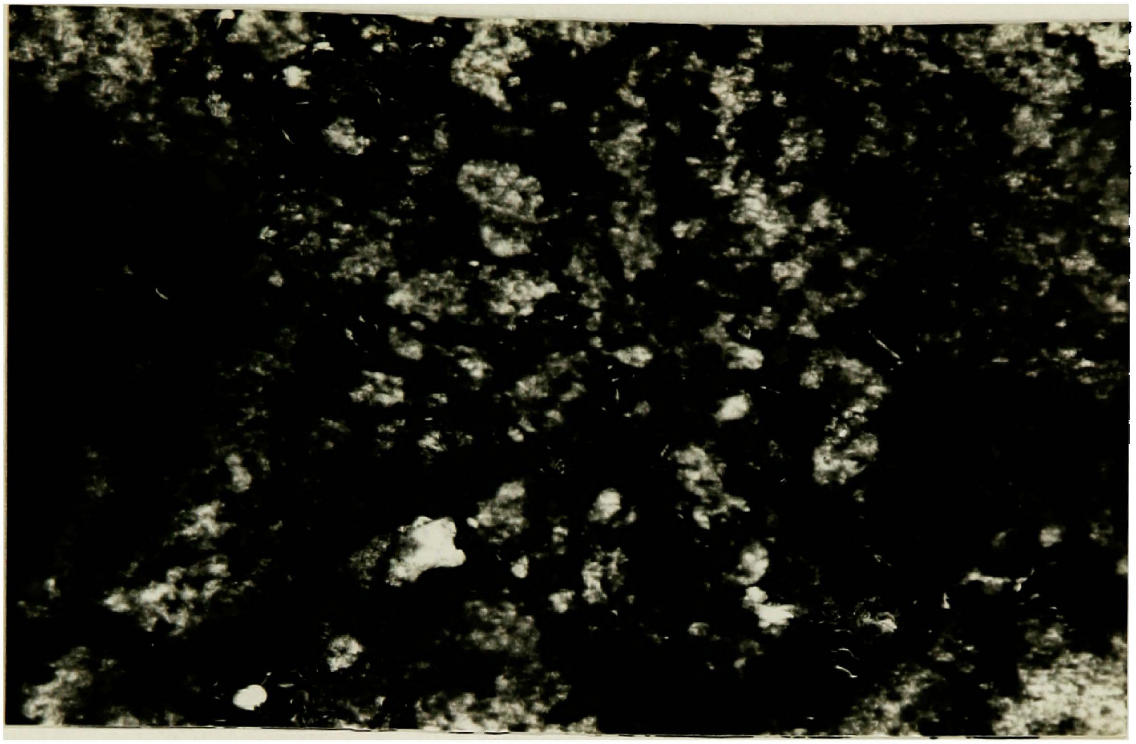


Figure 7

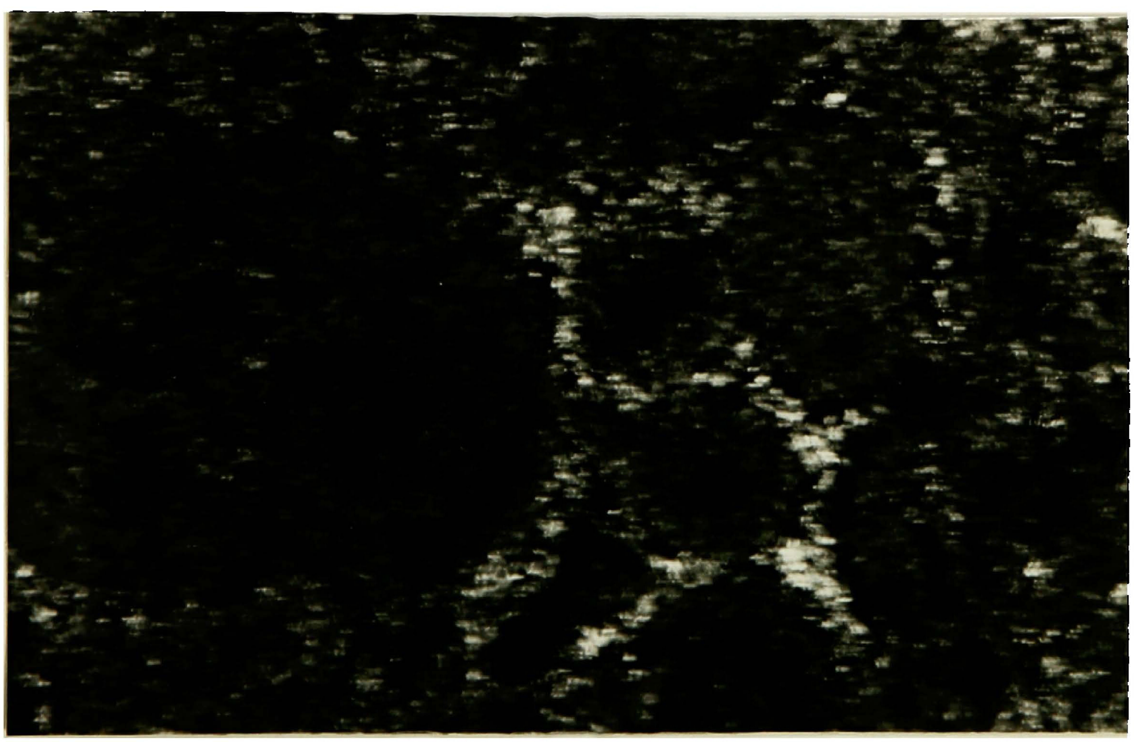


Figure 8

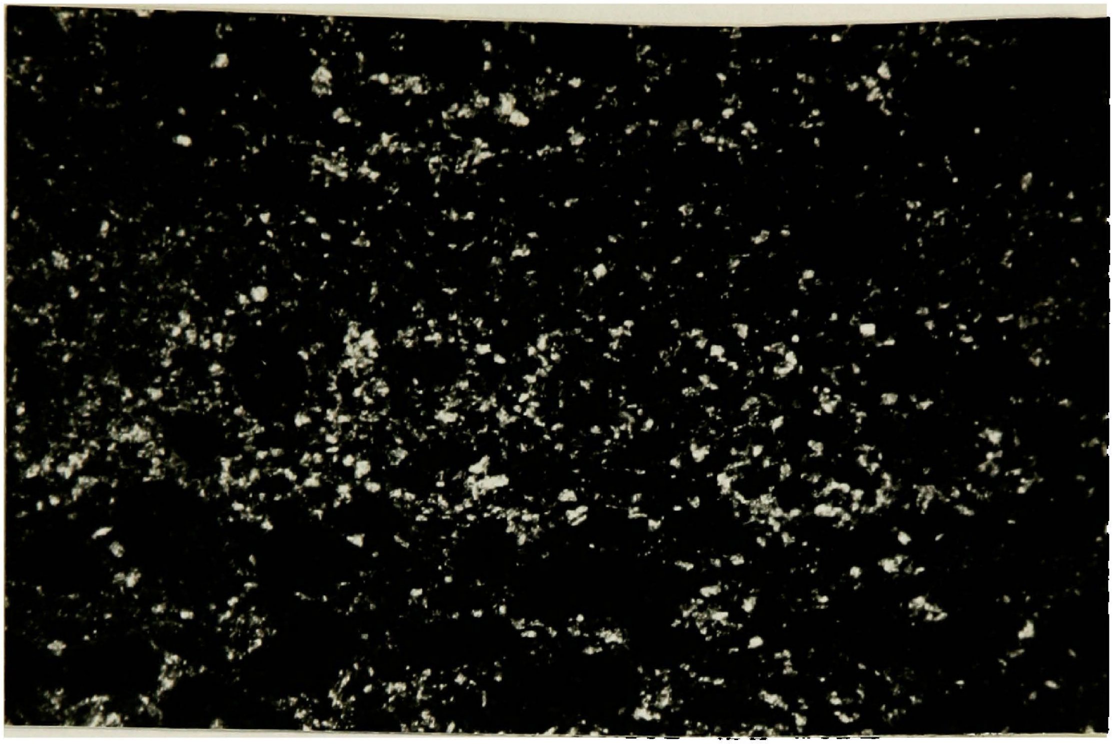


Figure 9

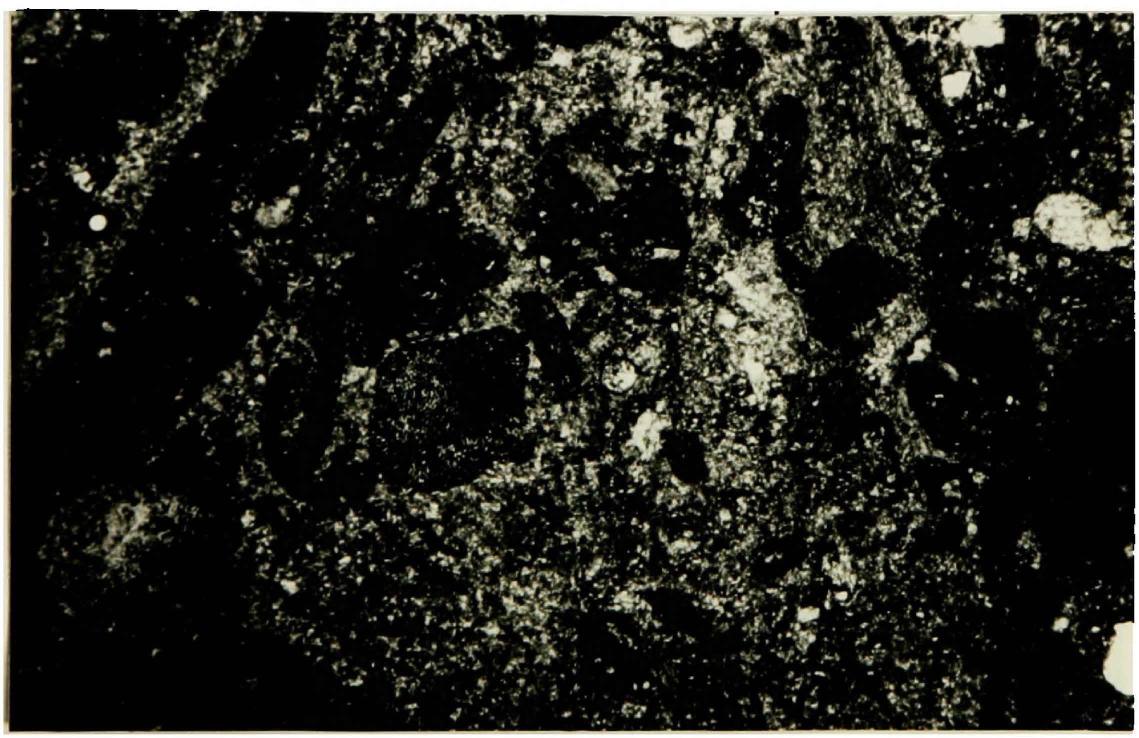


Figure 10

PLATE 1

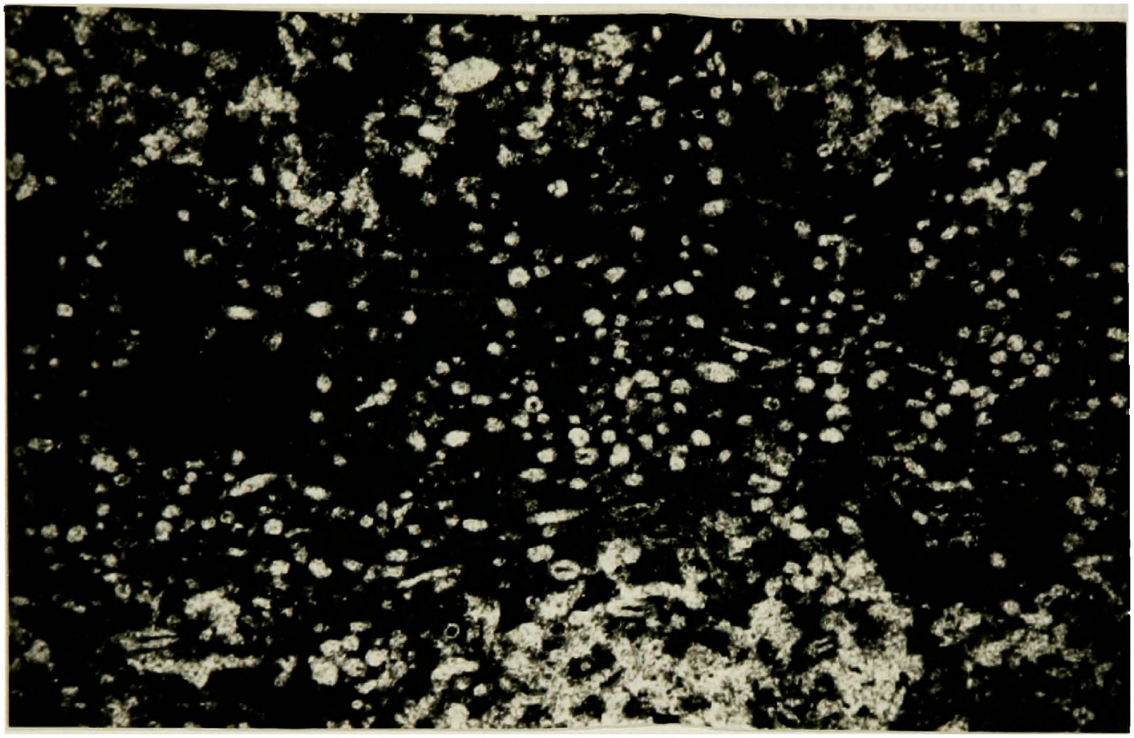


Figure 11

Diagenesis in Thaynes Formation rocks, southwestern Montana. Magnified 10X.

Figure 1. Bioclasts filled with sparry calcite.

2. Dissolution (leached) bioclastic grains with micrite envelopes in micrite matrix.

3. Silicification in Thaynes Formation.

4. Compaction of ooids before complete lithification of Thaynes Formation.

5. Styolites formed during pressure solution in Thaynes.

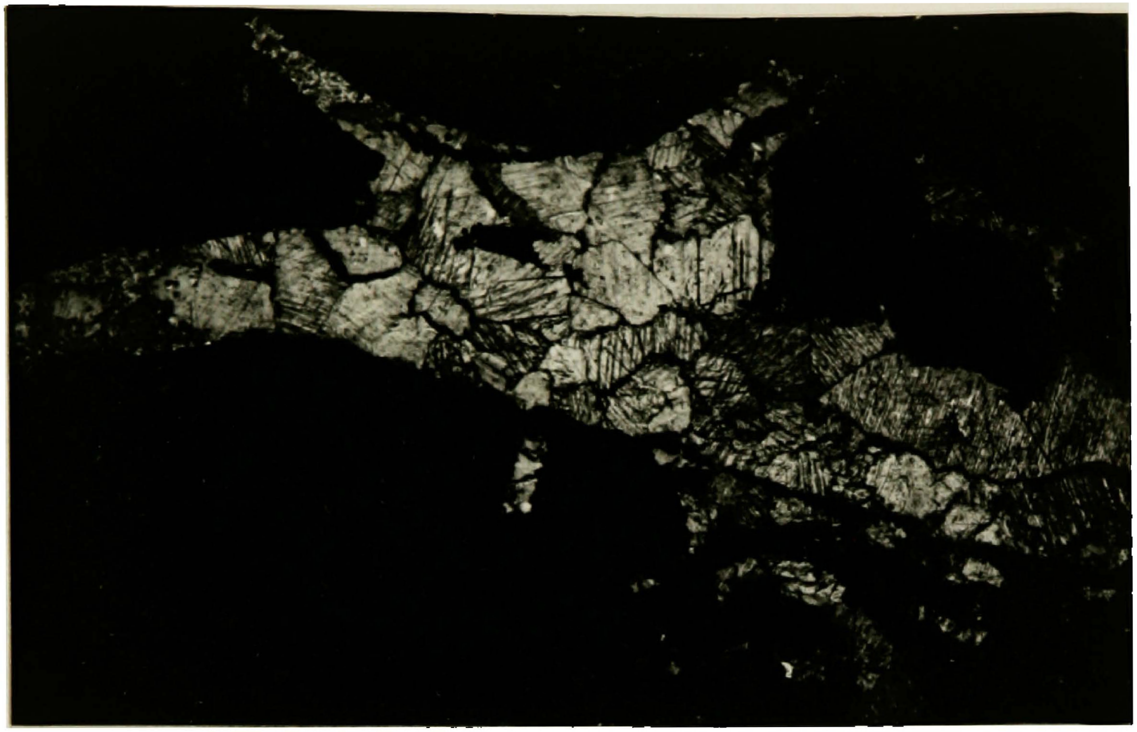


Figure 1

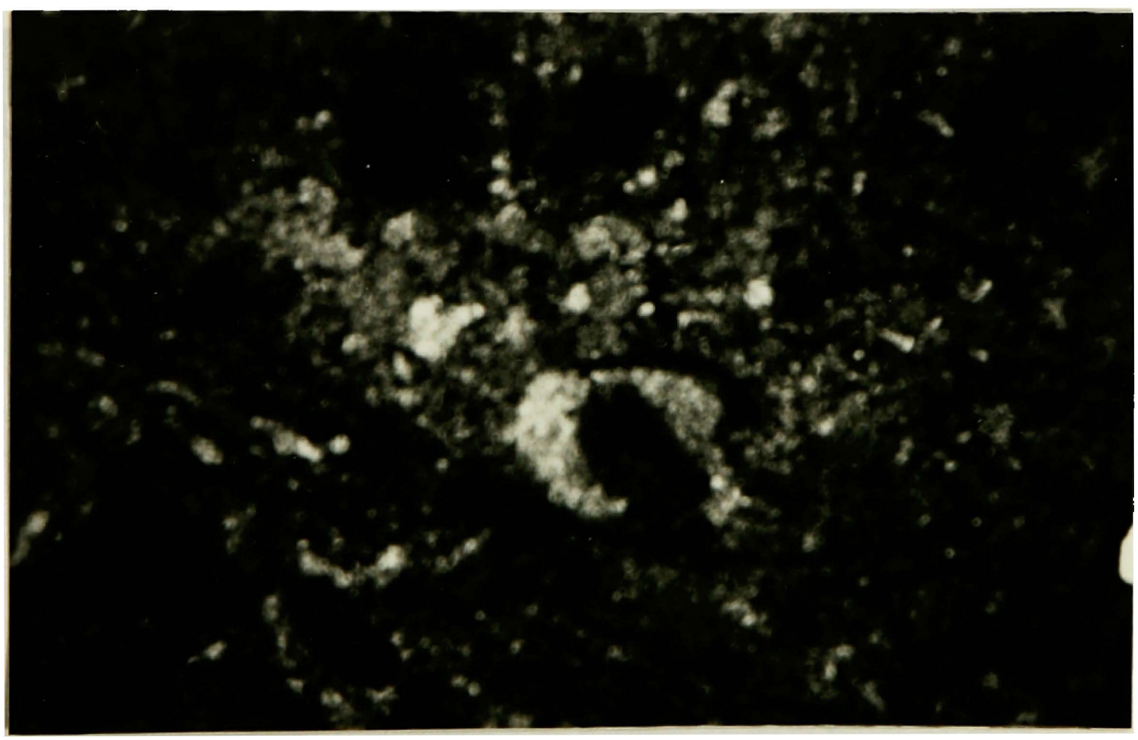


Figure 2

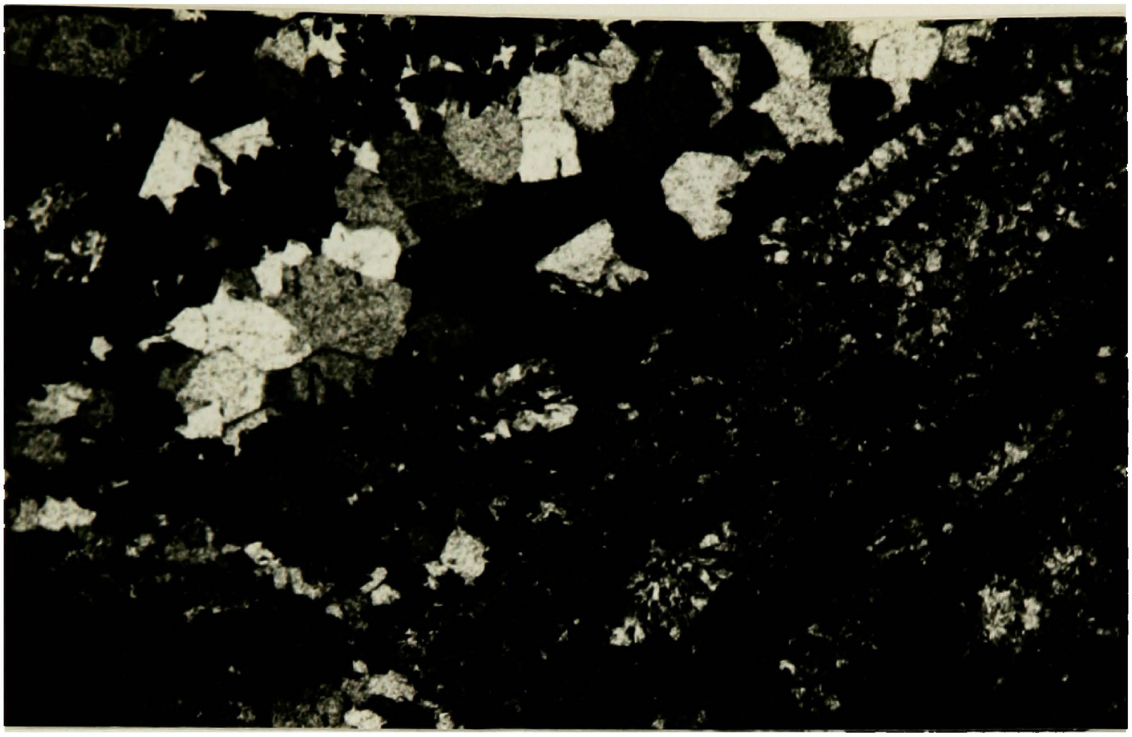


Figure 3

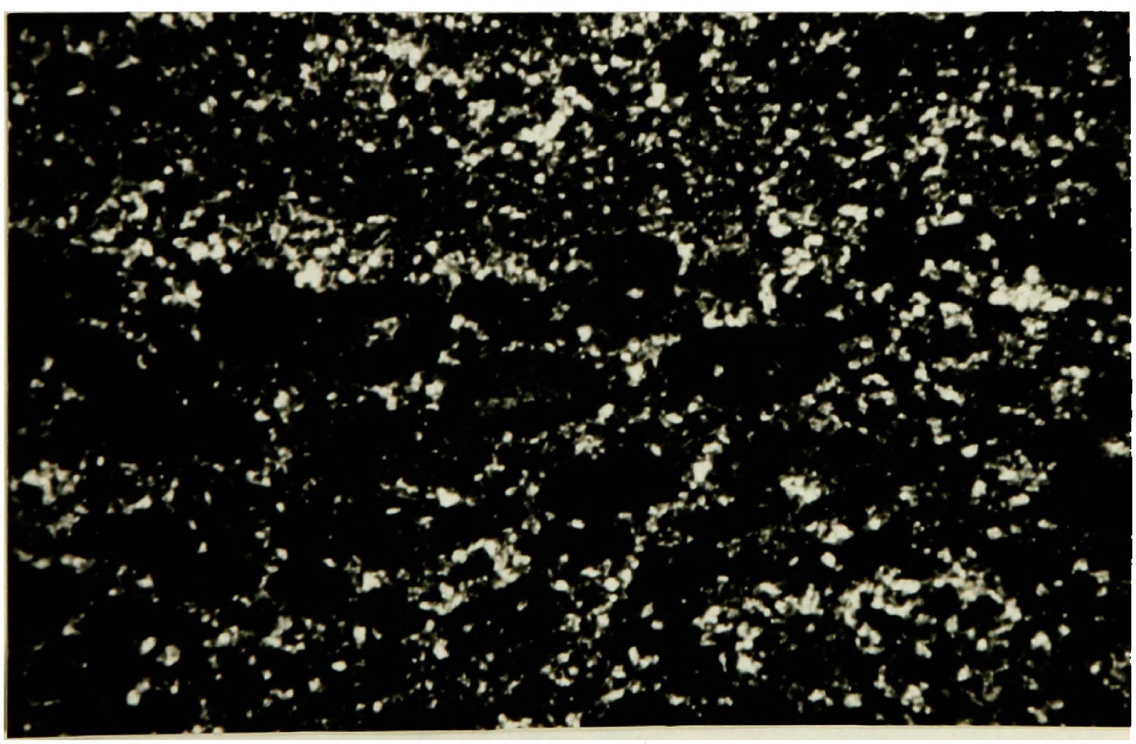


Figure 4

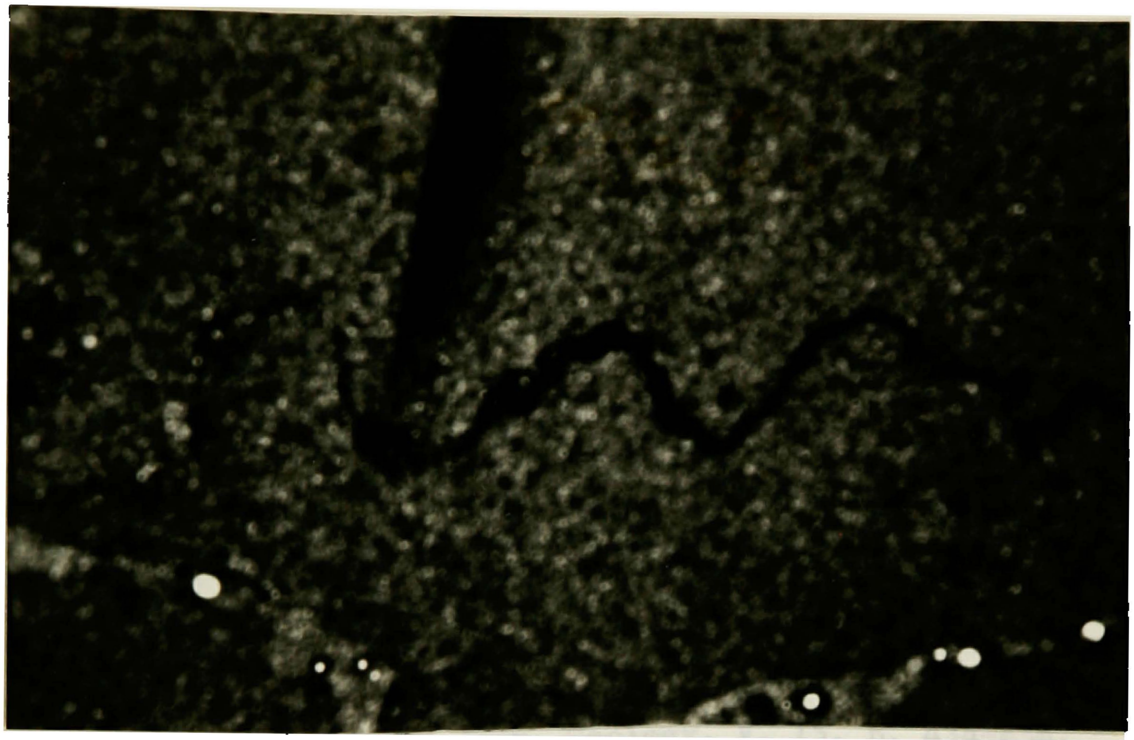


Figure 5

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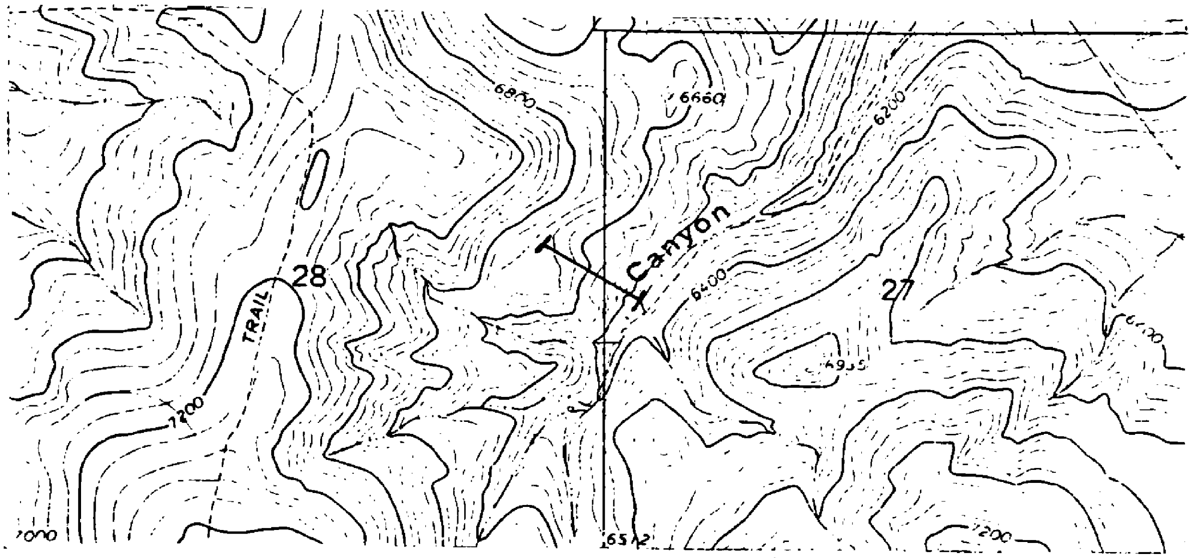
APPENDIX A: LOCATIONS AND DESCRIPTIONS OF MEASURED SECTIONS

GARFIELD CANYON

Garfield Canyon 7.5' Quadrangle
NE1/4 S28 & SW1/4 S27 T10S R11W
Beaverhead County, Montana

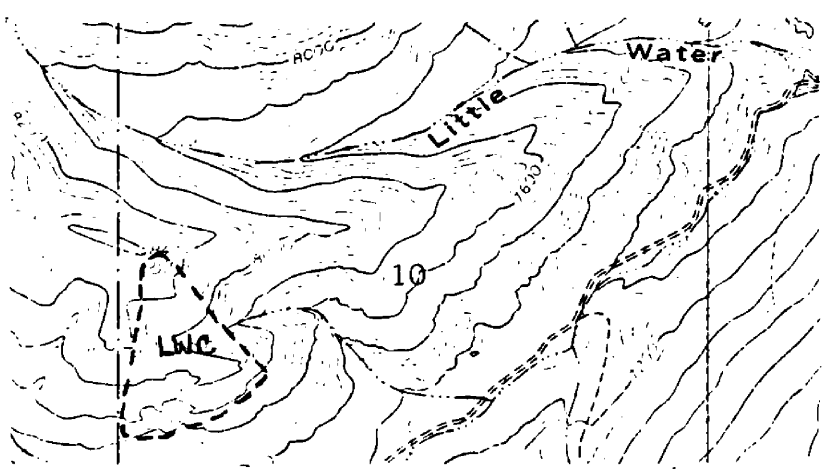
Begin description on ledge northwest of water trough. Lower portion is Triassic Dinwoody. Measured 7/83.



