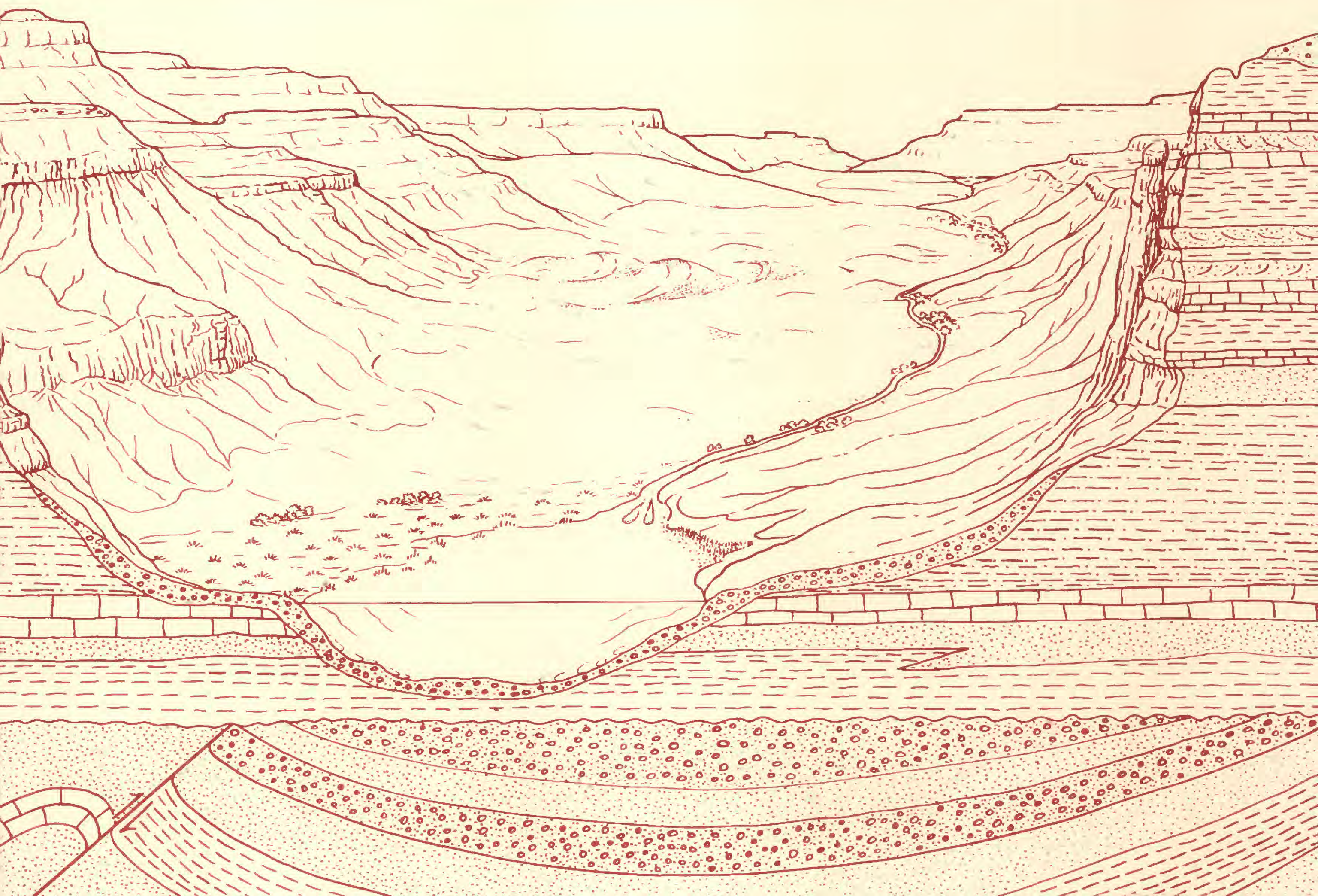
Stratigraphy of the Eocene Part of the Green River Formation in the South–Central Part of the Uinta Basin, Utah

U.S. GEOLOGICAL SURVEY BULLETIN 1787–BB



Chapter BB

Stratigraphy of the Eocene Part of the Green River Formation in the South-Central Part of the Uinta Basin, Utah

By ROBERT R. REMY

A multidisciplinary approach to research studies of sedimentary rocks and their constituents and the evolution of sedimentary basins, both ancient and modern

U.S. GEOLOGICAL SURVEY BULLETIN 1787

EVOLUTION OF SEDIMENTARY BASINS—UINTA AND PICEANCE BASINS

U.S. DEPARTMENT OF THE INTERIOR
MANUEL LUJAN, JR., Secretary

U.S. GEOLOGICAL SURVEY
Dallas L. Peck, Director

UNITED STATES GOVERNMENT PRINTING OFFICE: 1992

For sale by
Book and Open-File Report Sales
U.S. Geological Survey
Box 25286
Denver, CO 80225

Library of Congress Cataloging-in-Publication Data

Remy, Robert R.
Stratigraphy of the Eocene part of the Green River Formation in the south-central part of the Uinta Basin, Utah ; a multidisciplinary approach to research studies ... / by Robert R. Remy.
p. cm. — (U.S. Geological Survey bulletin ; 1787) (Evolution of sedimentary basins—Uinta and Piceance basins ; ch. BB)
Includes bibliographical references.
1. Geology, Stratigraphic—Eocene. 2. Geology—Uinta Basin (Utah and Colo.). 3. Green River Formation. I. Title. II. Series. III. Series: Evolution of sedimentary basins—Uinta and Piceance basins ; ch. BB.
QE75.B9 no. 1787–BB
[QE692.2]
557.3 s—dc20 91–34434
[551.7'84'09792] CIP

CONTENTS

PLATE

[Plate is in pocket]

FIGURES

TABLES

Stratigraphy of the Eocene Part of the Green River Formation in the South-Central Part of the Uinta Basin, Utah

By Robert R. Remy[1]

Abstract

Seventeen stratigraphic sections totalling 4,514.3 m were investigated and previous reports studied in order to clarify and illustrate the stratigraphy of most of the Eocene part of the fluvial and lacustrine Green River Formation in the south-central part of the Uinta basin of Utah. In the study area, the carbonate marker unit marks the base of the main body of the formation and consists of approximately 130 m of micrite, carbonate grainstone, dolostone, green mudstone, siltstone, and sandstone that accumulated in shallow water along the fluctuating southern shore of Lake Uinta.

The overlying delta facies is herein divided into two informal units: (1) a lower, 375-m-thick sequence named the Sunnyside delta interval and (2) an upper, 150-m-thick sequence named the transitional interval. In the Nine Mile Canyon area the Sunnyside delta interval consists of sandstone, red and green mudstone, and shallow-water limestone deposited in a large, fluvially dominated delta complex. The transitional interval is characterized by an upward increase from the base of the unit in the amount of open-lacustrine dolostone, kerogenous laminated dolostone (oil shale), and dark mudstone and a decrease in the amount of marginal-lacustrine green mudstone and shallow-water limestone. These lithologic changes record a major, but gradual, expansion of Lake Uinta.

Several transgressive limestone units in the Sunnyside delta interval and transitional interval serve as local stratigraphic markers. The top of the transitional interval is placed at the top of the S1 marker unit. The rocks of the Sunnyside delta interval and transitional interval in Nine Mile Canyon interfinger updip (southward) with lower deltaic to alluvial plain sandstone, mudstone, and minor limestone of the interfingering Green River and Colton Formations that crop out along the upper Roan Cliffs near Sunnyside, Utah.

In the area of Nine Mile Canyon the informal upper member of the Green River Formation overlies the transitional interval and consists of approximately 300 m of dark mudstone, dolostone, and kerogenous laminated dolostone (oil shale) and minor sandstone and siltstone. The generally fine grained rocks of the upper member were deposited in a low-energy open-lacustrine setting in Lake Uinta. The Mahogany oil-shale bed, S2 marker unit, Horse Bench Sandstone Bed, and an unnamed tuff serve as local to regional stratigraphic markers. The presence of the Mahogany oil-shale bed near the top of the Roan Cliffs demonstrates that the top 0–25 m of the Roan Cliffs is stratigraphically equivalent to the lower part of the upper member in Nine Mile Canyon.

Analysis of published paleontological data and $^{40}Ar/^{39}Ar$, K/Ar, and zircon fission-track dates suggests ages of approximately 54.0 Ma, 47.5 Ma, and 43 Ma for the base of the carbonate marker unit, the top of the transitional interval, and the top of the upper member, respectively, in the study area.

INTRODUCTION

The Green River Formation in the Uinta basin of northeastern Utah (fig. 1) accumulated in and adjacent to a large lake basin (Lake Uinta) during Paleocene and Eocene time (fig. 2). According to the model proposed by Ryder and others (1976), the lower part of the formation can be divided into a central core of organic-rich open-lacustrine claystone and mud-supported carbonate surrounded by marginal-lacustrine facies consisting of claystone, sandstone, and carbonate rocks deposited in deltaic, interdeltaic, and lake-margin carbonate-flat environments. The formation is enveloped by alluvial claystone, conglomerate, and sandstone of the Paleocene and Eocene Colton or Wasatch Formation and Eocene Uinta Formation that were deposited

Manuscript approved for publication, August 16, 1991.

[1]Institute for Energy Technology, Department of Reservoir and Exploration Technology, Boks 40, N–2007 Kjeller, Norway.

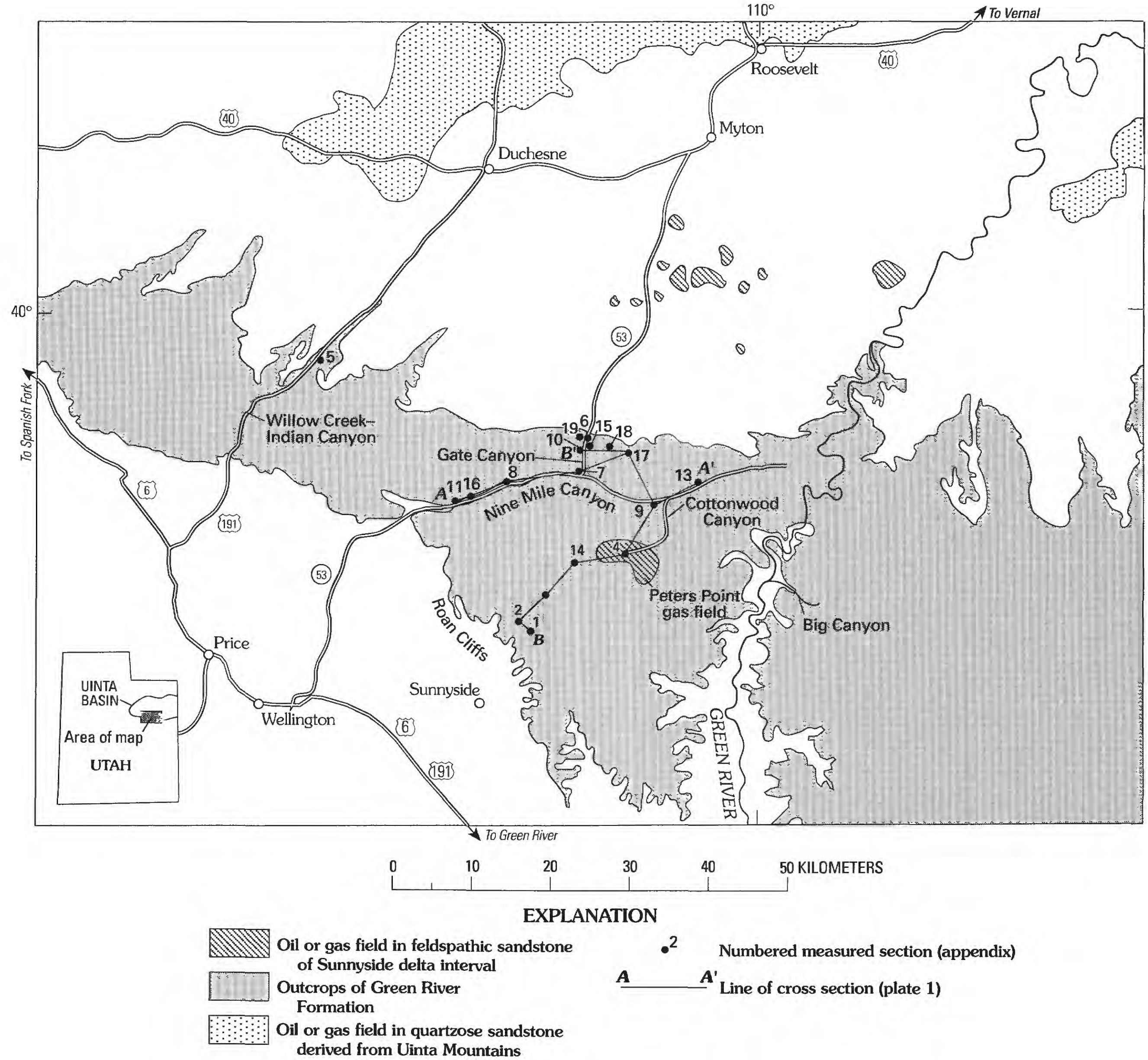


Figure 1. Outcrops of the Green River Formation in the south-central part of the Uinta basin. Geology modified from Hintze (1980). Positions of all oil and gas fields except Peters Point from Grugel and others (1983); position of Peters Point Field from Hendel (1957).

peripheral to the lake. Picard (1957, 1959), McDonald (1972), Fouch (1976, 1981), Ryder and others (1976), Fouch and Cashion (1979), Johnson (1985), Fouch and others (1987), and Bryant and others (1990) have illustrated and described the overall stratigraphy of the Green River Formation in the Uinta basin.

Numerous studies (Cashion, 1967; Picard and High, 1970; Fouch, 1975; Ryder and others, 1976; Pitman and others, 1982; Dickinson and others, 1986; Remy, 1991) demonstrate that one of the largest of several fluvial-deltaic complexes in the basin accumulated along the southern shore of Lake Uinta (fig. 2) and was centered around or east of the Green River (fig. 1). This delta received feldspathic sand from basement rocks exposed in the Laramide-age San Luis uplift in southwestern Colorado (Dickinson and others, 1986). Marginal-lacustrine feldspathic sandstone in the Pariette Bench (Pitman and others, 1982), Duck Creek (Osmond, 1985), Pleasant Valley (Colburn and others, 1985), and Monument Butte and other (Oleson, 1986) oil and gas fields indicates that the delta extended into the center of the basin, where it interfingered with quartzose sediment derived from the Uinta Mountains to the north (Sanborn and Goodwin, 1965; Koesoemadinata, 1970; Castle, 1990) (fig. 1). The western edge of the delta was

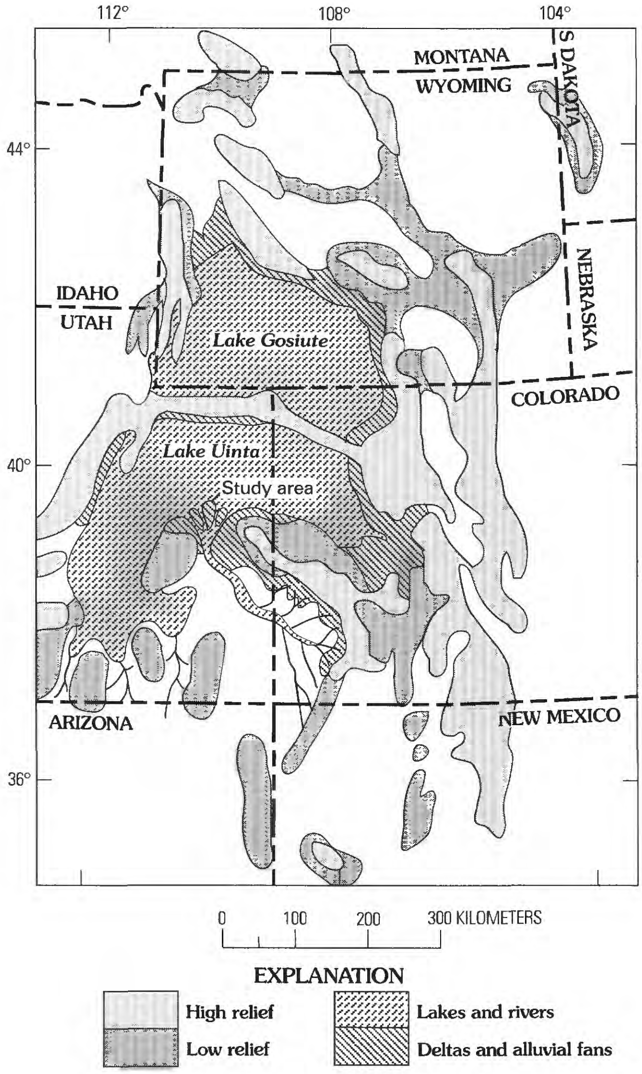


Figure 2. Paleogeography of the central Rocky Mountain region during late early to middle Eocene time showing location of Lakes Gosiute and Uinta and study area. Modified from McDonald (1972).

west of the Willow Creek–Indian Canyon area (Ryder and others, 1976, figs. 15, 16) and the location of the eastern edge of the delta is poorly constrained.

In the Nine Mile Canyon area of the south-central part of the Uinta basin (fig. 1), the western margin of the delta that was centered around the Green River is well exposed. This part of the delta was informally named the Sunnyside delta by Remy (1989a) and consists of approximately 375 m of fluvial-deltaic sandstone and mudstone and carbonate (Remy, 1989a, b, 1991). Similar marginal-lacustrine rocks are reservoirs for many of the oil and gas fields in the basin subsurface (Fouch, 1975; Franczyk and others, 1989), and their updip equivalents are the host for the Sunnyside tar sand deposit on the Roan Cliffs. The fluvial-deltaic rocks are underlain by a 130-m-thick carbonate-rich sequence that accumulated along the fluctuating southern shore of Lake Uinta before the major influx of sand deposited in the Sunnyside delta. The fluvial-deltaic deposits are overlain by about 500 m of generally fine grained, carbonate-rich, marginal- to open-lacustrine rocks that accumulated during a major expansion of the lake.

The stratigraphy and depositional environments of the Green River Formation in the south-central part of the Uinta basin were first described by Bradley (1931) (fig. 3, sections A and D). Subsequent workers (Dane, 1955; Ray and others, 1956; Hendel, 1957; Jacob, 1969; Ryder and others, 1976; Fouch and Cashion, 1979; Remy, 1989a, 1991; Weiss and others, 1990) provided additional information on the stratigraphy and depositional environments of the rocks and suggested a number of changes and additions to Bradley's (1931) stratigraphic nomenclature. Unfortunately, the variations in stratigraphic terminology used by different researchers and the occasionally vague descriptions of criteria used to identify boundaries between stratigraphic units make precise comparison of the results of these studies difficult. To date, no one has attempted a comprehensive review of this literature or conducted the detailed field work necessary to test the various stratigraphic schemes and produce a composite stratigraphic section for the Green River Formation in the south-central part of the Uinta basin. Moreover, little detailed information on the stratigraphy and lithology of the Green River Formation in the south-central part of the basin has been published, and the age of the rocks is poorly constrained, particularly in the lower part of the formation.

The purpose of this report is to provide a detailed analysis of the stratigraphy of most of the Eocene part of the Green River Formation in the area of Nine Mile Canyon and the Roan Cliffs near the Sunnyside tar sand deposit (fig. 1). Specifically, the report (1) summarizes and evaluates studies of the surface stratigraphy of most of the Eocene part of the Green River Formation in the south-central part of the Uinta basin, (2) describes and illustrates the stratigraphy of the rocks and briefly describes their lithology, depositional environments, and age, (3) illustrates the stratigraphic relation between the rocks exposed in Nine Mile Canyon and those exposed updip in the upper Roan Cliffs, and (4) presents 15 detailed measured sections and 2 cross sections of the formation.

Acknowledgment is made to the Donors of The Petroleum Research Fund, administered by the American Chemical Society, for support of this research. I would also like to thank Dag Nummedal, J.E. Hazel, C.L. McCabe, and R.E. Ferrell (Louisiana State University), W.B. Cashion and T.D. Fouch (U.S. Geological Survey), and J.A. Campbell (Oklahoma Geological Survey) for their valuable comments and suggestions; J.H. Hutchison (University of California, Berkeley) for identifying some turtle fragments;

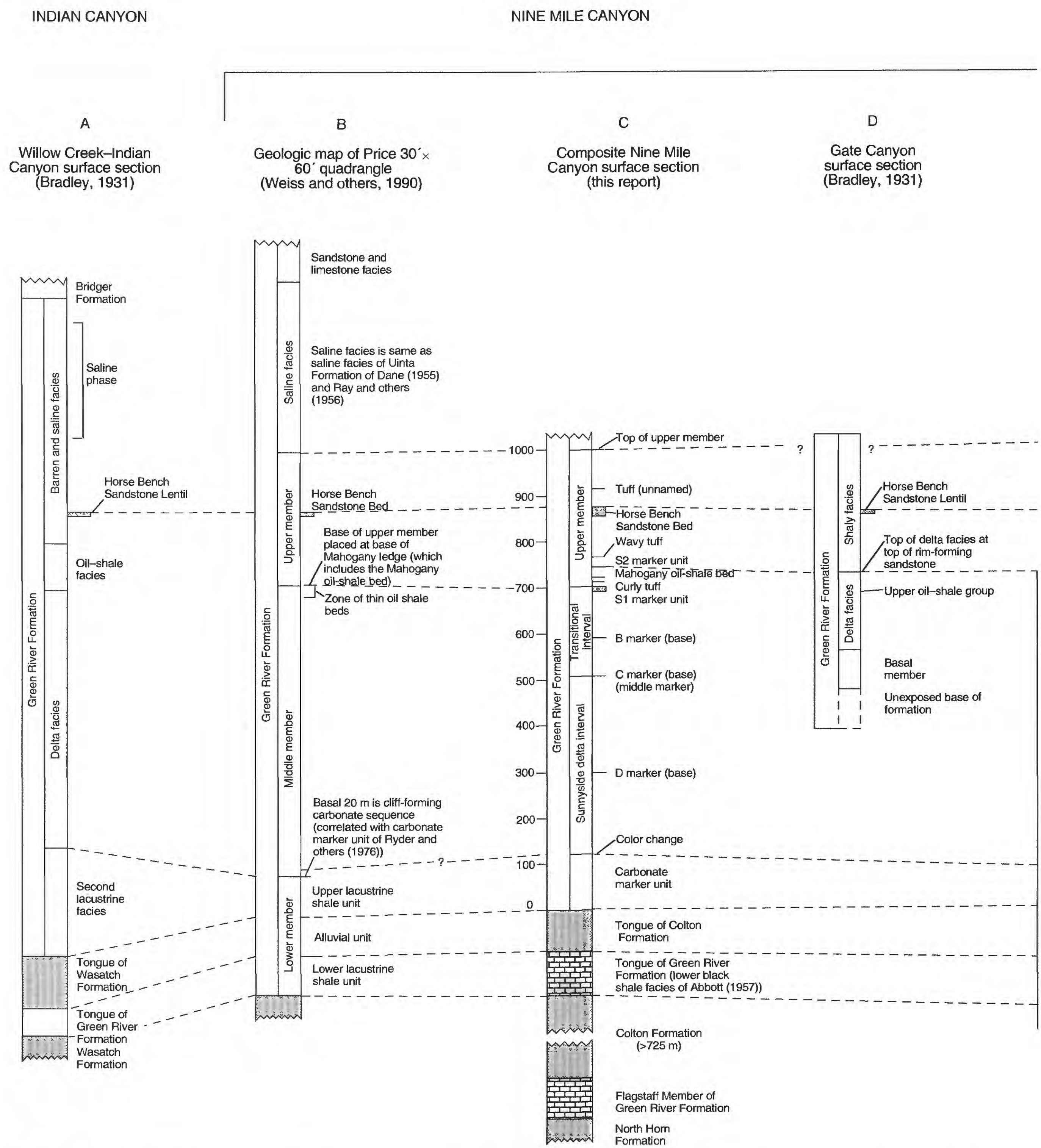
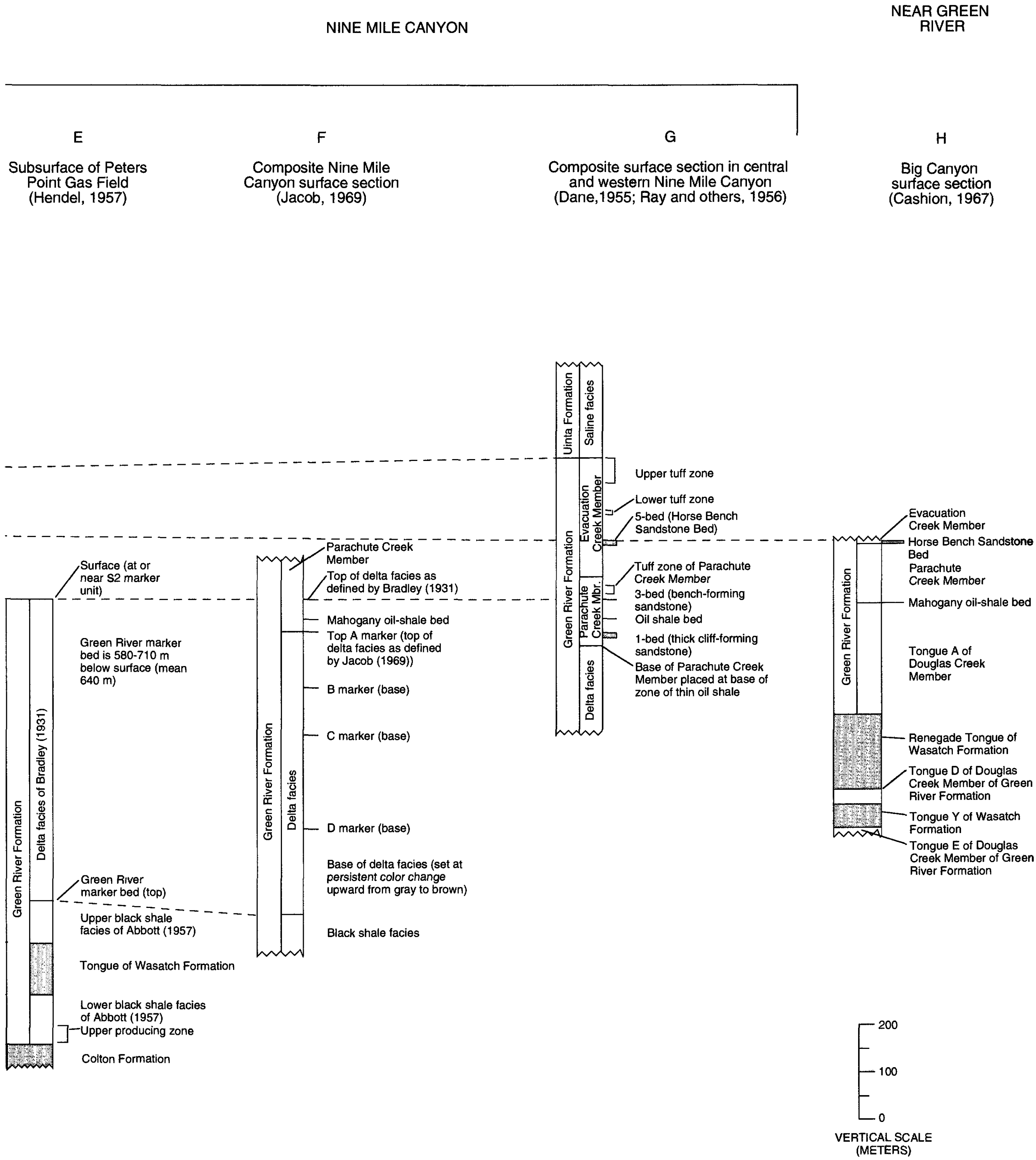


Figure 3 (above and facing page). Stratigraphic nomenclature of the Green River Formation in the south-central part of the Uinta basin, Utah.

Xudong Ying, Sean McLaughlin, and Richard Denne (Louisiana State University) for aiding me in the field; and Xudong Ying for providing me with measured sections 17, 18, and 19 of this report.

STUDY AREA AND METHODS

The study area in the south-central part of the Uinta basin (fig. 1) is bounded on the north by Nine Mile Canyon



and the lower 5 km of Gate Canyon, on the south by the Roan Cliffs near Sunnyside, Utah, on the west by the junction of Minnie Maude Creek and Nine Mile Creek, and on the east by the junction of Nine Mile Canyon and North Franks Canyon. The stratigraphic interval examined in this report includes all but the basal 30 m of the Eocene carbonate marker unit of Ryder and others (1976, p. 497), the delta facies of Bradley (1931), and the upper member of Weiss and others (1990) (equivalent to a part of the Parachute Creek Member of the Green River Formation of Cashion and Donnell (1974)).

Seventeen stratigraphic sections (fig. 1, appendix) totalling 4,514.3 m were investigated in order to determine the lithology, color, bedding thickness, grain size, nature of bounding surfaces, sedimentary structures, geometry, and fossil content of the rocks and to determine the position of stratigraphic markers. Fifteen of the seventeen measured sections that form the basis of this study are shown. In order to facilitate description of the measured sections, 12 lithofacies were defined. Their primary lithologic and sedimentologic characteristics and interpreted depositional environments are summarized in table 1, and their geographic and stratigraphic distributions are shown in table 2. The lithofacies are grouped into five depositional assemblages, which are described and illustrated on plate 1.

Photomosaics of the walls of Nine Mile Canyon and its tributaries and the Roan Cliffs were used to analyze the geometry of the rocks and to trace stratigraphic markers. Limestones, tuffs, distinctive sandstone units, and other types of lithologic markers were used to correlate the sections (appendix). The stratigraphic positions of the stratigraphic markers employed in this study are listed in the appendix, and correlations of the measured sections are shown on plate 1.

LITHOSTRATIGRAPHY OF THE GREEN RIVER FORMATION: NINE MILE CANYON

Units Underlying the Main Body of the Green River Formation

The Green River Formation can be visualized as a jagged-edged lens of open-and marginal-lacustrine rocks enveloped by alluvial rocks of the Paleocene and Eocene Colton or Wasatch Formation and the Eocene Uinta Formation (Cashion, 1967, p. 8). West of the Green River the Colton Formation is separated from the underlying similar-appearing North Horn Formation by the Flagstaff Member of the Green River Formation (as defined by Fouch, 1976) (Weiss and others, 1990). In areas where the Flagstaff Member is absent or thin, as it is east of the Green River, it has been common practice to group all of the rocks between the top of the Cretaceous and the base of the Green River Formation with the Wasatch Formation (McDonald, 1972, p. 249; Weiss and others, 1990).

In the area of Nine Mile Canyon, the Flagstaff Member is approximately 91 m thick and is overlain by more than 725 m of mainly alluvial rocks of the Colton Formation (Fouch and others, 1976, p. 365) (fig. 3, section C). The Colton Formation thins northward toward the center of the basin where the thickened Flagstaff Member and the main body of the Green River Formation merge and form a continuous lacustrine sequence (Fouch, 1976; Ryder and others, 1976)

The interfingering contact between the Wasatch Formation of Bradley (1931) and the overlying Green River Formation in the south-central part of the Uinta basin was first described by Bradley (1931). In the Willow Creek–Indian Canyon area (fig. 1) Bradley divided the rocks beneath his delta facies into (from base to top) (1) a tongue or phase of the Green River Formation, consisting of about 60 m of paper shale, marlstone, limestone, and minor carbonaceous shale and coal, (2) a tongue of the Wasatch Formation, consisting of 115 m of sandstone and drab, buff, greenish, and red mudstone, and (3) a second lacustrine phase or facies of the Green River Formation, consisting of 230 m of light-gray and brown shale, limestone, and minor sandstone (fig. 3, section A). In Gate Canyon (fig. 1), Bradley (1931) identified what he believed to be the basal member of the Green River Formation that he correlated with basal units in the Willow Creek–Indian Canyon area (fig 3, section D). Results of my investigation indicate, however, that the base of the surface section at Gate Canyon is several hundred meters stratigraphically above the top of the second lacustrine phase in the Willow Creek–Indian Canyon area.

Picard (1955, p. 83) designated the term "black shale facies" for dark-gray to black shale, limestone, grayish-green shale, sandstone, and minor oil shale that he placed at the base of the Green River Formation in the basin subsurface. He correlated the black shale facies with Bradley's (1931) tongue of the Green River Formation and the tongue of the Wasatch Formation. Abbott (1957) extended the black shale facies to surface exposures and recommended that the terms "upper black shale facies," "Colton tongue," and "lower black shale facies" be substituted for Bradley's (1931) second lacustrine facies, tongue of the Wasatch, and basal tongue of the Green River Formation, respectively. Picard and others (1973) divided the black shale facies into four lacustrine units designated "A" through "D" and one fluvial unit designated the "Wasatch tongue" of the black shale facies.

Recently, Weiss and others (1990) mapped the lower units of the Green River Formation as the lower member (fig. 3, section B). They observed that the lower member of the Green River Formation is composed of three lithologic units (base to top): (1) a lower lacustrine shale unit, which they correlated with the basal tongue of the Green River Formation of Bradley (1931), (2) an alluvial unit, which they correlated with Bradley's tongue of the Wasatch Formation, and (3) an upper lacustrine shale unit, which they correlated with Bradley's second lacustrine facies (fig. 3, compare sections A and B).

The interfingering Colton–Green River contact is well exposed in western Nine Mile Canyon. Fouch and others (1976, p. 365) described an "unnamed tongue of the Green River Formation" as a 96-m-thick interval of ostracode grainstone, thin mud-supported organic-rich carbonate rocks, grayish-green claystone, and sandstone. The thickness and lithology of this unit and its stratigraphic position above the main body of the Colton Formation suggest that it is equivalent to Bradley's (1931) basal tongue

Table 1. Summary of major lithologic and sedimentologic characteristics and interpretation of lithofacies of the Eocene part of the Green River Formation in the south-central part of the Uinta basin, Utah

Lithofacies definition	Code	Lithology and grain size	Sedimentary structures	Geometry and thickness	Other characteristics	Associated lithofacies	Interpretation
Thick (>15 m), scour-enclosed sandstone	Sa	Siltstone and sandstone (62-280 μ, mean=150 μ), some coarsen or fine upward, most have multiple vertical grain-size trends	Trough crossbeds, current and less common climbing ripples, planar laminations, much structureless, no consistent vertical arrangement of structures	Thinner sandbodies lenticular to tabular; thicker sandbodies tabular; 57 percent of sandbodies amalgamated, 15-41 m thick (mean=23.2 m)	Bases sharp and flat to scoured, basal intraformational conglomerate abundant, scours and intraformational conglomerate within sandbodies abundant	Common: Mr, Mg, Se, Sf Less common: Sb, L, C Rare: Ia Never: Sc, Sd, Ib	Nonsinuous streams on upper delta to alluvial plain
Laterally discontinuous sandstone, 3-15 m thick	Sb	Siltstone and sandstone (62-300 μ, mean=125 μ), 30 percent fine upward, 7 percent coarsen upward, 43 percent have multiple trends, 20 percent have uniform grain size	Trough crossbeds, current and wave ripples, planar laminations, much structureless, many sandbodies have upward decrease in size of structures	Lenticular to tabular geometry, sloping channel edges common; about 25 percent stacked sandbodies, mean thickness=5.8 m	Bases sharp and flat to scoured, lateral-accretion bedding and basal intraformational conglomerate abundant, scours and intraformational conglomerate within sandbodies common	Common: Mr, Mg, Se, Sf, L Less common: Sa, Sc, C, Rare: Ia, Ib (?) Never: Sd	Meandering delta distributary channels on delta plain and stacked crevasse splays and overbank sandsheets
Thick (>15 m), laterally interfingering sandstone	Sc	Siltstone and sandstone (62-275 μ, most less than 150 μ), uniform grain size or multiple fining- and coarsening-upward cycles	Current and wave ripples, planar and wavy planar laminations, hummocky cross-stratification (?), rare trough crossbeds and convolute bedding, wave-generated structures more common in lower halves of sandbodies	Lenticular geometry with irregular edges that interfinger laterally with other rocks, thick sandbodies composed of amalgamated lenticular sandbodies, amalgamated sandbodies 15-40+ m thick	Bases generally sharp and flat, basal intraformational conglomerate rare, internal scours and intraformational conglomerate common, rare downstream accretion bedding	Common: Mr, Mg, Se, Sf, L, Sb Rare: C Never: Sa, Sd, Ia, Ib	Stacked and amalgamated lenticular delta mouth bars
Laterally continuous sandstone, 3-15 m thick	Sd	Sandstone (62-350 μ), most have multiple fining- and coarsening-upward cycles, some fine upward, some contain green and gray mudstone	Trough crossbeds and planar laminations common, locally common ripples, convolute bedding and structureless zones, no consistent vertical arrangement of structures	Tabular geometry (can be traced for at least 2 km), consists of stacked sandbodies, 4.5-11.5 m thick	Base always sharp, basal scour with intraformational conglomerate common	Common: Se, Mg, Ia, Ib Never: all other lithofacies	Delta (front?) deposits that accumulated in Lake Uinta during a regional regression
Thin (<3 m) sandstone without basal or internal scour, coarsening-upward grain size, or accretion bedding	Se	Siltstone and fine-grained sandstone (generally less than 125 μ), most have uniform grain size, few fine upward	Current ripples, planar laminations, small-scale trough crossbeds, and mudcracks common, locally abundant wave ripples and wavy planar laminations	Tabular geometry (lateral continuity commonly more than a few hundred meters), lithofacies 0.5-3.0 m thick, individual beds a few centimeters to 3.0 m thick (but most less than 1.5 m thick)	Individual beds commonly have sharp and flat bases and tops, lithofacies generally encased in mudstone	Common: Sa, Sb, Sc, Sd, Sf, Mg, Mr, L, Ia, C Rare: Ib	Fluvial overbank and deltaic sandsheets that accumulated in fluvial, lower delta plain, and shallow lacustrine settings

Table 1. Summary of major lithologic and sedimentologic characteristics and interpretation of lithofacies of the Eocene part of the Green River Formation in the south-central part of the Uinta basin, Utah—Continued

Lithofacies definition	Code	Lithology and grain size	Sedimentary structures	Geometry and thickness	Other characteristics	Associated lithofacies	Interpretation
Thin (<3 m) sandstone with basal or internal scour, coarsening-upward grain size, or accretion bedding	Sf	Siltstone and fine-grained sandstone (generally less than 175 μ), most have uniform grain size, some fine or coarsen upward	Same as lithofacies Se except trough crossbeds more common	Tabular to lenticular geometry, lithofacies 0.5-3.0 m thick, individual beds as thick as 3.0 m	Basal scour and amalgamation of sandstone beds common, downstream accretion locally abundant, lithofacies generally encased in mudstones	Common: Sa, Sb, Sc, Sd, Se, Mg, Mr, L, Ia, C Rare: Ib	Crevasse splays, crevasse splay channels, and small, delta distributary channels that accumulated in fluvial, lower delta plain, and shallow lacustrine settings
Sand- and(or) mud-filled channel	C	Red and green mudstone, siltstone, and fine-grained sandstone (generally less than 150 μ)	Mudstone generally structureless; sandstone and siltstone contain ripples and planar laminations and are commonly structureless	Mudstone-, sandstone-, and siltstone-filled channels, size of channels from few meters wide to about 100 m wide by 10 m deep	Scours generally cut interbedded sandstone and mudstone, basal intraformational conglomerate common	Common: Mg, Mr, Se, Sf, L, Sa, Sb, Sc (?) Never: Ia, Ib, Sd	Passively filled abandoned channels (most probably are crevasse channels)
Green mudstone	Mg	Green, greenish-gray, and light-gray mudstone, minor sandstone, siltstone, limestone, and red and purple mudstone	Most mudstone structureless, rare planar laminations, ripples, small burrows, rootlets (?), mudcracks, and syneresis cracks	Tabular geometry, lithofacies 0.5-25 m thick, individual beds a few centimeters to 5 m thick	Base and top of individual beds sharp to gradational, ostracodes common in mudstone	Common: all lithofacies except Ib Rare: Ib	Shallow water subaqueous mudflats in interdistributary bays, in shallow nearshore parts of the lake, and perhaps in delta plain ponds and lakes
Red mudstone	Mr	Red and purple mudstone, minor sandstone, siltstone, limestone, and green, greenish-gray, and light-gray mudstone	Same as lithofacies Mg	Same as lithofacies Mg	Base and top of individual beds sharp to gradational, ostracodes rare	Common: all lithofacies except L, Ia, Ib Rare: L Never: Ia, Ib	Intermittently subaerially exposed mudflats
Limestone	L	Ostracode,ooid, intraclast, and pellet grainstone, micrite, and stromatolite, minor thin beds of sandstone, siltstone, green mudstone, and dolostone (including oil shale)	Ripples, small-scale trough crossbeds, planar and wavy planar laminations, and hummocky cross-stratification (?) in grainstones; some micrite has planar laminations but most is structureless; stromatolite has algal laminations	Tabular geometry for both lithofacies and individual beds, lithofacies 0.5-25 m thick, individual beds a few centimeters to a few meters thick	Bases of beds generally flat and unscoured, complex interbedding and interlaminations of different limestone types common	Common: all lithofacies except Mr, Ia, Ib Rare: Mr, Ib, Ib	Limestones deposited in shallow, quiet to wave-agitated water in interdistributary bays, in nearshore regions of the lake, and perhaps in delta plain ponds and lakes

Table 1. Summary of major lithologic and sedimentologic characteristics and interpretation of lithofacies of the Eocene part of the Green River Formation in the south-central part of the Uinta basin, Utah—Continued

Lithofacies definition		Lithology and grain size	Sedimentary structures	Geometry and thickness	Other characteristics	Associated lithofacies	Interpretation
Brown and gray mudstone, dolostone (<30 percent), and minor sandstone and siltstone	Ia	Gray to brown mudstone and dolostone (including oil shale), minor green mudstone, limestone, sandstone, and siltstone	Much dolostone and mudstone structureless, some has planar laminations in places; sandstones have a variety structures including ripples, planar and wavy planar laminations, hummocky cross-stratification, and trough crossbeds	Tabular geometry for both lithofacies and individual beds, lithofacies 0.5 to more than 100 m thick, individual beds as thick as 10 m	Some coarsening- and fining-upward trends, individual beds commonly have sharp flat bases and tops and are laterally continuous, ostracodes abundant in places	Common: Ib, Mg, Se, Sd, Sf Less common: Sb, L Rare: Sa, C, Sc Never: Mr	Proximal open-lacustrine environment: carbonate and siliciclastic mud deposited in low-energy nearshore to offshore regions of lake, some storm transport of sand into lake
Brown and gray mudstone, dolostone (>30 percent), and minor sandstone and siltstone	Ib	Similar to lithofacies Ia except more dolostone and less gray to brown mudstone, siltstone, sandstone, and green mudstone	Same as lithofacies Ia	Same as lithofacies Ia	Same as lithofacies Ia	Common: Ia, Sd Less common: Mg, Se, Sf, L Rare: Sa, Sb, Sc, Never: Mr, C	Distal open-lacustrine environment; same as lithofacies Ia except generally deeper water (?) and lower energy

of the Green River Formation and Abbott's (1957) lower black shale facies. Little (1988) described the depositional environments, petrology, and diagenesis of limestone in this unit.

In western Nine Mile Canyon the stratigraphic interval equivalent to the lower black shale facies of Abbott (1957) is overlain by a red claystone, siltstone, and lenticular sandstone assemblage (Fouch and others, 1976, p. 365). These rocks, which were described as "an unnamed tongue of the Colton" by Fouch and others (1976), are presumably stratigraphically equivalent to Bradley's (1931) tongue of the Wasatch and Abbott's (1957) Colton tongue.

In a study of the subsurface stratigraphy and lithology of the lower part of the Green River Formation in the Peters Point gas field (fig. 1), Hendel (1957) identified and briefly described the lower black shale, the Wasatch tongue, and the upper black shale (fig. 3, section E). He placed the Colton–lower black shale contact at the base of the lowest typical lake bed. His lower black shale consists of approximately 110 m of calcareous greenish-gray mudstone and shale, red mudstone, limestone, and sandstone. The lenticular sandstone in the lower part of this interval is the main producing interval for the Peters Point field. The overlying Wasatch tongue of Hendel (1957) is approximately 110 m thick and consists of fluvial deposits and minor lacustrine units. The stratigraphic positions and compositions of these units strongly suggest that the lower black shale is equivalent to Bradley's (1931) tongue of the Green River Formation and Abbott's (1957) lower black shale facies and that the Wasatch tongue is equivalent to Bradley's (1931) tongue of the Wasatch and Abbott's (1957) Colton tongue. The upper black shale is equivalent to the carbonate marker unit of this report and to Bradley's (1931) second lacustrine facies (fig. 3).

Carbonate Marker Unit

The carbonate marker unit of Ryder and others (1976) marks the base of the main body of the Green River Formation in the area of Nine Mile Canyon. In eastern Nine Mile Canyon the unit is approximately 130 m thick, the basal 25–30 m of which is poorly exposed. The upper 105 m of the unit is well exposed and consists of ostracode and ooid grainstone and micrite of the L lithofacies (16.3 percent), green mudstone of the Mg lithofacies (14.2 percent), sandstone of the Sb (12.5 percent), Se (9.9 percent), and Sf (5.7 percent) lithofacies, dark laminated mudstone and kerogenous laminated dolostone (oil shale) of the Ia (25.3 percent) and Ib (5.4 percent) lithofacies, and covered intervals (10.7 percent) probably underlain by mudstone or dolostone (table 2; appendix, units 1–66 of measured section 11). These rocks accumulated along the fluctuating southern shore of Lake Uinta (Fouch and others, 1976; Remy, 1989a, b, 1991) in lake-margin carbonate-flat, subaqueous mudflat, crevasse-splay, overbank and shallow-

Table 2. Stratigraphic and geographic distribution of lithofacies of the Eocene part of the Green River Formation in the south-central part of the Uinta basin, Utah

[In percent. Leader (–) indicates not present. Lithofacies defined in table 1]

	Nine Mile Canyon and tributaries[1]					Roan Cliffs[2]	
			Transitional interval[3]				
Lithofacies	Carbonate marker unit	Sunnyside delta interval	Lower	Upper	Upper member	Interfingering Green River and Colton Formations	Upper member of Green River Formation
Sa	–	–	–	–	–	37.7	–
Sb	12.5	23.6	9.5	12.1	4.6	14.8	–
Sc	–	4.0	–	–	–	–	–
Sd	–	–		5.2	5.0	–	–
Se	9.9	12.8	12.4	8.9	3.8	8.8	4.4
Sf	5.7	2.8	2.3	0.8	1.5	0.4	–
C	–	–	–	–	–	–	–
Mr	–	7.8	0.4	–	–	9.7	–
Mg	14.2	19.0	33.2	23.6	2.8	9.7	24.3
L	16.3	6.2	13.7	5.5	0.2	2.9	15.7
Ia	25.3	0.5	0.6	6.4	39.1	0.6	7.8
Ib	5.4	–	–	3.4	12.2	–	47.8
Covered interval	10.7	23.3	27.9	34.1	30.8	15.4	–

[1]Includes measured sections 4, 6–11, 13–17 (appendix).

[2]Includes measured sections 1 and 2 (appendix).

[3]Boundary between upper and lower parts of transitional interval placed at the B marker.

lacustrine sandsheet, delta distributary channel, and proximal open-lacustrine environments.

In the subsurface, the top of the carbonate marker unit is placed at the carbonate marker, a well-log response that can be recognized in most of the subsurface part of the basin (Ryder and others, 1976). In his study of the subsurface stratigraphy and lithology of the lower part of the Green River Formation in the Peters Point gas field, Hendel (1957) placed the boundary between the delta facies of Bradley (1931) and the upper black shale facies of Abbott (1957) at the Green River marker bed, which he described as a "persistent limestone" (fig. 3, section E). His upper black shale facies is a 90-m-thick interval of limestone, black and gray shale, and sandstone (Hendel, 1957, fig. 3). Similarities in stratigraphic position, lithology, and thickness suggest that the upper black shale facies is stratigraphically equivalent to the carbonate marker unit and that the Green River marker bed of Hendel (1957) is equivalent to the carbonate marker of Ryder and others (1976) (fig. 3, sections C and E).

I placed the top of the carbonate marker unit at a sharp distinctive change in the weathered color of the rocks (fig. 3, section C). The carbonate-rich carbonate marker unit weathers light gray, whereas the overlying carbonate-poor Sunnyside delta interval weathers light brown. Jacob (1969) used the same criteria to place the boundary between the black shale facies (carbonate marker unit of this report) and the delta facies of Bradley (1931) (fig. 3, section F).

Delta Facies (Sunnyside delta interval and transitional interval)

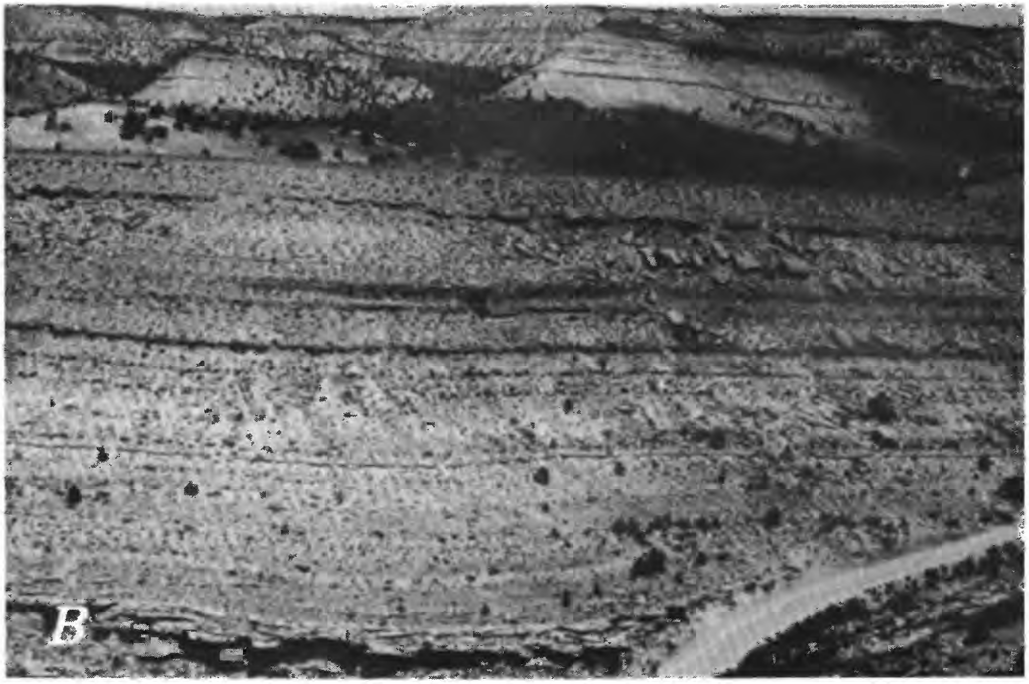
The interval between the carbonate marker unit and the mudstone- and dolostone-rich upper member consists of approximately 550 m of mainly fluvial and shallow-lacustrine sandstone and mudstone and shallow-water limestone; some dolostone and dark mudstone is present near the top of the sequence. Bradley (1931) examined this interval near the Duchesne–Uintah County line, approximately 9 km east of my easternmost measured section (measured section 13) (fig. 1), and at Gate Canyon. Because of the similarity of the sections, only the Gate Canyon section is shown in figure 3 (section D). Bradley (1931) divided the interval below his shaly facies (upper member of this report) into (1) the basal member, consisting of approximately 76 m of greenish-gray shale and subordinate sandstone, limestone, and low-grade oil shale, and (2) the delta facies, consisting of 152–183 m of sandstone (which constitutes 75–80 percent of the interval) and greenish-gray mudstone (fig. 3, section D). However, because the basal 80 m of the surface section at Gate Canyon is not significantly different from overlying rocks (fig. 4*A*; appendix, measured section 7), subsequent researchers (Hendel, 1957; Jacob, 1969; Remy, 1989a) dropped the term "basal member" and referred to all of the rocks beneath Bradley's (1931) shaly facies as the "delta facies of Bradley (1931)." According to McDonald (1972), the delta facies is equivalent to the

Figure 4 (above and following pages). Photographs of the Green River Formation. *A*, Sunnyside delta and transitional intervals at the junction of Gate and Nine Mile Canyons. Thick sandstones of Sb lithofacies (table 1) and associated thin sandstones of Se and Sf lithofacies, red and green mudstones of Mr and Mg lithofacies (covered intervals), and limestone of L lithofacies were deposited in and adjacent to a large, fluvially dominated delta. At this location the C marker of this report is approximately 15 m above a pair of prominent yellow-weathering limestones (arrows), the C2 and C3 markers of Jacob (1969). The C marker separates the Sunnyside delta interval from the overlying transitional interval. The interval from the base of the photograph to the C marker is approximately 170 m thick. *B*, Uppermost transitional interval and overlying open-lacustrine upper member in Gate Canyon. Note the S1 marker unit (S1), S2 marker unit (S2), and Horse Bench Sandstone Bed (HB). See measured section 10 (appendix) for a description of the rocks between the S1 and S2 marker units at this location. The interval from the base of the S1 unit to the top of the S2 unit is approximately 60 m thick. *C*, Stratigraphy of the upper part of the Green River Formation in central Nine Mile Canyon. Note the upper Sunnyside delta interval (SD) and transitional interval (T) exposed in the inner gorge of Nine Mile Canyon, the S2 marker unit (S2) underlying a broad plateau, the Horse Bench Sandstone Bed (HB) underlying an upper plateau, and the top of the upper member (arrows). View is from small airplane at approximate position of measured section 9 (fig. 1), looking eastward toward the Green River (not visible). Photograph provided by Xudong Ying (Louisiana State University). *D*, Stratigraphy of the upper part of the Green River Formation in eastern Nine Mile Canyon. Note the transitional interval (T), S2 marker unit (S2), and the broad plateau held up by Horse Bench Sandstone Bed (HB). View is from small airplane approximately half way between measured section 13 (fig. 1) and the Green River (not visible). Photograph provided by Xudong Ying (Louisiana State University). *E*, Bed of ooids with ostracode nuclei in D marker. Penny for scale.

Douglas Creek Member of the Green River Formation in the eastern part of the Uinta basin (fig. 3, section H).

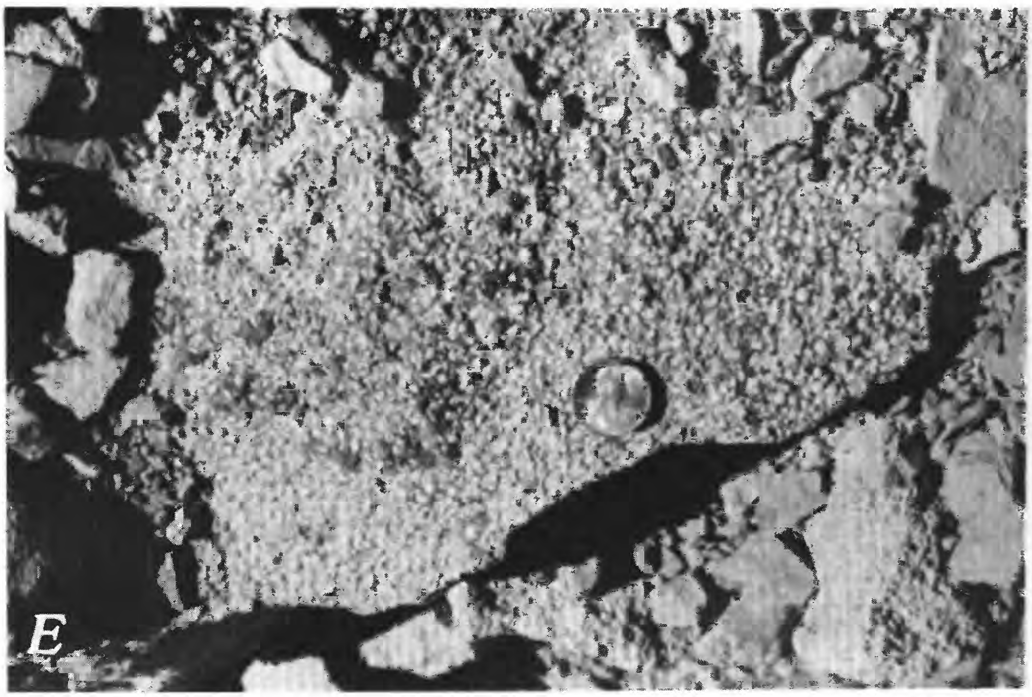
Picard (1957) recommended that the term "green shale facies" be substituted for the term "delta facies" in the western part of the basin in order to avoid environmental interpretation in a stratigraphic term and because the term is more indicative of the sediment type. The middle member of the Green River Formation of Weiss and others (1990) is equivalent to most of the delta facies of Bradley (1931).

Bradley (1931, p. 15) stated that "in Gate Canyon, the writer estimates that about 300 feet at the base is not exposed." It is unclear whether Bradley was referring to the base of the main body of the Green River Formation (that is, the base of the delta facies) or to the contact between his tongue of the Green River Formation and the underlying main body of the Colton Formation. Detailed correlations of the rocks (plate 1) indicate that Bradley was incorrect in either case. The base of the delta facies, as defined to include Bradley's (1931) basal member, is actually 160 m below the floor of Gate Canyon (see measured section 7, plate 1), and the contact between the tongue of the Green River Formation and the underlying main body of the Colton Formation is about 500 m below the floor of the canyon. Moreover, Bradley (1931, plate 3) erroneously



correlated his basal member at Gate Canyon with his basal lacustrine tongue, tongue of the Wasatch Formation, and second lacustrine phase in the Willow Creek–Indian Canyon area. His miscorrelation, together with the fact that he underestimated the thickness of the basal member and delta facies by approximately 100 m, led to his erroneous conclusion that the delta facies thickens dramatically westward toward the Willow Creek–Indian Canyon area. Results of my study indicate that the delta facies (Sunnyside delta interval and transitional interval of this report) is about the same thickness (550 m) in the Nine Mile Canyon and Willow Creek–Indian Canyon areas (fig. 3, compare sections A and C).

Several approaches have been taken in defining the top of the delta facies. Bradley (1931, p. 16, plate 9B) noted that the top of the delta facies is near the top of the inner gorge of eastern Nine Mile Canyon (which he referred to as the "canyon of Minnie Maude Creek"). In central and



eastern Nine Mile Canyon, the inner gorge of the canyon and its tributaries are held up by two sandstone-rich intervals (fig. 4*B*). The lower sandy interval was mapped as the "1-bed" by Ray and otheıs (1956) and informally named the "S1 marker" by Fouch and others (1976, p. 369). The upper sandy interval was mapped as the "3-bed" by Ray and others (1956) and informally named the "S2 marker unit" by Fouch and others (1976). Both units form narrow to broad plateaus in most places and are distinguished on the basis of their relationship with the Mahogany oil-shale bed (see below), which is between the S1 and the S2 units (plate 1). The S1 and S2 units are separated by 35–60 m of slope-forming, generally poorly exposed dolostone and mudstone and minor sandstone and silstone.

The S1 and S2 marker units exhibit variable lithology. In and near Gate Canyon for example, measured sections 7, 10, and 17 in the appendix) the S1 marker unit is a thick (6.7–11.5 m), prominent, cliff-forming, trough cross-stratified sandstone, and the S2 marker unit consists of about 1 m of very fine grained, hummocky cross-stratified sandstone and, in places, mudstone (see, for example, unit 25 of measured section 10 in the appendix)(fig. 4*B*). Both units underlie plateaus in this region. Toward the east, however, both marker units change lithology. The S1 thins, is finer grained, and is much less prominent than in Gate Canyon. The S2, on the other hand, thickens, is much coarser grained, and, in places, resembles the S1 of Gate Canyon. In this region the S2 underlies a broad plateau that can be traced continuously from a position several kilometers east of Gate Canyon to the Green River (figs. 4*C*, *D*).

Bradley (1931) did not directly specify which of the two rim-forming sandstones at the top of the inner gorge of Nine Mile Canyon defines the top of his delta facies nor did he publish his measured sections in Nine Mile Canyon. He did state, however, that a set of oil shales below the top of his delta facies represents the upper oil-shale group of the Parachute Creek Member (although he did not apply the term "Parachute Creek Member" to any beds west of the Green River). The Mahogany oil-shale bed is within the upper oil-shale group (W.B. Cashion, U.S. Geological Survey, written commun., 1990) and in Gate Canyon is between the S1 and the S2 marker units (Fouch and others, 1976). Therefore, the S1 marker unit must be below the top of the delta facies; thus Bradley (1931) placed the contact between his delta facies and his overlying shaly facies at or near the S2 marker unit.

Dane (1954, 1955) and Ray and others (1956), on the other hand, placed the top of the delta facies at the base of a set of oil shales that is about 30 m below their 1-bed (S1 marker unit of this report) (fig. 3, section G). These oil shales are present in several measured sections of this report (appendix), including section 9.

Jacob (1969) placed the top of the delta facies at the top of a persistent sandstone that is below the main body of oil shale (fig 3, section F). In his Devils Canyon measured section this sandstone, which he called "marker A," is approximately 55 m below the top of the rim-forming sandstone picked by Bradley (1931) as the top of the delta facies and 25 m below the Mahogany oil-shale bed. The lithology and stratigraphic position of marker A relative to the Mahogany oil-shale bed and the S2 marker unit (see measured section 10 in the appendix) indicate that marker A is equivalent to the 1-bed of Ray and others (1956) and the S1 marker unit of Fouch and others (1976).

Weiss and others (1990) placed the top of their middle member of the Green River Formation (delta facies of Bradley, 1931) at the base of the Mahogany ledge, a zone of several oil shale beds that includes the Mahogany oil-shale bed. The Mahogany ledge directly overlies the S1 marker unit. For ease of mapping, however, they drew the boundary between the upper and middle members at the top of the Mahogany oil-shale bed, which is about 10 m above the base of the Mahogany ledge (fig. 3, section B).

Several laterally continuous, yellow-weathering limestone units were employed by Jacob (1969) and by me to correlate and subdivide Bradley's (1931) delta facies (Sunnyside delta interval and transitional interval of this report). The stratigraphic positions of these markers are shown in the appendix and their correlations are illustrated on plate 1. Jacob's (1969) D marker consists of approximately 2.0 m of carbonate mudstone, ostracode grainstone, domal stromatolite, greenish-gray mudstone, and a distinctive bed of oolite grainstone containing ostracode nuclei (fig. 4*E*; appendix, units 3 and 4 of measured section 8). This unit is equivalent to Remy's (1989a) ostracode oolite marker; however, in this report I used Jacob's original name for the marker because it has precedence over the name I employed in 1989 and because the marker does not everywhere contain oolites with ostracode nuclei. The D marker is approximately 160 m above the top of the carbonate marker unit (plate 1) and can be traced from a position several kilometers west of measured section 16 through measured section 8 to a position 3 km west of measured section 7 (fig. 1) where it goes into the subsurface.

Jacob's (1969) C marker consists of three ostracode grainstones that he designated (from base to top) "C3," "C2," and "C1." Markers C3 and C2 form a prominent yellow double band that can be traced visually in the upper walls of central and eastern Nine Mile Canyon (fig. 4*A*). Jacob's (1969) C1 marker is approximately 4–17 m above the C2 marker and consists of 2–8 m of ostracode grainstone, domal stromatolites as much as 1 m wide by 50 cm high (fig. 5*A*), micrite, and minor sandstone and mudstone (see, for example, units 100 and 101 of measured section 8 and units 83–85 of measured section 9 in the appendix). Both the thickness of the marker and the size of the domal stromatolites decrease westward. The C1 marker of Jacob (1969) is equivalent to the stromatolite marker of Remy (1989a) and the C marker of this report. The C marker is approximately 215 m above the D marker and can be traced for 30 km along Nine Mile Canyon and for 15 km from the canyon southward toward the Roan Cliffs (plate 1). In this report the C marker serves as the boundary between the Sunnyside delta interval and the overlying transitional interval. The C marker is roughly stratigraphically equivalent to the middle marker of Ryder and others (1976) (T.D. Fouch, U.S. Geological Survey, oral commun., 1988).

Jacob's (1969) B marker is approximately 85 m above the stromatolite marker and 45–100 m below the base of the upper member (as defined by the top of the S1 marker unit). The unit is 0.5–4.0 m thick. In most measured sections the B marker is composed of ostracode grainstone (see, for example, unit 129 of measured section 8 in the appendix). In other places, however, the unit consists of ooid grainstone (unit 104, measured section 13) or micrite with oolites and

Figure 5 (above and following pages). Photographs of the Green River Formation. *A*, Large domal stromatolites in the C marker (unit 78, measured section 7, appendix). Ruler (15 cm) for scale. *B*, Sunnyside delta interval in western Nine Mile Canyon immediately west of measured section 11 (fig. 1). At this location the Sunnyside delta interval consists of tabular sandbodies of Sb lithofacies (two indicated with arrows), which are interpreted as meandering delta distributary channels, separated by red and green mudstone, thin sandstone, and limestone that accumulated in subaqueous and subaerial mudflat, crevasse-splay, overbank-sandsheet, and lake-margin carbonate-flat environments. Cliff at extreme right of photograph is 265 m high. *C*, Sunnyside delta interval in eastern Nine Mile Canyon opposite measured section 9 (fig. 1). At this location the Sunnyside delta interval consists of thick amalgamated sandbodies of Sc lithofacies, which are interpreted as stacked distributary mouth bars, and associated mudstone, thin sandstone, and limestone beds that accumulated in subaqueous and subaerial mudflat, crevasse-splay, overbank and shallow-lacustrine sandsheet, and lake-margin carbonate-flat environments. Cliff on left side of photograph is approximately 150 m high. *D*, Horse Bench Sandstone Bed of upper member in Gate Canyon. See measured section 6 (appendix) for detailed description of rocks. Jacob's staff (1.5 m) for scale (arrow). *E*, Upper Roan Cliffs and Sunnyside tar sand quarry. The quarry and all but top 0–30 m of the Roan Cliffs consist of interfingering alluvial to marginal-lacustrine deposits of the Colton and Green River Formations. Thick sandbodies of Sa lithofacies are exposed in the quarry and overlying interval (one sandbody indicated with arrow) and are interpreted as nonsinuous channels on an upper delta to alluvial plain. The top 0–30 m of the Roan Cliffs at this location consists predominantly of dark mudstone and dolostone and is stratigraphically equivalent to the lower part of the upper member in Nine Mile Canyon. Part of Roan Cliffs shown is approximately 500 m high.

ostracodes and domal stromatolites (unit 120, measured section 14). Similar to the C marker, the B marker can be traced throughout most of Nine Mile Canyon (plate 1).

Recently, I recognized that Bradley's (1931) delta facies in the Nine Mile Canyon area, as redefined to include his basal member, consists of two distinct suites of rocks: (1) a lower, 375-m-thick sequence of marginal-lacustrine rocks informally named the "Sunnyside delta interval" and (2) an upper, 150-m-thick sequence of marginal- to open-lacustrine rocks informally named the "transitional interval" (Remy, 1989a) (fig. 3, section C). The boundary between the units is placed at the C marker, and the B marker subdivides the transitional interval into informal upper and lower parts. In this report I placed the contact between the transitional interval and the overlying upper member at the top of the S1 marker unit. The S1 marker unit was employed for this purpose because the interval overlying the S1 consists mainly of dark mudstone and dolostone (including the Mahogany ledge), typical rock types in the upper member.

The Sunnyside delta interval was named for the Sunnyside tar sand deposit in the Roan Cliffs. Outcrops of the unit consist of sandstone of the Sb (23.6 percent), Sc (4.0 percent), Se (12.8 percent), and Sf (2.8 percent) lithofacies, red and green mudstone of the Mr (7.8 percent) and Mg (19.0 percent) lithofacies, respectively, carbonate

grainstone, micrite, and stromatolite of the L lithofacies (6.2 percent), very minor (0.5 percent) dark mudstone of the Ia lithofacies, and covered intervals (23.3 percent) probably underlain mainly by mudstone (table 2). These rocks accumulated in meandering delta distributary channel (fig. 5*B*), delta mouth bar (fig. 5*C*), crevasse-splay, overbank and shallow-lacustrine sandsheet, subaerial and subaqueous mudflat, lake-margin carbonate-flat, and minor open-lacustrine settings in and adjacent to a large fluvially dominated delta along the southern shore of Lake Uinta (Remy, 1989a, b, 1991). In this report the term "Sunnyside delta interval" refers to the stratigraphic interval deposited in the Sunnyside delta in the Nine Mile Canyon area. The Sunnyside delta interval and transitional interval of this report are equivalent to Picard's (1957, 1959) green shale facies.

As its name implies, the transitional interval is a zone of transition between the underlying sand-rich Sunnyside

delta interval and the overlying fine-grained, mudstone- and dolostone-rich upper member. The lower part of the transitional interval contains less sandstone (24.2 percent versus 43.2 percent) and red mudstone (0.4 percent versus 7.8 percent) and more green mudstone (33.2 percent versus 19.0 percent) and limestone (13.7 percent versus 6.2 percent) than the underlying Sunnyside delta interval. Measured sections of the lower half of the transitional interval consist of sandstone of the Sb (9.5 percent), Se (12.4 percent), and Sf (2.3 percent) lithofacies, green and very minor red mudstone of the Mg (33.2 percent) and Mr (0.4 percent) lithofacies, respectively, carbonate grainstone, micrite, and stromatolite of the L lithofacies (13.7 percent), dark mudstone and dolostone of the Ia lithofacies (0.6 percent), and covered intervals (27.9 percent) probably underlain mainly by mudstone (table 2). The lower part of the transitional interval is illustrated by units 83–163 of measured section 9 (appendix). The upper part of the transitional interval (that is, above the B marker), on the other hand, contains less green mudstone (23.6 percent versus 33.2 percent) and limestone (5.5 percent versus 13.7 percent) and more dark mudstone and dolostone of the Ia (6.4 percent versus 0.6 percent) and Ib (3.4 percent versus 0 percent) lithofacies than the lower part of the transitional interval. The transitional interval is interpreted to record a major, but gradual, expansion (transgression) of Lake Uinta (Remy, 1989a, b, 1991).

