UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Measured stratigraphic section of the Upper Cretaceous Frontier Formation near McLeod, Sweet Grass County, Montana

by

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

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ILLUSTRATIONS

MEASURED STRATIGRAPHIC SECTION OF THE UPPER CRETACEOUS FRONTIER FORMATION NEAR MCLEOD, SWEET GRASS COUNTY, MONTANA

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R.G. Tysdal and D.J. Nichols

INTRODUCTION

This section of the Upper Cretaceous Frontier Formation is one of several such sections that were measured for correlation of Cretaceous rocks in southwestern Montana. It was not published as part of a correlation chart as were other sections (for example, Tysdal and others, 1989; in press) and, therefore, is published separately here in order to make the data available to other workers. The Frontier section near McLeod was measured in gently dipping strata along the steep east face of the ridge in the SW1/4 sec. 12 and SE1/4 sec. 11, T. 3 S., R. 12 E., McLeod Basin 7.5-minute quadrangle, Sweet Grass County, Montana.

The Frontier of the measured section conformably overlies the Mowry Shale. Strata of the overlying Cody Shale are not preserved at the site of the measured section, but are present about 1 mile to the east where the contact is unconformable. The measured thickness of the Frontier is 709.5 ft. The thickness of the uppermost part of the Frontier, which is not present in the measured section, is uncertain, but probably is 100-200 ft.

The section was measured using a hand level mounted on a Jacob's staff. Palynomorphs from the Frontier Formation were identified by co-author D.J. Nichols. The mollusk from the underlying Mowry Shale was identified by W.A. Cobban (written commun., 1983). The stratigraphic position of each fossil locality is indicated by a solid circle in the graphic log and the locality number is in the accompanying descriptive text.

The palynomorph assemblages recovered from localities D6951-A and D6951-B of the Frontier Formation include both marine dinocysts and pollen, and spores of terrestrial origin. Species identified are characteristic of the *Alterberia* sp. A Interval Zone (marine) and the largely equivalent *Nyssapollenites* Interval Zone (nonmarine), which are Cenomanian through Turonian in age (Nichols and others, 1982). These assemblages are typical of the marine facies of the Frontier Formation. The mollusc *Neogastroplites* sp. from the upper part of the Mowry Shale is most probably of Cenomanian age (W.A. Cobban, oral commun., 1989). The Cenomanian age assignment is reflective of revision of the boundary between Lower and Upper Cretaceous rocks (Cobban and Kennedy, 1989).

The graphic log and text of the measured section were generated on a Laser printer using the LOGGER computer plotting program by RockWare, Inc., Wheat Ridge, Colo. Footage of the section is displayed as a borehole with increasing depth downsection. Lithostratigraphic unit numbers are at the right margin of the section.