LITTLE WATER CANYON

Dixon Mountain 7.5' Quadrangle
SW 1/4 S10 T13S R10W
Beaverhead County, Montana

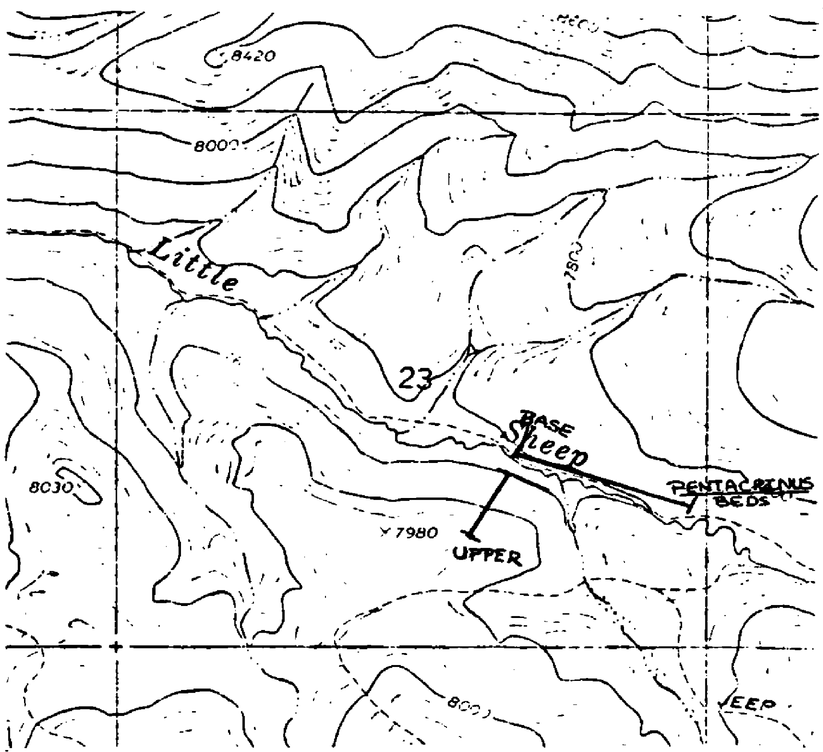
Begin description on north side of hogback in small drainage (approx. Trw &Trt contact of Klecker, 1980). Access to Forest Service road through private property. Measured 6/83.



LITTLE SHEEP CREEK

Gallagher Gulch 7.5' Quadrangle
SE1/4 S23 T15S R9W
Beaverhead County, Montana

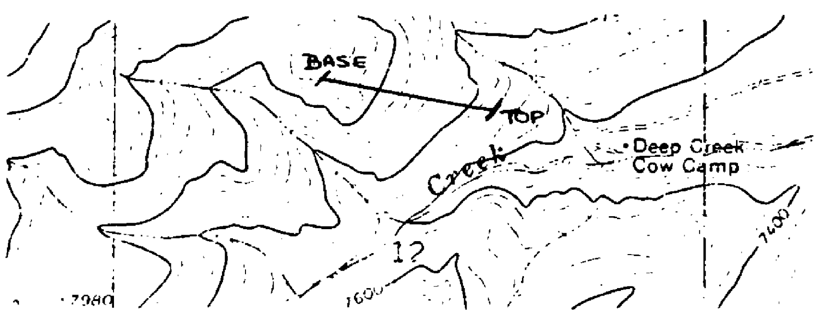
Begin description on cut-bank of Little Sheep Creek on F. S. Trail 40. Access same as West Sheep Creek. Measured 7/83.



DEEP CREEK COW CAMP

Lima Peaks 7.5' Quadrangle
NE1/4 OF NW1/4 & NW1/4 OF NE1/4 S12 T15S R8W
Beaverhead County, Montana

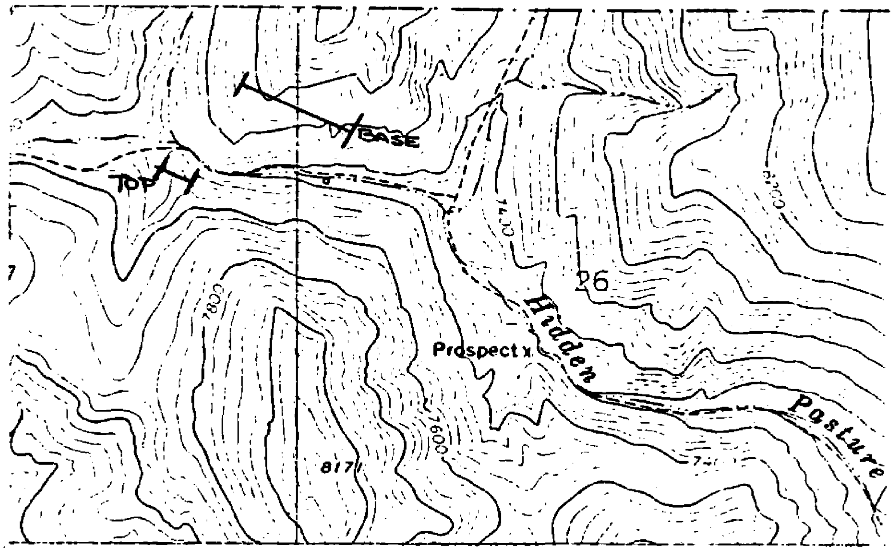
Section overturned. Base structurally deformed. Begin description approx. 1/4 mile NW of Cow Camp. Access to Forest Service road through private ranch.



HIDDEN PASTURE SPRING

Dixon Mountain 7.5' Quadrangle
NE1/4 S27 NW1/4 S26 T13S R10W
Beaverhead County, Montana

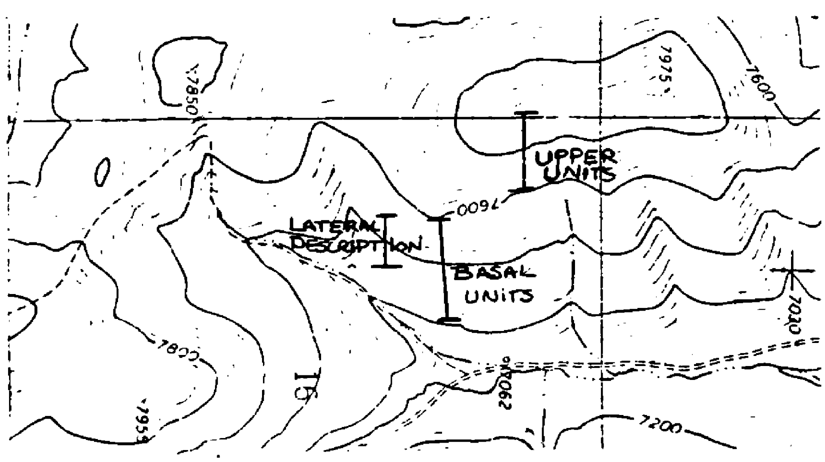
Begin description north of small cabin, just below base of main limestone ledge with large load structures. Measured 6/83.



WEST SHEEP CREEK

Gallagher Gulch 7.5 Quadrangle
NW1/4 S16 T15S R9W
Beaverhead County, Montana

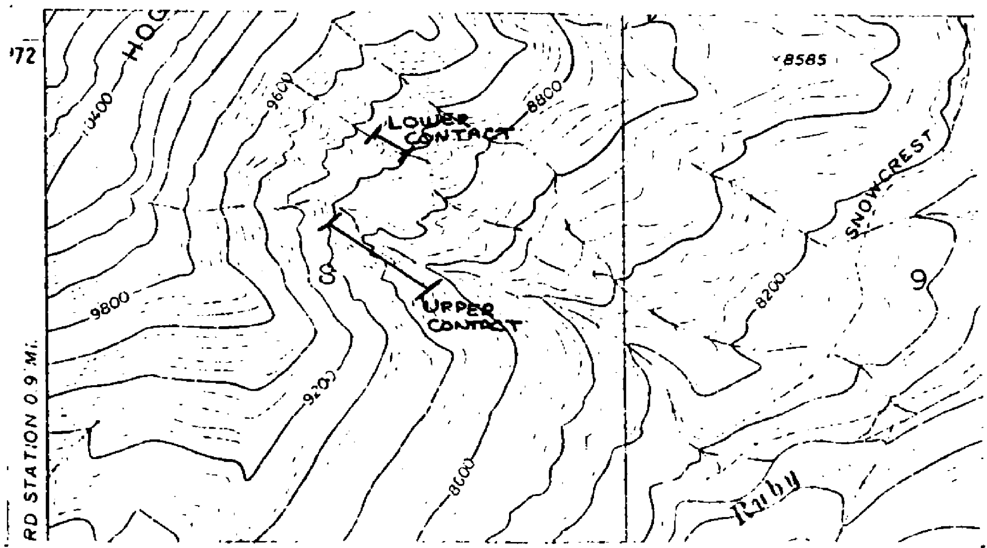
Begin description on jeep trail at base of isolated hill. Access through private property. Measured 6/83.



HOGBACK MOUNTAIN

Spur Mountain 7.5' Quadrangle
NE1/4 S8 T11S R4W
Madison County, Montana

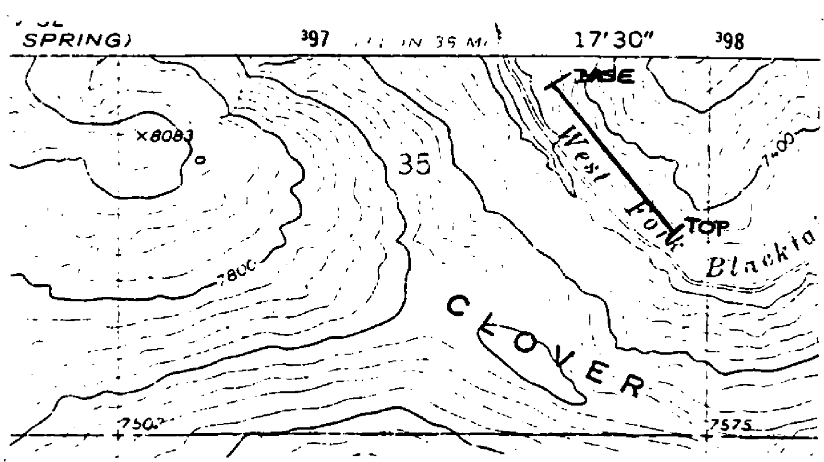
Section overturned. Upper and lower contacts well exposed. Begin description at upper (Kootenai) contact at south side of drainage on east side of Hogback Mountain. Measured 7/83.



BLACKTAIL DEER CREEK

Lima Dam 7.5' Quadrangle
SW1/4 S35 T12S R6W
Beaverhead County, ntana

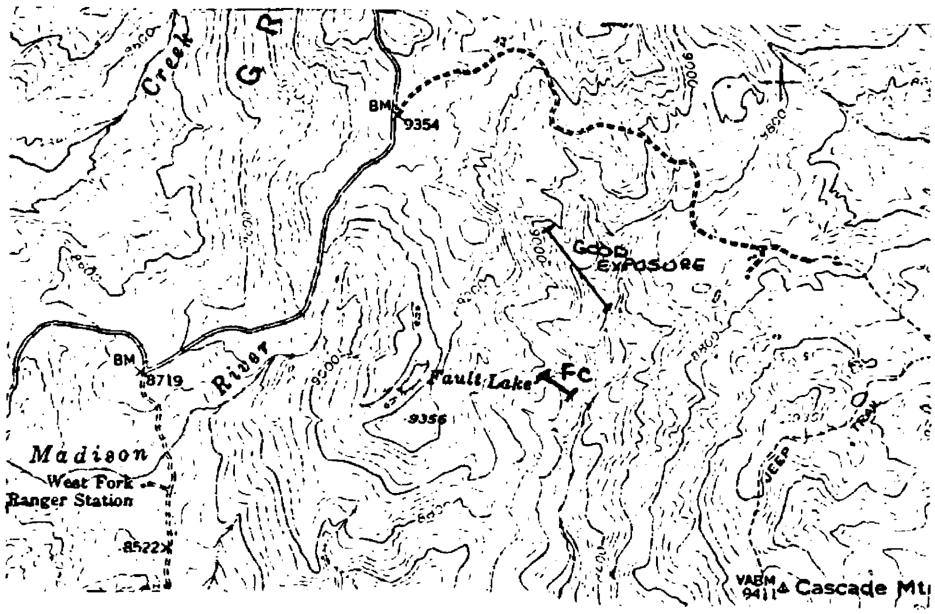
Begin description at base of small outcrop above red, woodside slope (in drainage). Measured 7/83.



FOSSIL CREEK

Monument Ridge 15' Quadrangle
S4 T12S R2W (UNSURVEYED)
Madison County, Montana

Begin description at first limestone ledge in dark red Woodside slope. Location approx. 1/2 mile east of Fault Lake. Similar exposures to north-northeast. Measured 7/83.



RUBY RIVER CANYON CAMP

Varney 15' Quadrangle
S17 T9S R3W
Madison County, Montana

Section overturned. Upper and lower contacts well exposed. Beg description in Kootenai sandstone on north side of Ruby River and road east of F. S. Canyon Camp and north of ranch. Measured 5/83.

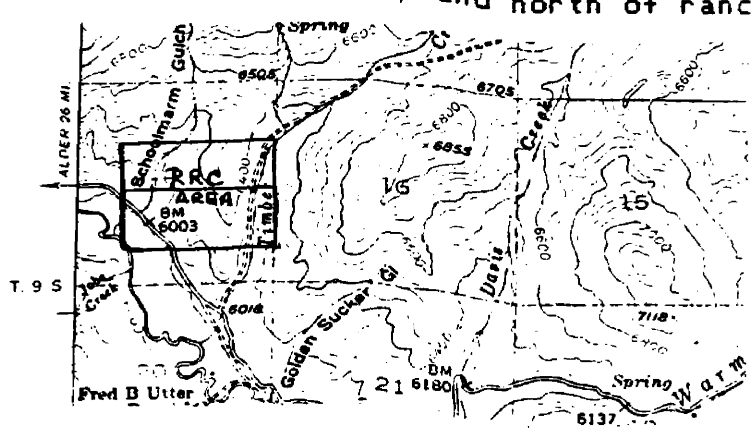


TABLE 7: ABBREVIATIONS USED IN MEASURED SECTIONS

ROCK TYPE

- Siltstone (slt)
- Muddy siltstone
- Calc. siltstone
- Sandstone (ss)
- Conglomeratic ss
- Calc. mudstone (ms)
- Interbedded ss & ms

- Bioclastic limestone
- Sandy limestone
- Silty limestone
- Nodular limestone
- Dolomitic limestone
- Covered

(Only most commonly occurring combinations of rock types shown.)

BIOTA

- Algae (framework)
- Algae (non-framework)
- Algae (undetermined type)
- Ammonite
- Bioturbation
- Bone (or scale)
- Brachiopod
- Burrows, distinct
  - anastomosing
  - branch, curve
  - horizontal
  - inclined
  - vertical
- Cephalopod (nautiloid)
- Crinoid

- Echinoid
- Foram
- Gastropod
  - upward-coil
  - planispiral
- Hash (unident.)
- Marker Bed (Field)
- Ostracod
- Pelecypod
- <u>Pentacrinus</u>
- Root
- Sponge
- Tooth
- Trail or Feed. Trace
- Wood

? Fossil type indicated but not positively identified

GRAIN SIZE AND SHAPE

Bc	Bioclastic (composed of abundant fossil hash of various sizes)
M	Mud (< .003 mm)
S	Silt (.003 - .062 mm)
V	Very-fine gr. sand (.06 - .12 mm)
F	Fine grained sand (.12 - .25 mm)
-->	> fine sand (>.25 mm) (rare)
sa	Subangular
sbrd or sr	Subrounded
rd	Rounded

BEDDING THICKNESS

lam	Laminated (.3-1 cm; .12-.4 in)
vth	Very thin (1-3 cm; .4-1.2 in)
th	Thin (3-10 cm; 1.2-4 in)
ave	Average (10-30 cm; 4-12 in)
tk	Thick (30-100 cm; 12-40 in)
mass	Massive (> 100 cm; >40 in)

TYPES OF LAMINATIONS

dell	Discontinuous, even parallel
dwll	Discontinuous, wavy parallel
dwnll	Discontinuous, wavy non-parallel
ell	Even, parallel
ewll	Even, wavy parallel

DESCRIPTORS FOR WAVY & RIPPLE BEDS

sym	Symmetrical
asymm	Asymmetrical
cl	Climbing
o.o.p.	Out-of-phase
1" c - c	1 inch crest-to-crest
H=1/8"	Ripple/wave amplitude

FORMATIONS/MEMBER

Trt	Triassic Thaynes Fm
Trw	Triassic Woodside Fm
Trd	Triassic Dinwoody Fm
Kk	Cretaceous Kootenai Fm
Jre	Jurassic Ellis Group

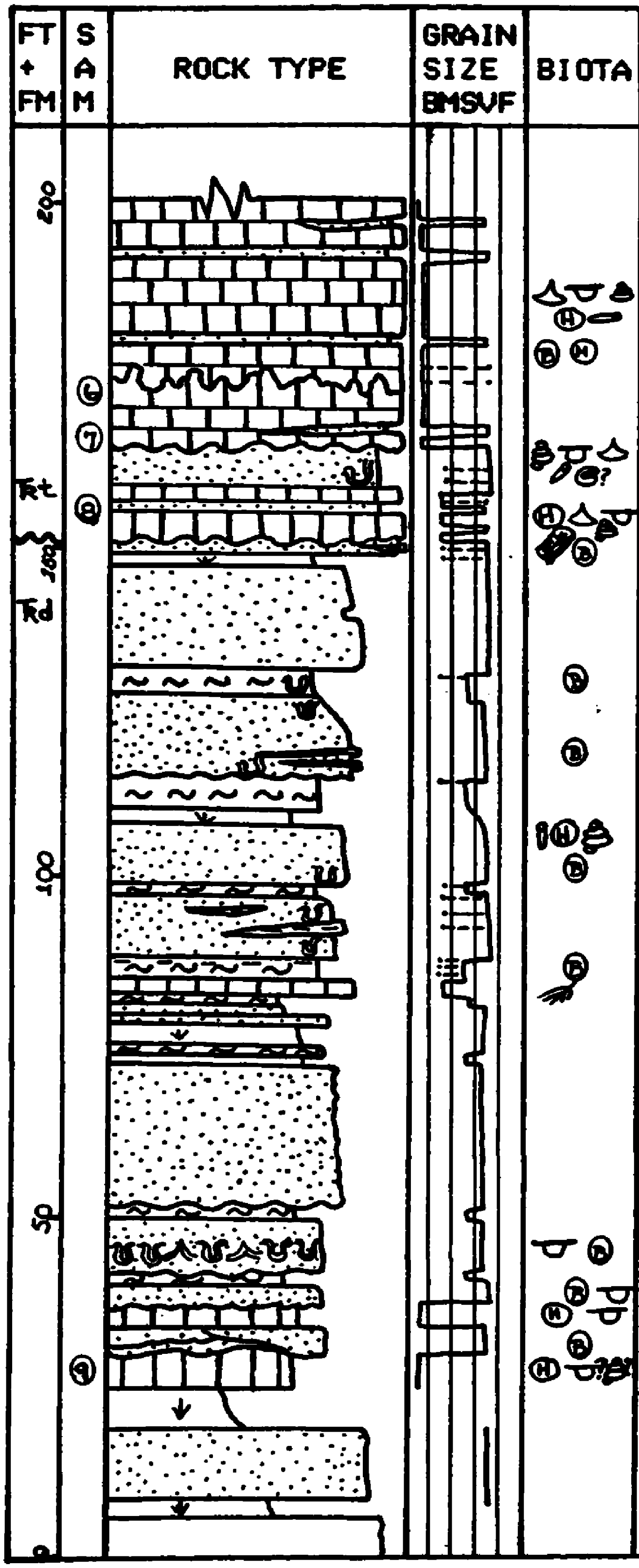
MISCELLANEOUS

(Si)	Chert (nodules, layers, lenses)
(Fe)	Iron-bearing nodules
	Contorted bedding
RU	Ripups
saa	Same as unit described above
sab	Same as unit described below
(1)	Sample number
5Y 6/1	Color (fresh surface)

GARFIELD CANYON

T10S R11W S28 (SW 1/4) & S27 (SE 1/4)

Pamela G. L. Sikkink



DESCRIPTION

Bioclastic limestone, brownish gray (5YR 4/1); ave - tk, wavy bedded with cl. ripples on bed surfaces; irregular surfaces on some beds; sandy with abundant lenses of chert and fossil hash. Thin interbedded sandstones, dusky yellow (5Y 7/4); vth - ave, cl. ripple bed; well sorted, rd; minor chert lenses; abundant bioturb.

Interbedded sandstone and limestone. Limestone, pale yellowish brown and lt. brownish gray (10YR 6/2 & 5Y 6/1); tk - mass., wavy bedded, abund. shells. Sandstone, yellowish gray (5Y 7/2), scour surfaces, ripple lams, and thin mud drapes.

Sandstone, weathers red brown, vth - lam.

Sandstone, yellow gray and pale yellowish brown (5Y 7/2 & 10YR 6/2); vth - ave bedded; v. f. gr. - silt, well sorted, rd; v. calc.; weathers tan & reddish brown @ base and yellow & purplish @ top; normally graded beds @ base.

Interbedded siltstone and sandstone, grayish (N 8, N 7, 10YR 7/4, 5GY 7/2), vth - ave & tk, tabular bed; some cl. rip. lams; well sort, rd, v. calc.; weathers red brown, tan & greenish.

Sandstone, dusky yellow (5Y 6/4); vth bedded with algal lams; normally graded beds, some ripple (?) lams; v. calc.; few lenticular mudstones.

Interbed. calc. sltstn and mudstn, varicolored.

Limestone, med. lt. gray (N 6); crinkly bedded.

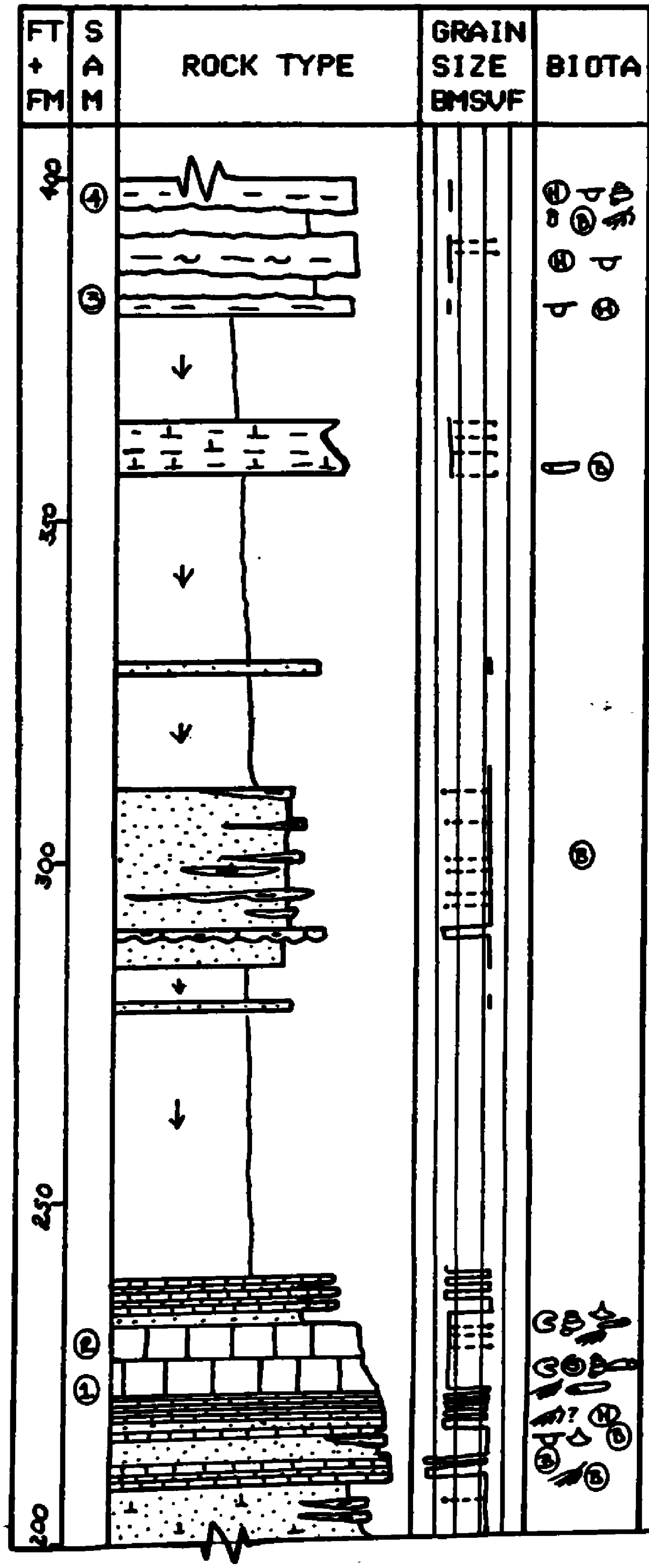
Sandstone, yellowish gray and med. lt. gray (5Y 7/2 & N 6); mainly vth - lam beds; basal 8 ft. (2.4 m) tk - mass. bed; lg. rip. and cl. rip. bed; well sorted, rd; v. calc.; highly bioturb. in areas; v. contort. with ball & pillow, water escape structures, and molds. Minor interbed. green/gray, calc., rip.-bed sltstn.

Interbedded sandstone, siltstone, and bioclastic limestone. v. pale orange (10YR 8/2) to yellowish gray (5Y 7/2); vth - ave bedded, ripple & cl. ripple lams and trough-shaped beds; well sorted, rd; v. calc.; thin mudstone drapes; numerous hash layers.

Sandstone, yellowish gray (5Y 7/2), th - ave bedded. Not described in detail.

Not described.

GARFIELD CANYON
(CONTINUED)



DESCRIPTION

Covered slope (Dug samples = yellow brown sand (5Y 6/4); v. f. gr., well sorted, rd; v. calc.).

Sandy, calcareous mudstone, dusky brown (5Y 2/2 - 10YR 2/2); th - vth, wavy and ripple bedded; v. calc.; bioturbated and burrowed; weathers reddish brown; sand grains v. f. gr., well sorted, rd.