Upper Member

In Nine Mile Canyon the transitional interval is overlain by approximately 300 m of predominantly fine grained rocks that generally form light-gray covered slopes (figs. 4*B*, *D*). Measured sections of this interval consist of gray to brown mudstone, dolostone, kerogenous laminated dolostone (oil shale) and minor sandstone of the Sb (4.6 percent), Sd (5.0 percent), Se (3.8 percent), and Sf (1.5 percent) lithofacies and limestone of the L lithofacies (0.2 percent), and covered intervals (30.8 percent) presumably underlain by mudstone and dolostone (table 2). Measured section 17 (appendix) illustrates these rocks. These typically fine grained rocks are interpreted to have been deposited in generally low energy, nearshore to offshore open-lacustrine settings (table 1) during a period when Lake Uinta was at its maximum extent (Remy, 1991). Several intervals in the member, including the interval capped by the S2 marker unit and the Horse Bench Sandstone Bed, contain significant amounts of sandstone and siltstone interbedded with green mudstone. The sandstone contains a variety of sedimentary structures including hummocky cross-stratification (Remy, 1989c, 1991), trough crossbeds, and ripples (wave, current, and combined flow). The high content of sandstone and siltstone, sedimentary structures indicative of relatively high energy, and the absence of open-lacustrine dolostone suggest that these sandy intervals record periods of major siliciclastic sediment influx into Lake Uinta, perhaps due to decreases in lake level.

Bradley (1931) named these rocks the "shaly facies" (fig. 3, section D). The shaly facies is, in part, equivalent to the upper part of the Bradley's (1931) Parachute Creek Member in the eastern Uinta basin (fig. 3, section H). Bradley (1931) did not apply the term "Parachute Creek Member" to the rocks overlying his delta facies because the Parachute Creek Member in the eastern Uinta basin consists predominantly of kerogenous dolostone, whereas the interval above the delta facies in the western Uinta basin consists predominantly of mudstone, siltstone, and lesser dolostone.

Dane (1954, 1955) and Ray and others (1956) divided Bradley's shaly facies into the Parachute Creek Member and the Evacuation Creek Member (fig. 3, section G), which are stratigraphic terms for the upper part of the Green River Formation originally assigned by Bradley (1931) to the formation in the eastern Uinta basin. Cashion and Donnell (1974) later abandoned the term "Evacuation Creek Member" and reassigned the rocks to the Parachute Creek Member in the eastern Uinta basin. Weiss and others (1990) did not use the terms "Parachute Creek Member" and "shaly facies" and assigned that part of the Green River Formation between the base of the Mahogany oil-shale zone and the base of the saline facies of Dane (1954, 1955) and Ray and others (1956) to the informal upper member. I employ the stratigraphic terminology of Weiss and others (1990) for this part of the Green River Formation and place the base of the upper member at the top of the S1 marker unit, which is also the base of the Mahogany ledge.

The most widespread outcrop and subsurface marker in the Green River Formation is the Mahogany oil-shale bed (Cashion, 1967; Fouch and Cashion, 1979). In the study area this unit is 11–35 m above the base of the upper member (as defined by the top of the S1 marker unit) and consists of 1–2 m of black, highly kerogenous, laminated dolostone (see, for example, units 12–15 of measured section 10 in the appendix). The Mahogany bed is the richest and most prominent oil shale in the Mahogany ledge, which consists of several resistant rich oil-shale beds (Cashion, 1967). This interval was named the Mahogany ledge by Bradley (1931, p. 23) because polished surfaces of the rock resemble old mahogany.

The S2 marker unit of Fouch and others (1976) is 30–60 m above the S1 marker unit. In and near Gate Canyon the S2 is a thin (1 m), ledge-forming, very fine grained sandstone containing ripples (wave, current, and combined flow), planar laminations, and hummocky cross-stratification (Remy, 1989c) (see, for example, unit 17 of measured section 15, appendix) and green mudstone in places. The unit consists of several stacked and amalgamated hummocky cross-stratified storm deposits that accumulated in an open-lacustrine environment (Remy, 1989c, 1991). Toward the east, the S2 thickens and is much coarser grained. As noted above, the S2 marker unit is equivalent to the 3-bed of Ray and others (1956). The S2 marker unit can be traced regionally along the south flank of the basin (Fouch and others, 1976).

In outcrops in the study area the most prominent unit in the upper member is a plateau-forming interval of sandstone and mudstone (figs. 4*C*, *D*, 5*D*) that Bradley (1931, p. 16) named the "Horse Bench Sandstone Lentil." Subsequent workers (Dane, 1955; Cashion, 1967; Fouch, 1975) referred to this unit as the "Horse Bench Sandstone Bed." In the study area the resistant Horse Bench Sandstone Bed forms a broad smooth plateau that is overlain and underlain by generally poorly exposed, slope-forming, mudstone and dolostone (fig. 4*C*, *D*). The base of the Horse Bench Sandstone Bed is approximately 150 m above the base of the upper member (that is, the top of S1 marker unit). It is a 10–20-m-thick interval consisting of greenish-gray to brown mudstone, siltstone, and sandstone (fig. 5*D*;

measured sections 5 and 6 and units 69–73 of measured section 17, appendix). Sedimentary structures include wave and current ripples, trough crossbeds, syneresis cracks, and burrows. The top of the Horse Bench Sandstone Bed and equivalent horizons are equivalent to the upper marker of Fouch (1975), which can be traced throughout most of the basin subsurface (Fouch and Cashion, 1979; Fouch, 1981).

Dane (1954, 1955) and Ray and others (1956) described two tuff zones above the Horse Bench Sandstone Bed. In the area of Gate Canyon, however, the only prominent stratigraphic marker I encountered in the upper part of the upper member was a tuff bed about 80 m below the top of the member. The tuff is approximately 20–35 cm thick, weathers yellow, and is characterized by abundant biotite crystals in the lower half of the bed (unit 86 of measured section 17, appendix).

In this study the top of the upper member is placed approximately 150 m above the base of the Horse Bench Sandstone Bed at the first occurrence upward of substantial sandstone beds above the Horse Bench Sandstone Bed. The contact is also marked by a change in the weathered color of the rocks. The upper member forms light-gray slopes, whereas overlying rocks weather light brown. In the area of Nine Mile Canyon, the upper member of the Green River Formation is overlain by the saline facies of the Green River Formation of Weiss and others (1990) and by the sandstone and limestone facies of Bryant (1990). The saline facies of Weiss and others (1990) is equivalent to the saline facies of the Uinta Formation of Dane (1954, 1955) and Ray and others (1956).

LITHOSTRATIGRAPHY OF THE GREEN RIVER FORMATION: ROAN CLIFFS

The upper 500 m of the Roan Cliffs near the Sunnyside tar sand deposit consists of a 470–500-m-thick sequence containing abundant sandstone and mudstone and rare limestone overlain by a 0–30-m-thick sequence containing abundant dolostone and green mudstone (fig. 5*E*; measured sections 1 and 2, appendix; plate 1). Measured sections of the lower sand-rich sequence consist of sandstone of the Sa (37.7 percent), Sb (14.8 percent), Se (8.8 percent), and Sf (0.4 percent) lithofacies, red and green mudstone of the Mr (9.7 percent) and Mg (9.7 percent) lithofacies, respectively, limestone of the L lithofacies (2.9 percent), dark mudstone of the Ia lithofacies (0.6 percent), and covered intervals (15.4 percent) that are probably underlain mainly by mudstone (table 2). These rocks are interpreted to have been deposited in nonsinuous channels, meandering delta distributary channels, crevasse splays, overbank sandsheets, subaerial and subaqueous interchannel mudflats, and rare lake-margin carbonate flats in a lower delta plain to alluvial setting (table 1, plate 1).

A measured section of the dolostone-rich interval at the top of the Roan Cliffs (units 81–95 of measured section 2, appendix) consists of sandstone of the Se lithofacies (4.4 percent), green mudstone of the Mg lithofacies (24.3 percent), carbonate grainstone and micrite of the L lithofacies (15.7 percent), and laminated and structureless dolostone and gray to brown mudstone of the Ia (7.8 percent) and Ib (47.8 percent) lithofacies. These rocks are interpreted to have been deposited in overbank and shallow-lacustrine sandsheet, subaqueous mudflat, lake-margin carbonate-flat, and open-lacustrine environments (table 1) (Remy, 1991). The lower green mudstone- and limestone-rich part of this sequence is interpreted to have accumulated in a shallow nearshore-lacustrine setting, and the upper dolostone-rich part of the sequence is interpreted to have accumulated in a proximal to distal open-lacustrine setting (plate 1).

The stratigraphic sequence that crops out in the upper Roan Cliffs near the Sunnyside tar sand deposit has been variously placed in the upper part of the Colton or Wasatch Formation and the lower part of the Green River Formation (Holmes and others, 1948; Williams, 1950; Abbott and Liscomb, 1956; Covington, 1975; Banks, 1981), in the upper black shale facies of Picard (1955, 1959) (Hendel, 1957; Murany, 1964), and in the lower part of the main body of the Green River Formation (Jacob, 1969; Ryder and others, 1976; Campbell and Ritzma, 1979). Recently, Weiss and others (1990) mapped the uppermost fine-grained sequence at the top of the cliffs as the upper member of the Green River Formation, the 200-m-thick sequence underlying the upper member as the middle member of the Green River Formation, and the underlying rocks as the Colton Formation.

Most workers (Jacob, 1969; Fouch and others, 1976, fig. 2; J.A. Campbell, Oklahoma Geological Survey, written commun., 1986; Weiss and others, 1990) agree that the Mahogany oil-shale bed is near the top of the Roan Cliffs. The same oil shale was also mapped by Winchester (1923, plate 16). In the Roan Cliffs above the Sunnyside tar sand quarry the Mahogany oil-shale bed is approximately 80 cm thick and consists of laminated, kerogenous dolostone (oil shale), structureless dolostone, and brown laminated dolostone or shale (basal 80 cm of unit 83, measured section 2, appendix). The Mahogany is underlain by limestone and overlain by green mudstone.

The presence of the Mahogany oil-shale bed at the top of the Roan Cliffs allows the stratigraphic section at the Roan Cliffs to be correlated with the Green River Formation in the area of Nine Mile Canyon (plate 1). This correlation demonstrates that the dolostone- and green-mudstone-rich interval at the top of the Roan Cliffs is stratigraphically equivalent to part of the lower part of the upper member of the Green River Formation in the Nine Mile Canyon area (Weiss and others, 1990). The underlying interfingering Green River and Colton Formations, which contain the Sunnyside tar sand deposit, are stratigraphically equivalent to the lowermost part of the upper member, all of the transitional interval, and the upper half of the Sunnyside delta interval. The facts that lithofacies characteristic of the lower delta plain assemblage (that is, lithofacies L, Mg, and Sb) are more abundant in the upper half of the interfingering Colton and Green River Formations than in the lower half and that lithofacies characteristic of the upper delta–alluvial plain assemblage (that is, lithofacies Mr and Sa) are more abundant in the lower half of the interval than in the upper half (plate 1) indicate that the expansion (transgression) of Lake Uinta suggested by the transitional interval in Nine Mile Canyon also affected sedimentation in the area that is now the Roan Cliffs.

As noted above, Weiss and others (1990) mapped the rocks above the Mahogany oil-shale bed at the Roan Cliffs near Sunnyside as the upper member of the Green River Formation and the sandstone-rich sequence below the Mahogany as the middle member of the Green River Formation underlain by the Colton Formation. The middle member as mapped by Weiss and others (1990) is approximately 200 m thick at this location. Measured sections 1 and 2 of this report (appendix) show, however, that there is no easily identifiable consistent lithologic break in the stratigraphic section that can be employed to distinguish the middle member from the Colton Formation. Moreover, lithofacies Sa, which is typical of inferred upper delta plain to alluvial deposits of the Colton Formation, is present within 100 m of the top of the Roan Cliffs (see, for example, unit 63 of measured section 2). Rather than having a sharp break between the Green River and Colton Formations, the upper Roan Cliffs beneath the fine-grained upper member of the Green River Formation consist of extensive interfingering of rocks typical of the Green River Formation and those typical of the Colton Formation. Therefore, I made no attempt to differentiate the middle member of the Green River Formation from the Colton Formation, and I refer to the entire 475–500-m-thick sequence beneath the upper member as the "interfingering Green River and Colton Formations" on plate 1.

The S1 and S2 marker units and limestone markers B and C pinch out or lose their identity somewhere between the Roan Cliffs (measured sections 1 and 2) and measured section 14, which is approximately 11 km north of the Roan Cliffs (fig. 1, plate 1). I could not confidently identify the carbonate marker unit in the Roan Cliffs beneath measured sections 1 and 2. The Mahogany oil-shale bed is, therefore, the only stratigraphic marker in the Green River Formation that can be confidently identified along the Roan Cliffs near the Sunnyside tar sand quarry.

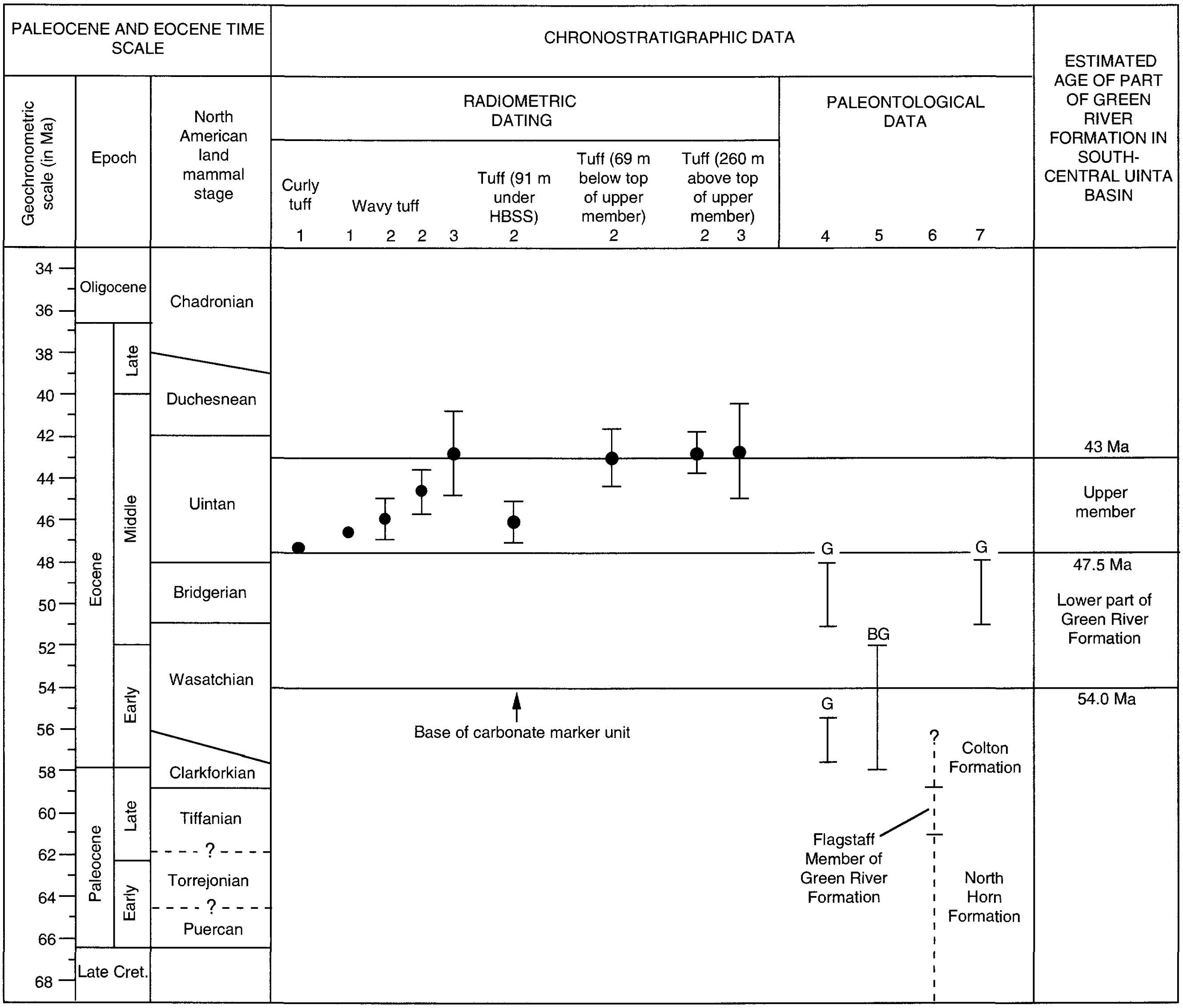
CHRONOSTRATIGRAPHY OF THE GREEN RIVER FORMATION

Unlike the upper member, the lower part of the Green River Formation (carbonate marker unit, Sunnyside delta interval, and transitional interval) does not contain tuffs that can be radiometrically dated; however, paleontological data can be used to roughly constrain the age of these rocks (fig. 6). Analysis of microfossils suggests that the Paleocene-Eocene boundary is in the upper third of the Colton Formation on the south flank of the basin (Ryder and others, 1976, p. 497). This interpretation is supported by the presence of late Paleocene nonmarine molluscs in the underlying Flagstaff Member of the Green River Formation in Price Canyon (Fouch and others, 1987). In the southern Uinta basin the Paleocene-Eocene boundary is approximately 550 m below the top of the carbonate marker unit (Fouch, 1981). In the study area the interval between the top of the carbonate marker unit and the top of the transitional interval is approximately 550 m thick. The 1,100 m of rocks between the Paleocene-Eocene boundary, which Berggren and others (1985) placed at approximately 58 Ma, and the top of the transitional interval, which radiometric dates on tuffs place at approximately 47.5 million years, accumulated in about 10.5 million years. These data suggest a rock accumulation rate of approximately 105 m per million years. This estimate is supported by Bradley (1929), who estimated that fluvial rocks above and below the Green River Formation accumulated at a rate of about 1 ft per 3,000 years (101.6 m per million years). Assuming that the generally sand-rich lower part of the Green River Formation accumulated at about the same rate as the underlying rocks, then the 700 m of the lower part of the Green River Formation (base of carbonate marker unit to top of transitional interval) accumulated in about 6.5 million years, and the age of the base of the main body of the Green River Formation in the area of Nine Mile Canyon is very roughly 54 Ma.

The upper member contains several tuffs that serve as regional stratigraphic markers. Radiometric dating of some of these tuffs (Mauger, 1977; O'Neill, 1980; O'Neill and others, 1981; Bryant and others, 1990) provides chronstratigraphic control on the upper member (fig. 6).

The curly tuff is between the S1 marker unit and the Mahogany oil shale bed (O'Neill, 1980) (fig. 3, section C). The tuff is 2.5–46 cm thick and characterized by undulatory upper and lower contacts and contorted bedding (Cashion, 1967, p. 16). A mean $^{40}Ar/^{39}Ar$ date on biotites from the tuff in Gate Canyon was initially reported by O'Neill (1980) as 46.2±0.7 Ma. O'Neill and others (1981) subsequently reported a date of 47.2 Ma for the same tuff. The latter date presumably represents reevaluation of the data originally reported in O'Neill (1980) and is therefore the date used in this study. The curly tuff lies a little above the S1 marker unit and is therefore a little younger than the base of the upper member; thus the age of the base of the member is approximately 47.5 Ma in the Gate Canyon area.

The wavy tuff is approximately 55 m above the Mahogany oil shale bed in Gate Canyon (O'Neill, 1980, fig. 32). The tuff has an average thickness of 30 cm (O'Neill, 1980) and is characterized by intercalated stringers of



EXPLANATION

HBSS, Horse Bench Sandstone Bed.
G, lower part of Green River Formation (carbonate marker unit, Sunnyside delta interval, and transitional interval).
BG, basal Green River Formation (beneath carbonate marker unit).

SOURCES OF DATA

1. $^{40}Ar/^{39}Ar$ radiometric date on tuff (O'Neill and others, 1981).
2. Recalibration of K/Ar radiometric date on tuff of Mauger (1977), as reported in Krishtalka and others (1987).
3. Fission-track ages of zircons in tuff (Bryant and others, 1990, table 1).
4. Bridgerian or possibly latest Graybullian (early Wasatchian) turtles in Sunnyside delta interval in Nine Mile Canyon (identified by J.H. Hutchison, written commun., 1989).
5. Early Eocene palynomorphs in attrital coal in basal Green River Formation beneath carbonate marker unit, Indian Canyon (Fouch and others, 1976, p. 371).
6. Analysis of palynomorphs, ostracodes, charophytes, and mollusks indicates that age of basal part of North Horn Formation is Late Cretaceous (Maastrichtian), upper part of the North Horn Formation is middle to late Paleocene, and Flagstaff Member of the Green River Formation in Price Canyon is late Paleocene (Fouch and others, 1987).
7. Bridgerian fauna is in Green River Formation, 82 m below Mahogany oil-shale bed in eastern Uinta basin (Krishtalka and others, 1987).

Figure 6. Chronostratigraphy of part of the Green River Formation in the south-central part of the Uinta basin. Time scale from Berggren and others (1985).

marlstone that accentuate the wavy bedding surfaces produced by plastic flow or differential compaction (Cashion, 1967, p. 16). O'Neill (1980) obtained a mean $^{40}Ar/^{39}Ar$ date of 46.2±0.5 Ma from biotite separates from this tuff. O'Neill and others (1981) subsequently reported a date of 46.7 Ma for the same tuff. The latter date is used in this study for the reason discussed earlier. Recalibration of K/Ar dates on biotites from the wavy tuff in Gate Canyon (Mauger, 1973; his sample RLM-7-70) and Indian Canyon (his sample RLM–2–70) yielded dates of 46.0±0.9 and 44.7±1.0 Ma, respectively (reported in Krishtalka and others, 1987, table 4.1). Bryant and others (1990, table 1) obtained a zircon fission-track age of 42.3±2.0 Ma for the wavy tuff in Indian Canyon (their locality 23). They noted, but did not offer an explanation for, the discrepancy between their results and those of Mauger (1977) and O'Neill and others (1981). Excluding the anomalous zircon fission-track age of Bryant and others (1990), the mean age of the wavy tuff is approximately 46.2 Ma, in reasonable agreement with a presumed age of 47.5 Ma for the base of the upper member based on the curly tuff.

Recalibration of Mauger's (1977) K-Ar date for an unnamed tuff (his sample RLM–2–69) 91 m below the base of the Horse Bench Sandstone Bed in Dane's (1955) Indian Canyon section yielded an age of 45.9±0.9 Ma (recalibrated date reported in Krishtalka and others, 1987, table 4.1). This tuff is 7 m above the wavy tuff, which is 98 m below the Horse Bench Sandstone Bed in Dane's (1955) Indian Canyon section (Mauger, 1977, table 1). Recalibration of Mauger's (1977) K-Ar date for a tuff (his sample RLM-1–69) 69 m below the top of Dane's (1954, 1955) Evacuation Creek Member (upper part of upper member of this report) in Indian Canyon yielded an age of 43.1±1.3 Ma (Krishtalka and others, 1987, table 4.1).

Recalibration of Mauger's (1977) K-Ar date on a tuff in Indian Canyon (his sample RLM–8–70) that is about 19 m below the the top of Dane's (1954, 1955) limestone-sandstone facies of the Uinta Formation yielded an age of 42.8±1.0 Ma (Krishtalka and others, 1987, table 4.1). This tuff is approximately 260 m above the top of the upper member as defined in this study. Bryant and others (1990, table 1) obtained a zircon fission-track age of 42.8±2.2 Ma for the same tuff in Indian Canyon (their locality 22). The top of the upper member is thereby bracketed by ages of tuffs above the wavy tuff of 45.9± 0.9 Ma and 43.1±1.3 Ma and by two age estimates of about 42.8 Ma for a tuff substantially above the top of the member. These data suggest an age of about 43 Ma for the top of the upper member in the study area.

To summarize, analysis of published paleontological and radiometric age data from the Green River Formation suggests ages of about 54.0 Ma for the base of the carbonate marker unit, about 47.5 Ma for the contact between the transitional interval and the upper member, and about 43 Ma for the top of the upper member in the study area. This interval extends from the late early Eocene to the upper half of the middle Eocene and from the middle Wasatchian to the late Uintan North American land mammal stages (time scale of Berggren and others, 1985) (fig. 6). The conclusion that the interval between the base of the carbonate marker unit and the top of the transitional interval spans the late Wasatchian, all of the Bridgerian, and part of the early part of the Uintan North American land mammal stages is supported by (1) the presence of Bridgerian or latest Graybullian (early Wasatchian) turtles in the Sunnyside delta interval (J.H. Hutchison, University of California, Berkeley, written commun., 1989), (2) a Bridgerian mammal fauna collected 82 m below the Mahogany oil shale bed in the eastern Uinta basin (Krishtalka and others, 1987, p. 101), and (3) early Eocene palynomorphs in attrital coal beneath the carbonate marker unit in Indian Canyon (Fouch and others, 1976, p. 371).

SUMMARY AND CONCLUSIONS

1. The carbonate marker unit (Fouch and others, 1976; Ryder and others, 1976) marks the base of the main body of the Eocene part of the Green River Formation in the south-central part of the Uinta basin. It consists of approximately 130 m of ostracode and ooid grainstone and micrite, green, gray, and brown mudstone, sandstone and siltstone, and uncommon dark laminated mudstone and kerogenous laminated dolostone (oil shale). These rocks accumulated along the fluctuating southern shore of Lake Uinta in lake-margin carbonate-flat, subaqueous mudflat, crevasse-splay, overbank and shallow-lacustrine sandsheet, delta distributary channel, and proximal open-lacustrine settings. Hendel's (1957) upper black shale of the Peters Point gas field is equivalent to the carbonate marker unit, and the distinct change in the weathered color of the rocks from light gray below to light brown above that marks the top of the carbonate marker unit in surface exposures is equivalent to the carbonate marker of Ryder and others (1976) in the subsurface rocks in the basin.

2. In the area of Nine Mile Canyon the delta facies of Bradley (1931), as redefined to include his basal member, consists of two distinct suites of rocks: (1) a lower, 375-m-thick sequence of marginal-lacustrine rocks informally named the Sunnyside delta interval and (2) an upper, 150-m-thick sequence of marginal- to open-lacustrine rocks informally named the transitional interval. In the Nine Mile Canyon area the Sunnyside delta interval consists of sandstone, red and green mudstone, and shallow-water carbonate rocks deposited in a large fluvially dominated delta system along the southern shore of Lake Uinta. The transitional interval is characterized by an upward increase from the base of the unit in the amount of open-lacustrine dolostone, kerogenous laminated dolostone (oil shale), and dark mudstone and a decrease in the amount of marginal-lacustrine green mudstone and shallow-water limestone. These lithologic changes record a major, but gradual, expansion of Lake Uinta.

3. Three transgressive shallow-water limestone units in the Sunnyside delta interval and transitional interval serve as local chronostratigraphic markers. These limestone units, which were originally identified by Jacob (1969), are

(from base to top) (1) the D marker, which is near the middle of the Sunnyside delta interval, (2) the C marker, which marks the top of the Sunnyside delta interval, and (3) the B marker, which is near the middle of the transitional interval. The boundary between the transitional interval and the overlying upper member of the Green River Formation is placed at the top of the S1 marker unit of Fouch and others (1976).

4. The upper member overlies the transitional interval in the area of Nine Mile Canyon and consists of approximately 300 m of dark mudstone, dolostone, and kerogenous laminated dolostone (oil shale) and minor sandstone and siltstone that accumulated in a relatively low energy open-lacustrine setting during a period when Lake Uinta was at its maximum size. The member contains several regional stratigraphic markers: (1) the Mahogany oil-shale bed, a 1–2-m-thick kerogenous laminated dolostone (oil shale) 18–32 m above the base of the upper member, (2) the S2 marker unit (Fouch and others, 1976), (3) the Horse Bench Sandstone Bed, a 10–20-m-thick interval of sandstone, siltstone, and greenish mudstone approximately 150 m above the base of the member, and (4) a 20–35-cm-thick unnamed tuff 80 m below the top of the upper member.

5. The upper Roan Cliffs near the Sunnyside tar sand quarry consist of several hundred meters of sandstone, red and green mudstone, and very minor limestone deposited in a lower delta plain to alluvial setting overlain, in places, by a 30-m-thick interval of limestone, green mudstone, dolostone, and minor sandstone deposited in shallow-nearshore and open-lacustrine settings. The presence of the Mahogany oil-shale bed near the top of the Roan Cliffs demonstrates that the top 0–30 m of the cliff is stratigraphically equivalent to the lower part of the upper member of the Green River Formation in Nine Mile Canyon and that the underlying rocks (including the tar sands), which represent a zone of interfingering between the marginal- and open-lacustrine Green River Formation and the alluvial Colton Formation, are stratigraphically equivalent to the lowermost upper member, the transitional interval, and the upper Sunnyside delta interval in the Nine Mile Canyon area.

6. Analysis of published paleontological data and $^{40}Ar/^{39}Ar$, K/Ar, and zircon fission-track dates from tuffs in the upper member suggests ages of approximately 54 Ma, 47.5 Ma, and 43 Ma for the base of the carbonate marker unit, the top of the transitional interval, and the top of the upper member, respectively, in the study area.

REFERENCES CITED

Abbott, Ward, 1957, Tertiary of the Uinta basin, *in* Seal, O.G., ed., Guidebook to the geology of the Uinta basin: Intermountain Association of Petroleum Geologists Annual Field Conference, 8th, Guidebook, p. 102–109.

Abbott, W.O., and Liscomb, R.L., 1956, Stratigraphy of the Book Cliffs in east central Utah, *in* Peterson, J.A., ed., Geology and economic deposits of east central Utah: Intermountain Association of Petroleum Geologists Annual Field Conference, 7th, Guidebook, p. 120–123.

Banks, E.Y., 1981, Petrographic characteristics and provenance of fluvial sandstone, Sunnyside oil-impregnated sandstone deposit, Carbon County, Utah: Salt Lake City, University of Utah, M.S. thesis, 112 p.

Berggren, W.A., Kent, D.V., Flynn, J.J., and Van Couvering, J.A., 1985, Cenozoic geochronology: Geological Society of America Bulletin, v. 96, p. 1407–1418.

Bradley, W.H., 1929, The varves and climate of the Green River epoch: U.S. Geological Survey Professional Paper 158-E, p. 87–110.

——— 1931, Origin and microfossils of the oil shale of the Green River Formation of Colorado and Utah: U.S. Geological Survey Professional Paper 168, 56 p.

Bryant, Bruce, 1990, Geologic map of the Salt Lake City 1°×2° quadrangle, Utah and Wyoming: U.S. Geological Survey Miscellaneous Investigations Series Map I–1997, 2 sheets.

Bryant, B., Naeser, C.W., Marvin, R. F., and Mehnert, H.H., 1990, Upper Cretaceous and Paleogene sedimentary rocks and isotopic ages of Paleogene tuffs, Uinta basin, Utah: U.S. Geological Survey Bulletin 1787–J, 22 p.

Campbell, J.A., and Ritzma, H.R., 1979, Geology and petroleum resources of the major oil impregnated sandstone deposits of Utah: Utah Geological and Mineral Survey Special Studies 50, 24 p.

Cashion, W.B., 1967, Geology and fuel resources of the Green River Formation, southeastern Uinta basin, Utah and Colorado: U.S. Geological Survey Professional Paper 548, 48 p.

Cashion, W.B., and Donnell, J.R., 1974, Revision of nomenclature of the upper part of the Green River Formation, Piceance Creek basin, Colorado, and eastern Uinta basin, Utah: U.S. Geological Survey Bulletin 1394–G, 9 p.

Castle, J.W., 1990, Sedimentation in Eocene Lake Uinta (Green River Formation), northeastern Uinta basin, Utah, *in* Katz, B.J., ed., Lacustrine basin exploration—Case studies and modern analogues: American Association of Petroleum Geologists Memoir 50, p. 243–263.

Colburn, J.A., Bereskin, S.R., McGinley, D.C., and Schiller, D.M., 1985, Lower Green River Formation in the Pleasant Valley producing area, Duchesne and Uinta Counties, Utah, *in* Picard, M.D., Geology and energy resources, Uinta basin, Utah: Utah Geological Association Publication 12, p. 177–186.

Covington, R.E., 1975, Oil-impregnated rocks of Utah—Distribution, geology, and reserves: Brigham Young University Geological Studies, v. 22, p. 143–150

Dane, C.H., 1954, Stratigraphic and facies relationships of upper part of Green River Formation and lower part of Uinta Formation in Duchesne, Uintah, and Wasatch Counties, Utah: American Association of Petroleum Geologists Bulletin, v. 38, p. 405–425.

——— 1955, Stratigraphic and facies relationships of the upper part of the Green River Formation and the lower part of the Uinta Formation in Duchesne, Uintah, and Wasatch Counties, Utah: U.S. Geological Survey Oil and Gas Investigations Chart OC–52, 2 sheets.

Dickinson, W.R., Lawton, T.F., and Inman, K.F., 1986, Sandstone detrital modes, central Utah foreland region—Stratigraphic record of Cretaceous-Paleogene tectonic evolution: Journal of Sedimentary Petrology, v. 56, p. 276–293.

Fouch, T.D, 1975, Lithofacies and related hydrocarbon accumulations in Tertiary strata of the western and central Uinta basin, Utah, *in* Bolyard, D.W., ed., Symposium on Deep Drilling Frontiers in the Central Rocky Mountains: Rocky Mountain Associations of Geologists, p. 163–173.

——— 1976, Revision of the lower part of the Tertiary System in the central and western Uinta basin, Utah: U.S. Geological Survey Bulletin 1405–C, p. C1–C7.

——— 1981, Distribution of rock types, lithologic groups, and interpreted depositional environments for some Lower Tertiary and Upper Cretaceous rocks from outcrops at Willow Creek–Indian Canyon through the subsurface of Duchesne and Altamont oil fields, southwest to north central parts of the Uinta basin, Utah: U.S. Geological Survey Oil and Gas Investigation Chart OC–81, 2 sheets.

Fouch, T.D., and Cashion, W.B., 1979, Preliminary chart showing distribution of rock types, lithologic groups and depositional environments for some Lower Tertiary, Upper and Lower Cretaceous, and Upper and Middle Jurassic rocks in the subsurface between Altamont oil field and San Arroyo gas field, northcentral to southeastern Uinta basin, Utah: U.S. Geological Survey Open-File Report 79–365, 2 sheets.

Fouch, T.D., Cashion, W.B., Ryder, R.T., and Campbell, J.A., 1976, Field guide to lacustrine and related nonmarine depositional environments in Tertiary rocks, Uinta basin, Utah, *in* Epis, R.C., and Weimer, R.J., eds., Studies in Colorado field geology: Professional Contributions Colorado School of Mines, v. 8, p. 358–385.

Fouch, T.D., Hanley, J.H., Forester, R.M., Keighin, C.W., Pitman, J.K., and Nichols, D.J., 1987, Chart showing lithology, mineralogy, and paleontology of the nonmarine North Horn Formation and Flagstaff Member of the Green River Formation, Price Canyon, central Utah—A principal reference section: U.S. Geological Survey Miscellaneous Investigations Series Map I–1797–A.

Franczyk, K.J., Pitman, J.K., Cashion, W.B., Dyni, J.R., Fouch, T.D., Johnson, R.C., Chan, M.A., Donnell, J.R., Lawton, T.F., and Remy, R.R., 1989, Evolution of resource-rich foreland and intermontane basins in eastern Utah and western Colorado: Washington, D.C., American Geophysical Union, International Geological Congress, 28th, Field Trip Guidebook T–324, 53 p.

Grugel, K.D., Jones, B.R., and Powers, D.E., 1983, Energy resources map of Utah: Utah Geological and Mineral Survey Map 68, scale 1:500,000, 1 sheet.

Hendel, C.W., 1957, The Peters Point gas field, *in* Seal, O.G., ed., Guidebook to the geology of the Uinta basin: Intermountain Association of Petroleum Geologists Annual Field Conference, 8th, Guidebook, p. 193–201.

Hintze, L.F., compiler, 1980, Geologic map of Utah: Utah Geological and Mineral Survey, scale 1:500,000, 2 sheets.

Holmes, C.N., Page, B.M., and Averitt, Paul, 1948, Geology of the bituminous sandstone deposits near Sunnyside, Carbon County, Utah: U.S. Geological Survey Preliminary Map 86, 1 sheet.

Jacob, A.F., 1969, Delta facies of the Green River Formation (Eocene), Carbon and Duchesne counties, Utah: Boulder, University of Colorado, Ph.D. thesis, 97 p.

Johnson, R.C., 1985, Early Cenozoic history of the Uinta and Piceance Creek basins, Utah and Colorado, with special reference to the development of Eocene Lake Uinta, *in* Flores, R.M., and Kaplan, S.S., eds., Cenozoic paleogeography of the west-central United States: Rocky Mountain Section, Society of Economic Paleontologists and Mineralogists, p. 247–276.

Koesoemadinata, R.P., 1970, Stratigraphy and petroleum occurrence, Green River Formation, Redwash Field, Utah: Colorado School of Mines Quarterly, v. 65, p. i-viii, 1–77.

Krishtalka, L., West, R.M., Black, C.C., Dawson, M.R., Flynn, J.J., Turnbull, W.D., Stucky, R.K., McKenna, M.C., Brown, T.M., Golz, D.J., and Lillegraven, J.A., 1987, Eocene (Wasatchian through Duchesnean) biochronology of North America, *in* Woodburne, M.O., ed., Cenozoic mammals of North America: Berkeley, University of California Press, p. 77–117.

Little, T.M., 1988, Depositional environments, petrology, and diagenesis of the basal limestone facies, Green River Formation (Eocene), Uinta basin, Utah: Salt Lake City, University of Utah, M.S. thesis, 154 p.

Mauger, R.L., 1977, K-Ar ages of biotites from tuffs in Eocene rocks of the Green River, Washakie, and Uinta basins, Utah, Wyoming, and Colorado: Contributions to Geology, University of Wyoming, v. 15, p. 17–41.

McDonald, R.E., 1972, Eocene and Paleocene rocks of the southern and central basins, *in* Mallory, W.W., ed., Geologic atlas of the Rocky Mountain Region: Rocky Mountain Association of Geologists, p. 243–256.

Murany, E.E., 1964, Wasatch Formation of the Uinta basin, *in* Sabatka, E.F., ed., Guidebook to the geology and mineral resources of the Uinta basin: Intermountain Association of Petroleum Geologists, Annual Field Conference, 13th, Guidebook, p. 145–155.

Oleson, N.E., 1986, Petroleum geology of the Eocene lower Green River Formation, Duchesne and Uintah Counties, Utah: Waco, Texas, Baylor University, M.S. thesis.

O'Neill, W.A.,1980, $^{40}Ar^{39}Ar$ ages of selected tuffs of the Green River Formation—Wyoming, Colorado, and Utah: Columbus, Ohio State University, M.S. thesis, 142 p.

O'Neill, W.A., Sutter, J.F., and Stanley, K.O., 1981, Sedimentation history of rich oil-shale sequences in Eocene Lakes Gosiute and Uinta, Wyoming and Utah: Geological Society of America Abstracts with Programs, v. 13, p. 222.

Osmond, J.C., 1985, Reservoir sandstone patterns, Green River Formation, Duck Creek oil field, Uintah County, Utah, *in* Picard, M.D., Geology and energy resources, Uinta basin, Utah: Utah Geological Association Publication 12, p. 187–192.

Picard, M.D., 1955, Subsurface stratigraphy and lithology of Green River Formation in the Uinta basin: American Association of Petroleum Geologists Bulletin, v. 39, p. 75–102.

——— 1957, Green shale facies, lower Green River Formation, Utah: American Association of Petroleum Geologists Bulletin, v. 41, p. 2373–2376.

——— 1959, Green River and lower Uinta Formation subsurface stratigraphy in western Uinta basin, *in* Williams, N.C., ed., Guidebook to the geology of the Wasatch and Uinta Mountains transition area: Intermountain Association of Petroleum Geologists Annual Field Conference, 10th, Guidebook, p. 139–149.

Picard, M.D., and High, L.R., 1970, Sedimentology of oil-impregnated, lacustrine and fluvial sandstone, P.R. Spring area, southeast Uinta basin, Utah: Utah Geological and Mineral Survey Special Studies 33, 32 p.

Picard, M.D., Thompson, W.D., and Williamson, C.R., 1973, Petrology, geochemistry, and stratigraphy of black shale facies of Green River Formation (Eocene), Uinta basin, Utah: Utah Geological and Mineral Survey Bulletin 100, 52 p.

Pitman, J.K., Fouch, T.D., and Goldhaber, M.B., 1982, Depositional setting and diagenetic evolution of some Tertiary unconventional reservoir rocks, Uinta basin, Utah: American Association of Petroleum Geologists Bulletin, v. 66, p. 1581–1596.

Ray, R.G., Kent, B.H., and Dane, C.H., 1956, Stratigraphy and photogeology of the southwestern part of Uinta basin, Duchesne and Uintah Counties, Utah: U.S. Geological Survey Oil and Gas Investigations Map OM–171, 2 sheets.

Remy, R.R.,1989a, Deltaic and lacustrine facies of the Green River Formation, southern Uinta basin, Utah, *in* Nummedal, D., and Remy, R.R., eds., Cretaceous shelf sandstones and shelf depositional sequences, Western Interior basin, Utah, Colorado and New Mexico: Washington, D.C., American Geophysical Union, International Geological Congress, 28th, Guidebook T–119, p. 1–11.

——— 1989b, Deltaic sedimentation and transgressive/regressive cycles in Green River Formation, southern Uinta basin, Utah: American Association of Petroleum Geologists Bulletin, v. 73, p. 404.

——— 1989c, Lacustrine hummocky cross-stratification in Green River Formation, southern Uinta basin, Utah: American Association of Petroleum Geologists Bulletin, v. 73, p. 1171.

——— 1991, Analysis of lacustrine deltaic sedimentation in the Green River Formation, southern Uinta basin, Utah: Baton Rouge, Louisiana State University, Ph.D. thesis, 395 p.

Ryder, R.T., Fouch, T.D., and Elison, J.H., 1976, Early Tertiary sedimentation in the western Uinta basin: Geological Society of America Bulletin, v. 87, p. 496–512.

Sanborn, A.F., and Goodwin, J.G., 1965, Green River Formation at Raven Ridge, Uintah County, Utah: The Mountain Geologist, v. 2, p. 109–114.

Weiss, M.P., Witkind, I.J., and Cashion, W.B., 1990, Geologic map of the Price 30′×60′ Quadrangle, Carbon, Duchesne, Uinta, Utah, and Wasatch Counties, Utah: U.S. Geological Survey Miscellaneous Investigations Series Map I–1981, 1 sheet.

Williams, M.D., 1950, Tertiary stratigraphy of the Uinta basin, *in* Petroleum geology of the Uinta basin: Intermountain Association of Petroleum Geologists Guidebook to the Geology of Utah, no. 5, p. 101–114.

Winchester, D.E., 1923, Oil shale of the Rocky Mountain region: U.S. Geological Survey Bulletin 729, 204 p.

APPENDIX—MEASURED STRATIGRAPHIC SECTIONS

A. Thickness, location, and stratigraphic markers of measured stratigraphic sections

[Leader (-) indicates marker is below or above section; query (?) indicates marker not identified]

Section number[1]	Thickness (meters)	Location[2]	Position of stratigraphic markers (in meters from base of section)									
			Lower part of Green River Fm.[3]					Upper member				
			Top carbonate marker unit	Base D marker	Base C marker	Base B marker	Top S1 marker unit	Base Mahogany oil-shale bed	Base S2 marker unit	Base Horse Bench SS Bed	Base tuff bed	Top upper member
1	504.7	Roan Cliffs. Base: NE1/4NE1/4, sec. 9, T. 14 S., R. 14 E. Top: SE1/4SW1/4, sec. 3, T. 14 S., R. 14 E., at top of cliff.	—	—	—	—	—	—	—	—	—	—
2	487.5	Roan Cliffs. Sec. 4, T. 14 S., R. 14 E., along road to Bruin Point, base at 8,800 ft (below north tar sand quarry), top at top of road.	—	—	—	—	—	463.3	—	—	—	—
4	172.6	Cottonwood Canyon. Base: NE1/4SW1/4, sec. 31, T. 12 S., R. 16 E. Top: NE1/4NE1/4, sec. 6, T. 13 S., R. 16 E.	—	—	—	72.1	124.2	155.3	163.3	—	—	—
5	7.6	Left fork of Indian Canyon (US Route 191). NW1/4NE1/4, sec. 22, T. 6 S., R. 7 W.	—	—	—	—	—	—	—	0	—	—
6	11.7	Gate Canyon. SE1/4NE1/4NE1/4, sec. 17, T. 11 S., R. 15 E.	—	—	—	—	—	—	—	0	—	—
7	392.9	Junction of Gate and Nine Mile Canyons. Base: NE1/4SE1/4, sec. 32. Top: NE1/4SW1/4, sec. 29; both T. 11 S., R. 15 E.	—	—	177.4	255.9	355.9	381.3	391.2	—	—	—
8	363.3	Nine Mile Canyon. Base: SW1/4NW1/4, sec. 4, T. 12 S., R. 14 E. (near abandoned farmhouse). Top: top of ridge due north of base at elevation of 7262 ft.	—	14.1	237.0	319.9	—	—	—	—	—	—
9	342.0	Nine Mile Canyon. Base: SE1/4SW1/4, sec. 8. Top: NW1/4SW1/4, sec. 17; both T. 12 S., R.16 E.	—	—	125.0	202.6	300.3	311.5	336.9	—	—	—
10	63.0	Gate Canyon. Base: NW1/4SE1/4NE1/4, sec. 20, T. 11 S., R. 15 E., at road level. Top: NE1/4 SW1/4NW1/4, sec. 20, T. 11 S., R. 15 E.	—	—	—	—	13.0	34.7	54.7	—	—	—
11[4]	264.3	Nine Mile Canyon. Base: SE1/4NW 1/4, sec. 15, T. 12 S., R. 13 E. Top: 350 m (horizontally) north-west of base at top of ridge (7,426 ft elevation)	105.7	—	—	—	—	—	—	—	—	—
13	260.0	Junction of Nine Mile and North Franks Canyons. Base: NW1/4NW1/4, sec. 1, T. 12 S., R. 16 E. Top: SE1/4SE1/4, sec. 35, T. 11 S., R. 16 E.	—	—	76.4	159.5	203.8	218.1	252.5	—	—	—
14	279.0	Dry Canyon. Base: SW1/4, sec. 5, T. 13 S., R. 15 E. Top: approximately 450 m (horizontally) northwest of base near 7,400 ft contour.	—	—	101.3	175.9	?	244.0	255.7	—	—	—
15	16.3	Base: NE1/4NE1/4NE1/4, sec. 20, T. 11S., R. 15 E. Top: NW1/4NW1/4NW1/4, sec. 21, T. 11 S., R. 15 E.	—	—	—	—	—	—	15.3	—	—	—
16	492.7	Nine Mile Canyon. Base: SE1/4SE1/4, sec. 11, T. 12 S., R. 13 E. Top: NE1/4NW1/4, sec. 11, T. 12 S., R. 13 E.	0	161.6	370.0	460.5	—	—	—	—	—	—
17	307.1	East Fork of Blind Canyon. Base: SW1/4, sec. 35. Top: NW1/4, sec. 24; both in T. 11S., R. 15 E.	—	—	—	—	12.0	44.0	72.2	162.5	227.8	307.1
18	272.4	Upper Water Canyon. Base: SW1/4, sec. 27. Top: SE1/4, sec. 15; both in T. 11 S., R. 15 E.	—	—	—	—	24.9	53.4	85.7	192.3	272.2	—
19	277.2	Gate Canyon. Base: SE1/4, sec. 20. Top: SE1/4 sec. 17; both in T. 11 S., R. 15 E.	—	—	—	—	49.4	75.2	111.1	222.1	276.9	—

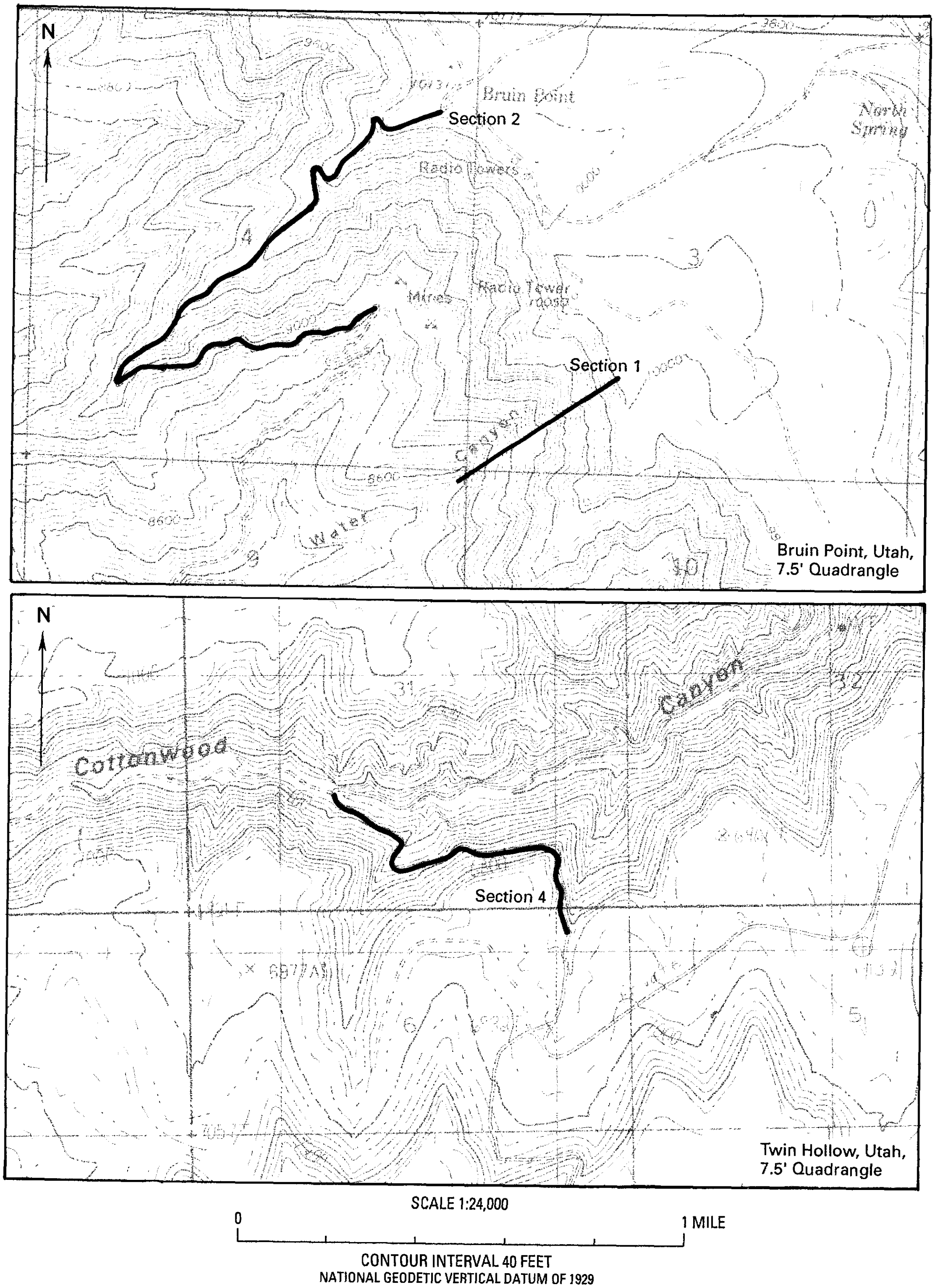
[1] Measured section 2 is a composite section of sections 2, 3, and 12. Measured sections 17, 18, and 19 were measured by Xudong Ying (Louisiana State University, written communication, 1988). Because of the similarity of sections 17, 18, and 19 only section 17 is published in this report.

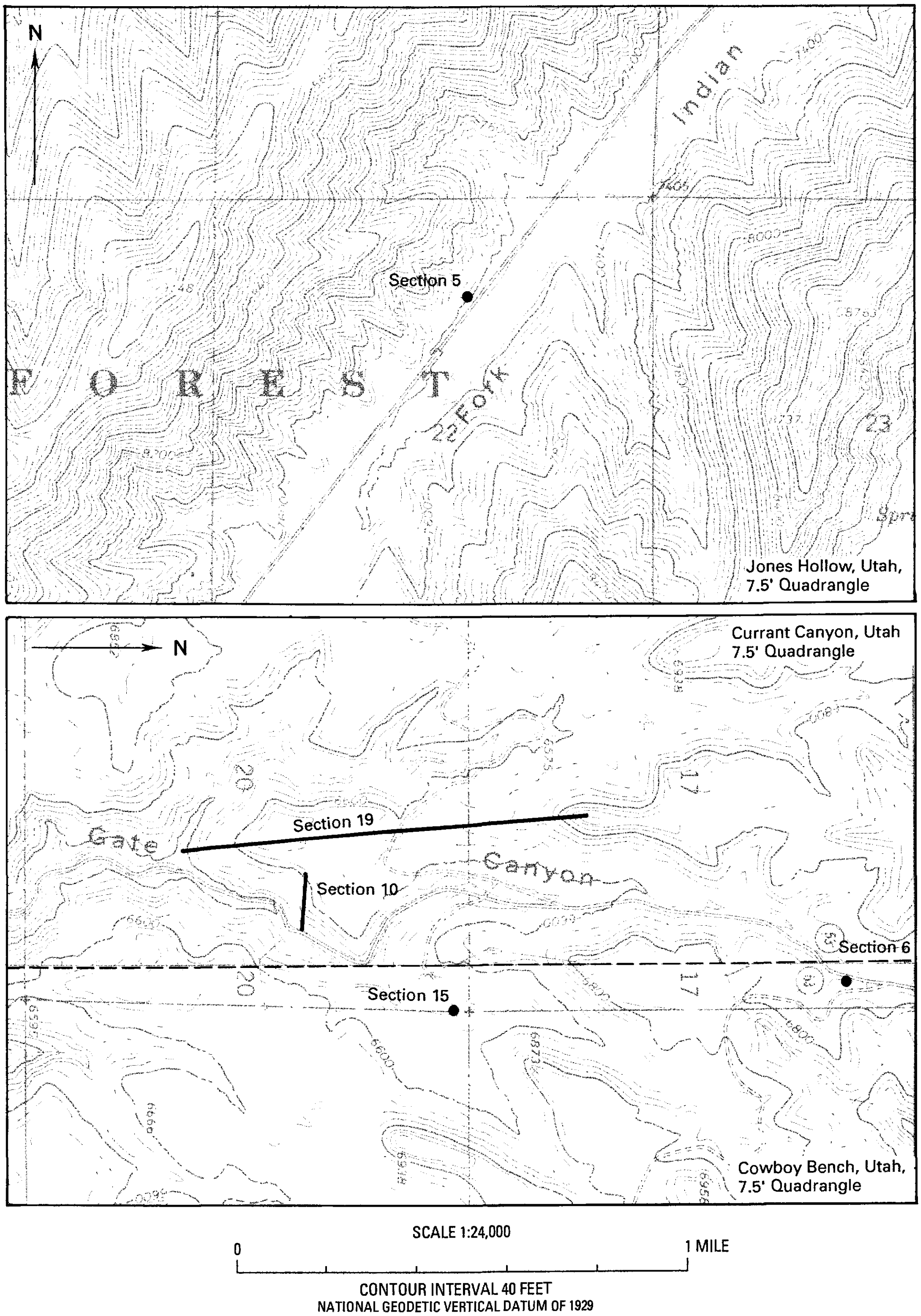
[2] Locations of measured sections are indicated on topographic maps following.

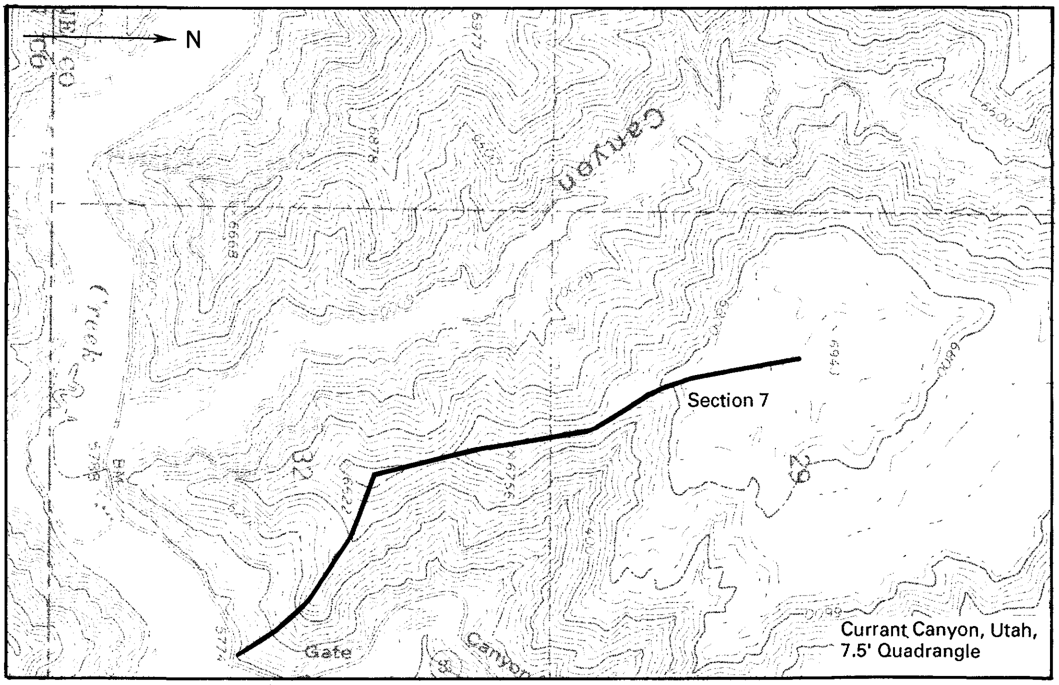
[3] Lower part of Green River Formation = carbonate marker unit, Sunnyside delta interval, and transitional interval.

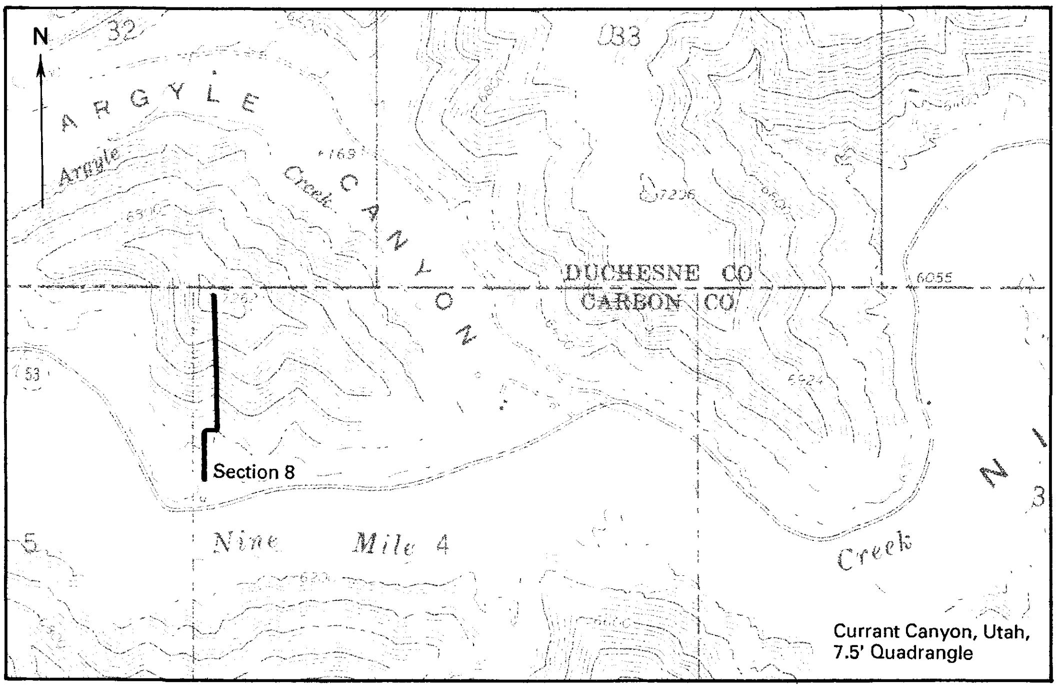
[4] Base of section 11 is 30 m above base of carbonate marker unit.

B. Locations of measured stratigraphic sections




N
Section 5
F O R E S T
Fork
Indian
23
Jones Hollow, Utah,
7.5' Quadrangle
N
Currant Canyon, Utah
7.5' Quadrangle
Gate
Canyon
Section 19
Section 10
Section 15
Section 6
20
17
Cowboy Bench, Utah,
7.5' Quadrangle
SCALE 1:24,000
0
1 MILE
CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929



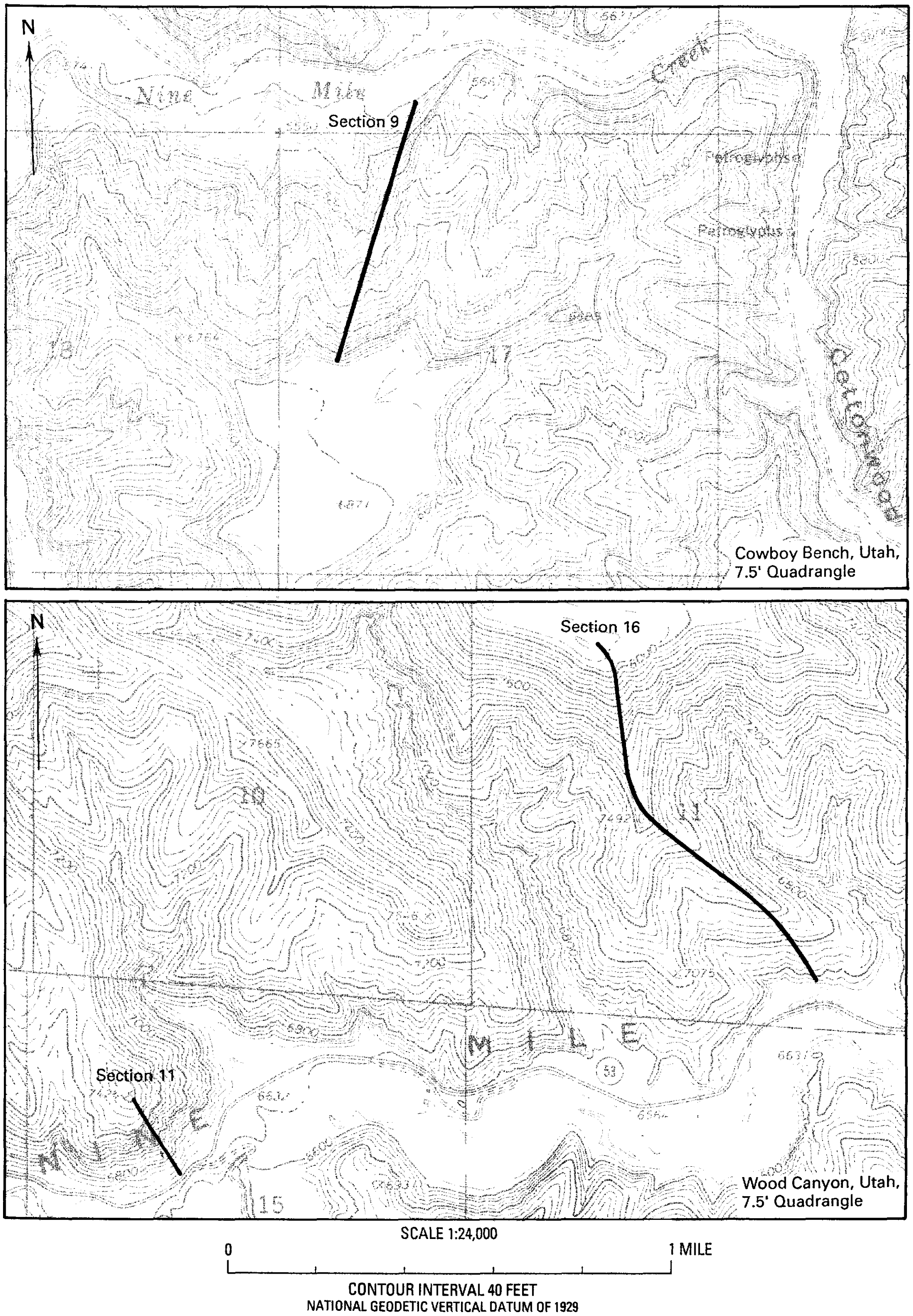


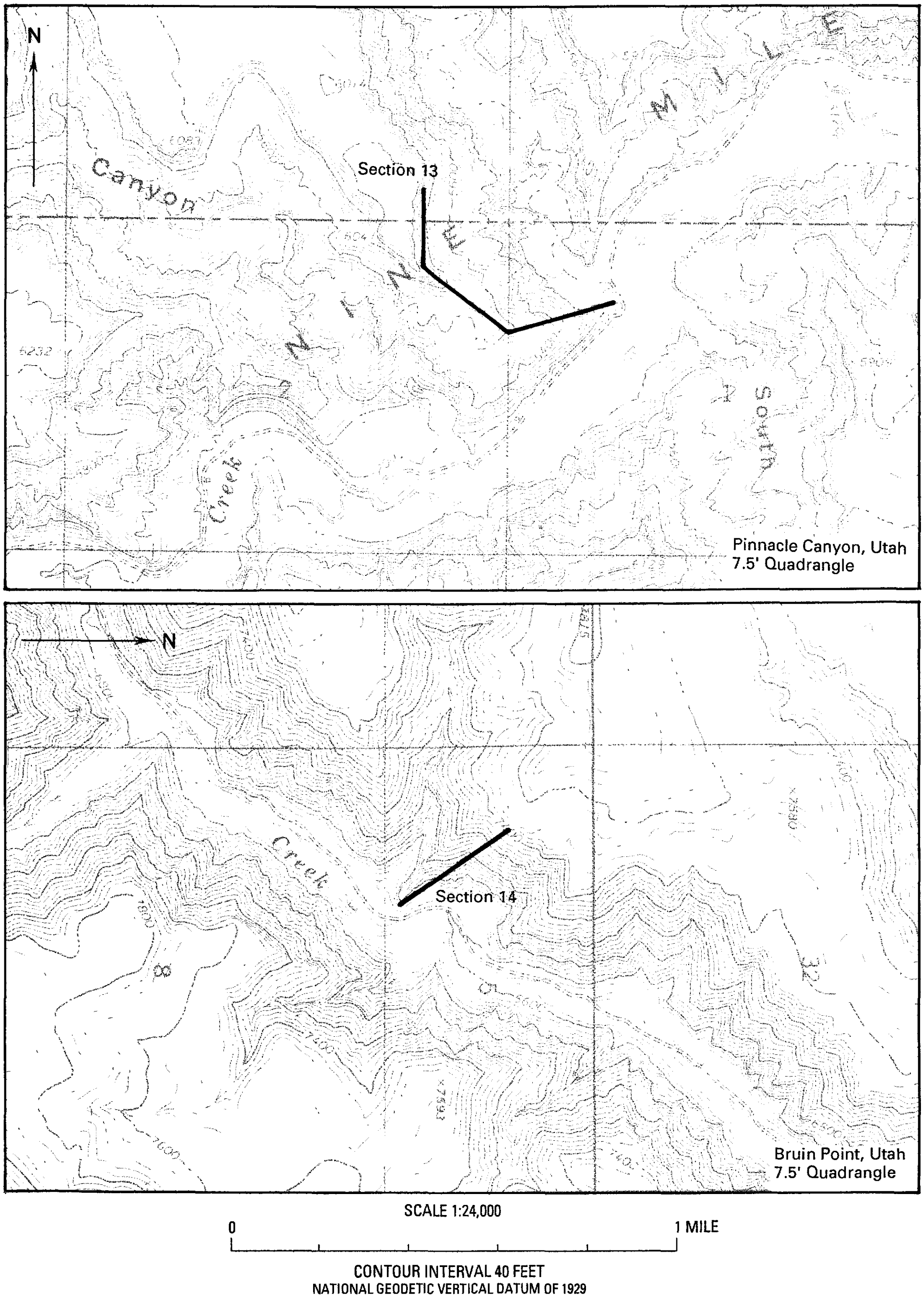
SCALE 1:24,000

0 — 1 MILE

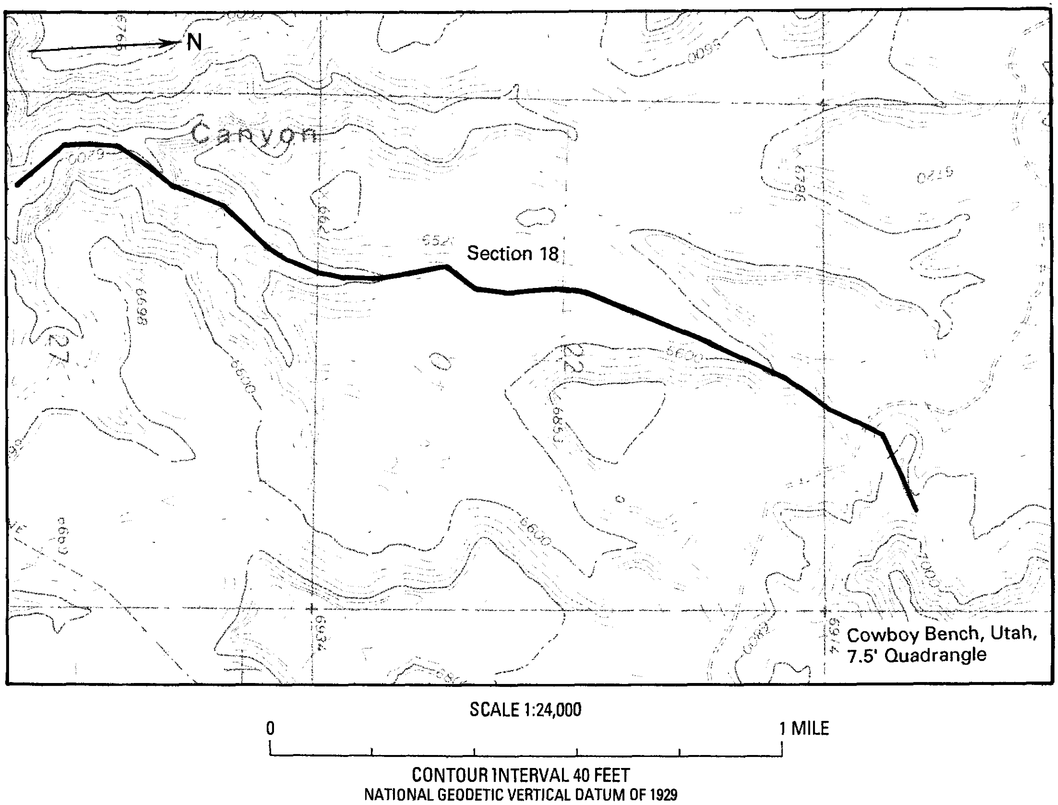
CONTOUR INTERVAL 40 FEET

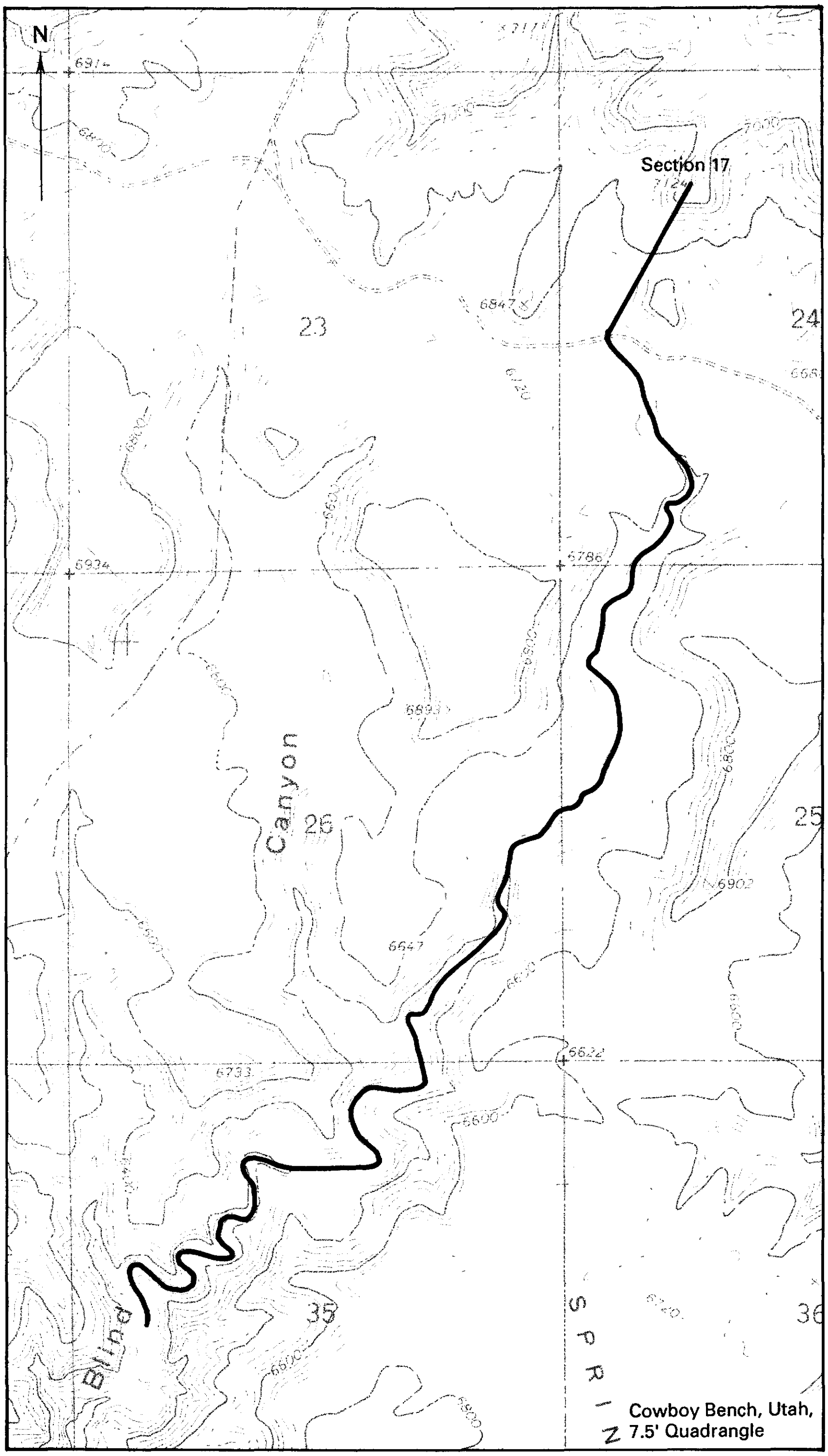
NATIONAL GEODETIC VERTICAL DATUM OF 1929