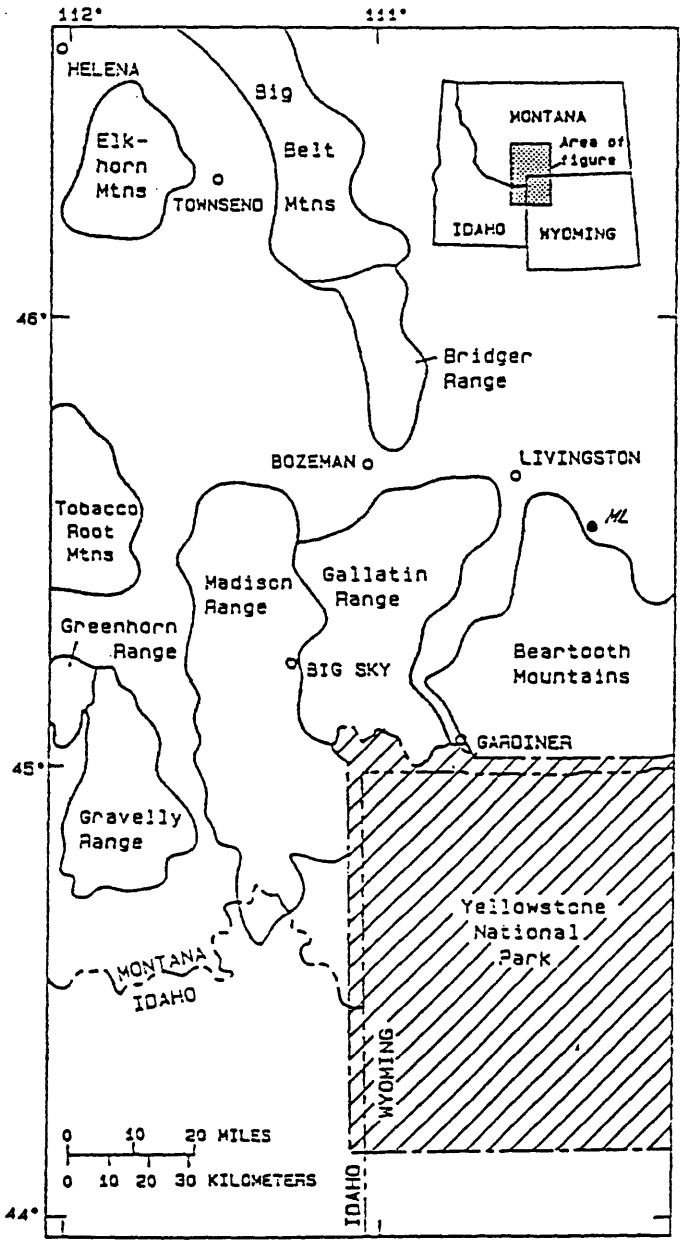
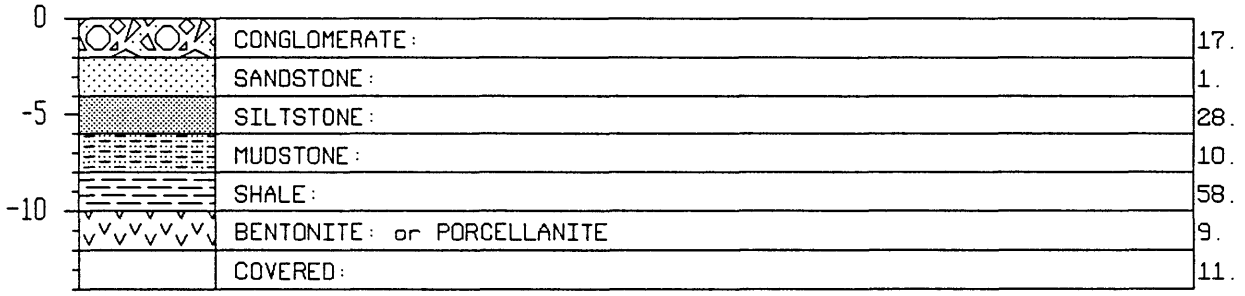


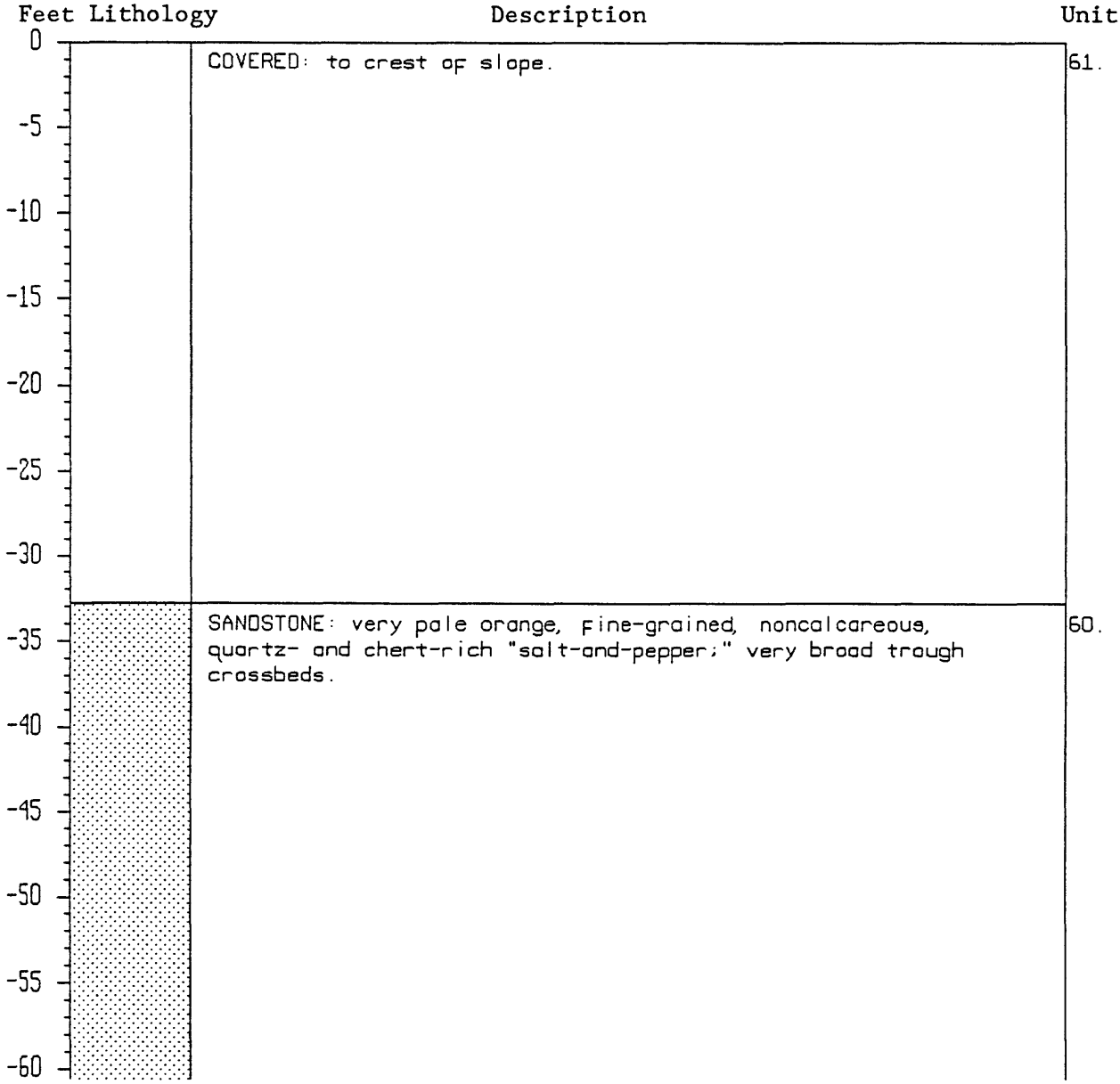
Figure 1. Index map of mountain ranges, cities, and location of McLeod measured section (*ML*), indicated by a solid circle.