Covered slope (Dug samples = interbedded brown sands (10YR 6/2) and greenish-gray (10GY 5/2) and red, sandy mudstones).

Sandstone, yellowish gray (5Y 7/2); vth - lam, trough x-beds, scour bases; well sorted, rd; v. calc.; x-beds bidirectional; small, discont. outcrop.

Covered slope (Dug samples = yellowish-brown and greenish clayey sandstone; vth bedded; v. f. gr., well sorted, rd.).

Interbedded muddy sandstone and mudstones, lt. olive gray and yellowish gray (5Y 6/1 & 5Y 7/2) and yellowish brown and olive gray (10YR 6/2 & 5Y 5/2), respectively; lam - vth bedded with cl. ripple lams (< 1 in. c - c., h<1/8 in.); v. calc.; grains v. f. gr., well sorted, rd; v. calc.; weathers reddish brown.

Sandstone, yellowish gray (5Y 7/2); vth - lam bedded with ewll lams; v. f. gr., well sorted, rd; v. calc.; small, discontinuous outcrops.

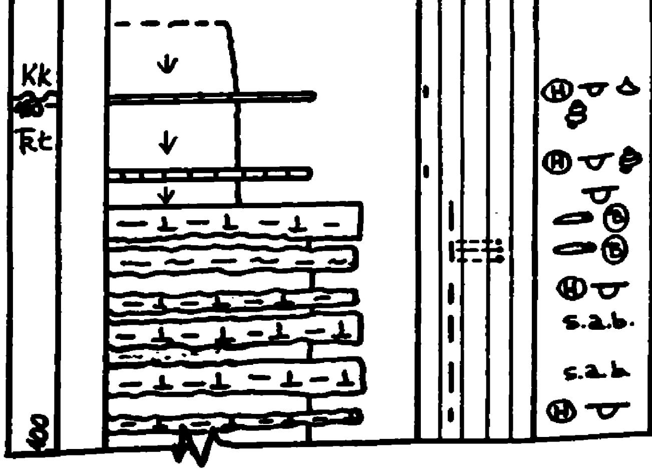
Covered slope (Dug samples = mod.-brown (5YR 4/4), calc., sandstone; v. f. gr., well sorted, rd).

Interbedded limestone and sandstones, lt. olive gray & yellow gray (5Y 6/1 & 5Y 7/2); vth - ave, wavy and lentiicular bedding. Limestones contain abundant fossil hash layers, Fe nodules and algal lams. Sandstones are v. f. gr., well sorted, rd; v calc.; contain ripple lams and bioturb. Unit weathers reddish brown. *Marker bed: Meekoceras ammonites and small nautiloids.

Sandstone yellowish gray (5Y 7/2); vth - fissile bed; cl. rip. and algal (?) lams; well sorted, rd; minor 1" tk mudstn interbeds.

GARFIELD CANYON
(CONTINUED)

FT + FM	SAM	ROCK TYPE	GRAIN SIZE BMSVF	BIOTA	DESCRIPTION



Bioclastic limestone, med. gray (N 5); tk bedded; v. fractured and silicified; abundant fossil hash; thins laterally.

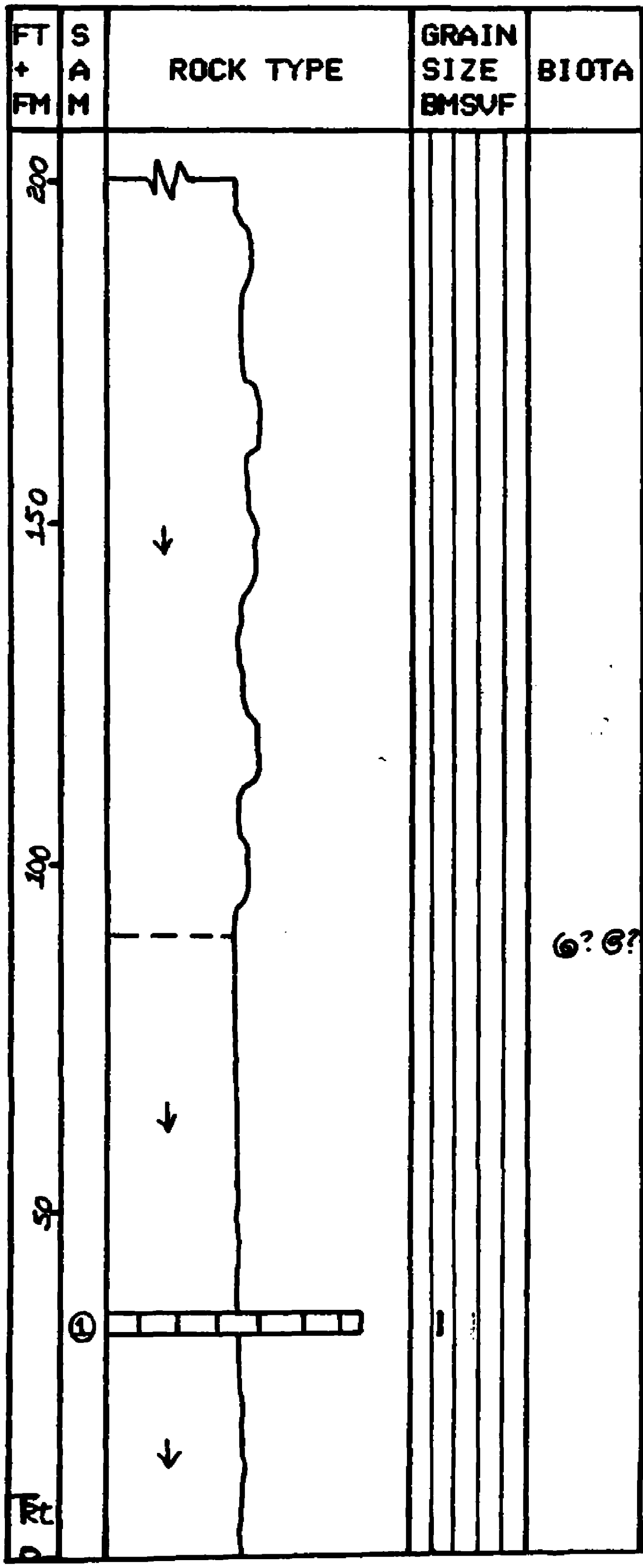
Bioclastic limestone, same as above.

Limestone, med. gray - grayish brown (N 6, N 5, 5YR 3/2); vth - ave, med. scale ripple and wavy bedded; abundant fossil hash and bioturb. throughout; some internal scours and ripple-bedded sandstones (3 - 6 in. c - c, (1/2 in. height); continuity of outcrops varies; structurally deformed in places; many ledges highly fractured and silicified. Minor chert nodules in basal portion.

LITTLE WATER CANYON

T13N R10W S10

Pamela G. L. Sikkink



DESCRIPTION

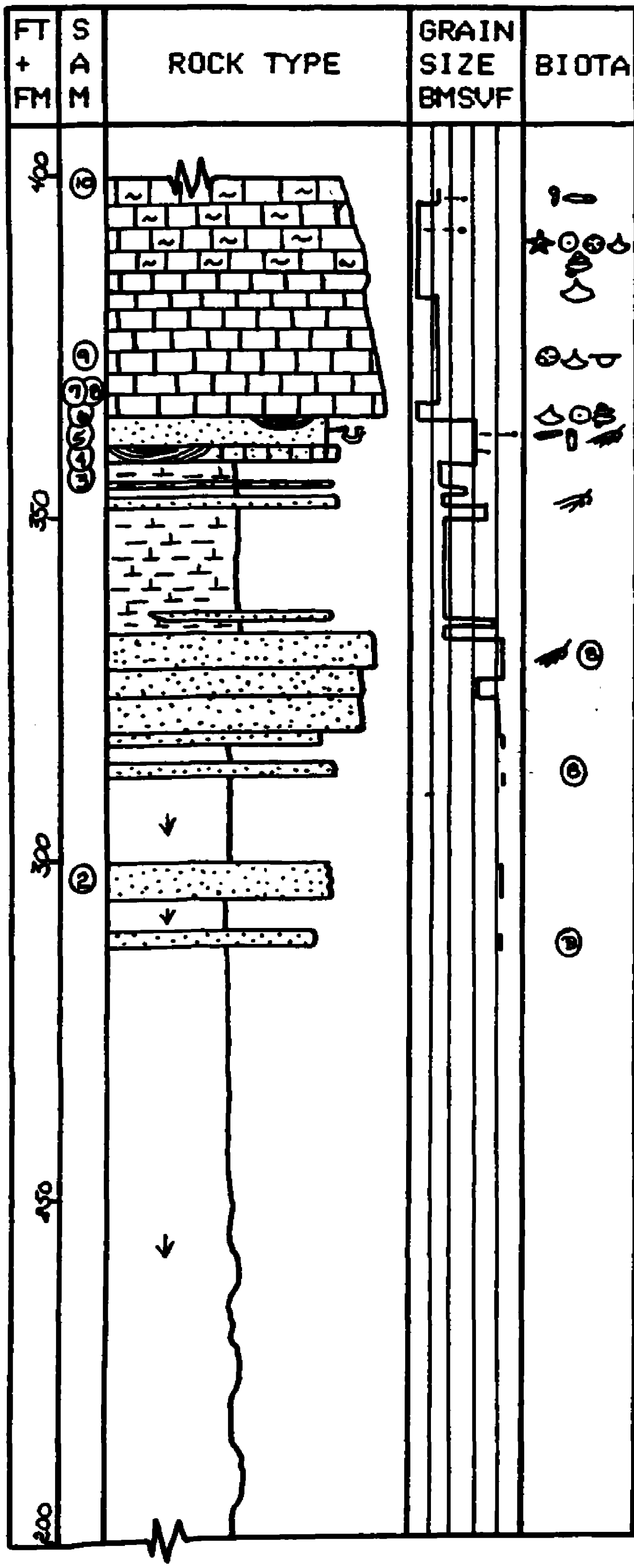
Covered slope (Dug samples = sandy clay and clayey sands, lt. brown, dk. brown and black; v. f. gr., well sorted, rd; sl. calc.; some more resistant ridges are present on slope). Interval mainly vegetated.

Covered slope (vegetated). Approximate location of Meekoceras ammonite beds of Kummel, 1954). Ledge not located in measured area.

Limestone, med. gray (N5), tk bedded; outcrops in drainage.

Approximate contact in drainage.

LITTLE WATER CANYON
(CONTINUED)



DESCRIPTION

Bioclastic, silty limestone, med. gray (N5); silicified fossils; mass. bedded. Upper 2 ft (.6 m) is vth bedded, burrowed with less shell debris. *Marker bed: Pentacrinus zone.

Limestone, yellowish gray and med. gray (5Y 7/2 & N5); mass. bedded; hash layers @ top and base; chert nodules abundant; silicified brachs @ top (Rynchonellids). Unit thickens laterally.

Sandstone, yellowish gray to dusky yellow (5Y 7/2 - 5Y 6/4); vth - ave, wavy, sm. scale trough and ripple bedded; well sorted, sbrd, sl. - v. calc.; wave ripples (up to 5" c-c); some sym; fetid.

Interbedded limestone and thin, calc. sandstone, lt. olive brown (5Y 5/6); vth bedded with sm. scale trough x-beds and cl. ripples; well sorted, rd, sl. calc.

Sandstone, yellowish gray (5Y 7/2); th - flaggy, sm. scale trough x-bedded; well sorted, rd; sl. calc.

Sandstone, mod. yellowish brown (10YR 5/4); vth bedded with sm. scale trough x-beds; well sorted, rd; v. calc.

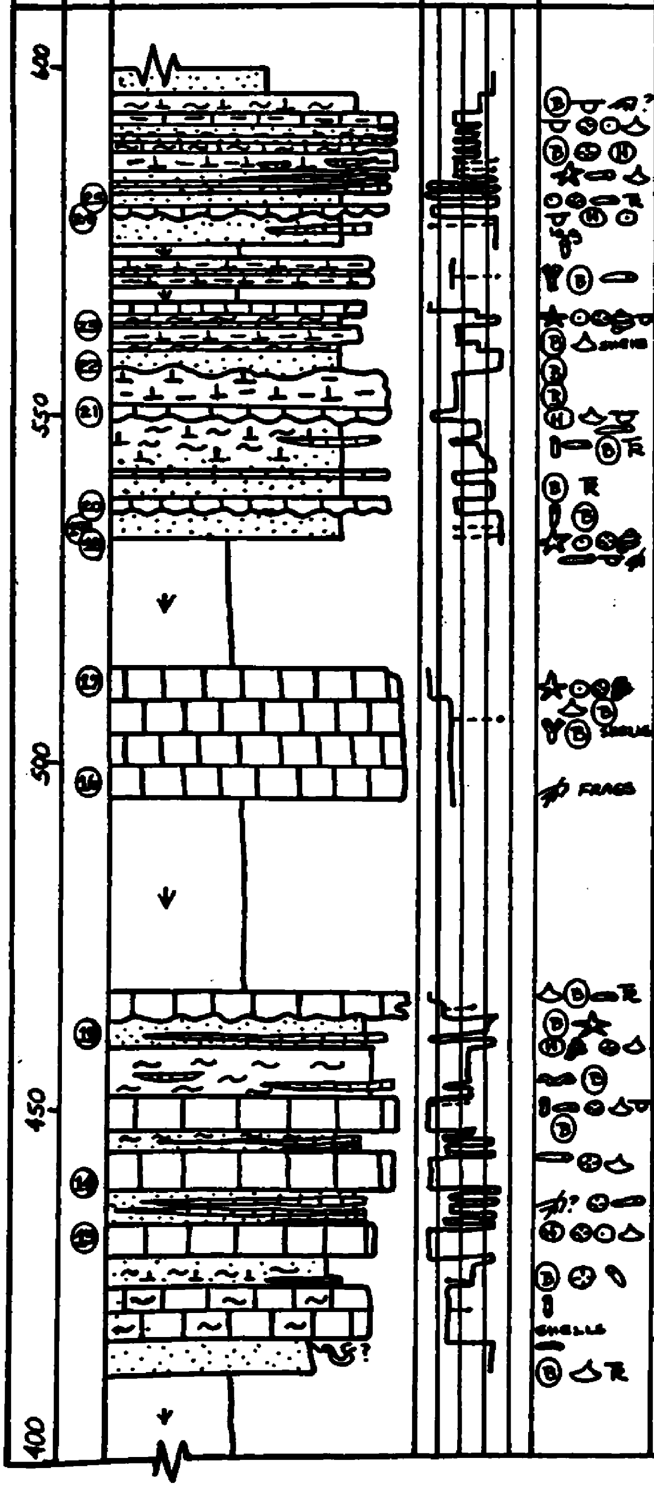
Sandstone, lt. brownish gray (5YR 6/1); th - ave, ripple and lent. bedded with sm. scale trough x-beds; well sorted, rd; sl. calc.; water escape structures and lams @ base.

Sandstone, lt. gray (N7); th bedded with minor ripples on bed surface; well sorted, well rd, v. sl. calc.; discontinuous, lenticular outcrop.

Covered slope (vegetated, clayey sand, dk. brown - black; v. calc.)

LITTLE WATER CANYON
(CONTINUED)

FT + FM | SAM | ROCK TYPE | GRAIN SIZE BMSVF | BIOTA | DESCRIPTION



Interbedded calcareous sandstone, siltstone, limey mudstone and bioclastic limestone. Sandstones, lt. olive gray (5Y 6/1); vth - ave, wavy, ripple, and cut-ripple bedded with some cl. ripples on bed surfaces; contacts with mudstones usually sharp. Siltstones, yellowish brown and yellowish gray (10YR 5/4 & 5Y 7/2), th - ave, wavyy and ripple bedded; v. bioturb. and burrowed. Mudstones, lt. - med. gray (N 7 - N 5), th - tk bedded (thin upward); some lumpy texture (algal balls?). Bioclastic limestone, tk bedded; abundant hash; whole crinoids found in units.

Sandstone, lt. gray - yellowish gray (N 7 - 5Y 7/2); vth - th, wavy, rippled, and cut-wave ripple bedded; well sorted, rd; sl. calc.; normally graded beds.

Bioclastic limestone, dusky yellow (5Y 6/4); tk bedded.

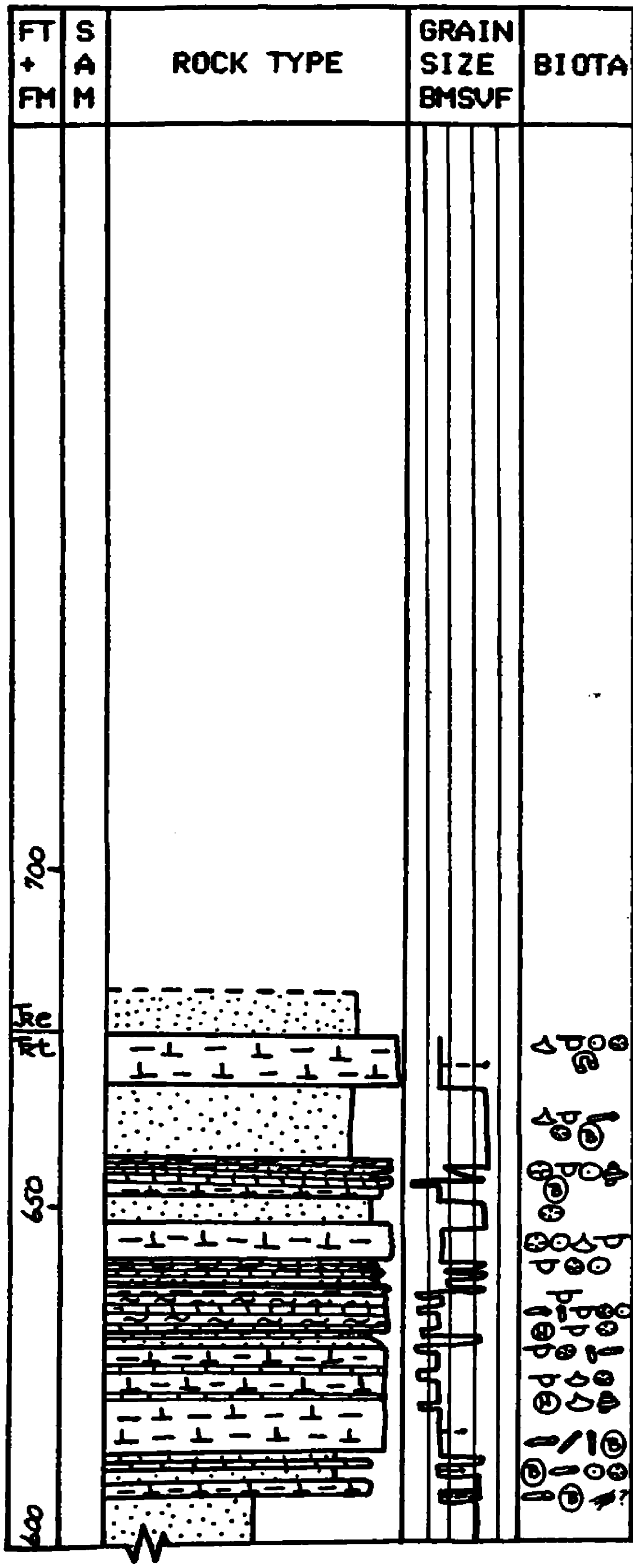
Sandy limestone, dusky yellow (5Y 6/4); th bedded with feeding traces and isolated shells.

Limestone, lt. brownish gray (5YR 6/1), th - tk bedded with lams (algal).

Interbedded bioclastic sandy and silty limestone, calc. sandstone, mudstone and siltstone, olive gray (5Y 5/2, 5Y 6/1), yellowish brown (10YR 6/2, 10YR 5/4), pale brown (5YR 5/2, 5YR 4/1); mainly ave - mass., wavy bedded with rippled tops; some lent. bedded and some vth - ave, wavy bedded; feeding traces and alligned shells present; chert layers, lenses and nodules v. abundant (6 - 12 in. intervals); bioclastic layers, fetid & cherty; sandstone, siltstone, well sorted, rd.

Sandstone, mod. yellowish brown (10YR 5/4); lam - vth, wavy and ripple bedded; well sorted, rd; v. calc.; silicified veins and patches; tracks and trails @ top surface; isolated shells.

LITTLE WATER CANYON
(CONTINUED)



DESCRIPTION

Sandstone, mainly covered.

Sandy mudstone, yellowish gray (5Y 7/2); tk - mass. bedded; v. calc; fossils alligned with bedding.

Sandstone, yellowish gray to yellowish brown (5Y 7/2 - 10YR 5/4); vth - tk, wavy bedded; v. calc.; chert nodules in upper half.

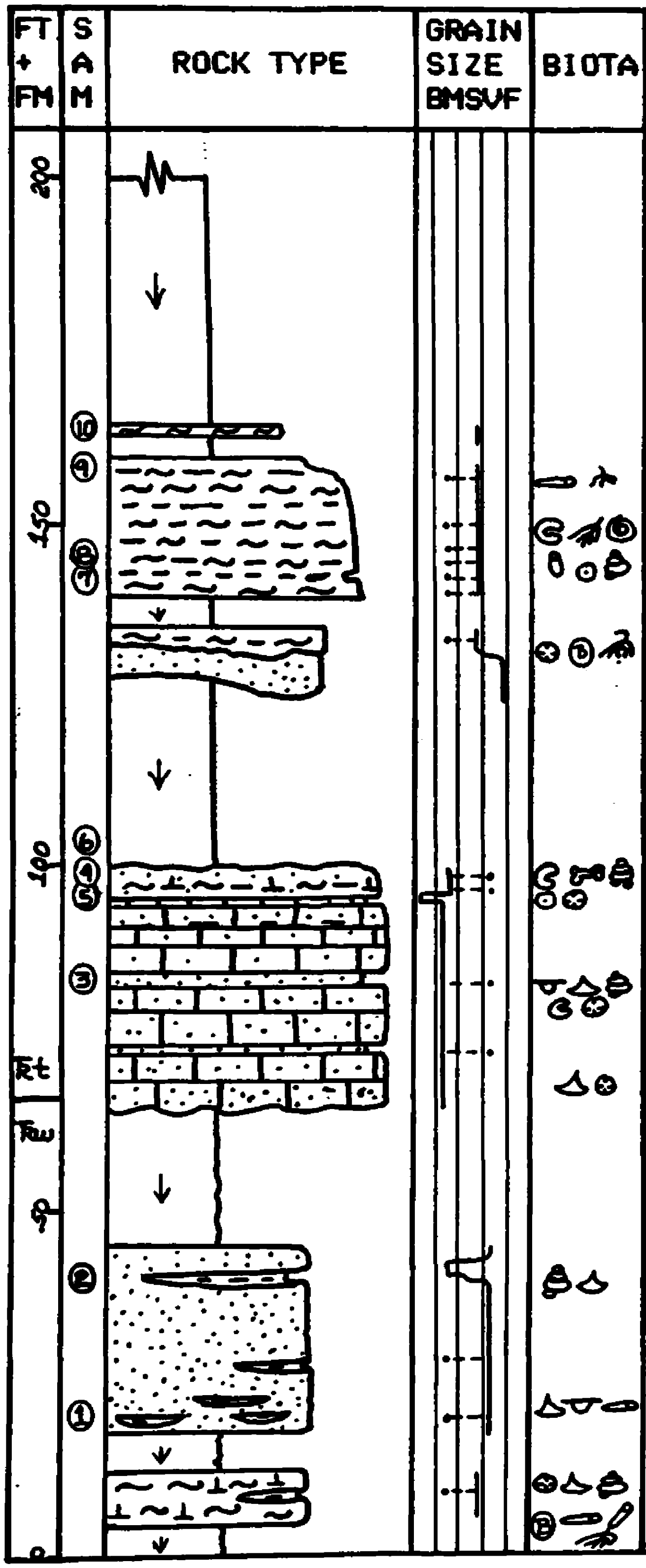
Interbedded calcareous sandstone, siltstone, limey mudstone and bioclastic limestone, as below except chert nodules in mudstones @ top and abundant mollusk fossils.

Sandstone, yellowish brown (10YR 5/4), covered in measured area;;down strike, consists of lg. scale, sym. ripples (approx. 3 ft. (.9m) c - c) with smaller scale ripples on bed surface; well sorted, rd; v. calc.

HIDDEN PASTURE SPRING

T13S R10W S27 (NE 1/4) & S26 (NW 1/4)

Pamela G. L. Sikkink



DESCRIPTION

Siltstone, yellowish gray (5Y 7/2), vth bedded; v. f. gr. sand to silt, well sorted, sbrd.

Muddy siltstone and silty mudstone, pale brown and brownish gray (5YR 5/2 & 5YR 4/1), some mottled red, white and brown; vth - ave, wavy, planar and lent. bed; well sorted, rd; some rip. lams (base & top); v. calc.; algal lams common; bioturb. (patchy), molds, and contorted beds. *Marker bed: Meekoceras and nautiloids.

Sandstone - siltstone, grayish-orange pink (5YR 7/2); vth - ave, lenticular with sm. scale trough x-beds, wavy, and some ripple bedded; bedding thickens upward; v. f. gr. sand to silt, well sorted, rded; v. calc.; abund. bioturbation and some algal lams.

Sandy limestone, olive gray (5Y 6/1 - 5Y 4/1); tk - ave, wavy and ripple bedded; interbeds of lenticular muddy sandstones and siltstones; minor hash layers; abundant bioturbation (patchy); scattered chert nodules restricted to lower half of bed.

Sandstone, lt. olive gray (5Y 6/1); vth - lam, wavy, contorted and lenticular bedded; some ripple bedding (crests 9" - 12") and sm. scale trough x-beds; v. f. gr., well sorted, rded, v. calc.; interbeds of lenticular, silty mudstones and muddy siltstones, dusky yellow (5Y 6/4); shell molds, burrows and bioturbation common.

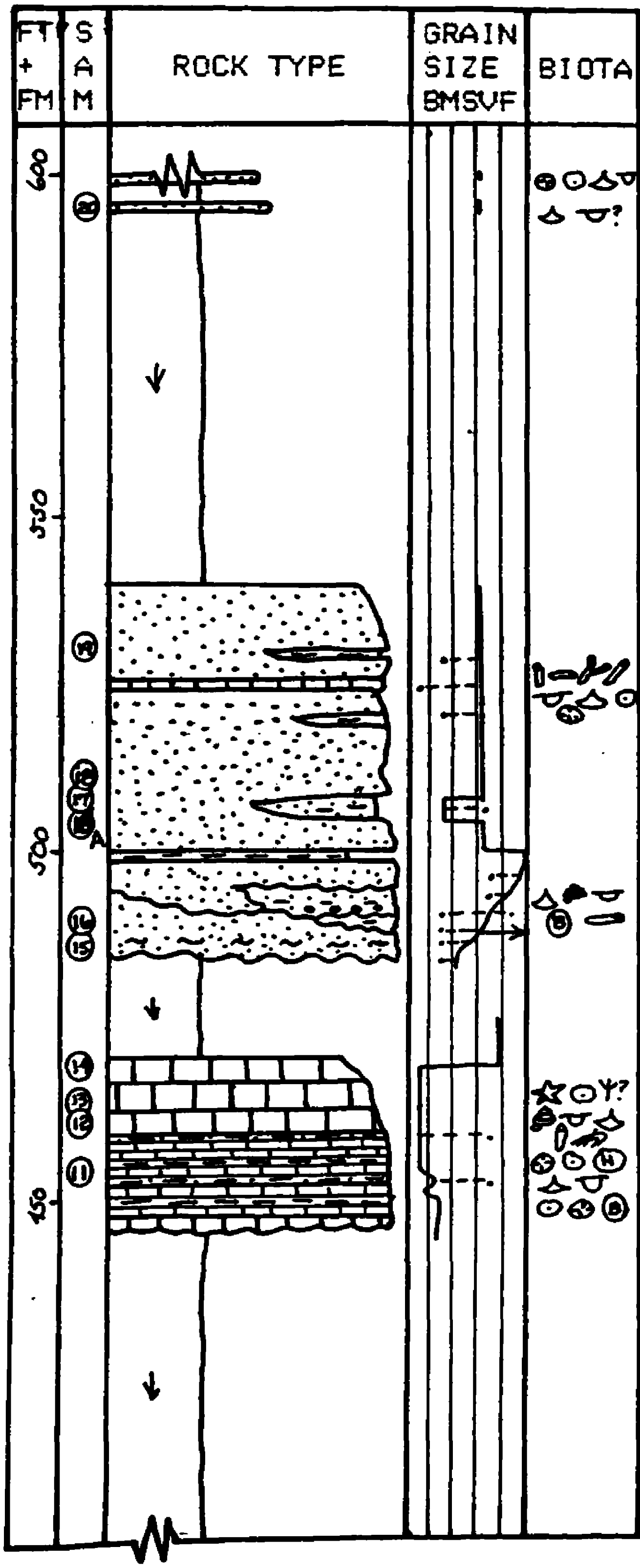
Siltstone, lt. olive gray (5Y 6/1); vth - lam, wavy, sm. scale rip. and lent. bed; well sorted, sr-sa; calc.; abund. hash and load casts (upper). Small, interbedded, lent. mudstones.