N
Nine Mile Creek
Section 9
Petroglyphs
Cottonwood
Cowboy Bench, Utah,
7.5' Quadrangle
N
Section 16
Section 11
NINE MILE
Wood Canyon, Utah,
7.5' Quadrangle
SCALE 1:24,000
0
1 MILE
CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929



N
Section 13
Canyon
NINE MILE
Creek
South
Pinnacle Canyon, Utah
7.5' Quadrangle
N
Creek
Section 14
Bruin Point, Utah
7.5' Quadrangle
SCALE 1:24,000
0
1 MILE
CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929


N
Canyon
Section 18
Cowboy Bench, Utah,
7.5' Quadrangle
SCALE 1:24,000
0
1 MILE
CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929



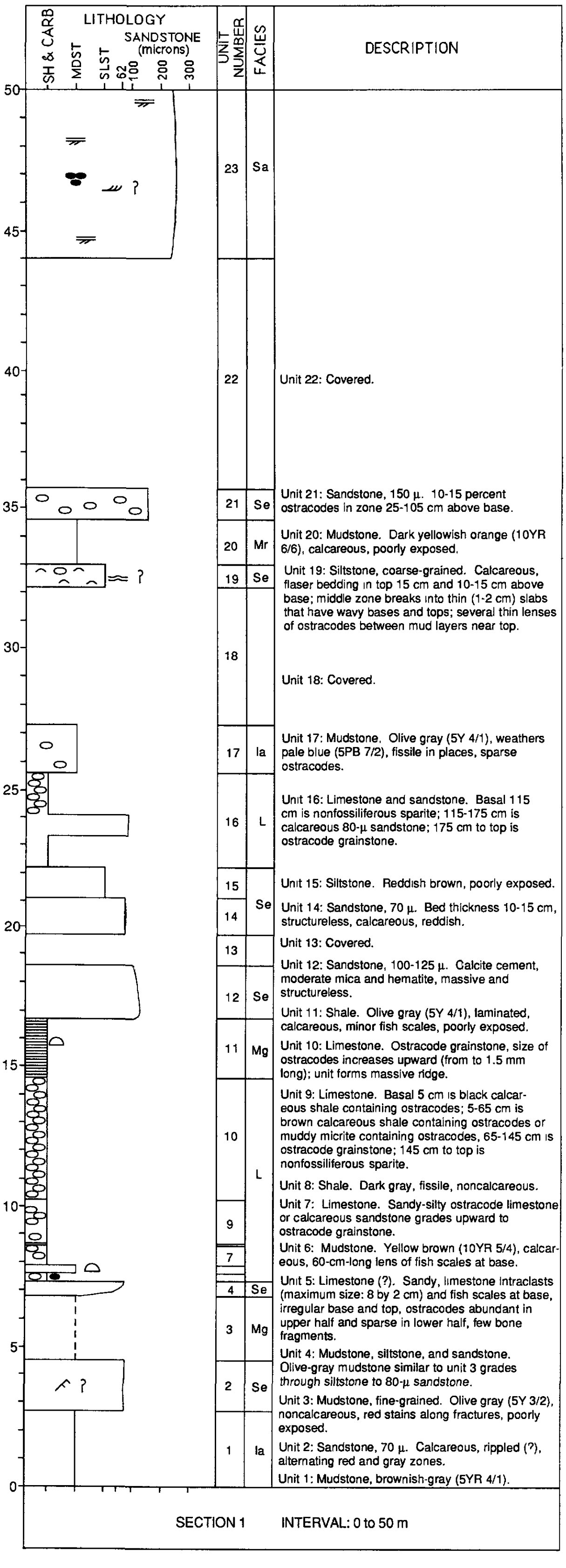
SCALE 1:24,000

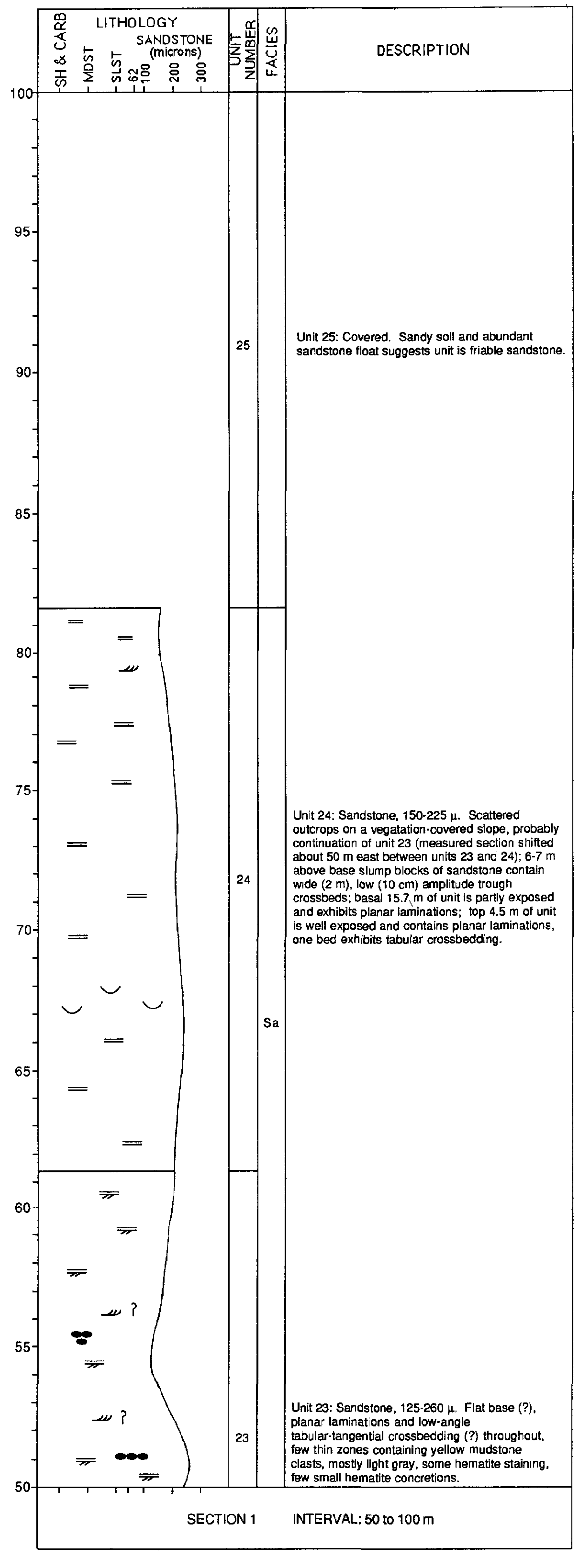
0 — 1 MILE

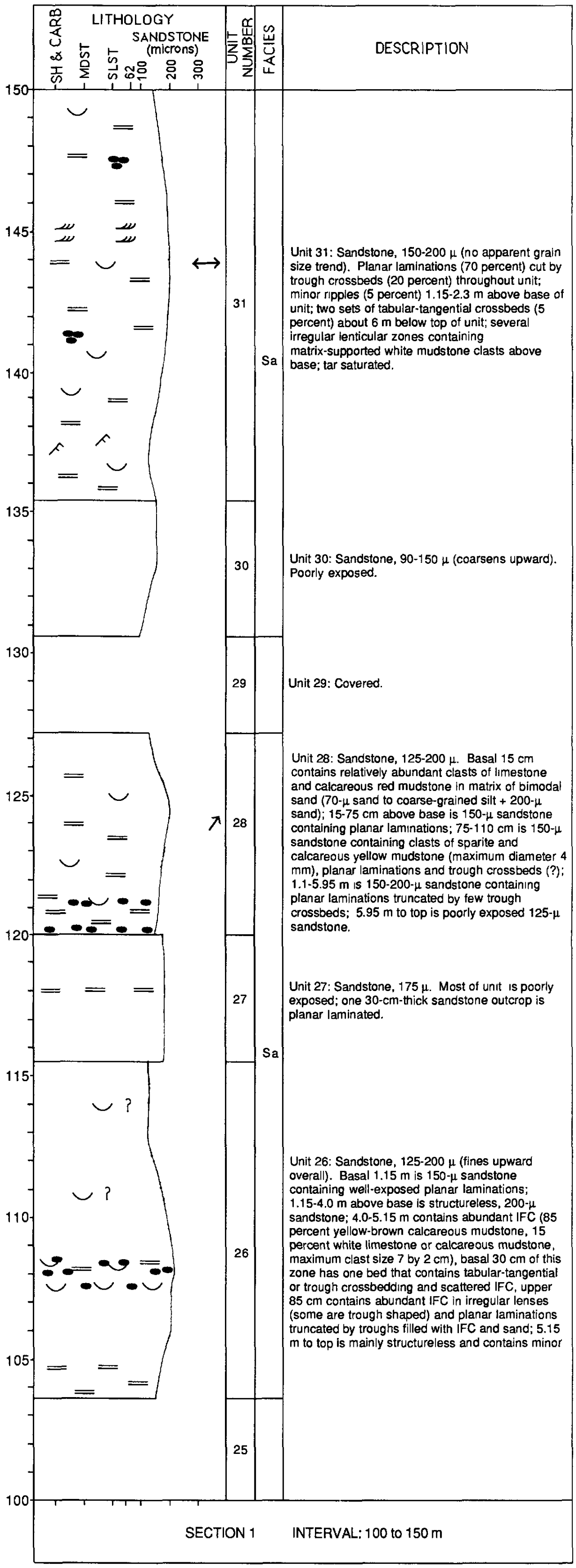
CONTOUR INTERVAL 40 FEET

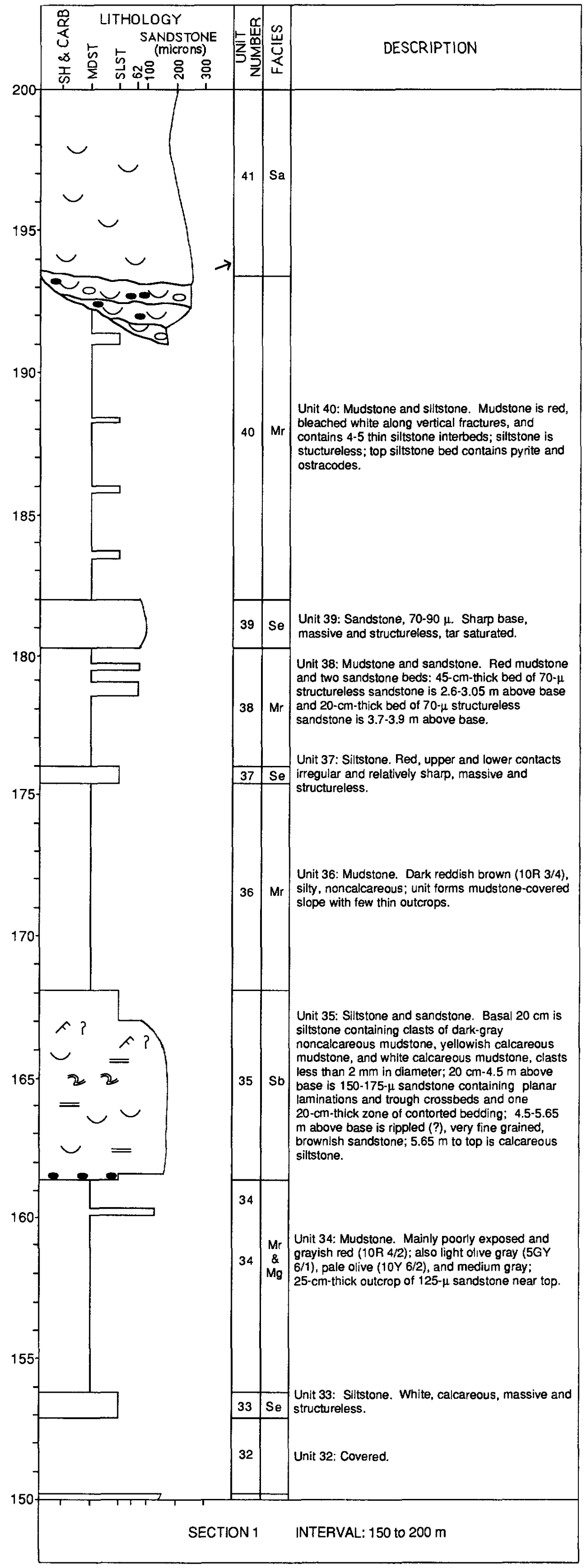
NATIONAL GEODETIC VERTICAL DATUM OF 1929

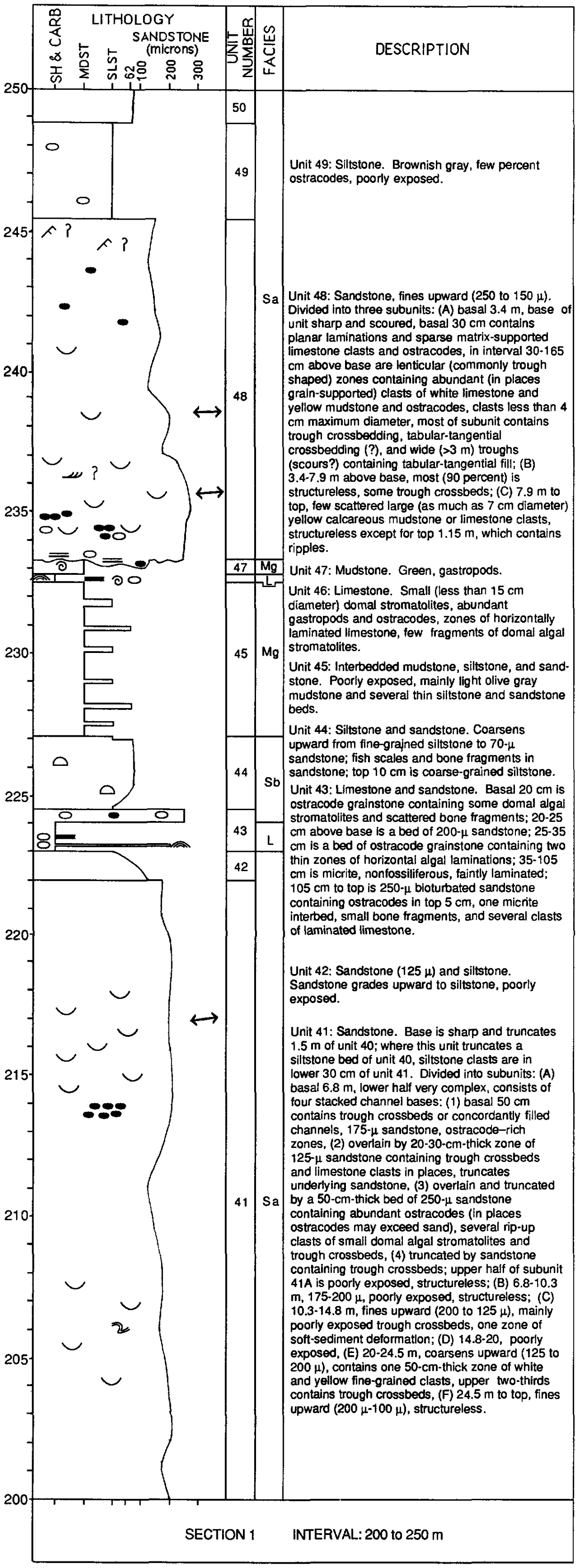
C. Measured stratigraphic sections

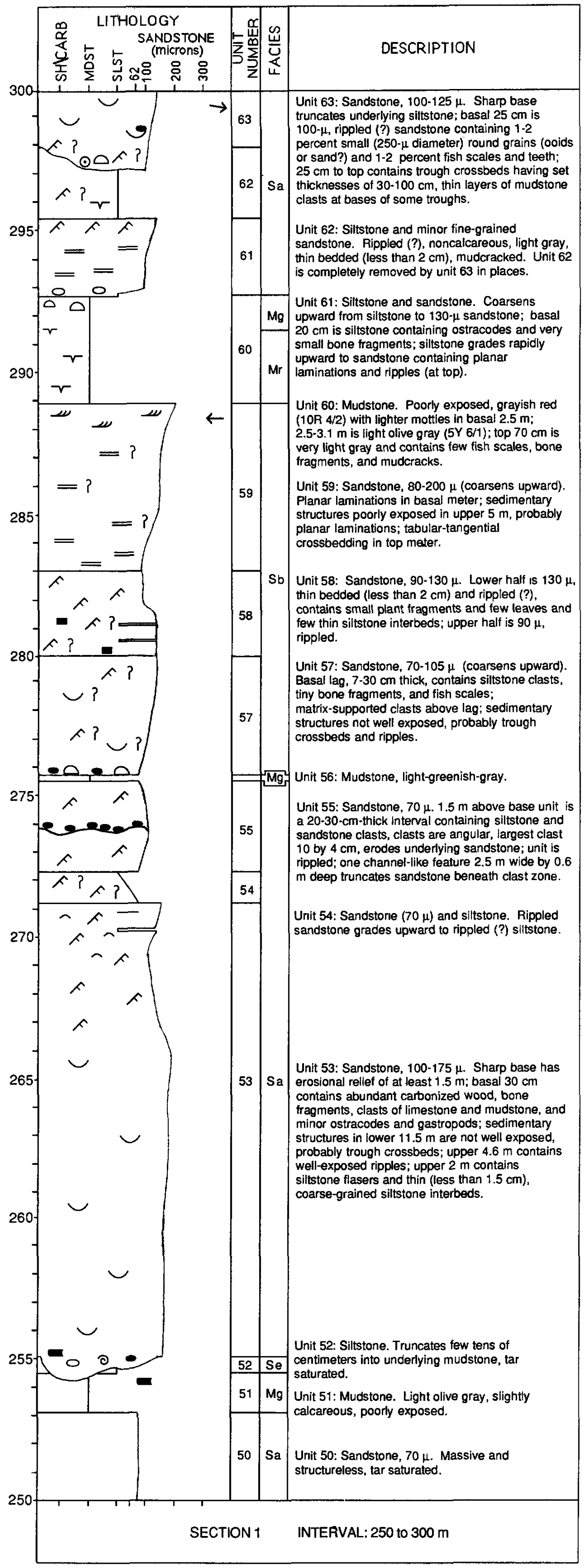


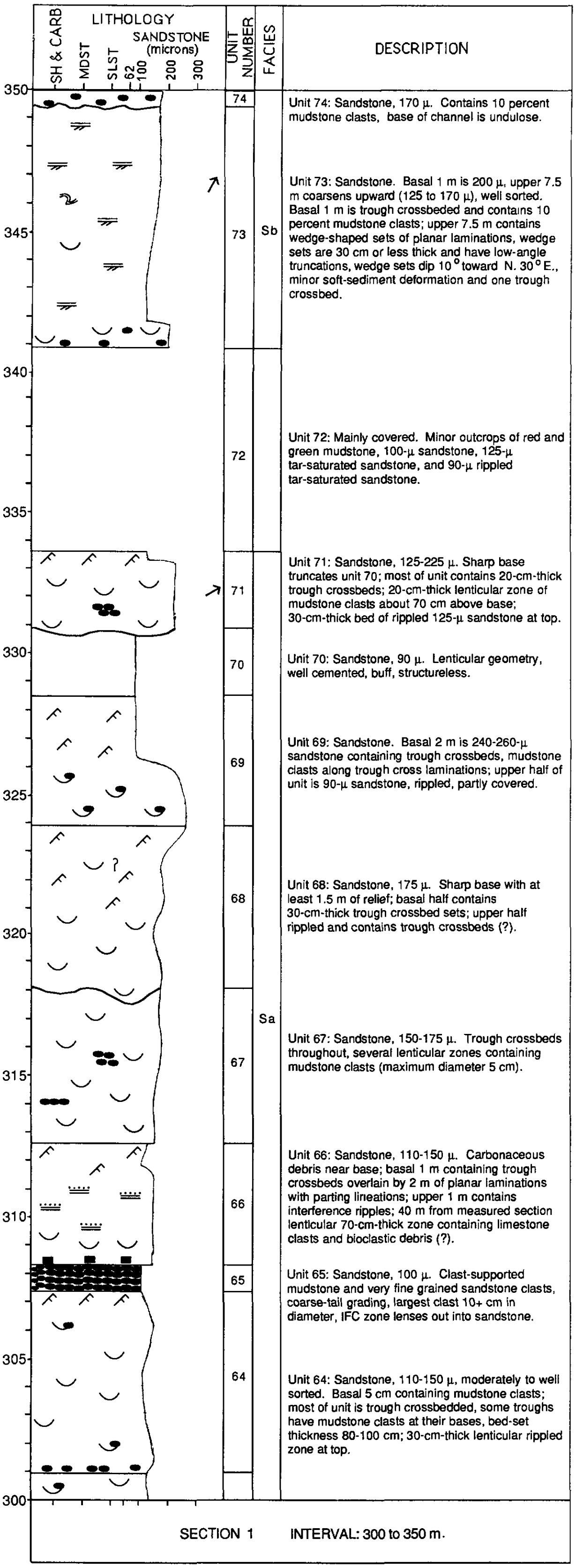


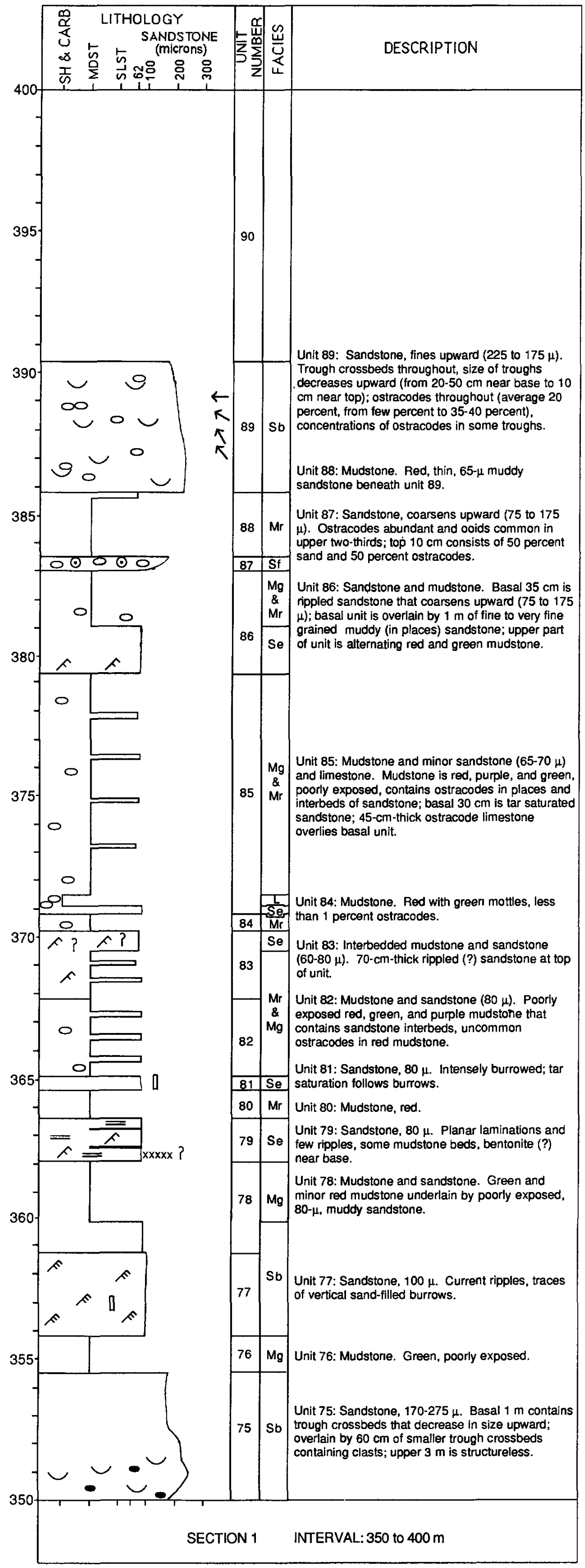

LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
150
145
140
135
130
125
120
115
110
105
100
31
Sa
Unit 31: Sandstone, 150-200 µ (no apparent grain size trend). Planar laminations (70 percent) cut by trough crossbeds (20 percent) throughout unit; minor ripples (5 percent) 1.15-2.3 m above base of unit; two sets of tabular-tangential crossbeds (5 percent) about 6 m below top of unit; several irregular lenticular zones containing matrix-supported white mudstone clasts above base; tar saturated.
30
Unit 30: Sandstone, 90-150 µ (coarsens upward). Poorly exposed.
29
Unit 29: Covered.
28
Unit 28: Sandstone, 125-200 µ. Basal 15 cm contains relatively abundant clasts of limestone and calcareous red mudstone in matrix of bimodal sand (70-µ sand to coarse-grained silt + 200-µ sand); 15-75 cm above base is 150-µ sandstone containing planar laminations; 75-110 cm is 150-µ sandstone containing clasts of sparite and calcareous yellow mudstone (maximum diameter 4 mm), planar laminations and trough crossbeds (?); 1.1-5.95 m is 150-200-µ sandstone containing planar laminations truncated by few trough crossbeds; 5.95 m to top is poorly exposed 125-µ sandstone.
27
Sa
Unit 27: Sandstone, 175 µ. Most of unit is poorly exposed; one 30-cm-thick sandstone outcrop is planar laminated.
26
Unit 26: Sandstone, 125-200 µ (fines upward overall). Basal 1.15 m is 150-µ sandstone containing well-exposed planar laminations; 1.15-4.0 m above base is structureless, 200-µ sandstone; 4.0-5.15 m contains abundant IFC (85 percent yellow-brown calcareous mudstone, 15 percent white limestone or calcareous mudstone, maximum clast size 7 by 2 cm), basal 30 cm of this zone has one bed that contains tabular-tangential or trough crossbedding and scattered IFC, upper 85 cm contains abundant IFC in irregular lenses (some are trough shaped) and planar laminations truncated by troughs filled with IFC and sand; 5.15 m to top is mainly structureless and contains minor
25
SECTION 1
INTERVAL: 100 to 150 m

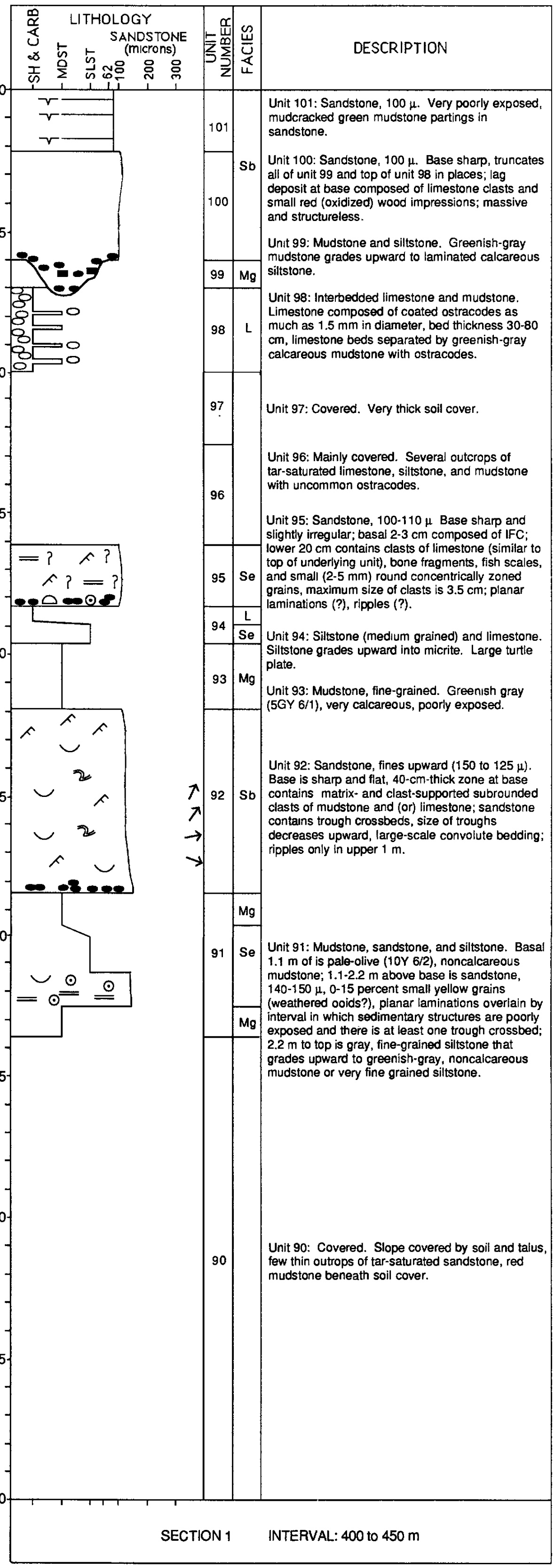

LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
200
195
190
185
180
175
170
165
160
155
150
41
Sa
40
Mr
Unit 40: Mudstone and siltstone. Mudstone is red, bleached white along vertical fractures, and contains 4-5 thin siltstone interbeds; siltstone is stuctureless; top siltstone bed contains pyrite and ostracodes.
39
Se
Unit 39: Sandstone, 70-90 µ. Sharp base, massive and structureless, tar saturated.
38
Mr
Unit 38: Mudstone and sandstone. Red mudstone and two sandstone beds: 45-cm-thick bed of 70-µ structureless sandstone is 2.6-3.05 m above base and 20-cm-thick bed of 70-µ structureless sandstone is 3.7-3.9 m above base.
37
Se
Unit 37: Siltstone. Red, upper and lower contacts irregular and relatively sharp, massive and structureless.
36
Mr
Unit 36: Mudstone. Dark reddish brown (10R 3/4), silty, noncalcareous; unit forms mudstone-covered slope with few thin outcrops.
35
Sb
Unit 35: Siltstone and sandstone. Basal 20 cm is siltstone containing clasts of dark-gray noncalcareous mudstone, yellowish calcareous mudstone, and white calcareous mudstone, clasts less than 2 mm in diameter; 20 cm-4.5 m above base is 150-175-µ sandstone containing planar laminations and trough crossbeds and one 20-cm-thick zone of contorted bedding; 4.5-5.65 m above base is rippled (?), very fine grained, brownish sandstone; 5.65 m to top is calcareous siltstone.
34
34
Mr & Mg
Unit 34: Mudstone. Mainly poorly exposed and grayish red (10R 4/2); also light olive gray (5GY 6/1), pale olive (10Y 6/2), and medium gray; 25-cm-thick outcrop of 125-µ sandstone near top.
33
Se
Unit 33: Siltstone. White, calcareous, massive and structureless.
32
Unit 32: Covered.
SECTION 1
INTERVAL: 150 to 200 m

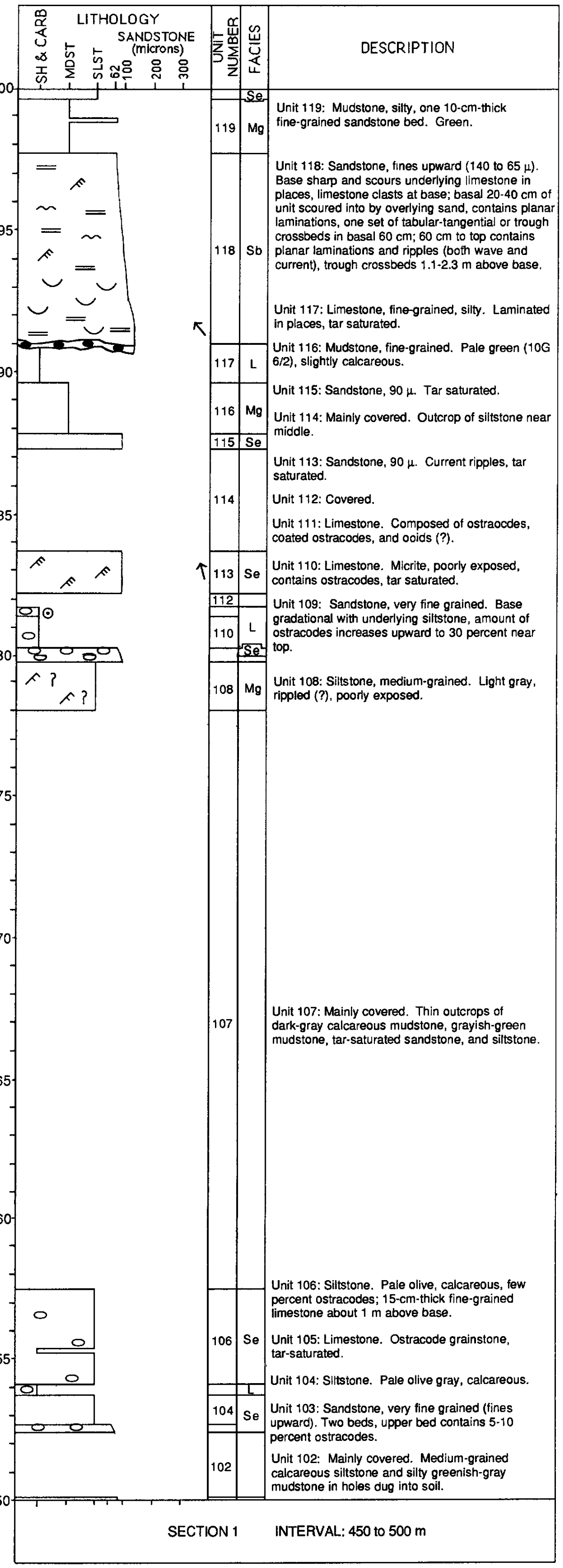

LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
250
245
240
235
230
225
220
215
210
205
200
50
49
48
47
45
44
43
42
41
Sa
Mg
L
Mg
Sb
L
Sa
Unit 49: Siltstone. Brownish gray, few percent ostracodes, poorly exposed.
Unit 48: Sandstone, fines upward (250 to 150 µ). Divided into three subunits: (A) basal 3.4 m, base of unit sharp and scoured, basal 30 cm contains planar laminations and sparse matrix-supported limestone clasts and ostracodes, in interval 30-165 cm above base are lenticular (commonly trough shaped) zones containing abundant (in places grain-supported) clasts of white limestone and yellow mudstone and ostracodes, clasts less than 4 cm maximum diameter, most of subunit contains trough crossbedding, tabular-tangential crossbedding (?), and wide (>3 m) troughs (scours?) containing tabular-tangential fill; (B) 3.4-7.9 m above base, most (90 percent) is structureless, some trough crossbeds; (C) 7.9 m to top, few scattered large (as much as 7 cm diameter) yellow calcareous mudstone or limestone clasts, structureless except for top 1.15 m, which contains ripples.
Unit 47: Mudstone. Green, gastropods.
Unit 46: Limestone. Small (less than 15 cm diameter) domal stromatolites, abundant gastropods and ostracodes, zones of horizontally laminated limestone, few fragments of domal algal stromatolites.
Unit 45: Interbedded mudstone, siltstone, and sandstone. Poorly exposed, mainly light olive gray mudstone and several thin siltstone and sandstone beds.
Unit 44: Siltstone and sandstone. Coarsens upward from fine-grained siltstone to 70-µ sandstone; fish scales and bone fragments in sandstone; top 10 cm is coarse-grained siltstone.
Unit 43: Limestone and sandstone. Basal 20 cm is ostracode grainstone containing some domal algal stromatolites and scattered bone fragments; 20-25 cm above base is a bed of 200-µ sandstone; 25-35 cm is a bed of ostracode grainstone containing two thin zones of horizontal algal laminations; 35-105 cm is micrite, nonfossiliferous, faintly laminated; 105 cm to top is 250-µ bioturbated sandstone containing ostracodes in top 5 cm, one micrite interbed, small bone fragments, and several clasts of laminated limestone.
Unit 42: Sandstone (125 µ) and siltstone. Sandstone grades upward to siltstone, poorly exposed.
Unit 41: Sandstone. Base is sharp and truncates 1.5 m of unit 40; where this unit truncates a siltstone bed of unit 40, siltstone clasts are in lower 30 cm of unit 41. Divided into subunits: (A) basal 6.8 m, lower half very complex, consists of four stacked channel bases: (1) basal 50 cm contains trough crossbeds or concordantly filled channels, 175-µ sandstone, ostracode–rich zones, (2) overlain by 20-30-cm-thick zone of 125-µ sandstone containing trough crossbeds and limestone clasts in places, truncates underlying sandstone, (3) overlain and truncated by a 50-cm-thick bed of 250-µ sandstone containing abundant ostracodes (in places ostracodes may exceed sand), several rip-up clasts of small domal algal stromatolites and trough crossbeds, (4) truncated by sandstone containing trough crossbeds; upper half of subunit 41A is poorly exposed, structureless; (B) 6.8-10.3 m, 175-200 µ, poorly exposed, structureless; (C) 10.3-14.8 m, fines upward (200 to 125 µ), mainly poorly exposed trough crossbeds, one zone of soft-sediment deformation; (D) 14.8-20, poorly exposed, (E) 20-24.5 m, coarsens upward (125 to 200 µ), contains one 50-cm-thick zone of white and yellow fine-grained clasts, upper two-thirds contains trough crossbeds, (F) 24.5 m to top, fines upward (200 µ-100 µ), structureless.
SECTION 1
INTERVAL: 200 to 250 m

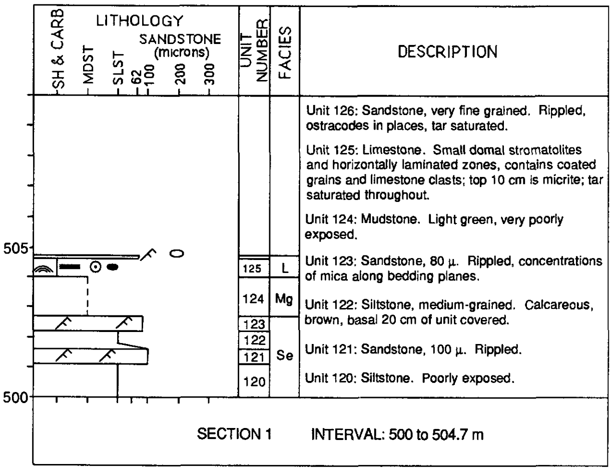

LITHOLOGY
SH/CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
300
295
290
285
280
275
270
265
260
255
250
63
62
61
60
59
58
57
55
54
53
52
51
50
Sa
Mg
Mr
Sb
Mg
Sa
Se
Mg
Sa
Unit 63: Sandstone, 100-125 µ. Sharp base truncates underlying siltstone; basal 25 cm is 100-µ, rippled (?) sandstone containing 1-2 percent small (250-µ diameter) round grains (ooids or sand?) and 1-2 percent fish scales and teeth; 25 cm to top contains trough crossbeds having set thicknesses of 30-100 cm, thin layers of mudstone clasts at bases of some troughs.
Unit 62: Siltstone and minor fine-grained sandstone. Rippled (?), noncalcareous, light gray, thin bedded (less than 2 cm), mudcracked. Unit 62 is completely removed by unit 63 in places.
Unit 61: Siltstone and sandstone. Coarsens upward from siltstone to 130-µ sandstone; basal 20 cm is siltstone containing ostracodes and very small bone fragments; siltstone grades rapidly upward to sandstone containing planar laminations and ripples (at top).
Unit 60: Mudstone. Poorly exposed, grayish red (10R 4/2) with lighter mottles in basal 2.5 m; 2.5-3.1 m is light olive gray (5Y 6/1); top 70 cm is very light gray and contains few fish scales, bone fragments, and mudcracks.
Unit 59: Sandstone, 80-200 µ (coarsens upward). Planar laminations in basal meter; sedimentary structures poorly exposed in upper 5 m, probably planar laminations; tabular-tangential crossbedding in top meter.
Unit 58: Sandstone, 90-130 µ. Lower half is 130 µ, thin bedded (less than 2 cm) and rippled (?), contains small plant fragments and few leaves and few thin siltstone interbeds; upper half is 90 µ, rippled.
Unit 57: Sandstone, 70-105 µ (coarsens upward). Basal lag, 7-30 cm thick, contains siltstone clasts, tiny bone fragments, and fish scales; matrix-supported clasts above lag; sedimentary structures not well exposed, probably trough crossbeds and ripples.
Unit 56: Mudstone, light-greenish-gray.
Unit 55: Sandstone, 70 µ. 1.5 m above base unit is a 20-30-cm-thick interval containing siltstone and sandstone clasts, clasts are angular, largest clast 10 by 4 cm, erodes underlying sandstone; unit is rippled; one channel-like feature 2.5 m wide by 0.6 m deep truncates sandstone beneath clast zone.
Unit 54: Sandstone (70 µ) and siltstone. Rippled sandstone grades upward to rippled (?) siltstone.
Unit 53: Sandstone, 100-175 µ. Sharp base has erosional relief of at least 1.5 m; basal 30 cm contains abundant carbonized wood, bone fragments, clasts of limestone and mudstone, and minor ostracodes and gastropods; sedimentary structures in lower 11.5 m are not well exposed, probably trough crossbeds; upper 4.6 m contains well-exposed ripples; upper 2 m contains siltstone flasers and thin (less than 1.5 cm), coarse-grained siltstone interbeds.
Unit 52: Siltstone. Truncates few tens of centimeters into underlying mudstone, tar saturated.
Unit 51: Mudstone. Light olive gray, slightly calcareous, poorly exposed.
Unit 50: Sandstone, 70 µ. Massive and structureless, tar saturated.
SECTION 1
INTERVAL: 250 to 300 m

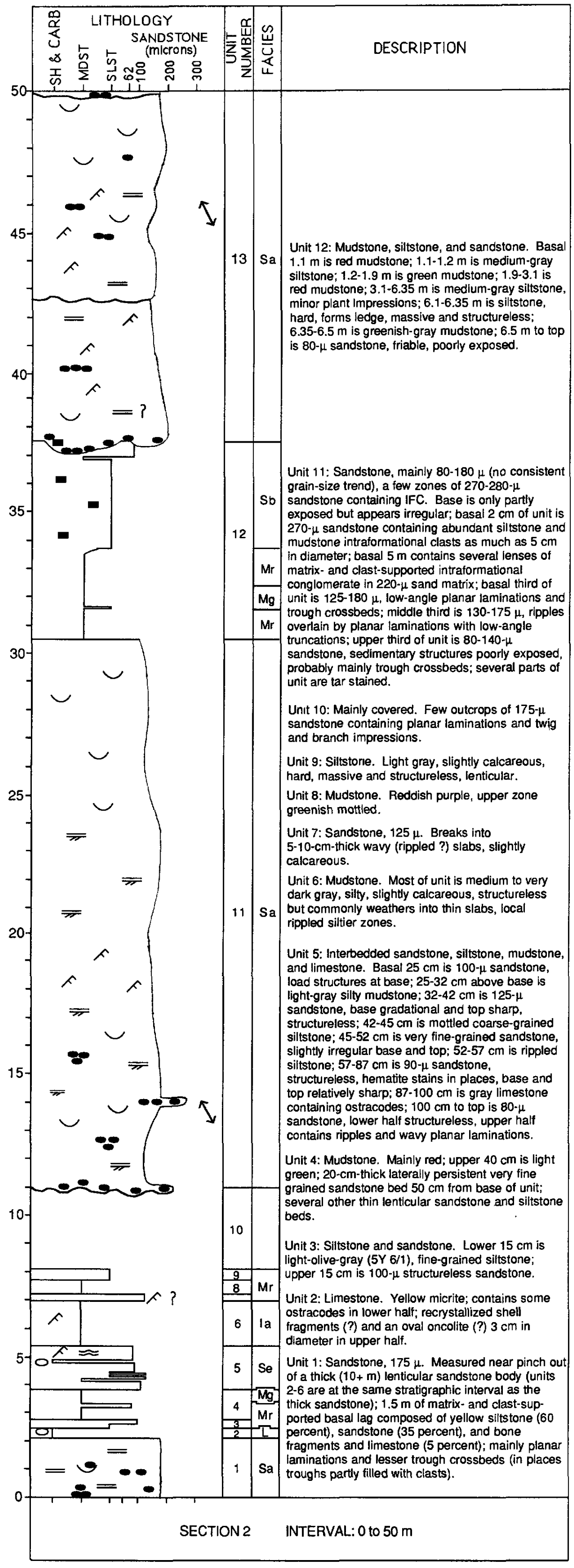

LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
350
345
340
335
330
325
320
315
310
305
300
74
Unit 74: Sandstone, 170 µ. Contains 10 percent mudstone clasts, base of channel is undulose.
73
Sb
Unit 73: Sandstone. Basal 1 m is 200 µ, upper 7.5 m coarsens upward (125 to 170 µ), well sorted. Basal 1 m is trough crossbeded and contains 10 percent mudstone clasts; upper 7.5 m contains wedge-shaped sets of planar laminations, wedge sets are 30 cm or less thick and have low-angle truncations, wedge sets dip 10° toward N. 30° E., minor soft-sediment deformation and one trough crossbed.
72
Unit 72: Mainly covered. Minor outcrops of red and green mudstone, 100-µ sandstone, 125-µ tar-saturated sandstone, and 90-µ rippled tar-saturated sandstone.
71
Unit 71: Sandstone, 125-225 µ. Sharp base truncates unit 70; most of unit contains 20-cm-thick trough crossbeds; 20-cm-thick lenticular zone of mudstone clasts about 70 cm above base; 30-cm-thick bed of rippled 125-µ sandstone at top.
70
Unit 70: Sandstone, 90 µ. Lenticular geometry, well cemented, buff, structureless.
69
Unit 69: Sandstone. Basal 2 m is 240-260-µ sandstone containing trough crossbeds, mudstone clasts along trough cross laminations; upper half of unit is 90-µ sandstone, rippled, partly covered.
68
Unit 68: Sandstone, 175 µ. Sharp base with at least 1.5 m of relief; basal half contains 30-cm-thick trough crossbed sets; upper half rippled and contains trough crossbeds (?).
67
Sa
Unit 67: Sandstone, 150-175 µ. Trough crossbeds throughout, several lenticular zones containing mudstone clasts (maximum diameter 5 cm).
66
Unit 66: Sandstone, 110-150 µ. Carbonaceous debris near base; basal 1 m containing trough crossbeds overlain by 2 m of planar laminations with parting lineations; upper 1 m contains interference ripples; 40 m from measured section lenticular 70-cm-thick zone containing limestone clasts and bioclastic debris (?).
65
Unit 65: Sandstone, 100 µ. Clast-supported mudstone and very fine grained sandstone clasts, coarse-tail grading, largest clast 10+ cm in diameter, IFC zone lenses out into sandstone.
64
Unit 64: Sandstone, 110-150 µ, moderately to well sorted. Basal 5 cm containing mudstone clasts; most of unit is trough crossbedded, some troughs have mudstone clasts at their bases, bed-set thickness 80-100 cm; 30-cm-thick lenticular rippled zone at top.
SECTION 1
INTERVAL: 300 to 350 m.

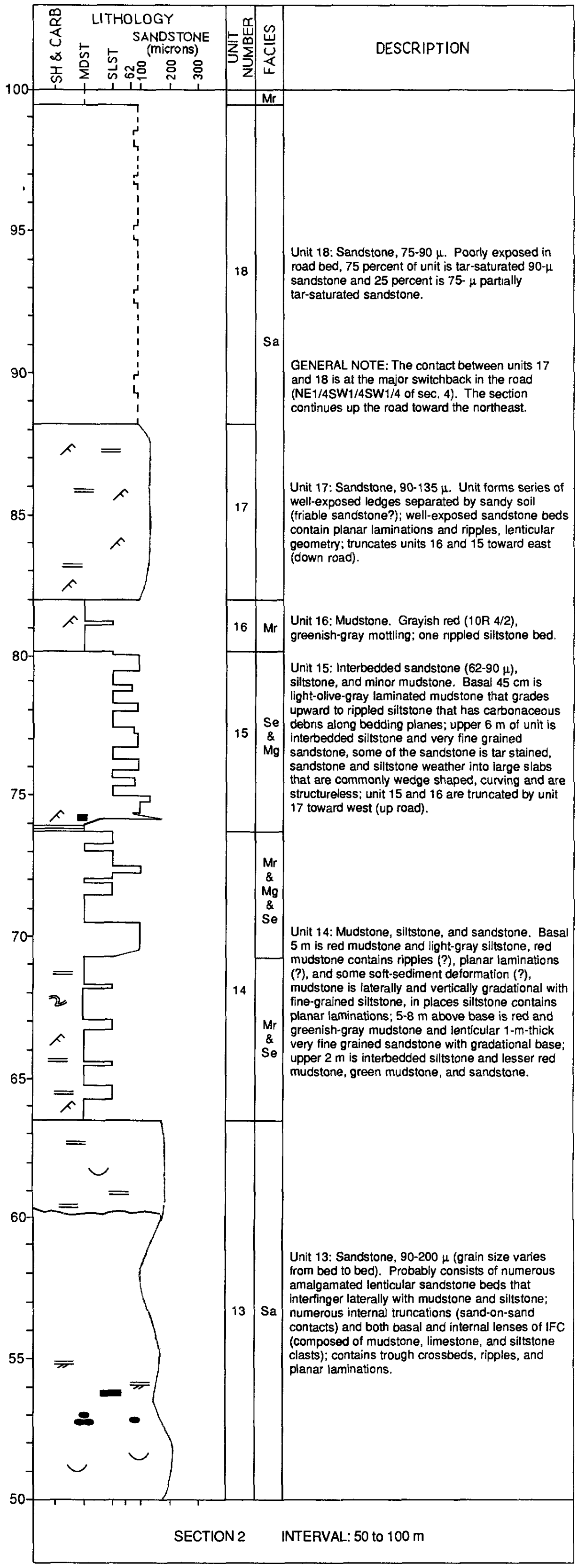

LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
400
395
390
385
380
375
370
365
360
355
350
90
89
Sb
Unit 89: Sandstone, fines upward (225 to 175 µ). Trough crossbeds throughout, size of troughs decreases upward (from 20-50 cm near base to 10 cm near top); ostracodes throughout (average 20 percent, from few percent to 35-40 percent), concentrations of ostracodes in some troughs.
Unit 88: Mudstone. Red, thin, 65-µ muddy sandstone beneath unit 89.
88
Mr
Unit 87: Sandstone, coarsens upward (75 to 175 µ). Ostracodes abundant and ooids common in upper two-thirds; top 10 cm consists of 50 percent sand and 50 percent ostracodes.
87
Sf
86
Mg & Mr
Se
Unit 86: Sandstone and mudstone. Basal 35 cm is rippled sandstone that coarsens upward (75 to 175 µ); basal unit is overlain by 1 m of fine to very fine grained muddy (in places) sandstone; upper part of unit is alternating red and green mudstone.
85
Mg & Mr
Unit 85: Mudstone and minor sandstone (65-70 µ) and limestone. Mudstone is red, purple, and green, poorly exposed, contains ostracodes in places and interbeds of sandstone; basal 30 cm is tar saturated sandstone; 45-cm-thick ostracode limestone overlies basal unit.
L
Se
84
Mr
Unit 84: Mudstone. Red with green mottles, less than 1 percent ostracodes.
83
Se
Unit 83: Interbedded mudstone and sandstone (60-80 µ). 70-cm-thick rippled (?) sandstone at top of unit.
82
Mr & Mg
Unit 82: Mudstone and sandstone (80 µ). Poorly exposed red, green, and purple mudstone that contains sandstone interbeds, uncommon ostracodes in red mudstone.
81
Se
Unit 81: Sandstone, 80 µ. Intensely burrowed; tar saturation follows burrows.
80
Mr
Unit 80: Mudstone, red.
79
Se
xxxxx ?
Unit 79: Sandstone, 80 µ. Planar laminations and few ripples, some mudstone beds, bentonite (?) near base.
78
Mg
Unit 78: Mudstone and sandstone. Green and minor red mudstone underlain by poorly exposed, 80-µ, muddy sandstone.
77
Sb
Unit 77: Sandstone, 100 µ. Current ripples, traces of vertical sand-filled burrows.
76
Mg
Unit 76: Mudstone. Green, poorly exposed.
75
Sb
Unit 75: Sandstone, 170-275 µ. Basal 1 m contains trough crossbeds that decrease in size upward; overlain by 60 cm of smaller trough crossbeds containing clasts; upper 3 m is structureless.
SECTION 1
INTERVAL: 350 to 400 m

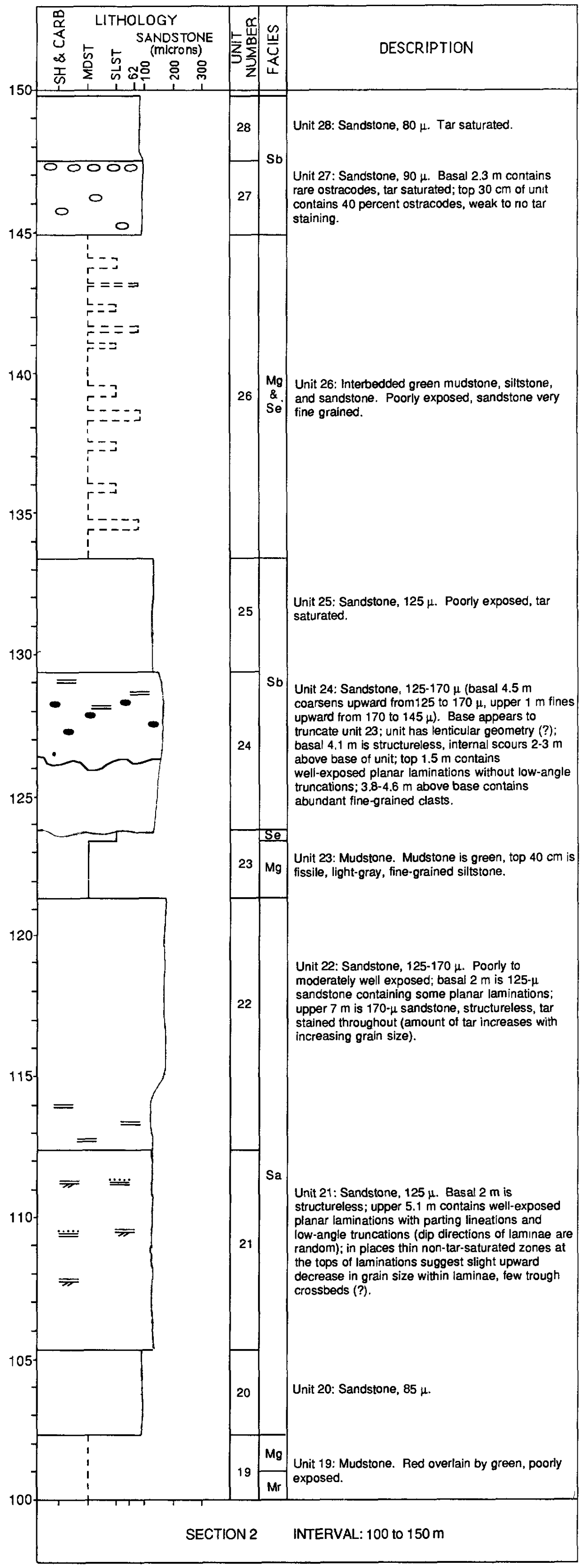

LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
450
445
440
435
430
425
420
415
410
405
400
Unit 101: Sandstone, 100 μ. Very poorly exposed, mudcracked green mudstone partings in sandstone.
Unit 100: Sandstone, 100 μ. Base sharp, truncates all of unit 99 and top of unit 98 in places; lag deposit at base composed of limestone clasts and small red (oxidized) wood impressions; massive and structureless.
Unit 99: Mudstone and siltstone. Greenish-gray mudstone grades upward to laminated calcareous siltstone.
Unit 98: Interbedded limestone and mudstone. Limestone composed of coated ostracodes as much as 1.5 mm in diameter, bed thickness 30-80 cm, limestone beds separated by greenish-gray calcareous mudstone with ostracodes.
Unit 97: Covered. Very thick soil cover.
Unit 96: Mainly covered. Several outcrops of tar-saturated limestone, siltstone, and mudstone with uncommon ostracodes.
Unit 95: Sandstone, 100-110 μ Base sharp and slightly irregular; basal 2-3 cm composed of IFC; lower 20 cm contains clasts of limestone (similar to top of underlying unit), bone fragments, fish scales, and small (2-5 mm) round concentrically zoned grains, maximum size of clasts is 3.5 cm; planar laminations (?), ripples (?).
Unit 94: Siltstone (medium grained) and limestone. Siltstone grades upward into micrite. Large turtle plate.
Unit 93: Mudstone, fine-grained. Greenish gray (5GY 6/1), very calcareous, poorly exposed.
Unit 92: Sandstone, fines upward (150 to 125 μ). Base is sharp and flat, 40-cm-thick zone at base contains matrix- and clast-supported subrounded clasts of mudstone and (or) limestone; sandstone contains trough crossbeds, size of troughs decreases upward, large-scale convolute bedding; ripples only in upper 1 m.
Unit 91: Mudstone, sandstone, and siltstone. Basal 1.1 m of is pale-olive (10Y 6/2), noncalcareous mudstone; 1.1-2.2 m above base is sandstone, 140-150 μ, 0-15 percent small yellow grains (weathered ooids?), planar laminations overlain by interval in which sedimentary structures are poorly exposed and there is at least one trough crossbed; 2.2 m to top is gray, fine-grained siltstone that grades upward to greenish-gray, noncalcareous mudstone or very fine grained siltstone.
Unit 90: Covered. Slope covered by soil and talus, few thin outrops of tar-saturated sandstone, red mudstone beneath soil cover.
101
100 Sb
99 Mg
98 L
97
96
95 Se
94 L Se
93 Mg
92 Sb
91 Mg Se Mg
90
SECTION 1
INTERVAL: 400 to 450 m

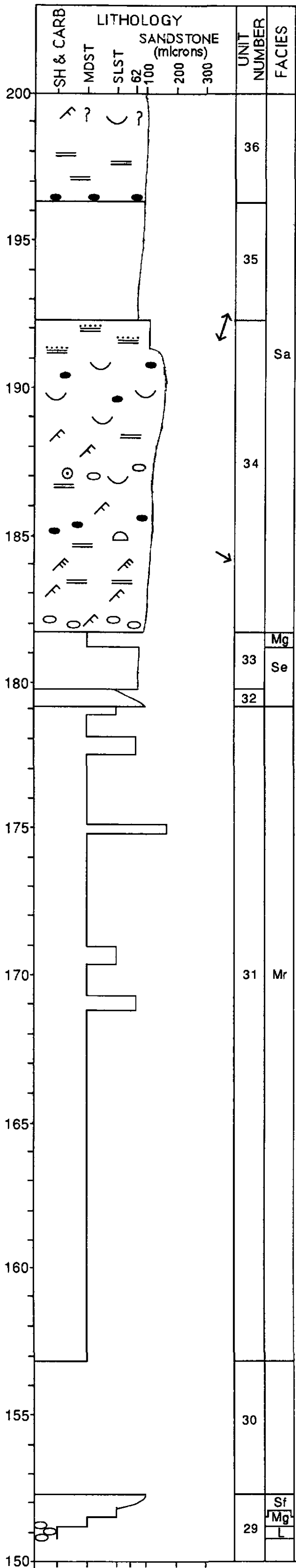

LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
500
495
490
485
480
475
470
465
460
455
450
Unit 119: Mudstone, silty, one 10-cm-thick fine-grained sandstone bed. Green.
Unit 118: Sandstone, fines upward (140 to 65 μ). Base sharp and scours underlying limestone in places, limestone clasts at base; basal 20-40 cm of unit scoured into by overlying sand, contains planar laminations, one set of tabular-tangential or trough crossbeds in basal 60 cm; 60 cm to top contains planar laminations and ripples (both wave and current), trough crossbeds 1.1-2.3 m above base.
Unit 117: Limestone, fine-grained, silty. Laminated in places, tar saturated.
Unit 116: Mudstone, fine-grained. Pale green (10G 6/2), slightly calcareous.
Unit 115: Sandstone, 90 μ. Tar saturated.
Unit 114: Mainly covered. Outcrop of siltstone near middle.
Unit 113: Sandstone, 90 μ. Current ripples, tar saturated.
Unit 112: Covered.
Unit 111: Limestone. Composed of ostraocdes, coated ostracodes, and ooids (?).
Unit 110: Limestone. Micrite, poorly exposed, contains ostracodes, tar saturated.
Unit 109: Sandstone, very fine grained. Base gradational with underlying siltstone, amount of ostracodes increases upward to 30 percent near top.
Unit 108: Siltstone, medium-grained. Light gray, rippled (?), poorly exposed.
Unit 107: Mainly covered. Thin outcrops of dark-gray calcareous mudstone, grayish-green mudstone, tar-saturated sandstone, and siltstone.
Unit 106: Siltstone. Pale olive, calcareous, few percent ostracodes; 15-cm-thick fine-grained limestone about 1 m above base.
Unit 105: Limestone. Ostracode grainstone, tar-saturated.
Unit 104: Siltstone. Pale olive gray, calcareous.
Unit 103: Sandstone, very fine grained (fines upward). Two beds, upper bed contains 5-10 percent ostracodes.
Unit 102: Mainly covered. Medium-grained calcareous siltstone and silty greenish-gray mudstone in holes dug into soil.
Se
119 Mg
118 Sb
117 L
116 Mg
115 Se
114
113 Se
112
110 L
Se
108 Mg
107
106 Se
L
104 Se
102
SECTION 1
INTERVAL: 450 to 500 m


LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
505
500
125 L
124 Mg
123
122
121 Se
120
Unit 126: Sandstone, very fine grained. Rippled, ostracodes in places, tar saturated.
Unit 125: Limestone. Small domal stromatolites and horizontally laminated zones, contains coated grains and limestone clasts; top 10 cm is micrite; tar saturated throughout.
Unit 124: Mudstone. Light green, very poorly exposed.
Unit 123: Sandstone, 80 μ. Rippled, concentrations of mica along bedding planes.
Unit 122: Siltstone, medium-grained. Calcareous, brown, basal 20 cm of unit covered.
Unit 121: Sandstone, 100 μ. Rippled.
Unit 120: Siltstone. Poorly exposed.
SECTION 1
INTERVAL: 500 to 504.7 m


LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
50
45
40
35
30
25
20
15
10
5
0
13 Sa
12 Sb
Mr
Mg
Mr
11 Sa
10
9
8 Mr
6 Ia
5 Se
Mg
4 Mr
3
2 L
1 Sa
Unit 12: Mudstone, siltstone, and sandstone. Basal 1.1 m is red mudstone; 1.1-1.2 m is medium-gray siltstone; 1.2-1.9 m is green mudstone; 1.9-3.1 is red mudstone; 3.1-6.35 m is medium-gray siltstone, minor plant impressions; 6.1-6.35 m is siltstone, hard, forms ledge, massive and structureless; 6.35-6.5 m is greenish-gray mudstone; 6.5 m to top is 80-μ sandstone, friable, poorly exposed.
Unit 11: Sandstone, mainly 80-180 μ (no consistent grain-size trend), a few zones of 270-280-μ sandstone containing IFC. Base is only partly exposed but appears irregular; basal 2 cm of unit is 270-μ sandstone containing abundant siltstone and mudstone intraformational clasts as much as 5 cm in diameter; basal 5 m contains several lenses of matrix- and clast-supported intraformational conglomerate in 220-μ sand matrix; basal third of unit is 125-180 μ, low-angle planar laminations and trough crossbeds; middle third is 130-175 μ, ripples overlain by planar laminations with low-angle truncations; upper third of unit is 80-140-μ sandstone, sedimentary structures poorly exposed, probably mainly trough crossbeds; several parts of unit are tar stained.
Unit 10: Mainly covered. Few outcrops of 175-μ sandstone containing planar laminations and twig and branch impressions.
Unit 9: Siltstone. Light gray, slightly calcareous, hard, massive and structureless, lenticular.
Unit 8: Mudstone. Reddish purple, upper zone greenish mottled.
Unit 7: Sandstone, 125 μ. Breaks into 5-10-cm-thick wavy (rippled ?) slabs, slightly calcareous.
Unit 6: Mudstone. Most of unit is medium to very dark gray, silty, slightly calcareous, structureless but commonly weathers into thin slabs, local rippled siltier zones.
Unit 5: Interbedded sandstone, siltstone, mudstone, and limestone. Basal 25 cm is 100-μ sandstone, load structures at base; 25-32 cm above base is light-gray silty mudstone; 32-42 cm is 125-μ sandstone, base gradational and top sharp, structureless; 42-45 cm is mottled coarse-grained siltstone; 45-52 cm is very fine-grained sandstone, slightly irregular base and top; 52-57 cm is rippled siltstone; 57-87 cm is 90-μ sandstone, structureless, hematite stains in places, base and top relatively sharp; 87-100 cm is gray limestone containing ostracodes; 100 cm to top is 80-μ sandstone, lower half structureless, upper half contains ripples and wavy planar laminations.
Unit 4: Mudstone. Mainly red; upper 40 cm is light green; 20-cm-thick laterally persistent very fine grained sandstone bed 50 cm from base of unit; several other thin lenticular sandstone and siltstone beds.
Unit 3: Siltstone and sandstone. Lower 15 cm is light-olive-gray (5Y 6/1), fine-grained siltstone; upper 15 cm is 100-μ structureless sandstone.
Unit 2: Limestone. Yellow micrite; contains some ostracodes in lower half; recrystallized shell fragments (?) and an oval oncolite (?) 3 cm in diameter in upper half.
Unit 1: Sandstone, 175 μ. Measured near pinch out of a thick (10+ m) lenticular sandstone body (units 2-6 are at the same stratigraphic interval as the thick sandstone); 1.5 m of matrix- and clast-supported basal lag composed of yellow siltstone (60 percent), sandstone (35 percent), and bone fragments and limestone (5 percent); mainly planar laminations and lesser trough crossbeds (in places troughs partly filled with clasts).
SECTION 2
INTERVAL: 0 to 50 m


SH & CARB
LITHOLOGY
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
100
95
90
85
80
75
70
65
60
55
50
Mr
18
Sa
Unit 18: Sandstone, 75-90 μ. Poorly exposed in road bed, 75 percent of unit is tar-saturated 90-μ sandstone and 25 percent is 75- μ partially tar-saturated sandstone.
GENERAL NOTE: The contact between units 17 and 18 is at the major switchback in the road (NE1/4SW1/4SW1/4 of sec. 4). The section continues up the road toward the northeast.
17
Unit 17: Sandstone, 90-135 μ. Unit forms series of well-exposed ledges separated by sandy soil (friable sandstone?); well-exposed sandstone beds contain planar laminations and ripples, lenticular geometry; truncates units 16 and 15 toward east (down road).
16
Mr
Unit 16: Mudstone. Grayish red (10R 4/2), greenish-gray mottling; one rippled siltstone bed.
15
Se & Mg
Unit 15: Interbedded sandstone (62-90 μ), siltstone, and minor mudstone. Basal 45 cm is light-olive-gray laminated mudstone that grades upward to rippled siltstone that has carbonaceous debris along bedding planes; upper 6 m of unit is interbedded siltstone and very fine grained sandstone, some of the sandstone is tar stained, sandstone and siltstone weather into large slabs that are commonly wedge shaped, curving and are structureless; unit 15 and 16 are truncated by unit 17 toward west (up road).
Mr & Mg & Se
14
Mr & Se
Unit 14: Mudstone, siltstone, and sandstone. Basal 5 m is red mudstone and light-gray siltstone, red mudstone contains ripples (?), planar laminations (?), and some soft-sediment deformation (?), mudstone is laterally and vertically gradational with fine-grained siltstone, in places siltstone contains planar laminations; 5-8 m above base is red and greenish-gray mudstone and lenticular 1-m-thick very fine grained sandstone with gradational base; upper 2 m is interbedded siltstone and lesser red mudstone, green mudstone, and sandstone.
13
Sa
Unit 13: Sandstone, 90-200 μ (grain size varies from bed to bed). Probably consists of numerous amalgamated lenticular sandstone beds that interfinger laterally with mudstone and siltstone; numerous internal truncations (sand-on-sand contacts) and both basal and internal lenses of IFC (composed of mudstone, limestone, and siltstone clasts); contains trough crossbeds, ripples, and planar laminations.
SECTION 2
INTERVAL: 50 to 100 m


SH & CARB
LITHOLOGY
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
150
145
140
135
130
125
120
115
110
105
100
28
Sb
Unit 28: Sandstone, 80 μ. Tar saturated.
27
Unit 27: Sandstone, 90 μ. Basal 2.3 m contains rare ostracodes, tar saturated; top 30 cm of unit contains 40 percent ostracodes, weak to no tar staining.
26
Mg & Se
Unit 26: Interbedded green mudstone, siltstone, and sandstone. Poorly exposed, sandstone very fine grained.
25
Unit 25: Sandstone, 125 μ. Poorly exposed, tar saturated.
24
Sb
Unit 24: Sandstone, 125-170 μ (basal 4.5 m coarsens upward from125 to 170 μ, upper 1 m fines upward from 170 to 145 μ). Base appears to truncate unit 23; unit has lenticular geometry (?); basal 4.1 m is structureless, internal scours 2-3 m above base of unit; top 1.5 m contains well-exposed planar laminations without low-angle truncations; 3.8-4.6 m above base contains abundant fine-grained clasts.
Se
23
Mg
Unit 23: Mudstone. Mudstone is green, top 40 cm is fissile, light-gray, fine-grained siltstone.
22
Unit 22: Sandstone, 125-170 μ. Poorly to moderately well exposed; basal 2 m is 125-μ sandstone containing some planar laminations; upper 7 m is 170-μ sandstone, structureless, tar stained throughout (amount of tar increases with increasing grain size).
Sa
21
Unit 21: Sandstone, 125 μ. Basal 2 m is structureless; upper 5.1 m contains well-exposed planar laminations with parting lineations and low-angle truncations (dip directions of laminae are random); in places thin non-tar-saturated zones at the tops of laminations suggest slight upward decrease in grain size within laminae, few trough crossbeds (?).
20
Unit 20: Sandstone, 85 μ.
19
Mg
Mr
Unit 19: Mudstone. Red overlain by green, poorly exposed.
SECTION 2
INTERVAL: 100 to 150 m



DESCRIPTION

Unit 38: Sandstone, 95-105 μ. Minor matrix-supported clasts near base, basal 2 m contains planar laminations (without parting lineations or low-angle truncations); upper 2 m is mainly (80 percent) structureless, ripples (?) near top and one trough crossbed (?) or scour (?).

Unit 35: Sandstone, coarsens upward slightly (70 to 90 μ). Weak tar stain.

Unit 34: Sandstone, 90-150 μ, basal 9.3 m coarsens upward from 90 to 150 μ, upper 1.3 m fines upward from 150 to 110 μ. Base sharp and flat; basal 40 cm has 10-15 percent ostracodes, rippled; 0.4-1.5 m contains ripples; 1.5-1.8 m contains planar laminations, 1.8-2.2 m contains current ripples; 2.2-7 m conatins mainly planar laminations and ripples and some trough crossbeds, 3.3-3.7 m above base is a zone contains abundant small (under 2.5 cm diameter) limestone clasts and a few fish scales; at 5 m above base 10 percent very small yellow grains (ostracodes and (or) ooids?); 7-9.3 m contains 50 percent trough crossbeds and scattered clasts of sandstone and siltstone and 50 percent structureless; 9.3 m to top contains planar laminations with parting lineations.

Unit 33: Sandstone, siltstone, and mudstone. Unit consists of 1.5 m of very fine grained sandstone and lesser coarse grained siltstone overlain by 50 cm of green mudstone.

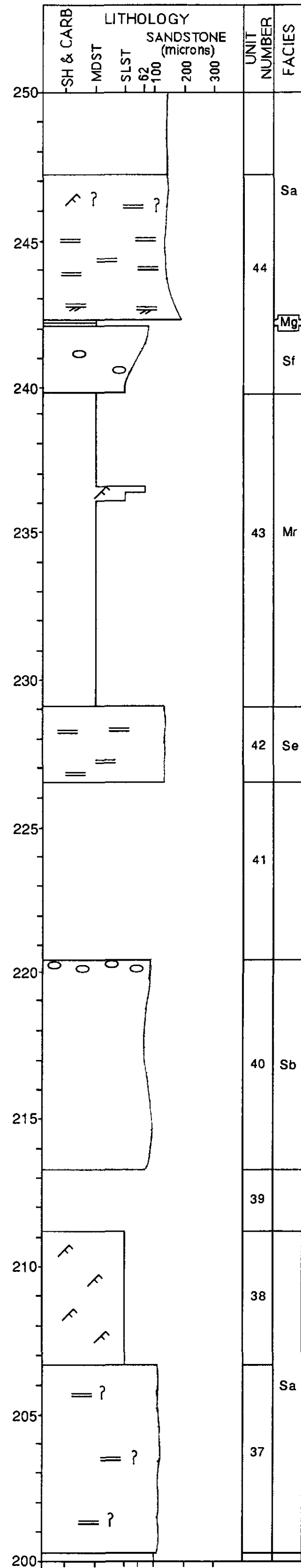
Unit 32: Sandstone and siltstone. 100-μ sandstone grades upward to very coarse grained siltstone.

Unit 31: Mudstone. Red, contains several thin (less than 1 m) outcrops of siltstone and very fine grained sandstone in upper half.

Unit 30: Covered.

Unit 29: Limestone, mudstone, siltstone and sandstone. Basal 1 m is covered; 1-1.45 above base is ostracode grainstone; 1.45-1.60 m is green mudstone; 1.60-1.70 is red mudstone; 1.70 m to top is coarse-grained siltstone that grades upward to 100-μ sandstone.

SECTION 2 INTERVAL: 150 to 200 m



DESCRIPTION

Unit 44: Sandstone and siltstone. Base poorly exposed; basal 2.3 m is very coarse grained siltstone that grades upward to very fine grained sandstone, sandstone contains 15 percent ostracodes in places; 2.3-2.45 m is bed of medium-brownish-gray laminated mudstone, slightly silty, calcareous; 2.45 m to top is sandstone, fines upward (185 to 135 μ), tar saturated; 2.45-3.1 m contains planar laminations with low-angle truncations; 3.1-3.8 m is structureless; 3.8-5.4 m contains moderately to poorly exposed planar laminations; 5.4 m to top sedimentary structures obscured by tar, may contain planar laminations (?) and ripples (?).

Unit 43: Mudstone. Mainly red, some green near base; 7.0-7.5 m above unit base is very coarse grained siltstone overlain by 20-cm-thick bed of 65-μ rippled (in places) sandstone.

Unit 42: Sandstone, 130 μ. Planar laminations, crops out in road bed, tar saturated.

Unit 41: Covered.

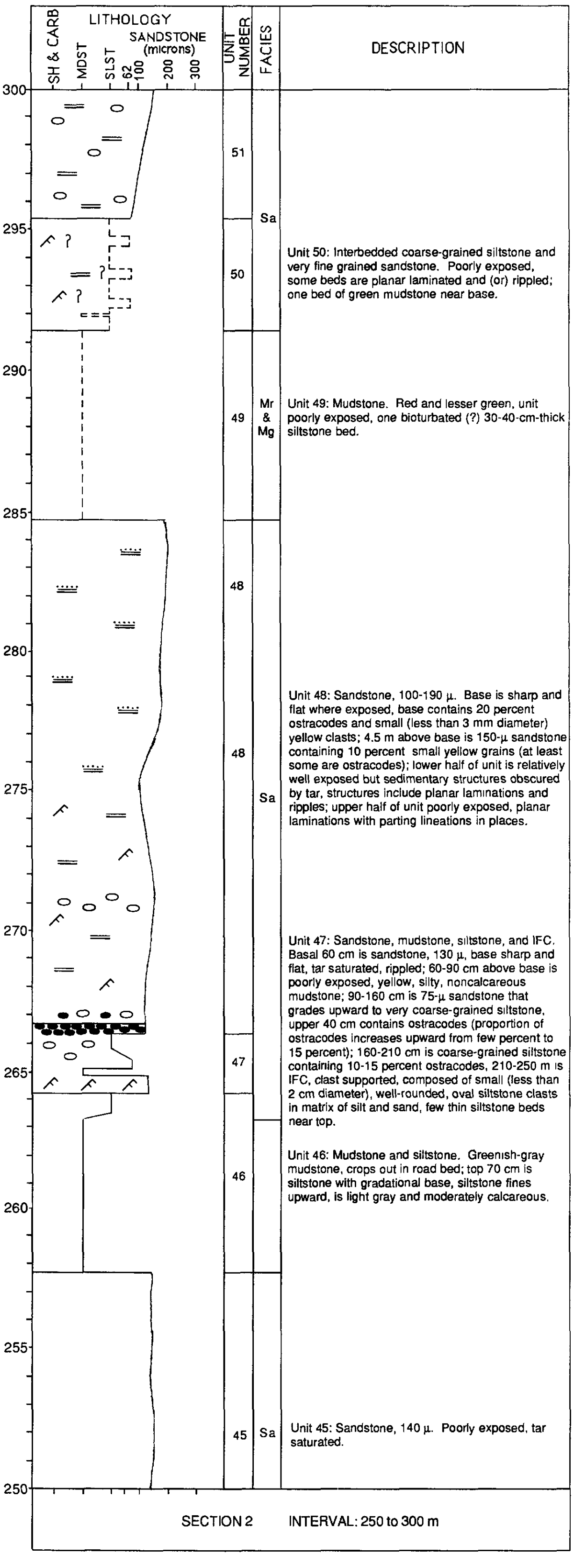
Unit 40: Sandstone, 65-90 μ. Crops out in road bed, top contains 10-15 percent ostracodes.

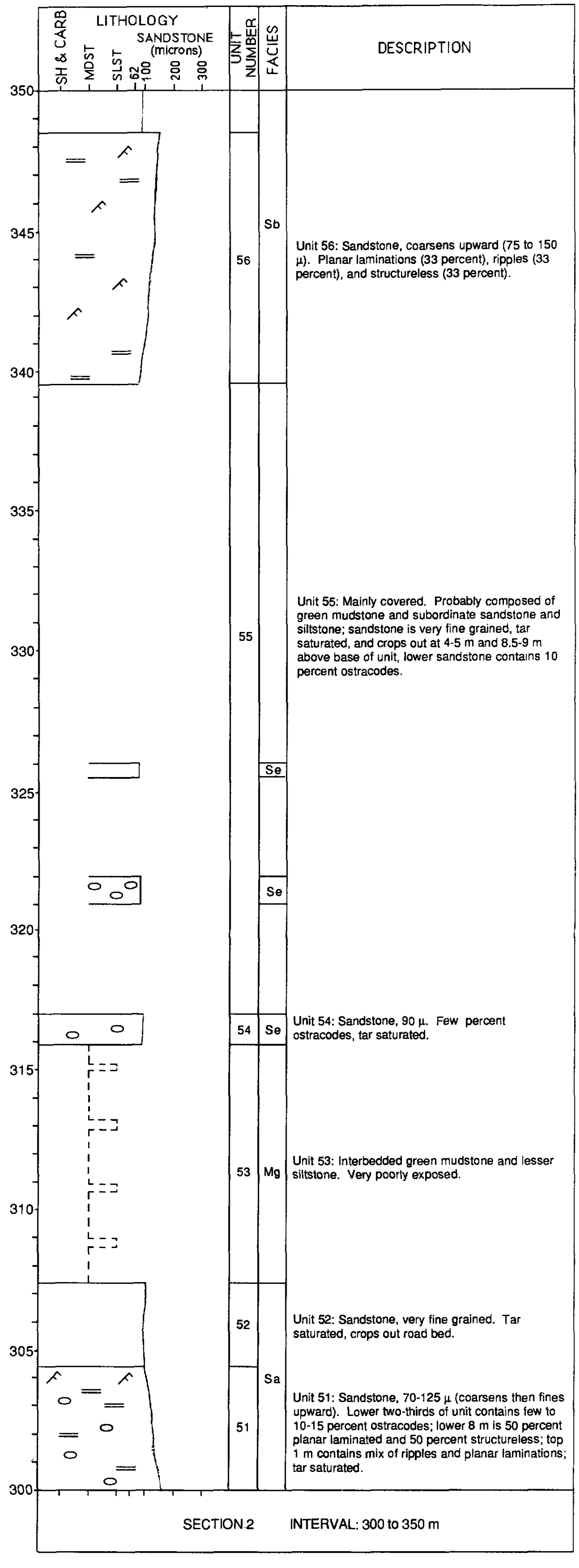
Unit 39: Covered.

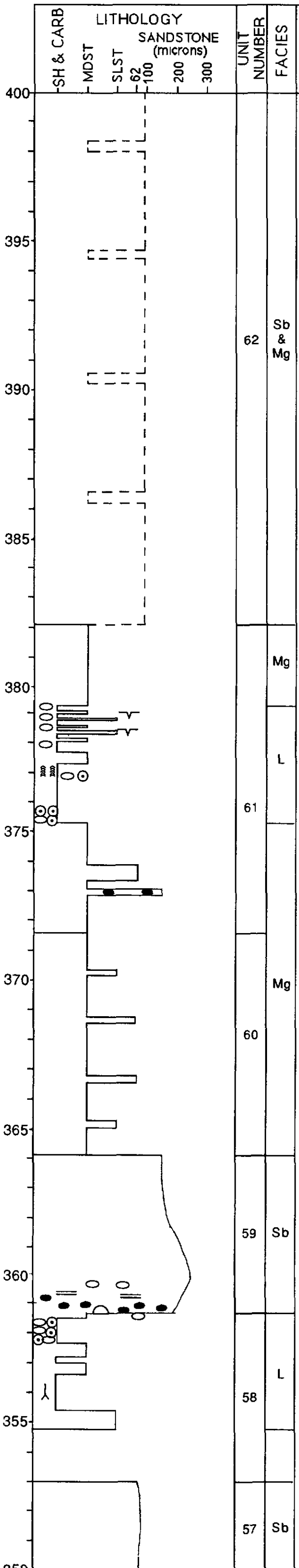
Unit 38: Siltstone, coarse-grained. Rippled, tar saturated in places.

Unit 37: Sandstone, 110 μ. Poorly exposed, in road bed only, rock breaks into thin sheets that suggest planar laminations.

SECTION 2 INTERVAL: 200 to 250 m


LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
300
295
290
285
280
275
270
265
260
255
250
51
Sa
50
Unit 50: Interbedded coarse-grained siltstone and very fine grained sandstone. Poorly exposed, some beds are planar laminated and (or) rippled; one bed of green mudstone near base.
49
Mr & Mg
Unit 49: Mudstone. Red and lesser green, unit poorly exposed, one bioturbated (?) 30-40-cm-thick siltstone bed.
48
Unit 48: Sandstone, 100-190 µ. Base is sharp and flat where exposed, base contains 20 percent ostracodes and small (less than 3 mm diameter) yellow clasts; 4.5 m above base is 150-µ sandstone containing 10 percent small yellow grains (at least some are ostracodes); lower half of unit is relatively well exposed but sedimentary structures obscured by tar, structures include planar laminations and ripples; upper half of unit poorly exposed, planar laminations with parting lineations in places.
48
Sa
47
Unit 47: Sandstone, mudstone, siltstone, and IFC. Basal 60 cm is sandstone, 130 µ, base sharp and flat, tar saturated, rippled; 60-90 cm above base is poorly exposed, yellow, silty, noncalcareous mudstone; 90-160 cm is 75-µ sandstone that grades upward to very coarse-grained siltstone, upper 40 cm contains ostracodes (proportion of ostracodes increases upward from few percent to 15 percent); 160-210 cm is coarse-grained siltstone containing 10-15 percent ostracodes, 210-250 m is IFC, clast supported, composed of small (less than 2 cm diameter), well-rounded, oval siltstone clasts in matrix of silt and sand, few thin siltstone beds near top.
46
Unit 46: Mudstone and siltstone. Greenish-gray mudstone, crops out in road bed; top 70 cm is siltstone with gradational base, siltstone fines upward, is light gray and moderately calcareous.
45
Sa
Unit 45: Sandstone, 140 µ. Poorly exposed, tar saturated.
SECTION 2
INTERVAL: 250 to 300 m


LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
350
345
340
335
330
325
320
315
310
305
300
56
Sb
Unit 56: Sandstone, coarsens upward (75 to 150 µ). Planar laminations (33 percent), ripples (33 percent), and structureless (33 percent).
55
Unit 55: Mainly covered. Probably composed of green mudstone and subordinate sandstone and siltstone; sandstone is very fine grained, tar saturated, and crops out at 4-5 m and 8.5-9 m above base of unit, lower sandstone contains 10 percent ostracodes.
Se
Se
54
Se
Unit 54: Sandstone, 90 µ. Few percent ostracodes, tar saturated.
53
Mg
Unit 53: Interbedded green mudstone and lesser siltstone. Very poorly exposed.
52
Unit 52: Sandstone, very fine grained. Tar saturated, crops out road bed.
Sa
51
Unit 51: Sandstone, 70-125 µ (coarsens then fines upward). Lower two-thirds of unit contains few to 10-15 percent ostracodes; lower 8 m is 50 percent planar laminated and 50 percent structureless; top 1 m contains mix of ripples and planar laminations; tar saturated.
SECTION 2
INTERVAL: 300 to 350 m



DESCRIPTION

Unit 62: Sandstone. Poorly exposed in road bed, minor green mudstone.

Unit 61: Interbedded limestone and green mudstone. Basal 3.7 m is green mudstone containing two sandstone beds (lower bed 20 cm thick and 150 µ, and contains small clasts; upper bed is 50 cm thick and 70 µ) near middle of subunit; 3.7-4.3 m above base is ooid limestone containing some ostracodes, 4.3-5 m is silty micrite (?), very light gray, contains sparse to abundant limestone clasts and ostracodes; 5-5.7 m is limestone composed of pillar-type stromatolites and abundant ostracodes and ooids (?) and minor bone fragments and fish scales; 5.7-6.1 m is green fissile mudstone containing few thin interlaminations and irregular patches of ostracodes; 6.1-6.3 m is ostracode grainstone; 6.3-7.6 m is interbedded green mudstone (60 percent), ostracode grainstone (20 percent), and siltstone (20 percent), green mudstone contains ostracode-filled mudcracks, some siltstone beds contain ostracodes and mudcracks; 7.6 m to top is green mudstone.

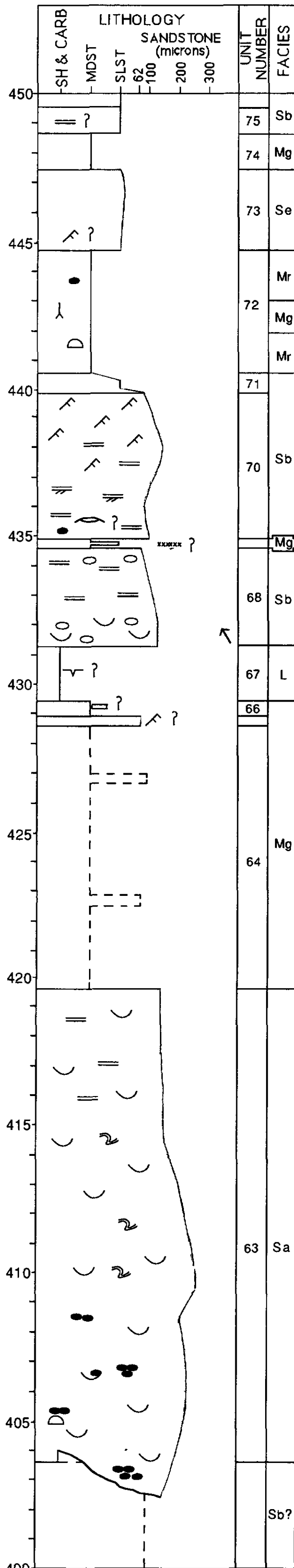
Unit 60: Green mudstone and minor sandstone and siltstone. Greenish-gray mudstone crops out in road bed, several 25-40-cm-thick sandstone and siltstone beds.

Unit 59: Sandstone, 150-250 µ. Base is sharp with minor relief; basal 50 cm contains planar laminations and matrix-supported clasts of mudstone, siltstone, and some limestone, clasts sand sized to 3 cm diameter, ostracodes, fish scales, and bone fragments; 50 cm to top is structureless, few percent ostracodes in 250-µ sandstone about 1 m above base of unit.

Unit 58: Interbedded siltstone, mudstone, and limestone. Basal 1.7 m is covered; 1.7-2.4 m above base is fine- to coarse-grained siltstone, light gray, slightly calcareous, contact with overlying limestone gradational; 2.4-3.6 m is silty micrite (?), yellow, structureless, local small irregular hematite-filled tubes (roots tubes?); 3.6-4 m is greenish-gray mudstone, base gradational and top fairly sharp, calcareous, silty, typical mudstone weathering; 4-4.2 m is silty micrite similar to siltstone 2.4-3.6 m above base; 4.2-4.65 m is greenish-gray and yellow mudstone, silty, calcareous, base sharp and top gradational; 4.65-5.5 m is ooid (?) limestone containing ostracodes and small limestone clasts near center, 5.5 m to top is silty mudstone, upper few centimeters laminated, most has typical mudstone weathering.

Unit 57: Sandstone, very fine grained. Tar stained.

SECTION 2 INTERVAL: 350 to 400 m



DESCRIPTION

Unit 75: Siltstone. Weathers into thin (less than 1 cm) plates suggesting planar laminations.

Unit 74: Mudstone. Greenish gray, massive and structureless, reddish-brown mottling in places.

Unit 73: Siltstone. Basal 15 cm is tar-saturated, coarse grained, rippled (?) siltstone overlain by finer grained, generally poorly exposed, siltstone.

Unit 72: Mudstone. Basal 1 m is grayish red (5R 4/2 to 10R 4/2); 1-1.3 m is transitional color zone of mottled red and green; 1.3-2.5 m is greenish gray (10GY 5/2), calcareous, contains small bone fragments, clasts, and fish scales and thin tubes (roots ?); 2.5 m to top is grayish red, contact with underlying green mudstone sharp; massive and structureless.

Unit 71: Siltstone. Grades downward to underlying sandstone and upward to overlying mudstone.

Unit 70: Sandstone, coarsens upward from 100 to 140 µ, then fines upward from 140 to 80 µ. Sharp base with few centimeters relief; basal 90 cm contains well-exposed planar laminations and hummocky cross-stratification (?) (probably mainly swales), small minor (less than 1 percent) mudstone chips, and moderately abundant mica concentrated along bedding planes, base of 100 µ and upper zone bimodal (100 and 250 µ sand) averaging around 125 µ; 90-180 cm above base contains planar laminations with low-angle truncations and scourlike features (troughs? and (or) swales?); 180-350 cm is planar laminated (70 percent) and rippled (30 percent); 350 cm to top is rippled.

Unit 69: Mudstone and siltstone. Base of unit is yellowish-gray (5Y 7/2) and dusky yellow (5Y 6/4) mudstone; center of unit is tar-saturated siltstone; top of unit is light-greenish-gray mudstone grading upward to yellow gritty rock (tuff?).

Unit 68: Sandstone, mainly 70-90 µ, zones of 200-µ sandstone (?). Base is sharp; basal 1 m contains trough crossbeds and abundant ostracodes, has bimodal size distribution (70-90-µ sandstone and 250-µ sandstone and ostracodes); middle of unit contains planar laminations; top 30 cm contains planar laminations and thin zones of clasts and ostracodes.

Unit 67: Calcareous mudstone or silty limestone. Base is sharp and slightly irregular, mudcracks (?) at top of unit, tar saturated.

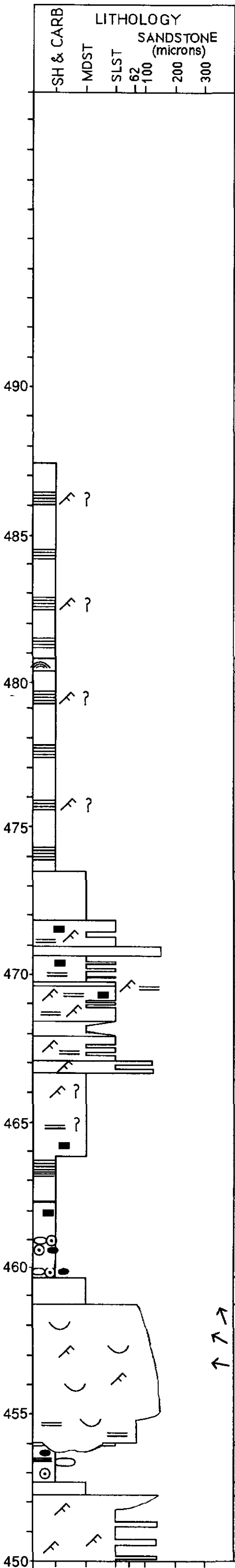
Unit 66: Mudstone. Olive gray and light greenish gray, in places colors interlaminated, burrows (?), typical mudstone weathering.

Unit 65: Sandstone, 70 µ. Base of unit covered, rippled (?).

Unit 64: Green mudstone. Poorly exposed in road bed, few thin sandstone beds.

Unit 63: Sandstone, 140–240 µ, lower half of unit coarsens upward from160 to 240 µ, upper half of unit fines upward from 240 to 140 µ. Underlain by at least 70 cm of tar-saturated fine-grained limestone; base of sandstone is sharp and has at least 1.5 m of erosional relief; basal 5.5 m has clast- and matrix-supported IFC, IFC zones laterally discontinuous, pod and lens shaped, IFC zones 2-40 cm thick, some clasts at bottom of troughs, clasts composed of fine-grained limestone (probably eroded from underlying limestone) and generally angular and as wide as 10+ cm, minor bone fragments and fish scales; basal 3.5 m of unit is trough crossbedded; 3.5-12 m contains trough crossbeds (70 percent) and trough crossbeds deformed by soft-sediment deformation (30 percent) (amount of soft-sediment deformation decreases upward); 12 m to top is planar laminated and trough crossbeded, 50 percent is structureless.

SECTION 2 INTERVAL: 400 to 450 m



UNIT NUMBER	FACIES
95	Ib
94	L
93	Ib
92	Mg
91	Se
89	Ia
87	
86	
85	
84	Mg
83	
82	L
81	Mg
80	Sb
78	L
77	
76	Sb

DESCRIPTION

Unit 95: Dolostone. Same as unit 93.

Unit 94: Limestone. Domal algal stromatolites, maximum size: 40 cm high by 75 cm wide.

Unit 93: Dolostone. Weathered surface very light gray, fresh surface light to medium gray or grayish brown, structureless (50 percent) and laminated (50 percent), generally laminations are not strictly parallel but appear wavy (probably rippled), interlayering of light and dark (organic-rich ?) layers in places, some zones calcareous, silty in places.

Unit 92: Mudstone. Lower half covered, light greenish gray to medium brown.

Unit 91: Siltstone. Basal 10 cm is thin bedded (less than 3 mm) and contains abundant small plant fragments along bedding planes; planar laminations (?) and ripples (?) throughout; one 15-cm-thick mudstone bed.

Unit 90: Sandstone, 150 μ. Massive and structureless, base sharp and slightly irregular, top gradational into overlying siltstone, thickens and thins.

Unit 89: Mudstone. Light brownish gray, local carbonized plant debris, laminated (?), calcareous, few siltstone interbeds.

Unit 88: Coarse-grained siltstone to very fine grained sandstone. Planar laminations (?) and

Unit 87: Siltstone. Carbonized plant debris along some bedding planes, ripples and planar laminations; middle of unit consists of 30-cm-thick bed of siltstone containing flasers and interbeds of brown mudstone.

Unit 86: Mudstone. Medium brown and greenish gray, upper and lower contacts gradational.

Unit 85: Interbedded siltstone and mudstone. Siltstone is rippled and planar laminated.

Unit 84: Sandstone and siltstone. Consists of two beds of sandstone separated by siltstone, lower sandstone bed is 15 cm thick, 225 μ, thickens and thins (15 to 8 cm), base contains load structures (?), top irregular, rippled; upper sandstone is 15 cm thick, thickens and thins, base sharp and irregular in places, well-exposed ripples.

Unit 83: Dolostone, limestone, and mudstone. Basal 20 cm is laminated, kerogenous dolostone (oil shale); 20-60 cm is brown, laminated dolostone or shale, poorly exposed, alternating lighter and darker bands; 60-80 cm is dolostone (?), laminated in places, in places laminae are wavy or truncate each other; 80 cm to top is interbedded light-olive-gray and medium-brown mudstone, laminated (?) and rippled (?), plant fragments and pyrite.

Unit 82: Limestone and dolostone (?). Basal 30 cm contains ooids, ostracodes (?), and limestone clasts (?), upper part laminated in places, tar saturated; 60-90 cm above base is fine-grained carbonate, massive and structureless; 90-135 cm is same as basal 30 cm; 135-215 cm is similar to 60-90 cm; 215-255 cm is dolostone (?), massive and structureless, dark gray, small fragments of carbonized plant debris; 255-257 cm is 2-cm-thick coal or highly carbonaceous shale, laterally persistent; 257 cm to top is fine-grained limestone.

Unit 81: Siltstone or silty mudstone. Light greenish gray, massive and structureless, weathers into thin irregular chips.

Unit 80: Sandstone, 70–250 μ. Base is sharp and truncates top of unit 78; basal 50-100 cm contains planar laminations and trough or tabular-tangential crossbeds; upper part of unit fines upward (250 to 175 μ) and contains trough crossbeds with thin ripple sets.

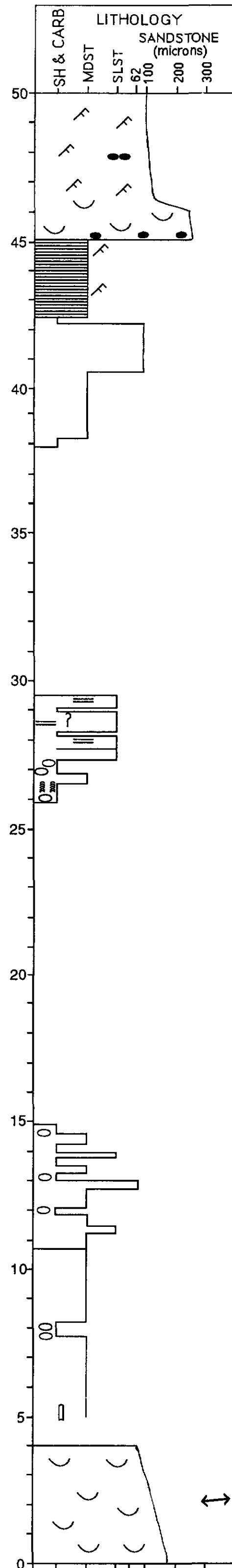
Unit 79: Siltstone.

Unit 78: Limestone. Basal 80 cm and top 95 cm is tar-saturated fine-grained micrite (may be a massive dolostone), bone fragments, ooids (?), and limestone clasts, amount of clasts and ooids increases upward in lower micrite; 80-95 cm above base is lenticular bed of algally laminated limestone, consists of horizontal to gently curving laminations and tubelike concentrically laminated oncolites (?) as much as 6 cm in diameter, oncolites (?) stacked like logs, micrite, oolites (?), and limestone clasts between the oncolites (?).

Unit 77: Mudstone. Light greenish gray (5GY 8/1), slightly calcareous, massive and structureless, highly fractured, red staining along some fractures.

Unit 76: Interbedded siltstone and sandstone. Siltstone is rippled in places but generally structureless; sandstone is 140 μ; top 1 m of unit is siltstone that grades upward to 140-μ sandstone that is structureless except for rippled basal 10 cm.

SECTION 2 INTERVAL: 450 to 487.5 m



UNIT NUMBER	FACIES
9	Sb
8	Mg
7	Se
	Mg
6	
5	Se
	L
4	
3	L
	Mg
2	Mr
	L
	Mg
	Ia
1	Sb

DESCRIPTION

Unit 9: Sandstone, fines upward (250 μ at base, above base 100-130 μ). Base sharp and only slightly irregular, small zones containing IFC at base and above base; trough crossbeds in basal 1.5 m; rippled in upper part, tar stained.

Unit 8: Mudstone. Green, laminated, abundant mica, some ripples; various shades of greenish gray and grayish green, near top color changes to yellow white.

Unit 7: Limestone, mudstone, and sandstone. Basal 30 cm is silty micrite or calcareous siltstone; 0.3-1.7 m above base is calcareous green mudstone, planar laminations and red mottles in places; 1.7-4.3 m is 90-μ sandstone; 4.3 m to top is medium-gray fine-grained limestone.

Unit 6: Covered.

Unit 5: Mudstone, siltstone, and limestone. Basal third of unit is interbedded ostracode grainstone, green mudstone, and pillar-type stromatolites; upper two-thirds is interbedded, very light gray, calcareous siltstone containing planar laminations (?) and silty micrite or calcareous fine-grained siltstone.

Unit 4: Mainly covered. Some outcrops of green mudstone, limestone (including ostracode grainstone), siltstone, and very fine grained sandstone.

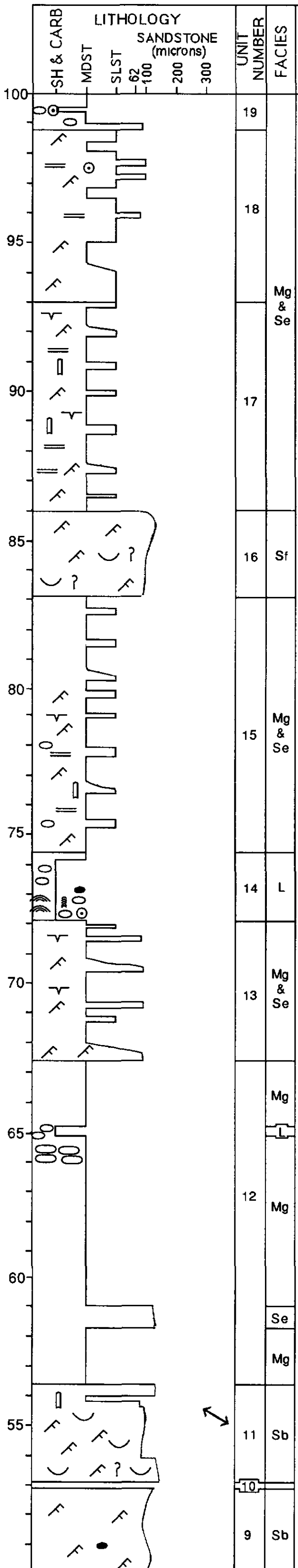
Unit 3: Interbedded mudstone, limestone, sandstone, and siltstone. Poorly exposed; mudstone is green; limestone includes ostracode grainstone, light-gray micrite, and medium-brown micrite; sandstone is very fine grained.

Unit 2: Mudstone. Basal 1.0 m is covered; 1.0-2.5 m above base is medium-dark-gray mudstone containing green mottles, one burrow filled with green mudstone; 2.5-3.7 m is greenish-gray mudstone that in places grades upward to very pale orange, fine-grained siltstone; 3.7-4.2 is limestone containing ostracodes; 4.2-5.7 is grayish-red mudstone containing mottles and bands of greenish-gray mudstone; 5.7 m to top is greenish-gray, calcareous mudstone.

Unit 1: Sandstone, fines upward (175 to 70 μ). Base not exposed, trough crossbeds (size of troughs increases upward).

SECTION 4 INTERVAL: 0 to 50 m

☆U.S. GOVERNMENT PRINTING OFFICE: 1993-774-049/66025



DESCRIPTION

Unit 19: Interbedded mudstone, sandstone, and limestone. Basal 20 cm is 90-μ sandstone containing minor ostracodes; 20-60 cm is mudstone (?) containing ostracodes (?) and ooids (?); 60-72 cm is micrite (?) containing ooids (?) and ostracodes (?), bioturbated (?); 72-87 cm is medium-gray mudstone, bioturbated (?); 87 cm to top is calcareous mudstone, light to medium gray, laminated in places.

Unit 18: Interbedded mudstone, siltstone, and sandstone. Mudstone is green; sandstone and siltstone contains ripples and planar laminations, in few places sandstone contains ooids.

Unit 17: Interbedded mudstone (70 percent) and siltstone (30 percent). Mudstone is green, mudcracked, some planar laminations but most is structureless; siltstone contains planar laminations and ripples and commonly grades upward to mudstone; some bioturbation in siltstone and mudstone.

Unit 16: Sandstone, 65-130 μ. Basal 1 m is poorly exposed; unit contains well-exposed ripples throughout; lower 2.5 m also contains trough crossbeds (?).

Unit 15: Interbedded mudstone and lesser siltstone. Mudstone is green, zones with ostracodes and ooids, contains mudcracks (?), burrows (?), ripples, and planar laminations; siltstone grades upward to mudstone in places.

Unit 14: Limestone. Basal 25 cm is limestone containing ostracodes, ooids (?), and intraclasts (?); 25-90 cm above base consists of large (as much as 30 by 60 cm) domal stromatolites, between domes are pillar-type stromatolites, ostracodes, and ooids (?); 90 cm to 2.3 m is white to light-gray micrite, few percent ostracodes; 2.3 m to top is green mudstone.

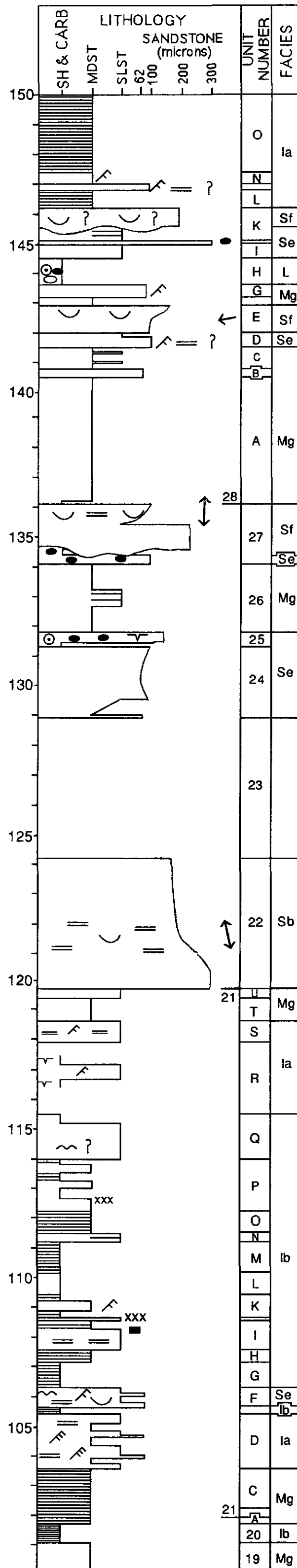
Unit 13: Interbedded mudstone (50 percent), sandstone (25 percent), and siltstone (25 percent). Sandstone is generally rippled and less than 100 μ; mudstone is green and contains mudcracks; in places rippled sandstone grades through rippled siltstone to green mudstone.

Unit 12: Mudstone and lesser sandstone and limestone. Basal 1.9 m is greenish-gray mudstone containing intraclasts of yellow limestone; 1.9-2.7 m is 125-μ sandstone; 2.7-8.0 m is greenish-gray mudstone; 8.0-8.3 is greenish-gray mudstone containing intraclasts of stromatolite and (or) oncolites, limestone fragments as long as 20 cm and well rounded; 8.3-8.5 m is greenish-gray mudstone; 8.5-8.75 m is ostracode grainstone; 8.75 m to top is greenish-gray mudstone. NOTE: This unit is covered along the road but is well-exposed in a gully near the road.

Unit 11: Sandstone (80-140 μ) and minor mudstone. Base is sharp and slightly irregular; basal 80 cm is 135-140-μ sandstone, ripples (?) and trough crossbeds; 0.8-2.5 m above base is 90-μ sandstone, ripples and trough crossbeds in upper half; 2.5-2.7 m is 80-μ sandstone; 2.7-2.9 m is pale-yellowish-brown, calcareous mudstone containing sand-filled burrow; 2.9 m to top is 130-μ sandstone, structureless.

Unit 10: Mudstone, greenish-gray.

SECTION 4 INTERVAL: 50 to 100 m



DESCRIPTION

Unit 25: Limestone and sandstone. Basal 15 cm is very light gray, chalky limestone containing abundant coated grains in places; upper 30 cm is two beds of sandstone, lower sandstone is 110 μ, few millimeters thick, mudstone drapes and mudcracks at top, upper sandstone is 140 μ, IFC.

Unit 24: Sandstone, siltstone, and mudstone. Basal 10 cm is 70-μ sandstone; 10-70 cm above base is laminated, silty, olive-gray mudstone that grades upward to olive-gray, muddy, very coarse grained siltstone; 90 cm to top is sandstone, 70-100 μ, structureless, hematite stained in places.

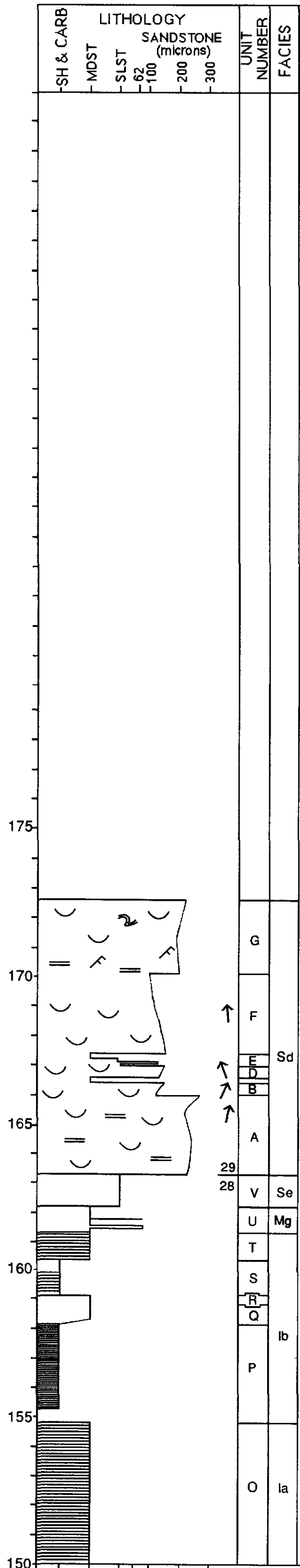
Unit 23: Covered.

Unit 22: Sandstone, fines upward (300 to 125 μ). Basal 1.5 m structureless; 1.5-2.5 m contains planar laminations and one trough crossbed; 2.5 m to top is structureless, tar stained in places.

Unit 21: Interbedded dolostone, mudstone, siltstone, and sandstone. Divided into subunits (top to base):
(U) 17.7-18.05 m, siltstone;
(T) 16.9-17.7 m, mudstone, poorly exposed, greenish-gray;
(S) 16.2-16.9 m, siltstone, medium-grained, laminated and rippled, forms resistant ledge;
(R) 13.8-16.2 m, siltstone and shale, only partly exposed; 60 cm of well-exposed medium- to coarse-grained siltstone with ripples; some outcrops and float of dark-brown laminated shale and light-gray mudcracked mudstone;
(Q) 12.3-13.8 m, lower 12 cm is wave (?)-rippled, medium- to coarse-grained siltstone; upper 3 cm is micrite (?) containing irregular lenses of ooids, in places micrite is laminated and rippled;
(P) 10.55-12.3 m, mudstone, shale, siltstone, and tuff (?); basal 55 cm is yellowish mudstone; overlain by two beds of tuff (?), lower tuff is 2-6 cm thick with pinch-and-swell bedding, upper tuff is 2 cm thick, both tuffs reddish yellow; tuffs overlain by fissile, dark-gray shale and fine-grained mudstone that grades upward to rippled siltstone; upper 20 cm of subunit is greenish-gray shale;
(O) 9.85-10.55 m, mudstone, medium-grayish-brown, laminated, fine-grained, calcareous;
(N) 9.5-9.85 m, two beds of siltstone separated by 5 cm of finely laminated brown mudstone;
(M) 8.45-9.5 m, shale, dark-brown, laminated, calcareous;
(L) 7.75-8.45 m, limestone (?), lower half is white micrite (?), upper half is sandy micrite (?) containing carbonate clasts;
(K) 6.95-7.75 m, shale and mudstone, shale is dark brown, fissile, and slightly calcareous; mudstone is greenish gray, silty, and rippled;
(J) 6.85-6.95 m, tuff (?), yellowish-red, silty, pinches and swells, in few places breaks into two beds separated by dark-brown fissile shale;
(I) 5.86–6.85 m, siltstone and mudstone, basal 70 cm is very light gray, coarse-grained, laminated, burrowed siltstone; upper 55 cm is dark-brownish-gray, very calcareous, laminated mudstone; at contact between siltstone and mudstone a 2-cm-thick zone contains carbonaceous debris;
(H) 5.45-5.85 m, mudstone, light-greenish-gray, probably laminated or very thinly bedded,
(G) 4.6-5.45 m, shale, medium-brown, fissile, basal contact gradational, contains 2-cm-thick bed of 200-μ sandstone;
(F) 3.95-4.6 m, very fine grained sandstone and coarse-grained siltstone, basal 15 cm contains planar laminations; 15-45 cm above base of subunit contains wave ripples and small (10-15 cm wide) trough crossbeds; 45-65 cm contains wave ripples; 65-75 cm is rippled sandstone encased in siltstone, rhythmically scoured surface at 65 cm;
(E) 3.7-3.95 m, dolostone, kerogenous and laminated (oil shale), weathers to paper shale, few-centimeter-thick bed of yellow silty rock (tuff?) in center;
(D) 1.85-3.7 m, interbedded siltstone, mudstone, and minor very fine grained sandstone, planar laminations and ripples, contacts between beds gradational;
(C) 0.55-1.85 cm, mudstone, greenish-gray to medium-gray, slightly to moderately calcareous, laminated to thinly bedded (beds as thick as 1 cm), concretions in places, small spots of hematite (oxidized pyrite?);
(B) 0.2-0.55 cm, mudstone, very light gray, lower half noncalcareous, upper half calcareous and silty, laminated (?);
(A) 0-0.2 m, shale or mudstone, dark-yellowish-brown, laminated to very thinly bedded, noncalcareous.

Unit 20: Dolostone. Kerogenous and laminated (oil shale), top 45 cm weathers to paper shale.

SECTION 4 INTERVAL: 100 to 150 m



DESCRIPTION

Unit 29: Sandstone, divided into subunits:

(G) 6.8 m to top, sandstone, forms ledge, 190–220 μ, basal 1 m contains planar laminations and ripples; upper 1.5 m contains trough crossbeds; in places subunit contains convolute bedding;

(F) 4.10-6.8 m, sandstone, fines upward (150 to 110 μ), lower 1.65 m trough crossbeded;

(E) 3.65-4.10 m, mudstone and subordinate siltstone and sandstone, basal 5 cm is coarse-grained siltstone; overlain by 8-cm-thick bed of 125-μ sandstone; rest of subunit is olive-gray siltstone that grades upward to olive-gray calcareous mudstone;

(D) 3.25-3.65 m, sandstone, coarsens upward slightly (130 to 150 μ), one 40-cm-thick set of trough crossbeds;

(C) 3.1-3.25 m, mudstone, olive-gray;

(B) 2.7-3.1 m, sandstone, coarsens upward (125 to 150 μ), trough crossbeds;

(A) 0-2.7 m, sandstone, one bed, 225-265 μ, large-scale (> 50 cm wide) trough crossbeds and planar laminations, base sharp and flat.

Unit 28: Interbedded carbonate, mudstone, siltstone, and sandstone. Divided into subunits:

(V) 26.3 m to top, siltstone, olive-gray, calcareous;

(U) 25.4-26.3 m, mudstone, olive-gray, has fine-grained siltstone in places;

(T) 24.5-25.4 m, mudstone, medium-brown, laminated, noncalcareous, weathers white (forms prominent white band);

(S) 23.5-24.5 m, shale, dark-brown, fissile, slightly calcareous, darkens toward top;

(R) 23.2-23.5 m, shale, light-olive-gray, fissile;

(Q) 22.2-23.2 m, mudstone, light-olive-gray, slightly calcareous, base gradational over 10 cm;

(P) 19.0-22.2 m, dolostone, laminated and kerogenous (oil shale), base gradational with underlying mudstone, paper shale in places;

(O) 11.25-19.0 m, mudstone, dark-brown to olive-gray, laminated, oily smell15.5-16.0 m;

(N) 10.85-11.25 m, mudstone, light- to dark-gray, calcareous, siltstone lenses in places, in places laminated or rippled;

(M) 10.65-10.85 m, sandstone, 90 μ, planar laminations (?), ripples at top (?);

(L) 10.1-10.65 m, mudstone, dark-brown at base to light-gray at top, calcareous, laminated;

(K) 9.0-10.1 m, siltstone and sandstone, basal 50 cm is siltstone, light-gray, medium-grained, few thin greenish mudstone interbeds; upper 60 cm is sandstone, 190 μ, scours into underlying siltstone, trough crossbeds (?);

(J) 8.9-9.0 m, sandstone, 300 μ, flat intraformational clasts of siltstone and limestone;

(I) 8.4-8.9 m, siltstone, light-gray, medium-grained;

(H) 7.5-8.4 m, limestone, chalky micrite, base contains clasts of green mudstone and limestone (?) and ooids (?) and (or) ostracodes (?); scour surfaces with lenses of ooids and limestone clasts throughout subunit; rippled (?);

(G) 7.1-7.5 m, sandstone, 80 μ, poorly sorted, rippled;

(F) 6.8-7.1 m, mudstone, light-olive-gray, calcareous;

(E) 5.9-6.8 m, sandstone, 90-160 μ, basal two-thirds is structureless, upper third trough crossbeded;

(D) 5.4-5.9 m, sandstone and siltstone, basal 35 cm is two beds of 100-μ sandstone containing laminations (?) and ripples (?); upper 15 cm is olive-gray siltstone;

(C) 4.7-5.4 m, mudstone, olive-gray, silty, and calcareous, contains beds of dark-gray siltstone;

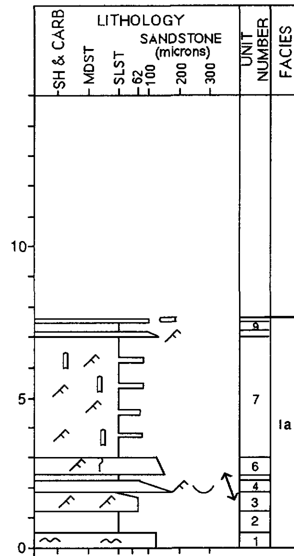
(B) 4.4-4.7 m, sandstone, light-medium-brownish-gray, 70 μ, calcareous, gradational base and top;

(A) 0-4.4 m, mudstone, olive-gray, calcareous, silty, faint laminations in places but most is structureless, basal 10 cm fissile, dark-brown shale.

Unit 27: Sandstone, siltstone, and limestone. Basal 30 cm is 90-μ sandstone, abundant mica and small IFC clasts at base, base of sandstone sharp; 0.3-0.8 m is micrite, abundant carbonate clasts; 0.8-1.2 m above base is sandstone, 225 μ, in places basal scour completely removes underlying micrite and scours basal sandstone, trough crossbeds; 1.2 m to top is coarse-grained siltstone that grades upward to 100-μ sandstone, 150-μ sand in few places, upper half of subunit is trough crossbeded and planar laminationed, with rhythmically scoured truncations.

Unit 26: Interbedded mudstone and siltstone. Olive-gray silty mudstone contains one 50-cm-thick bed of brown medium-grained siltstone containing mudstone-shale interlaminations.

SECTION 4 INTERVAL: 150 to 172.6 m



DESCRIPTION

Unit 10: Sandstone, 100 μ.

Unit 9: Siltstone, medium-grained. Medium to dark greenish brown, in places breaks into slabs that have bioturbated bedding planes.

Unit 8: Sandstone, fines upward (135 to 90 μ). Sharp base, rippled.

Unit 7: Interbedded siltstone (75 percent) and fine-grained sandstone to coarse-grained siltstone (25 percent). Siltstone is medium to dark brownish green, medium grained, calcareous, several burrows filled with finer grained sediment; sandstone and coarse grained siltstone are rippled (type of ripple unknown), sandstone less than 100 μ, bed thickness less than 25 cm.

Unit 6: Sandstone, fines upward (150 to 125 μ). Base sharp, ripped (?).

Unit 5: Siltstone, coarse-grained. Dark brownish gray, calcareous.

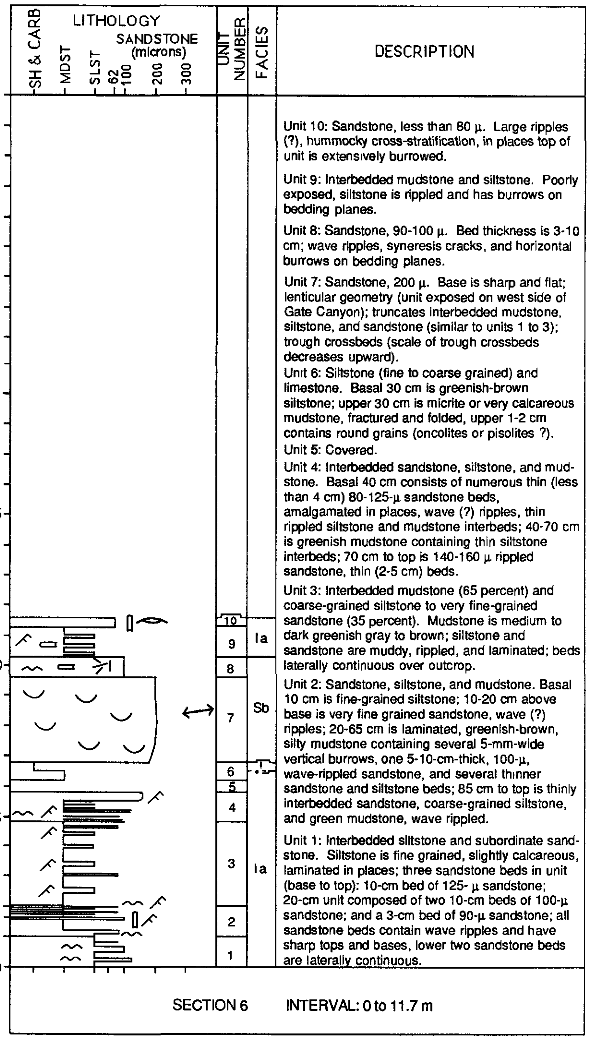
Unit 4: Sandstone, fines upward (175 to 70 μ). Rippled, one 15-cm-thick trough crossbed.

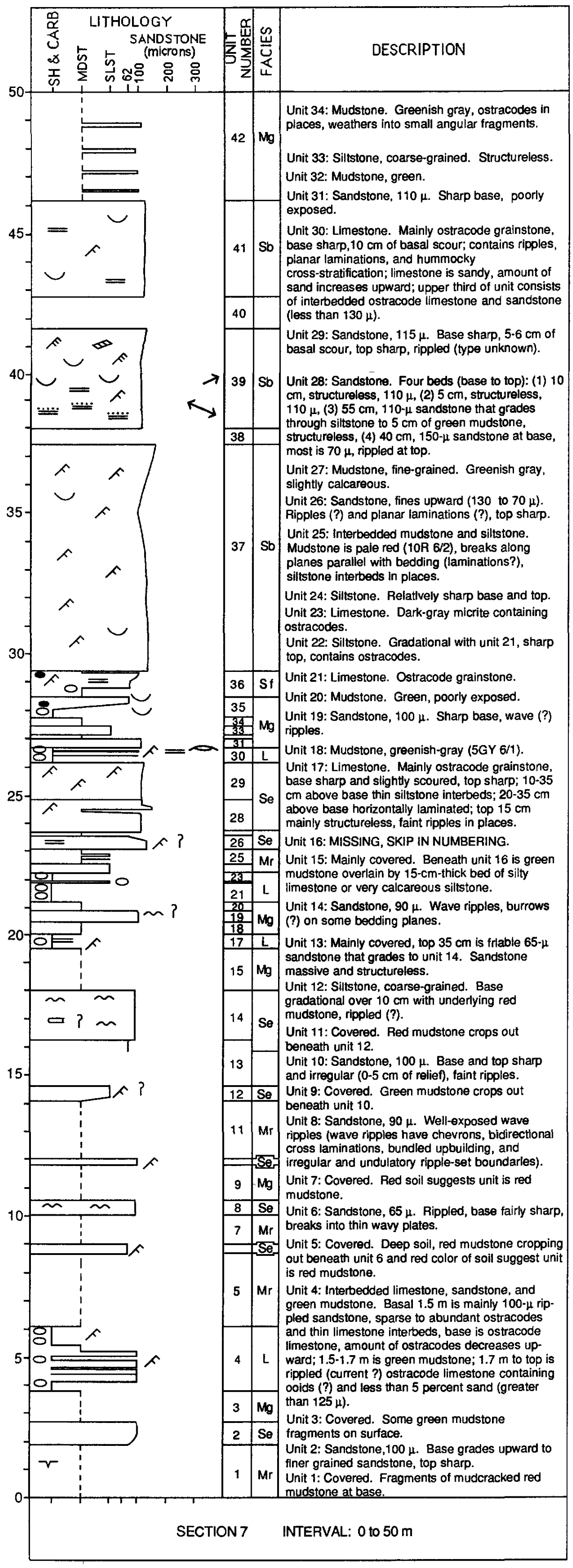
Unit 3: Sandstone, 65 μ at base, grades upward to very coarse grained siltstone. Rippled.

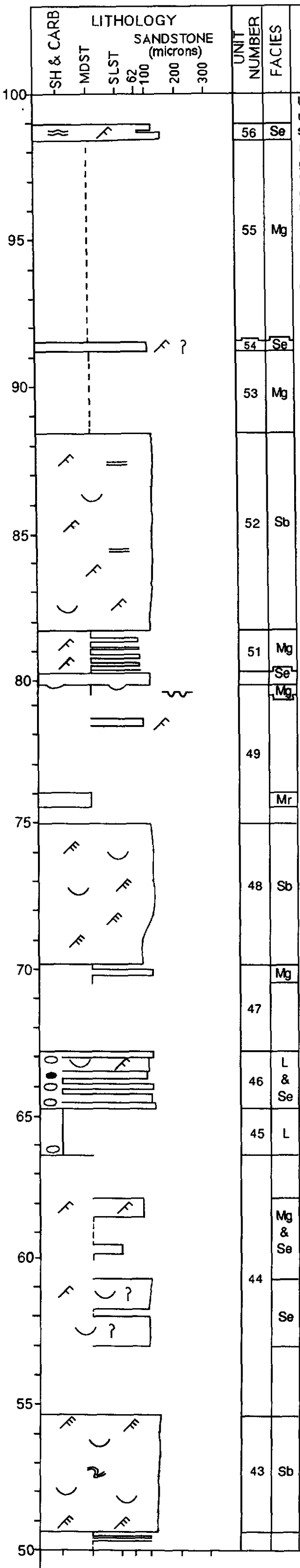
Unit 2: Siltstone, coarse-grained. Poorly exposed, greenish brown, calcareous.

Unit 1: Sandstone, 125 μ. Three beds, bed thickness (base to top): 5, 5, 40 cm; wave (?) ripples.

SECTION 5 INTERVAL: 0 to 7.6 m


LITHOLOGY
SANDSTONE (microns)
SH & CARB
MDST
SLST
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
Unit 10: Sandstone, less than 80 µ. Large ripples (?), hummocky cross-stratification, in places top of unit is extensively burrowed.
Unit 9: Interbedded mudstone and siltstone. Poorly exposed, siltstone is rippled and has burrows on bedding planes.
Unit 8: Sandstone, 90-100 µ. Bed thickness is 3-10 cm; wave ripples, syneresis cracks, and horizontal burrows on bedding planes.
Unit 7: Sandstone, 200 µ. Base is sharp and flat; lenticular geometry (unit exposed on west side of Gate Canyon); truncates interbedded mudstone, siltstone, and sandstone (similar to units 1 to 3); trough crossbeds (scale of trough crossbeds decreases upward).
Unit 6: Siltstone (fine to coarse grained) and limestone. Basal 30 cm is greenish-brown siltstone; upper 30 cm is micrite or very calcareous mudstone, fractured and folded, upper 1-2 cm contains round grains (oncolites or pisolites ?).
Unit 5: Covered.
Unit 4: Interbedded sandstone, siltstone, and mudstone. Basal 40 cm consists of numerous thin (less than 4 cm) 80-125-µ sandstone beds, amalgamated in places, wave (?) ripples, thin rippled siltstone and mudstone interbeds; 40-70 cm is greenish mudstone containing thin siltstone interbeds; 70 cm to top is 140-160 µ rippled sandstone, thin (2-5 cm) beds.
Unit 3: Interbedded mudstone (65 percent) and coarse-grained siltstone to very fine-grained sandstone (35 percent). Mudstone is medium to dark greenish gray to brown; siltstone and sandstone are muddy, rippled, and laminated; beds laterally continuous over outcrop.
Unit 2: Sandstone, siltstone, and mudstone. Basal 10 cm is fine-grained siltstone; 10-20 cm above base is very fine grained sandstone, wave (?) ripples; 20-65 cm is laminated, greenish-brown, silty mudstone containing several 5-mm-wide vertical burrows, one 5-10-cm-thick, 100-µ, wave-rippled sandstone, and several thinner sandstone and siltstone beds; 85 cm to top is thinly interbedded sandstone, coarse-grained siltstone, and green mudstone, wave rippled.
Unit 1: Interbedded siltstone and subordinate sandstone. Siltstone is fine grained, slightly calcareous, laminated in places; three sandstone beds in unit (base to top): 10-cm bed of 125-µ sandstone; 20-cm unit composed of two 10-cm beds of 100-µ sandstone; and a 3-cm bed of 90-µ sandstone; all sandstone beds contain wave ripples and have sharp tops and bases, lower two sandstone beds are laterally continuous.
SECTION 6 INTERVAL: 0 to 11.7 m


LITHOLOGY
SANDSTONE (microns)
SH & CARB
MDST
SLST
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
Unit 34: Mudstone. Greenish gray, ostracodes in places, weathers into small angular fragments.
Unit 33: Siltstone, coarse-grained. Structureless.
Unit 32: Mudstone, green.
Unit 31: Sandstone, 110 µ. Sharp base, poorly exposed.
Unit 30: Limestone. Mainly ostracode grainstone, base sharp,10 cm of basal scour; contains ripples, planar laminations, and hummocky cross-stratification; limestone is sandy, amount of sand increases upward; upper third of unit consists of interbedded ostracode limestone and sandstone (less than 130 µ).
Unit 29: Sandstone, 115 µ. Base sharp, 5-6 cm of basal scour, top sharp, rippled (type unknown).
Unit 28: Sandstone. Four beds (base to top): (1) 10 cm, structureless, 110 µ, (2) 5 cm, structureless, 110 µ, (3) 55 cm, 110-µ sandstone that grades through siltstone to 5 cm of green mudstone, structureless, (4) 40 cm, 150-µ sandstone at base, most is 70 µ, rippled at top.
Unit 27: Mudstone, fine-grained. Greenish gray, slightly calcareous.
Unit 26: Sandstone, fines upward (130 to 70 µ). Ripples (?) and planar laminations (?), top sharp.
Unit 25: Interbedded mudstone and siltstone. Mudstone is pale red (10R 6/2), breaks along planes parallel with bedding (laminations?), siltstone interbeds in places.
Unit 24: Siltstone. Relatively sharp base and top.
Unit 23: Limestone. Dark-gray micrite containing ostracodes.
Unit 22: Siltstone. Gradational with unit 21, sharp top, contains ostracodes.
Unit 21: Limestone. Ostracode grainstone.
Unit 20: Mudstone. Green, poorly exposed.
Unit 19: Sandstone, 100 µ. Sharp base, wave (?) ripples.
Unit 18: Mudstone, greenish-gray (5GY 6/1).
Unit 17: Limestone. Mainly ostracode grainstone, base sharp and slightly scoured, top sharp; 10-35 cm above base thin siltstone interbeds; 20-35 cm above base horizontally laminated; top 15 cm mainly structureless, faint ripples in places.
Unit 16: MISSING, SKIP IN NUMBERING.
Unit 15: Mainly covered. Beneath unit 16 is green mudstone overlain by 15-cm-thick bed of silty limestone or very calcareous siltstone.
Unit 14: Sandstone, 90 µ. Wave ripples, burrows (?) on some bedding planes.
Unit 13: Mainly covered, top 35 cm is friable 65-µ sandstone that grades to unit 14. Sandstone massive and structureless.
Unit 12: Siltstone, coarse-grained. Base gradational over 10 cm with underlying red mudstone, rippled (?).
Unit 11: Covered. Red mudstone crops out beneath unit 12.
Unit 10: Sandstone, 100 µ. Base and top sharp and irregular (0-5 cm of relief), faint ripples.
Unit 9: Covered. Green mudstone crops out beneath unit 10.
Unit 8: Sandstone, 90 µ. Well-exposed wave ripples (wave ripples have chevrons, bidirectional cross laminations, bundled upbuilding, and irregular and undulatory ripple-set boundaries).
Unit 7: Covered. Red soil suggests unit is red mudstone.
Unit 6: Sandstone, 65 µ. Rippled, base fairly sharp, breaks into thin wavy plates.
Unit 5: Covered. Deep soil, red mudstone cropping out beneath unit 6 and red color of soil suggest unit is red mudstone.
Unit 4: Interbedded limestone, sandstone, and green mudstone. Basal 1.5 m is mainly 100-µ rippled sandstone, sparse to abundant ostracodes and thin limestone interbeds, base is ostracode limestone, amount of ostracodes decreases upward; 1.5-1.7 m is green mudstone; 1.7 m to top is rippled (current ?) ostracode limestone containing ooids (?) and less than 5 percent sand (greater than 125 µ).
Unit 3: Covered. Some green mudstone fragments on surface.
Unit 2: Sandstone,100 µ. Base grades upward to finer grained sandstone, top sharp.
Unit 1: Covered. Fragments of mudcracked red mudstone at base.
SECTION 7 INTERVAL: 0 to 50 m



DESCRIPTION

Unit 50: Sandstone, 100 µ. Base contains sole marks, load structures, and tool marks or flutes; sandstone contains well-exposed ripples.

Unit 49: Mainly covered. One outcrop of purplish gray mudstone; one thin bed of very fine grained rippled sandstone 1 m below top; 35-cm-thick bed of greenish-gray mudstone crops out beneath unit 50.

Unit 48: Sandstone, coarsens upward (65 to 110 µ). Base sharp and somewhat irregular, abundant current ripples (linguoid ripples exposed at top of unit) and lesser trough crossbeds.

Unit 47: Mainly covered. One 20-cm-thick bed of 110-µ sandstone and green mudstone crops out beneath unit 48.

Unit 46: Sandstone,100-120 µ. Complex interlensing of sandstone and lesser ostracode limestone and limestone composed of limestone intraclasts; individual beds discontinuous; ostracode and intraclast-rich zones generally trough shaped and more abundant in lower half of unit; upper half contains trough crossbeds, ripples, and some small channels; unit thickens toward east.

Unit 45: Limestone. Basal 20 cm is sandy ostracode grainstone; most of unit is dark-yellowish-orange micrite, minor ostracodes and ooids (?).

Unit 44: Partly exposed interval of sandstone, mudstone, and siltstone. Interval is 60 percent covered; 2.4-3.5 m above base is 1.1-m-thick bed of 90-µ sandstone containing possible small-scale (20-30 cm diameter) low-amplitude trough crossbeds; 3.7-4.7 m is 85-100-µ sandstone containing ripples and small-scale (20-30 cm diameter) trough crossbeds (?), overlies green mudstone; 5.7-6 m is very coarse grained siltstone overlying green mudstone; 6.7-7.45 m is rippled 60-80-µ sandstone overlying green mudstone.

Unit 43: Sandstone, 120-130 µ. Sharp and almost flat base; most of unit contains large-scale (as much as 2 m in diameter) trough crossbeds and large-scale soft sediment deformation; current ripples at base and in top 50 cm of unit.

Unit 42: Mainly covered. Four or five thin (less than 40 cm thick) outcrops of rippled (in places) fine-grained sandstone; 40-cm-thick interval of interbedded fine-grained sandstone and greenish-gray mudstone crops out beneath unit 43.

Unit 41: Sandstone, 120-130 µ. Planar laminations, trough crossbeds, and some ripples.

Unit 40: Covered. Greenish-gray mudstone and fissile medium-grained siltstone beneath soil.

Unit 39: Sandstone, 110-150 µ. Basal 80 cm contains planar laminations that have parting lineations; 80 cm-1.75 m above base contains trough crossbeds, ripples, and some planar laminations; upper 1.95 m contains three-dimensional current ripples, some climbing ripples, and trough crossbeds.

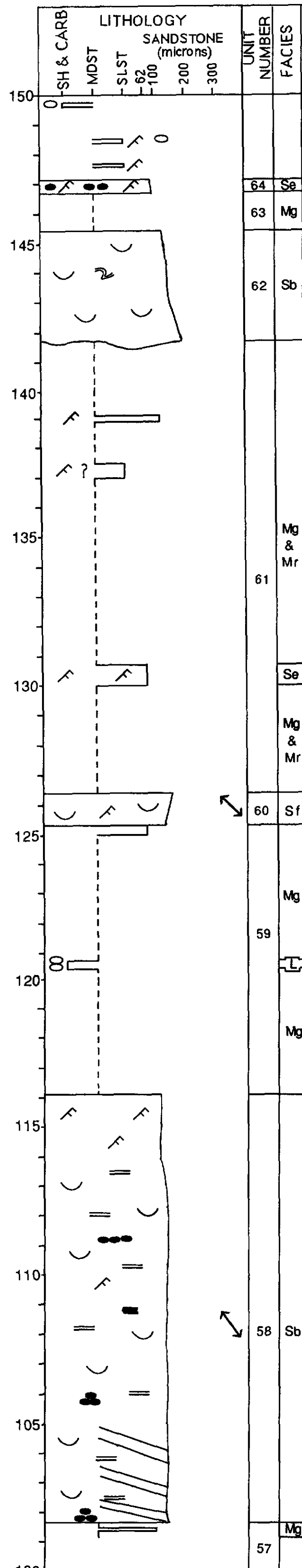
Unit 38: Mainly covered. Unit forms bench between ledges formed by units 37 and 39, bench covered by sandy soil and large sandstone blocks from unit 39; one 25-cm-thick outcrop of wave-rippled 75-µ sandstone in center; laminated very coarse-grained siltstone and green mudstone crops out beneath unit 39 in places.