HIDDEN PASTURE SPRING
(CONTINUED)

FT + FM	SAM	ROCK TYPE	GRAIN SIZE BMSVF	BIOTA	DESCRIPTION
400					
350					
300					Covered slope (Dug sample = silty sandstone, yellowish to reddish brown, v. f. gr., well sorted, sbrd-rded, v. calc.).
250					
200					

HIDDEN PASTURE SPRING

(CONTINUED)



DESCRIPTION

Mainly covered slope .Dug sample and small exposures = calc. sandstone and muddy sandstone, mod. brown and yellowish brown (10YR 6/2 & 5YR 5/4); thin bedded; v. f. gr., well sorted, sbrd - rded). Exposed areas contain shell molds and echinoid frags.

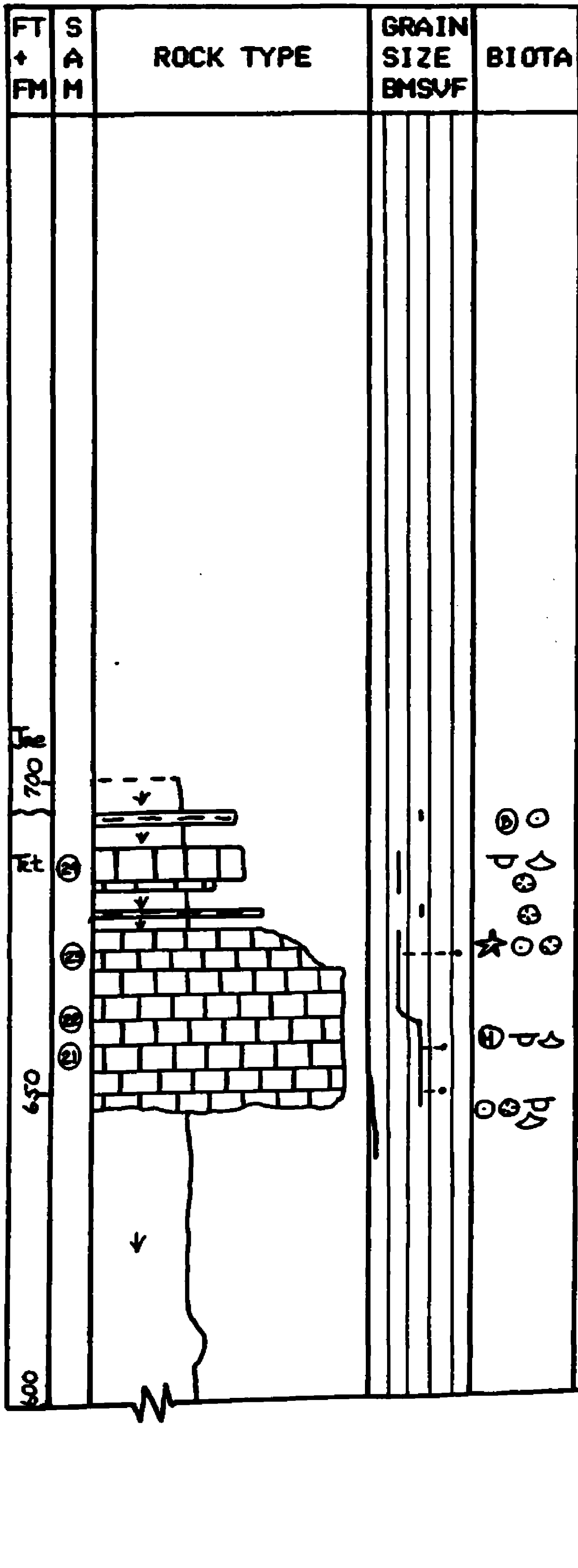
Sandstone, lt. olive gray (5Y 5/2); thin - ave bedded; well sorted, sr - rd; v. calc., v. abund chert nod., lenses and layers. Thin interbeds of calc. mudstone and bioclastic limestone, yellowish gray (5Y 7/2); vth - lam bed with minor rip. lams and sm. scale trough x-beds; cherts less abundant than in sltstn. Contains horizontal burrows on basal surfaces (Planolites), abund. bioturb., and possible storm layers near top. Two gypsum beds (< 4" thick) (mid unit).

Muddy sandstone, brownish gray and grayish red (5YR 4/1 & 5R 4/2); vth - mass., lent., tab., sm. & med. scale trough x-bed; silt - coarse gr., poor - well sorted, rd- sr; v. calc.; complex rip. lams; lenses of coarse gr., disturbed sediments; highly bioturb.; some horiz. burrows; zones of chert and limestone nodules along bedding. Evidence of reworked sediments.

Bioclastic limestone, olive gray (5Y 4/1), tk bed with some lent.; poor to good sorting; mainly crinoids & echinoids. Minor discont. lenses of brach & pelecypod (<4" thick); unit thins slightly laterally. *Marker bed: Pentacrinus

Limestone of cyclic hash layers and micrite; med. lt. gray (N 6); mass. bedded, some wavy. Upper portion: mainly interbedded mudstone with hash layers, some chert nodules parallel to bedding, bioturbation and contorted beds. Hash beds thin, dip slightly and some pinch out laterally. Lower portion: nodular mudstone, mass. bedded, fetid, abundant chert nodules scattered and along bedding (most < 1" in dia.), and some quartz "eyes".

HIDDEN PASTURE SPRING
(CONTINUED)



DESCRIPTION

Mudstone, pale yellowish brown (10YR 6/2); ave - tk bedded.

Bioclastic limestone, grayish orange pink (5YR 7/2); tk - mass., tabular bedded; abundant hash, shells alligned, some geopetal.

Mudstone, lt. gray (N 7); v. calc.

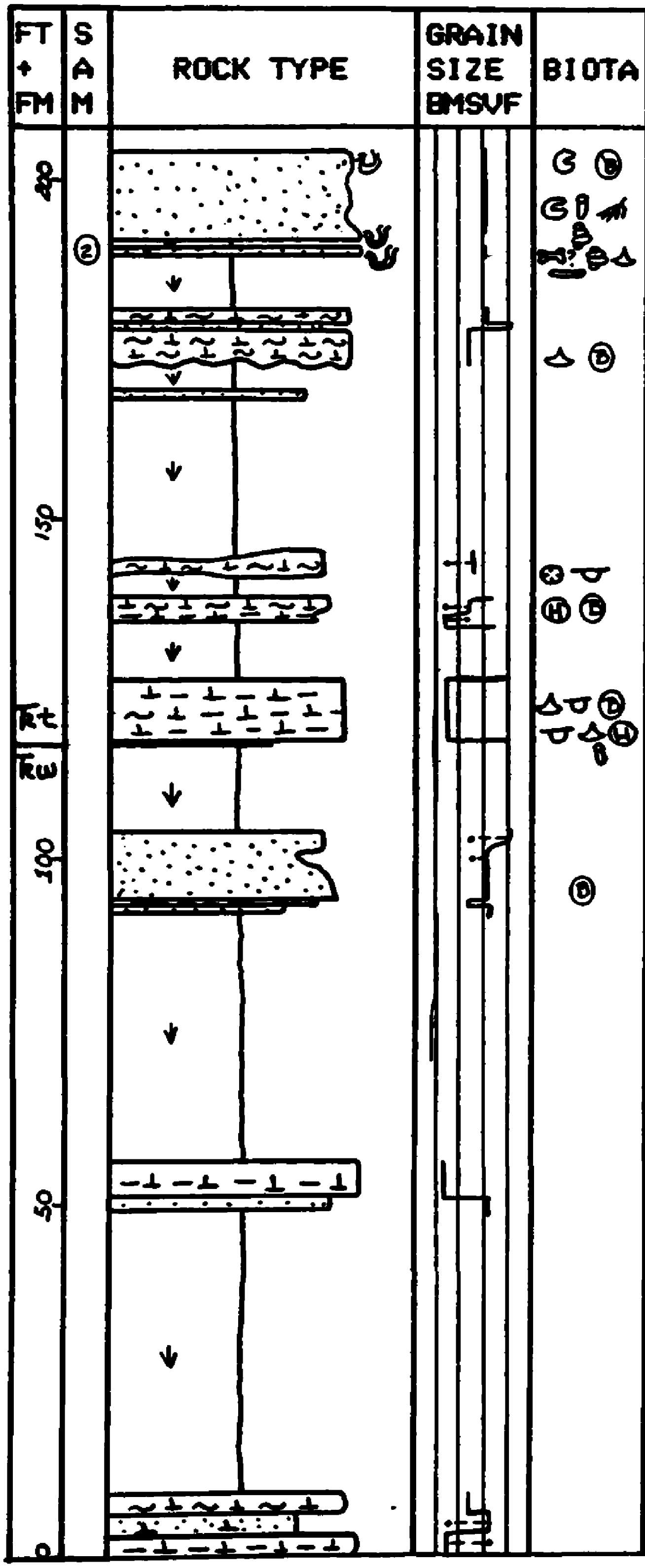
Bioclastic, sandy limestone, yellowish brown (10YR 6/2), th - lam; mod. sorted, sbrd; conc. of <u>Pentacrinus</u> as below.

Limestone, pale yellowish brown and med. gray (10YR 6/2 & N 5); th - tk, tabular bedded; poorly sorted; pelecypod coquina; hash scattered in cyclic layers; sm. lithoclasts in lower portion.

WEST SHEEP CREEK (LOWER UNITS)

T15S R9W S16

Pamela G. L. Sikkink



DESCRIPTION

Silt- to sandstone, grayish red - pale yellowish brown (5R 4/2 - 10YR 6/2); th - ave, wavy bedded with dell lams; well sorted, rded, v. calc.; outcrops discontinuous; graded and contorted beds common. Possible megaripples. *Conodont sample.

Calcareous siltstone and sandstone, pale yellowish brown (10YR 6/2); vth-th, wavy bedded with minor dell & ell lams.

Sandstone, v. pale orange (10YR 8/2); vth, wavy bedded; well sorted, rded, v. calc.

Covered slope (same as below).

Lenticular, calcareous siltstone; ave-th, wavy bedded.

Clayey siltstone and silty mudstone; th-ave, wavy bedded; contorted base; vth sandstone drapes in mudstone beds; v. calc.

Silty, calcareous mudstone, pale yellowish brown (10YR 6/2); vth-ave, tabular and wavy bedded with minor lams; some silicified fossils.

Covered slope, same as below.

Silty sandstone, dk. yellowish brown - v. pale orange (10YR 4/2 - 10YR 8/2); vth, wavy bedded at top; th-mass. bedded with med. scale trough x-beds and lenticular beds at base; gr. size coarsens upward, well sorted, rded, v. calc. Minor chert nodules in upper portion.

Covered slope (Dug samples @ 3 ft. (1 m) intervals = sandstone, dusky yellow (5Y 6/4) with some red and yellow mottled; f. gr., well sorted, sbrd, v. calc.).

Limey mudstone, brownish gray (5YR 4/1); ave-tk, lenticular bedded; v. calc.

Sandstone, dusky yellow (5Y 6/4); vth bedded; well sorted, sbrd, v. calc.

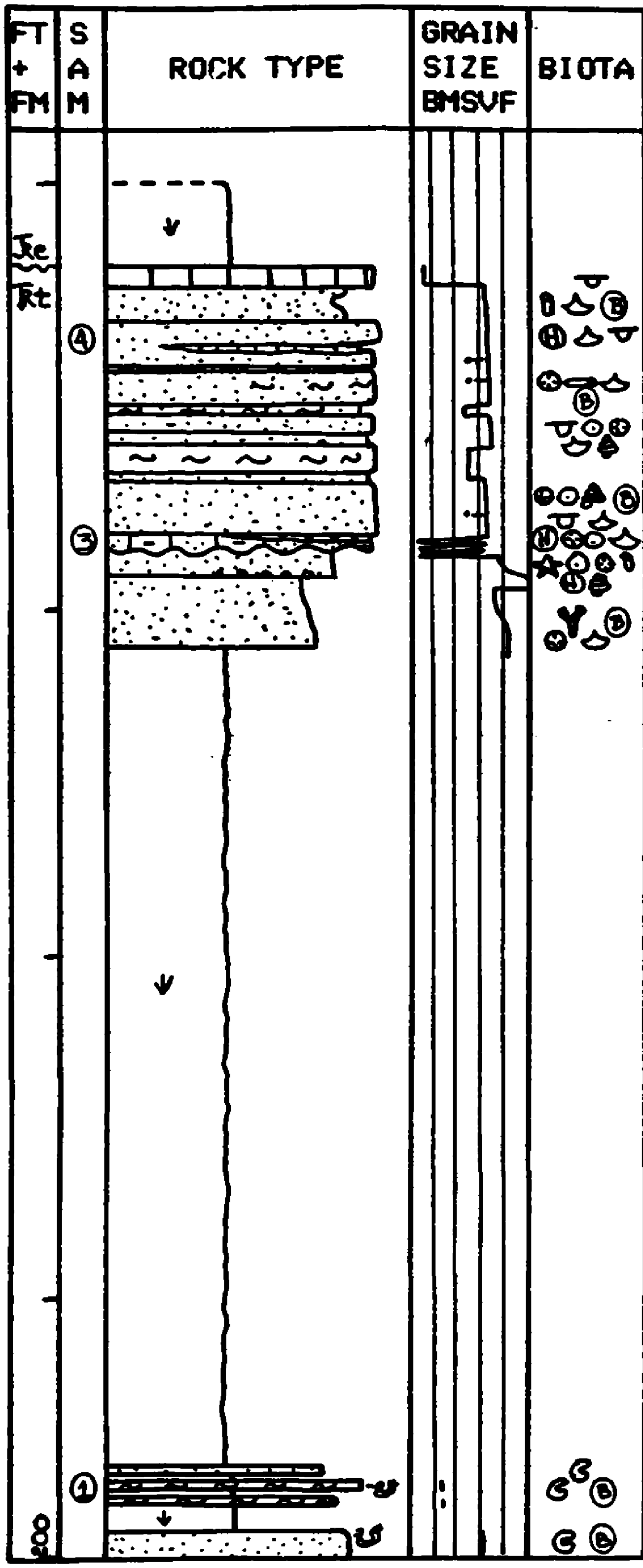
Covered slope (Dug samples @ 3 ft (1 m) intervals = clayey sands, moderate brown (5YR 4/4); v. calc., f. gr., fair- to well-sorted, sbrd-rd).

Clayey siltstone, yellowish brown (10YR 6/2), v. calc.

Clayey sandstone, mod. brown (5YR 4/4), v. calc.

Calcareous mudstone, lt. olive gray (5Y 6/1), v. calc.

WEST SHEEP CREEK (UPPER UNIT)
(CONTINUED)



DESCRIPTION

Bioclastic limestone, lt. olive gray (5Y 6/1); tk bedded.

Sandstone, grayish orange (10YR 7/4); vth-th, wavy, ripple and cut wave-ripple bedded; scattered molds and shells; well sorted, sbrd; v. calc.

Interbedded calc. silty sandstone, sandy siltstone and bioclastic limestone. Ss and sltstn, yellowish gray and grayish orange (5Y 7/2 - 10YR 7/4); vth - tk, wavy and tabular bedded; some normally graded and contorted beds; fossils alligned and in layers; some silicification; fair - poor sorted, rd-sr, v. calc. Limestone abundant at base. Nod. and layer chert.

Sandstone, olive gray (5Y 4/1); vth-th, contort and rip. bed; abund. hash; poor sort, v. calc.

Sandstone, moderate yellowish brown (10YR 5/4), vth-tk, wavy and tabular bedded with complex sm. scale trough x-beds; v.f. - f. gr., well sorted, rd-sbrd; v. calc. Abundant chert nodules at base.

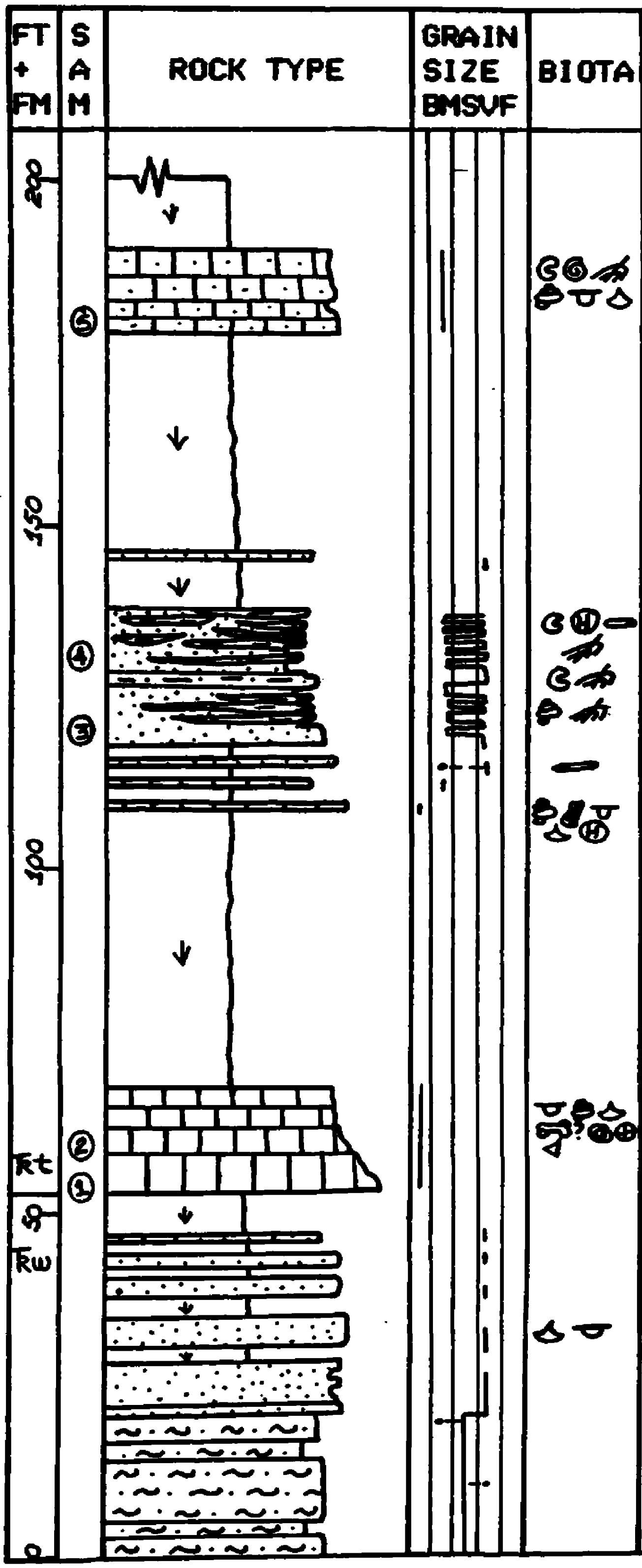
**Unknown thickness (dip change occurs in covered slope between lower unit and upper unit. Measured 590 ft (180 m) of covered at strike and dip of lower unit. Adjustment to gradual dip change results in approx. 540 ft (165 m) covered. <u>Pentacrinus</u> samples found as float on slope between upper and lower units. No <u>Pentacrinus</u> ledge located on slope).

Mud- to siltstone, grayish red (5R 4/2), discontinuous outcrops similar to silt- to sandstone interval below. *Marker bed: <u>Meekoceras</u> ammonites and small nautiloids.

LITTLE SHEEP CREEK

T15S R9W S23

Pamela G. L. Sikkink



DESCRIPTION

Sandy limestone, brownish gray (5YR 4/1); th-ave, wavy bedded; abundant fossil hash; weathers reddish purple. *Marker bed: <u>Meekoceras</u> ammonites and small nautiloids.

Sandstone, pale yellowish brown (10YR 6/2), v. calc.

Interbedded calc. sandstones and sandy mudstones. Ss, lt. olive gray (5Y 5/2); vth-th, wavy and rip. bed; well sorted, well rounded; mudst., med. gray (N 5); vth-ave, wavy and lent. bed; weathers red brown. Ss more abund. at base; mudst at top.

Sandstone, lt. olive gray (5Y 5/2); ave, tabular bedded; v. calc.

Limestone, dk. gray (N4); th, wavy bed; weathers red.

Bioclastic limestone, med. dk. gray (N 4); ave. bedded; weathers purplish.

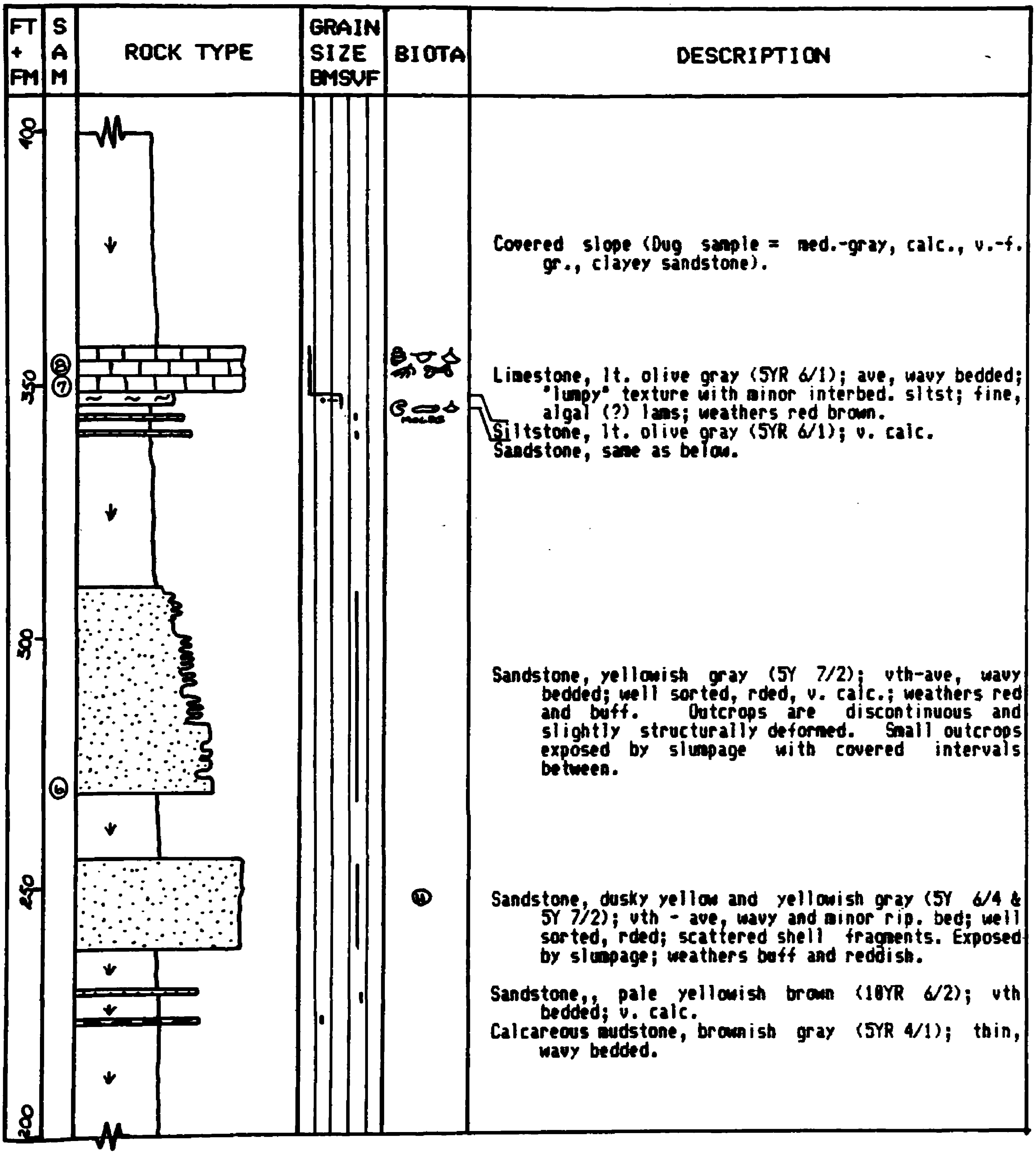
Covered slope (Dug sample = med. brown, calc. sandstone).

Bioclastic limestone, medium gray (N 5) to lt. brownish gray (5YR 6/1); tk - mass. bedding; abundant fossil hash; *two kinds of snails; weathers purplish.

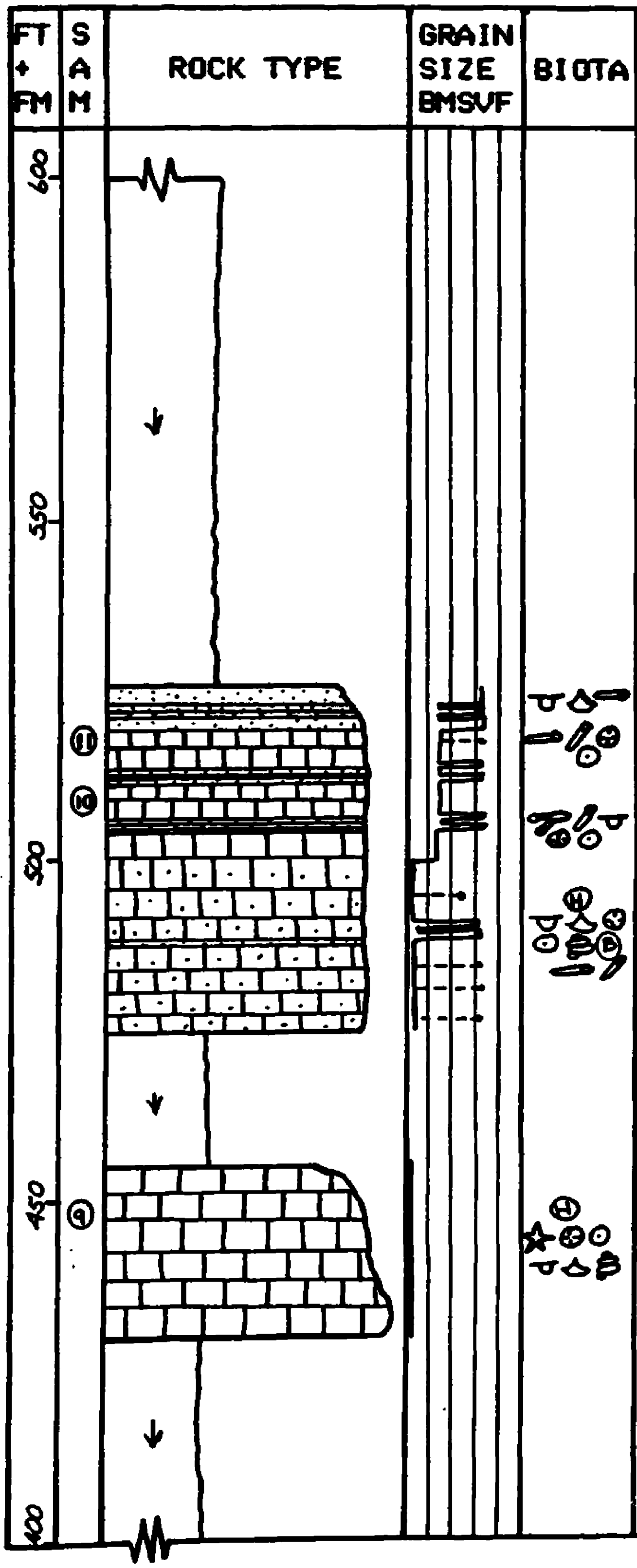
Sandstone, yellowish gray (5Y 7/2), lt. gray (N 7), and very pale orange (10YR 8/2); vth - ave, wavy bedding with minor ripple lams on surface; well sorted, rounded; v. calc.; scattered molds and shells.

Sandy siltstone, mottled red and green (10R 3/4 and 5GY 7/2); vth, wavy bedded to fissile; very well sorted; v. calc.

LITTLE SHEEP CREEK
(CONTINUED)



LITTLE SHEEP CREEK
(CONTINUED)



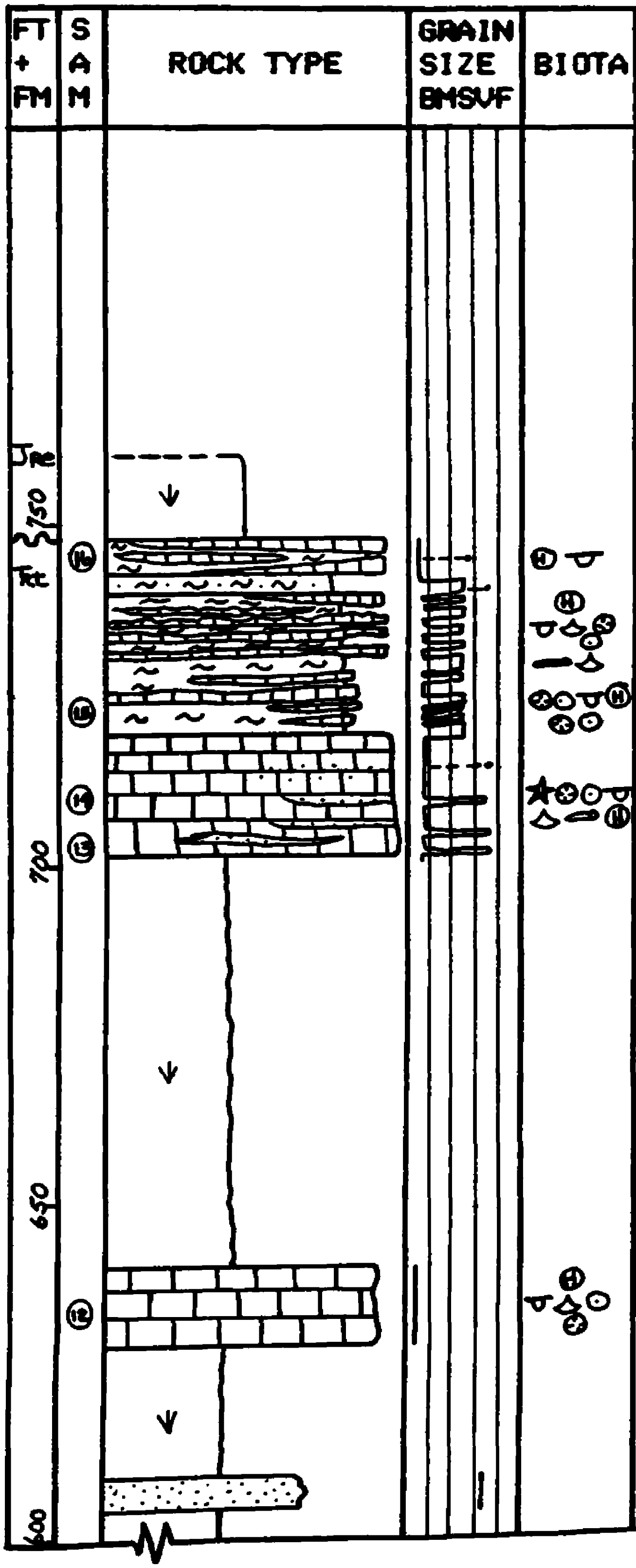
Calcareous sandstone and lenticular mudstone, dusky yellow (5Y 6/4); vth-ave, wavy and lenticular bedded; minor fossil molds and chert.

Limestone, yellowish brown (10YR 6/2); th bed to lam (base); tk-mass. bed with lams (top); v. abund. chert layers and nodules; cherts lam; abund. silic. & mud-filled, horiz. burrows (Planolites) on bedding surface. Thin interbed. sands, well sorted, sbrd.

Sandy limestone, grayish orange (10YR 7/4) to pale yellowish brown (10YR 6/2); th-mass., wavy and ripple bedded; thin interbeds of sandstone throughout; v. f. gr., well sorted, rded, and very calcareous. Bed thickness and composition vary laterally. Minor scattered chert nodules. Weathers purplish and buff.

Bioclastic limestone, lt. brownish gray (5YR 6/1) and med. gray (N 5); ave-tk, bedded; abundant fossil hash; "lumpy" texture and abundant chert nodules in lower half. Upper 5 ft. (1.5 m) has cyclic hash layers and crinoid-echinoid layers. *Marker bed: Pentacrinus zone.

LITTLE SHEEP CREEK
(CONTINUED)



DESCRIPTION

Large covered interval.

Interbedded bioclastic limestone and siltstone, pale yellowish brown (10YR 6/2); ave, wavy bedded; "lumpy" texture; pelecypod hash; minor chert.

Interbedded lent. limestone and siltstone; grayish yellow (5Y 7/2), dk. yellowish orange (10YR 6/6) and lt. brownish gray (5YR 6/1); vth-ave, wavy and rip. bed; hash in ls, scattered molds and burrows in sltst; chert nodules and layers.

Sandy limestone, moderate yellowish brown (10YR 5/4) and grayish orange (10YR 7/4); ave-tk, wavy and ripple bedded; abundant fossil hash throughout. Interbedded thin, lent., v. f. gr., calc. sandstones. Abund. chert nodules and layers. *Marker bed: Pentacrinus.

Covered slope (vegetated).

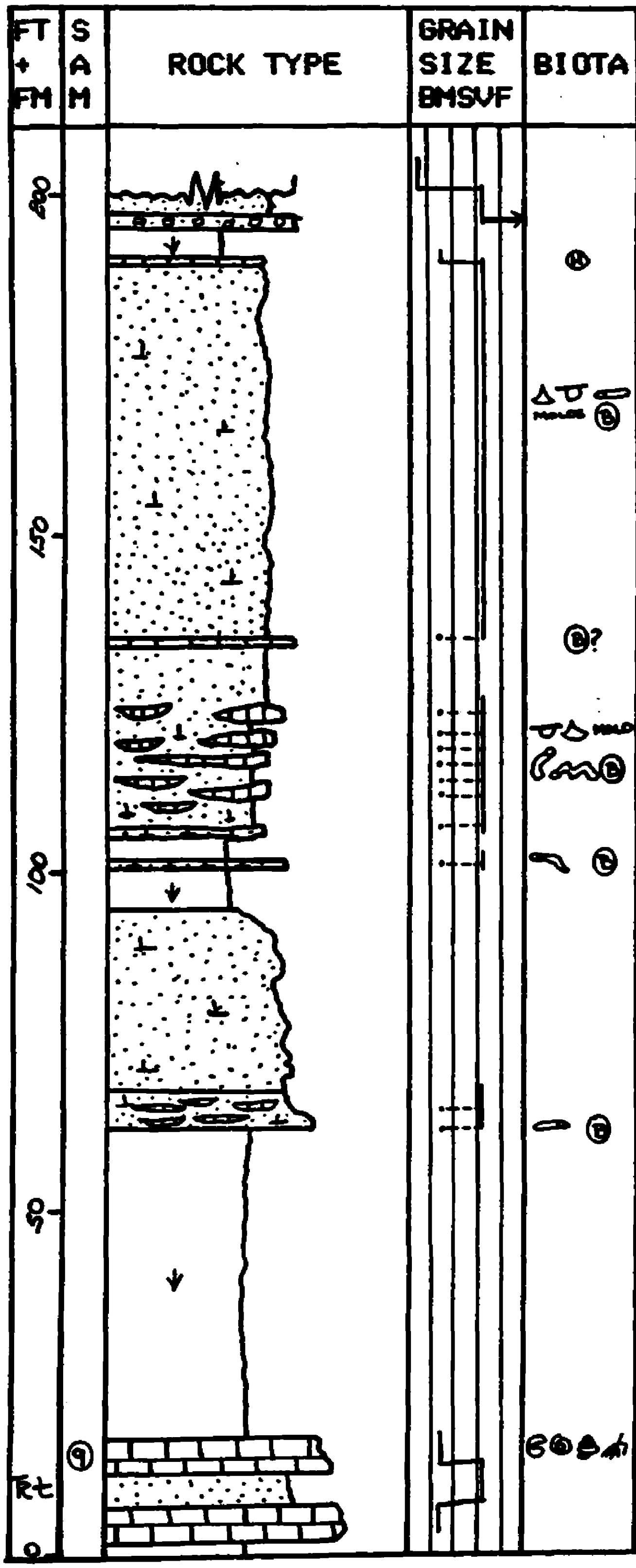
Bioclastic limestone, med. lt. gray (N 6); mass. bedded; abundant fossil hash in layers and patches; hash layers cyclic; pelecypods concentrated near top.

Sandstone, grayish orange (10YR 7/4); th-ave, wavy and irregular bedded; v. f. gr., well sorted, rded; v. calc.; outcrop small and discontinuous.

DEEP CREEK COW CAMP

T15S R8W S12

Pamela G. L. Sikkink



DESCRIPTION

Sandstone, brownish gray (5YR 4/1); th - tk, wavy to cl. ripple bedding; basal portion contains red sandstone ripups with internal lams, wavy - trough x-bedded; weathers red brown.

Limestone, yellowish gray (5Y 7/2); th bedded.

Sandstone, yellowish gray (5Y 7/2) and dusky yelow (5Y 6/4); vth - ave, wavy bedded; v. f. gr., well sorted, rd; v. calc.; isolated shell molds and straight, horizontal burrows; weathers red-brown and buff; some veg. and talus slope.

Sandy limestone, lt. brownish gray 5Y 6/1); vth, wavy to sm. scale trough x-bedded; thins laterally.

Sandstone, same as above.

Interbedded limey sandstone and lenticular limestone, yellowish gray(5Y 7/2) & lt. brownish gray (5Y 6/1); vth - ave, wavy, lenticular bedded; isolated shell molds and complex, horiz. burrows; lower half weathers mottled green, reddish brown and med. gray.

Calcareous sandstone, yellowish gray (5Y 7/2); th bedded.

Sandstone, yellowish gray (5Y 7/2); vth - tk, wavy bedded; v. calc.; some mica; minor structural deformation.

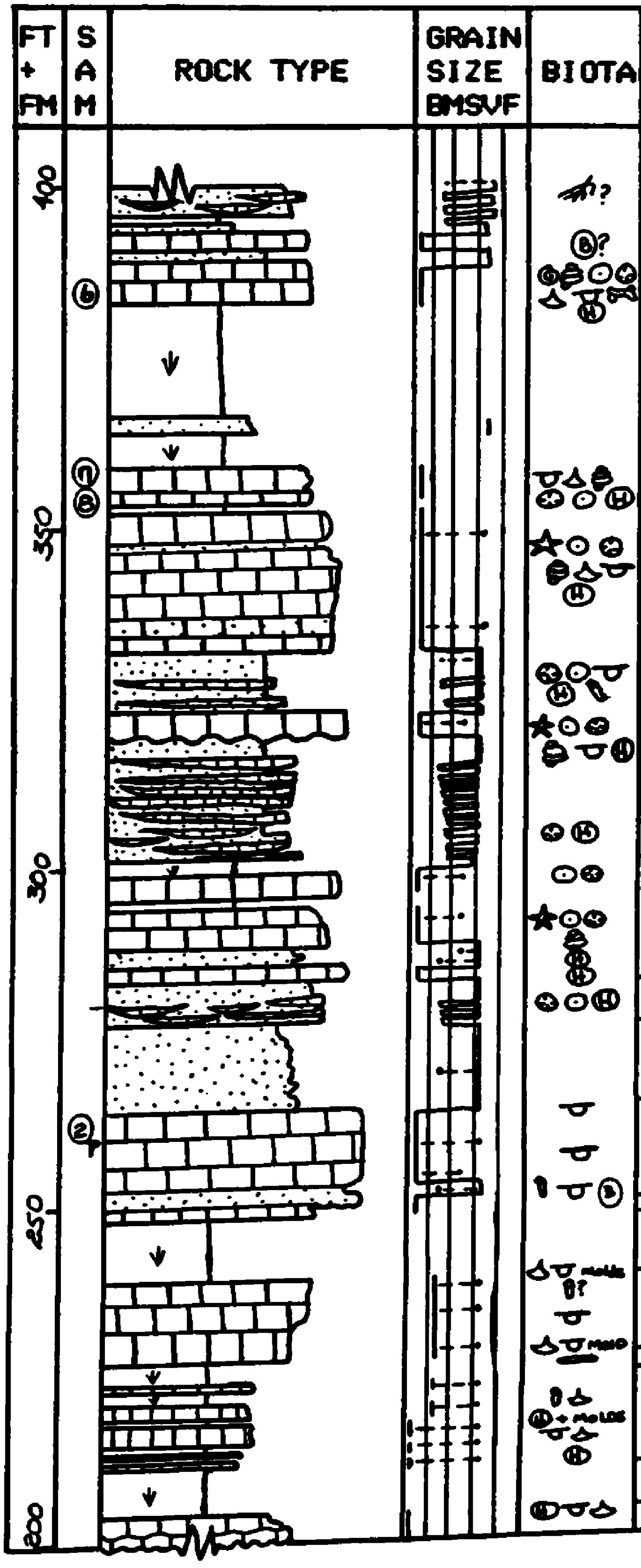
Interbedded sandstone and lenticular limestone, yellowish gray (5Y 7/2); vth, wavy bedded; v. calc.

Mainly covered slope. Contains structurally deformed sandstones. Thickness may be slightly less than portrayed due to structural deformation.

Limestone, brownish gray (5YR 4/1); ave bedded with fine lams; thin, interbedded, ss layer; weathers reddish brown. *Marker bed: Meekoceras ammonites and small nautiloids.

Not measured (structurally deformed).

DEEP CREEK COW CAMP
(CONTINUED)



DESCRIPTION

Interbedded calc. sandstone and sandy, lent. mudstone, yellowish gray (5Y 7/2) to lt. brownish gray (5Y 6/1); th - ave, wavy and ripple (?) bedded at base; tk - mass., disturbed bedding at top. Ss: well sort, rd. Abund. chert lenses.

Bioclastic limestone, pale brown (5YR 5/2); tk - mass. bedded. *Two types of snails - upward coil & planispiral.

Sandstone, dusky yellow (5Y 6/4); vth, wavy to sm. scale trough x-bedded; well sort, rd; discontinuous outcrop.

Bioclastic limestone, med. gray (N 5); same as below, except no Pentacrinus or chert nodules.

Bioclastic, sandy limestone, lt. olive gray (5Y 5/2) at base to pale pinkish brown (5YR 6/2) at top; mainly ave - mass, wavy bedded with cl. ripples (?); lumpy texture in areas; chert nodules up to 1/2 in. dia.; fossil hash common throughout.

Interbedded calcareous sandstone and sandy limestone, pale yellowish brown (10YR 6/2); th - tk, wavy bedded with lams; v. calc.; lumpy texture.

Silty, bioclastic limestone, (10YR 7/4), s. a. b.

Interbedded calcareous sandstone and lenticular, sandy mudstone, yellowish gray (5Y 7/2) and lt. brownish gray (5Y 6/1); red, brown & greenish gray mottled near base; vth - ave, wavy bedded with wavy lams; rare shell fragments.

Silty, bioclastic limestone, yellowish gray (5Y 7/2) and lt. brownish gray (5Y 6/1); tk - mass. bed (top), th - ave, wavy bed (base); minor chert nodules. *Marker bed: Pentacrinus (two types).

Interbedded sandstone and lenticular mudstone; vth - ave, wavy and lent. bed; v. calc.

Clayey sandstone, red and green mottled (10YR 4/6 & 5GY 6/1); well sort, rd; v. calc.; some greenish clay chips in matrix.

Sandy and silty, bioclastic limestone, (5Y 7/2) and (5Y 6/4); ave - tk, wavy bed; minor trough-shaped beds, ss interbeds and chert lenses; hash alligned & conc. in 1 - 2" beds.

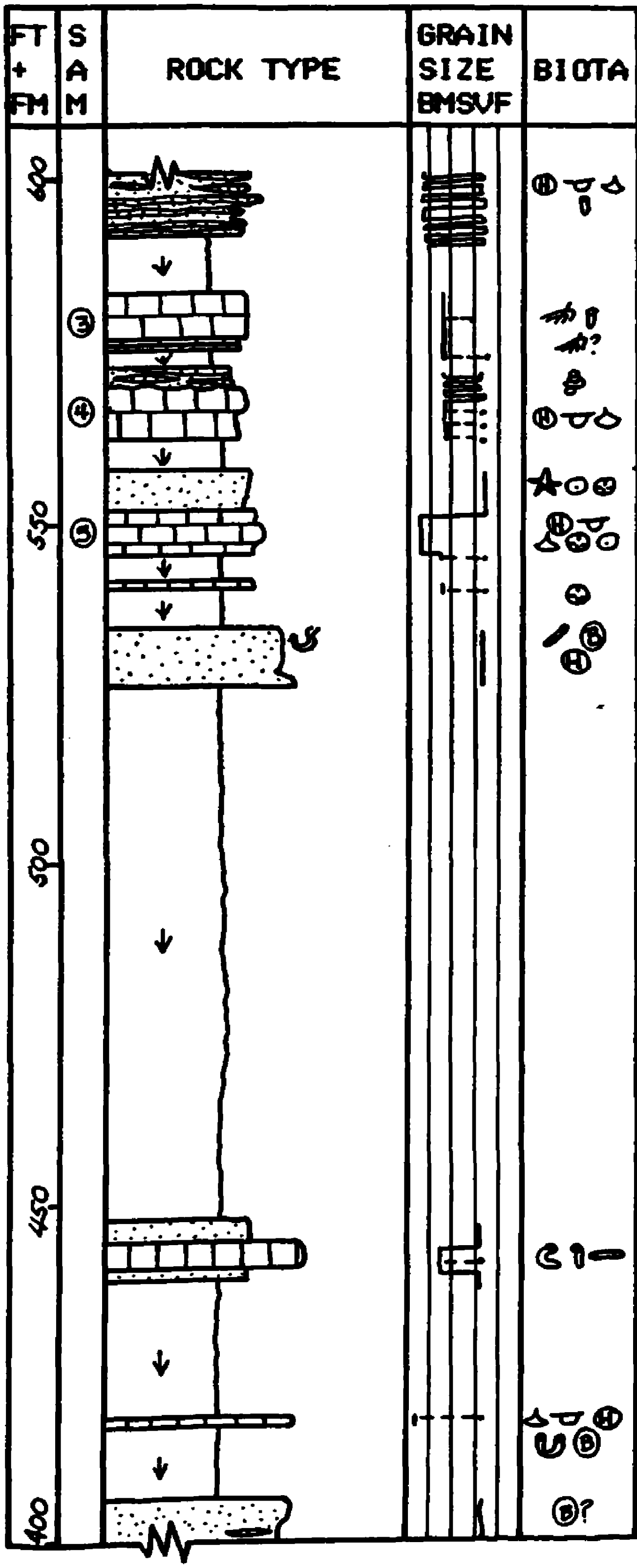
Description above.

Sandy limestone, lt. olive gray (5Y 6/1) to grayish red (10R 4/2); ave - mass. bedded; isolated shell molds (small) and horizontal & vertical burrows; unit poorly exposed, highly fractured.

Sandy limestone, same as above except ave bedded and shell hash layers at base.

Limestone, lt. brownish gray (5Y 6/1); ave, wavy bedded; weathers reddish brown & purplish; bedding thins near top.

DEEP CREEK COW CAMP
(CONTINUED)



DESCRIPTION

Interbedded bioclastic limestone and calcareous sandstone, brownish gray (5YR 4/1); vth - ave, wavy and ripple bedded; abundant alligned fossil hash; weathers purplish.

Silty limestone, pale yellowish brown (10YR 6/2) to yellowish gray (5Y 7/2); ave - mass., wavy bedded with wavy lams; weathers white - buff.

Interbedded calcareous sandstone and lenticular, sandy limestone, lt. olive gray (5Y 6/1) to brownish gray (5YR 4/1); th - ave, wavy and ripple bedded; abundant fossil hash and chert lenses and layers throughout. Chert contains lams.

Sandstone, lt. brownish gray (5Y 6/1), tk - mass bed; well sorted, rd; sl. calc.

Bioclastic, sandy limestone, yellowish gray (5Y 7/2); tk - mass. bedded; abundant hash and pelecypod shells. Chert lenses near base.

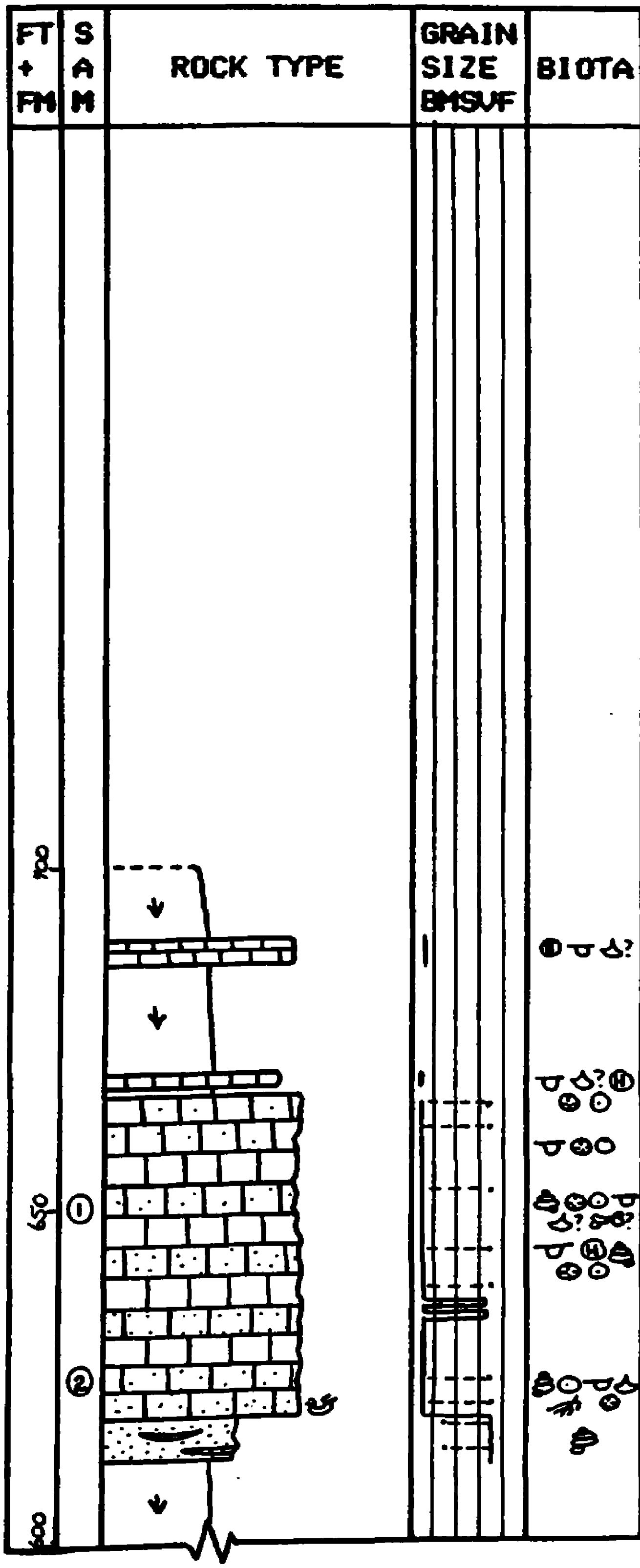
Calcareous sandstone, lt. gray (N 7) and yellowish gray (5Y 7/2); vth - ave, wavy to ripple bedded at base; tk - mass. bedded with ewll lams at top; v. f. gr., well sorted, rd; weathers buff and lt. gray.

Calc. sandstone and sandy limestone. Ss: yellowish gray (5Y 7/2); vth - th, wavy & sm. scale trough x-bedded; well sort, rd; v. calc. Ls: dusky yellow (5Y 6/4); ave - tk bed; irregular, "lumpy" surfaces; abund. chert layers.

Covered slope (Dug samples = lt. olive-gray, clayey sandstone).

Bioclastic, sandy limestone, discontinuous outcrop.

DEEP CREEK COW CAMP
(CONTINUED)



DESCRIPTION

Covered slope.

Bioclastic limestone, pale yellowish brown (10YR 6/2); ave - tk, wavy bedded; abundant fossil hash; outcrop discontinuous; weathers purplish.

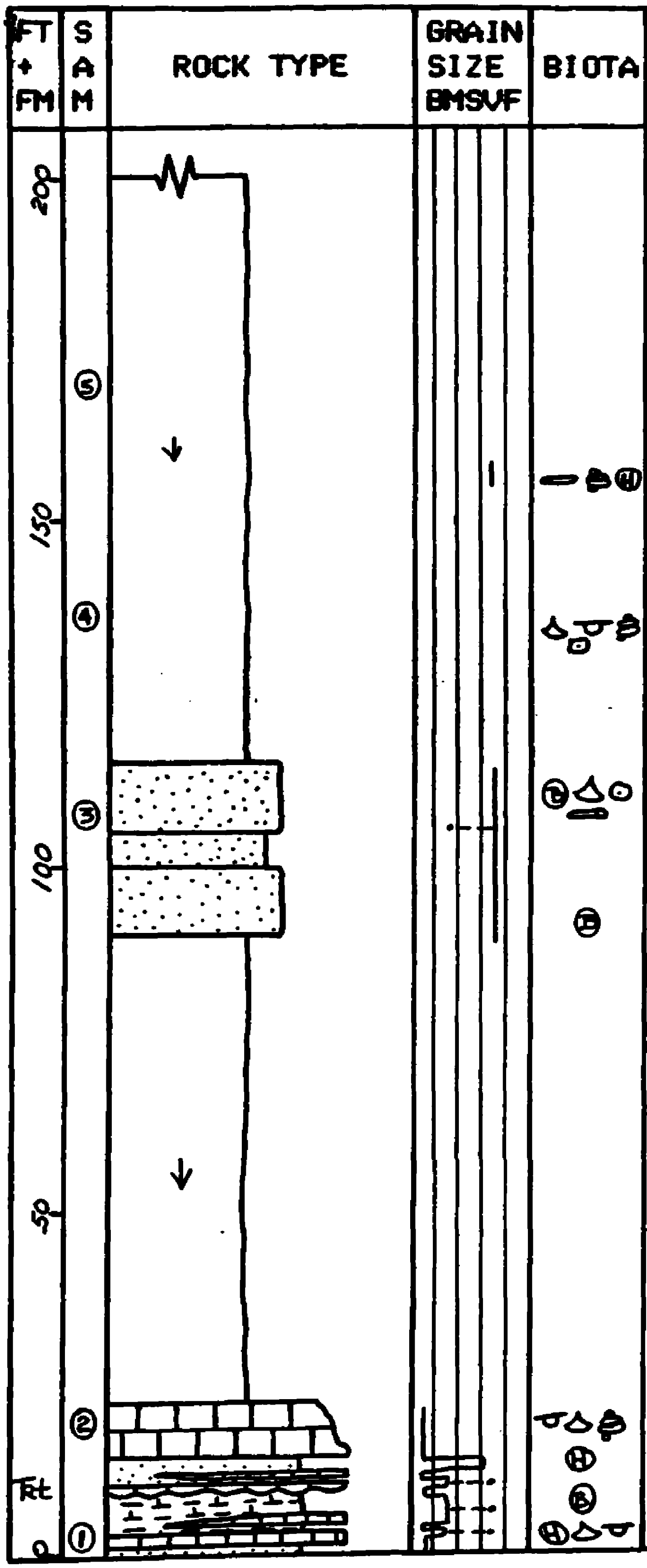
Sandy, bioclastic limestone, lt. brownish gray (5YR 6/1) and pale yellowish brown (10YR 6/2); vth - ave, wavy bedded with wavy lams and minor ripple beds; hash alligned and in layers; chert lenses and nodules throughout; basal portion contains algal lams, no fossils; weathers lt. brown & purple. Minor interbedded v.-f. gr., sandstone.

Calcareous sandstone, lt. brownish gray (5YR 6/1); vth - ave, wavy and ripple bedded with lams; v. f. gr., with minor lenticular, calc. limestone. Chert nodules and layers common.

BLACKTAIL DEER CREEK

T12S R6W S35

Pamela G. L. Sikkink



DESCRIPTION

Mainly covered slope (Dug samples and small outcrops = sandstone with some interbedded bioclastic layers. Sandstone, yellowish gray - lt. brownish gray (5Y 7/2 - 5Y 6/1); th - ave, wavy or indistict bedding; isolated shell fragments, molds and burrows; v. f. gr., well sorted, sbrd - rd; sl. calc. Hydrocarbons and calcite in fractures).