Unit 37: Sandstone, 100-160 µ. Base sharp, tool marks and load structures; massive except for one distinct 20-cm-thick bed about 2 m above base that contains soft-sediment deformation (oversteepened foresets on trough crossbeds) and one distinct 25-cm-thick bed at top that contains ripples and a few trough crossbeds.

Unit 36: Interbedded sandstone, green mudstone, and ostracode limestone. Beds are lenticular and contain local concentrations of carbonized wood and (or) small clasts of sandstone and limestone. Unit consists of (base to top): (1) 0-35 cm, green mudstone; (2) 35-55 cm, 70-µ sandstone, cuts steep-sided channel into underlying subunit, structureless; (3) 55-90 cm, interbedded 70-130-µ sandstone, some beds contain ostracodes and small clasts, rippled, top 10 cm contains planar laminations; (4) 90 cm to top, green mudstone.

Unit 35: Limestone and sandstone. Sandy ostracode limestone containing small (not greater than 3 cm) clasts (very light gray, moderately calcareous) at base; grades upward through mix of sand and ostracodes to 65-µ sandstone containing ostracodes at top; trough crossbeds or scours throughout; linguoid ripples at top of unit. Unit grades laterally into interval consisting of complex mix of sand and ostracodes having no vertical trends.

SECTION 7 INTERVAL: 50 to 100 m



DESCRIPTION

Unit 64: Sandstone, 90 µ. Rippled, sparse to abundant clasts in upper half.

Unit 63: Covered. Abundant green mudstone fragments.

Unit 62: Sandstone, fines upward (190 to 125 µ). Base sharp, 50 cm of basal scour; unit contains trough crossbeds, some troughs have oversteepened crossbeds; in many places sedimentary structures are not well exposed.

Unit 61: Mainly covered. Thick soil and abundant float, sparse to abundant fragments of green and subordinate red mudstone over slope; 2.6 m above base is purple mudstone; 3.9-4.65 m above base are two beds of rippled (?) 70-µ sandstone; 7.5-11.3 m are red mudstone fragments; 11.55-12.1 m is very coarse grained siltstone; 12.5 m above base is outcrop of rippled 125-µ sandstone; 13 m above base is outcrop of green mudstone.

Unit 60: Sandstone, 125-155 µ. Sharp and flat base, trough crossbeds and lesser ripples.

Unit 59: Mainly covered. Thick soil and abundant talus, abundant fragments of green mudstone; two beds of ostracode limestone and micrite (?) in center of unit; friable very fine grained sandstone crops out beneath unit 60.

Unit 58: Sandstone, most of unit is 120-150 µ, upper 2 m is 110 µ. Probably composite amalgamated sandbody containing scattered internal IFC zones and multiple internal scoured sandstone-sandstone and sandstone-mudstone contacts. Most of unit contains planar laminations with low-angle truncations and lesser trough crossbeds and ripples, few log impressions; basal 3 m exhibit lateral-accretion bedding, beds dip northeast, dipping sandstone beds separated by green mudstone, sandstones downlap channel base and truncate green mudstones downdip; sandstones beds are 50-120 cm thick and contain scattered IFC, trough crossbeds, and planar laminations; top 2 m of unit is rippled 110-µ sandstone.

Unit 57: Mainly covered. Beneath unit 58 is 50-cm-thick interval of interbedded siltstone, sandstone, and green mudstone.

Unit 56: Sandstone, 70-150 µ. Base is gradational over 10 cm with underlying green mudstone; composed of four or five sandstone beds containing ripples and wavy planar laminations; sandstone-sandstone contacts are sharp.

Unit 55: Covered. Green soil and green mudstone chips suggest unit is green mudstone.

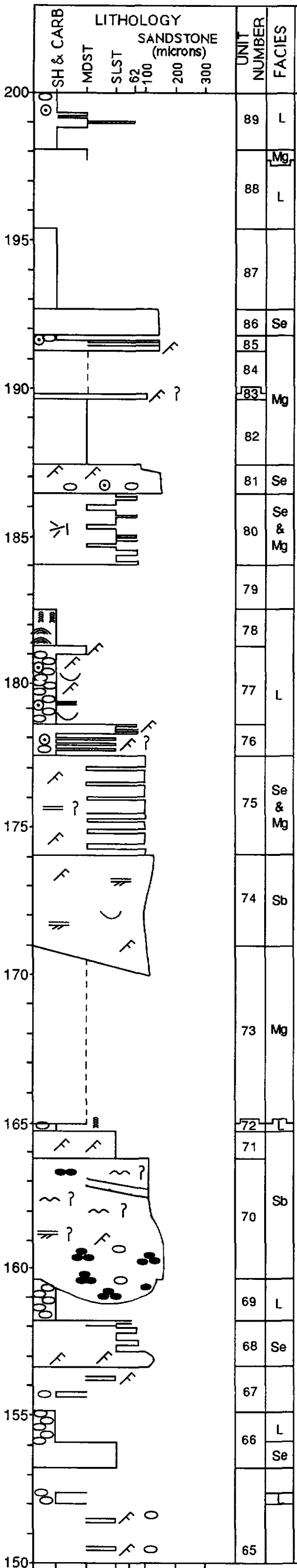
Unit 54: Sandstone, 100 µ. Gradational base, rippled (?).

Unit 53: Covered. Green soil and abundant green mudstone fragments and green mudstone beneath unit 54 suggests unit consist of greenish-gray mudstone.

Unit 52: Sandstone, 100-110 µ. Few thin mudstone interbeds; numerous stacked and mutually truncating lenticular 10-15-m-wide sandbodies; abundant ripples, some trough crossbeds and dipping planar laminations (concordant channel fill ?).

Unit 51: Interbedded sandstone and green mudstone. Bed thickness 20 cm or less; sandstones 65 µ, rippled, lenticular.

SECTION 7 INTERVAL: 100 to 150



DESCRIPTION

Unit 87: Limestone (?). Silty micrite (?), fine-grained to moderately silty, very calcareous, commonly breaks into thin wavy plates.

Unit 86: Sandstone, 140 µ. Structureless.

Unit 85: Sandstone, green mudstone, and limestone. Lower two-thirds is 140-µ rippled sandstone, bed thickness less than 2 cm, greenish-gray mudstone interbeds and partings and syneresis cracks; upper third is limestone containing ostracodes, ooids, few coated grains, and 120-130-µ sand.

Unit 64: Mainly covered. Abundant green mudstone fragments and green mudstone beneath unit 85.

Unit 83: Sandstone, 100 µ. Rippled (?).

Unit 82: Mudstone. Greenish gray, poorly exposed.

Unit 81: Sandstone, mainly 150 µ, top 20 cm is 80 µ. Most structureless except for ripples (?) in top 20 cm; abundant ostracodes, ooids (?) and other carbonate grains in places; one fragment of algally laminated limestone

Unit 80: Interbedded sandstone (less than 100 µ), siltstone, and green mudstone (15 percent). Syneresis cracks on bedding planes.

Unit 79: Covered.

Unit 78: Limestone. Lower half consists of large (as much as 60 cm high by 100 cm wide) domal stromatolites; upper half consists of pillar-type stromatolites.

Unit 77: Limestone. Mainly ostracode grainstone, minor ooids (?) and algal laminations, ripples and trough crossbeds; top 30 cm is siltstone (?) containing ostracodes.

Unit 76: Limestone, siltstone, and sandstone. Overall unit coarsens upward; basal 20 cm is ostracode grainstone; 20-50 cm is interbedded siltstone and ooid limestone, rippled (?); 50 cm to top is thinly interbedded rippled very fine grained sandstone and coarse-grained siltstone.

Unit 75: Interbedded sandstone (less than 100 µ) (80 percent) and green mudstone (20 percent). Sandstone beds are as thick as 40 cm, sandstone generally structureless, some ripples and planar laminations (?), some beds have thin streaks of green mudstone; green mudstone beds generally less than 15 cm thick.

Unit 74: Sandstone, 90-125 µ. Base dips 15° WNW (285°); ripples and planar laminations with low-angle truncations (planar laminations are parallel with base of unit in places), and minor trough cross beds.

Unit 73: Covered. Abundant green mudstone fragments and green mudstone beneath unit 74.

Unit 72: Limestone. Ostracode grainstone, sharp base and top, in place base has small pillar-type stromatolites.

Unit 71: Siltstone, coarse-grained. Rippled, poorly exposed.

Unit 70: Sandstone, fines upward (160 to 110 µ). Base sharp, scours all of unit 69 and top of unit 68 in places. Consists of two subunits: (1) basal lag deposit 0 to few meters thick, small to large (as much as 40 cm in diameter) angular fragments of limestone from unit 69, IFC as multiple lenses, matrix of well-sorted 160-µ sand with yellowish patches (weathered ostracodes ?), planar laminations (?) with low-angle truncations and ripples; (2) upper zone of 120-110-µ sandstone, 2 to 4 m thick, lateral-accretion bedding cuts through subunit 1 and into unit 68 downdip, multiple internal scours and ripples (wave?), thin green mudstone interbed and thin IFC lens near top.

Unit 69: Limestone. Basal 1.0 m is ostracode grainstone; top 40 cm is silty micrite (?) containing ostracodes.

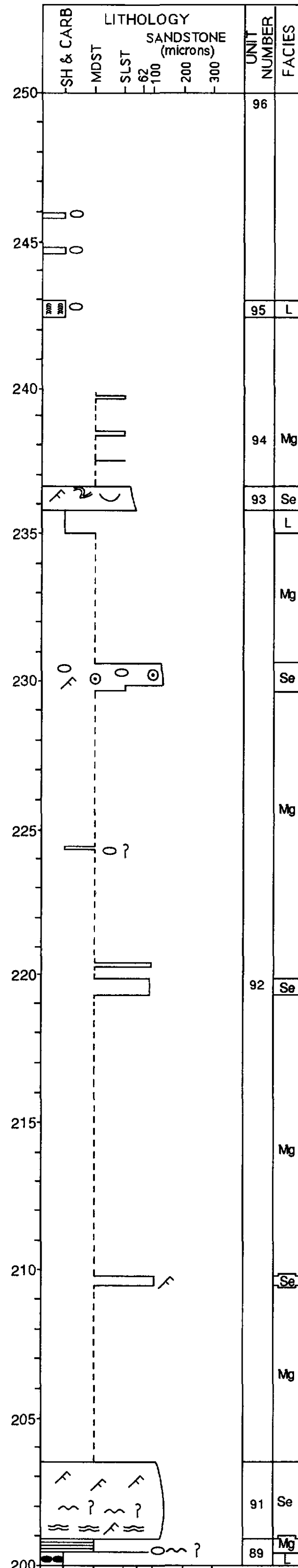
Unit 68: Sandstone and siltstone. Basal 60 cm is rippled sandstone (100-130 µ); top 1 m consists of interbedded siltstone and very fine grained sandstone and one green mudstone bed.

Unit 67: Mainly covered. Similar to unit 65.

Unit 68: Siltstone and limestone. Lower half mainly thin bedded siltstone; upper half mainly ostracode grainstone.

Unit 65: Mainly covered. Numerous thin outcrops of rippled siltstone and ostracode limestone, complete gradation from siltstone with no ostracodes through ostracode-rich siltstone and silty ostracode limestone to silt-poor limestone; amount of ostracodes increase upward in unit.

SECTION 7 INTERVAL: 150 to 200 m



DESCRIPTION

Unit 96: Mainly covered. Slope covered with soil and talus; few thin outcrops of ostracode limestone near base.

Unit 95: Limestone. Pillar-type stromatolites and a few very small domal stromatolites near base, sparse to abundant ostracodes.

Unit 94: Mainly covered. Scattered fragments of green mudstone and a few very thin outcrops of siltstone.

Unit 93: Sandstone, fines upward (140 to 125 µ). Base sharp and flat, small-scale trough crossbeds, ripples and minor soft-sediment deformation.

Unit 92: Mainly covered. Abundant fragments of greenish-gray mudstone; 6.0-6.3 m above base is rippled 100-µ sandstone; 15.8-16.35 m is structureless 95-µ sandstone; 16.8-17.0 m is structureless 90 µ sandstone; 20.8-20.95 is micrite (?) containing few ostracodes (?); at 24.5 m is thin greenish-gray mudstone; 26.2-27.1 m is 20-cm-thick, rippled, very coarse grained siltstone overlain by 125-150 µ sandstone containing abundant ostracodes and ooids; beneath unit 93 is 15-cm-thick bed of greenish-gray mudstone overlain by 85-cm-thick bed of very calcareous fine-grained siltstone-mudstone or micrite.

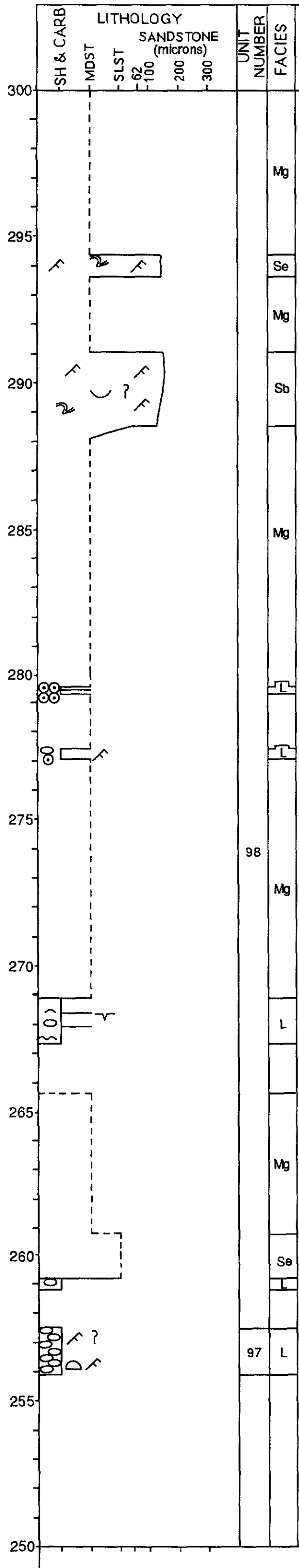
Unit 91: Sandstone, 110-135 µ. Base sharp and flat, well-exposed ripples throughout; 50 cm above base wavy planar laminations are overlain by wave (?) ripples; ripples near top probably are current ripples.

UNIT 90: MISSING, NUMBER SKIPPED.

Unit 89: Limestone, sandstone, and green mudstone. Basal 75 cm is micrite (?), light-gray, fine-grained; 75-115 cm is green mudstone, one thin bed of very fine grained sandstone and one bed of silty micrite (?); 115-235 cm is 1-m-thick bed of silty micrite (?) containing ostracodes and ooids (?) overlain by limestone composed of coated grains and limestone IFC (including some with algal laminations) overlain by 5-cm-thick bed of wave (?)-rippled very fine grained sandstone containing ostracodes (?); top 45 cm is laminated green mudstone.

Unit 88: Mainly covered. Green mudstone crops out beneath unit 89.

SECTION 7 INTERVAL: 200 to 250 m

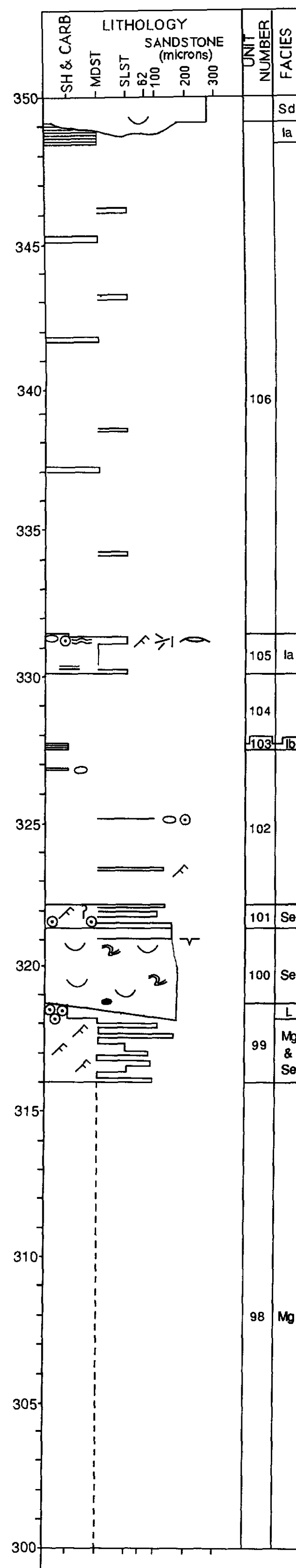


DESCRIPTION

Unit 98: Poorly exposed interval. 1.1-1.65 m above base is ostracode grainstone; 1.65-3.3 m is poorly exposed interval of very light gray silty micrite or calcareous siltstone; 3.3-8.1 m is greenish soil and abundant green mudstone fragments; 9.8-11.4 m is silty micrite (?) containing green mudstone partings and thin interbeds, and ostracodes and wave ripples (?), breaks into thin slabs, near top is a green mudstone bed with ostracodes and mudcracks (?); 11.4-19.6 m above base is poorly exposed green mudstone; 19.6-19.95 is rippled ostracode limestone containing ooids (?); 19.95-21.8 m is poorly exposed interval of green mudstone; at 21.8 m above base of unit is a thin outcrop of limestone consisting of coated carbonate grains, green mudstone interbeds and partings, and relatively abundant green mudstone fragments; 22.1-31.4 m is poorly exposed green mudstone; 31.4-33.6 m is sandstone, 150-125 μ, lenticular geometry, channeled base, wide (2.5 m+) channels within sandstone, ripples, trough crossbeds (?), some soft-sediment deformation; 33.6-35.5 m is poorly exposed green mudstone; 35.5-36.2 m is sandstone, 130-140 μ, lenticular geometry, lateral-accretion bedding (beds dip 20° NE.), rippled, soft-sediment deformation in lower half; 36.2 m to top green mudstone fragments on slope, no outcrops.

Unit 97: Limestone. Basal 20 cm is very light gray micrite; 20-40 cm is rippled ostracode grainstone containing minor carbonate intraclasts and fish scales (?); 40 cm to top is rippled (?) ostracode grainstone.

SECTION 7 INTERVAL: 250 to 300 m



DESCRIPTION

Unit 106: Mainly covered. Light-grayish soil, few thin outcrops of light-gray, calcareous, coarse-grained siltstone, finer grained, light-greenish-gray siltstone or mudstone, and medium-brown slightly calcareous siltstone or mudstone; brown laminated mudstone crops out beneath unit 107.

Unit 105: Interbedded siltstone, mudstone, and limestone. Basal 16 cm is siltstone that is coarse grained and contains planar laminations; 16-27 cm is covered; 27-103 is light-olive-gray, calcareous, massive mudstone that grades upward to laminated, silty mudstone; 103-130 cm is calcareous, very coarse grained siltstone containing wavy planar laminations and ripples (?), top surfaces of some beds appear hummocky, and exhibits syneresis cracks; 130 cm to top is sandy limestone composed of ooids with sand nuclei.

Unit 104: Covered.

Unit 103: Dolostone. Laminated and kerogenous (oil shale), light-bluish-gray weathered color, very dark gray fresh color, slight oily smell, weathers into thin slabs (but not paper shale).

Unit 102: Mainly covered. Unit forms slope with thick cover of light-gray soil, three thin outcrops (base to top): (1) several thin (less than 5 cm) beds of lenticular, rippled 125-μ sandstone; (2) 90-μ sandstone containing minor ostracodes and ooids (?), rippled; (3) 5-cm-thick bed of ostracode grainstone containing larger carbonate grains.

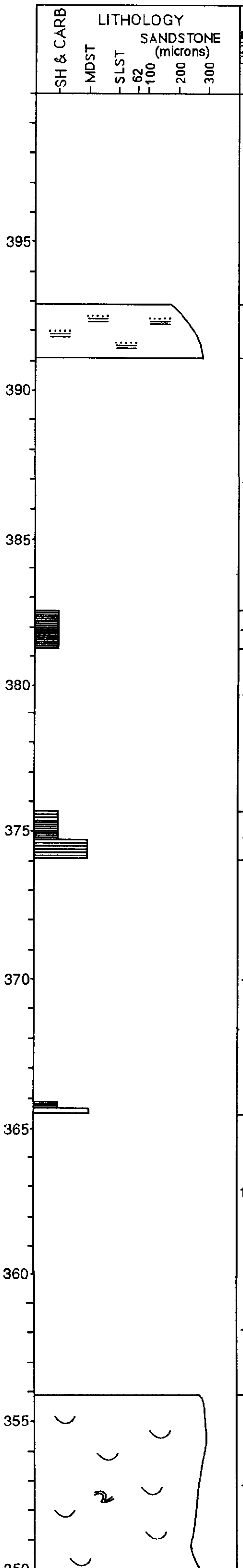
Unit 101: Sandstone, 105-150 μ. Unit consists of three beds separated by covered intervals (base to top): (1) 15-cm-thick, 150-μ, numerous small yellow grains (ooids ?); (2) 20-cm-thick, 105 μ; (3) 8-cm-thick, 130 μ. All three beds contain poorly exposed ripples (?).

Unit 100: Sandstone, fines upward (175 to 150 μ). Base is sharp and dips about 5° toward N. 30° E. truncating unit 99, base generally lacks lag deposits but in one place contains large (as much as 30 by 15 by 15 cm) angular limestone blocks from top of unit 99; trough crossbeds, abundant small- to large-scale soft-sediment deformation, mudcracked thin green mudstone interbeds near top.

Unit 99: Interbedded green mudstone, sandstone, siltstone, and limestone. Bed thickness less than 80 cm, sandstone-mudstone contacts generally flat and sharp; siltstone very coarse grained and rippled; grain size of sandstones as much as 160 μ; in places top of unit 99 consists of a 35-cm-thick bed of ooid grainstone.

SECTION 7 INTERVAL: 300 to 350 m

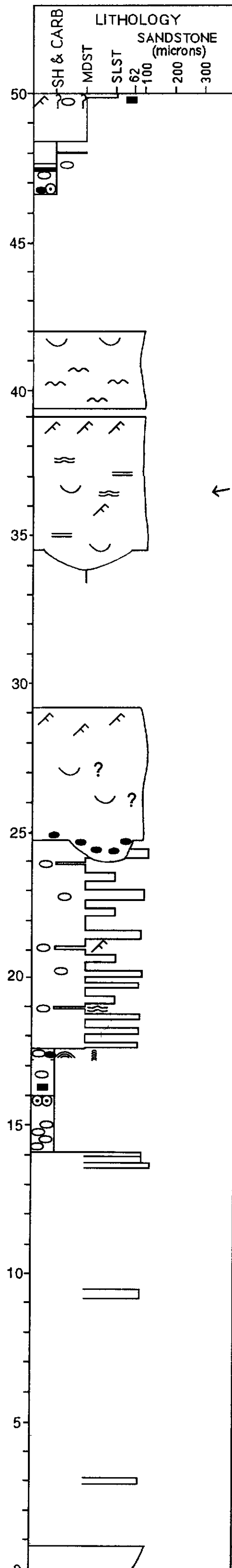
SECTION 7 — INTERVAL: 350 to 392.9 m



UNIT NUMBER	FACIES	DESCRIPTION
114	Se	Unit 114: Sandstone, fines upward (280 to 170 μ). Planar laminations with parting lineations.
113		Unit 113: Covered.
112	Ib	Unit 112: Dolostone. Laminated and kerogenous (oil shale), upper half weathers to paper shale.
111		Unit 111: Covered.
110	Ib	Unit 110: Mudstone and dolostone. Unit crops out beneath large sandstone block; basal 60 cm is yellowish-brown mudstone, laminated, slightly calcareous; 60-130 cm is laminated, kerogenous dolostone (oil shale); 130 cm to top is medium-brown, laminated dolostone. All three subunits contain numerous thin (less than 15 mm) streaks of yellowish silty rock (tuffs ?).
109	Ib	Unit 109: Mainly covered. Greenish-gray mudstone in hole dug in center of unit; beneath talus block near base of unit a 25-cm-thick bed of light-brown calcareous mudstone grades upward into laminated, kerogenous dolostone (oil shale).
108		Unit 108: Covered. Thick soil, no outcrops.
108		
107	Sd	Unit 107: Sandstone, 175-300 μ (no grain size trend). Base sharp and scours 20 cm or more into underlying mudstone; well-exposed large-scale (some are almost 1 m high by 3+ m wide) trough crossbeds, in few places cross laminations are oversteepened.

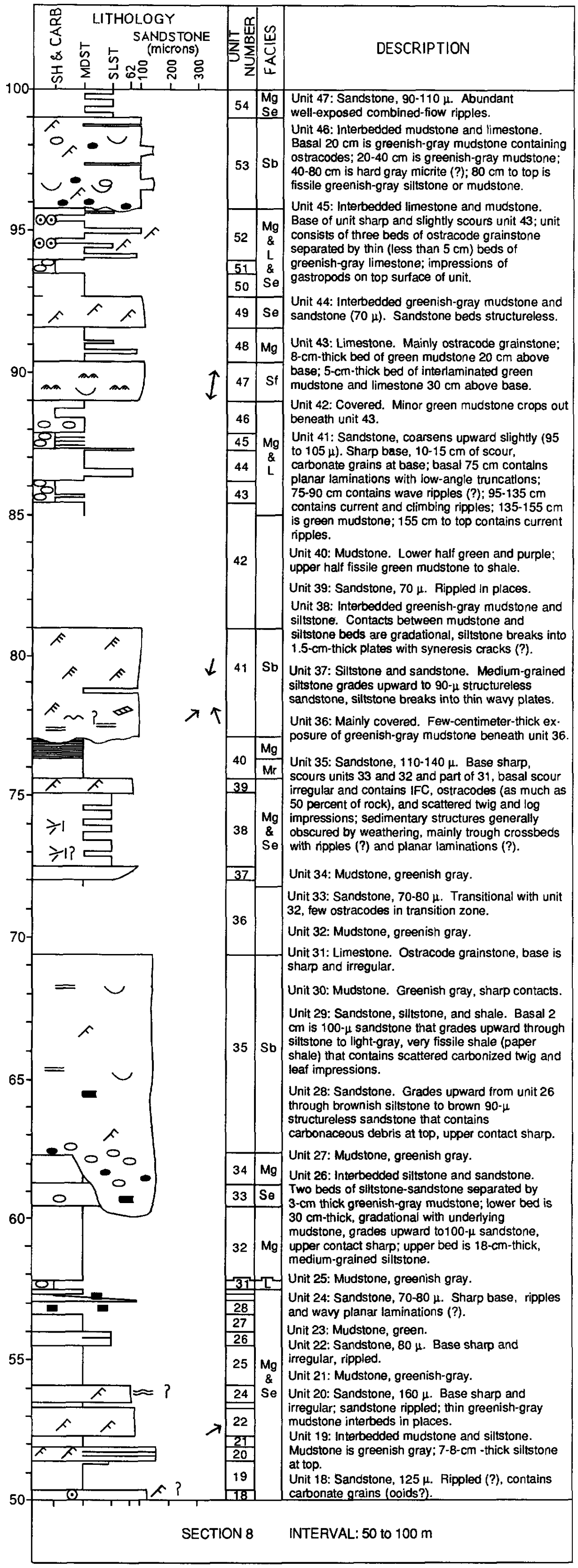
SECTION 7 INTERVAL: 350 to 392.9 m

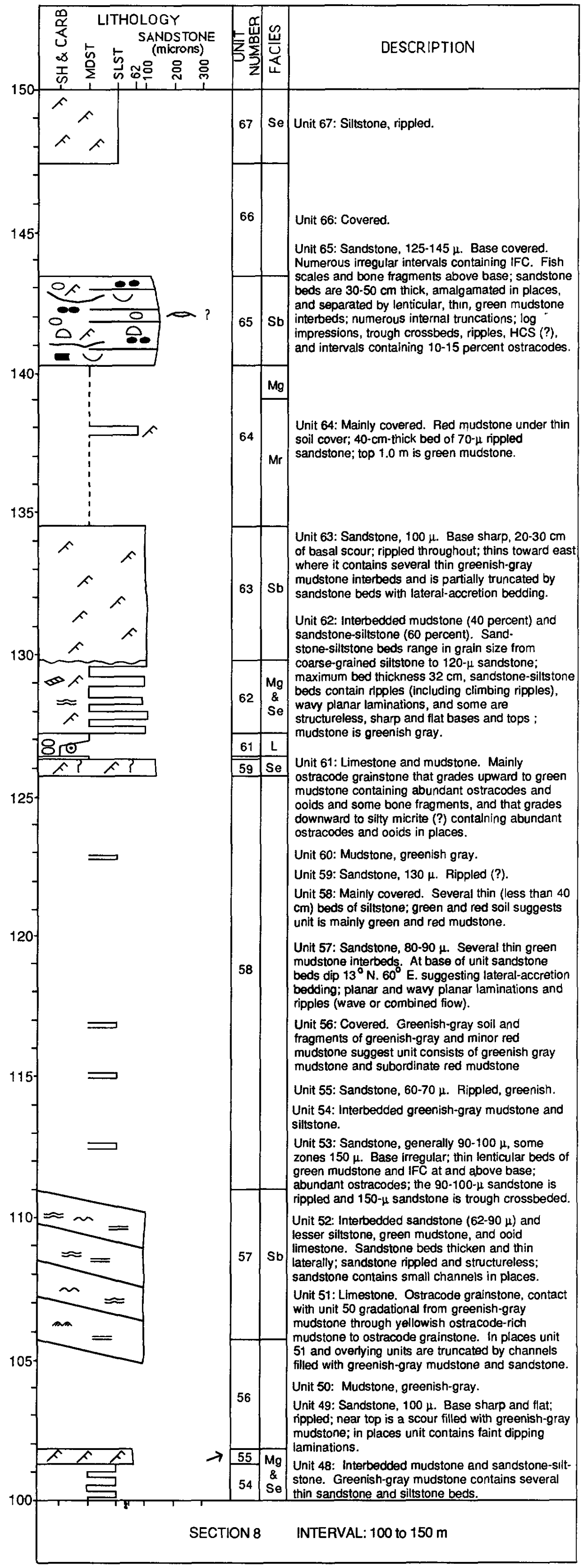
SECTION 8 — INTERVAL: 0 to 50 meters

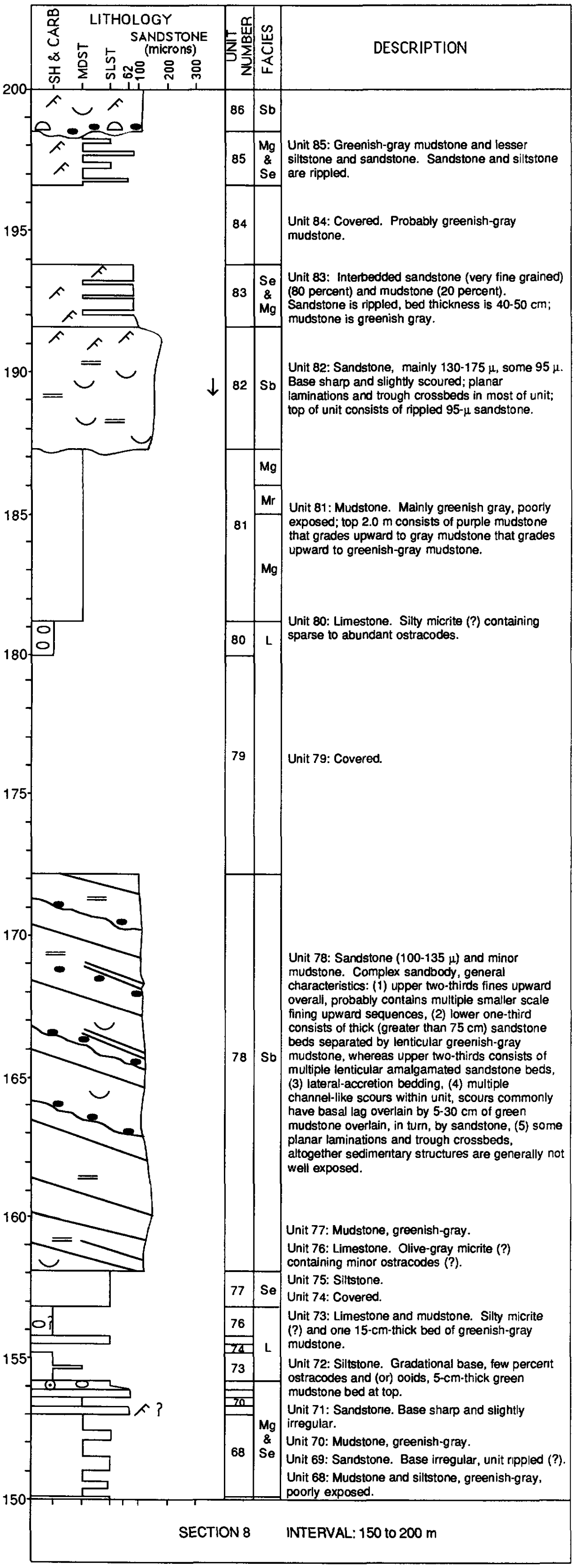


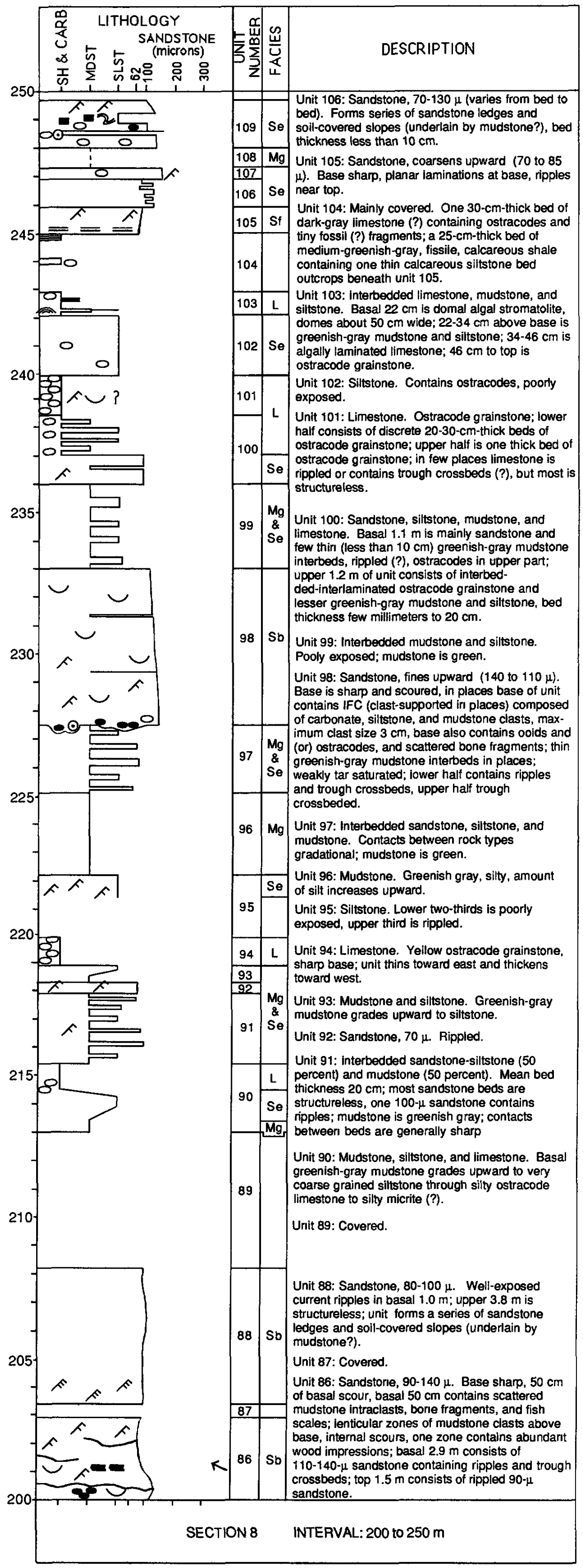
UNIT NUMBER	FACIES	DESCRIPTION
17	Mg	Unit 17: Mudstone and siltstone. Gray, moderately calcareous; top 20 cm is rippled (?) siltstone containing carbonaceous debris and yellowish grains (carbonate?).
16	L	Unit 16: Limestone. Two beds of hard, gray micrite or fine-grained calcareous mudstone separated by 7.5-cm-thick bed of dark-brown, fissile, calcareous shale; limestone beds have sharp bases.
15		Unit 15: Limestone. Type uncertain, may be composed of indistinct (recrystallized?) carbonate grains; contains minor ostracodes.
14		Unit 14: Dolostone. Dark-gray, some zones kerogenous (oil shale).
13		Unit 13: Limestone. Silty micrite (?), contains ostracodes, ooids, and limestone intraclasts; top 5-10 cm is ostracode grainstone, ostracodes probably are coated.
12		Unit 12: Covered.
11	Se	Unit 11: Sandstone, 80-100 μ. Basal 1.0 m only partly exposed; wave ripples, several trough crossbeds near top.
10		Unit 10: Covered.
9	Sb	Unit 9: Sandstone, 95-110 μ. Base sharp and scoured; planar and wavy planar laminations, ripples, and trough crossbeds (25-30 percent); top 50 cm contains well-exposed ripples.
8	Mg	Unit 8: Mainly covered. Green mudstone crops out beneath unit 8, scattered fragments of red and green mudstone on surface.
7	Sb	Unit 7: Sandstone, 80-105 μ. Base sharp, 1 m of scour; few small zones with intraclasts; sedimentary structures generally poorly exposed, probably mainly trough crossbeds or small channels; top 1.0 m has abundant ripples.
6	Mr & Mr & Se	Unit 6: Interbedded mudstone, siltstone, sandstone, and minor limestone. Mudstone is green, gray, and purple and exhibits lateral and vertical color transitions; sandstone has sharp and flat to scoured bases and is structureless, less than 125 μ; sandstone thickens and thins, tops of beds are sharp and flat, in one place scour cuts into top of sandstone bed that is filled with green mudstone; in places sandstone contains ostracodes and (or) bone fragments; siltstone beds have irregular and gradational (into mudstone) bases and tops, most siltstone beds are structureless; few thin ostracode limestone beds are wavy planar laminationed and rippled.
5	L	Unit 5: Limestone. Base sharp, 20 cm of scour, carbonate clasts (maximum size 4-5 cm diameter, most less than 2 cm) and ostracodes; grades upward into silty micrite (?); top 10 cm of unit is domal- and pillar-type algal stromatolites (?).
4	L	Unit 4: Limestone. Micrite, medium-brownish-gray to dark-gray, mainly poorly exposed, small carbonized twigs in places, few ostracodes, splits into thin plates suggesting rock is laminated.
3	L	Unit 3: Limestone. Base sharp, a few centimeters of scour; basal 70 cm is ostracode grainstone, upper contact gradational; 70-155 cm is yellow silty micrite; 155 cm to top is ooid grainstone, ooids oval due to ostracode nuclei, base of subunit sharp, in few places ooids supported by matrix of brown micrite.
2	Se	Unit 2: Mainly covered. Several thin sandstone beds crop out, greenish-gray soil suggests interval is mainly green or gray mudstone; 50-cm-thick sandstone consisting of three 15-cm-thick beds separated by thin greenish gray mudstone beds crops out beneath unit 2.
1	?	Unit 1: Sandstone. Coarsens upward, rippled.

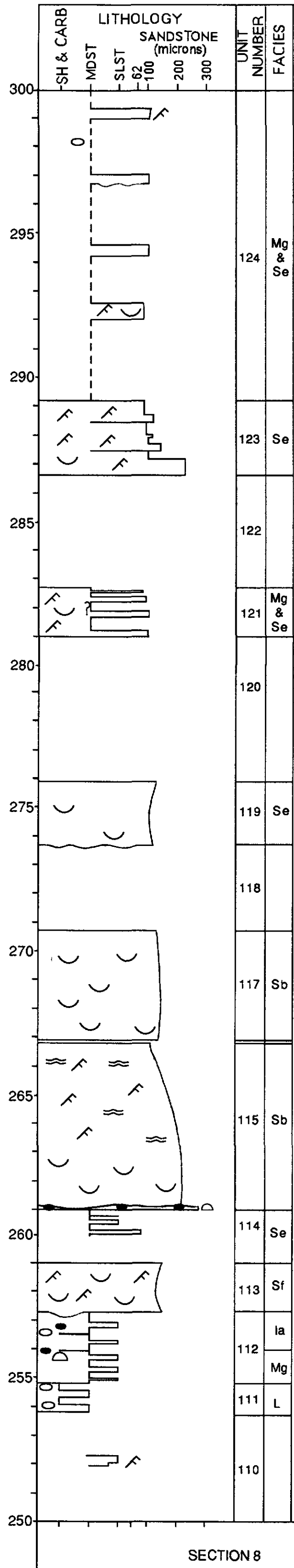
SECTION 8 INTERVAL: 0 to 50 meters


LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
Unit 47: Sandstone, 90-110 µ. Abundant well-exposed combined-flow ripples.
Unit 46: Interbedded mudstone and limestone. Basal 20 cm is greenish-gray mudstone containing ostracodes; 20-40 cm is greenish-gray mudstone; 40-80 cm is hard gray micrite (?); 80 cm to top is fissile greenish-gray siltstone or mudstone.
Unit 45: Interbedded limestone and mudstone. Base of unit sharp and slightly scours unit 43; unit consists of three beds of ostracode grainstone separated by thin (less than 5 cm) beds of greenish-gray limestone; impressions of gastropods on top surface of unit.
Unit 44: Interbedded greenish-gray mudstone and sandstone (70 µ). Sandstone beds structureless.
Unit 43: Limestone. Mainly ostracode grainstone; 8-cm-thick bed of green mudstone 20 cm above base; 5-cm-thick bed of interlaminated green mudstone and limestone 30 cm above base.
Unit 42: Covered. Minor green mudstone crops out beneath unit 43.
Unit 41: Sandstone, coarsens upward slightly (95 to 105 µ). Sharp base, 10-15 cm of scour, carbonate grains at base; basal 75 cm contains planar laminations with low-angle truncations; 75-90 cm contains wave ripples (?); 95-135 cm contains current and climbing ripples; 135-155 cm is green mudstone; 155 cm to top contains current ripples.
Unit 40: Mudstone. Lower half green and purple; upper half fissile green mudstone to shale.
Unit 39: Sandstone, 70 µ. Rippled in places.
Unit 38: Interbedded greenish-gray mudstone and siltstone. Contacts between mudstone and siltstone beds are gradational, siltstone breaks into 1.5-cm-thick plates with syneresis cracks (?).
Unit 37: Siltstone and sandstone. Medium-grained siltstone grades upward to 90-µ structureless sandstone, siltstone breaks into thin wavy plates.
Unit 36: Mainly covered. Few-centimeter-thick exposure of greenish-gray mudstone beneath unit 36.
Unit 35: Sandstone, 110-140 µ. Base sharp, scours units 33 and 32 and part of 31, basal scour irregular and contains IFC, ostracodes (as much as 50 percent of rock), and scattered twig and log impressions; sedimentary structures generally obscured by weathering, mainly trough crossbeds with ripples (?) and planar laminations (?).
Unit 34: Mudstone, greenish gray.
Unit 33: Sandstone, 70-80 µ. Transitional with unit 32, few ostracodes in transition zone.
Unit 32: Mudstone, greenish gray.
Unit 31: Limestone. Ostracode grainstone, base is sharp and irregular.
Unit 30: Mudstone. Greenish gray, sharp contacts.
Unit 29: Sandstone, siltstone, and shale. Basal 2 cm is 100-µ sandstone that grades upward through siltstone to light-gray, very fissile shale (paper shale) that contains scattered carbonized twig and leaf impressions.
Unit 28: Sandstone. Grades upward from unit 26 through brownish siltstone to brown 90-µ structureless sandstone that contains carbonaceous debris at top, upper contact sharp.
Unit 27: Mudstone, greenish gray.
Unit 26: Interbedded siltstone and sandstone. Two beds of siltstone-sandstone separated by 3-cm thick greenish-gray mudstone; lower bed is 30 cm-thick, gradational with underlying mudstone, grades upward to100-µ sandstone, upper contact sharp; upper bed is 18-cm-thick, medium-grained siltstone.
Unit 25: Mudstone, greenish gray.
Unit 24: Sandstone, 70-80 µ. Sharp base, ripples and wavy planar laminations (?).
Unit 23: Mudstone, green.
Unit 22: Sandstone, 80 µ. Base sharp and irregular, rippled.
Unit 21: Mudstone, greenish-gray.
Unit 20: Sandstone, 160 µ. Base sharp and irregular; sandstone rippled; thin greenish-gray mudstone interbeds in places.
Unit 19: Interbedded mudstone and siltstone. Mudstone is greenish gray; 7-8-cm -thick siltstone at top.
Unit 18: Sandstone, 125 µ. Rippled (?), contains carbonate grains (ooids?).
SECTION 8
INTERVAL: 50 to 100 m


LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
Unit 67: Siltstone, rippled.
Unit 66: Covered.
Unit 65: Sandstone, 125-145 µ. Base covered. Numerous irregular intervals containing IFC. Fish scales and bone fragments above base; sandstone beds are 30-50 cm thick, amalgamated in places, and separated by lenticular, thin, green mudstone interbeds; numerous internal truncations; log impressions, trough crossbeds, ripples, HCS (?), and intervals containing 10-15 percent ostracodes.
Unit 64: Mainly covered. Red mudstone under thin soil cover; 40-cm-thick bed of 70-µ rippled sandstone; top 1.0 m is green mudstone.
Unit 63: Sandstone, 100 µ. Base sharp, 20-30 cm of basal scour; rippled throughout; thins toward east where it contains several thin greenish-gray mudstone interbeds and is partially truncated by sandstone beds with lateral-accretion bedding.
Unit 62: Interbedded mudstone (40 percent) and sandstone-siltstone (60 percent). Sandstone-siltstone beds range in grain size from coarse-grained siltstone to 120-µ sandstone; maximum bed thickness 32 cm, sandstone-siltstone beds contain ripples (including climbing ripples), wavy planar laminations, and some are structureless, sharp and flat bases and tops ; mudstone is greenish gray.
Unit 61: Limestone and mudstone. Mainly ostracode grainstone that grades upward to green mudstone containing abundant ostracodes and ooids and some bone fragments, and that grades downward to silty micrite (?) containing abundant ostracodes and ooids in places.
Unit 60: Mudstone, greenish gray.
Unit 59: Sandstone, 130 µ. Rippled (?).
Unit 58: Mainly covered. Several thin (less than 40 cm) beds of siltstone; green and red soil suggests unit is mainly green and red mudstone.
Unit 57: Sandstone, 80-90 µ. Several thin green mudstone interbeds. At base of unit sandstone beds dip 13° N. 60° E. suggesting lateral-accretion bedding; planar and wavy planar laminations and ripples (wave or combined flow).
Unit 56: Covered. Greenish-gray soil and fragments of greenish-gray and minor red mudstone suggest unit consists of greenish gray mudstone and subordinate red mudstone
Unit 55: Sandstone, 60-70 µ. Rippled, greenish.
Unit 54: Interbedded greenish-gray mudstone and siltstone.
Unit 53: Sandstone, generally 90-100 µ, some zones 150 µ. Base irregular; thin lenticular beds of green mudstone and IFC at and above base; abundant ostracodes; the 90-100-µ sandstone is rippled and 150-µ sandstone is trough crossbeded.
Unit 52: Interbedded sandstone (62-90 µ) and lesser siltstone, green mudstone, and ooid limestone. Sandstone beds thicken and thin laterally; sandstone rippled and structureless; sandstone contains small channels in places.
Unit 51: Limestone. Ostracode grainstone, contact with unit 50 gradational from greenish-gray mudstone through yellowish ostracode-rich mudstone to ostracode grainstone. In places unit 51 and overlying units are truncated by channels filled with greenish-gray mudstone and sandstone.
Unit 50: Mudstone, greenish-gray.
Unit 49: Sandstone, 100 µ. Base sharp and flat; rippled; near top is a scour filled with greenish-gray mudstone; in places unit contains faint dipping laminations.
Unit 48: Interbedded mudstone and sandstone-siltstone. Greenish-gray mudstone contains several thin sandstone and siltstone beds.
SECTION 8
INTERVAL: 100 to 150 m


LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
200
195
190
185
180
175
170
165
160
155
150
86 Sb
85 Mg & Se
Unit 85: Greenish-gray mudstone and lesser siltstone and sandstone. Sandstone and siltstone are rippled.
84
Unit 84: Covered. Probably greenish-gray mudstone.
83 Se & Mg
Unit 83: Interbedded sandstone (very fine grained) (80 percent) and mudstone (20 percent). Sandstone is rippled, bed thickness is 40-50 cm; mudstone is greenish gray.
82 Sb
Unit 82: Sandstone, mainly 130-175 µ, some 95 µ. Base sharp and slightly scoured; planar laminations and trough crossbeds in most of unit; top of unit consists of rippled 95-µ sandstone.
81 Mg Mr Mg
Unit 81: Mudstone. Mainly greenish gray, poorly exposed; top 2.0 m consists of purple mudstone that grades upward to gray mudstone that grades upward to greenish-gray mudstone.
80 L
Unit 80: Limestone. Silty micrite (?) containing sparse to abundant ostracodes.
79
Unit 79: Covered.
78 Sb
Unit 78: Sandstone (100-135 µ) and minor mudstone. Complex sandbody, general characteristics: (1) upper two-thirds fines upward overall, probably contains multiple smaller scale fining upward sequences, (2) lower one-third consists of thick (greater than 75 cm) sandstone beds separated by lenticular greenish-gray mudstone, whereas upper two-thirds consists of multiple lenticular amalgamated sandstone beds, (3) lateral-accretion bedding, (4) multiple channel-like scours within unit, scours commonly have basal lag overlain by 5-30 cm of green mudstone overlain, in turn, by sandstone, (5) some planar laminations and trough crossbeds, altogether sedimentary structures are generally not well exposed.
77 Se
76
74 L
73
70
68 Mg & Se
Unit 77: Mudstone, greenish-gray.
Unit 76: Limestone. Olive-gray micrite (?) containing minor ostracodes (?).
Unit 75: Siltstone.
Unit 74: Covered.
Unit 73: Limestone and mudstone. Silty micrite (?) and one 15-cm-thick bed of greenish-gray mudstone.
Unit 72: Siltstone. Gradational base, few percent ostracodes and (or) ooids, 5-cm-thick green mudstone bed at top.
Unit 71: Sandstone. Base sharp and slightly irregular.
Unit 70: Mudstone, greenish-gray.
Unit 69: Sandstone. Base irregular, unit rippled (?).
Unit 68: Mudstone and siltstone, greenish-gray, poorly exposed.
SECTION 8
INTERVAL: 150 to 200 m


LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
250
245
240
235
230
225
220
215
210
205
200
109 Se
108 Mg
107
106 Se
105 Sf
104
103 L
102 Se
101 L
100 Se
99 Mg & Se
98 Sb
97 Mg & Se
96 Mg
95 Se
94 L
93
92
91 Mg & Se
90 L Se Mg
89
88 Sb
87
86 Sb
Unit 106: Sandstone, 70-130 µ (varies from bed to bed). Forms series of sandstone ledges and soil-covered slopes (underlain by mudstone?), bed thickness less than 10 cm.
Unit 105: Sandstone, coarsens upward (70 to 85 µ). Base sharp, planar laminations at base, ripples near top.
Unit 104: Mainly covered. One 30-cm-thick bed of dark-gray limestone (?) containing ostracodes and tiny fossil (?) fragments; a 25-cm-thick bed of medium-greenish-gray, fissile, calcareous shale containing one thin calcareous siltstone bed outcrops beneath unit 105.
Unit 103: Interbedded limestone, mudstone, and siltstone. Basal 22 cm is domal algal stromatolite, domes about 50 cm wide; 22-34 cm above base is greenish-gray mudstone and siltstone; 34-46 cm is algally laminated limestone; 46 cm to top is ostracode grainstone.
Unit 102: Siltstone. Contains ostracodes, poorly exposed.
Unit 101: Limestone. Ostracode grainstone; lower half consists of discrete 20-30-cm-thick beds of ostracode grainstone; upper half is one thick bed of ostracode grainstone; in few places limestone is rippled or contains trough crossbeds (?), but most is structureless.
Unit 100: Sandstone, siltstone, mudstone, and limestone. Basal 1.1 m is mainly sandstone and few thin (less than 10 cm) greenish-gray mudstone interbeds, rippled (?), ostracodes in upper part; upper 1.2 m of unit consists of interbedded-interlaminated ostracode grainstone and lesser greenish-gray mudstone and siltstone, bed thickness few millimeters to 20 cm.
Unit 99: Interbedded mudstone and siltstone. Pooly exposed; mudstone is green.
Unit 98: Sandstone, fines upward (140 to 110 µ). Base is sharp and scoured, in places base of unit contains IFC (clast-supported in places) composed of carbonate, siltstone, and mudstone clasts, maximum clast size 3 cm, base also contains ooids and (or) ostracodes, and scattered bone fragments; thin greenish-gray mudstone interbeds in places; weakly tar saturated; lower half contains ripples and trough crossbeds, upper half trough crossbeded.
Unit 97: Interbedded sandstone, siltstone, and mudstone. Contacts between rock types gradational; mudstone is green.
Unit 96: Mudstone. Greenish gray, silty, amount of silt increases upward.
Unit 95: Siltstone. Lower two-thirds is poorly exposed, upper third is rippled.
Unit 94: Limestone. Yellow ostracode grainstone, sharp base; unit thins toward east and thickens toward west.
Unit 93: Mudstone and siltstone. Greenish-gray mudstone grades upward to siltstone.
Unit 92: Sandstone, 70 µ. Rippled.
Unit 91: Interbedded sandstone-siltstone (50 percent) and mudstone (50 percent). Mean bed thickness 20 cm; most sandstone beds are structureless, one 100-µ sandstone contains ripples; mudstone is greenish gray; contacts between beds are generally sharp
Unit 90: Mudstone, siltstone, and limestone. Basal greenish-gray mudstone grades upward to very coarse grained siltstone through silty ostracode limestone to silty micrite (?).
Unit 89: Covered.
Unit 88: Sandstone, 80-100 µ. Well-exposed current ripples in basal 1.0 m; upper 3.8 m is structureless; unit forms a series of sandstone ledges and soil-covered slopes (underlain by mudstone?).
Unit 87: Covered.
Unit 86: Sandstone, 90-140 µ. Base sharp, 50 cm of basal scour, basal 50 cm contains scattered mudstone intraclasts, bone fragments, and fish scales; lenticular zones of mudstone clasts above base, internal scours, one zone contains abundant wood impressions; basal 2.9 m consists of 110-140-µ sandstone containing ripples and trough crossbeds; top 1.5 m consists of rippled 90-µ sandstone.
SECTION 8
INTERVAL: 200 to 250 m



DESCRIPTION

Unit 124: Interbedded mudstone and siltstone (70-80 percent) and sandstone (20-30 percent). Thin (less than 1.0 m thick) sandstone beds are separated by covered intervals (greenish-gray mudstone?) and minor outcrops of greenish-gray mudstone and siltstone (some contains ostracodes); sandstone is 80-120 µ, slightly scoured bases, most is structureless, some ripples and few trough crossbeds, bed thickness sandstone 0.2-1.0 m

Unit 123: Sandstone, most is 100-150 µ, basal bed 220 µ. Base sharp and flat; in places sandstone beds separated by greenish-gray mudstone; bed thickness 10-60 cm; ripples and a few trough crossbeds.

Unit 122: Mainly covered, Scattered outcrops of silty micrite (?).

Unit 121: Interbedded 90-125-µ sandstone (70 percent) and mudstone (30 percent). Mudstone is green and is present as thin discontinuous interbeds in sandstone and as one 50-cm-thick bed 20-75 cm above base of unit; sandstone has ripples and trough crossbeds (?).

Unit 120: Mainly covered.

GENERAL NOTE: The interval from unit 107 to the top of the measured section consists of a series of lenticular sandbodies separated by greenish-gray mudstone and subordinate limestone. The sandstone bodies are as much as 100 m wide and 3 m thick and exhibit ripples and trough crossbeds. In places, lenticular sandstones truncate other sandstones (that is, are stacked and in places amalgamated).

Unit 119: Sandstone, 100–125 µ. Base sharp and slightly scoured, ripples and minor trough crossbeds, sandstone beds are amalgamated (?).

Unit 118: Mainly covered. Thin bed of silty micrite (?) in center; greenish-gray mudstone containing few-centimeter-thick tuff (?) crops out beneath unit 119.

Unit 117: Sandstone, 125-135 µ. Base covered, trough crossbeds.

Unit 116: Covered. Probably greenish-gray mudstone.

Unit 115: Sandstone, 110-275 µ. Basal 10-30 cm consists of 275-µ sandstone containing laminated yellow mudstone clasts 5-6 cm long and fish scales overlain by 220-µ sandstone that scours into basal bed; upper 5.5 m fines upward (275 to 110 µ), trough crossbeds in lower third and ripples and wavy planar laminations in upper two-thirds; sandstone is tar saturated.

Unit 114: Interbedded mudstone, siltstone, and sandstone. Lower half of unit covered; mudstone is green.

Unit 113: Sandstone,125-150 µ. Base sharp and flat in places, elsewhere has 30-40 cm of scour; trough crossbeds and ripples, unit thickens west, tar saturated.

Unit 112: Interbedded mudstone, siltstone and limestone. Lower half of unit is interbedded greenish-gray mudstone and light-gray siltstone; upper half is interbedded-interlaminated light-brown mudstone, siltstone, and thin (less than 5 cm) carbonate beds consisting of carbonate intraclasts, ooids (?), ostracodes, and fish scales; contacts between beds sharp to gradational.

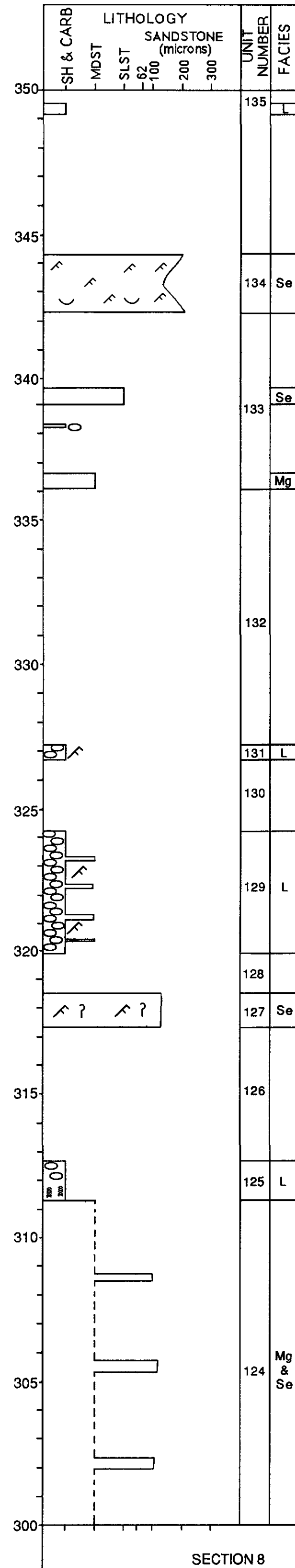
Unit 111: Interbedded greenish-gray mudstone and limestone. Basal 30 cm is green mudstone containing minor ostracodes; 30-50 cm is ostracode limestone; 50-80 cm is green mudstone; 80 cm to top is ostracode limestone, base is matrix supported, top is grain supported; top 3-4 cm is brownish gray micrite (?).

Unit 109: Interbedded sandstone and limestone. Basal 50 cm is 130-µ sandstone containing 5-10 percent yellow carbonate grains, structureless; 50-55 cm is yellow, sandy (?) ostracode and ooid (?) limestone; 55-80 cm is sandstone, basal 5 cm is160-µ sandstone containing 10-15 percent ostracodes, lesser IFC clasts, and one bone fragment, most of bed is 100-µ poorly sorted sandstone containing 10 percent yellow carbonate grains, weakly tar stained, soft-sediment deformation (?) in basal 20 cm of bed; 80-100 cm above base is siltstone containing carbonaceous debris; 100 cm to top is sandstone, basal bed fines upward, rest of unit is 100 µ, rippled in places.

Unit 108: Mainly covered. Some green mudstone in places.

Unit 107: Sandstone, 150 µ. Sharp base, yellow carbonate grains (altered ostracodes?) near base; upper half of unit is tar saturated; sedimentary structures indistinct, probably mostly ripples.

SECTION 8 INTERVAL: 250 to 300 m



DESCRIPTION

Unit 135: Mainly covered. One outcrop of silty micrite (?); greenish gray mudstone and light-gray calcareous siltstone crop out beneath unit 136.

Unit 134: Sandstone, 135-210 µ. Base covered, abundant ripples throughout unit, few trough crossbeds near base.

Unit 133: Mainly covered. Some outcrops of greenish-gray mudstone, one 10-cm-thick bed of ostracode limestone, and one 50-cm-thick outcrop of laminated light-gray siltstone 2.5 cm above base.

Unit 132: Covered. Greenish soil cover and fragments of greenish-gray mudstone suggest unit consists mainly of green mudstone.

Unit 131: Limestone. Ostracode grainstone, beds 2-8 cm thick, beds thicken and thin, rippled.

Unit 130: Mainly covered. Outcrops of greenish-gray mudstone.

Unit 129: Limestone (80 percent) and mudstone (20 percent). Consists of interbedded ostracode grainstone and greenish-gray mudstone, ostracode grainstone is rippled in fow places.

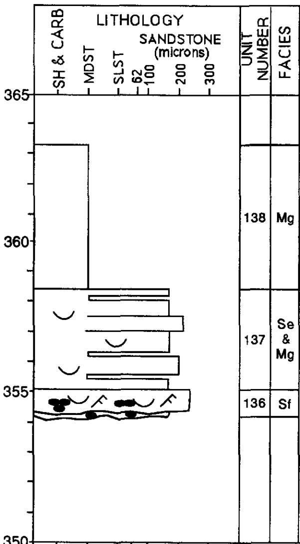
Unit 128: Covered.

Unit 127: Sandstone, 130 µ. Base not exposed, rippled (?).

Unit 126: Mainly covered. Few thin outcrops of silty limestone or calcareous mudstone, some contain ostracodes.

Unit 125: Limestone. Lower two-thirds consists of pillar-type stromatolites; upper third is hard, light-gray to yellow micrite containing ostracodes.

SECTION 8 INTERVAL: 300 to 350 m



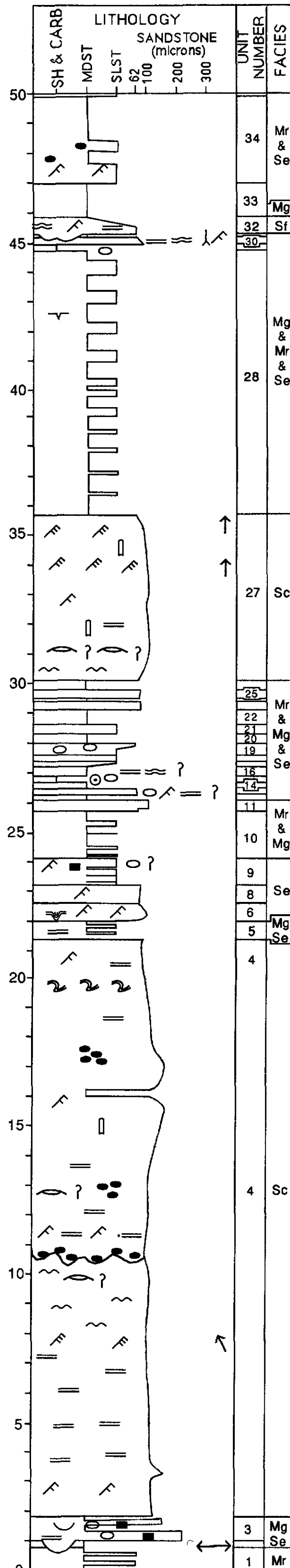
DESCRIPTION

Unit 138: Mudstone, greenish-gray.

Unit 137: Sandstone (175–220 µ) and minor mudstone. Bed thickness of sandstones 0.1-1.5 m, trough crossbeds common but much of unit is structureless; mudstone is greenish gray and is present as thin interbeds within sandstone. 10-15 m east of measured section, units 136 and 137 form continuous sandstone containing only a few thin greenish gray-mudstone interbeds.

Unit 136: Sandstone, most 230-250 µ, 175 µ at base. Base sharp, 10-15 cm of basal scour, in places has basal lag of yellow calcareous mudstone or limestone in matrix of 175-µ sand, basal lag deposits truncated by overlying sandstone beds; scattered zones above base contain IFC; sandstone is trough crossbeded and rippled.

SECTION 8 INTERVAL: 350 to 363.3 m



DESCRIPTION

Unit 20: Mudstone, greenish gray.

Unit 19: Siltstone and sandstone. Base gradational with underlying siltstone; top 10 cm of unit is very fine grained sandstone containing 10 percent ostracodes, in places top 10 cm of unit is ostracode and ooid (?) grainstone containing some bone fragments, fish scales, and teeth.

Unit 18: Siltstone, very coarse grained. Light gray.

Unit 17: Mudstone and siltstone. Greenish-gray mudstone grades upward to coarse-grained siltstone; base irregular; planar (?) and (or) wavy planar laminations (?).

Unit 16: Mudstone. Greenish gray, concretions in places.

Unit 15: Limestone. Consists of grain-supported ostracodes and ooids (?) and 40 percent 100-µ sand, top and base sharp and flat.

Unit 14: Mudstone, greenish-gray.

Unit 13: Sandstone, 70-80 µ. Contains ostracodes and ooids that are disseminated, occur in discrete laminae and in thin silty limestone beds, upward increase in proportion of ostracodes and ooids; top few cm of unit is silty ostracode and ooid grainstone that has planar laminations (?) and ripples (?), most of unit obscured by desert varnish.

Unit 12: Mudstone, greenish-gray.

Unit 11: Sandstone, 70-115 µ. Unit consists of 12-cm-thick bed of 70-µ structureless sandstone overlain by 28-cm-thick bed of 115-µ structureless sandstone; in places beds separated by green mudstone.

Unit 10: Interbedded mudstone and siltstone. Basal 50 cm is interbedded red and greenish-gray mudstone and siltstone, mudstone-siltstone contacts are gradational; top 1.1 m is grayish-red and subordinate greenish-gray mudstone, both color types mottled.

Unit 9: Interbedded siltstone and mudstone. Mainly light-greenish coarse grained siltstone containing light-colored mudstone interbeds, siltstone-mudstone contacts gradational; most is structureless; top 10 cm consists of rippled very coarse grained siltstone that contains minor carbonaceous debris and ostracodes an (or) ooids (?).

Unit 8: Sandstone, 65-80 µ. Greenish-gray mudstone near base in places, some ripples but most of sandstone is structureless.

Unit 7: Mudstone, greenish gray.

Unit 6: Sandstone, 100-200 µ. Base gradational, sandstone contains ripples and backfilled burrows, top sharp and flat; unit has lenticular geometry.

Unit 5: Interbedded mudstone and siltstone. Basal 20 cm covered; mudstone is greenish gray and red; siltstone is laminated and very coarse grained in places; contacts between mudstone and siltstone beds gradational.

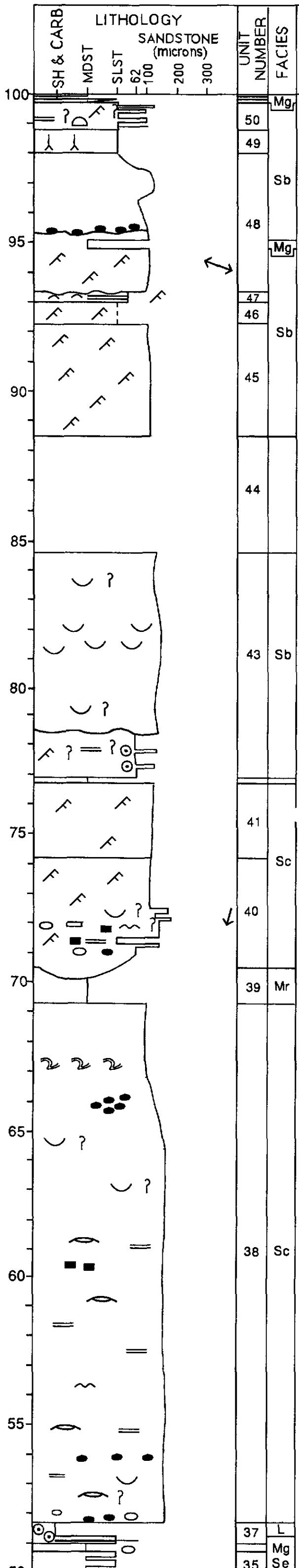
Unit 4: Sandstone. Base sharp and slightly irregular; unit divided into two subunits: (1) basal 8.7 m is 70 µ at base, 110-150 µ above base, basal 2.0 m is mainly structureless with some ripples, overlain by 3.5 m of planar laminations, overlain by 70 cm of current ripples, overlain by 2.5 m of wave ripples and HCS (?); (2) 8.7 m to top, base of subunit is a scoured surface having 40-50 cm of relief and a basal lag of clasts of greenish-gray mud- stone as wide as 40 cm and smaller siltstone and sandstone clasts in matrix of 110-120-µ sand, and trough-shaped lenses of greenish gray mudstone, above base of subunit 2 is 90-160-µ sandstone has several lenticular and commonly scoured beds of greenish-gray mudstone, few zones of small sandstone, siltstone, and mudstone clasts, HCS (?), planar laminations, and ripples, soft-sediment deformation 2 m below top.

Unit 3: Interbedded limestone, mudstone, siltstone, and sandstone. Basal 25 cm is 225-µ sandstone, grades upward to siltstone, scours units 1 and 2 in places, laminated, minor carbonaceous debris, contains lenticular 2-15-mm-thick lenses of ostracodes, few meters to south entire subunit consists of ostracode grainstone containing carbonaceous debris; 25-50 cm above base is green mudstone, base gradational with underlying siltstone; 50-90 cm is 125-µ sandstone, 20 percent ostracodes, scattered carbonaceous debris and few intervals containing abundant carbonized plant fragments and bone fragments, 50 percent troughs and 50 percent structureless, truncates underlying green mudstone; 90 cm to top is greenish-gray mudstone.

Unit 2: Mudstone. Red and green, basal tool marks oriented east-west.

Unit 1: Interbedded sandstone (90 µ) and mudstone. Base of unit indistinct; mudstone is green and red, structureless; sandstone is structureless; contacts between beds are indistinct.

SECTION 9 INTERVAL: 0 to 50 m



DESCRIPTION

Unit 39: Mudstone, red.