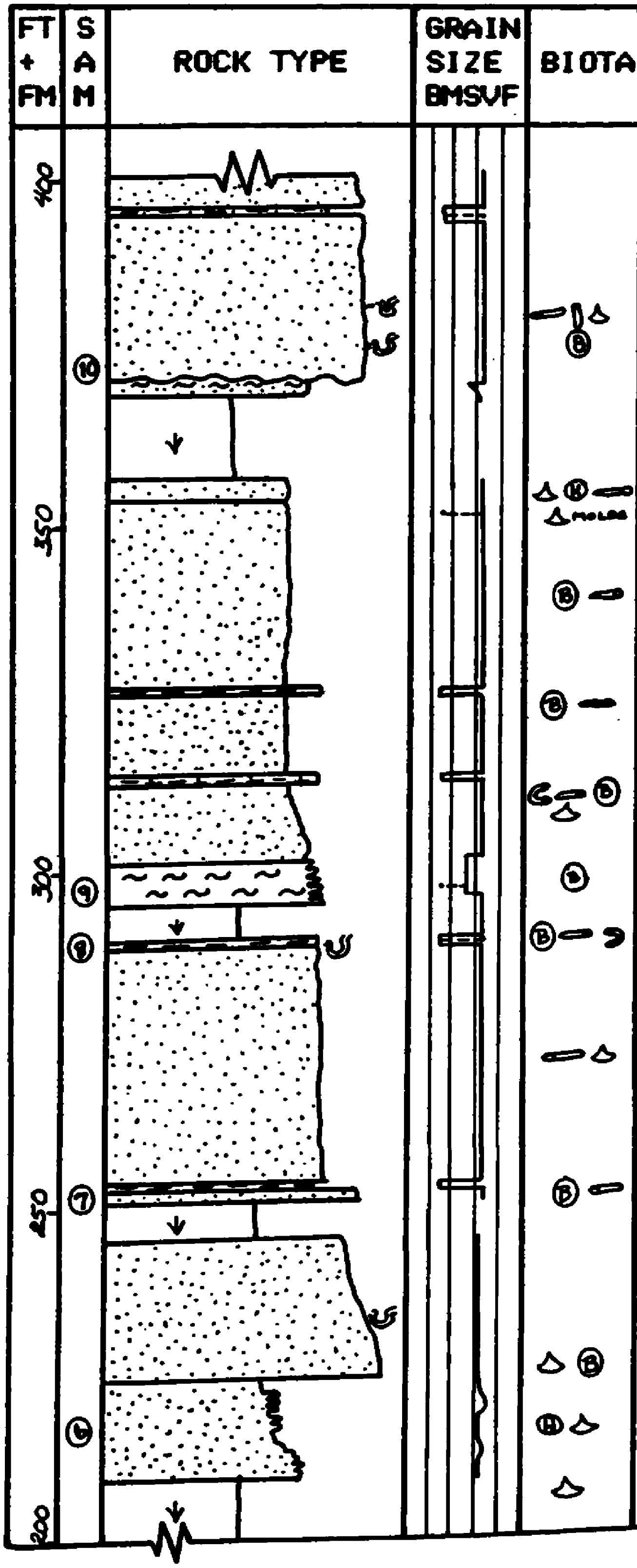
Sandstone, dusky yellow (5Y 6/4); vth - th, ripple bedded; v. f. gr., well sorted, rd-sbrd; sl. calc; isolated molds and shells.

Covered slope, vegetated, sandy, with abundant talus blocks (Dug sample = clayey sandstone, dk. yellowish brown; v. f. gr., well sorted, rd - sa; v. calc.).

Sandy limestone and bioclastic limestone, pale brown (5YR 5/2 & 10YR 6/2); vth - ave, ripple bedded with some lams; hash highly fragmented, alligned in layers; molds common; ripples up to 4 in. c - c, sym. & complex.

BLACKTAIL DEER CREEK

(CONTINUED)



DESCRIPTION

Sandy mudstone, same as below.

Sandstone, grayish orange to mod. yellowish brown (10YR 7/4 - 10YR 5/4); lam - vth, wavy and rip. bed; rip. complex, cl., assym. and sym., 1/2 - 3" c - c, flattened, straight and branch crests; wave bases 6 - 18" c - c; well sorted, rd; isolated molds; Fe nod. common.

Sand- to siltstone, mottled orange & green (5Y 5/2 & 10YR 6/6); vth bedded.

Sandstone, s. a. b., but vth bedded with abund. burrows and molds and minor hash.

Sandstone, grayish orange (10YR 7/4); vth - ave, wavy and ripple bedded; lower half vth - th bedded; rip. sym., flattened, staight crests, 1 in. c - c; well sorted, rd - sbrd; v. sl. - mod. calc.

Mudstone, same as below; sl. calc.

Sandstone, dk. yellowish brown (10YR 4/2), s. a. b. with mud-filled burrows.

Calcareous mudstone, yellowish gray (5Y 7/2); s. a. b.

Sandstone, yellowish orange (10YR 7/4); vth - th, rip. bed; rip. flattened, sym.; minor wavy bases on beds; well sorted, rd; mod. - non calc.; outcrops discont., mottled orange and white.

Clayey siltstone, mottled green & red (10YR 6/2 & 10GY 5/2); vth - th bedded; sl. calc.; discontinuous outcrops weather bluish.

Mudstone, pale blue green (5BG 7/2); vth, ripple bedded; sl. calc.

Sandstone, mod. yellowish brown, grayish orange, and olive brown (10YR 5/4, 10YR 7/4, 5Y 5/2); lam - vth, ripple and minor wavy bedded; v. f. gr., well sorted, sbrd - rd; sl. calc.; isolated molds and burrows; minor Fe nodules.

Mudstone, ave - tk bedded; sl. calc.

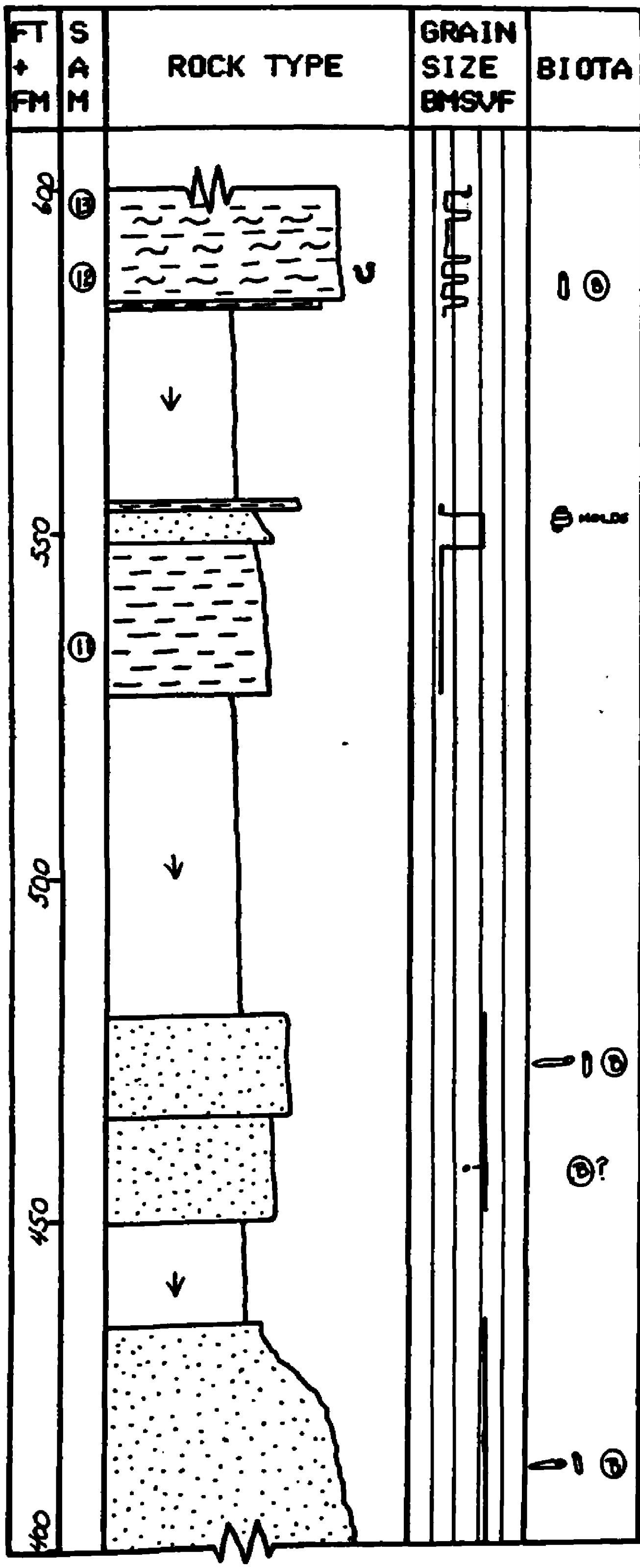
Sandstone, mottled; ave - tk bedded; same as below.

Covered slope (talus).

Sandstone, same as below, plus burrows, contorted beds and Fe nodules.

Sandstone, grayish orange and yellowish gray (10YR 7/4 & 5Y 7/2); lam - th, wavy and ripple bedded; ripples complex and flattened with straight and branching crests; well sorted, rd; v. calc.; scattered hash layers and calcite-filled molds.

BLACKTAIL DEER CREEK
(CONTINUED)



DESCRIPTION

Interbedded calc. siltstone and mudstone, lt. olive gray and med. gray (5Y 5/2 & N 5); vth - tk, wavy and rip. bed; graded beds common; rip. 1 - 4" c - c, wave rip. up to 2' (.6 m) c - c; some scour bases on beds; abund. chert nod. and layers; chert lam; calcite and quartz "eyes" abund.

Mudstone, lt. olive gray (5Y 5/2); th - ave bedded; non- calc.

Sandy mudstone, yellowish brown; rip. base; calc.

Sandstone, v. pale orange (10YR 8/2); same as below.

Mud- or siltstone, varicolored; highly silicified and Fe altered; ave - tk bedded.

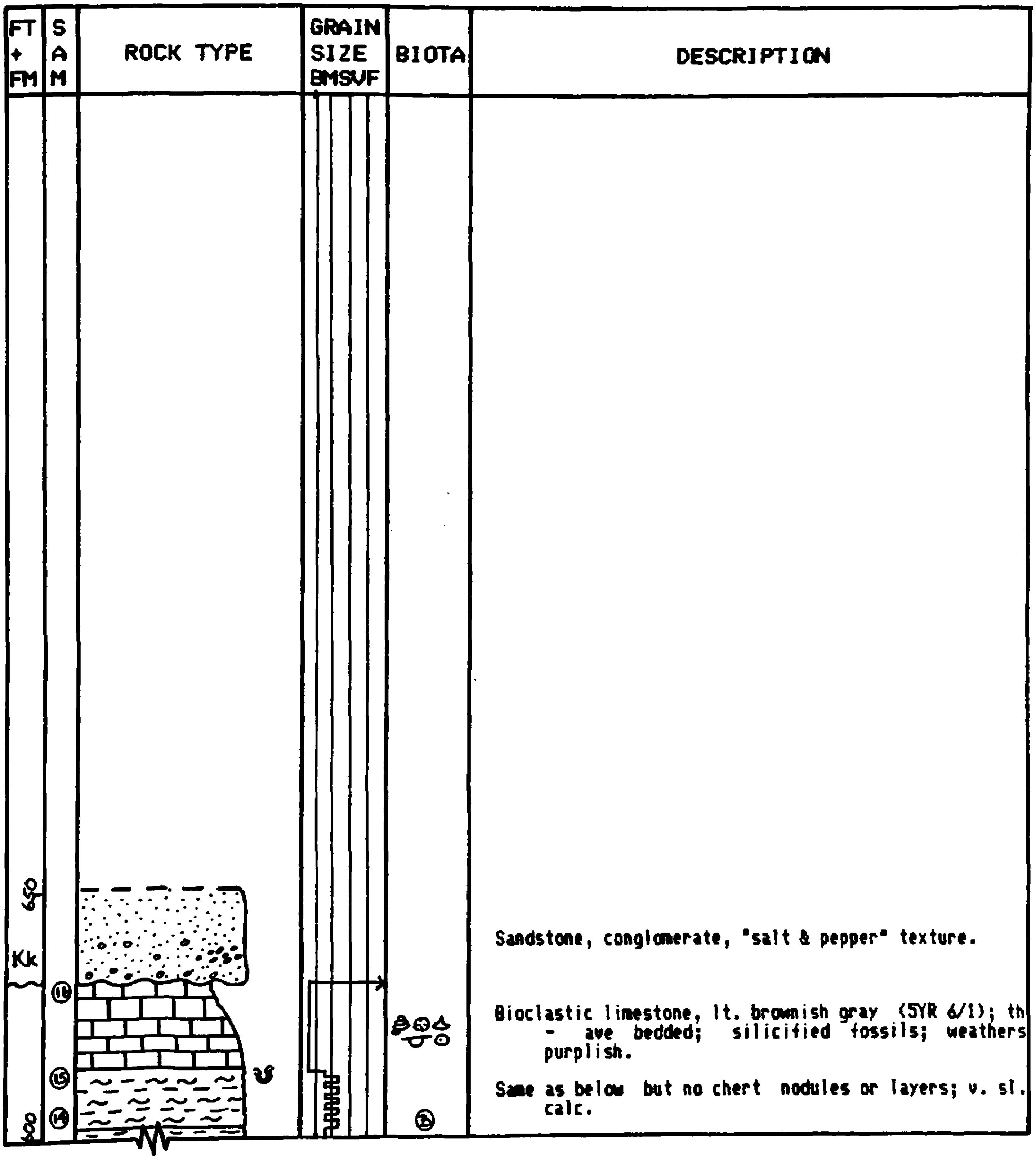
Sandstone, grayish orange (10YR 7/4); vth bedded, same as below (s. a. b). Horizontal burrows up to 2" long; Fe nod.

Silty sandstone, lt. gray (N 7); th - ave bedded; s. a. b. ; Fe nodules.

Covered slope (Dug samples = sandstone, mottled v. lt orange and lt. gray; well sorted, rd, v. sl. calc.).

Sandstone, same as below.

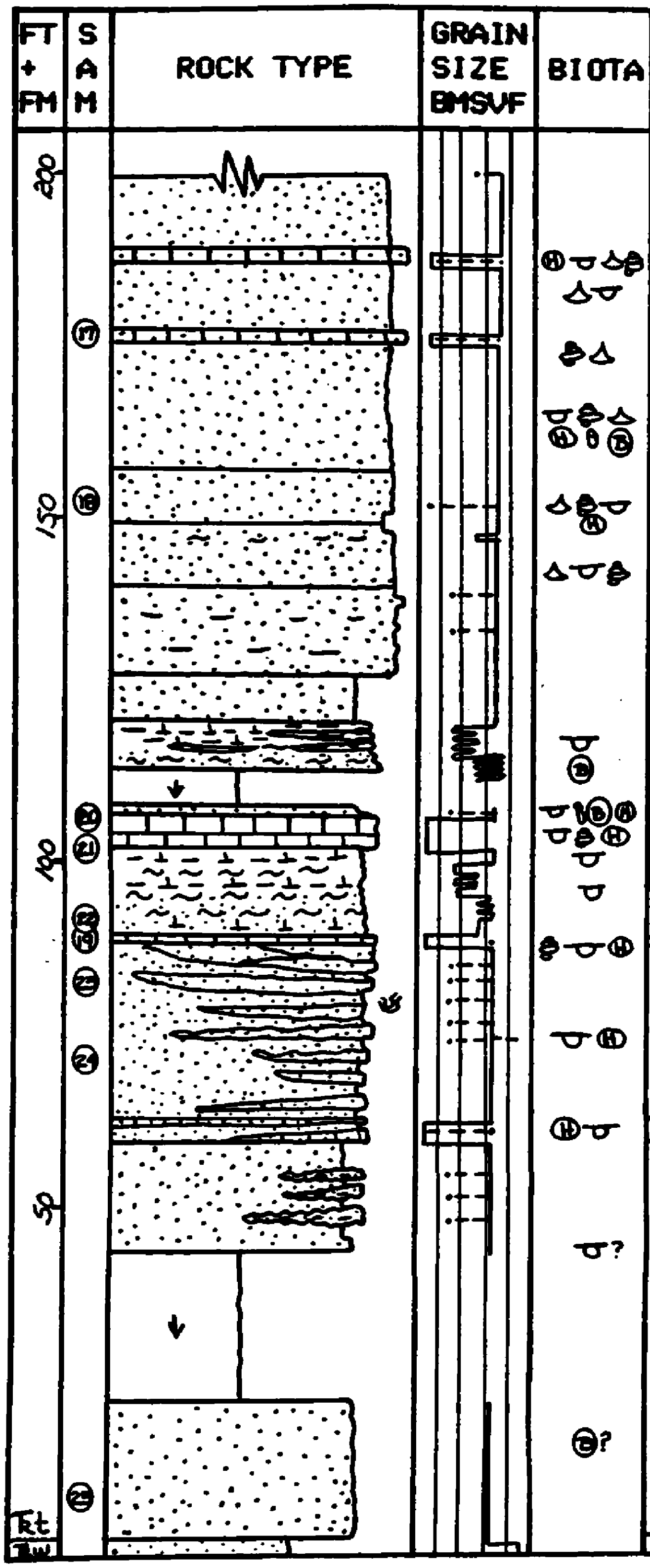
BLACKTAIL DEER CREEK
(CONTINUED)



HOGBACK MOUNTAIN

T11S R4W S8

Pamela G. L. Sikkink



DESCRIPTION

Sandy, bioclastic limestone, vth bed; hash & molds.

Sandstone, grayish yellow green (5GY 7/2); vth - ave, wavy and ripple bedded; v. f. gr., well sorted, rd; v. calc.; molds common, trails present.

Sandy, bioclastic limestone, yellowish gray (5Y 7/2); excellent silicified mollusk molds.

Sandstone, grayish yellow green (5GY 7/2); same as above.

Sandstone, grayish orange, same as above.

Sandstone, grayish yellow green and lt. gray (5GY 7/2 & N 7); same as above, silicified fossils.

Muddy sandstone, mod. brown (5YR 3/4); slope former; no fossils; mod. sorted, rd; mod. calc.

Sandstone, green and red mottled (10YR 4/2 & 10GY 5/2); same as above.

Interbed. lent., calc. ss, sltstn and mudstn, (5Y 5/2 & N 8); vth - th, ripple & wavy bed; isolated molds; Fe nod.

Muddy sandstone; vth, rip. and wavy bed; hash.

Bioclastic limestone, grayish and yellowish orange (10YR 6/6 & 10YR 7/4); ave - tk, wavy & rip. bed.

Interbedded calc., muddy ss, sltstn and sandy mudstn, varicolored; wavy and rip. bed; rip. o. o. p., 2" c - c, low amp.; molds and silic. frags.

Sandy, bioclastic limestone, (10YR 7/4 & N 1).

Mainly sandstone with muddy sandstone and fossil hash layers, yellow green and grayish orange (5GY 7/2 & 10YR 7/4); th - tk, wavy, ripple, graded and trough x- bedded; some green sand ripups; molds, hash abund. and aligned; th, green mudstn interbeds (upper).

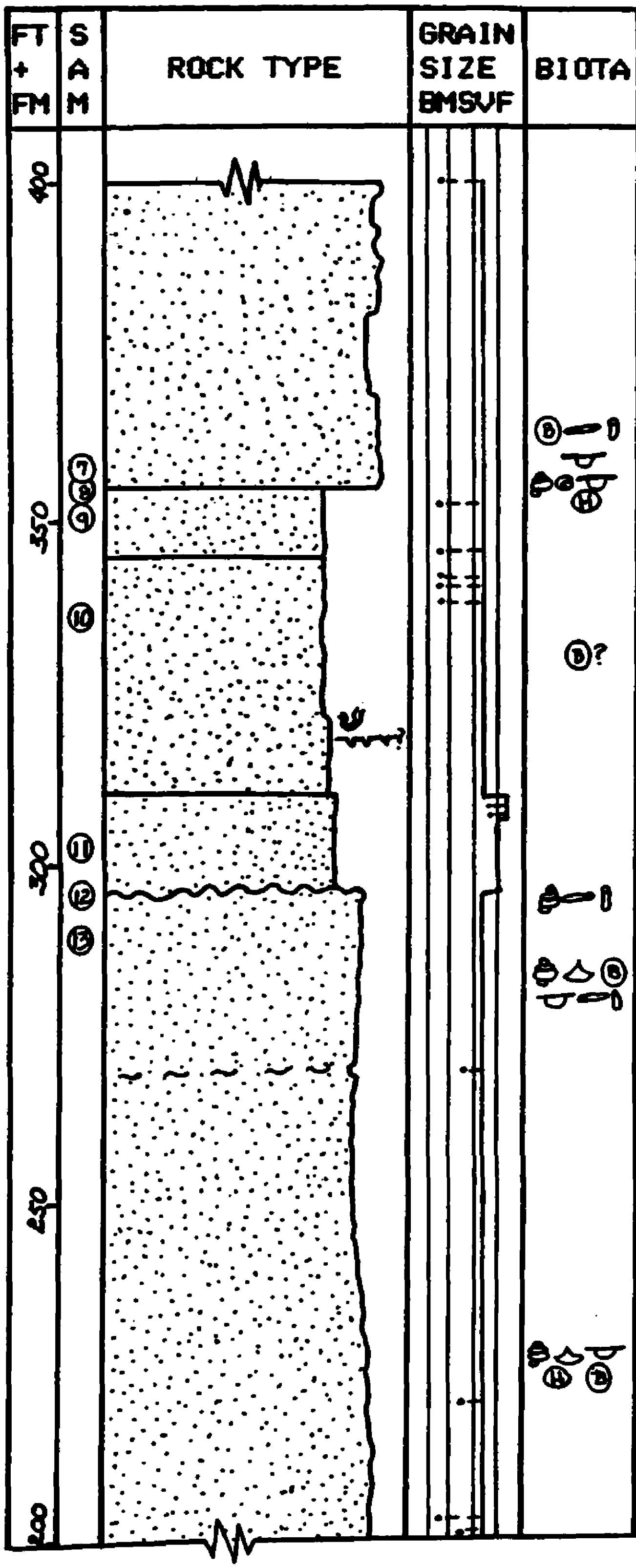
Sandy, bioclastic limestone, greenish gray (5GY 6/1); ave bed, lent. beds; molds on bed surface.

Sandstone, greenish gray and lt. gray (5GY 6/1 & N 7); vth - ave, wavy and ripple bedded; v. f. gr., well sorted, rd; v. calc. Minor trough-shaped beds, normal graded beds, shell molds, and mottled, interbedded, red mudstones.

Sandstone, lt. olive gray (5Y 6/1); lam - th, ripple and tabular beds; well sorted, rd; v. sl. calc.

Sandstone, dk. reddish brown (10YR 3/4); th bedded; lt. gray lenses.

HOGBACK MOUNTAIN
(CONTINUED)



DESCRIPTION

Sandstone and muddy sandstone, lt. olive gray and yellowish gray (5Y 6/1 & 5Y 7/2); bedding, vth - mass. (thickness varies throughout), wavy, rippled and flaser (?); ewll & dwnll lams; v. f. gr., well sorted, rd; v. calc.; mud drapes rare; mottled layers; Fe nodules.

Sandstone, dusky yellow green (5GY 5/2); vth - ave, ripple bedded, same as above; weathers greenish brown. Color change sharp above & below.

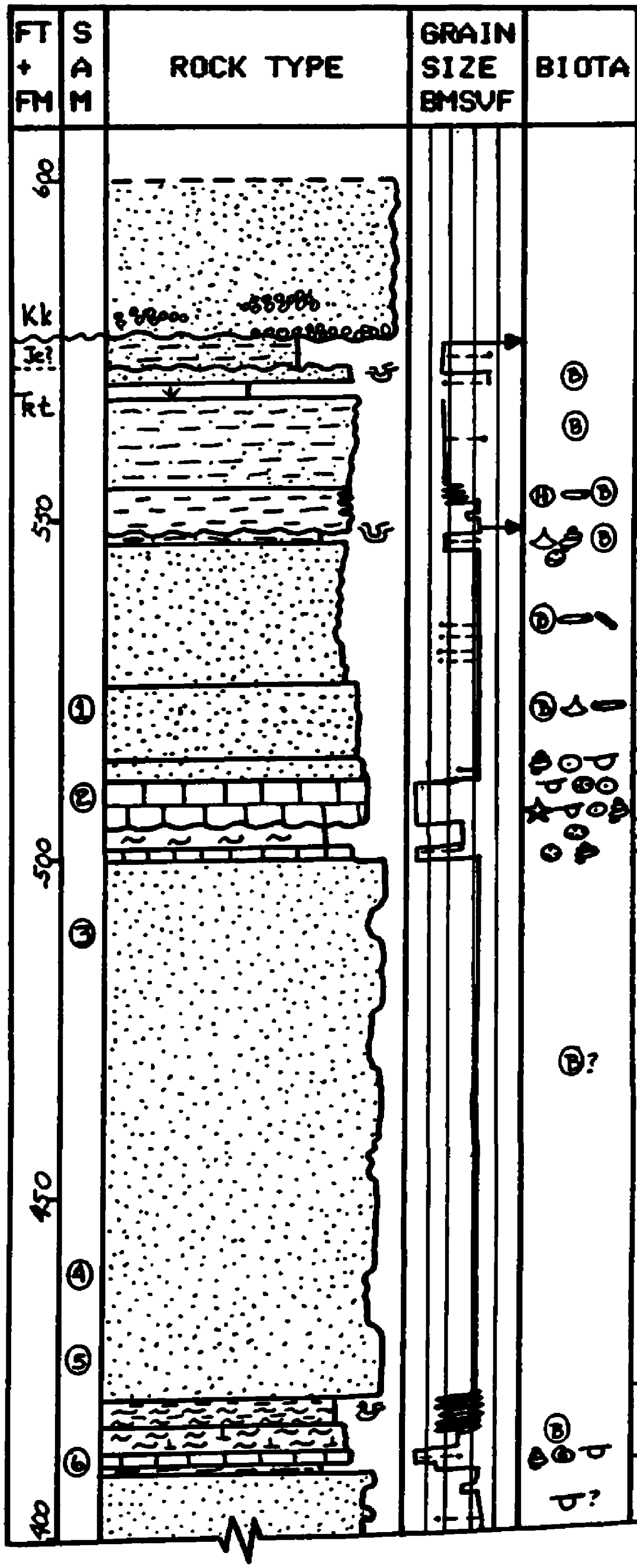
Sandstone and muddy sandstone, red and green mottled and alternating layers (5R 4/2 & 5GY 5/2); vth - ave, ripple & wavy bedded; ripples climb.; cracked & mottled bed surfaces @ 320 ft (97 m).

Sandstone, grayish orange (10YR 7/4); color change with above is sharp; bedding thickness varies, thinner @ top and base; same as above.

Sandstone, same as below.

Sandstone, olive green and grayish orange (5Y 5/2, 5Y 6/1, & 10YR 7/4); vth - tk, wavy and ripple bedded; minor trough-shaped beds; ripples complex + interferance; shell molds, fossils, fossil hash, and burrows scattered and conc. and alligned in thin layers throughout; v. f. gr., well sorted, rd; v. calc.; minor Fe nodules.

HOGBACK MOUNTAIN
(CONTINUED)



DESCRIPTION

Cong. sandstone, med. scale troughs; poor sort.

Sandy mudstone, pale green (10G 6/2); vth bed.

Sandstone, tk - ave bedded; lams, scours; cherty.

Sandy mudstn, (5Y 6/1 & N 5); th- ave bed (base); ave-tk (top); scours, wave rip. (1′ c - c); lam chert nod., lenses; qtz. "eyes".

Interbed. calc. ss, sltstn and mudstn, green. gray and yellow. brown (5GY 6/1 & 10YR 4/2); lam - vth, rip. and normal graded bed; basal units, poorly sorted, round. shell frags; mottled.

Sandstone, greenish and yellowish gray and yellowish orange (5Y 5/2 & 10YR 7/4); vth - ave, wavy and rip. bed; some lent. beds; rip. complex, sym. & assym., flattened, < 6" c - c, low amp., some 45 deg. to base; wave ripples < 1′ (.3 m) c - c.; th mud drapes; well sort, rd; v. calc.; Fe nod. abund.; isolated molds.

Sandstone, olive gray (5YR 4/1); tk - mass. bedded; shell molds, starfish mold (?), trails; Fe nod.

Silt- to sandstone; limestone nodules and ripups.

Bioclastic limestone; limestone nodules and patches; chert layer.

Calc. sltstn, ave-tk bed; ewll lams; minor chert.

Silty limestone, ave - tk bedded.