Unit 38: Sandstone, 85-160 µ. Base sharp and generally flat and contains scattered intraclasts (including one 40 cm long) and some ostracodes; lower two-thirds of unit is 160 µ, upper third of unit fines upward from 100 to 85 µ; above base are several lenticular zones of small (under 4 cm) sandstone, siltstone, and mudstone clasts, lower half of unit has several scour surfaces with intraclasts; lower 10 m contains abundant well-exposed planar laminations (some with laminae that dip generally northeast), HCS (?) (in placed disturbed by soft sediment deformation), and minor trough crossbeds, in places plant debris is concentrated along bedding planes; in upper 7.6 m sedimentary structures are poorly exposed, perhaps channels or troughs, lateral-accretion bedding dips to northeast, and one 1.5-m-thick interval has abundant soft-sediment deformation.

Unit 37: Interbedded limestone, siltstone, mudstone, and sandstone. Basal 5 cm is dark-brown, carbonaceous, calcareous siltstone (?); 5-8 cm above base is limestone containing coated ostracodes (?); 8-12 cm is very fine grained sandstone; 12-25 cm is calcareous gray siltstone or mudstone; 25-28 cm is limestone (?) containing small (less than 2 cm) shell fragments (?); 28-39 cm is limestone or calcareous siltstone; 39-57 cm is laminated dolostone (?); 57 cm to top is medium-gray mudstone.

Unit 36: Mudstone. Greenish gray, 2-10 percent ostracodes.

Unit 35: Interbedded mudstone and siltstone (coarse grained). Siltstone is light gray and calcareous; mudstone is very silty, and is present as two beds (10 and 15 cm thick) in the siltstone.

Unit 34: Siltstone and mudstone. Basal 75 cm is siltstone, sedimentary structures indistinct except for ripples near top; 75-125 cm above base red mudstone contains small mudstone clasts and one thin siltstone bed; 125-150 cm is light-greenish-gray siltstone; 150 cm to top is reddish-purple and purple mudstone.

Unit 33: Mudstone. Colors (base to top): greenish gray, red with light-green interbeds and mottling, grayish red, purple with green mottles; contacts between different colors irregular and gradational.

Unit 32: Sandstone, 65-70 µ. Base sharp and has 30 cm of scour; planar and wavy planar laminations (?) and ripples (?), top grades upward to overlying mudstone.

Unit 31: Mudstone. Greenish gray overlain by red.

Unit 30: Sandstone, fines upward (95 to 65 µ). Base has 10 cm of scour; planar laminations, wavy planar laminations, ripples, and scattered root traces; top gradational with overlying mudstone.

Unit 29: Limestone. Light gray, hard, contains mud- to grain-supported ostracodes, base transitional with underlying green mudstone, top sharp and scoured by overlying sandstone.

Unit 28: Interbedded sandstone-siltstone (50 percent), red mudstone (30 percent), and greenish-gray mudstone (20 percent). Basal 3.3 m is mainly green mudstone; 3.3-8.7 is red mudstone containing green mottles, and subordinate green mudstone containing abundant rippled sandstone and siltstone; thicker (40-70 cm) sandstone and siltstone beds have sharp flat bases and tops and are laterally continuous; top 30 cm of unit is greenish-gray mudstone.

Unit 27: Sandstone, 70-115 µ. Base sharp and flat, vertical burrows in places; basal 0.3 m is structureless; 0.3-0.7 m contains 30 cm of wave ripples overlain by 10 cm of HCS (?); 0.7-4.0 m contains faint ripples and planar laminations but most covered by desert varnish; 4.0-4.3 m current ripples; 4.3-4.8 is structureless; 4.8 m to top current ripples.

Unit 26: Mudstone. Basal 25 cm red; top 5 cm green.

Unit 25: Sandstone, 70-80 µ. Base and top sharp and flat, rippled (?)

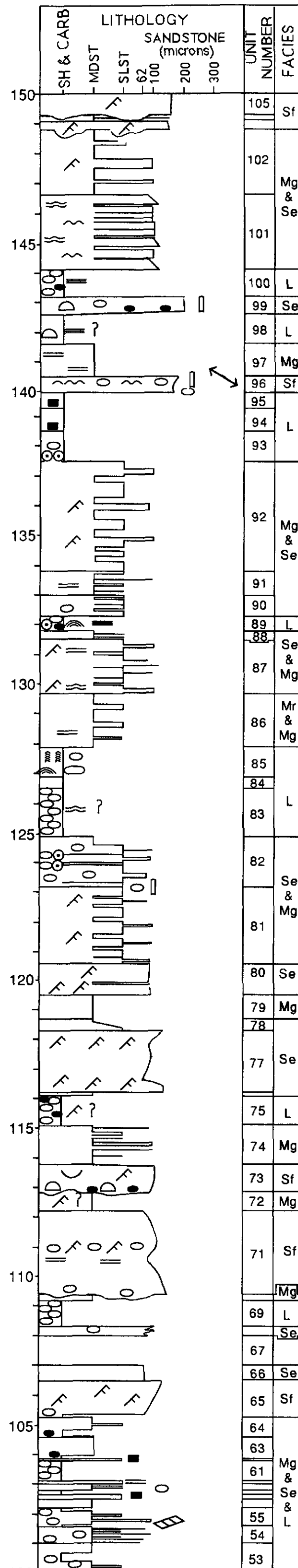
Unit 24: Mudstone. Consists of 1-cm-thick bed of greenish-gray mudstone overlain by 9-cm-thick bed of red mudstone, laminated (?).

Unit 23: Sandstone, 70-80 µ. Sharp and flat base and top.

Unit 22: Mudstone. Red and lesser green, mottles of greenish-gray mudstone in the red mudstone.

Unit 21: Siltstone (very coarse grained) and sandstone (100 µ). Sharp base and top, grades upward from siltstone to sandstone, sedimentary structures obscured by weathering.

SECTION 9 INTERVAL: 50 to 100 m



DESCRIPTION

Unit 61: Limestone. Ostracode grainstone, few bone fragments.

Unit 60: Siltstone.

Unit 59: Mudstone and siltstone. Laminated.

Unit 58: Limestone. Ostracode grainstone, sharp base and top.

Unit 57: Siltstone. Plant debris on bedding planes.

Unit 56: Mudstone. Light olive gray, moderately calcareous, slightly silty.

Unit 55: Interbedded mudstone, siltstone, sandstone, and limestone. Basal 10 cm and upper 9-13 cm are ostracode grainstone; middle of unit is thinly interbedded mudstone, siltstone, and sandstone that contains climbing ripples and ostracodes.

Unit 54: Interbedded sandstone (62-125 µ), mudstone, and siltstone. Bed thickness 4-8 cm, beds have sharp bases and tops; sandstone contains as much as 20 percent ostracodes (?) in places.

Unit 53: Interbedded limestone, mudstone, and siltstone. Basal 35 cm is thinly interbedded fine-grained mudstone, medium-grained siltstone with ostracodes, and ostracode grainstone; 35-75 cm above base is limestone containing ostracodes; top 35 cm is light-greenish-gray mudstone, faintly to moderately laminated, slightly calcareous, slightly silty.

Unit 52: Dolostone. Sharp and flat base and top, laminated (laminations somewhat wavy and disturbed), olive gray.

Unit 51: Mudstone and siltstone. Very pale orange, slightly calcareous siltstone grades upward to light-greenish-gray; moderately calcareous, siltier mudstone that grades upward to yellowish-orange, very calcareous, silty mudstone or siltstone.

Unit 50: Sandstone (62-130 µ) and siltstone (very coarse grained). Slightly to very calcareous, scattered fish scales in center, planar laminations (?) and ripples (?).

Unit 49: Siltstone-very coarse grained mudstone. Base gradational, very silty, structureless, slightly calcareous, tiny (1 mm by few mm) irregular tubes (rootlets ?); top gradational over few centimetrs.

Unit 48: Sandstone, 70-120 µ. Base sharp and slightly irregular; 30-cm-thick bed of greenish-gray mudstone about 1.4 m above base; scour surface that has IFC 1.8 m above base; top 50 cm of unit is gradational to overlying greenish-gray mudstone; basal 1.8 m contains well-exposed ripples and in upper 2.8 m sedimentary structures obscured by desert varnish.

Unit 47: Siltstone-sandstone and mudstone. Unit consists of rippled very coarse grained siltstone and (or) very fine grained sandstone containing greenish gray mudstone flasers and several thin (less than 5 cm) greenish-gray mudstone beds

Unit 46: Siltstone, very coarse grained. Rippled.

Unit 45: Sandstone, 110 µ. Rippled.

Unit 44: Covered.

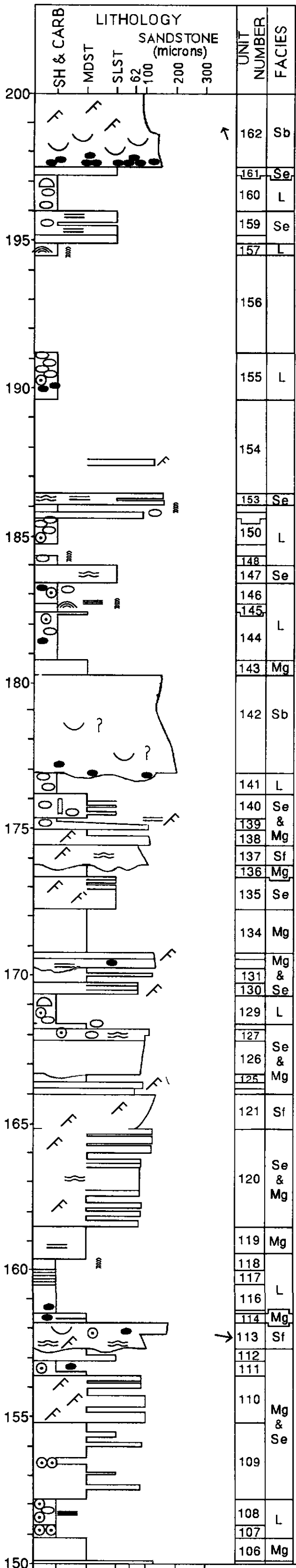
Unit 43: Sandstone, 60-150 µ. Basal 1.6 m 60-70 µ, poorly exposed wavy planar laminations (?) and ripples (?) and a few thin (1-2 cm) beds of 125 µ sandstone that contains abundant ooids; 1.6 m to top is 125-150-µ sandstone with scoured base, generally poorly exposed trough crossbeds and structureless zones, and one 1.0-m-thick zone that has well-exposed trough crossbeds.

Unit 42: Mudstone, greenish gray.

Unit 41: Covered along measured section Few meters north this interval is continuation of unit 40F (rippled very fine grained sandstone).

Unit 40: Sandstone and siltstone. Unit scours interval of interbedded sandstone and red and green mudstone. Divided into six subunits: (A) basal 65 cm coarsens up from red mudstone through green mudstone to siltstone to structureless very fine grained sandstone; (B) 65-75 cm above base consists of 130-140-µ sandstone containing ostracodes and small (less than 3 cm) siltstone and mudstone clasts, base of subunit has minor relief; (C) 75-100 cm is mainly medium to coarse grained laminated and rippled siltstone containing one bed of sandstone and thinner sandstone laminae, abundant carbonized plant debris (leaves, twigs, stems, and logs) in upper half; (D) 100-160 cm is rippled 130-140-µ sandstone containing scattered carbonaceous debris and concentrations of carbonaceous debris and mica along bedding planes, horizontal tubelike burrows on few bedding planes, has wave (?) ripples and 0-10 percent ostracodes; (E) 160-195 cm is ostracode-rich sandstone, tabular-tangential and (or) trough crossbeds, 130-180 µ (grain size varies from bed to bed); (F) 195 cm to top is rippled 110-µ sandstone.

SECTION 9 INTERVAL: 100 to 150 m



DESCRIPTION

Unit 85: Limestone. Algally laminated, basal 40 cm consists of large (100 cm wide by 30-40 cm high) domal stromatolites; ostracodes, oncolites, and tube-type stromatolites are present between the domes; upper 60 cm consists of tube-type stromatolites, tubes concentrically laminated, 2-5 mm wide by 1-2 cm long, in places ostracodes are present between tubes, in places tubes are horizontal and parallel and in other places have no preferred orientation, top of limestone is sharp and irregular

Unit 84: Limestone. Micrite (?), base gradational over 3-5 cm, very light gray, fine-grained.

Unit 83: Limestone. Ostracode grainstone, ripples and wavy planar laminations (?) in places; 3-cm-thick zone of small (less than 1.5 cm) intraclasts 60 cm above base.

Unit 82: Interbedded and interlaminated limestone, siltstone, sandstone, and mudstone. Basal 20 cm is light-greenish-gray siltstone containing ostracodes and vertical burrows 4-10 mm in diameter and 2-8 cm long; 20-115 cm is interlaminated to thinly interbedded rippled siltstone, sandstone, and ostracode and ooid grainstone, most sandstone and siltstone beds have ostracodes and (or) ooids; 115 cm to top is poorly exposed green mudstone

Unit 81: Interbedded green mudstone (40 percent) and very fine grained sandstone-siltstone (60 percent). Most contacts gradational, sandstone rippled in places.

Unit 80: Sandstone, 70-95 µ. Rippled in places, one thin bed of green mudstone near center.

Unit 79: Mudstone. Light olive, middle 35 cm is mottled light olive gray and purple.

Unit 78: Siltstone and green mudstone. Siltstone at base grades upward to green mudstone.

Unit 77: Sandstone, 62-130 µ. Base sharp and flat, unit structureless except for ripples in basal 50 cm and 1.85-2.15 cm above base.

Unit 76: Mudstone. Green, base sharp or gradational over few centimeters.

Unit 75: Limestone. Composed of ostracodes and 15-20 percent carbonate intraclasts (as long as 3 cm) composed of very fine grained, partly laminated limestone, clasts are mainly 20-60 cm above base, few bone fragments; 95 percent structureless and 5 percent rippled (?).

Unit 74: Interbedded olive-gray mudstone, siltstone, and sandstone. Contacts between rock types gradational, bed thickness 7-30 cm, all rocks structureless.

Unit 73: Sandstone, coarsens upward slightly (90 to 110 µ). Base sharp and slightly irregular, has a 5-7-cm-thick lag consisting of fish scales and small (less than 1 cm) yellow, noncalcareous mudstone clasts; sandstone contains well-exposed ripples and trough crossbeds; top 5-10 cm of unit grades upward to greenish-gray mudstone.

Unit 72. Mudstone. Greenish gray, moderately silty, moderately calcareous, siltier and more rippled (?) toward top.

Unit 71: Sandstone, two fining-upward sequences (145 to 85 µ and 125 to 70 µ). Base sharp and truncates unit 70, sparse ostracodes near base, base of second fining-upward sequnce contains 20 percent yellow limestone grains; most of unit is structureless, planar laminations overlain by ripples 1.2-1.5 m above base.

Unit 70: Mudstone, greenish-gray.

Unit 69: Limestone. Ostracode grainstone, yellow, top and base sharp and relatively flat. Unit forms yellow band visible toward the north and east.

Unit 68: Sandstone, 70-105 µ. Top and base are sharp, sparse ostracodes and ostracode limestone clasts near top.

Unit 67: Sandstone, 70 µ. Sharp base and top, top is irregular, structureless.

Unit 66: Interbedded sandstone (70-110 µ) and mudstone. Consists of several structureless sandstone beds separated by 5-8-cm-thick beds of greenish-gray mudstone.

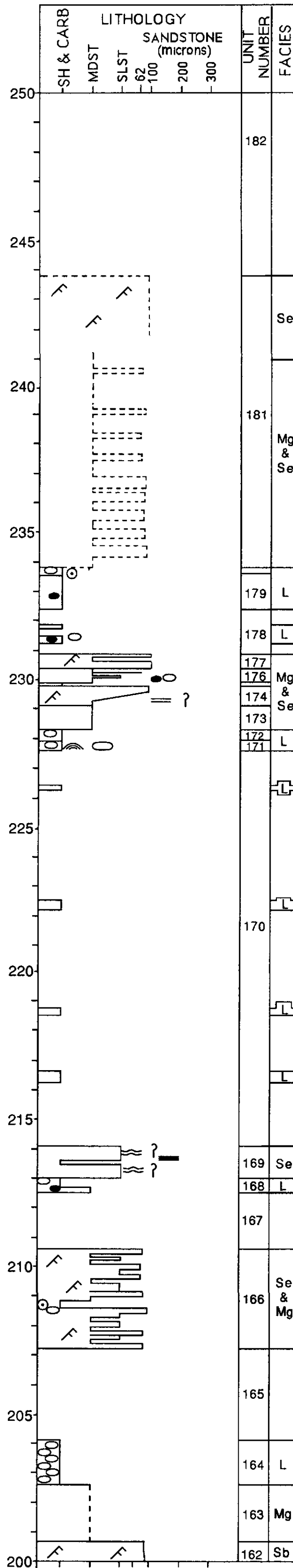
Unit 65: Limestone and sandstone (65-125 µ). Basal 6 cm is ostracode grainstone; upper 120 cm is rippled sandstone.

Unit 64: Mudstone, limestone, and siltstone. Basal medium-brownish gray, calcareous mudstone grades upward to intraclast limestone that grades upward to a 40-cm-thick bed of olive-gray mudstone containing a 10-cm-thick siltstone bed.

Unit 63: Mudstone and limestone. Mainly very pale orange, calcareous mudstone; basal 7-8 cm is limestone consisting of small (4-5 mm maximum diameter) calcareous plates (algal?) and round carbonate grains.

Unit 62. Siltstone, medium-grained. Medium gray, laminated, fine-grained carbonaceous debris.

SECTION 9 INTERVAL: 150 to 200 m



DESCRIPTION

Unit 106: Mudstone, green.

Unit 105: Sandstone, fines upward (160 to 125 µ). Base is sharp and truncates unit 104 in places, rippled in places; top 10 cm grades upward to green mudstone.

Unit 104: Mudstone. Green, base and top sharp, with intervals of abundant 150-175-µ sand.

Unit 103: Sandstone, 150 µ. Base sharp, scours as much as 60 cm of unit 102; entire unit rippled.

Unit 102: Interbedded mudstone (70 percent) and sandstone-siltstone (30 percent). Most sandstone-siltstone beds are less than 15 cm thick; 1 m below top is a 25-cm-thick bed of rippled 100-µ sandstone; mudstone is green.

Unit 101: Interbedded 80-125-µ sandstone (80-90 percent) and mudstone (10-20 percent). Mudstone is green and thin bedded; sandstone beds are as thick as 30 cm thick and contain well-exposed wave ripples and wavy planar laminations.

Unit 100: Limestone. Composed of ostracodes, limestone intraclasts, and 10-20 percent sand (100-150 µ); base gradational, near base is in-place and ripped-up algally laminated limestone; 10-20 cm below top rock breaks into thin (1 cm) plates that have abundant carbonaceous debris along bedding planes; top 10 cm is algally laminated limestone (subhorizontal and tube type).

Unit 99: Sandstone, 200-220 µ. Base gradational, 5-10-cm-thick basal interval of bone fragments, fish teeth, and limestone clasts as long as 8 cm; ostracodes near top; several vertical to oblique 8-cm-long burrows filled with limestone.

Unit 98: Limestone. Micrite (?), light- to medium-gray, fine-grained, base gradational (?), scattered fish scales, one algally (?) laminated zone, weathers yellow to orange yellow.

Unit 97: Mudstone. Green, laminated in places, 12-cm-thick zone in center is medium gray and calcareous.

Unit 96: Sandstone, 165-180 µ. Base is sharp and flat; basal 35 cm contains 5-10 percent ostracodes and is structureless; upper 35 cm wave rippled; contains green mudstone flasers (especially in lower 10 cm) and a few 2-3-cm-thick green mudstone beds with sand-filled vertical burrows; top 10 cm contains abundant yellow ostracodes and limestone clasts and thin laminae of finer grained rock.

Unit 95: Limestone (?). Silty micrite (?), base gradational, laminated, carbonaceous debris along some bedding planes, top is sharp.

Unit 94: Limestone (?). Light to medium brownish gray, very calcareous, fine grained, laminated in places; a thin interval containing carbonaceous debris along bedding plane is near base.

Unit 93: Limestone. Basal 25 cm is mainly ooid grainstone; 25-35 cm is light-green siltstone; 35-37 cm is ostracode grainstone containing small carbonate clasts, erosively truncates underlying siltstone; 37-59 cm is laminated ooid (?) limestone containing minor ostracodes and limestone clasts; 50-62 cm is medium-gray micrite (?), irregular base and top; 62 cm to top is light-gray to light-brown silty micrite (?) containing one 2-3-cm-thick bed of algally laminated micrite.

Unit 92: Interbedded mudstone (50 percent) and sandstone-siltstone (50 percent). Bed thickness 20-60 cm, contacts sharp to gradational; mudstone pale green; sedimentary structures in sandstone generally poorly exposed, rippled in places.

Unit 91: Interbedded mudstone (70 percent) and sandstone-siltstone (30 percent). Mudstone is light olive gray and laminated (?).

Unit 90: Interbedded siltstone and mudstone. Contacts indistinct, siltstone contains sparse ostracodes.

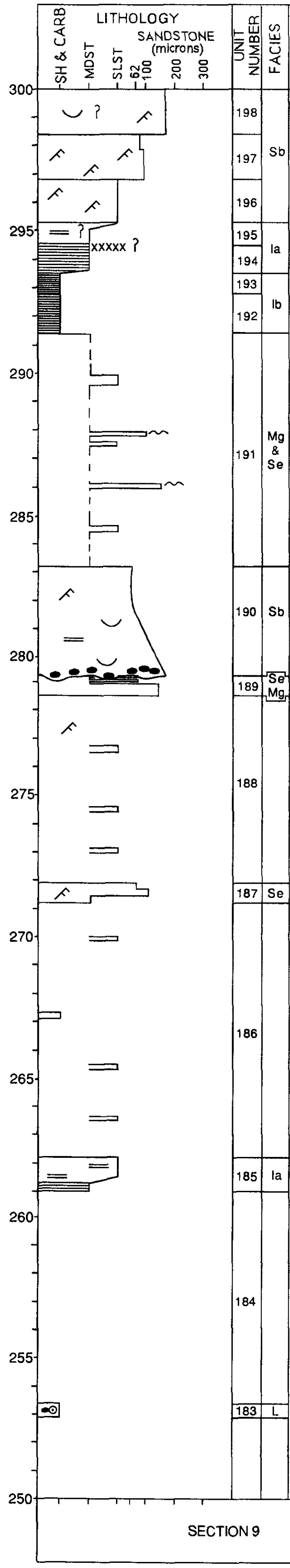
Unit 89: Limestone. Most consists of micrite that contains ooids, ostracodes, fragments of laminated limestone (sandsized to 10+ cm in diameter), and a few bone fragments; 10-20 percent laminated limestone (horizontal laminations, small asymmetric domes, and oncolites (?) 30 cm long by 5 cm thick).

Unit 88: Mudstone. Green, three thin siltstone beds.

Unit 87: Interbedded sandstone-siltstone (80 precent) and mudstone (20 percent). Sandstone -siltstone consists of coarse-grained siltstone to 125-µ sandstone, some sandstone beds fine up (125 to 80 µ), bed thickness 4-30 cm, some beds amalgamated, bases and tops generally sharp, some ripples and planar and wavy planar laminations, but much is structureless, few vertical burrows, one sandstone bed contains bone fragments and fish scales; mudstone is green and thin bedded.

Unit 86: Mudstone and siltstone. Mainly laminated (in places) mottled green, brown, and reddish-purple mudstone, minor siltstone, mudstone fills irregularities in top of unit 85.

SECTION 9 INTERVAL: 200 to 250 m



DESCRIPTION

Unit 131: Mudstone. Grayish olive, contains one thin bed of lenticular 125-μ sandstone.

Unit 130: Sandstone, 75 μ. Rippled, contains a few thin mudstone beds.

Unit 129: Limestone. Base sharp, 7-8 cm of scour; basal 15 cm is sandy (as much as 50 percent sand in places) ostracode and ooid (?) grainstone; 15-45 cm above base is light-gray silty micrite (?) truncated by troughs or channels filled with ostracode grainstone; 45 cm to top is silty micrite (?) containing lenses of fish scales near base.

Unit 128: Mudstone. Green, silty, minor ostracodes.

Unit 127: Sandstone, 100-115 μ. Base sharp and flat; 12-23 cm above base contains 30 percent ooids and ostracodes; wavy planar laminations in lower 23 cm; upper 17 cm structureless.

Unit 126: Sandstone, coarsens upward slightly (80 to 95 μ). Base sharp and irregular (slight erosion of underlying mudstone?), sedimentary structures obscured by weathering and desert varnish, small orange concretions near top.

Unit 125: Mudstone, pale-olive.

Unit 124: NONE (NUMBER SKIPPED).

Unit 123: Sandstone, 90 μ. Rippled.

Unit 122: Sandstone, 65-70 μ.

Unit 121: Sandstone, coarsens upward (70 to 130 μ). Base is sharp and irregular (due to loading?); large ripples in places, sedimentary stuctures obscured by desert varnish in places.

Unit 120: Interbedded 65-130-μ sandstone (65 percent) and mudstone (35 percent). Sandstone beds are 2-25 cm thick, generally sharp sandstone-mudstone contacts, one bed contains clasts of very fine grained sandstone, some beds are structureless and some contain ripples and wavy planar laminations, one bed contains ball-and-pillow structures; mudstone is olive gray.

Unit 119: Mudstone. Light olive gray, laminated in places, abundant fractures filled with gypsum.

Unit 118: Limestone. Algally laminated, mainly pillar-type stromatolites, some horizontal laminations, top of bed has irregular mounds.

Unit 117: Limestone. Micrite (?), laminated, white; upper half contains small lenses of ooids, proportion of ooids increases upward.

Unit 116: Limestone. Micrite (?), very light gray, weathers yellow to orange, silty.

Unit 115: Limestone. Composed of well-rounded limestone intraclasts (sand sized to 5 mm in diameter), clasts fine upward.

Unit 114: Mudstone. Green; one 5-cm-thick bed of limestone composed of well-rounded limestone intraclasts (similar to unit 115).

Unit 113: Sandstone, 80-175 μ. Base sharp, 30 cm of scour; basal 55 cm coarsens upward (80 to 100 μ) and has 10 cm of ripples overlain by wavy planar laminations; 55 cm to top fines upward (175 to 130 μ), sharp contact with underlying finer sandstone, abundant ooids and fragments of algally laminated limestone in lower 7-8 cm of upper part, two sets of tabular-tangential or trough crossbeds.

Unit 112: Mudstone and siltstone. Unit consists of green mudstone overlain by greenish siltstone.

Unit 111: Siltstone and limestone. Basal 15 cm is calcareous siltstone (?); upper 35 cm is limestone composed of ooids and small (less than 3 cm) well-rounded limestone clasts.

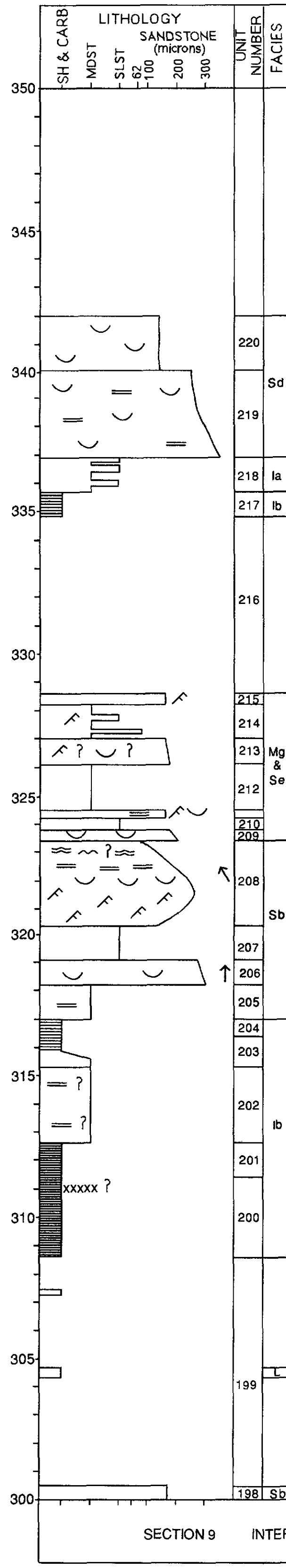
Unit 110: Interbedded sandstone (60 percent) and mudstone (40 percent). Mudstone is green and is present as three 20-30-cm-thick beds; two lowest sandstone beds are about 30 cm thick and contain ripples, upper sandstone beds are finer (70-80 μ), thinner, and structureless.

Unit 109: Interbedded mudstone (60 percent), sandstone-siltstone (30 percent), and limestone (10 percent). Mudstone mainly green, one bed near base contains purple mottles, contacts with mudstone beds sharp to gradational; limestone is one 20-cm-thick bed of ooid grainstone; sandstone-siltstone beds are 10-25 cm thick, grain size medium-grained silt to very fine grained sand.

Unit 108: Limestone. Basal 10 cm contains abundant ostracodes, coated ostracodes (?), and limestone clasts; 10-35 cm is ooid grainstone; 35-60 cm is algally laminated (subhorizontal), and contains abundant ostracodes and coated ostracodes (?) and ooids; 60-75 cm consists of grain-supported small (less than 1 cm) limestone clasts and ostracodes (?), and ooids (?) and coated ostracodes (?); 75 cm to top is transitional to green mudstone.

Unit 107: Limestone (?). Contains ooids (?), base gradational, top sharp, structureless, light gray, weathers yellow.

SECTION 9 INTERVAL: 250 to 300 m



DESCRIPTION

Unit 161: Siltstone, medium-grained. Medium gray, fissile.

Unit 160: Limestone. Silty micrite (?) containing two intervals of abundant ostracodes, two intervals of fish scales, relatively large bone fragments in center.

Unit 159: Siltstone. Laminated, one 9-cm-thick bed of rippled ostrocode grainstone near middle.

Unit 158: Siltstone. Light gray, medium grained, weathers like mudstone.

Unit 157: Limestone. Pillar-type algal stromatolites and small (less than 10 cm high) domal stromatolites at base, pillars generally 4-5 mm wide and 3-6 cm long and subparallel.

Unit 156: Covered.

Unit 155: Limestone. Basal 40 cm is silty micrite (?); 40-60 cm above base are grain-supported, small (0.2 to 1.5 mm), well-rounded limestone clasts; 60 cm to top is ostracode grainstone containing some ooids and small zones with laminated limestone.

Unit 154: Mainly covered. Unit has one 23-cm-thick bed of rippled 125-μ sandstone 1 m above base.

Unit 153: Siltstone and sandstone (160 μ). Thin-bedded siltstone, one sandstone bed in top 5 cm; planar and wavy planar laminations.

Unit 152: Limestone. Pillar-type algal stromatolites, pillars less than 4 mm in diameter.

Unit 151: Sandstone, 90 μ. Sparse ostracodes.

Unit 150: Limestone. Ooid (?) grainstone in lower half grades upwards to ostracode grainstone.

Unit 149: Covered.

Unit 148: Limestone. Pillar-type stromaolites having ostracodes between pillars; some intervals of ostracode grainstone planar laminated.

Unit 147: Siltstone. Medium gray, calcareous, wavy planar laminations, rock breaks into thin slabs less than 1.5 cm thick.

Unit 146: Limestone. Silty micrite (?) containing sparse to abundant ostracodes, ooids, and scattered fish scales; top 10 cm composed of limestone intraclasts (sand sized to 2.5 cm wide).

Unit 145: Limestone. Composed of small (less than 15 cm in diameter) domal algal stromatolites, pillar-type stromatolites and some subhorizontal laminations; base sharp and irregular; top 7-10 cm is ostracode grainstone.

Unit 144: Limestone. Mainly silty micrite (?), base gradational over few centimeters; 60-90 cm contains sparse to abundant ostracodes and some limestone clasts as long as 3 cm; 10-20 cm below top is micrite containing ooids and larger round grains as wide as 3 mm; top 10 cm is green mudstone.

Unit 143: Mudstone, pale-green.

Unit 142: Sandstone, fines upward (200 to 150 μ). Base is sharp, 10-15 cm of scour and contains scattered small (less than 3 cm) limestone clasts; sedimentary structures poorly exposed, trough crossbeds in lower few meters (?); upper half of unit contains lateral accretion bedding that dips 14° N. 70° E.

Unit 141: Limestone. Ostracode grainstone grades upward to silty micrite (?), in transition zone the limestone laminated.

Unit 140: Mudstone. Green; top 15 cm contains scattered ostracodes, few patches with abundant ostracodes, and ostracode-filled burrows; top 10 cm gradational with unit 141.

Unit 139: Sandstone (110 μ) and limestone. Sharp base, sandstone containing ostracodes grades upward to ostracode grainstone; planar laminations and ripples in upper half.

Unit 138: Interbedded sandstone (110 μ) and mudstone. Thin beds of rippled sandstone are separated by thinner green mudstone beds, mudstone beds are truncated by sandstone in places; top 15 cm is green mudstone.

Unit 137: Sandstone, fines upward (110 to70 μ). Base sharp and irregular; ripples and wavy planar laminations in upper half.

Unit 136: Mudstone. Greenish, unit thins to 10-15 cm 5 m to west.

Unit 135: Siltstone. Greenish gray, rippled in places; green mudstone beds near top.

Unit 134: Mudstone, light-olive-gray to brownish-gray.

Unit 133: Sandstone, 125 μ. Rippled.

Unit 132: Sandstone, 125–135 μ. Base is sharp, 5 cm of scour, and contains 20-25 percent small (less than 1 mm) clasts of fine-grained limestone; planar laminations.

SECTION 9 INTERVAL: 300 to 342 m

SECTION 9 — DESCRIPTION ONLY

DESCRIPTION Units 162-187

Unit 187: Siltstone (coarse grained) and sandstone (75-100 μ). Basal 25 cm is calcareous siltstone; 25-50 cm is rippled 100-μ sandstone; 50 cm to top is structureless 75-μ sandstone.

Unit 186: Mainly covered. Minor outcrops of light gray laminated siltstone and light-gray carbonate (?) rock.

Unit 185: Mudstone and siltstone. Laminated dark-yellowish-brown mudstone grades upward to laminated, light-gray, fine-grained siltstone that grades upward to coarse-grained light-gray siltstone containing wavy planar laminations.

Unit 184: Covered. Abundant float of tar-saturated limestone (some with ooids).

Unit 183: Limestone. Mainly of fine carbonate grains and larger (as much as 4 cm diameter) grains and zones of brecciated laminated limestone

Unit 182: Covered

Unit 181: Sandstone and mudstone. Unit covered along section but lower 6.6 m of interval exposed in nearby cliff where it consists of (thicknesses estimated) basal 1.9 m interbedded green mudstone and fine-grained sandstone; 1.9-5.0 m green mudstone and several sandstone-siltstone interbeds; 5-5.3 m unidentified bed; 5.3-6.6 rippled 90-μ sandstone.

Unit 180: Limestone. Grain-supported ooids and ostracodes (?), base sharp and irregular.

Unit 179: Limestone. Micrite (?), white, very fine grained, laminated in few places, minor carbonate grains in places.

Unit 178: Mainly covered. One bed of ostracode and ooid grainstone containing limestone clasts and one 15-cm-thick bed of brownish-gray micrite.

Unit 177: Sandstone (100 μ) and mudstone. Rippled sandstone breaks into slabs 2-8 cm thick; 15-cm-thick bed of fissile green mudstone 10-25 cm from top.

Unit 176: Mudstone and siltstone. Basal 20 cm is fissile green mudstone; upper 30 cm is interbedded mudstone and siltstone.

Unit 175. Limestone. Base sharp; composed of ostracodes, small round carbonate grains (no nuclei or concentric layering), and larger, more angular limestone clasts.

Unit 174: Siltstone and sandstone. Base grades upward from mudstone to 90-μ sandstone; top grades upward to coarse-grained siltstone; contains planar laminations (?) and ripples (?).

Unit 173: Mudstone, greenish-gray.

Unit 172: Limestone. Basal 20 cm is light yellowish gray, composed of silt- to very fine sand-sized carbonate grains and less than 10 percent ostracodes; upper 20 cm is interbedded limestone composed of ostracodes and other carbonate grains and limestone similar to basal 20 cm.

Unit 171. Limestone. Oncolites, angular fragments of laminated limestone, and small domal stromatolites in matrix of fine-grained limestone containing ostracodes.

Unit 170: Mainly covered. Few outcrops of thin bedded to laminated limestone, abundant green mudstone float on surface.

Unit 169: Siltstone and limestone. Siltstone is light gray and moderately calcareous, contains wavy planar laminations (?), breaks into slabs 2-10 mm thick, one 0-15-cm-thick bed of laminated (algally?) limestone disrupts siltstone bedding.

Unit 168: Mudstone and limestone. Basal 20 cm is green mudstone containing limestone clasts and thin limestone interbeds; basal mudstone grades upward to limestone composed of ostracodes and small (100 μ-1 cm diameter), spherical to oval limestone clasts.

Unit 167: Covered.

Unit 166: Interbedded sandstone, siltstone, mudstone (30-40 percent), and limestone. Bed thickness 5-30 cm; sandstone and siltstone are rippled; mudstone is green; limestone is one 25-cm-thick bed of silty micrite (?) containing ooids (?) and ostracodes.

Unit 165: Covered.

Unit 164: Limestone. Ostracode grainstone.

Unit 163: Mudstone. Green, poorly exposed.

Unit 162: Sandstone, fines upward (160 to 85 μ). Base sharp and flat; basal 0-50 cm contains abundant (clast supported in places), small (2.5 cm maximum diameter), well-rounded limestone clasts in matrix of 140-160-μ sand, IFC overlain by 75-100-cm interval of trough crossbeds overlain by ripples, top of unit contains abundant chert pebbles and fish scales.

DESCRIPTION Units 188-220

Unit 220: Sandstone, 135 μ. Thin bedded, trough crossbeds (at least in places).

Unit 219: Sandstone, fines upward (350 250 μ). Base sharp and flat; planar laminations and trough crossbeds.

Unit 218: Siltstone and mudstone. Siltstone is very light gray and medium-grained; mudstone is light to medium brownish gray.

Unit 217: Dolostone. Laminated, medium brownish gray, kerogenous in places.

Unit 216: Covered.

Unit 215: Sandstone, 160 μ. Base sharp and flat; unit rippled in places.

Unit 214: Interbedded olive mudstone, siltstone, and very fine grained sandstone. Sandstone is rippled.

Unit 213: Sandstone, fines upward slightly (175 to 160 μ). Base sharp and flat; sedimentary structures not well exposed, ripples (?), small trough crossbeds (?), bedding deformed in places.

Unit 212: Mudstone. Olive gray, silty.

Unit 211: Sandstone, 160 μ. Sharp and flat base; unit thickens north; contains ripples, planar laminations (?), and trough crossbeds (?).

Unit 210: Siltstone.

Unit 209: Sandstone, fines upward (200 to 175 μ). Base sharp and flat, trough crossbeds.

Unit 208: Sandstone, variable grain size (75-260 μ). Base sharp and flat; basal 1.2 m rippled; 1.2-2.0 m is trough crossbedded; 2.0-2.5 m is planar laminated; 2.5 m to top is wave rippled (?) and wavy planar laminated.

Unit 207: Siltstone, olive-gray.

Unit 206: Sandstone, fines upward (300 to 250 μ). Base sharp and flat, faint trough crossbeds.

Unit 205: Mudstone. Olive-brown, silty, laminated.

Unit 204: Dolostone. Very dark gray, laminated on weathered surfaces.

Unit 203: Mudstone and dolostone. Medium-brownish-gray, moderately calcareous mudstone grades upward to very dark gray dolostone that appears laminated on weathered surfaces.

Unit 202: Mudstone. Light to medium brownish gray, moderately calcareous, fine grained to moderately silty, weathers very light gray, some zones are laminated (?) on weathered surfaces.

Unit 201: Dolostone. Laminated, very kerogenous (oil shale), weathers to paper shale in places.

Unit 200: Dolostone. Laminated and moderately kerogenous (oil shale), weathers to paper shale in places; 2-cm-thick tuff (?) near top.

Unit 199: Mainly covered. Few thin outcrops of brown dolostone.

Unit 198: Sandstone, 170 μ. Base sharp and scours underlying sandstone; most structureless, well-exposed ripples in places and trough crossbeds in lower half (?).

Unit 197: Sandstone, 70-90 μ. Basal two-thirds is 90 μ and rippled; upper third is 70-80 μ, forms recess.

Unit 196: Siltstone, medium- to coarse-grained. Base gradational over 15 cm with underlying mudstone, rippled in places.

Unit 195: Mudstone. Sharp base; light-brownish-gray, moderately calcareous mudstone grades upward to very light gray, slightly calcareous mudstone; unit weathers white and is laminated (?) in places.

Unit 194: Mudstone. Olive-gray, laminated, gradational contact (over 20 cm) with underlying laminated dolostone; 50 cm from top an 8-cm-thick bed of orange-red rock (tuff ?) has sharp base and top and irregular bedding.

Unit 193: Dolostone. Laminated; basal 20 cm moderately kerogenous (oil shale).

Unit 192: Dolostone. Laminated and very kerogenous (oil shale), weathers to paper shale in places.

Unit 191: Siltstone, sandstone, and mudstone. Much of unit covered; abundant siltstone and wave-rippled sandstone (65-150 μ), and olive-gray mudstone in places.

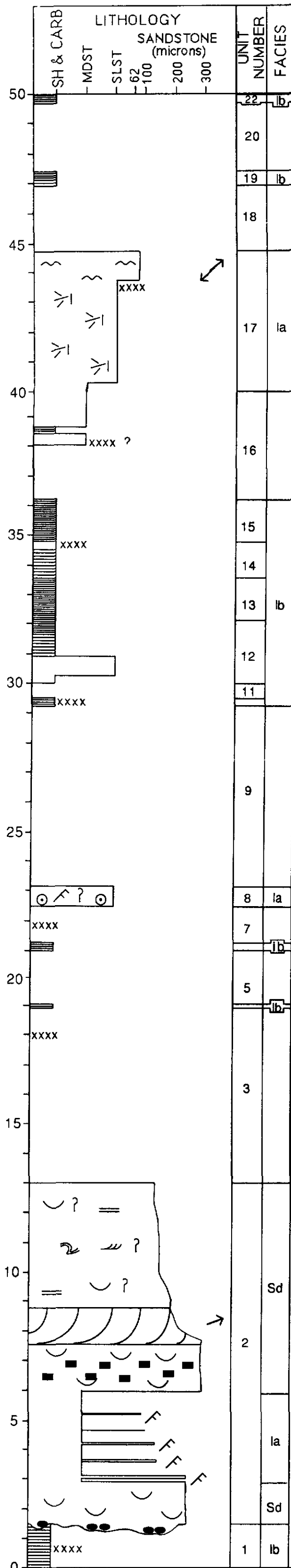
Unit 190: Sandstone, fines upward (175 to 150 μ). Base sharp, less than 30 cm of scour; 0-40-cm-thick zone containing mudstone clasts at base; most of unit structureless, minor trough crossbeds, ripples, and planar laminations.

Unit 189: Sandstone-siltstone and mudstone. Three 13-18-cm-thick beds of 140-μ sandstone overlain by 20-cm-thick interval of interbedded green mudstone and coarse-grained siltstone.

Unit 188: Mainly covered. Several outcrops of laminated to thinly bedded, light-gray calcareous siltstone; 50-cm-thick bed of dusky-yellow-green mudstone crops out beneath unit 189.

SECTION 9 DESCRIPTION ONLY

SECTION 10 — INTERVAL: 0 to 50 m



DESCRIPTION

Unit 17: Dolostone, mudstone, siltstone, and sandstone. Basal 40 cm is mudstone, medium brown, moderately calcareous, slightly kerogenous, moderately fissile, with a thin (about 5 mm) reddish brown tuff about 5 cm above base; 40-80 cm is kerogenous, laminated dolostone (oil shale), top gradational; 80-220 cm is mudstone, medium grayish brown, calcareous, slightly laminated; 220-660 cm is medium- to coarse-grained siltstone, coarsens upward (?), syneresis cracks, light gray to medium brownish gray, calcareous, near top is 20-cm-thick tuff (Mahogany Marker?), weathers light to medium grayish brown with some reddish brown zones, base and top sharp, contains 3 or 4 thin mudstone interbeds, sparse to abundant spots of hematite, slightly calcareous; 660 cm to top is sandstone, less than 100 μ, bed thickness less than 10 cm in lower half and 15-20 cm in upper half, wave ripples.

Unit 16: Covered.

Unit 15: Dolostone (Mahogany oil-shale bed). Laminated and very kerogenous, weathers light to medium bluish gray; top 90 cm weathers to paper shale, forms ledge, fresh surface smells oily.

Unit 14: Dolostone (?). Dark yellowish brown, slightly to moderately calcareous, laminations disappear toward top. Tuff bed at top, 1.7-3-cm thick, pinches-and-swells, weathers light gray to mottled reddish brown, fresh surface is medium gray to medium grayish brown, slightly calcareous.

Unit 13: Dolostone. Partly exposed, medium-brown, laminatod dolostone and very kerogenous, laminated dolostone (oil shale).

Unit 12: Limestone, siltstone, and dolostone. Basal 25 cm is limestone (?), light brown, fine grained; 25-75 cm is very calcareous siltstone (?); 75-95 cm is very light gray, calcareous siltstone; 95-170 cm is dolostone. medium brown. laminated. slightly to moderately calcareous; 170 cm to top is laminated, kerogenous dolostone (oil shale), weathers to paper shale in places.

Unit 11: Covered.

Unit 10: Dolostone. Laminated and kerogenous (i.e. oil shale). Two-cm-thick tuff in center, base irregular, weathers light gray with reddish mottles, fresh surface is light gray, few percent dark grains with hematite halos, calcareous

Unit 9: Covered.

Unit 8: Siltstone. Basal 30 cm contains ooids and other carbonate grains; upper 40 cm breaks into thin wavy (rippled?) plates.

Unit 7: Mainly covered. Tuff (Fred Bed?) 70 cm below top, 4-7 cm thick, relatively flat base and top, medium gray with reddish brown stains, about 10 percent dark grains, calcareous in places.

Unit 6: Dolostone. Laminated and moderately kerogenous (oil shale).

Unit 5: Covered.

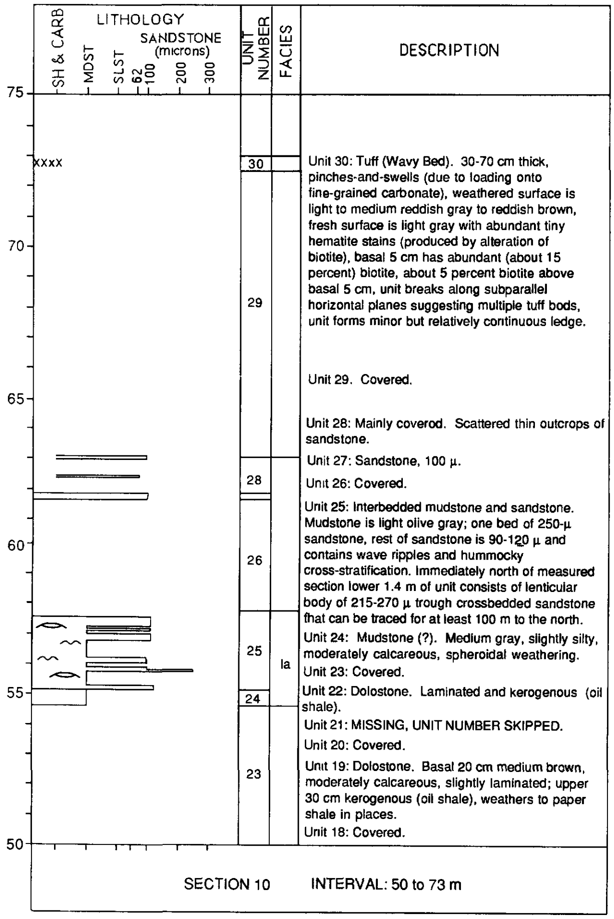
Unit 4: Dolostone. Laminated and kerogenous.

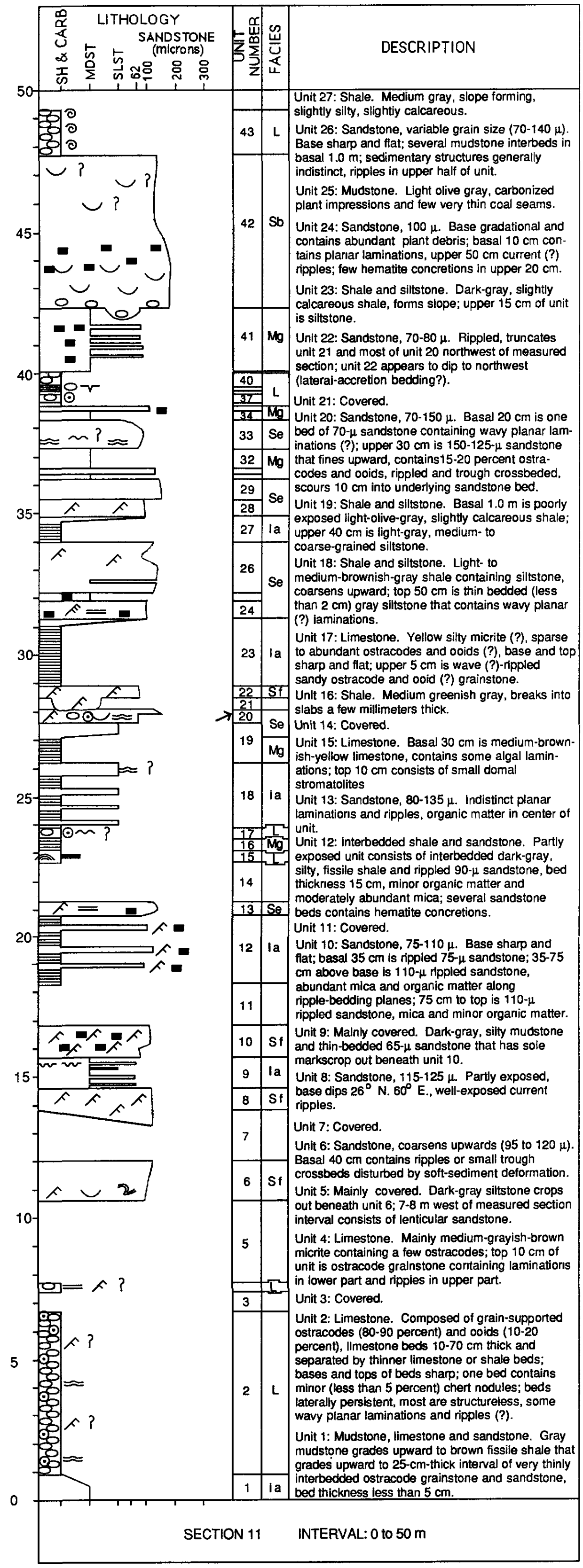
Unit 3: Mainly covered. Tuff (Curly Tuff?) 5.1 m above base, 20-50 cm, pinches-and-swells, weathered and fresh surfaces light gray, 2-15 percent biotite, noncalcareous, poorly exposed.

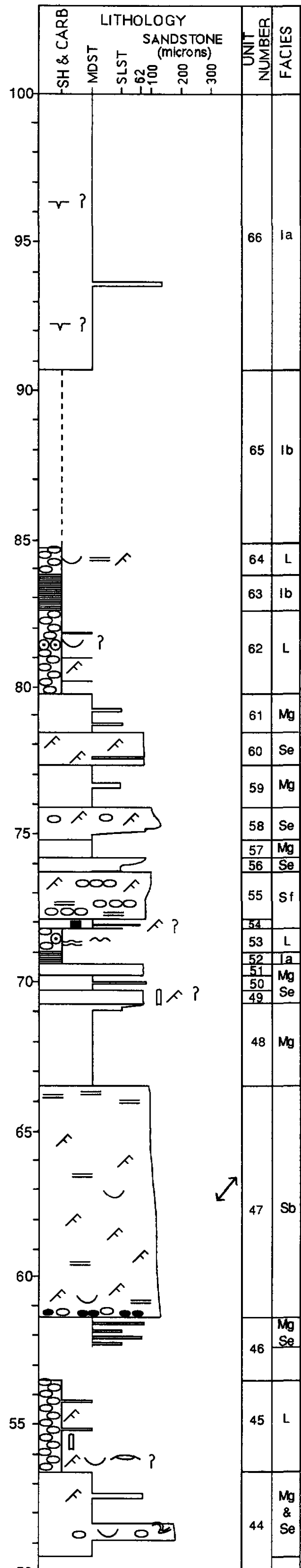
Unit 2: Sandstone and mudstone. Basal 1.4 m is sandstone containing trough crossbeds, sharp undulatory base with 30 cm of scour, 250 μ, 0-7-cm-thick basal lag with white, very fine grained clasts as long as 10 cm; 1.4-4.5 m above base is interbedded light-olive-gray mudstone (70 percent) and rippled sandstone (30 percent), sandstone beds less than 15 cm thick, grain size of sandstones decreases upward (250 to 100 μ), bases and tops of beds sharp and flat, beds laterally continuous; 4.5 m to top is sandstone, fines upward (300 to 140 μ); 50-cm-thick zone of extensive hematite and limonite staining and some carbonaceous debris 50-100 cm above base of subunit; base of subunit to 1.5 m contains trough crossbeds; 1.5-2.8 m above base of subunit a set of tabular-tangential crossbeds can be traced 15 m toward southwest where it thins; 2.8 m to top of subunit sedimentary structures partly covered by desert varnish, trough or tabular tangential crossbeds and planar beds dip 11° toward 65°, bedding convolute in places.

Unit 1: Dolostone. Laminated, pale yellowish brown to light gray, very fine grained; 80 cm above base is a 5-cm-thick bed of bright-yellow tuff (?).

SECTION 10 INTERVAL: 0 to 50 m


LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62 100 200 300
UNIT NUMBER
FACIES
DESCRIPTION
Unit 30: Tuff (Wavy Bed). 30-70 cm thick, pinches-and-swells (due to loading onto fine-grained carbonate), weathered surface is light to medium reddish gray to reddish brown, fresh surface is light gray with abundant tiny hematite stains (produced by alteration of biotite), basal 5 cm has abundant (about 15 percent) biotite, about 5 percent biotite above basal 5 cm, unit breaks along subparallel horizontal planes suggesting multiple tuff beds, unit forms minor but relatively continuous ledge.
Unit 29. Covered.
Unit 28: Mainly covered. Scattered thin outcrops of sandstone.
Unit 27: Sandstone, 100 µ.
Unit 26: Covered.
Unit 25: Interbedded mudstone and sandstone. Mudstone is light olive gray; one bed of 250-µ sandstone, rest of sandstone is 90-120 µ and contains wave ripples and hummocky cross-stratification. Immediately north of measured section lower 1.4 m of unit consists of lenticular body of 215-270 µ trough crossbedded sandstone that can be traced for at least 100 m to the north.
Unit 24: Mudstone (?). Medium gray, slightly silty, moderately calcareous, spheroidal weathering.
Unit 23: Covered.
Unit 22: Dolostone. Laminated and kerogenous (oil shale).
Unit 21: MISSING, UNIT NUMBER SKIPPED.
Unit 20: Covered.
Unit 19: Dolostone. Basal 20 cm medium brown, moderately calcareous, slightly laminated; upper 30 cm kerogenous (oil shale), weathers to paper shale in places.
Unit 18: Covered.
SECTION 10
INTERVAL: 50 to 73 m


LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62 100 200 300
UNIT NUMBER
FACIES
DESCRIPTION
Unit 27: Shale. Medium gray, slope forming, slightly silty, slightiy calcareous.
Unit 26: Sandstone, variable grain size (70-140 µ). Base sharp and flat; several mudstone interbeds in basal 1.0 m; sedimentary structures generally indistinct, ripples in upper half of unit.
Unit 25: Mudstone. Light olive gray, carbonized plant impressions and few very thin coal seams.
Unit 24: Sandstone, 100 µ. Base gradational and contains abundant plant debris; basal 10 cm contains planar laminations, upper 50 cm current (?) ripples; few hematite concretions in upper 20 cm.
Unit 23: Shale and siltstone. Dark-gray, slightly calcareous shale, forms slope; upper 15 cm of unit is siltstone.
Unit 22: Sandstone, 70-80 µ. Rippled, truncates unit 21 and most of unit 20 northwest of measured section; unit 22 appears to dip to northwest (lateral-accretion bedding?).
Unit 21: Covered.
Unit 20: Sandstone, 70-150 µ. Basal 20 cm is one bed of 70-µ sandstone containing wavy planar laminations (?); upper 30 cm is 150-125-µ sandstone that fines upward, contains15-20 percent ostracodes and ooids, rippled and trough crossbeded, scours 10 cm into underlying sandstone bed.
Unit 19: Shale and siltstone. Basal 1.0 m is poorly exposed light-olive-gray, slightly calcareous shale; upper 40 cm is light-gray, medium- to coarse-grained siltstone.
Unit 18: Shale and siltstone. Light- to medium-brownish-gray shale containing siltstone, coarsens upward; top 50 cm is thin bedded (less than 2 cm) gray siltstone that contains wavy planar (?) laminations.
Unit 17: Limestone. Yellow silty micrite (?), sparse to abundant ostracodes and ooids (?), base and top sharp and flat; upper 5 cm is wave (?)-rippled sandy ostracode and ooid (?) grainstone.
Unit 16: Shale. Medium greenish gray, breaks into slabs a few millimeters thick.
Unit 14: Covered.
Unit 15: Limestone. Basal 30 cm is medium-brownish-yellow limestone, contains some algal laminations; top 10 cm consists of small domal stromatolites
Unit 13: Sandstone, 80-135 µ. Indistinct planar laminations and ripples, organic matter in center of unit.
Unit 12: Interbedded shale and sandstone. Partly exposed unit consists of interbedded dark-gray, silty, fissile shale and rippled 90-µ sandstone, bed thickness 15 cm, minor organic matter and moderately abundant mica; several sandstone beds contains hematite concretions.
Unit 11: Covered.
Unit 10: Sandstone, 75-110 µ. Base sharp and flat; basal 35 cm is rippled 75-µ sandstone; 35-75 cm above base is 110-µ rippled sandstone, abundant mica and organic matter along ripple-bedding planes; 75 cm to top is 110-µ rippled sandstone, mica and minor organic matter.
Unit 9: Mainly covered. Dark-gray, silty mudstone and thin-bedded 65-µ sandstone that has sole markscrop out beneath unit 10.
Unit 8: Sandstone, 115-125 µ. Partly exposed, base dips 26° N. 60° E., well-exposed current ripples.
Unit 7: Covered.
Unit 6: Sandstone, coarsens upwards (95 to 120 µ). Basal 40 cm contains ripples or small trough crossbeds disturbed by soft-sediment deformation.
Unit 5: Mainly covered. Dark-gray siltstone crops out beneath unit 6; 7-8 m west of measured section interval consists of lenticular sandstone.
Unit 4: Limestone. Mainly medium-grayish-brown micrite containing a few ostracodes; top 10 cm of unit is ostracode grainstone containing laminations in lower part and ripples in upper part.
Unit 3: Covered.
Unit 2: Limestone. Composed of grain-supported ostracodes (80-90 percent) and ooids (10-20 percent), limestone beds 10-70 cm thick and separated by thinner limestone or shale beds; bases and tops of beds sharp; one bed contains minor (less than 5 percent) chert nodules; beds laterally persistent, most are structureless, some wavy planar laminations and ripples (?).
Unit 1: Mudstone, limestone and sandstone. Gray mudstone grades upward to brown fissile shale that grades upward to 25-cm-thick interval of very thinly interbedded ostracode grainstone and sandstone, bed thickness less than 5 cm.
SECTION 11
INTERVAL: 0 to 50 m



DESCRIPTION

Unit 49: Sandstone, 65-70 µ. Gradational base; basal 15 cm structureless; upper 25 cm rippled (?), few vertical burrows.

Unit 48: Mudstone and siltstone. Mudstone dusky yellow green, poorly exposed; 20-cm-thick bed of very coarse grained siltstone crops out beneath unit 49.

Unit 47: Sandstone, fines upward (160 to 90 µ). Base sharp and flat; basal 10 cm consists of matrix of 160-µ sand and angular mudstone clasts as long as 10 cm, hematite-stained plant debris, muscovite, small yellow limestone fragments, and ostracodes; basal 6.6 m contains ripples (50 percent), planar laminations (30 percent), trough crossbeds (10 percent), and structureless (10 percent); top 40 cm contains laminations that dip as much as 20° toward 310° (lateral-accretion bedding?); unit is laterally persistent for at least 75 m but appears to thicken and thin.

Unit 46: Interbedded green mudstone (65 percent) and sandstone-siltstone (35 percent). Lower half covered; sandstone is very fine grained; sandstone and siltstone beds have sharp bases and tops and are less than 10 cm thick; mudstone is moderately to very silty and calcareous.

Unit 45: Limestone. Ostracode grainstone, flat base and top; basal 1.0 m contains wavy planar laminations that have low-angle truncations (HCS?), trough crossbeds, and minor (less than 15 percent) ripples; upper 2.1 m is mainly structureless and contains few ripple foresets or wavy surfaces, burrows, and thin mudstone interbeds; unit is laterally continuous for at least 75 m and probably crops out on ridge 0.4 km to east.

Unit 44: Mudstone and sandstone. Basal third covered; upper two-thirds green mudstone containing one 20-cm-thick bed of rippled very fine grained sandstone and one 60-cm-thick bed of 175-µ trough crossbedded sandstone containing ostracodes in places and some soft-sediment deformation.

Unit 43: Limestone. Ostracode grainstone, relatively abundant gastropods, base sharp.

Unit 42: Sandstone, fines upward (175 to 135 µ). Base sharp and generally flat except for one zone with 30-40 cm of scour; base contains 15-20 percent ostracodes; basal 1.5 m has trough crossbeds that give scattered paleoflow directions; 1.2-1.8 m above base abundant carbonaceous debris and mica along bedding planes; sedimentary structures indistinct in top 2.0 m (may be trough crossbeds ?).

Unit 41: Interbedded mudstone (60 percent) and sandstone (40 percent). Basal 50 cm and upper 30 cm are mainly green mudstone; middle is interbedded green mudstone and very fine grained sandstone containing abundant fine-grained carbonaceous debris along some bedding planes, bed thickness 10-15 cm.

Unit 40: Limestone. Ostracode grainstone, base irregular, top sharp and flat.

Unit 39: Dolostone and limestone. Brown, kerogenous, laminated dolostone (oil shale) with very large mudcracks (some 4 cm wide by 10 cm deep) filled with ostracode grainstone.

Unit 38: Limestone. Clast-supported mix of ooids, ostracodes, and 0.1-to-15-mm-long micrite intraclasts.

Unit 37: Limestone. Several beds of ostracode grainstone.

Unit 36: Dolostone. Medium brownish gray, structureless, very fine grained, weathers light green, abundant mudcracks filled with ostracodes.

Unit 35: Sandstone, 110 µ. Lower few centimeters contains carbonaceous debris in places; thickens and thins.

Unit 34: Mudstone. Greenish gray, top contains carbonaceous debris.

Unit 33: Sandstone and siltstone. Base gradational over few centimeters; lower half coarsens upward from 65- to 85-µ sandstone; upper half is fine to very coarse grained siltstone, lower 65 cm contains wavy planar laminations and wave (?) ripples.

Unit 32: Mudstone. Greenish gray, similar to unit 30.

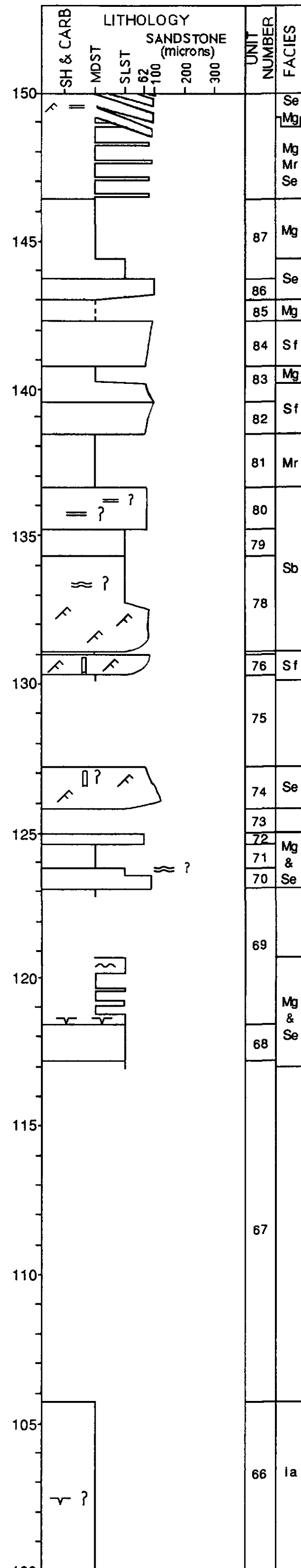
Unit 31: Sandstone, 125 µ. Base sharp and slightly irregular, structureless.

Unit 30: Mudstone. Greenish gray, moderately silty, moderately calcareous, typical mudstone weathering.

Unit 29: Sandstone, fines upward (150 to 125 µ). Base sharp and flat, unit thickens to west, contains scattered small hematite concretions.

Unit 28: Sandstone, less than 90 µ. Gradational base, sandstone rippled in places.

SECTION 11 INTERVAL: 50 to 100 m



DESCRIPTION

Unit 71: Mudstone. Green, silty, poorly exposed.

Unit 70: Sandstone and siltstone. Base transitional from silty mudstone to siltstone to 95-µ sandstone; top of unit grades into siltstone that breaks to wavy plates.

Unit 69: Siltstone and mudstone, 50 percent covered. Base is medium-grained calcareous brownish-gray siltstone, large mudcracks; 2.0-2.6 (?) m is calcareous medium-gray siltstone, breaks into thin (1 cm) plates, some of which exhibit symmetrical undulations (wave ripples ?); 2.6-4.5 m is covered; 4.5 m to top is silty greenish-gray mudstone.

Unit 68: Siltstone, very coarse grained. Calcareous, forms resistant ledge.

Unit 67: Mainly covered. Top of unit is 20-cm-thick bed of coarse-grained siltstone.

NOTE: At contact between units 66 and 67 there is a regional change in the weathered color of the rocks from light gray below to brown above.

Unit 66: Mudstone-siltstone. Moderately fissile, slightly to moderately calcareous silty mudstone-siltstone, variable colors: basal 3.1 m is medium brown; 3.1-4.1 m is light medium gray; 4.1-13 m is medium brownish gray; 13 m to top is light gray; mudcracks (?) in places; 15-cm-thick bed of 135-µ sandstone 1.5 m above base.

Unit 65: Dolostone. Poorly exposed, laminated, medium to dark brown, weathers into paper shale.

Unit 64: Limestone. Ostracode grainstone, most structureless, minor ripples and trough crossbeds in places, unit breaks into thin wavy slabs suggesting wavy planar laminations or HCS (?).

Unit 63: Dolostone and limestone. Basal 5 cm of unit is white limestone (micrite ?) interbedded with ostracode grainstone; most of unit is laminated and kerogenous (oil shale), calcareous, medium brown, some ostracodes.

Unit 62: Limestone. Ostracode grainstone, base sharp and flat, bed thickness 10-40 cm, few thin greenish-gray mudstone and brown fissile shale interbeds; 70-80 percent of unit structureless, 20-30 percent has trough crossbeds (?) and ripples; one bed in center of unit contains coated ostracodes in top 5-10 cm of bed.

Unit 61: Mudstone and siltstone. Greenish-gray to light-gray mudstone containg beds of light-gray medium-grained siltstone; upper 30 cm is all greenish gray mudstone.

Unit 60: Sandstone, 70–80 µ. Base sharp, rippled, few thin green mudstone interbeds near base.

Unit 59: Mudstone and siltstone. Green mudstone containing one 20-30-cm-thick bed of siltstone in center, mudstone-siltstone contacts are gradational.

Unit 58: Sandstone. Basal 65 cm grades upward from mudstone through siltstone to very fine grained sandstone; upper 45 cm fines upward (130 to 100 µ), 0-10 percent ostracodes, rippled.

Unit 57: Mudstone, green.

Unit 56: Mudstone, siltstone, and sandstone. Grades upward from green mudstone through siltstone to 70-80-µ sandstone.

Unit 55: Sandstone, 80-100 µ (coarsens upward). Base sharp and flat; basal 65 cm contains planar laminations and ostracode limestone laminae (20 percent of interval); upper 95 cm contains a few ostracode limestone laminae and is rippled and tar saturated in places.

Unit 54: Interbedded siltstone, mudstone, and sandstone. Basal 3 cm is laminated siltstone containing plant debris; 3-11 cm is light- to medium-gray calcareous mudstone; 11-15 cm is 65-µ rippled (?) sandstone containing some ostracodes and minor plant debris; 15 cm to top is olive-gray to greenish-gray mudstone.

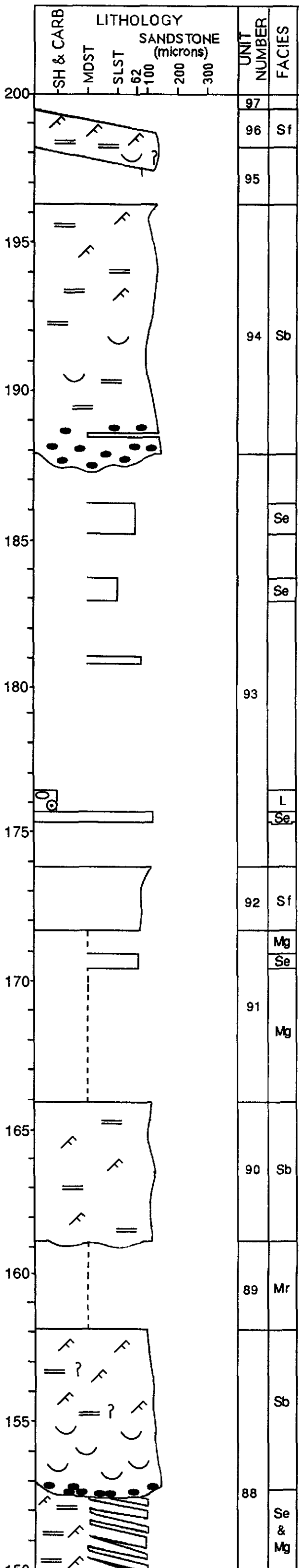
Unit 53: Limestone. Basal 30 cm is ostracode grainstone that contains wavy planar laminations and few thin (less than 3 cm) interbeds of grayish-brown, fissile dolostone, limestone bed thickness less than 10 cm, some beds have symmetrical undulatory bases with wavelength of 12 cm (wave ripples?); middle 30 cm is ostracode grainstone; top 20 cm consists of well-rounded carbonate grains as much as 5 mm in diameter but mostly less than 2.5 mm, minor ostracodes.

Unit 52: Dolostone. Laminated and kerogenous (oil shale), grayish brown (5YR 3/2).

Unit 51: Sandstone, 65-70 µ. Base sharp and flat.

Unit 50: Mudstone and sandstone. Poorly exposed green mudstone containing one 10-cm-thick bed of very fine grained sandstone in center.

SECTION 11 INTERVAL: 100 to 150 m



DESCRIPTION

Unit 93: Covered (65 percent), minor sandstone, siltstone, and limestone. Basal 0.5 m covered; 0.5-3.2 m above base several thin (10-20 cm) 125-µ sandstone beds are overlain by 50-60-cm-thick bed of silty micrite (?) containing ostracodes and oolites (?); 6.0 m above base is 20-cm-thick bed of 80-µ sandstone; 8.3–9.1 m is siltstone; 11.5-12.5 m is 65-µ sandstone.

Unit 92: Sandstone, coarsens upward (70 to 115 µ). Base sharp and flat, bed thickness 50-60 cm, small (1.5 m wide by 0.35 cm deep) sand-filled channel cuts top of unit, structureless.

Unit 91: Mainly covered. Several outcrops of green mudstone; 50-cm-thick bed of 70-µ sandstone near top; toward west unit is all sandstone.

Unit 90: Sandstone, 100-125 µ (no grain size trend). Base is sharp and scoured; 80 percent structureless, 10 percent planar laminated, and 10 percent rippled: lenticular geometry, sandstone beds within unit dip 20° N. 5° E. (lateral-accretion bedding).

Unit 89: Mudstone. Red, mainly covered.

Unit 88: Sandstone and mudstone. Complex sandstone body composed of three subunits: (1) basal 3.0 m is interbedded red and green mudstone (80 percent) and very fine grained sandstone (20 percent), bed thickness less than 25 cm, sandstones have sharp bases and tops, base of subunit flat, subunit thins to 1.5 m thick 10 m to northeast due to truncation by northeast-dipping subunit (2), 10 m northeast of measured section have within subunit (1) a 1.0-m-thick lenticular body of sandstone fines upward (110 to 70 µ) and contains scattered IFC at its base; (2) 3.0-6.7 m above base is interbedded sandstone (80 percent) and mudstone (20 percent), beds dip 35° NE. (lateral-accretion bedding), sandstone beds merge updip and truncate mudstones, sandstones are 80-110 µ, 50 pecent structureless, 30 percent rippled, and 20 precent planar laminated; (3) 6.7 m to top is sandstone, fines upward (140 to 100 µ), mudstone clasts at base, trough crossbeds in lower 2.0 m, ripples and planar laminations (?) in upper half of subunit.

Unit 87: Siltstone and mudstone. Basal 70 cm is siltstone; upper 2.0 m is red mudstone overlain by 30-cm-thick bed of green mudstone.

Unit 86: Sandstone, 100 µ. Base gradational, structureless.

Unit 85: Mudstone. Green, poorly exposed.

Unit 84: Sandstone, coarsens upward (65 to 90 µ).

Unit 83: Sandstone (67-70 µ) and green mudstone. Poorly exposed; lower half sandstone; upper half green mudstone.

Unit 82: Sandstone, coarsens upward (65 to 100 µ). Structureless.

Unit 81: Mudstone. Poorly exposed; light to medium grayish purple in lower 1.2 m; green in upper 0.6 m.

Unit 80: Sandstone, 65-70 µ. Base fairly sharp, structureless except for laminations (?) at base, breaks into thin slabs.

Unit 79: Siltstone. Medium brownish gray, slightly calcareous, poorly exposed.

Unit 78: Siltstone and sandstone (80 µ). Basal 1.0 m grades from siltstone to sandstone; upper 2.2 m is siltstone, breaks into curving plates.

Unit 77: Mudstone, green.

Unit 76: Sandstone. Base gradational from green mudstone through siltstone to 70-80-µ sandstone; 60 percent of unit structureless and 40 percent rippled; vertical burrows, laterally persistent.

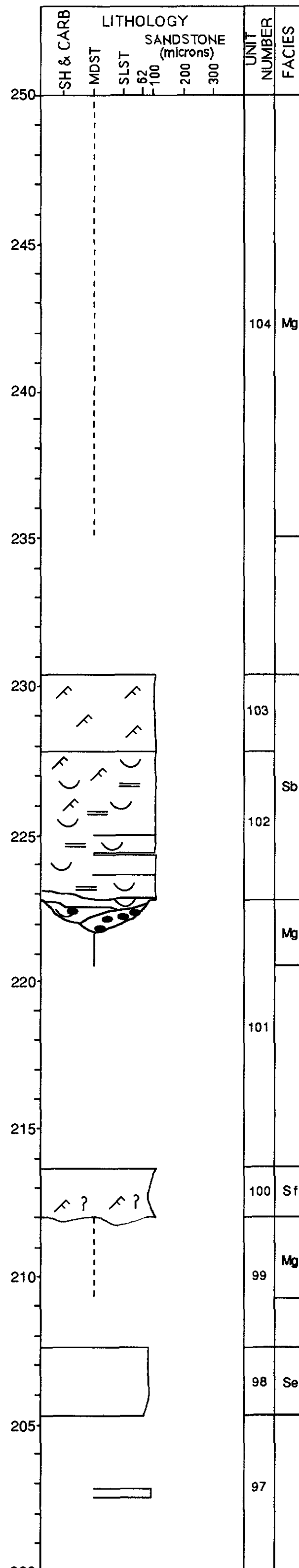
Unit 75: Covered. Green mudstone 20 cm thick at top.

Unit 74: Sandstone, fines upward (105 to 65 µ). Base gradational from very coarse grained siltstone to sandstone; 85-90 percent of unit structureless, 10-15 percent rippled; upper third of unit contains small (2-3 mm diameter) concretions or burrows.

Unit 73: Covered. Green mudstone under soil.

Unit 72: Sandstone, 65-70 µ. Base sharp, structureless, moderately calcareous.

SECTION 11 INTERVAL: 150 to 200 m



DESCRIPTION

Unit 104: Covered. Green mudstone fragments in upper 17 m; green mudstone crops out beneath unit 105.

Unit 103: Sandstone, 105 µ. Poorly exposed, rippled (50 percent) and structureless (50 percent).

Unit 102: Sandstone, 105 µ. Base sharp, several meters of scour; base of unit is composed of several lenticular sandstones; basal 75 cm has several zones of generally well rounded siltstone and mudstone clasts as long as 8 cm; trough crossbeds and planar laminations that dip (due to lateral accretion bedding?) are throughout unit; upper 2.0 m contains abundant ripples; abundant scour and fill within unit; mudstone interbeds in lower half only.

Unit 101: Mainly covered. Silty light-gray mudstone 2 m thick crops out beneath unit 102.

Unit 100: Sandstone, 80-110 µ. Base sharp, scoured, dips northeast; most of unit is structureless, ripples (?) in basal 40 cm.

Unit 99: Mainly covered. Lower 1.6 m is covered by thick soil; upper 2.8 m has abundant fragments of green mudstone on surface.

Unit 98: Sandstone, 65-80 µ. Base is covered, structureless.

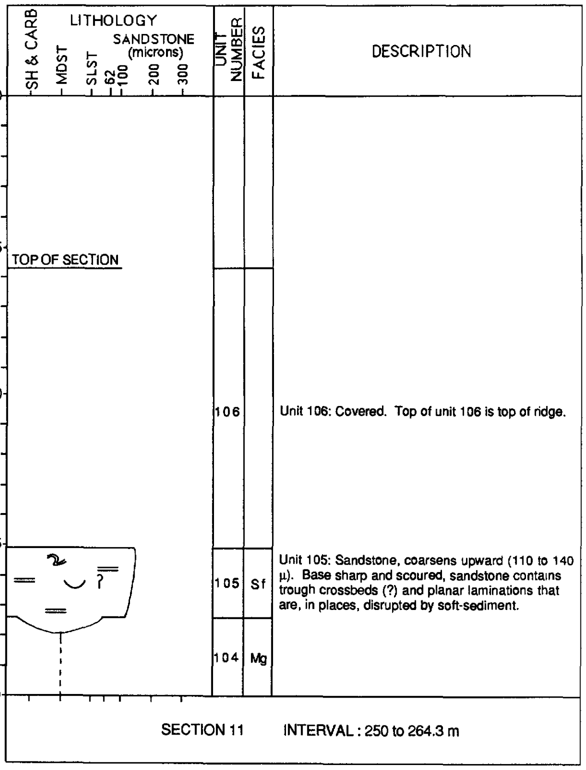
Unit 97: Mainly covered. Unit has one poorly exposed 90-µ sandstone.

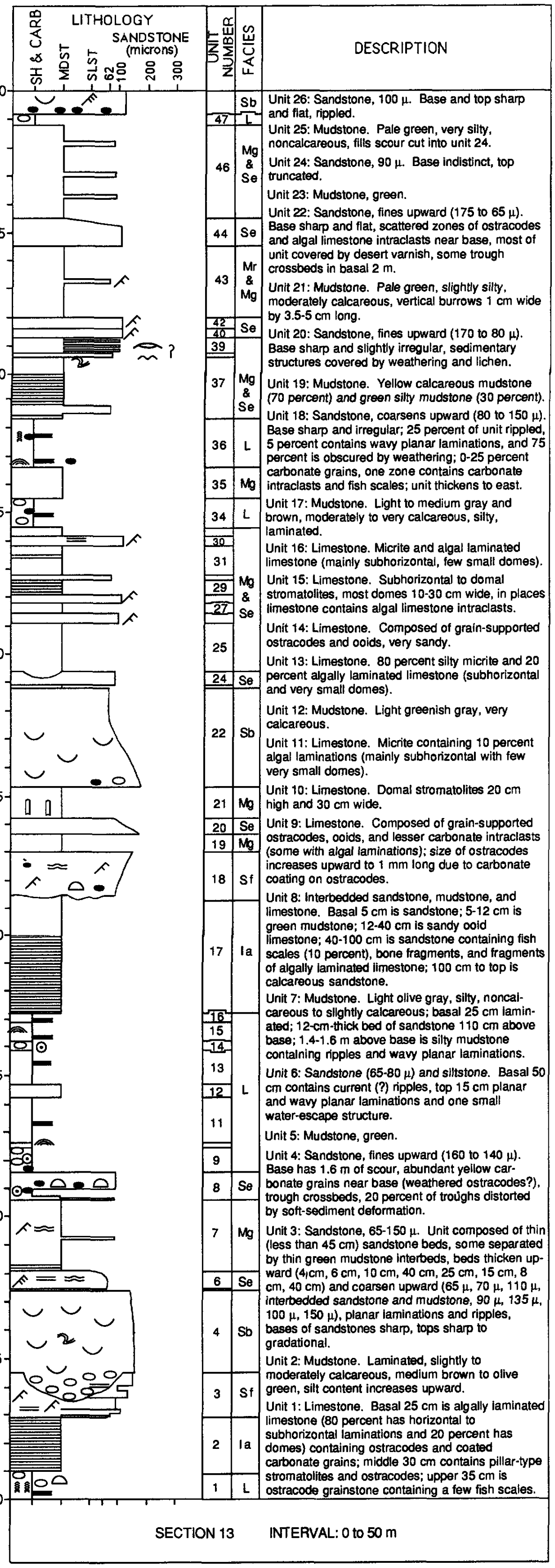
Unit 96: Sandstone, 125 µ. Base and top of unit dip 15° NW. (i.e. lateral-accretion bedding); planar laminations (some disturbed by soft-sediment deformation) and few trough crossbeds (?); upper 20-30 cm rippled; unit thins toward northwest.

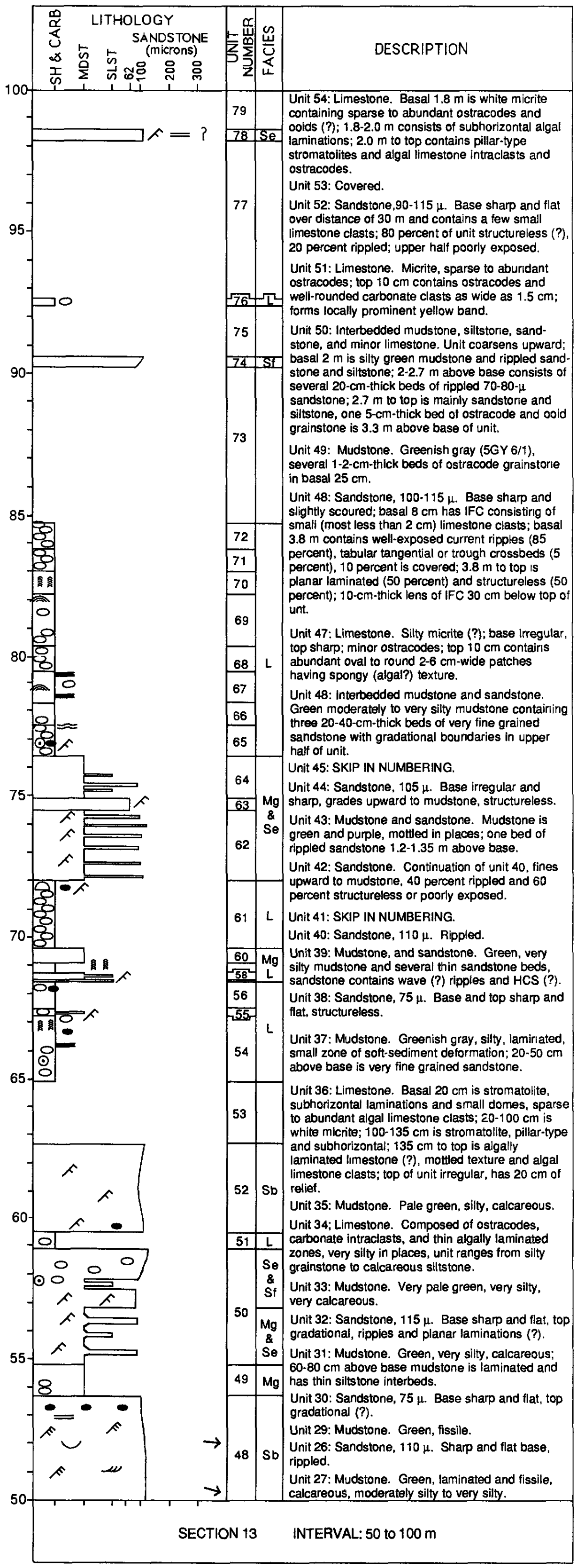
Unit 95: Mainly covered. Friable, very fine grained sandstone crops out beneath unit 96.

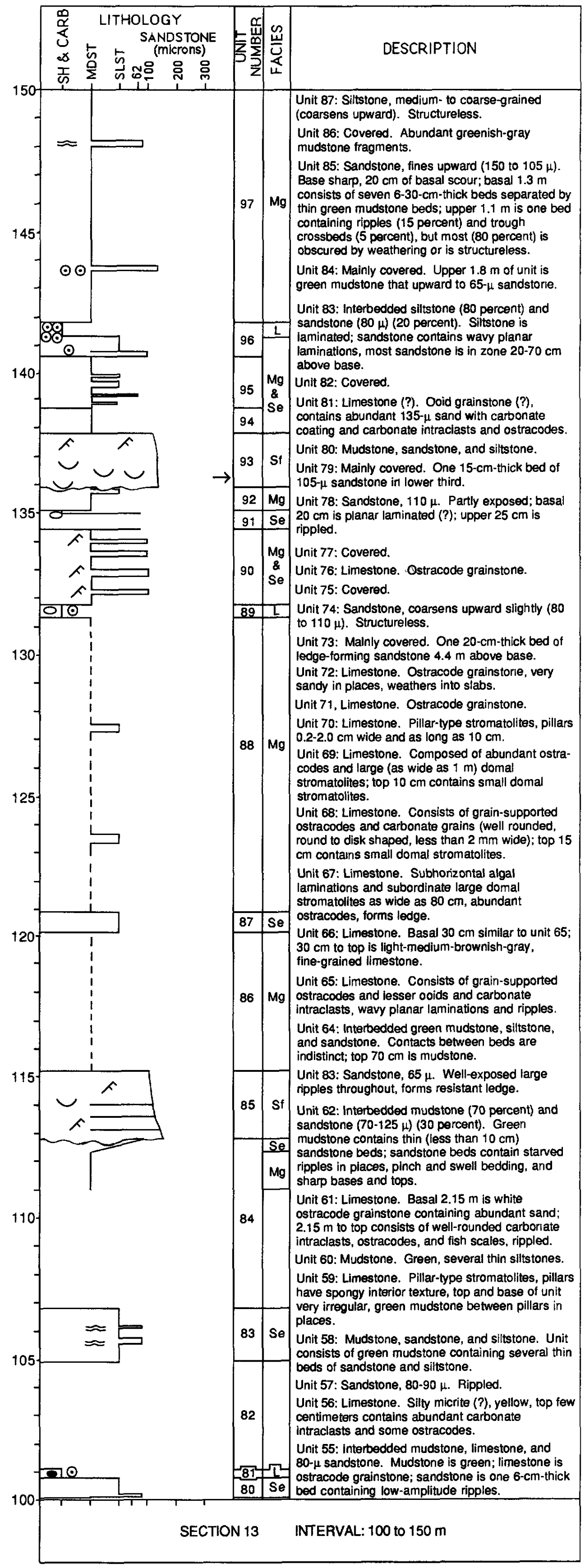
Unit 94: Sandstone, 100-140 µ. Base sharp, 50-60 cm of scour (truncates siltstone and mudstone); basal 50-60 cm is 140-µ sandstone containing mudstone clasts, bed thins to east and west; 60-80 cm above base is mudstone; 0.8-5.1 m is sandstone, base sharp and irregular and has basal siltstone clasts as long as 10 cm, 50 percent structureless, 20 percent planar laminated, 10 percent trough crossbedded, and 20 percent soft-sediment deformation and water-escape structures; 5.1 m to top contains planar laminations (40 percent) and ripples (40 percent), 20 percent structureless. Beds of unit are horizontal along measured section but 50-75 m west same unit contains lateral-accretion beds that dip to northeast (sandstone beds are 2-3 m thick and thin downdip, mudstone interbeds thicken downdip).

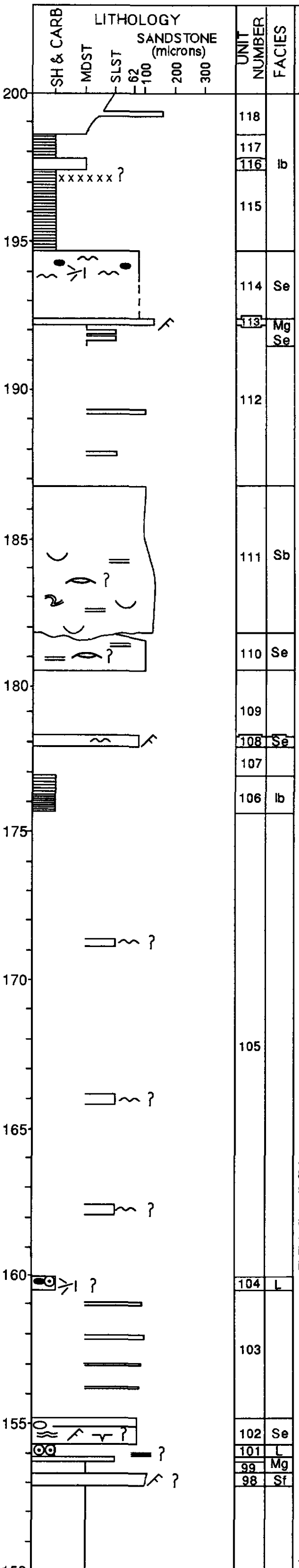
SECTION 11 INTERVAL: 200 to 250 m


LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
270
265
260
255
250
TOP OF SECTION
106
Unit 106: Covered. Top of unit 106 is top of ridge.
105
Sf
Unit 105: Sandstone, coarsens upward (110 to 140 µ). Base sharp and scoured, sandstone contains trough crossbeds (?) and planar laminations that are, in places, disrupted by soft-sediment.
104
Mg
SECTION 11
INTERVAL : 250 to 264.3 m


LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
Unit 26: Sandstone, 100 µ. Base and top sharp and flat, rippled.
Unit 25: Mudstone. Pale green, very silty, noncalcareous, fills scour cut into unit 24.
Unit 24: Sandstone, 90 µ. Base indistinct, top truncated.
Unit 23: Mudstone, green.
Unit 22: Sandstone, fines upward (175 to 65 µ). Base sharp and flat, scattered zones of ostracodes and algal limestone intraclasts near base, most of unit covered by desert varnish, some trough crossbeds in basal 2 m.
Unit 21: Mudstone. Pale green, slightly silty, moderately calcareous, vertical burrows 1 cm wide by 3.5-5 cm long.
Unit 20: Sandstone, fines upward (170 to 80 µ). Base sharp and slightly irregular, sedimentary structures covered by weathering and lichen.
Unit 19: Mudstone. Yellow calcareous mudstone (70 percent) and green silty mudstone (30 percent).
Unit 18: Sandstone, coarsens upward (80 to 150 µ). Base sharp and irregular; 25 percent of unit rippled, 5 percent contains wavy planar laminations, and 75 percent is obscured by weathering; 0-25 percent carbonate grains, one zone contains carbonate intraclasts and fish scales; unit thickens to east.
Unit 17: Mudstone. Light to medium gray and brown, moderately to very calcareous, silty, laminated.
Unit 16: Limestone. Micrite and algal laminated limestone (mainly subhorizontal, few small domes).
Unit 15: Limestone. Subhorizontal to domal stromatolites, most domes 10-30 cm wide, in places limestone contains algal limestone intraclasts.
Unit 14: Limestone. Composed of grain-supported ostracodes and ooids, very sandy.
Unit 13: Limestone. 80 percent silty micrite and 20 percent algally laminated limestone (subhorizontal and very small domes).
Unit 12: Mudstone. Light greenish gray, very calcareous.
Unit 11: Limestone. Micrite containing 10 percent algal laminations (mainly subhorizontal with few very small domes).
Unit 10: Limestone. Domal stromatolites 20 cm high and 30 cm wide.
Unit 9: Limestone. Composed of grain-supported ostracodes, ooids, and lesser carbonate intraclasts (some with algal laminations); size of ostracodes increases upward to 1 mm long due to carbonate coating on ostracodes.
Unit 8: Interbedded sandstone, mudstone, and limestone. Basal 5 cm is sandstone; 5-12 cm is green mudstone; 12-40 cm is sandy ooid limestone; 40-100 cm is sandstone containing fish scales (10 percent), bone fragments, and fragments of algally laminated limestone; 100 cm to top is calcareous sandstone.
Unit 7: Mudstone. Light olive gray, silty, noncalcareous to slightly calcareous; basal 25 cm laminated; 12-cm-thick bed of sandstone 110 cm above base; 1.4-1.6 m above base is silty mudstone containing ripples and wavy planar laminations.
Unit 6: Sandstone (65-80 µ) and siltstone. Basal 50 cm contains current (?) ripples, top 15 cm planar and wavy planar laminations and one small water-escape structure.
Unit 5: Mudstone, green.
Unit 4: Sandstone, fines upward (160 to 140 µ). Base has 1.6 m of scour, abundant yellow carbonate grains near base (weathered ostracodes?), trough crossbeds, 20 percent of troughs distorted by soft-sediment deformation.
Unit 3: Sandstone, 65-150 µ. Unit composed of thin (less than 45 cm) sandstone beds, some separated by thin green mudstone interbeds, beds thicken upward (4 cm, 6 cm, 10 cm, 40 cm, 25 cm, 15 cm, 8 cm, 40 cm) and coarsen upward (65 µ, 70 µ, 110 µ, interbedded sandstone and mudstone, 90 µ, 135 µ, 100 µ, 150 µ), planar laminations and ripples, bases of sandstones sharp, tops sharp to gradational.
Unit 2: Mudstone. Laminated, slightly to moderately calcareous, medium brown to olive green, silt content increases upward.
Unit 1: Limestone. Basal 25 cm is algally laminated limestone (80 percent has horizontal to subhorizontal laminations and 20 percent has domes) containing ostracodes and coated carbonate grains; middle 30 cm contains pillar-type stromatolites and ostracodes; upper 35 cm is ostracode grainstone containing a few fish scales.
SECTION 13
INTERVAL: 0 to 50 m


LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
Unit 54: Limestone. Basal 1.8 m is white micrite containing sparse to abundant ostracodes and ooids (?); 1.8-2.0 m consists of subhorizontal algal laminations; 2.0 m to top contains pillar-type stromatolites and algal limestone intraclasts and ostracodes.
Unit 53: Covered.
Unit 52: Sandstone,90-115 μ. Base sharp and flat over distance of 30 m and contains a few small limestone clasts; 80 percent of unit structureless (?), 20 percent rippled; upper half poorly exposed.
Unit 51: Limestone. Micrite, sparse to abundant ostracodes; top 10 cm contains ostracodes and well-rounded carbonate clasts as wide as 1.5 cm; forms locally prominent yellow band.
Unit 50: Interbedded mudstone, siltstone, sandstone, and minor limestone. Unit coarsens upward; basal 2 m is silty green mudstone and rippled sandstone and siltstone; 2-2.7 m above base consists of several 20-cm-thick beds of rippled 70-80-μ sandstone; 2.7 m to top is mainly sandstone and siltstone, one 5-cm-thick bed of ostracode and ooid grainstone is 3.3 m above base of unit.
Unit 49: Mudstone. Greenish gray (5GY 6/1), several 1-2-cm-thick beds of ostracode grainstone in basal 25 cm.
Unit 48: Sandstone, 100-115 μ. Base sharp and slightly scoured; basal 8 cm has IFC consisting of small (most less than 2 cm) limestone clasts; basal 3.8 m contains well-exposed current ripples (85 percent), tabular tangential or trough crossbeds (5 percent), 10 percent is covered; 3.8 m to top is planar laminated (50 percent) and structureless (50 percent); 10-cm-thick lens of IFC 30 cm below top of unt.
Unit 47: Limestone. Silty micrite (?); base irregular, top sharp; minor ostracodes; top 10 cm contains abundant oval to round 2-6 cm-wide patches having spongy (algal?) texture.
Unit 48: Interbedded mudstone and sandstone. Green moderately to very silty mudstone containing three 20-40-cm-thick beds of very fine grained sandstone with gradational boundaries in upper half of unit.
Unit 45: SKIP IN NUMBERING.
Unit 44: Sandstone, 105 μ. Base irregular and sharp, grades upward to mudstone, structureless.
Unit 43: Mudstone and sandstone. Mudstone is green and purple, mottled in places; one bed of rippled sandstone 1.2-1.35 m above base.
Unit 42: Sandstone. Continuation of unit 40, fines upward to mudstone, 40 percent rippled and 60 percent structureless or poorly exposed.
Unit 41: SKIP IN NUMBERING.
Unit 40: Sandstone, 110 μ. Rippled.
Unit 39: Mudstone, and sandstone. Green, very silty mudstone and several thin sandstone beds, sandstone contains wave (?) ripples and HCS (?).
Unit 38: Sandstone, 75 μ. Base and top sharp and flat, structureless.
Unit 37: Mudstone. Greenish gray, silty, laminated, small zone of soft-sediment deformation; 20-50 cm above base is very fine grained sandstone.
Unit 36: Limestone. Basal 20 cm is stromatolite, subhorizontal laminations and small domes, sparse to abundant algal limestone clasts; 20-100 cm is white micrite; 100-135 cm is stromatolite, pillar-type and subhorizontal; 135 cm to top is algally laminated limestone (?), mottled texture and algal limestone clasts; top of unit irregular, has 20 cm of relief.
Unit 35: Mudstone. Pale green, silty, calcareous.
Unit 34; Limestone. Composed of ostracodes, carbonate intraclasts, and thin algally laminated zones, very silty in places, unit ranges from silty grainstone to calcareous siltstone.
Unit 33: Mudstone. Very pale green, very silty, very calcareous.
Unit 32: Sandstone, 115 μ. Base sharp and flat, top gradational, ripples and planar laminations (?).
Unit 31: Mudstone. Green, very silty, calcareous; 60-80 cm above base mudstone is laminated and has thin siltstone interbeds.
Unit 30: Sandstone, 75 μ. Base sharp and flat, top gradational (?).
Unit 29: Mudstone. Green, fissile.
Unit 26: Sandstone, 110 μ. Sharp and flat base, rippled.
Unit 27: Mudstone. Green, laminated and fissile, calcareous, moderately silty to very silty.
SECTION 13
INTERVAL: 50 to 100 m


LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
Unit 87: Siltstone, medium- to coarse-grained (coarsens upward). Structureless.
Unit 86: Covered. Abundant greenish-gray mudstone fragments.
Unit 85: Sandstone, fines upward (150 to 105 μ). Base sharp, 20 cm of basal scour; basal 1.3 m consists of seven 6-30-cm-thick beds separated by thin green mudstone beds; upper 1.1 m is one bed containing ripples (15 percent) and trough crossbeds (5 percent), but most (80 percent) is obscured by weathering or is structureless.
Unit 84: Mainly covered. Upper 1.8 m of unit is green mudstone that upward to 65-μ sandstone.
Unit 83: Interbedded siltstone (80 percent) and sandstone (80 μ) (20 percent). Siltstone is laminated; sandstone contains wavy planar laminations, most sandstone is in zone 20-70 cm above base.
Unit 82: Covered.
Unit 81: Limestone (?). Ooid grainstone (?), contains abundant 135-μ sand with carbonate coating and carbonate intraclasts and ostracodes.
Unit 80: Mudstone, sandstone, and siltstone.
Unit 79: Mainly covered. One 15-cm-thick bed of 105-μ sandstone in lower third.
Unit 78: Sandstone, 110 μ. Partly exposed; basal 20 cm is planar laminated (?); upper 25 cm is rippled.
Unit 77: Covered.
Unit 76: Limestone. Ostracode grainstone.
Unit 75: Covered.
Unit 74: Sandstone, coarsens upward slightly (80 to 110 μ). Structureless.
Unit 73: Mainly covered. One 20-cm-thick bed of ledge-forming sandstone 4.4 m above base.
Unit 72: Limestone. Ostracode grainstone, very sandy in places, weathers into slabs.
Unit 71, Limestone. Ostracode grainstone.
Unit 70: Limestone. Pillar-type stromatolites, pillars 0.2-2.0 cm wide and as long as 10 cm.
Unit 69: Limestone. Composed of abundant ostracodes and large (as wide as 1 m) domal stromatolites; top 10 cm contains small domal stromatolites.
Unit 68: Limestone. Consists of grain-supported ostracodes and carbonate grains (well rounded, round to disk shaped, less than 2 mm wide); top 15 cm contains small domal stromatolites.
Unit 67: Limestone. Subhorizontal algal laminations and subordinate large domal stromatolites as wide as 80 cm, abundant ostracodes, forms ledge.
Unit 66: Limestone. Basal 30 cm similar to unit 65; 30 cm to top is light-medium-brownish-gray, fine-grained limestone.
Unit 65: Limestone. Consists of grain-supported ostracodes and lesser ooids and carbonate intraclasts, wavy planar laminations and ripples.
Unit 64: Interbedded green mudstone, siltstone, and sandstone. Contacts between beds are indistinct; top 70 cm is mudstone.
Unit 83: Sandstone, 65 μ. Well-exposed large ripples throughout, forms resistant ledge.
Unit 62: Interbedded mudstone (70 percent) and sandstone (70-125 μ) (30 percent). Green mudstone contains thin (less than 10 cm) sandstone beds; sandstone beds contain starved ripples in places, pinch and swell bedding, and sharp bases and tops.
Unit 61: Limestone. Basal 2.15 m is white ostracode grainstone containing abundant sand; 2.15 m to top consists of well-rounded carbonate intraclasts, ostracodes, and fish scales, rippled.
Unit 60: Mudstone. Green, several thin siltstones.
Unit 59: Limestone. Pillar-type stromatolites, pillars have spongy interior texture, top and base of unit very irregular, green mudstone between pillars in places.
Unit 58: Mudstone, sandstone, and siltstone. Unit consists of green mudstone containing several thin beds of sandstone and siltstone.
Unit 57: Sandstone, 80-90 μ. Rippled.
Unit 56: Limestone. Silty micrite (?), yellow, top few centimeters contains abundant carbonate intraclasts and some ostracodes.
Unit 55: Interbedded mudstone, limestone, and 80-μ sandstone. Mudstone is green; limestone is ostracode grainstone; sandstone is one 6-cm-thick bed containing low-amplitude ripples.
SECTION 13
INTERVAL: 100 to 150 m



DESCRIPTION

Unit 114: Sandstone, 65 μ. Basal 1.3 m is poorly exposed; upper 1.0 m contains wave ripples (with offshoots, ripple antiforms, etc.), syneresis cracks, and zones containing small carbonate clasts.

Unit 113: Sandstone, 130 μ, one 3-4 cm-thick zone of 160-μ sand near top. Rippled.

Unit 112: Mainly covered. Several thin (less than 40 cm) beds of sandstone and siltstone; 50 cm of greenish-brown siltstone and green mudstone crops out beneath unit 113.

Unit 111: Sandstone, 100-130 μ. Base sharp, 10-15 cm of scour; basal 3.0 m contains 30 percent trough crossbeds (some disturbed by soft-sediment deformation), 20 percent planar laminations (some laminations may be slightly curved, HCS?), and 50 percent sedimentary structures obscured or structureless; upper 2.0 m structureless.

Unit 110: Sandstone, 90-100 μ. Grades upward to medium-grained siltstone at top, some planar laminations and HCS (?) but most sedimentary structures obscured by weathering and desert varnish.

Unit 109: Covered.

Unit 108: Sandstone, 75 μ. Well-exposed ripples (some are wave ripples).

Unit 107: Covered.

Unit 106: Dolostone. Basal 60 cm is laminated, medium to dark brown, few thin (few cm) kerogenous zones have faint oily smell (oil shale); upper 60 cm is laminated dolostone, medium to light brownish gray, breaks into 1-5-mm-thick slabs, very slightly calcareous, very slightly silty.

Unit 105: Mainly covered. Soil and float are very light gray, float and minor outcrop of white, calcareous wave (?)-rippled medium-grained siltstone.

Unit 104: Limestone. Basal 15 cm is tar-stained ooid limestone that contains syneresis cracks (?) at top; upper 25 cm is composed of coated grains (no nuclei observed) and minor laminated limestone intraclasts.

Unit 103: Mainly covered. Unit has 4-5 thin (10-15 cm) beds of laterally persistent very fine-grained sandstone.

Unit 102: Sandstone, 65-70 μ. Planar laminations, some beds wavy, and minor ripples; few thin ostracode limestone interbeds; several mudcracked (?) zones; forms regionally prominent ledge.

Unit 101: Limestone. Basal 20 cm is algally laminated (?); upper 20 cm is grain-supported ooids without obvious nuclei.

Unit 100: Siltstone, medium-grained. Very calcareous, white.

Unit 99: Mudstone. Green, poorly exposed.

Unit 98: Sandstone, coarsens upward slightly (90 to 110 μ). Rippled (?).

Unit 97: Mainly covered. Unit probably mainly green mudstone; 1.8 m above base is 20-cm-thick bed of 135-μ sandstone containing ooids; 6.2 m above base is laterally persistant 20-cm-thick bed of 75-80-μ sandstone that contains wavy planar laminations.

Unit 96: Sandstone, siltstone, and limestone. Basal 20 cm is sandstone, calcareous, contains ooids; 20-85 cm is siltstone, medium- to coarse-grained; 85 cm to top is limestone composed of ooids with sand nuclei, sand coarsens upward (90 to 120 μ).

Unit 95: Interbedded siltstone (50 percent), green mudstone (30 percent), and sandstone (20 percent). Siltstone is calcareous and thin bedded; sandstone is one 25-cm-thick bed 1.3 m above base; top 30 cm is green mudstone.

Unit 94: Mudstone, green.

Unit 93: Sandstone, 115-135 μ. Base sharp, 20-30 cm of scour; basal 1.0 m contains trough crossbeds; upper 0.9 m is 90 percent covered by desert varnish and 10 percent rippled.

Unit 92: Mudstone and siltstone. Basal 50 cm is green mudstone; upper 30 cm is silty green mudstone and siltstone.

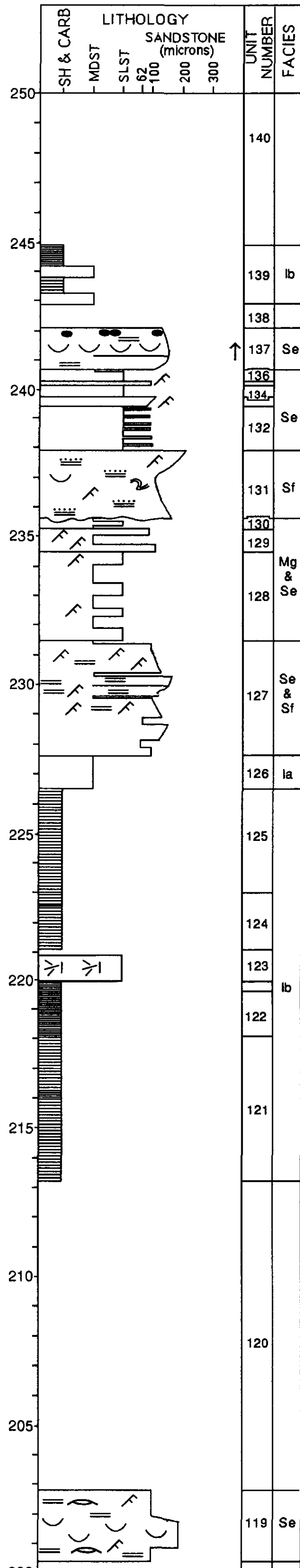
Unit 91: Sandstone, 62-110 μ (coarsens upward from mudstone). Base gradational and top sharp, top 13 cm is limestone containing ostracodes.

Unit 90: Interbedded green mudstone (60 percent) and sandstone (40 percent). Sandstone beds are rippled in places and are 2-15 cm thick.

Unit 89: Limestone. Composed of ostracodes and ooids (with well-developed concentric layers), and minor laminated (?) algal limestone clasts.

Unit 88: Covered. Greenish-gray mudstone fragments common, few thin siltstone beds.

SECTION 13 INTERVAL: 150 to 200 m



DESCRIPTION

Unit 138: Covered.

Unit 137: Sandstone, 95-125 μ. One set of trough crossbeds in center of unit; some planar laminations; sedimentary structures in most of unit obscured; top 10-15 cm contains abundant yellow brown mudstone chips as long as 5 cm; one 2-cm-thick interbed of yellow-brown mudcracked mudstone.

Unit 136: Siltstone, coarse-grained. Top 10 cm is green silty mudstone.

Unit 135: Sandstone, 95 μ. Rippled.

Unit 134: Siltstone, very coarse grained. Friable.

Unit 133: Sandstone, coarsens upward (65 to 110 μ). Rippled.

Unit 132: Siltstone and sandstone. Unit consists of 5-6 4-5-cm-thick sandstone beds within siltstone.

Unit 131: Sandstone, 110-210 μ. Base sharp and slightly scoured; 65 percent planar laminations containing parting lineations, 25 percent ripples, 5 percent soft-sediment deformation, and 5 percent trough or tabular-tangential crossbeds.

Unit 130: Mudstone-siltstone. Very silty green mudstone or medium-grained siltstone.

Unit 129: Sandstone (90-110 μ) and mudstone. Basal 25 cm is rippled 110-μ sandstone; 25-55 cm is very silty green mudstone; 55 cm to top is rippled 90-μ sandstone.

Unit 128: Mudstone-siltstone. Medium-greenish-brown, very silty mudstone or medium-grained siltstone, coarser zones rippled in places.

Unit 127: Sandstone (65-125 μ) and mudstone. Basal 30 cm consists of five beds of 100-μ structureless sandstone; 30-55 cm is 65-70-μ sandstone; 55-115 cm is sandstone, coarsens upward; 115-130 cm is 65-70-μ sandstone; 130-185 cm is sandstone, fines upward (130 to 100 μ), basal few centimeters rippled, rest of bed planar laminated; 185-192 cm is green mudstone; 192-240 cm is 120-μ sandstone that is rippled and planar laminated; 240-243 cm is green mudstone; 243-273 cm is planar laminated 155-165-μ sandstone; 273-290 cm is green mudstone; 290-360 cm is rippled (70 percent) and planar laminated (30 percent) sandstone, fines upward (125 to 100 μ); 360-387 cm is 105-μ rippled sandstone; 380 cm to top is green mudstone; all sandstone beds have sharp flat bases and tops.

Unit 126: Mudstone. Medium olive brown, calcareous.

Unit 125: Shale. Medium brownish gray, fissile, calcareous.

Unit 124: Dolostone. Laminated; 10-cm-thick kerogenous, laminated dolostone (oil shale) 1.4 m above base.

Unit 123: Dolostone and siltstone. Basal 40 cm is kerogenous, laminated dolostone (oil shale); 40-130 cm is siltstone, calcareous, syneresis cracks; 130 cm to top is covered.

Unit 122: Dolostone. Kerogenous and laminated (oil shale), very dark gray, bluish-gray weathered color.

Unit 121: Dolostone. Brown, laminated, one 20-cm-thick kerogenous dolostone (oil shale) and a few 1-2-cm-thick beds of chert.

Unit 120: Covered.

Unit 119: Sandstone,110-165 μ. Basal 50 cm and 160 cm to top 110-μ sandstone that contains planar laminations (60 percent), HCS (mainly synforms and abundant low-angle truncations) (35 percent), and ripples (5 percent); 50-160 cm above base is 185-μ sandstone, base sharp with few centimeters relief, top is sharp, top 20 cm fines to 100 μ, trough crossbeds, top 10 cm contains HCS.

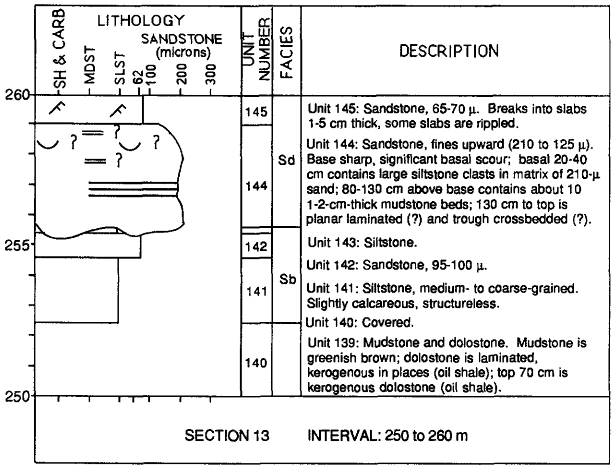
Unit 118: Mudstone, siltstone, and sandstone (160 μ). Grain size increases upward, one 25-cm-thick bed of lenticular sandstone and several thinner sandstones, sandstone beds mainly in upper half.

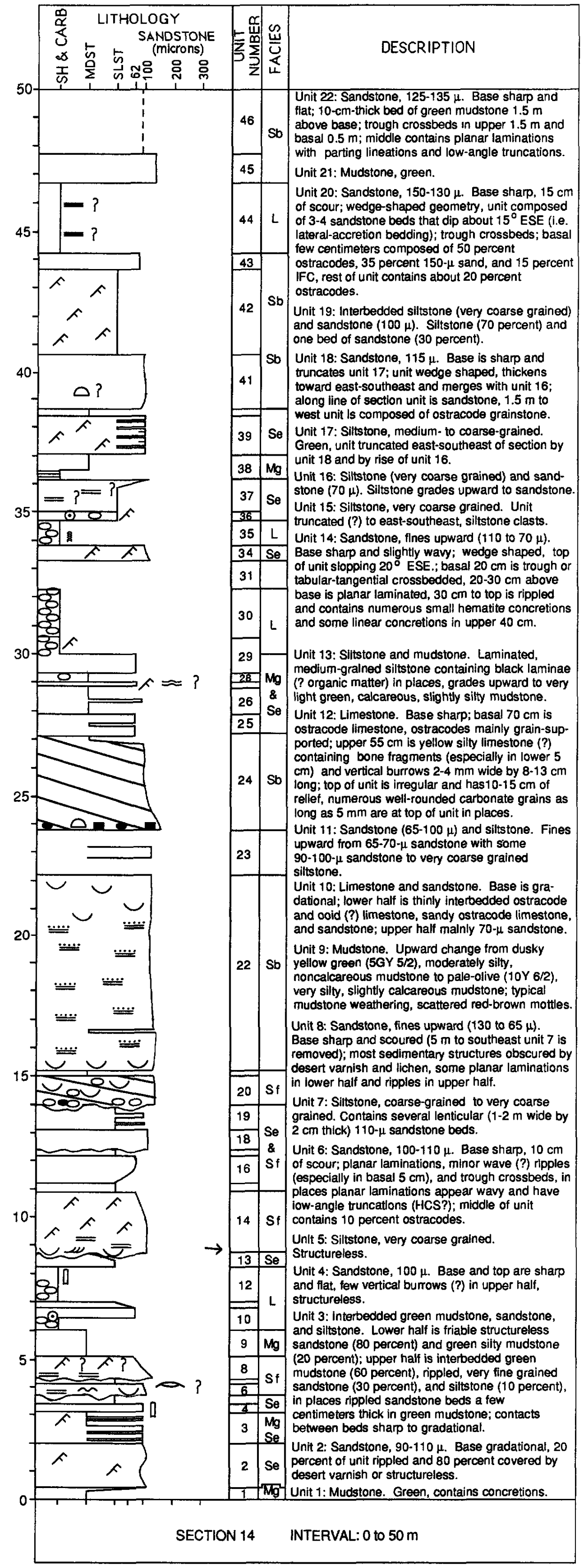
Unit 117: Dolostone. Basal 30 cm laminated, light to medium brown; upper 50 cm brecciated and laminated, slightly calcareous, slightly silty.

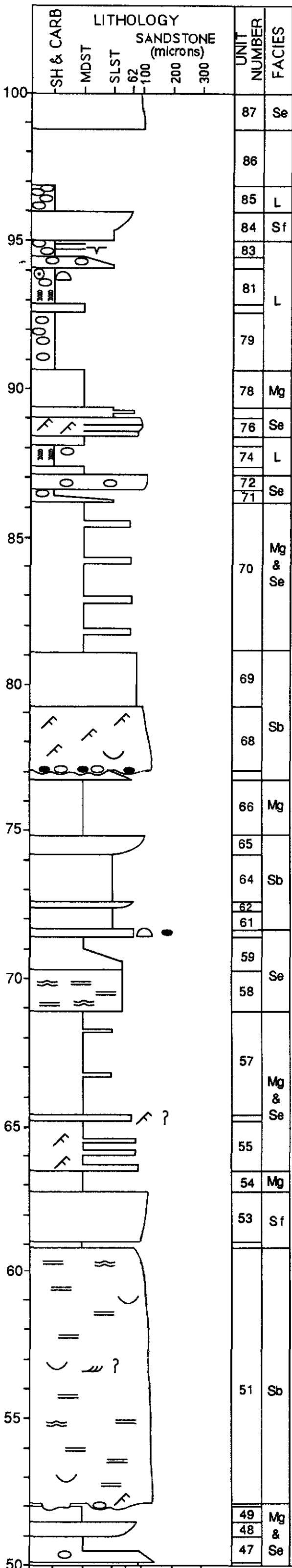
Unit 116: Mudstone. Green, laminated.

Unit 115: Dolostone. Laminated, brown, lower half poorly exposed, 7-cm-thick tuff (?) near top.

SECTION 13 INTERVAL: 200 to 250 m


LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
Unit 145: Sandstone, 65-70 µ. Breaks into slabs 1-5 cm thick, some slabs are rippled.
Unit 144: Sandstone, fines upward (210 to 125 µ). Base sharp, significant basal scour; basal 20-40 cm contains large siltstone clasts in matrix of 210-µ sand; 80-130 cm above base contains about 10 1-2-cm-thick mudstone beds; 130 cm to top is planar laminated (?) and trough crossbedded (?).
Unit 143: Siltstone.
Unit 142: Sandstone, 95-100 µ.
Unit 141: Siltstone, medium- to coarse-grained. Slightly calcareous, structureless.
Unit 140: Covered.
Unit 139: Mudstone and dolostone. Mudstone is greenish brown; dolostone is laminated, kerogenous in places (oil shale); top 70 cm is kerogenous dolostone (oil shale).
SECTION 13
INTERVAL: 250 to 260 m


LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
Unit 22: Sandstone, 125-135 µ. Base sharp and flat; 10-cm-thick bed of green mudstone 1.5 m above base; trough crossbeds in upper 1.5 m and basal 0.5 m; middle contains planar laminations with parting lineations and low-angle truncations.
Unit 21: Mudstone, green.
Unit 20: Sandstone, 150-130 µ. Base sharp, 15 cm of scour; wedge-shaped geometry, unit composed of 3-4 sandstone beds that dip about 15° ESE (i.e. lateral-accretion bedding); trough crossbeds; basal few centimeters composed of 50 percent ostracodes, 35 percent 150-µ sand, and 15 percent IFC, rest of unit contains about 20 percent ostracodes.
Unit 19: Interbedded siltstone (very coarse grained) and sandstone (100 µ). Siltstone (70 percent) and one bed of sandstone (30 percent).
Unit 18: Sandstone, 115 µ. Base is sharp and truncates unit 17; unit wedge shaped, thickens toward east-southeast and merges with unit 16; along line of section unit is sandstone, 1.5 m to west unit is composed of ostracode grainstone.
Unit 17: Siltstone, medium- to coarse-grained. Green, unit truncated east-southeast of section by unit 18 and by rise of unit 16.
Unit 16: Siltstone (very coarse grained) and sandstone (70 µ). Siltstone grades upward to sandstone.
Unit 15: Siltstone, very coarse grained. Unit truncated (?) to east-southeast, siltstone clasts.
Unit 14: Sandstone, fines upward (110 to 70 µ). Base sharp and slightly wavy; wedge shaped, top of unit slopping 20° ESE.; basal 20 cm is trough or tabular-tangential crossbedded, 20-30 cm above base is planar laminated, 30 cm to top is rippled and contains numerous small hematite concretions and some linear concretions in upper 40 cm.
Unit 13: Siltstone and mudstone. Laminated, medium-grained siltstone containing black laminae (? organic matter) in places, grades upward to very light green, calcareous, slightly silty mudstone.
Unit 12: Limestone. Base sharp; basal 70 cm is ostracode limestone, ostracodes mainly grain-supported; upper 55 cm is yellow silty limestone (?) containing bone fragments (especially in lower 5 cm) and vertical burrows 2-4 mm wide by 8-13 cm long; top of unit is irregular and has10-15 cm of relief, numerous well-rounded carbonate grains as long as 5 mm are at top of unit in places.
Unit 11: Sandstone (65-100 µ) and siltstone. Fines upward from 65-70-µ sandstone with some 90-100-µ sandstone to very coarse grained siltstone.
Unit 10: Limestone and sandstone. Base is gradational; lower half is thinly interbedded ostracode and ooid (?) limestone, sandy ostracode limestone, and sandstone; upper half mainly 70-µ sandstone.
Unit 9: Mudstone. Upward change from dusky yellow green (5GY 5/2), moderately silty, noncalcareous mudstone to pale-olive (10Y 6/2), very silty, slightly calcareous mudstone; typical mudstone weathering, scattered red-brown mottles.
Unit 8: Sandstone, fines upward (130 to 65 µ). Base sharp and scoured (5 m to southeast unit 7 is removed); most sedimentary structures obscured by desert varnish and lichen, some planar laminations in lower half and ripples in upper half.
Unit 7: Siltstone, coarse-grained to very coarse grained. Contains several lenticular (1-2 m wide by 2 cm thick) 110-µ sandstone beds.
Unit 6: Sandstone, 100-110 µ. Base sharp, 10 cm of scour; planar laminations, minor wave (?) ripples (especially in basal 5 cm), and trough crossbeds, in places planar laminations appear wavy and have low-angle truncations (HCS?); middle of unit contains 10 percent ostracodes.
Unit 5: Siltstone, very coarse grained. Structureless.
Unit 4: Sandstone, 100 µ. Base and top are sharp and flat, few vertical burrows (?) in upper half, structureless.
Unit 3: Interbedded green mudstone, sandstone, and siltstone. Lower half is friable structureless sandstone (80 percent) and green silty mudstone (20 percent); upper half is interbedded green mudstone (60 percent), rippled, very fine grained sandstone (30 percent), and siltstone (10 percent), in places rippled sandstone beds a few centimeters thick in green mudstone; contacts between beds sharp to gradational.
Unit 2: Sandstone, 90-110 µ. Base gradational, 20 percent of unit rippled and 80 percent covered by desert varnish or structureless.
Unit 1: Mudstone. Green, contains concretions.
SECTION 14
INTERVAL: 0 to 50 m



DESCRIPTION

Unit 55: Mudstone-siltstone and sandstone. Interbedded very silty green mudstone or siltstone (60 percent) and sandstone (40 percent); ripples (?) in upper sandstone.

Unit 54: Mudstone, green.

Unit 53: Sandstone, coarsens upward (95 to 120 μ). Structureless, numerous hematite concretions.

Unit 52: Mudstone, green.

Unit 51: Sandstone, fines upward (135 to 70 μ). Base sharp and in places scours units 50 and 49; mainly planar laminations, some trough crossbeds (20 percent), wavy planar laminations with low-angle truncations, and minor tabular-tangential crossbeds (?).

Unit 50: Limestone. Very fine grained carbonate grains and some ostracodes, sandy, wavy planar laminations and ripples.

Unit 49: Mudstone. Light gray, very silty, noncalcareous, typical mudstone weathering.

Unit 48: Siltstone (coarse grained) and sandstone (70-80 μ). Coarsens upward from siltstone to sandstone at top, structureless.

Unit 47: Sandstone (90-140 μ) and mudstone. Basal 40 cm consists of sandstone that fines upward (140 to 90 μ), ostracodes, obscure sedimentary structures; upper 50 cm green mudstone.

Unit 46: Sandstone. Partly exposed.

Unit 45: Sandstone, 135 μ. Base covered.

Unit 44: Limestone. Algal (?), blotchy porous texture, partly exposed.

Unit 43: Sandstone, very fine grained. Structureless.

Unit 42: Siltstone, rippled.

Unit 41: Sandstone, 80-100 μ. Few fish scales (?) and bone fragments.

Unit 40: Mudstone. Green, some intervals fissile.

Unit 39: Interbedded sandstone (90-105 μ) and siltstone (very coarse grained). Four or five 2-15-cm-thick beds of sandstone separated by siltstone, sandstone beds pinch-and-swell, sandstone coarsens upward from 90 to 105 μ and is rippled in places.

Unit 38: Mudstone and shale. Basal 40 cm is dark-brown, silty, fissile shale; upper 50 cm is silty, green, calcareous mudstone, some fissile zones.

Unit 37: Siltstone (medium to coarse grained) and sandstone (110 μ). Unit coarsens upward from siltstone to sandstone; calcareous and planar laminated (?).

Unit 36: Siltstone, coarse-grained. Rippled, sparse to 20 percent ostracodes and ooids (?).

Unit 35: Limestone. Ostracode grainstone, pillar-type algal stromatolites (?) in lower 20 cm.

Unit 34: Sandstone, fines upward slightly (115 to 95 μ). Rippled.

Units 32 and 33: NONE (UNIT NUMBER SKIPPED).

Unit 31: Covered.

Unit 30: Limestone. Basal 60 cm is ostracode grainstone that grades upward to ooid grainstone consisting of carbonate-coated ostracodes, overall coarsening upward due to carbonate coatings on ostracodes; upper 1.1 m is ostracode grainstone.

Unit 29: Sandstone (very fine grained), siltstone, and limestone. Basal 70 cm is indistinctly bedded sandstone and siltstone; upper 55 cm is mainly rippled ostracode grainstone containing sand stringers.

Unit 28: Mudstone. Pale olive (10Y 6/2); 5 cm above base is 1-cm-thick band of orange ostracode grainstone, above this bed are a few less distinct bands of ostracode grainstone.

Unit 27: Sandstone, 65-70 μ. Base sharp, ripples (?) or wavy planar (?) laminations.

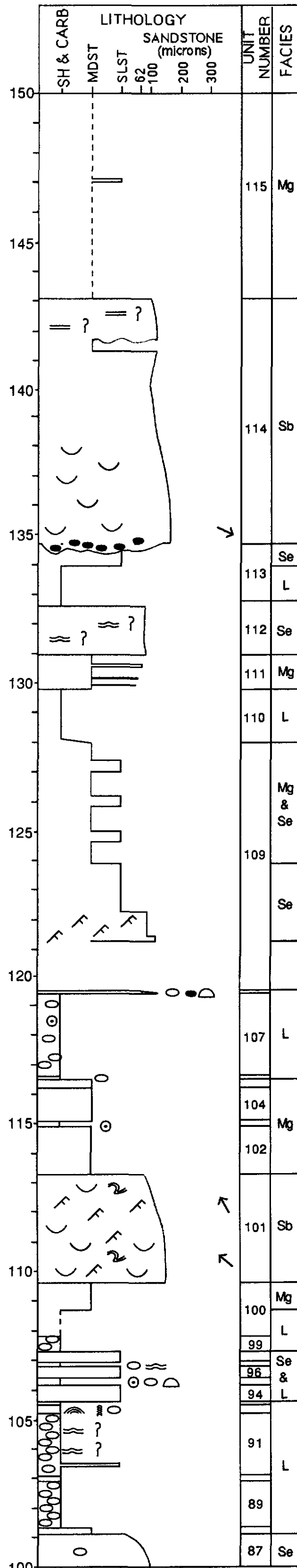
Unit 26: Mudstone. Green, silty; 12-cm-thick 90-μ sandstone bed in center and 5-cm-thick sandstone bed about 10 cm from top.

Unit 25: Sandstone, 60-70 μ. Gradational base and top; friable, structureless; 10-15-cm-thick green mudstone bedin center.

Unit 24: Sandstone, fines upward (150 to 90 μ). Base poorly exposed; basal few centimeters contains carbonaceous debris, IFC, few bone fragments and fish scales (?); wedge shaped geometry, wedge thins toward southeast, sandstone beds dip 11° SSW (lateral-accretion bedding); sedimentary structures obscured but probably no large-scale structures; top 30 cm grades to green mudstone. 7 m southeast of section unit is composed of sandstone (40 percent) and covered intervals (60 percent) (mudstone?).

Unit 23: Mainly covered. One 40-cm-thick 125-μ sandstone bed in center.

SECTION 14 INTERVAL: 50 to 100 m



DESCRIPTION

Unit 88: Mudstone. Green; lower half typical mudstone weathering; upper half spheroidal weathering and hematite stains.

Unit 87: Sandstone (62-100 μ) and siltstone (coarse grained). Lower half is 100-μ structureless sandstone; upper half grades upward to siltstone.

Unit 86: Covered.

Unit 85: Limestone. Ostracode grainstone; top 2-3 cm of unit is sandy; weathers orange yellow.

Unit 84: Siltstone (medium to coarse grained) and sandstone (65-70 μ). Unit coarsens upward from siltstone to laminated (?) sandstone.

Unit 83: Limestone. Ostracode grainstone; upper half contains thin (0.5-2 cm) beds of ostracode grainstone separated by thin (few millimeters) mudcracked green mudstone drapes.

Unit 82: Interbedded green mudstone and siltstone. Unit fines upward; top 6 cm contains 50 percent ostracodes.

Unit 81: Limestone. Basal 25-60 cm consists of pillar-type algal stromatolites, top of lower zone is very irregular, overlain by silty micrite (?) containing 20 percent ostracodes and ooids; upper 20 cm contains abundant fish scales.

Unit 80: Mudstone. Light green, silty, calcareous.

Unit 79: Limestone. Silty micrite (?), basal 1.6 m *has upward increase in proportion of ostracodes* from none to 25 percent; upper 30 cm contains minor ostracodes; structureless.

Unit 78: Mudstone. Grayish green (5G 5/2) to pale green (10G 6/2), some spheroidal weathering but most has typical mudstone weathering.

Unit 77: Interbedded siltstone (coarse grained) and sandstone (very fine grained). Bedding and contacts between beds indistinct.

Unit 76: Sandstone, 80-100 μ. Unit consists of rippled sandstone beds separated by 1-4-cm-thick beds of green mudstone.

Unit 75: Mudstone. Green, typical mudstone weathering.

Unit 74: Limestone. Silty micrite (?), 5-10 percent ostracodes; upper 10 cm contains pillar-type algal stromatolites (?).

Unit 73: Mudstone, green.

Unit 72: Sandstone, 100-115 μ. Basal 10 cm consists of 2-3 beds of 100-μ sandstone containing 5-10 percent ostracodes; upper 40 cm is structureless 115-μ sandstone.

Unit 71: Sandstone (65 μ) and limestone. Sandstone containing minor ostracodes that *grades upward to sandy ostracode limestone*, ostracodes look abraded.

Unit 70: Mudstone and sandstone (65-80 μ). Green mudstone containing 4-5 20-35-cm-thick beds of sandstone.

Unit 69: Sandstone, 70-90 μ. Friable, structureless.

Unit 68: Sandstone, fines upward (125 to 105 μ). Base sharp and has 20 cm of scour, in places 7-cm-thick basal lag consists of carbonate clasts, carbonaceous debris, and ostracodes in matrix of 160-μ sand; unit mainly rippled, minor trough crossbeds in lower half.

Unit 67: Siltstone (coarse grained) and sandstone (65-70 μ). Basal 10 cm is sandstone; upper 24 cm is calcareous siltstone.

Unit 66: Mudstone. Green, spheroidal weathering in places, most weathers like typical mudstone.

Unit 65: Siltstone (very coarse grained) and sandstone (62-110 μ). Siltstone that coarsens upward to 110-μ sandstone, numerous small bone and turtle shell fragments on top of unit.

Unit 64: Siltstone, very coarse-grained. Poorly exposed, green.

Unit 63: NONE (UNIT NUMBER SKIPPED).

Unit 62: Sandstone, 70 μ. Base gradational with unit 61, bed thickness 1-8 cm.

Unit 61: Siltstone, green.

Unit 60: Sandstone, 70 μ. Fish scales and IFC in basal 8 cm.

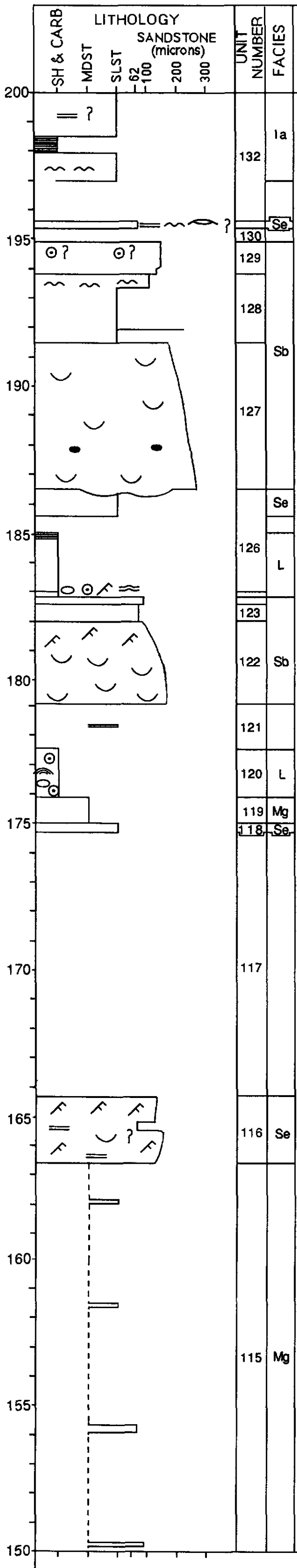
Unit 59: Poorly exposed. Lower half continuation of unit 58; upper half green mudstone.

Unit 58: Siltstone (very coarse grained) and sandstone (very fine grained). Planar and wavy planar laminations.

Unit 57: Mudstone. Green, few thin beds of sandstone.

Unit 58: Sandstone, 65 μ. Rippled (?).

SECTION 14 INTERVAL: 100 to 150 m



DESCRIPTION

Unit 119: Mudstone. Green, poorly exposed.

Unit 118: Siltstone. Forms resistant ledge.

Unit 117: Mainly covered. Minor (10 percent of unit) outcrops of green mudstone, siltstone, and sandstone.

Unit 116: Sandstone, 65-150 μ. Basal 1.5 m is planar laminated, rippled, and trough crossbedded (?); 1.5 m to top is rippled; very weakly tar stained in places.

Unit 115: Mainly covered. Abundant green mudstone float suggests unit is mainly green mudstone, 4-5 thin sandstone and siltstone beds.

Unit 114: Sandstone (fines upward (160 to 100 μ)) and minor mudstone. Base sharp, scours unit 113; basal 20 cm has lag consisting of small (less than 1.5 cm diameter) limestone clasts; 1.8-1.4 m below top is bed of green mudstone scoured by overlying sandstone; basal 3.0 m of unit is trough crossbedded; upper 1.4 m planar laminated (?).

Unit 113: Limestone and siltstone (medium to coarse grained). Basal 1.3 m is light-gray micrite; 1.3 m to top is light-gray siltstone.

Unit 112: Sandstone, 70-80 μ. Wavy planar laminations (?).

Unit 111: Interbedded green mudstone and sandstone. Upward increase in bed thickness (1 to 5 cm) and amount of sandstone; 40 cm above base is 7-cm-thick bed of sandstone containing 20 percent carbonate clasts.

Unit 110: Limestone. Micrite or very calcareous mudstone, light-gray, weathers yellow, fine-grained, base gradational over 15-20 cm with underlying mudstone, top sharp.

Unit 109: Sandstone (80-115 μ), siltstone, and mudstone. Basal 1.8 m is covered; 1.8-2.0 m above base is rippled 115-μ sandstone; 2.0-2.8 m is rippled 80-μ sandstone; 2.8–4.4 m is very coarse grained structureless siltstone; 4.4 to top is silty green mudstone containing three 35-50-cm-thick beds of structureless siltstone.

Unit 108: Sandstone, fines upward (125 to 65 μ). Contains as much as 10 percent fish scales, carbonate clasts, and ostracodes.

Unit 107: Limestone. Silty micrite (?), abundant ostracodes 50-75 cm above base, other thin zones of ostracodes and ooids (?) throughout unit.

Unit 106: Limestone. Ostracode grainstone.

Unit 105: Mudstone. Consists of 10-cm-thick bed of medium-gray calcareous mudstone that weathers orange overlain by 20-cm-thick bed of light-gray moderately calcareous mudstone.

Unit 104: Mudstone. Green, calcareous, silty, typical mudstone weathering.

Unit 103: Limestone. Mainly silty micrite (?); basal 2 cm is ooid grainstone.

Unit 102: Mudstone. Green, poorly exposed.

Unit 101: Sandstone, fines upward (150 to 75 μ). Base is sharp and flat; basal 1.3 m contains trough crossbeds and large-scale soft sediment deformation; 1.3 m to top contains ripples, trough crossbeds, and minor small-scale soft-sediment deformation.

Unit 100: Mainly covered. Lower half is probably ostracode grainstone; olive-gray, fine-grained mudstone crops out beneath unit 101.

Unit 99: Limestone. Ostracode grainstone.

Unit 98: Siltstone (?). Very calcareous, laminated.

Unit 97: Limestone. Ostracode grainstone, wavy planar laminations.

Unit 96: Siltstone, coarse-grained. Light gray, calcareous, massive.

Unit 95: Limestone. Lower half is ostracode and ooid (?) grainstone containing fish scales; upper half is ooid grainstone (?).

Unit 94: Siltstone (?). Laminated (?), calcareous.

Unit 93: Limestone. Consists of small domal and pillar-type stromatolites, and ostracodes.

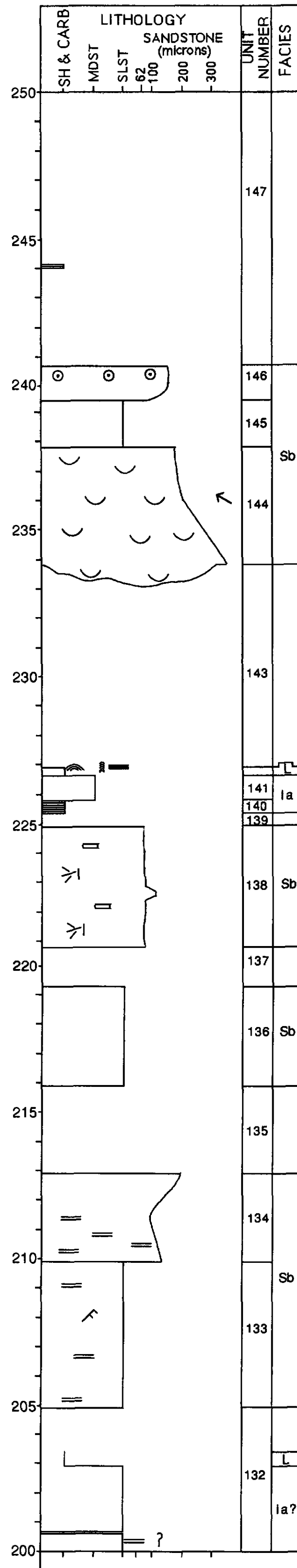
Unit 92: Limestone. Silty micrite (?) containing ostracodes.

Unit 91: Limestone. Ostracode grainstone, wavy planar laminations (?); 40 cm above base is 10-cm-thick bed of siltstone.

Unit 90: Limestone. Unit consists of ostracode grainstone that grades upward to light-gray silty limestone containing 10 percent ostracodes; top 2 cm is dark-gray laminated chert.

Unit 89: Limestone. Basal 25 cm is micrite (?) containing minor ostracodes; upper 130 cm is ostracode grainstone.

SECTION 14 INTERVAL: 150 to 200 m



DESCRIPTION

Unit 146: Sandstone, coarsens upward (80 to 150 μ). Basal 40 cm is composed of interbedded sandstone and siltstone; sand grains in top 20 cm of unit are coated with calcite and 15 percent of the unit is composed of coated grains.

Unit 145: Siltstone, coars- to very coarse grained. Structureless.

Unit 144: Sandstone, fines upward (350 to 180 μ). Lenticular geometry (shaped like a half-lens), sandbody is 4 m thick at southwest edge and pinches out 15 m to northeast; 1.0 m southwest of edge of sandbody is 1.0-m-thick bed of algal limestone; base of unit sharp and scoured; trough crossbeds throughout.

Unit 143: Covered.

Unit 142: Limestone. Lower half contains pillar-type algal stromatolites, upper half contains subhorizontal algal laminations and small (4-5 cm diameter) domal algal stromatolites.

Unit 141: Mudstone. Light brownish gray, noncalcareous; lower 50 cm is faintly laminated, upper 30 cm is not laminated.