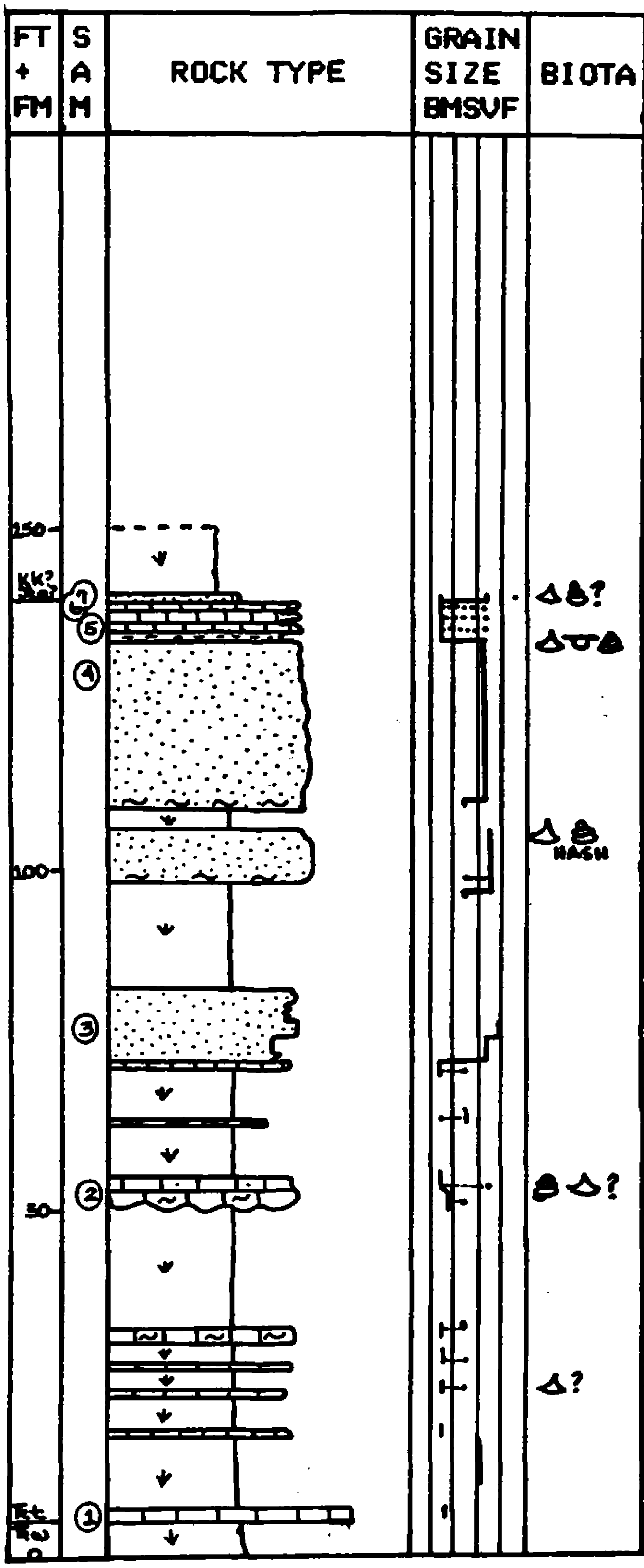
Sandstone, yellowish gray and lt. olive gray (5Y 7/2 & 5Y 6/1); bedding thickness varies throughout, wavy and rippled, with some dwnll lams; wave ripples up to 8 in. c - c, low amplitude; v. f. gr., well sorted, rd; v. calc.; Fe nodules scattered.

Interbedded calcareous, sandy siltstone and mudstone and bioclastic limestone, dusky yellow and grayish orange (5Y 6/4 & 10YR 7/4); vth - tk, ripple, flaser (?), graded and irregular bedded; mud drapes. Bioclastic layer contains 2 types of gastropods. Fe nodules present.

FOSSIL CREEK

T12S R2W S4

Pamela G. L. Sikkink



DESCRIPTION

Sandstone (3 in. bed), th - ave bedded; mod. - poor sorted; contains clay ripups.

Silty limestone, (10YR 8/6); th - ave, wavy and irreg. bed; green & gray clay ripups common. Regular interbeds of green claystone (10GY 5/2) and green & red shale.

Sandstone, v. lt. gray (N8); tk - ave, wavy bedded; some small lams; fair - well sorted, rd; minor siltstone interbeds; weathers lt. gray.

Sandstone, v. lt. gray (N6); same as below; minor siltstone interbeds at base; weathers lt. gray.

Sandstone, lt. olive gray (5Y 6/1) to med. lt. gray (N6); vth - ave, wavy bedded with minor lams; sl. calc.; well sorted; rd; irreg. outcrops.

Silty limestone, lt. olive gray (5Y 6/1); vth, wavy bedded; weathers lt. gray.

Calcareous siltstone, yellowish gray (5Y 7/2); vth, wavy & irregular bedding; some green, fissile shale at base.

Silty and sandy limestone, (5Y 6/4) and (N8); th, wavy bedded; vth mud drapes (<1/16 ") separate beds.

Siltstone, red, calcareous; forms talus & vegetated slope.

Same as below, very silicified.

Same as below; thins laterally.

Silty limestone, lt. brownish gray (5YR 6/1); ave, wavy bedded; small, silicified fossils; outcrops discontinuous.

Same as below.

Covered slope, red.

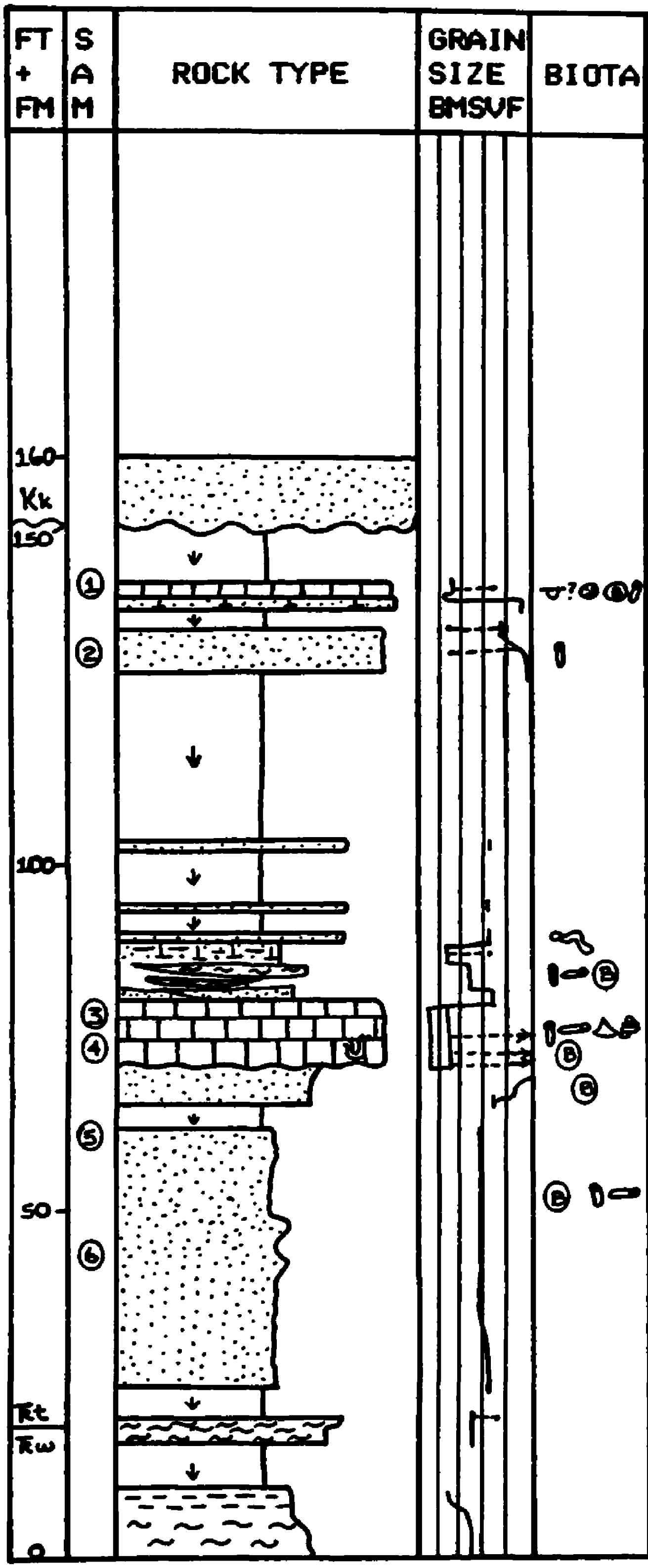
Limestone, lt. brownish gray (5YR 6/1); vth-ave bedded; green clay chips at base.

Siltstone, reddish brown.

RUBY RIVER CANYON CAMP

T9S R3W S17

Pamela G. L. Sikkink



DESCRIPTION

Sandstone and conglomerate, undetermined thickness, med. gray (N 5), "salt & pepper" texture; med. gr., mod. sorted, sa - ang.

Sandy limestone and limey sandstone, brownish gray (5YR 4/1); ave - tk, wavy bedded; fair sorted, sbrd-rd; middle shale (6 in. thick), gray, fissile, v. calc.

Sandstone, lt. olive gray (5Y 5/2); ave - th, wavy bedded; well sorted, sbrd-sa, mod. calc.; some thin, sm. scale ripples near top. Unit highly fractured. Weathers reddish.

Sandstone, grayish yellow green (5GY 7/2), th-tk, wavy bedded; well sorted, rd; v. calc.; fractured.

Sandstone, olive gray (5Y 4/1), same as above.

Sandstone, dk. yellowish brown (10YR 4/2), s. a. a.

Sandy shale, red and green mottled, v. calc.

Calcareous siltstone and sandstone, th - ave bedded; well sorted, rd; mod. calc.

Sandy limestone, med.- to light gray (N5 - N6); tk - mass., contorted and loaded beds; sand lenses are coarse grained, poorly sorted, sa-ang; chert lenses abundant.

Sandstone, dusky yellow (5Y 6/4); th-tk, wavy bedded; mod. - poor sorted, sbrd - ang; chert nodules and lenses; minor limestone interbeds.

Sandy siltstone and sandstone, pale yellowish brown and brownish gray (10YR 6/2 & 5YR 4/1); vth - ave, wavy and cl. ripple bedded; v. f. gr. - silt, well sorted, rd; fines slightly upward; weathers red-brown and lt. gray.

Siltstone, pale yellowish brown (10YR 6/2); ave - vth, wavy bedded; v. sl. calc.; weathers lt. gray & greenish. Thickens laterally.

Calc. siltstone and mudstone, reddish brown (10R 4/6); vth-ave, wavy and cl. rip. bed; v. calc.; lower part sandy with fine, well sorted, rd grains.

APPENDIX B: PETROGRAPHIC DATA

TABLE 8: ABBREVIATIONS USED IN PETROGRAPHIC [illegible]

Classifications after Folk (1959, 1962); Dunham (1962); and Wilson (1975) in Flugel (1982). Abbreviated as needed.

CEMENT	
Blocky, Blky	Blocky
Dt	Dogtooth
Dr	Drusy
Fib, Fi	Fibrous
Mic, Mi	Micrite
Min	Miniscus
R	Rims
FOSSILS	
Amm	Ammonites (and Nautiloids)
Brach, Bra	Brachiopods
Cr	Crinoid ossicles
Ech, Ec	Echinoderms
Fs	Fish scales
Foram	Forams
Gast, Gas, Ga	Gastropods
Os	Ostracods
Pel	Pelecypods
Sp	Sponge
ALGAE	
BGrn	Cyanophyte
Dasy	Dasyclad
Green, Grn	Chlorophyta
Mat	Algal mat
Org	Unidentified organics
Red	Rhodophyta
Stro	Stromatolite
FABRIC	
Bio, Bi	Bioturbation
Bu	Distinct burrows
Ca	Cryptalgal
Fe	Fenestral
Fiss, Fi	Fissure [illegible]
Gb	Graded beds
Gp	Geopetal
Homo	Homogeneous
Lam, La	Laminations
Nod	Nodular
Os	Open space
Rh	Root hairs
[illegible]	[illegible]
[illegible]	[illegible]

TABLE 8: ABBREVIATIONS USED IN PETROGRAPHIC DATA CONTINUED

LIMESTONE PARTICLES	
Agg, Ag	Aggregate grains
Bc	Bioclast
Bm	Eiomorph
Cort, Cor	Cortoid
Cs	Calcispheres
Crypt	Crypto-crystalline
Lith, L, Lc	Lithoclast (intra- or extra-clast)
Oo	Ooid
On	Oncoid
Pel, Pe	Peloid
DIAGENETIC MINERALS	
Dolo	Dolomite
Chert	Chert
COLOR	
Bk	Black
Br	Brown
Gr	Green
Rd	Rd
SIZE	
Cm	Centimeter
Mic	Micron
Mm	Millimeter
RELATIVE ABUNDANCE	
A	Abundant
C	Common
P	Present
R	Rare
N	Not found

* Most abundant feature in each category listed first on Table ## ... Cast Pel, Cr = Cast >Pel >Cr.

** ? = questionable identification of fossil, texture, etc.

Table 9.--Standard Microfacies Types (after Wilson, 1975, and E. Flugel, 1972) (From Flugel, 1982, p. 406-407)

SMF TYPE	FEATURES	FACIES ZONE
1	SPICULITE. Dark clayey mudstone or wackestone rich in organic substance, or siliceous spiculitic calcisiltite. Spicules usually oriented, generally siliceous monaxons, commonly replaced by calcite	Basin, deep water environment with slow sedimentation
2	MICROBIOCLASTIC CALCISILTITE. Small bioclasts and peloids in very fine-grained grainstone or packstone; mm ripple cross-bedding common	Basin; Open sea shelf near the lower slope; deeper shelf margin
3	PELAGIC MUDSTONE AND WACKESTONE. Micritic matrix containing scattered pelagic microfossils (e.g. radiolarians or globigerinids) or megafauna (e.g. graptolites or thin-shelled pelecypod fragments)	Basin, deep water environment with slow sedimentation; deeper shelf margin
4	MICROBRECCIA OR BIOCLASTIC-LITHOCLASTIC PACKSTONE. Worn grains, often graded. Polymict or monomict in origin. Also quartz, cherts, and carbonate detritus	Deep shelf margin; fore-slope talus (include the "allodapic limestones" after Meischner (1965))
5	GRAINSTONE-PACKSTONE OR FLOATSTONE with bioclasts derived from reef dwellers and reef builders. Geopetal filling and umbrella effects from infiltered finer sediment	Typical reef flank facies
6	REEF RUDSTONE with large bioclasts or broken colonies of framework builders; no matrix material	Fore-reef slope, debris from the reef; commonly in high-energy zone
7	BOUNDSTONE. Sessile organisms in situ. Subtypes framestone, bindstone, or bafflestone	Organic reef, often found on platform margin
8	WACKESTONE WITH WHOLE ORGANISMS which are rooted in micrite. Only a few bioclasts. Well-preserved infauna and epifauna	Open sea shelf near the lower slope; shelf lagoon with open circulation; quiet water below normal wave base
9	BIOCLASTIC WACKESTONE or bioclastic micrite. Fragments of diverse organisms which have been texturally homogenized through bioturbation. Bioclasts may be micritized	Open sea shelf near the lower slope; shallow waters with open circulation at or just below wave base
10	PACKSTONE-WACKESTONE with coated and worn bioclasts	Open sea shelf near the lower slope; textural inversion; dominant particles are from high-energy environment on shoals and have moved down local slopes to be deposited in quiet water
11	GRAINSTONES with coated bioclasts in sparry cement	Winnowed platform edge sands; areas with constant wave action, at or above wave base
12	COQUINA, BIOCLASTIC PACKSTONE, GRAINSTONE OR RUDSTONE WITH CONCENTRATIONS OF ORGANISMS, whereby certain types of organisms dominate (e.g. dasyclads, shells, or crinoids)	Commonly on slopes and shelf edges

TABLE 9 (CONTINUED)

13	ONCOID BIOSPARITE GRAINSTONE	Moderately high-energy area, very shallow water
14	LAGS. Coated and worn particles, in places mixed with ooids and peloids which are blackened and iron stained; with phosphate; also allochthonous lithoclasts; usually thin beds	Slowed accumulation of coarse materials in zoone of winnowing
15	OOLITES of well-sorted, well-formed ooids with tangential microstructures, commonly from 0.5 to 1.5 mm in diameter, fabric usually overpacked; always cross-bedded	High-energy environment on oolite shoals, beaches, and tidal bars
16	GRAINSTONE WITH PELLETS. Probably fecal pellets, in places admixed with concentrated ostracod tests or foraminifera	Textural inversion; or very warm shallow water with only moderate water circulation
17	GRAPESTONE, PELSPARITE OR GRAINSTONE with aggregate grains (grapestones and lumps), isolated and agglutinated peloids, some coated particles	Textural inversion; or shelf with restricted water circulation and tidal flats
18	FORAMINIFERAL OR DASYCLADACEAN GRAINSTONES with concentrations of their skeletal grains	Textural inversion; or in tidal bars and channels of lagoons
19	LOFERITE, LAMINATED mudstone-wackestone, grading occasionally into pelsparite with fenestral fabrics. Often ostracod-peloid assemblage, sporadic foraminifera, gastropods, and algae	Very restricted bays and ponds
20	ALGAL STROMATOLITE MUDSTONE	
21	SPONGIOSTROME MUDSTONE. Tufted algal fabric in fine-grained micrite lime mud sediment	In tidal ponds
22	MICRITE WITH LARGE ONCOIDS, wackestone or floatstone	Quiet water environments, shallow water, backreef; often on the edges of ponds or channels
23	UNLAMINATED, HOMOGENEOUS UNFOSSILIFEROUS PURE MICRITE, sometimes crystals of evaporitic minerals	Restricted platforms; in hypersaline tidal ponds
24	RUDSTONE OR FLOATSTONE WITH COARSE lithoclasts and bioclasts. Clasts usually consist of unfossiliferous micrite or calcisiltite; sometimes imbricate texture and crossbedding; matrix sparse	Formed as a lag deposit in tidal channels ("intraformational breccia")

SAMPLE NUM	FIELD DIV.	FOLK CLASS	DUNHAM CLA	MICROFACIE
GC-06	A	BIOMICRITE	BINDSTONE	20
GC-08	A	CLASTIC	CLASTIC	0
HPS-03	A	SPAR.BIOMICRITE	MUD-WACKESTONE	9
HPS-04	A	BIOPELMICRITE	WACKESTONE	9
HPS-05	A	FOSSIL-MICRITE	MUDSTONE	14
LSC-01	A	BIOSPARITE	PACKSTONE	14
LSC-02	A	PACK.BIOMICRITE	WACKE-PACKSTONE	10
LWC-01	A	BIOMICRITE	WACKESTONE	9
LSC-03	B	CLASTIC	CLASTIC	0
DCC-09	C	BIOSPARITE	BIOCLAS-GRAINST	14
GC-01	C	BIOSPARITE	WACKESTONE	9
GC-02	C	BIOMICRITE	BINDSTONE	20
HPS-07	C	BIOPELMICRITE	WACKE-GRAINSTON	16
HPS-08	C	PELMICRITE/SLT	BINDSTONE	20
HPS-09	C	SANDY MICRITE	WACKESTONE	9
HPS-10	C	CLASTIC	CLASTIC	0
LSC-05	C	PELMICRITE	PELOID MUDSTONE	9
WSC-01	C	BIOSPARITE	SANDY MUDSTONE	9
WSC-02	C	PELSPARITE	PELLET MUDSTONE	9
LSC-06	D	CLASTIC	CLASTIC	0
DCC-02	E	BIOSPARITE	PELEC-PACKSTONE	12
DCC-07	E	PACK.BIOMICRITE	ECH. PACKSTONE	10
GC-04	E	BIOMICRITE	BINDSTONE	20
GC-05	E	BIOMICRITE	WACKESTONE	14
LSC-08	E	MICRITE	WACKESTONE+PEL	23
LWC-02	F	PELMICRITE	MUD- WACKESTONE	23
LWC-03	F	PELLETIF-MICRIT	MUDSTONE	20
LWC-04	F	PELMICRITE	MUDSTONE	20
LWC-05	F	MICRITE	MUDSTONE	20
DCC-08	G	MICRITE	SILTY MUDSTONE	23
HPS-11	G	BIOMICRITE	MOLL. WACKESTN	9
HPS-12	G	PACK BIOMICRITE	BIOCL. PACKSTN	12
HPS-14	G	BIOMICRITE	ECH. PACKSTONE	12
LSC-09	G	BIOMICRITE	WACKESTONE	0
LWC-07	G	INTRABIOSPARITE	RUDSTONE	24
LWC-08	G	BIOCLAS.SPARITE	WACKE-PACKSTONE	14
LWC-09	G	SPAR.BIOMICRITE	WACKESTONE	9
LWC-10	G	BIOMICRITE	ECH. PACKSTONE	14
LWC-11	G	BIOMICRITE	WACKESTONE	9
LWC-12	G	BIOMICRITE	ECH. PACKSTONE	12
DCC-06	H	DISMICRITE	MUDSTONE	23
HPS-16	H	ALGALBIOMICRITE	ALGAL WACKESTN	19
HPS-16A	H	DOLOMICRITE	CHERTY MUDSTONE	0
HPS-17	H	SANDY MICRITE	SANDY MUDSTONE	14
HPS-17A	H	CHERTY MICRITE	CHERTY MUDSTONE	0
HPS-19	H	PELMICRITE	PEL. WACKESTONE	9
LWC-13	H	PACK.BIOMICRITE	WACKE- PACKSTN	10
LWC-14	H	BIOMICRITE	WACKESTONE	14
LWC-15	H	MICRITE	MUDSTONE	0

SAMPLE NUM	FIELD DIV.	FOLK CLASS	DUNHAM CLA	MICROFACIE
DCC-03	I	OOLITIC MICRITE	OOLITIC PACKSTN	10
DCC-04	I	SILTY MICRITE	SILTY MUDSTONE	23
DCC-05	I	ALG.BIOMICRITE	BINDSTONE	14
HPS-20	I	CLASIC	CLASTIC	0
LSC-12	I	BIOMICRITE	WACKE-BINDSTONE	14
LWC-16	I	MICRITE	MUDSTONE	23
LWC-17L	I	SILT.BIOMICRITE	ECH. WACKESTONE	9
LWC-17P	I	SILTY BIOMICRIT	ECH. WACKESTONE	9
LWC-18	I	SANDY OOMICRITE	OOLITIC PACKSTN	15
LWC-19	I	SILTY OOMICRITE	OOLITIC PACKSTN	15
LWC-20	I	OOMICRITE	OOLITIC PACKSTN	15
DCC-01	J	SPARITE	MUDSTONE	0
HPS-21	J	BIOSPARITE	WACKE-PACKSTONE	9
HPS-22	J	BIOSPARITE	WACKE-BINDSTONE	9
LSC-13	J	PELLET.MICRITE	SANDY WACKESTN	10
LSC-15	J	PELLET.MICRITE	PELET.MUDSTONE	23
LWC-21	J	SRT. BIOMICRITE	PACKSTONE	12
LWC-22	J	CLASTIC	CLASTIC	0
LWC-23	J	ECH. BIOMICRITE	ECH. WACKESTONE	14
LWC-24	J	REXTALIZED	REXTAL BINDSTN?	0
LWC-25	J	CLASTIC	CLASTIC	0
WSC-03	J	BIOSPARITE	WACKESTONE	10
HPS-24	K	SPARITE	MUDSTONE?	23
LSC-16	K	BIOMICRITE	WACKESTONE	14
LWC-26	K	PELLET.BIOMICRI	PELLET.WACKESTN	10
LWC-27	K	PACK.BIOMICRITE	PELEC.PACKSTONE	0
LWC-28	K	CLASTIC	CLASTIC	0
LWC-29	K	BIOMICRITE	WACKE-PACKSTONE	12
WSC-04	K	MOLL. BIOMICRIT	MOLL. PACKSTONE	14
HPS-01	TRANS	CLASTIC	CLASTIC	0
HPS-02	TRANS	BIOMICRITE	WACKESTONE	9

SAMPLE NUM	CLASTIC GR	LIMESTN PA	DIAGENIC M	CEMENT
GC-06	RARE	BC/COR/LI		BLKY/FIBR
GC-08	ABUNDANT	PEL	DOLO?	MICRITE
HPS-03	COMMON	BC/BM/PEL		BLKY/FIBR
HPS-04	COMMON	OO/PE/LI/BM/BC		MICRITE/RIMS
HPS-05	RARE	BC/PE/LI	SILICA	MICRITE
LSC-01	NONE	BC/PE/BM/CORT	CHERT	BLOCKY
LSC-02	COMMON	BC/LI/BM	CHERT	MIC/BLKY/RIM
LWC-01	NONE	BM/BC/PE	CHERT	MICRITE
LSC-03	ABUNDANT	BC/PEL	CHERT?/DOLO	BLOCKY
DCC-09	ABUNDANT	BC/COR/LITH/PEL	DOLO	BLOCKY
GC-01	LAYERS(COMMON)	PE/LITH/CORT/BC		BLKY/MICR/FIB
GC-02	ABUNDANT	PE/LITH/BC		MICR/FIB
HPS-07	ABUNDANT	PE/BC/BM/LI/CS	DOLO	MIC/BLKY/FIB
HPS-08	ABUNDANT	PEL		FIBR
HPS-09	ABUNDANT			MICRITE
HPS-10	ABUNDANT	PEL		MICR/FIBR
LSC-05	ABUNDANT	PEL		MICR/FIB
WSC-01	LAYER(COMMON)	AG/PE/CORT		BLKY?
WSC-02	COMMON	PEL		BLOCK
LSC-06	ABUNDANT	PEL		MICRITE
DCC-02	ABUNDANT	BC/PEL/LIT		MICR/FIB
DCC-07	NONE	BC/PEL	CHERT	MIC/BLKY/FIB
GC-04	RARE (IN ALGAE)	BC		BLOCKY
GC-05	NONE	BM/BC/PEL/LITH		MICRITE
LSC-08	COMMON	PEL/LITH		MICRITE/BLKY
LWC-02	ABUNDANT	PEL	DOLO	MICRITE
LWC-03	COMMON	PEL	DOLO?	MICRITE
LWC-04	NONE	PE	CHERT	MICRITE
LWC-05	LAYERS(ABUND)	NONE	MANG.OXIDE	MICRITE
DCC-08	COMMON	BC/PEL/LITH		MICR/BLKY
HPS-11	COMMON	BC/PEL/CORT	CHERT	MICR+BLKY
HPS-12	NONE	BC/PEL/CORT	CHERT	MIC/BLKY/FIB
HPS-14	RARE-NONE	BC/CORT/PEL/LIT	CHERT	BLKY/MICR
LSC-09	RARE	BC	CHERT	MIC/BLKY/FIB
LWC-07	NONE	CS/PE/LI/BC/COR	CHERT/DOLO	BLKY/RIMS
LWC-08	NONE	BC	QTZ	BLKY+SILICA
LWC-09	COMMON (PATCHY)	BC/PEL/LITH	CHERT	MICR/FIB
LWC-10	NONE	BC/CORT	CHERT	MICR+BLKY
LWC-11	RARE (IN ALGAE)	BC/CORT	CHERT	MICR/BLKY
LWC-12	NONE	BC/CORT	CHERT	MICR+BLKY
DCC-06	NONE	BC	CHERT?	MICRITE
HPS-16	NONE	BC/OO/LC	CHERT/DOLO	MICR/BLKY/RIM
HPS-16A	NONE	PEL/CS	CHERT/DOLO	SILICA
HPS-17	COMMON	LC(SILICA)/CS	CHERT	MICRITE
HPS-17A	NONE	PEL/CS/BC	CHERT/DOLO	SILICA
HPS-19	ABUNDANT	PEL/OO/CS	DOLO	MICRITE
LWC-13	RARE (IN LITHC)	BC/LC/CO/PEL	CHERT	MICRITE
LWC-14	RARE	BC/PEL	CHERT	MICRITE
LWC-15	COMMON	PEL/CS/LI?	CHERT/DOLO	MICR(PATCHY)