Unit 140: Dolostone. Very dark gray, kerogenous and laminated dolostone (oil shale).

Unit 139: Covered.

Unit 138: Sandstone, mainly 65-105 μ. Syneresis cracks and horizontal burrows.

Unit 137: Covered.

Unit 136: Siltstone, very coarse grained. Structureless, upper 1.1 m is calcareous.

Unit 135: Covered.

Unit 134: Sandstone, 90-190 μ. Base sharp and flat; basal 1.5 m is planar laminated, 1.5 m to top structureless.

Unit 133: Siltstone, medium- to coarse-grained. Most (80 percent) of unit covered by desert varnish, 15 percent is planar laminated and 5 percent is rippled.

Unit 132: Siltstone, limestone, and dolostone. Basal 1.4 m is covered; 1.4-2.5 m above base is siltstone, slightly calcareous, mainly structureless with one zone of wave ripples; 2.5-2.9 m is laminated, kerogenous dolostone (oil shale); 2.9-5.0 m is siltstone, slightly calcareous, laminated (?); 5-5.02 m is kerogenous, laminated dolostone (oil shale); 5.02-7.3 m is siltstone, medium- to fine-grained; 7.3-7.8 m is micrite (?), very light gray; 7.8 m to top is covered.

Unit 131: Sandstone, 90 μ. Ripples, planar laminations, and HCS (?).

Unit 130: Covered.

Unit 129: Sandstone, 135-150 μ. Basal 20 cm is 135 μ sandstone; upper 45 cm is 150-μ sandstone containing 10-20 percent carbonate grains (coated grains?).

Unit 128: Siltstone (very coarse grained) and sandstone (110 and 225 μ). Unit consists of siltstone with 2-cm-thick bed of 225-μ sandstone 40 cm above base and 40-cm-thick bed of wave-rippled 110-μ sandstone at top.

Unit 127: Sandstone, fines upward (265 to 175 μ). Base sharp, 1.0 m of scour; unit is trough crossbedded (50 percent) and structureless or covered (50 percent); tar saturated; few scattered limestone clasts 1.5 m above base.

Unit 126: Limestone, dolostone, and mudstone. Basal 1.8 m is very light gray micrite; 1.8-2.1 m is laminated, kerogenous dolostone (oil shale); 2.1-2.5 m is covered; 2.5 m to top is fissile, very silty mudstone or medium-grained siltstone.

Unit 125: Limestone. Composed of ooids that have sand nuclei and some ostracodes; basal 4 cm is rippled; upper 11 cm wavy planar laminated.

Unit 124: Sandstone, 90 μ.

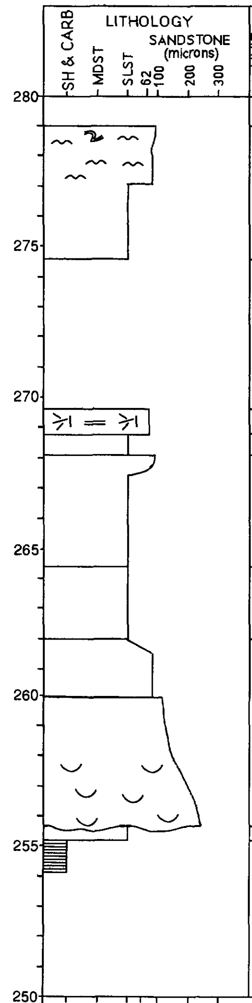
Unit 123: Sandstone, 70 μ. Poorly exposed.

Unit 122: Sandstone, fines upward (160 to 75 μ). Base covered; basal 2.0 m is trough crossbedded; upper 0.9 m is rippled.

Unit 121: Mainly covered. One 10-cm-thick bed of siltstone 0.6 m below top of unit.

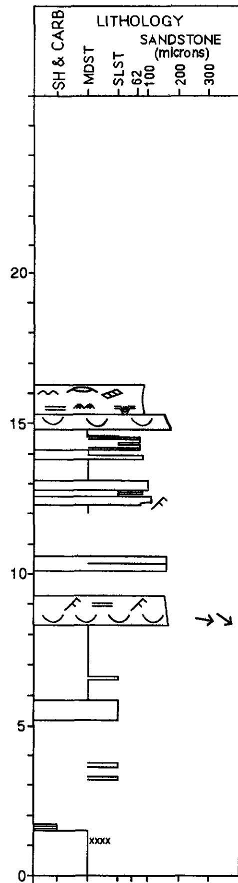
Unit 120: Limestone. Mainly ooid grainstone, ooids have sand nuclei; 25-40 cm above base limestone contains ostracodes and ooids (?); 70-80 cm contains very small domal algal stromatolites and ostracodes; unit weathers yellow-orange, very weakly tar stained.

SECTION 14 INTERVAL: 200 to 250 m



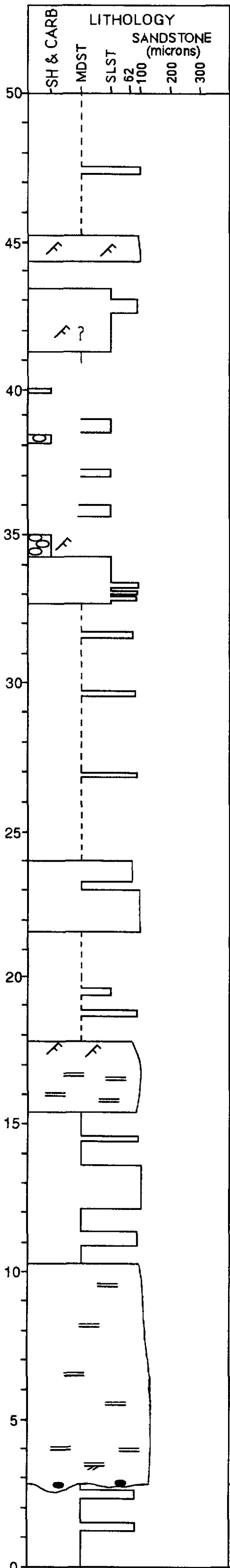
UNIT NUMBER	FACIES	DESCRIPTION
156	Sb	Unit 156: Siltstone (very coarse grained) and sandstone (70-90 μ). Basal 2.5 m is siltstone; at 2.5 m grain size abruptly increases to 70-80-μ sandstone containing wave ripples; top 60 cm is 90-μ sandstone containing wave ripples and 10 percent soft-sediment deformation.
155		Unit 155: Covered.
154		Unit 154: Sandstone, 70 μ. Laminated (?), syneresis cracks.
153		Unit 153: Siltstone, coarse-grained. Green.
152	Sb	Unit 152: Siltstone (coarse grained) and sandstone (85 μ). Mainly siltstone; top 35 cm is sandstone.
151		Unit 151: Siltstone, very coarse grained. Base gradational, structureless.
150		Unit 150: Sandstone, 70-80 μ. Base sharp and top gradational, structureless.
149	Sd	Unit 149: Sandstone, fines upward (240 to 115 μ). Base sharp, 20-30 cm of scour; basal 2.0 m is trough crossbedded, 2.0 m to top is structureless.
148	Ia	Unit 148: Siltstone, coarse-grained. Weakly tarstained, structureless.
147		Unit 147: Mainly covered. A 10-cm-thick bed of kerogenous, laminated dolostone (oil shale) is 3.4 m above base; top 1.0 m is light-brownish-gray, laminated mudstone or dolostone.

SECTION 14 INTERVAL: 250 to 279 m



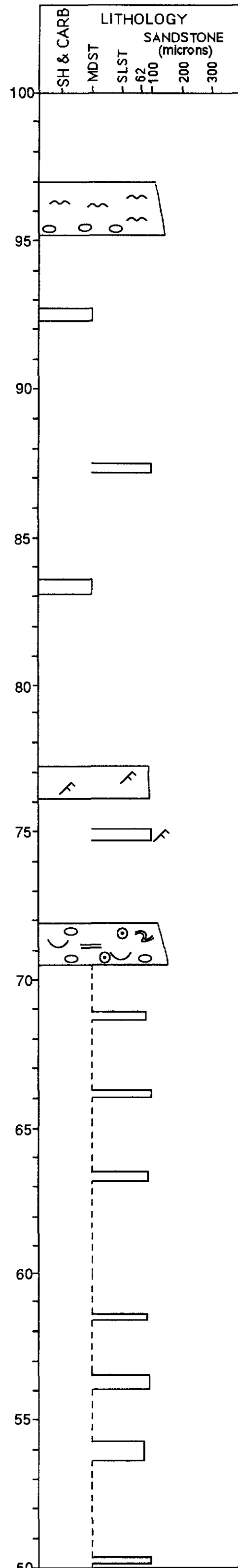
UNIT NUMBER	FACIES	DESCRIPTION
		Unit 17: Sandstone, 75-80 μ. Tabular geometry, appears to drape unit 16; contains hummocky cross-stratification, ripples (wave, combined-flow, and climbing), planar laminations, escape burrows, and small scours.
		Unit 16: Sandstone, 150 μ. Trough crossbeds, lenticular geometry.
		Unit 15: Sandstone, siltstone, and mudstone. Basal 45 cm is interbedded 70-μ sandstone (60 percent) and siltstone-mudstone (40 percent); top 20 cm is silty, light olive gray mudstone.
		Unit 14: Sandstone (70-80 μ) and mudstone. Consists of 15-cm-thick bed of sandstone bed overlain by 20-cm-thick bed of olive-gray mudstone.
		Unit 13: Mudstone. Light olive gray, silty, poorly exposed.
		Unit 12: Sandstone, 100 μ.
17		Unit 11: Interbedded siltstone and very fine grained sandstone.
16		
15	Ia	Unit 10: Sandstone, 70-110 μ. Four beds separated by thin siltstone beds (bese to top): 70, 110, 110, 110 μ; rippled.
13		
11		Unit 9: Mainly covered. Beneath unit 10 is a 30-cm-thick bed of silty, moderately calcareous, light-olive-gray mudstone.
9		Unit 8: Sandstone, 160 μ. Two beds of sandstone separated by thin mudstone.
8	Ia	Unit 7: Covered.
7		Unit 6: Sandstone, fines upward (175 to 150 μ). Trough crossbeds in lower 50 cm; ripples and planar laminations in upper 50 cm.
6		
5	Ia	Unit 5: Mudstone. Light olive gray (5Y 5/2); upward increase in silt and calcite; concretions in top 1.5 m; 10-cm-thick siltstone 0.7 m above unit base.
4		Unit 4: Very coarse grained siltstone-very fine grained sandstone. Partly exposed.
3		Unit 3: Mainly covered. 10-cm-thick, very coarse grained siltstone 1.5 m above base and 15-cm-thick, very coarse grained siltstone containing planar laminations 2 m above base.
		Unit 2: Dolostone. Kerogenous and laminated (oil shale).
1	Ia	Unit 1: Mudstone. Light olive gray (5Y 5/2), moderately silty, slightly calcareous, faintly laminated; yellowish-orange tuff near top, tuff thickens and thins and has an average thickness of 1 cm.

SECTION 15 INTERVAL: 0 to 16.3 m



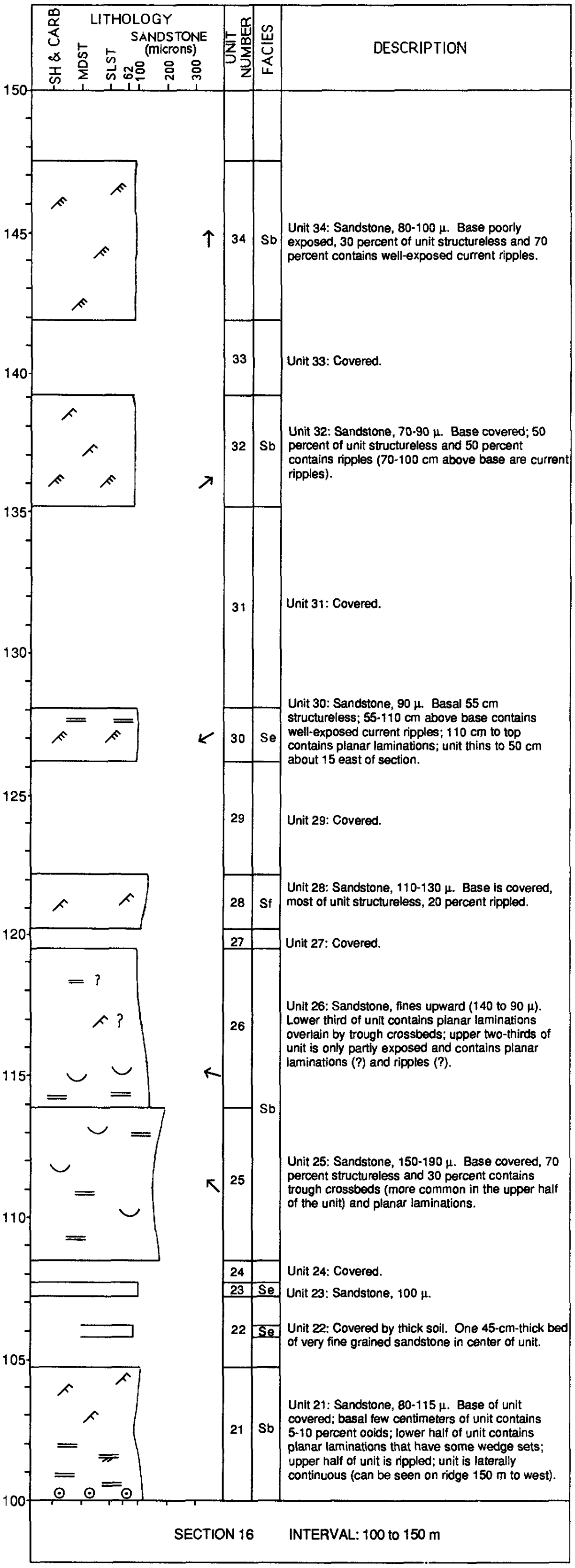
UNIT NUMBER	FACIES	DESCRIPTION
14	Mr & Se	
13	Se	Unit 13: Sandstone, 90-100 µ. Rippled.
12		Unit 12: Covered.
11	Se	Unit 11: Siltstone and sandstone. Basal 1.25 m is fissile, rippled (?) siltstone; 1.25-1.50 m is very fine grained sandstone; 1.50 m to top is siltstone.
10		Unit 10: Mainly (60 percent) covered and lesser (40 percent) siltstone and limestone. Limestone contains sparse ostracodes; 35-cm-thick bed of gray mudstone crops out beneath unit 11.
9	L	Unit 9: Limestone. Mainly rippled ostracode grainstone, several 5-15-mm-thick micrite interbeds in upper half, micrite is brecciated (?) or mudcracked in places.
8	Se	Unit 8: Interbedded siltstone (70 percent) and sandstone (30 percent). Sandstone is very fine grained, generally forms ledges; siltstone generally forms slope.
7	Mr	Unit 7: Mainly covered. Most (85 percent) of unit is covered and has red soil (probably weathered red mudstone); few thin outcrops of red mudstone (10 percent of unit) and minor (5 percent) thin beds of very fine grained sandstone.
6	Se	Unit 6: Sandstone (70-100 µ) and minor mudstone. Basal 1.4 m consists of structureless 100-µ sandstone; 1.4-1.7 m is red mudstone; 1.7 m to top is structureless 70-µ sandstone.
5	Mr	Unit 5: Mainly covered. Red soil covers 85 percent of unit, few outcrops of very fine grained sandstone and siltstone in lower half of unit, bed thickness of sandstone-siltstone is 30-40 cm.
4	Se	Unit 4: Sandstone, 70-90 µ. Base sharp and flat, well-exposed planar laminations throughout except for top 5 cm, which is rippled.
3	Se & Mr & Mg	Unit 3: Interbedded sandstone (50 percent), red mudstone (45 percent), and green mudstone (5 percent). Middle of unit consists of 1.5- m-thick bed of very fine grained sandstone.
2	Sb	Unit 2: Sandstone, 90-130 µ. Base sharp, about 20 cm of scour, few small intraformational clasts at base; basal 1.0 m contains well-exposed planar laminations with low-angle truncations in a few places; upper 7 m of unit contains some planar laminations (40 percent), but most (60 percent) is structureless.
1	Mr, Mg, Se	Unit 1: Interbedded mudstone (70 percent) and sandstone (30 percent). Mudstone is red and green; sandstone is two 30-cm-thick beds, top of upper sandstone is 20 cm below unit 2.

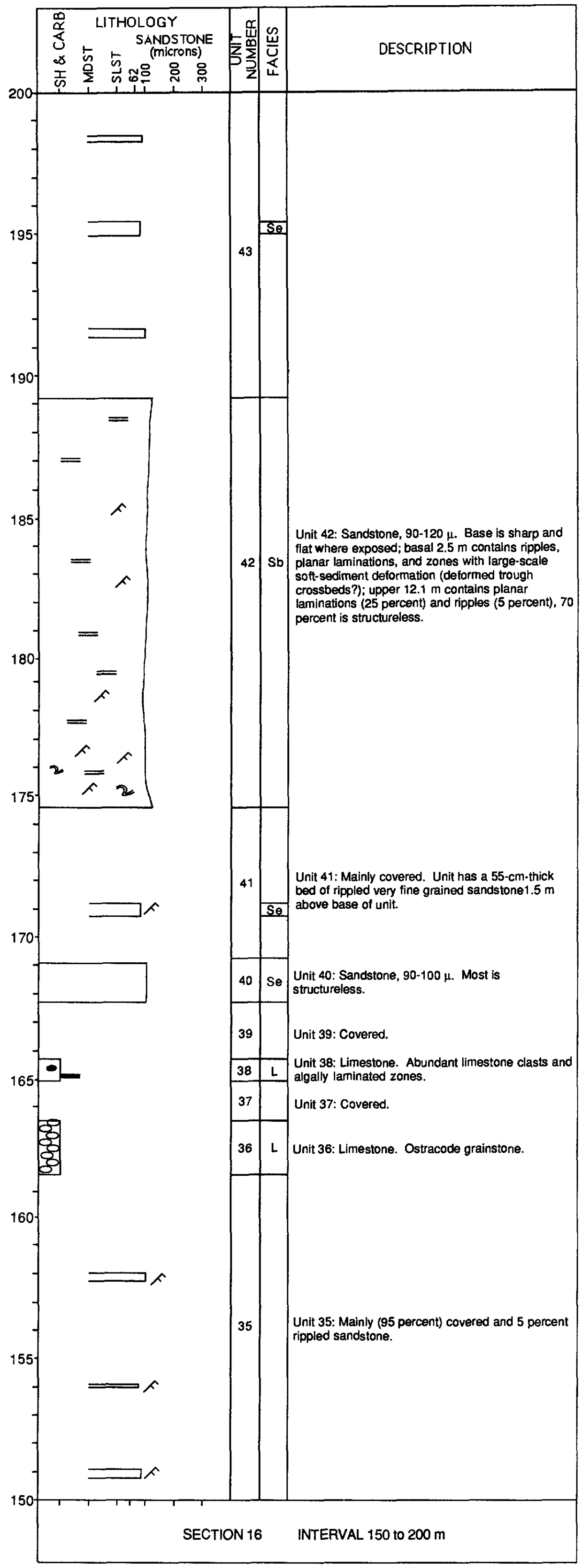
SECTION 16 INTERVAL: 0 to 50 m

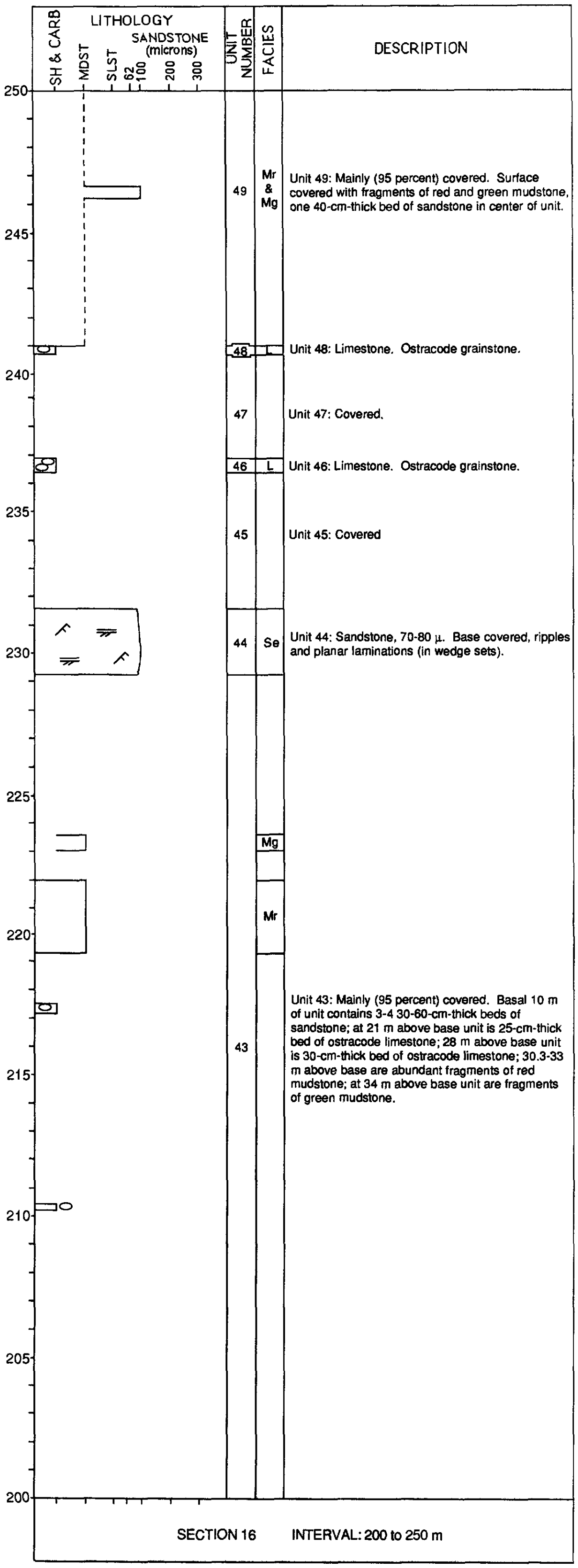


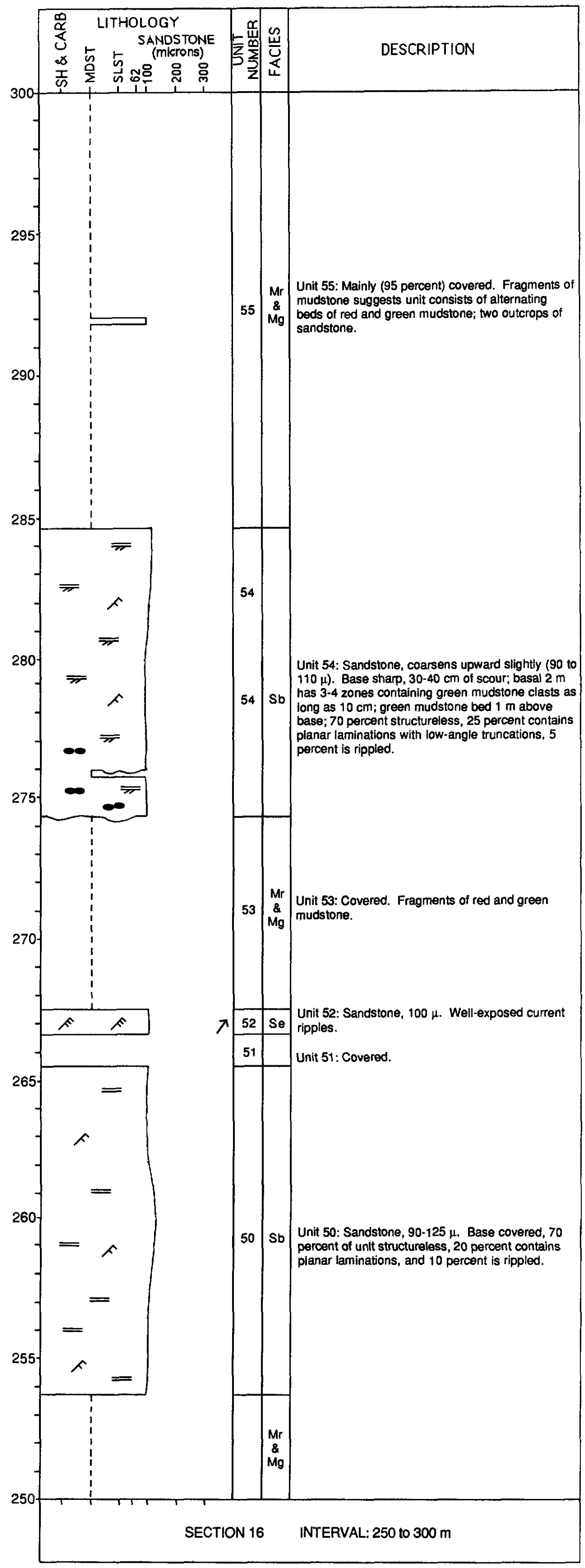
UNIT NUMBER	FACIES	DESCRIPTION
20		Unit 20: Covered.
19	Se	Unit 19: Sandstone, fines upward (140 to 110 µ). Lenticular bed of ostracode grainstone about 5 cm above base of unit; wave (?) rippled in places; unit is probably composed of amalgamated 15-30-cm-thick sandstone beds .
18	Mg; Mg	Unit 18: Mainly (95 percent) covered. Few minor outcrops of green mudstone and sandstone, soil is gray.
17	Se	Unit 17: Sandstone, 90 µ. Rippled.
16		Unit 16: Covered by soil and talus, One 40-cm-thick bed of rippled, very fine grained sandstone.
15	Se	Unit 15: Sandstone, fines upward slightly (150 to 120 µ). Base contains 5-10 percent ostracodes, top of unit 10% ostracodes and ooids; unit is planar laminated (50 percent) and trough crossbedded (50 percent), about half of trough crossbeds exhibit soft-sediment deformation.
14	Mg & Se; Mr & Se	Unit 14: Mainly (90 percent) covered. Lower third has red soil (underlain by red mudstone); upper two-thirds has light gray soil (underlain by green mudstone); few (10 percent) 20-50-cm-thick beds of sandstone.

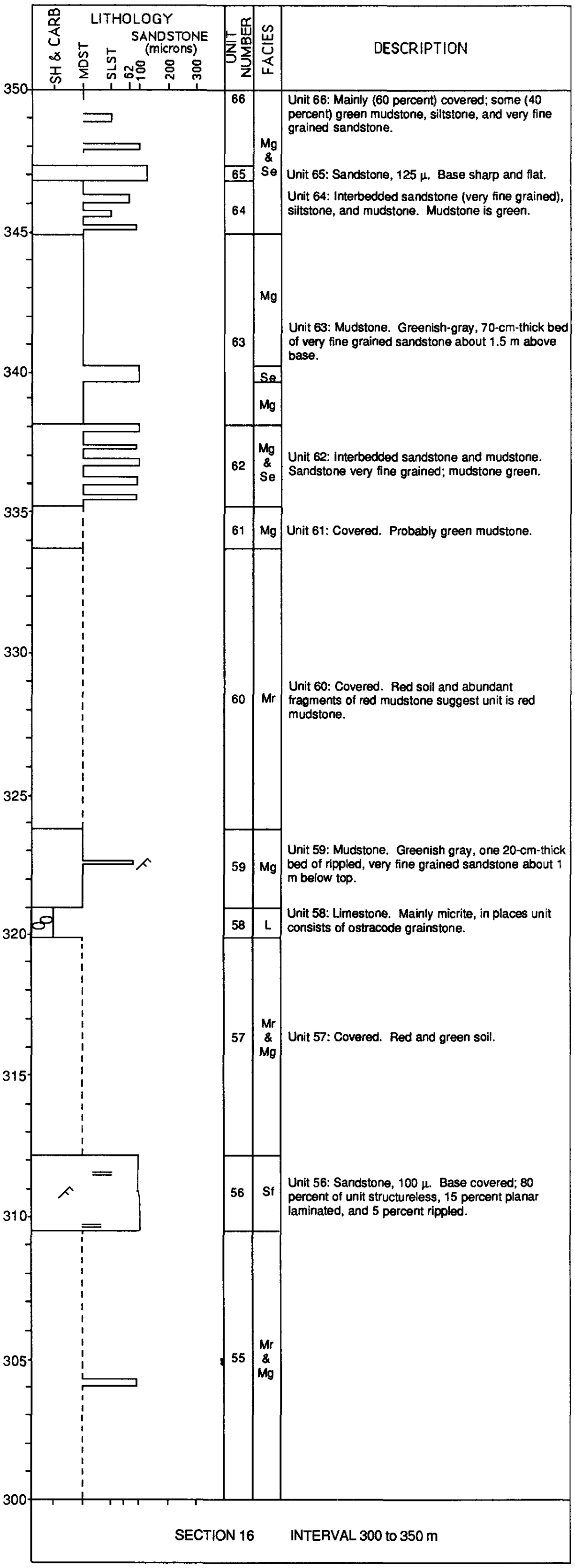
SECTION 16 INTERVAL: 50 to 100 m

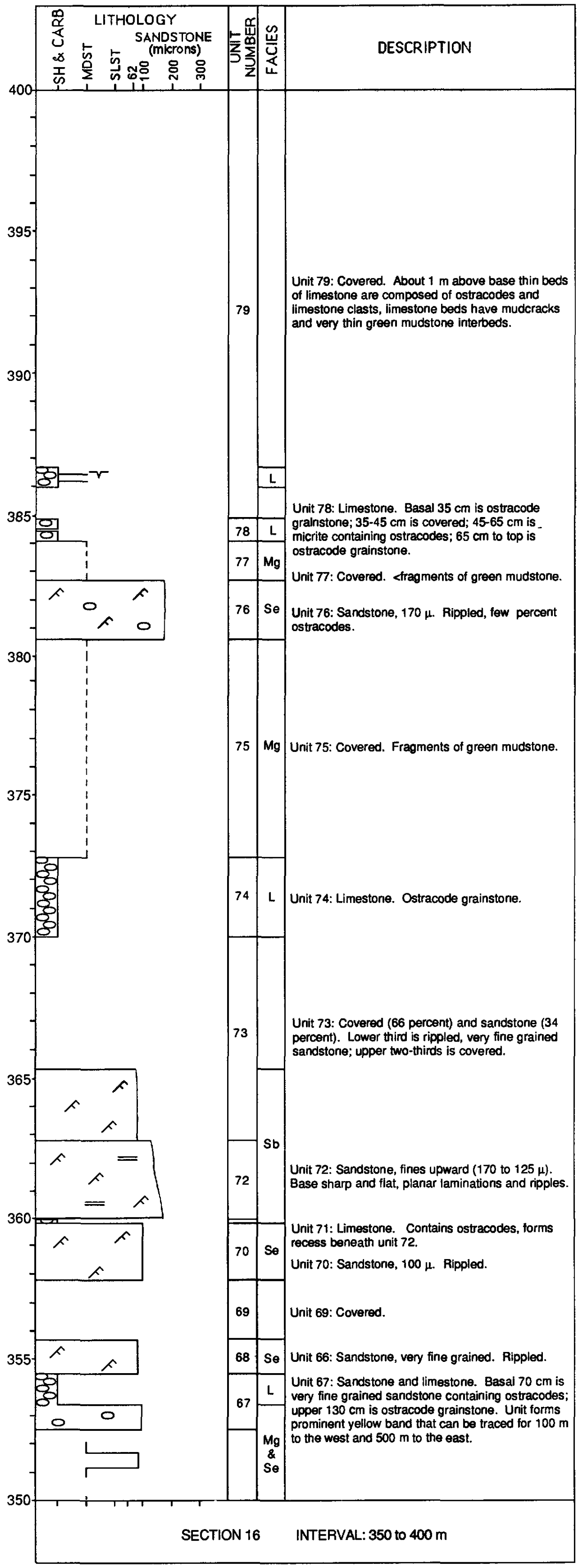

LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
150
145
140
135
130
125
120
115
110
105
100
34 Sb Unit 34: Sandstone, 80-100 µ. Base poorly exposed, 30 percent of unit structureless and 70 percent contains well-exposed current ripples.
33 Unit 33: Covered.
32 Sb Unit 32: Sandstone, 70-90 µ. Base covered; 50 percent of unit structureless and 50 percent contains ripples (70-100 cm above base are current ripples).
31 Unit 31: Covered.
30 Se Unit 30: Sandstone, 90 µ. Basal 55 cm structureless; 55-110 cm above base contains well-exposed current ripples; 110 cm to top contains planar laminations; unit thins to 50 cm about 15 east of section.
29 Unit 29: Covered.
28 Sf Unit 28: Sandstone, 110-130 µ. Base is covered, most of unit structureless, 20 percent rippled.
27 Unit 27: Covered.
26 Unit 26: Sandstone, fines upward (140 to 90 µ). Lower third of unit contains planar laminations overlain by trough crossbeds; upper two-thirds of unit is only partly exposed and contains planar laminations (?) and ripples (?).
Sb
25 Unit 25: Sandstone, 150-190 µ. Base covered, 70 percent structureless and 30 percent contains trough crossbeds (more common in the upper half of the unit) and planar laminations.
24 Unit 24: Covered.
23 Se Unit 23: Sandstone, 100 µ.
22 Se Unit 22: Covered by thick soil. One 45-cm-thick bed of very fine grained sandstone in center of unit.
21 Sb Unit 21: Sandstone, 80-115 µ. Base of unit covered; basal few centimeters of unit contains 5-10 percent ooids; lower half of unit contains planar laminations that have some wedge sets; upper half of unit is rippled; unit is laterally continuous (can be seen on ridge 150 m to west).
SECTION 16 INTERVAL: 100 to 150 m

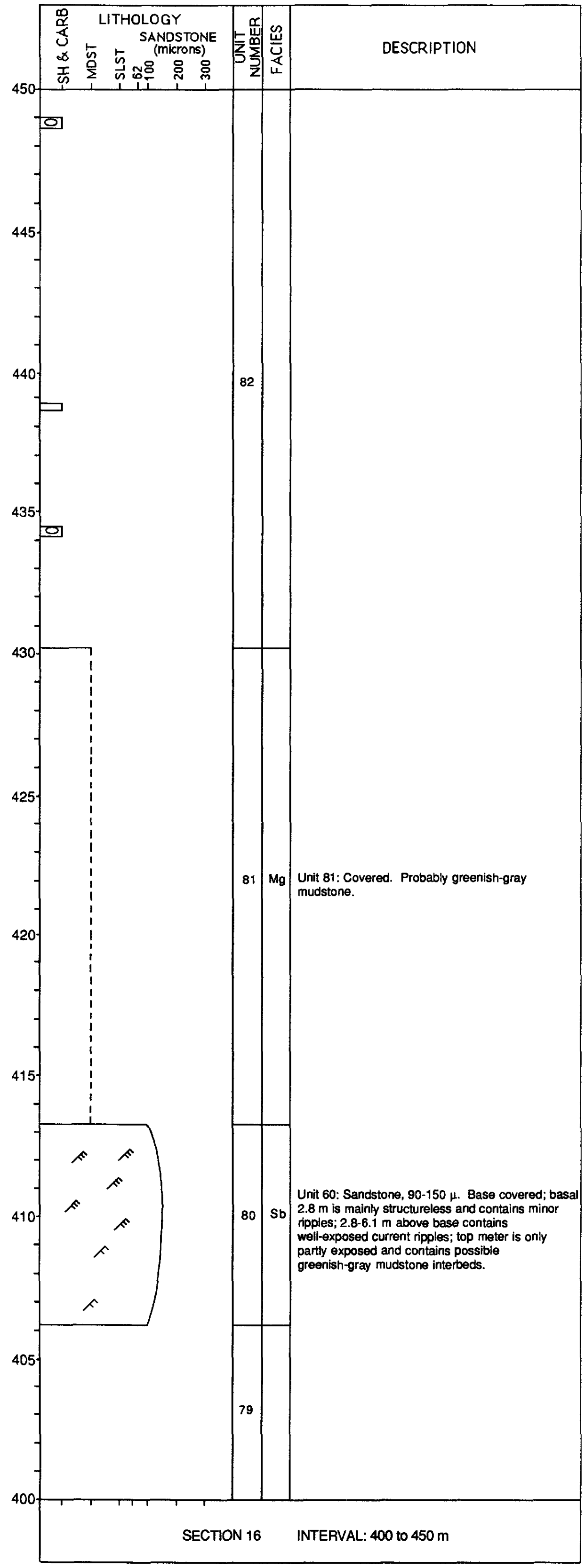

LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
200
195
190
185
180
175
170
165
160
155
150
43 Se
42 Sb Unit 42: Sandstone, 90-120 µ. Base is sharp and flat where exposed; basal 2.5 m contains ripples, planar laminations, and zones with large-scale soft-sediment deformation (deformed trough crossbeds?); upper 12.1 m contains planar laminations (25 percent) and ripples (5 percent), 70 percent is structureless.
41 Se Unit 41: Mainly covered. Unit has a 55-cm-thick bed of rippled very fine grained sandstone1.5 m above base of unit.
40 Se Unit 40: Sandstone, 90-100 µ. Most is structureless.
39 Unit 39: Covered.
38 L Unit 38: Limestone. Abundant limestone clasts and algally laminated zones.
37 Unit 37: Covered.
36 L Unit 36: Limestone. Ostracode grainstone.
35 Unit 35: Mainly (95 percent) covered and 5 percent rippled sandstone.
SECTION 16 INTERVAL 150 to 200 m

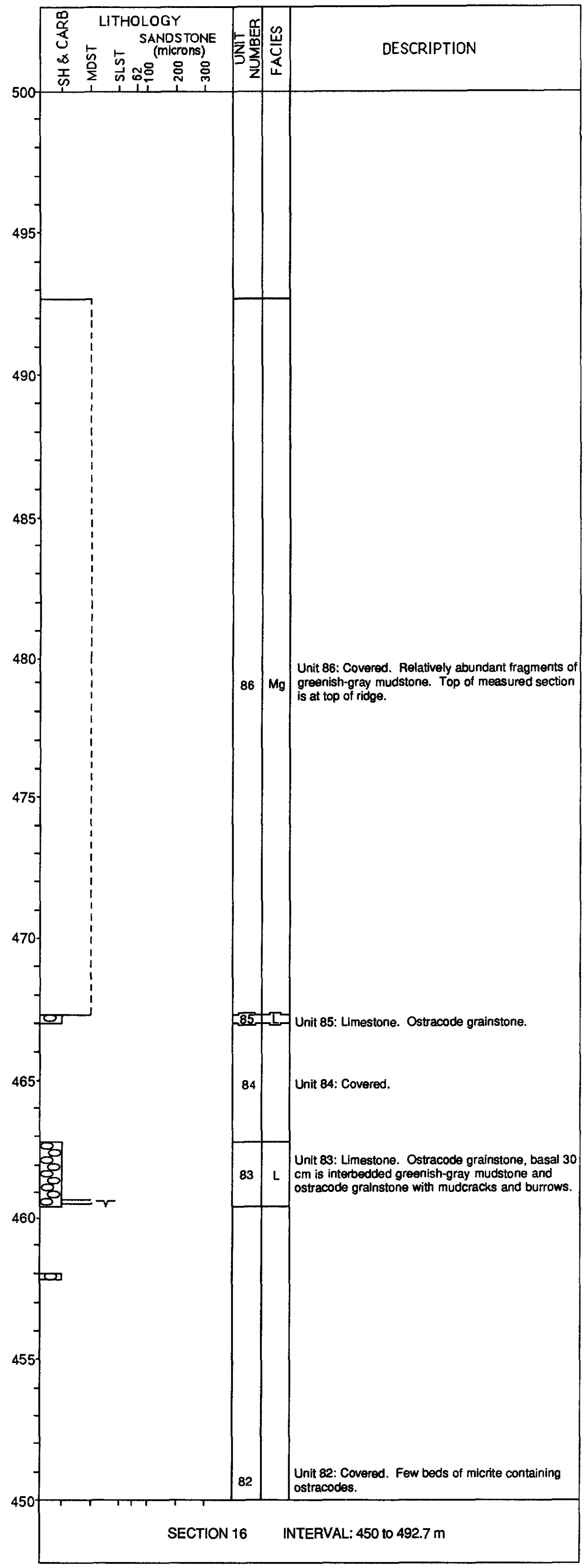

LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
250
245
240
235
230
225
220
215
210
205
200
49
Mr & Mg
Unit 49: Mainly (95 percent) covered. Surface covered with fragments of red and green mudstone, one 40-cm-thick bed of sandstone in center of unit.
48
L
Unit 48: Limestone. Ostracode grainstone.
47
Unit 47: Covered.
46
L
Unit 46: Limestone. Ostracode grainstone.
45
Unit 45: Covered
44
Se
Unit 44: Sandstone, 70-80 μ. Base covered, ripples and planar laminations (in wedge sets).
Mg
Mr
43
Unit 43: Mainly (95 percent) covered. Basal 10 m of unit contains 3-4 30-60-cm-thick beds of sandstone; at 21 m above base unit is 25-cm-thick bed of ostracode limestone; 28 m above base unit is 30-cm-thick bed of ostracode limestone; 30.3-33 m above base are abundant fragments of red mudstone; at 34 m above base unit are fragments of green mudstone.
SECTION 16
INTERVAL: 200 to 250 m

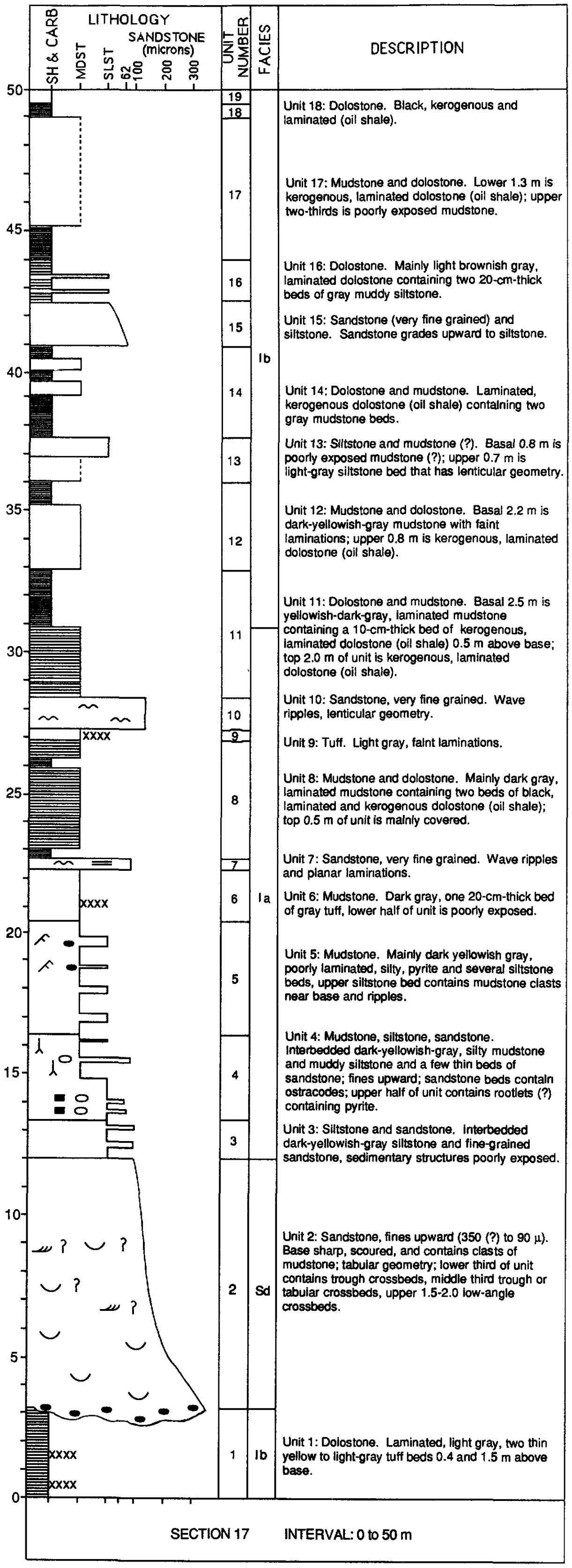

LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
300
295
290
285
280
275
270
265
260
255
250
55
Mr & Mg
Unit 55: Mainly (95 percent) covered. Fragments of mudstone suggests unit consists of alternating beds of red and green mudstone; two outcrops of sandstone.
54
54
Sb
Unit 54: Sandstone, coarsens upward slightly (90 to 110 μ). Base sharp, 30-40 cm of scour; basal 2 m has 3-4 zones containing green mudstone clasts as long as 10 cm; green mudstone bed 1 m above base; 70 percent structureless, 25 percent contains planar laminations with low-angle truncations, 5 percent is rippled.
53
Mr & Mg
Unit 53: Covered. Fragments of red and green mudstone.
52
Se
Unit 52: Sandstone, 100 μ. Well-exposed current ripples.
51
Unit 51: Covered.
50
Sb
Unit 50: Sandstone, 90-125 μ. Base covered, 70 percent of unit structureless, 20 percent contains planar laminations, and 10 percent is rippled.
Mr & Mg
SECTION 16
INTERVAL: 250 to 300 m

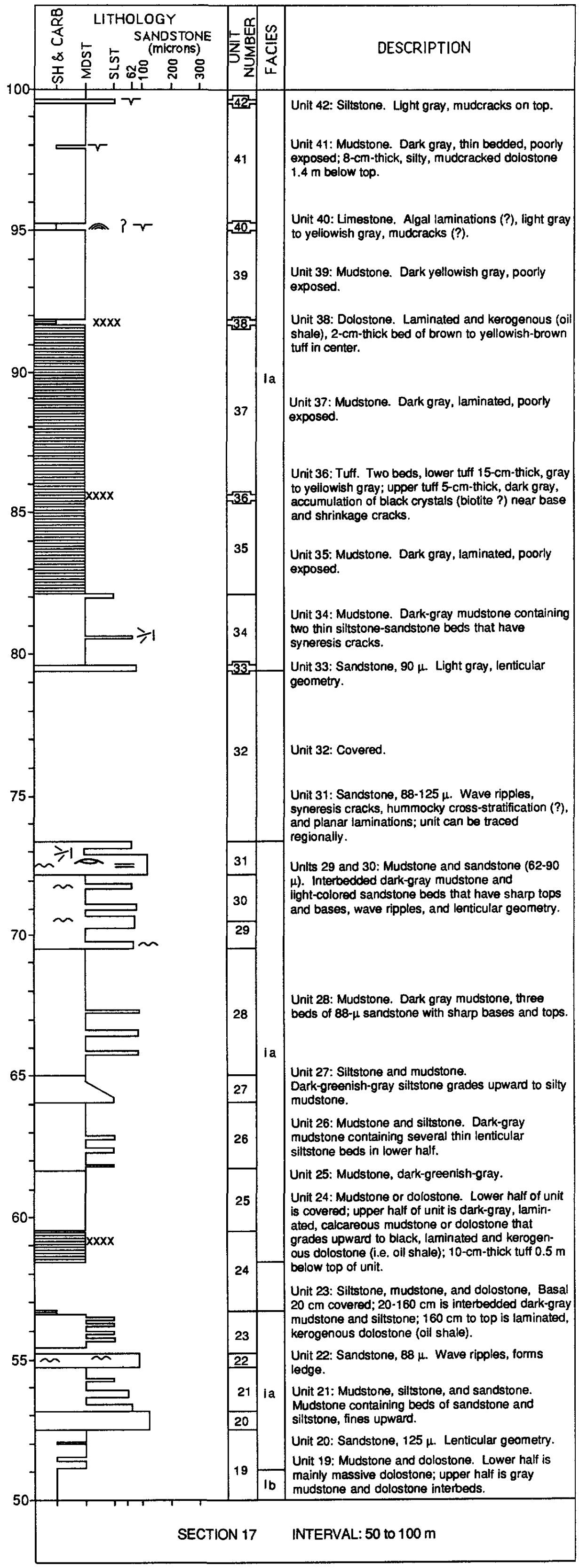

LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
350
345
340
335
330
325
320
315
310
305
300
66
Mg & Se
Unit 66: Mainly (60 percent) covered; some (40 percent) green mudstone, siltstone, and very fine grained sandstone.
65
Se
Unit 65: Sandstone, 125 μ. Base sharp and flat.
64
Unit 64: Interbedded sandstone (very fine grained), siltstone, and mudstone. Mudstone is green.
63
Mg
Unit 63: Mudstone. Greenish-gray, 70-cm-thick bed of very fine grained sandstone about 1.5 m above base.
Se
Mg
62
Mg & Se
Unit 62: Interbedded sandstone and mudstone. Sandstone very fine grained; mudstone green.
61
Mg
Unit 61: Covered. Probably green mudstone.
60
Mr
Unit 60: Covered. Red soil and abundant fragments of red mudstone suggest unit is red mudstone.
59
Mg
Unit 59: Mudstone. Greenish gray, one 20-cm-thick bed of rippled, very fine grained sandstone about 1 m below top.
58
L
Unit 58: Limestone. Mainly micrite, in places unit consists of ostracode grainstone.
57
Mr & Mg
Unit 57: Covered. Red and green soil.
56
Sf
Unit 56: Sandstone, 100 μ. Base covered; 80 percent of unit structureless, 15 percent planar laminated, and 5 percent rippled.
55
Mr & Mg
SECTION 16
INTERVAL 300 to 350 m

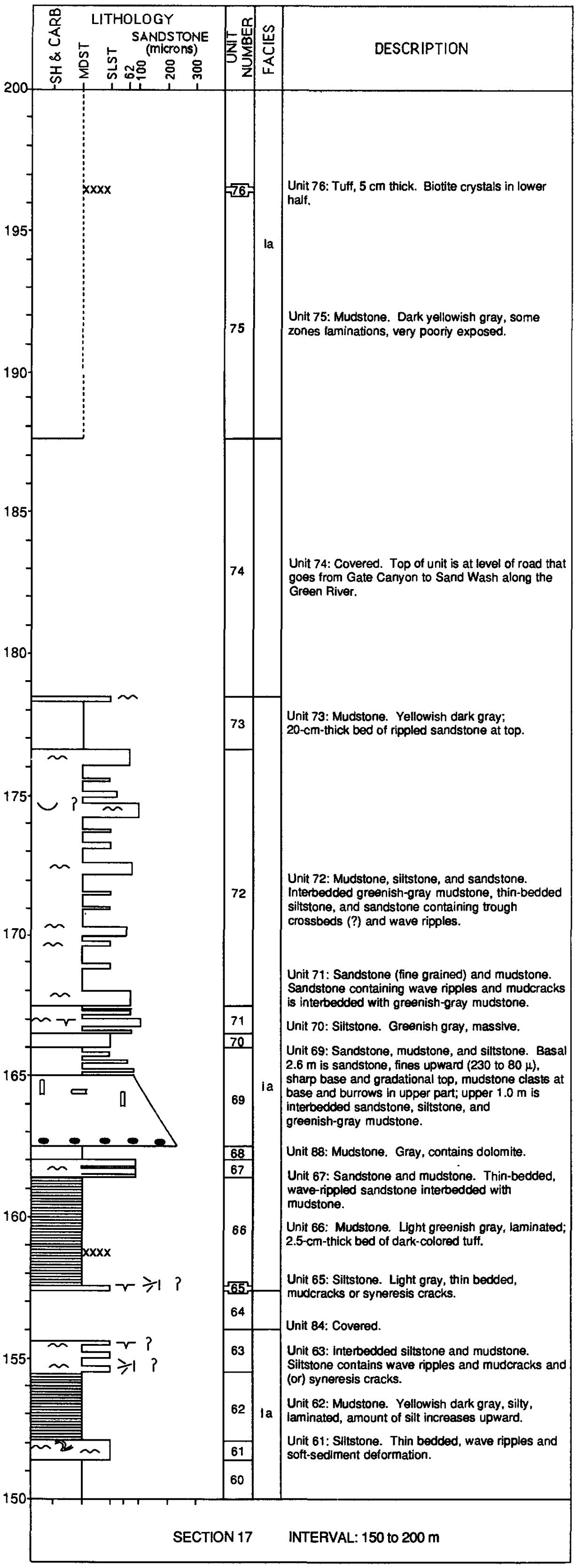

LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
400
395
390
385
380
375
370
365
360
355
350
79
Unit 79: Covered. About 1 m above base thin beds of limestone are composed of ostracodes and limestone clasts, limestone beds have mudcracks and very thin green mudstone interbeds.
L
78
L
Unit 78: Limestone. Basal 35 cm is ostracode grainstone; 35-45 cm is covered; 45-65 cm is micrite containing ostracodes; 65 cm to top is ostracode grainstone.
77
Mg
Unit 77: Covered. <fragments of green mudstone.
76
Se
Unit 76: Sandstone, 170 μ. Rippled, few percent ostracodes.
75
Mg
Unit 75: Covered. Fragments of green mudstone.
74
L
Unit 74: Limestone. Ostracode grainstone.
73
Unit 73: Covered (66 percent) and sandstone (34 percent). Lower third is rippled, very fine grained sandstone; upper two-thirds is covered.
Sb
72
Unit 72: Sandstone, fines upward (170 to 125 μ). Base sharp and flat, planar laminations and ripples.
Unit 71: Limestone. Contains ostracodes, forms recess beneath unit 72.
70
Se
Unit 70: Sandstone, 100 μ. Rippled.
69
Unit 69: Covered.
68
Se
Unit 66: Sandstone, very fine grained. Rippled.
67
L
Mg & Se
Unit 67: Sandstone and limestone. Basal 70 cm is very fine grained sandstone containing ostracodes; upper 130 cm is ostracode grainstone. Unit forms prominent yellow band that can be traced for 100 m to the west and 500 m to the east.
SECTION 16
INTERVAL: 350 to 400 m

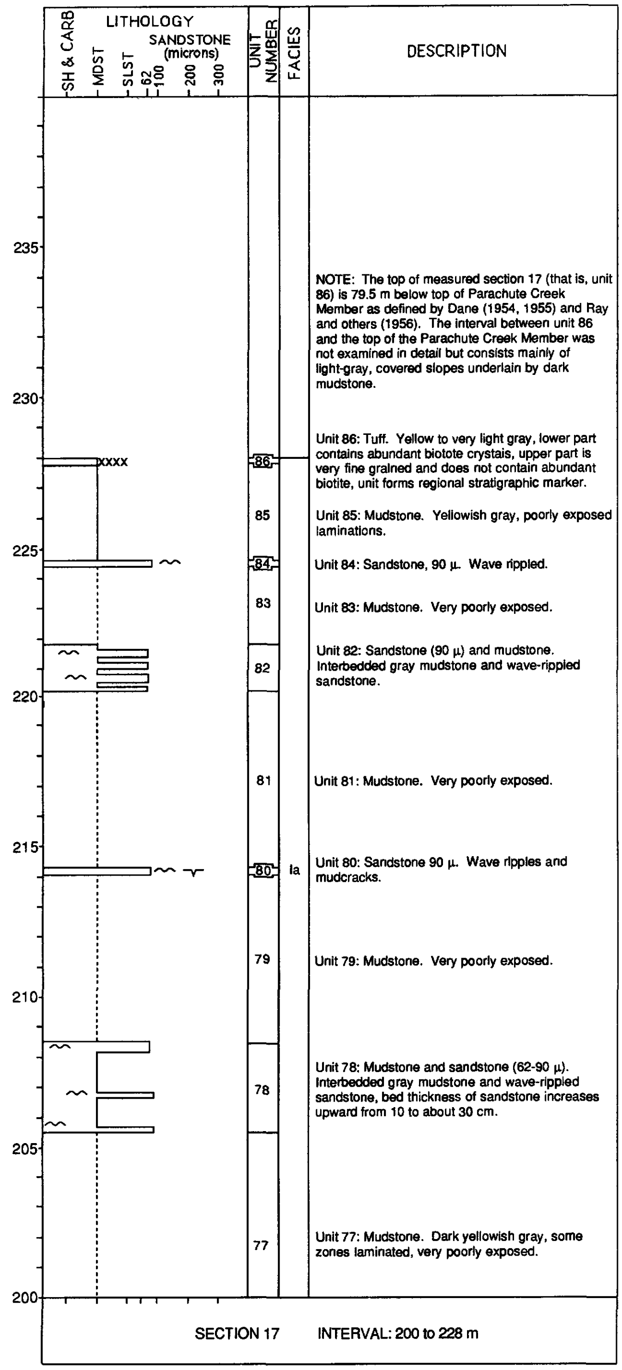

LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
450
445
440
435
430
425
420
415
410
405
400
82
81
Mg
Unit 81: Covered. Probably greenish-gray mudstone.
80
Sb
Unit 60: Sandstone, 90-150 μ. Base covered; basal 2.8 m is mainly structureless and contains minor ripples; 2.8-6.1 m above base contains well-exposed current ripples; top meter is only partly exposed and contains possible greenish-gray mudstone interbeds.
79
SECTION 16
INTERVAL: 400 to 450 m

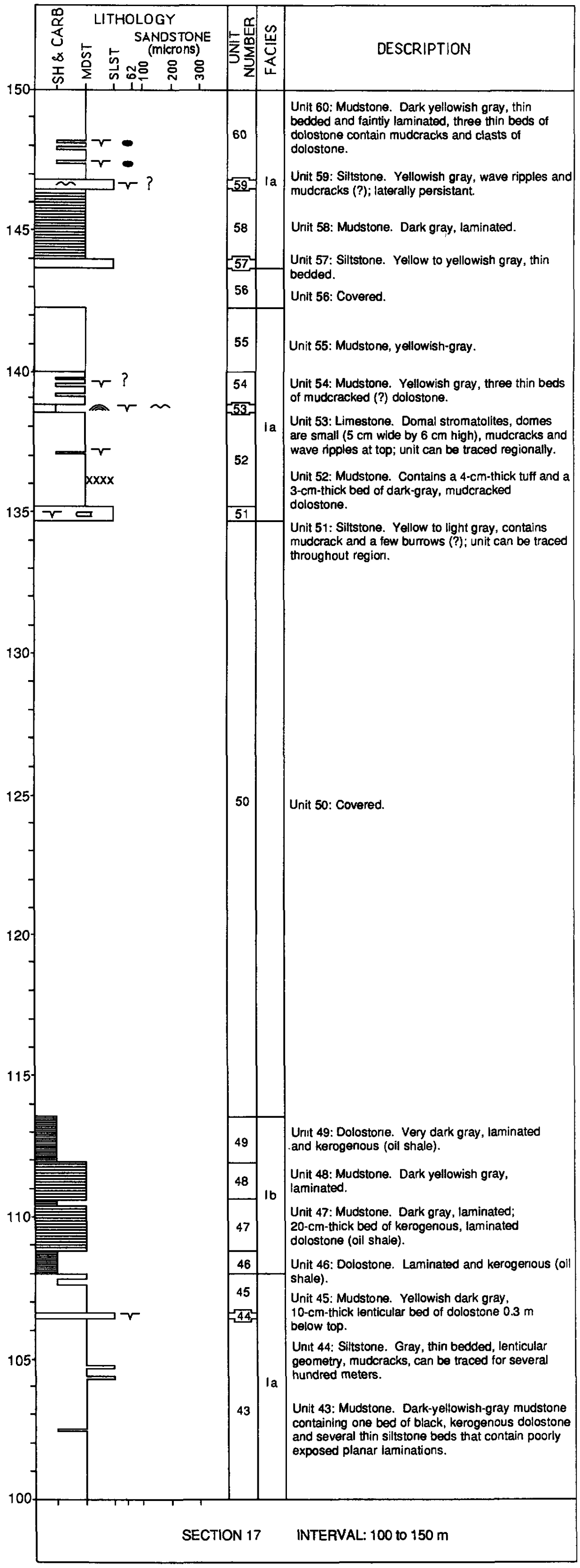

LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
500
495
490
485
480
475
470
465
460
455
450
86
Mg
Unit 86: Covered. Relatively abundant fragments of greenish-gray mudstone. Top of measured section is at top of ridge.
85
L
Unit 85: Limestone. Ostracode grainstone.
84
Unit 84: Covered.
83
L
Unit 83: Limestone. Ostracode grainstone, basal 30 cm is interbedded greenish-gray mudstone and ostracode grainstone with mudcracks and burrows.
82
Unit 82: Covered. Few beds of micrite containing ostracodes.
SECTION 16
INTERVAL: 450 to 492.7 m


LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
Unit 18: Dolostone. Black, kerogenous and laminated (oil shale).
Unit 17: Mudstone and dolostone. Lower 1.3 m is kerogenous, laminated dolostone (oil shale); upper two-thirds is poorly exposed mudstone.
Unit 16: Dolostone. Mainly light brownish gray, laminated dolostone containing two 20-cm-thick beds of gray muddy siltstone.
Unit 15: Sandstone (very fine grained) and siltstone. Sandstone grades upward to siltstone.
Unit 14: Dolostone and mudstone. Laminated, kerogenous dolostone (oil shale) containing two gray mudstone beds.
Unit 13: Siltstone and mudstone (?). Basal 0.8 m is poorly exposed mudstone (?); upper 0.7 m is light-gray siltstone bed that has lenticular geometry.
Unit 12: Mudstone and dolostone. Basal 2.2 m is dark-yellowish-gray mudstone with faint laminations; upper 0.8 m is kerogenous, laminated dolostone (oil shale).
Unit 11: Dolostone and mudstone. Basal 2.5 m is yellowish-dark-gray, laminated mudstone containing a 10-cm-thick bed of kerogenous, laminated dolostone (oil shale) 0.5 m above base; top 2.0 m of unit is kerogenous, laminated dolostone (oil shale).
Unit 10: Sandstone, very fine grained. Wave ripples, lenticular geometry.
Unit 9: Tuff. Light gray, faint laminations.
Unit 8: Mudstone and dolostone. Mainly dark gray, laminated mudstone containing two beds of black, laminated and kerogenous dolostone (oil shale); top 0.5 m of unit is mainly covered.
Unit 7: Sandstone, very fine grained. Wave ripples and planar laminations.
Unit 6: Mudstone. Dark gray, one 20-cm-thick bed of gray tuff, lower half of unit is poorly exposed.
Unit 5: Mudstone. Mainly dark yellowish gray, poorly laminated, silty, pyrite and several siltstone beds, upper siltstone bed contains mudstone clasts near base and ripples.
Unit 4: Mudstone, siltstone, sandstone. Interbedded dark-yellowish-gray, silty mudstone and muddy siltstone and a few thin beds of sandstone; fines upward; sandstone beds contain ostracodes; upper half of unit contains rootlets (?) containing pyrite.
Unit 3: Siltstone and sandstone. Interbedded dark-yellowish-gray siltstone and fine-grained sandstone, sedimentary structures poorly exposed.
Unit 2: Sandstone, fines upward (350 (?) to 90 µ). Base sharp, scoured, and contains clasts of mudstone; tabular geometry; lower third of unit contains trough crossbeds, middle third trough or tabular crossbeds, upper 1.5-2.0 low-angle crossbeds.
Unit 1: Dolostone. Laminated, light gray, two thin yellow to light-gray tuff beds 0.4 and 1.5 m above base.
SECTION 17
INTERVAL: 0 to 50 m

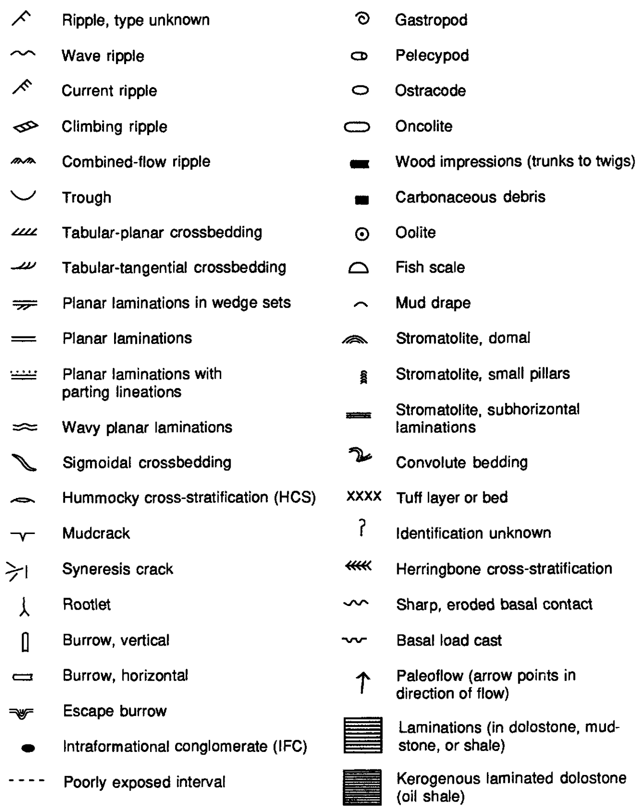

LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
Unit 42: Siltstone. Light gray, mudcracks on top.
Unit 41: Mudstone. Dark gray, thin bedded, poorly exposed; 8-cm-thick, silty, mudcracked dolostone 1.4 m below top.
Unit 40: Limestone. Algal laminations (?), light gray to yellowish gray, mudcracks (?).
Unit 39: Mudstone. Dark yellowish gray, poorly exposed.
Unit 38: Dolostone. Laminated and kerogenous (oil shale), 2-cm-thick bed of brown to yellowish-brown tuff in center.
Unit 37: Mudstone. Dark gray, laminated, poorly exposed.
Unit 36: Tuff. Two beds, lower tuff 15-cm-thick, gray to yellowish gray; upper tuff 5-cm-thick, dark gray, accumulation of black crystals (biotite ?) near base and shrinkage cracks.
Unit 35: Mudstone. Dark gray, laminated, poorly exposed.
Unit 34: Mudstone. Dark-gray mudstone containing two thin siltstone-sandstone beds that have syneresis cracks.
Unit 33: Sandstone, 90 µ. Light gray, lenticular geometry.
Unit 32: Covered.
Unit 31: Sandstone, 88-125 µ. Wave ripples, syneresis cracks, hummocky cross-stratification (?), and planar laminations; unit can be traced regionally.
Units 29 and 30: Mudstone and sandstone (62-90 µ). Interbedded dark-gray mudstone and light-colored sandstone beds that have sharp tops and bases, wave ripples, and lenticular geometry.
Unit 28: Mudstone. Dark gray mudstone, three beds of 88-µ sandstone with sharp bases and tops.
Unit 27: Siltstone and mudstone. Dark-greenish-gray siltstone grades upward to silty mudstone.
Unit 26: Mudstone and siltstone. Dark-gray mudstone containing several thin lenticular siltstone beds in lower half.
Unit 25: Mudstone, dark-greenish-gray.
Unit 24: Mudstone or dolostone. Lower half of unit is covered; upper half of unit is dark-gray, laminated, calcareous mudstone or dolostone that grades upward to black, laminated and kerogenous dolostone (i.e. oil shale); 10-cm-thick tuff 0.5 m below top of unit.
Unit 23: Siltstone, mudstone, and dolostone. Basal 20 cm covered; 20-160 cm is interbedded dark-gray mudstone and siltstone; 160 cm to top is laminated, kerogenous dolostone (oil shale).
Unit 22: Sandstone, 88 µ. Wave ripples, forms ledge.
Unit 21: Mudstone, siltstone, and sandstone. Mudstone containing beds of sandstone and siltstone, fines upward.
Unit 20: Sandstone, 125 µ. Lenticular geometry.
Unit 19: Mudstone and dolostone. Lower half is mainly massive dolostone; upper half is gray mudstone and dolostone interbeds.
SECTION 17
INTERVAL: 50 to 100 m


LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
Unit 76: Tuff, 5 cm thick. Biotite crystals in lower half.
Unit 75: Mudstone. Dark yellowish gray, some zones laminations, very poorly exposed.
Unit 74: Covered. Top of unit is at level of road that goes from Gate Canyon to Sand Wash along the Green River.
Unit 73: Mudstone. Yellowish dark gray; 20-cm-thick bed of rippled sandstone at top.
Unit 72: Mudstone, siltstone, and sandstone. Interbedded greenish-gray mudstone, thin-bedded siltstone, and sandstone containing trough crossbeds (?) and wave ripples.
Unit 71: Sandstone (fine grained) and mudstone. Sandstone containing wave ripples and mudcracks is interbedded with greenish-gray mudstone.
Unit 70: Siltstone. Greenish gray, massive.
Unit 69: Sandstone, mudstone, and siltstone. Basal 2.6 m is sandstone, fines upward (230 to 80 μ), sharp base and gradational top, mudstone clasts at base and burrows in upper part; upper 1.0 m is interbedded sandstone, siltstone, and greenish-gray mudstone.
Unit 68: Mudstone. Gray, contains dolomite.
Unit 67: Sandstone and mudstone. Thin-bedded, wave-rippled sandstone interbedded with mudstone.
Unit 66: Mudstone. Light greenish gray, laminated; 2.5-cm-thick bed of dark-colored tuff.
Unit 65: Siltstone. Light gray, thin bedded, mudcracks or syneresis cracks.
Unit 64: Covered.
Unit 63: Interbedded siltstone and mudstone. Siltstone contains wave ripples and mudcracks and (or) syneresis cracks.
Unit 62: Mudstone. Yellowish dark gray, silty, laminated, amount of silt increases upward.
Unit 61: Siltstone. Thin bedded, wave ripples and soft-sediment deformation.
SECTION 17
INTERVAL: 150 to 200 m


LITHOLOGY
SH & CARB
MDST
SLST
SANDSTONE (microns)
62
100
200
300
UNIT NUMBER
FACIES
DESCRIPTION
NOTE: The top of measured section 17 (that is, unit 86) is 79.5 m below top of Parachute Creek Member as defined by Dane (1954, 1955) and Ray and others (1956). The interval between unit 86 and the top of the Parachute Creek Member was not examined in detail but consists mainly of light-gray, covered slopes underlain by dark mudstone.
Unit 86: Tuff. Yellow to very light gray, lower part contains abundant biotote crystals, upper part is very fine grained and does not contain abundant biotite, unit forms regional stratigraphic marker.
Unit 85: Mudstone. Yellowish gray, poorly exposed laminations.
Unit 84: Sandstone, 90 μ. Wave rippled.
Unit 83: Mudstone. Very poorly exposed.
Unit 82: Sandstone (90 μ) and mudstone. Interbedded gray mudstone and wave-rippled sandstone.
Unit 81: Mudstone. Very poorly exposed.
Unit 80: Sandstone 90 μ. Wave ripples and mudcracks.
Unit 79: Mudstone. Very poorly exposed.
Unit 78: Mudstone and sandstone (62-90 μ). Interbedded gray mudstone and wave-rippled sandstone, bed thickness of sandstone increases upward from 10 to about 30 cm.
Unit 77: Mudstone. Dark yellowish gray, some zones laminated, very poorly exposed.
SECTION 17
INTERVAL: 200 to 228 m



EXPLANATION



☆U.S. GOVERNMENT PRINTING OFFICE: 1992-774-049/66025