SAMPLE NUM	CLASTIC GR	LIMESTN PA	DIAGENIC M	CEMENT
DCC-03	RARE	ON/OO	DOLO/CHERT	MIC/BLKY
DCC-04	ABUNDANT	NONE	CHALCEDONY	MICRITE
DCC-05	NONE	BC/PEL/LC?	DOLO/CHERT	BLOCKY
HPS-20	ABUNDANT	PEL?		MICRITE
LSC-12	COMMON	PEL/CS	QTZ	MICRITE
LWC-16	RARE	NONE		MICRITE
LWC-17L	COMMON	BC	CHERT	MICRITE
LWC-17P	COMMON	BC/PEL	CHERT	MICRITE
LWC-18	ABUNDANT	OO/LITH		MICRITE
LWC-19	ABUNDANT	OO		MICRITE
LWC-20	NONE	OO		MIC/BLKY
DCC-01	NONE		CHERT	BLKY/MICR
HPS-21	RARE	BC/CORT	DOLO?/CHERT	BLOCKY
HPS-22	NONE	BC/CORT	CHERT/DOLO?	BLKY/MICR
LSC-13	ABUND.(IN ALGA)	CS/BC/CORT/PEL	CHERT	MICR/BLKY
LSC-15	NONE	CS/PEL/BC	CHERT/DOLO	SILICA
LWC-21	NONE	BC	QTZ	BLKY/FIB/RIM
LWC-22	ABUNDANT	PEL?		MICRITE
LWC-23	NONE-RARE(LITH)	ON/BC/LITH/CORT	DOLO/CHERT	MICR/BLKY
LWC-24	NONE	BC?/CORT?	CHERT	BLKY/FIBR
LWC-25	ABUNDANT	PEL	CHERT	MICRITE
WSC-03	COMMON	PEL/CORT/LC/BC	CHERT	MICR/BLKY
HPS-24	ABUNDANT	BC/LITH	DOLO RHOMBS	MICR/BLKY
LSC-16	RARE (IN ALGAE?	CORT/CS/PEL?	CHERT	BLKY/MICR
LWC-26	NONE	CS/BC/CORT/PEL	CHERT	MICR/BLKY
LWC-27	NONE	CORT	CHERT/QTZ	SILICA
LWC-28	ABUNDANT	PEL		MICRITE
LWC-29	COMMON	BC/OO	CHERT/DOLO	MICR/BLKY
WSC-04	ABUND-COMMON	BC	CHERT	MICRITE
HPS-01	ABUNDANT	PEL		MICRITE
HPS-02	COMMON	BC	CHERT/DOLO	BLKY/FIB/RIM

SAMPLE NUM	FABRIC	SUPPORT	LITHOCLAST	MAX. GRAIN
GC-06	LAM/BIO/BU?	MATRIX	SLTST	1.5 MM
GC-08	BIO/GP	GRAIN	NONE	5 MIC
HPS-03	BIO/LAM/GP/BU?	MATRIX	NONE	10 MIC
HPS-04	BIO/OS/LAM	MATRIX	SLTST+SHELL	50 MIC
HPS-05	BIO/LAM	MATRIX	SLTSTN	5 MIC
LSC-01	BIO/OS/GP	GRAIN & MATRIX	NONE	1 MM
LSC-02	BIO/LAM/GP	GRAIN & MATRIX	MIC W/SLT&SHELL	7 MIC.
LWC-01	BU/STYO	MATRIX	NONE	5 MIC
LSC-03	LAM(VAGUE)	GRAIN	NONE	5 MIC
DCC-09	LAM/BU	GRAIN & MUD	SLTST + ORG	1 MM
GC-01	CA/FE/GB/LAM/BU	MATRIX	SLTST W/MICROFO	4 MM (CLAST)
GC-02	CA/LAM/BI	GRAIN	MICRITE	1 MM
HPS-07	LA/BI/DIS/GB/XB	GRAIN & MATRIX	SLST	10 MIC
HPS-08	LAM/CA/BIO/FISS	GRAIN	MICRITE?	5 MIC
HPS-09	LA/BIO/BU/GB/CA	GRAIN + MATRIX	NONE	5 MIC
HPS-10	LAM(INDISTINCT)	GRAIN	NONE	7 MIC
LSC-05	BIO/LAM/FISS/CA	MATRIX	NONE	7 MIC
WSC-01	LAM	MATRIX	NONE	2 MIC
WSC-02	LAM/BIO?/CA?	MATRIX	NONE	7 MIC
LSC-06	VAGUE LAM-HOMOG	GRAIN	NONE	5 MIC
DCC-02	VAGUE LAM	GRAIN	SLTST	15 MM
DCC-07	BIO/BU	GRAIN	NONE	20 MIC (SPINE)
GC-04	BIO/BU/LAM	MATRIX	NONE	5 MIC
GC-05	BIO/BU/GP/OS	MATRIX	SLTST	50 MIC
LSC-08	STYO/BIO?	MATRIX	SLTST +MICRITE	5 MIC
LWC-02	HOMOGENOUS	MATRIX	NONE	5 MIC
LWC-03	CA/LAM/OS/FE	MATRIX	NONE	2 MIC
LWC-04	LAM/CA/FE	MATRIX	NONE	1 MIC
LWC-05	LAM/OS/CA?	MATRIX	NONE	5 MIC
DCC-08	BIO/BU	MATRIX	SILTY MICRITE	5 MIC
HPS-11	OS/GP/LAM	MATRIX	NONE	10 MIC (BC)
HPS-12	GP/BU/LAM	GRAIN	NONE	1.5 MM
HPS-14	BIO	MATRIX & GRAIN		10 MIC (BC)
LSC-09	LAM/GR/STYO	MATRIX	NONE	2 MM
LWC-07	BIO/GP?	GRAIN	RED INTRACLASTS	2 MM (LITHO)
LWC-08	GP	GRAIN	NONE	1 MM
LWC-09	BIO?	MATRIX	SLTST(BORE+FRAG	1 MM
LWC-10		MATRIX & GRAIN	NONE	1 MM
LWC-11	BIO/BU	MATRIX	NONE	1 MM
LWC-12	BIO/BU	MATRIX & GRAIN	NONE	1 MM
DCC-06	BIO?	MATRIX	NONE	2 MIC
HPS-16	LAM/OS/CA/GB	MATRIX	RARE(MIC + SLT)	.5 MIC
HPS-16A	LAM	MATRIX	NONE	
HPS-17	PATCHY	MATRIX	1 LG. GRAY MUD	1 CM (LITHO)
HPS-17A	BIO/LAM/CA?	MATRIX	NONE	7 MIC
HPS-19	BIO/BUR	MATRIX	GRAY MUD+FORAMS	5 MIC
LWC-13	BIO	MATRIX	SLT IN MICRITE	.5 MM (LITH)
LWC-14	BIO	MATRIX	NONE	1 MM (BC)
LWC-15	BIO/DISS?	MATRIX	PATCHY AREAS?	5 MIC

PETROGRAPHIC DATA - TENDOY MOUNTAINS

SAMPLE NUM	FABRIC	SUPPORT	LITHOCLAST	MAX. GRAIN
DCC-03	GB/LAM/FE/OS	MATRIX	NONE	.5 MM
DCC-04	FE/LAM/BU?	MATRIX	NONE	1 MIC
DCC-05	DISS?/CA?	MATRIX	NONE	10 MIC
HPS-20	HOMO	GRAIN	NONE	7 MIC
LSC-12	BIO/BU?	MATRIX	NONE	50 MIC (BC)
LWC-16	HOMO	MATRIX	NONE	7 MIC
LWC-17L	HOMOGENEOUS	MATRIX	NONE	1 MIC
LWC-17P	HOMOGENEOUS	MATRIX	NONE	1 MIC
LWC-18	LAM/BIO/XBED	GRAIN	MICRITE (RD)	50 MIC
LWC-19	GB/LAM/XBED	GRAIN & MATRIX	NONE	30 MIC
LWC-20	HOMO/BIO?	GRAIN	NONE	25 MIC
DCC-01	STYO/REXTALIZED	GRAIN & MATRIX		10 MIC
HPS-21	FIBR/REXTAL/GP?	MATRIX	NONE	1 MM (BC)
HPS-22	FIBR/CA?	MATRIX	NONE	50 MIC
LSC-13	BIO/BU?	MATRIX	NONE	10 MIC
LSC-15	HOMO/LAM	MATRIX	NONE	
LWC-21	LAM/GB/BIO/OS	GRAIN	NONE	1 CM (BC)
LWC-22	HOMO	GRAIN	NONE	7 MIC
LWC-23	GP	MATRIX	RD SLTSTN	7 MM (LC)
LWC-24	REXTALIZED	MATRIX	NONE	
LWC-25	BIO/BU	GRAIN & MATRIX	NONE	5 MIC
WSC-03		MATRIX	WELL RD SLTSTN	20 MIC (BC)
HPS-24	GP?/BU?/GB/RH?	MATRIX	RARE (SLTSTN)	7 MIC
LSC-16	HOMO	MATRIX	NONE	20 MIC
LWC-26	LAM (VAGUE)	MATRIX	NONE	10 MIC
LWC-27	LAM/REXTAL	GRAIN?	NONE	
LWC-28	HOMO	GRAIN	NONE	10 MIC
LWC-29	GP	MATRIX	NONE	1 CM (BC)
WSC-04	LAM/BIO	GRAIN & MATRIX	NONE	1MM (BC)
HPS-01	HOMOGENEOUS	GRAIN	NONE	7 MIC
HPS-02	BIO/GP	MATRIX	NONE	1 MM (BC)

SAMPLE NUM	SORT / ROU	MICROFOSSI	MACROFOSSI	COLOR
GC-06	WELL/SR-RD	GRN/FORAMS	BRACH/GAST/LIM	BR
GC-08	WELL/SR-SA	NONE	BRACH	BR
HPS-03	MOD/SA-SR	FORAM	BRACH/GAS/AMMO	BR
HPS-04	MOD/RD-SR	FORAMS/ALGAE	GAS/BRACH/ROOT	BR
HPS-05	WELL/RD	FORAM	BRACH/LIM ECH	BR
LSC-01	POOR/SR-SA	BLUEGRN?	GAS/BRACH/LIMEC	BK
LSC-02	WELL/SR-RD	ROOT?	BRA/GA/AM/LIMEC	BK
LWC-01	WELL/SR-RD	FORAM/ALGA?	GAST	BR
LSC-03	WELL/SR-RD	NONE	CR	BR-BK
DCC-09	WELL/RD-SR	FORAM/GREEN	AM/BR/GA/EC/LIM	BK
GC-01	MOD/SR-RD	FORAM/GRN	GAST/AMMO?/LIM?	BK
GC-02	MOD/SR-RD	ALGAE(PHYLLOID)	BRACH	BK
HPS-07	WELL/SR-SA	ALGAE/FORAM	GAST	BK
HPS-08	VERY WELL/SR	ALGAE (GRN?)	NONE	BK-BR
HPS-09	WELL/SR-RD		ESCAPE BURROW	BK
HPS-10	VERY WELL/SR	ALGAE (GRN?)		BK
LSC-05	MOD/SA-SR	FORAM/GREEN?		BK
WSC-01	WELL/SA-SR	FORAMS/ALGAE/CS	GAST	BK
WSC-02	MOD/SR	FORAM/ALGAE?		BK
LSC-06	WELL/SA-SR	NONE	NONE	BR
DCC-02	WELL/SR-RD		PELECYPODS	BR
DCC-07	POOR/SA-SR	GREEN/BGRN?	EC/GA/BR/CR/LIM	BK
GC-04	WELL/SA-SR	ALGAE	PEL	BK-BR
GC-05	MOD/SR-SA	FORAM/GRN?	GA/BR/ROOT?/LIM	BK
LSC-08	WELL/SR-RD	NONE	NONE	BK-BR
LWC-02	SELL/SR-RD	NONE	NONE	BR
LWC-03	WELL/RD	ALGAE	NONE	BR
LWC-04	WELL	ALGAE UNSTRUCT.	NONE	RED
LWC-05	WLL/SR-RD	ALGAE?	NONE	RED
DCC-08	WELL/SA-ANG	ORG/BGRN?/GRN?	BRACH?	BR
HPS-11	BIOMODAL/SR-SA	GREEN+ENCRUST.	BRACH	BR
HPS-12	POOR/SR-SA	ALGAE (GRN)	EC/CR/BRA/PEL	BR
HPS-14	MOD-POOR/SR-RD	FORAM(RARE)	ECH/CR/BRA/GAS	BR-BK
LSC-09	POOR/SR-ANG	GRN?BGRN?	ECH/CR/PEL/BRA	BR
LWC-07	POOR/RD	FORAMS	EC/CR/GA/BRACH	RED
LWC-08	POOR/SR-RD		PEL?/ECH/LIMEC	BK
LWC-09	MOD-POOR/SR-SA	ALGAE(CYAN?)	EC/CR/GA/PE/BRA	BR
LWC-10	MOD-POOR/SR-SA		EC/CR/BR/PE/LIM	BR
LWC-11	POOR/RD-SA	ALGAE(ENCR+GRN)	ECH/CR/BRA/PEL	BR
LWC-12		ALGAE UNSTRUCT.	ECH/CR/BRACH	BR
DCC-06	V. WELL	NONE	NONE	BR
HPS-16	WELL/RD-ANG	GREEN	ECH/GAS/CR/LIM	BR-BK
HPS-16A			ECH(RARE)	BR
HPS-17	WELL/SR-RD	FORAMS	LIMONITE ECH	BR
HPS-17A	WELL/SR-SA	NONE	ECH/BRACH(RARE)	BR
HPS-19	WELL/SA-SR	FORAMS	ECH/GAS/BRACH	BR
LWC-13	BIMODAL/RD-SBRD	FORAMS	ECH/BRA/GAS/LIM	BR
LWC-14	MOD-POOR/SR-SA	FORAMS	GAS/BRA/ECH/LIM	BR-BK
LWC-15	WELL-MOD/SR-RD	FORAMS	NONE	BR

SAMPLE NUM	SORT / ROU	MICROFOSSI	MACROFOSSI	COLOR
DCC-03	POOR/RD-SR	NONE	NONE	BR
DCC-04	WELL/SA-RD	NONE	NONE	BR
DCC-05	POOR/SR-SA	FORAM	PEL?/ECH/LIMECH	BR
HPS-20	WELL/SR-SA		NONE	BR-BK
LSC-12	POOR/SR-SA		ECH/LIM ECH	BR
LWC-16	WELL/SR-RD	NONE	NONE	BR
LWC-17L	WELL/SR-SA	NONE	ECH/CR	BR
LWC-17P	WELL/SR-SA	NONE	ECH/CR/BRA/PEL	BR
LWC-18	WELL/RD	NONE	NONE	BR
LWC-19	WELL/RD	NONE	NONE	BR
LWC-20	MOD-WELL/RD	NONE	NONE	BR
DCC-01	MOD/SR-RD	FOR/GRN/BGRN?	BRACH(RARE)/LIM	BR
HPS-21	POOR/SR-RD	GRN?	ECH/BRACH?/LIM	BR
HPS-22	WELL	ORG	ECH/BRACH/LIMEC	BR-BK
LSC-13	WELL/SR-SA		ECH?/LIM ECH	BR
LSC-15		ORG?	NONE	BR
LWC-21	WELL/SA-SR	NONE	PEL/GAS?	BR-BK
LWC-22	WELL/SR-SA	ORG	NONE	BR
LWC-23	POOR/SR-RD	ENCR ALGAE	EC/CR/GA/BR/LIM	BR
LWC-24		ALGAE?(GRN?)	PEL?	BR
LWC-25	WELL/SR-RD	NONE	NONE	BR
WSC-03	WELL/SA-SR	FORAM	ECH/GAST/LIM EC	BR
HPS-24	WELL/SA-SR		CR/BRA	BR
LSC-16	MOD/RD-SR		ECH/LIM ECH	BR
LWC-26	WELL/SR-RD	ALGAE/FORAMS	PEL	BR
LWC-27		NONE	ECH/PEL?	BR-BK
LWC-28	WELL/SA-SR	NONE	NONE	RED
LWC-29	WELL/SR	NONE	MOLLUSK	BR
WSC-04	POOR-MOD/SA-SR		PE/BR/EC/GA/LIM	BR
HPS-01	WELL/SR-RD	NONE	NONE	BR
HPS-02	WELL/SR	NONE	GAS/BRACH	BR-BK

SAMPLE NUM	FIELD DIV.	FOLK CLASS	DUNHAM CLA	MICROFACIE
FC-01		MICRITE	MUDSTONE	0
FC-02		OOSPARITE	GRAINSTONE	15
FC-04		CLASTIC+MICRITE	CLASTIC+MUDSTN	0
FC-05		OOMICRITE	PACKSTONE	15
FC-06		SANDY MICRITE	SANDY MICRITE	0
FC-07		OOINTRAMICRITE	FLOATSTONE	22
RRC-01		MICRITE	MUDSTONE	23
RRC-02		CLASTIC	CLASTIC	0
RRC-03		ALGA.BIOMICRITE	MUDSTONE	14
RRC-04		CLASTIC	CLASTIC	0
RRC-05		CLASTIC	CLASTIC	0
RRC-06		CLASTIC	CLASTIC	0
BDC-01	LOWER	PACK. BIOMICRIT	WACKE-PACKSTN	14
BDC-02	LOWER	PACK. BIOMICRIT	WACKE-PACKSTN	14
HM-19	LOWER	BIOMICRITE	MOLLUSK WACKEST	14
HM-20	LOWER	BIOMICRITE	BIOMICRITE	14
HM-21	LOWER	PACK. BIOMICRIT	WACKE- PACKSTN	9
HM-22	LOWER	CLASTIC	CLASTIC	0
HM-23	LOWER	CLASTIC	CLASTIC	0
HM-24	LOWER	BIOMICRITE	MUDSTN+CLASTIC	0
HM-25	LOWER	CLASIC	CLASTIC	0
BDC-04	MIDDLE	PACK. BIOMICRIT	PACKSTN +SLTSTN	14
BDC-06	MIDDLE	CLASTIC	CLASTIC	0
BDC-07	MIDDLE	CLASTIC	CLASTIC	0
BDC-09	MIDDLE	CLASTIC	CLASTIC	0
BDC-10	MIDDLE	CLASTIC	CLASTIC	0
BDC-11	MIDDLE	SPARCE BIOMICRI	MUDSTONE	9
HM-03	MIDDLE	CLASTIC	CLASTIC	0
HM-06	MIDDLE	FOSS. OOMICRITE	FLOATSTONE	22
HM-08	MIDDLE	MICRITE	MUDSTONE	0
HM-10A	MIDDLE	PELLET. MICRITE	SANDY MUDSTONE	23
HM-10B	MIDDLE	DISMICRITE	SANDY MUDSTONE	23
HM-11	MIDDLE	CLASTIC	CLASTIC	0
HM-12	MIDDLE	CLASTIC	CLASTIC	0
HM-15	MIDDLE	CLASTIC	CLASTIC	0
HM-16	MIDDLE	CLASTIC	CLASTIC	0
HM-17	MIDDLE	CLASTIC	CLASTIC	0
HM-18	MIDDLE	CLASTIC	CLASTIC	0
BDC-12	UPPER	CLASTIC	CLASTIC	0
BDC-13	UPPER	FOSS. DOLOMICRI	MUDSTN & BINDST	20
BDC-15	UPPER	SAND. BIOMICRIT	WACKESTN-BINDST	3
BDC-16	UPPER	BIOMICRITE	WACKESTONE	14
HM-02	UPPER	PACK. BIOMICRIT	WACKESTONE	9

SAMPLE NUM	CLASTIC GR	LIMESTN PA	DIAGENIC M	CEMENT
FC-01	COMMON	NONE		MIC/BLKY
FC-02	RARE (PATCHY)	OO/ON		MICR/BLKY
FC-04	ABUNDANT	NONE		MICRITE
FC-05	COMMON	OO/ON (MICRITE)	CHERT	MICRITE
FC-06	ABUNDANT	NONE	CHERT	MICRITE
FC-07	COMMON	OO/ON/LITH	CHERT?	MICR/BLKY
RRC-01	RARE-COMMON	NONE	DOLO/FRACTURES	MICRITE
RRC-02	ABUNDANT	NONE		MICR/BLKY
RRC-03		CS/OO?	CHERT	MICR/BLKY
RRC-04	RARE	LC/ON		MICRITE
RRC-05	ABUNDANT	NONE		MICRITE
RRC-06	ABUNDANT	NONE		MICRITE
BDC-01	RARE (IN LITH)	BC/CS/LI/CO/PEL		MICRITE
BDC-02	COMMON	CORT/PEL/CS/BC		MICRITE
HM-19	COMMON	BC/COR/BM/AGG		MICRITE
HM-20	RARE	BC		MICRITE
HM-21	COMMON	BC/CORT		MICRITE
HM-22	ABUNDANT	PEL/BC	CHERT	BLOCKY
HM-23	ABUNDANT	PEL	CHERT	MICRITE
HM-24	ABUNDANT(LENS)	BC		MICRITE
HM-25	ABUNDANT	PEL	DOLO	DOLO?
BDC-04	ABUND. IN LAYER	BC/CO/CS/PEL/LI	DOLO (PART)	MICRITE
BDC-06	ABUNDANT	BC (RARE)		MICR (RARE)
BDC-07	ABUNDANT	NONE		MICRITE
BDC-09	ABUNDANT	NONE	DOLO	MICRITE
BDC-10	ABUNDANT	BC (RARE)	DOLO?	MICRITE
BDC-11	RARE	BS/CS/PEL	CHERT	SILICA
HM-03	ABUNDANT	NONE	DOLO RHOMBS	MICRITE
HM-06	RARE	OO/COR/AG/BC/ON	DOLOMITE	MIC/BLKY/RIM
HM-08		BC?		MICRITE
HM-10A	ABUNDANT	PEL		MICRITE
HM-10B	ABUNDANT	PEL		MICRITE
HM-11	ABUNDANT	NONE		MICRITE
HM-12	ABUNDANT	BC		MICRITE
HM-15	ABUNDANT	PEL?		MICRITE
HM-16	ABUNDANT	NONE		MICRITE
HM-17	ABUNDANT	NONE		
HM-18	ABUNDANT	NONE		MICRITE
BDC-12	ABUNDANT	PEL (RARE)	CHERT	MICRITE
BDC-13	ABUNDANT	BC	CHERT/DOLO	MICRITE
BDC-15	ABUNDANT	BC/ON/CS	CHERT	MICRITE
BDC-16	RARE	BC/CORT/PEL	CHERT	MICRITE
HM-02	COMMON	BC/CS/PEL/CORT	CHERT	MICRITE

SAMPLE NUM	FABRIC	SUPPORT	LITHOCLAST	MAX. GRAIN
FC-01	BIO/OS	MATRIX	NONE	1 MIC
FC-02	HOMO	GRAIN	NONE	20 MIC (OO)
FC-04	LAM/GB/OS/XBED	MATRIX+GRAIN	NONE	10 MIC
FC-05	HOMO/OS	GRAIN	NONE	25 MIC (OO)
FC-06	BIO/BU/OS	MATRIX	NONE	10 MIC
FC-07	OS/GB/XBED	GRAIN+MATRIX	MICRITE INTRACL	50 MIC (LC)
RRC-01	FRACTURED	MATRIX	NONE	5 MIC
RRC-02	HOMOGENEOUS/BU?	GRAIN	NONE	20 MIC
RRC-03	OS/BU(FILLED?)	MATRIX	NONE	1 MIC
RRC-04	COARSE GRAINS	MATRIX/GRAIN	RD. SLTSTN	50 MIC
RRC-05	LAM (RARE)	GRAIN	NONE	5 MIC
RRC-06	LAM/OS	GRAIN	NONE	5 MIC
BDC-01	BIO/LAM/OS	GRAIN & MATRIX	RD SLTSTN + MIC	1 MM (LC)
BDC-02	GB/XB/OS/BIO	GRAIN & MUD	NONE	5 MIC
HM-19	OS/LAM/BIO/BU	MATRIX	NONE	1 MM (BC)
HM-20	FE/OS/BU	MATRIX	NONE	1 MIC
HM-21	LAM/OS	MATRIX/GRAIN	NONE	1 MIC
HM-22	HOMO/OS	GRAIN	NONE	7 MIC
HM-23	HOMO/BIO	MATRIX	NONE	1 MIC
HM-24	LAM/X-LAM/BIO	MATRIX/GRAIN	NONE	5 MIC
HM-25	XB/GB/LAM/BI/BU	GRAIN & MATRIX	NONE	2 MIC
BDC-04	DISCONT/FE/BU	GRAIN & MUD	RD SLTSTN	1 MM (LC)
BDC-06	LAM/BIO/FE/OS	GRAIN	NONE	10 MIC
BDC-07	HOMO/OS/BIO?	GRAIN	NONE	10 MIC
BDC-09	BIO/FE/LAM	GRAIN	NONE	5 MIC
BDC-10	LAM/GB/CA	GRAIN	NONE	5 MIC
BDC-11	HOMOGENEOUS	MATRIX	NONE	50 MIC (BC)
HM-03	HOMOGENEOUS	GRAIN	NONE	7 MIC
HM-06	GP	GRAIN	NONE	2 MM (BC)
HM-08		MATRIX		1 MIC
HM-10A	HOMOGENEOUS	GRAIN	NONE	5 MIC
HM-10B	OS/FENE?	MATRIX/GRAIN	NONE	1 MIC
HM-11	OS/CA?	GRAIN	NONE	10 MIC
HM-12	BIO	GRAIN	NONE	5 MIC
HM-15	HOMO/OS	GRAIN	NONE	5 MIC
HM-16	HOMOGENEOUS	GRAIN	NONE	7 MIC
HM-17	HOMO/BIO?	GRAIN	NONE	7 MIC
HM-18	HOMOGENEOUS	GRAIN	NONE	5 MIC
BDC-12	BU/BIO?	GRAIN	NONE	10 MIC
BDC-13	DISCON/LA/BI/BU	GRAIN	NONE	7 MIC
BDC-15	LAM/OS/FE/GB/BI	GRAIN & MATRIX	NONE	30 MIC (BC)
BDC-16	HOMOGENEOUS/GP	MATRIX	NONE	1 MM (BC)
HM-02	BIO?	MATRIX	NONE	

SAMPLE NUM	SORT / ROU	MICROFOSSI	MACROFOSSI	COLOR
FC-01	WELL/SA-SR	CHARA (VEG?)?	NONE	RED+BK
FC-02	POOR/RD	NONE	NONE	BR
FC-04	WELL/SR-SA	NONE	NONE	BR
FC-05	MOD-WELL/RD-SA	NONE	NONE	BR
FC-06	MOD/ SA	ENCR ALGAE?	NONE	BR
FC-07	MOD/SR	NONE	NONE	BR
RRC-01	WELL/SA-SR	NONE	NONE	BK
RRC-02	MOD WELL/SR-SA	NONE	NONE	BR
RRC-03	WELL		LIMONITE ECH	BK
RRC-04	MOD-POOR/SR-ANG	NONE	NONE	BK
RRC-05	WELL/SA-RD	NONE	NONE	BK-BR
RRC-06	WELL/SR-RD	NONE	NONE	BR
BDC-01	POOR/SA-SR	FORAM	GAST/PEL/LIM EC	BR-BK
BDC-02	WELL/SA-SR	GRN/FORAM	GAST/PEL/LIM EC	BK
HM-19	MOD/SA-SR	GRN/FORAM	GAST/PEL/LIM EC	BR
HM-20	WELL		BR (RARE)/LIMEC	BR
HM-21	WELL/SR-RD	FORAM/DASY?	ECH/ MOLLUSK	BR
HM-22	MOD WELL/SA-ANG	NONE	NONE	BK
HM-23	WELL/SA-ANG	STROM?	NONE	BK
HM-24	WELL/SA-SR	ALGAL?	BRACH	RED+GRN
HM-25	WELL/SA-SR	NONE	NONE	BK
BDC-04	POOR+WELL/SR-SA	FORAM?	EC/PE/GA/CR/LIM	BR
BDC-06	WELL/SA-SR	NONE	PEL (RARE)	BR
BDC-07	WELL/SR-SA	NONE	NONE	BR
BDC-09	WELL/SR-SA	NONE	NONE	BR
BDC-10	WELL/SR-SA	NONE	UNIDENT.	BR
BDC-11	WELL/SA-SR		ECH/ SPONGE/LIM	BK-BR
HM-03	MOD/SR-SA	NONE	NONE	BR
HM-06	MOD-POOR/RD-SR	NONE	GAST/PEL?/BRA?	BR
HM-08	WELL	NONE	GAST?	BR
HM-10A	WELL/SA-SR	NONE	NONE	BR-BK
HM-10B	WELL/SA-SR	NONE	NONE	RED
HM-11	MOD/RD-SR	ALGAE?	NONE	BK-BR
HM-12	WELL/SR-RD	ALGAE?	ECH(RARE)	BK
HM-15	WELL/SR-SA	NONE	NONE	BR
HM-16	WELL/SR-SA	NONE	NONE	BR
HM-17	WELL/SR-RD		PEL/GAST?/LIMEC	BR-BK
HM-18	WELL/SR-RD	NONE	NONE	BR
BDC-12	WELL/SA-ANG	NONE	NONE	BR
BDC-13	WELL/SR-SA	NONE	BR?/PEL?/SPONGE	BR&BK
BDC-15	MOD WELL/SR-SA	STROM/FORAM?	SPONGE(MONOAX)	BR
BDC-16	MOD (BIMODAL)		EC/PE/GA/LIM EC	BK
HM-02	MOD-WELL/SR-SA	FORAM	ECH/CR/LIM EC	BK