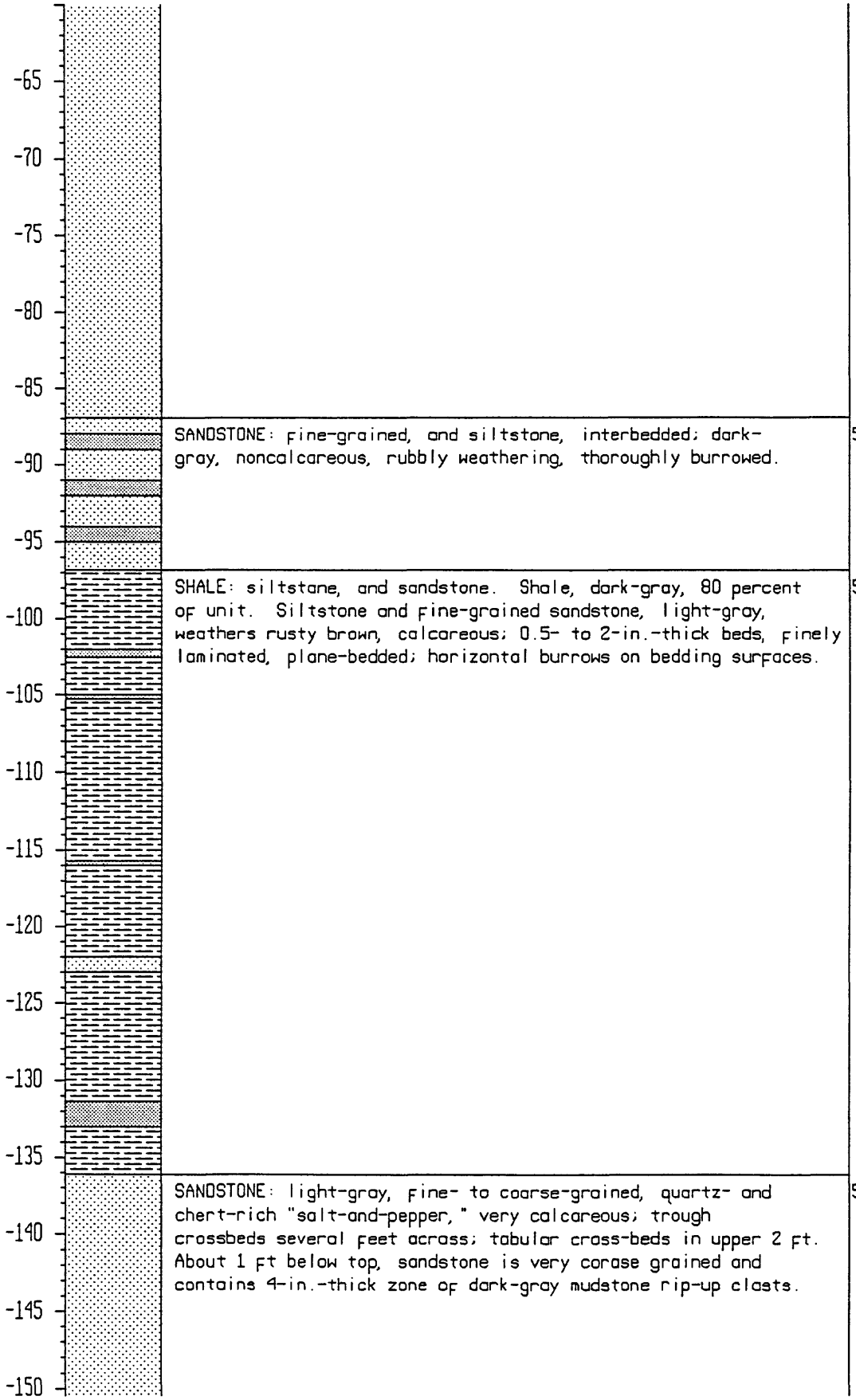
EXPLANATION OF MEASURED SECTION



MEASURED SECTION OF FRONTIER FORMATION

scale: 1 in. = 10 ft

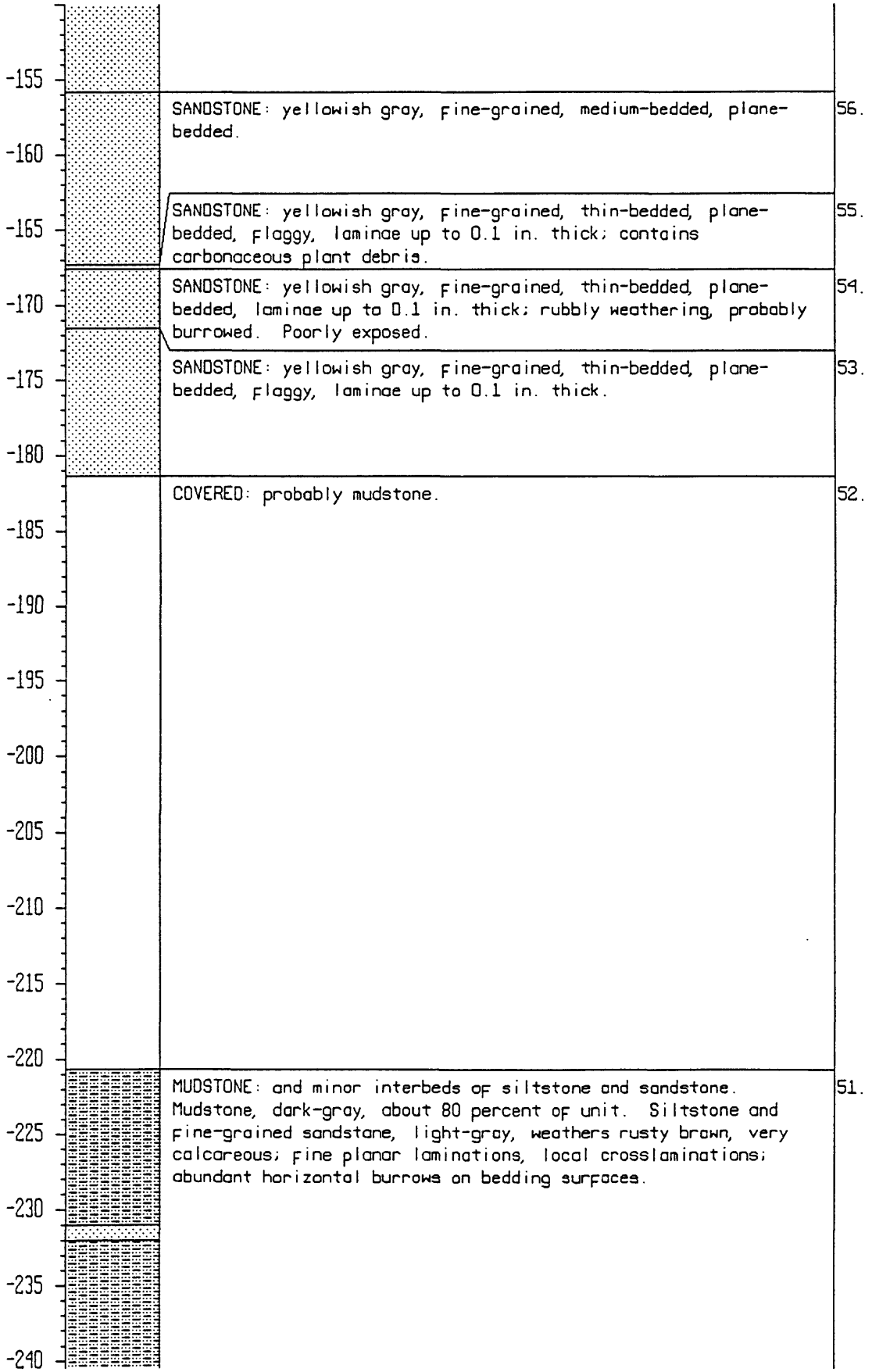




SANDSTONE: fine-grained, and siltstone, interbedded; dark-gray, noncalcareous, rubbly weathering, thoroughly burrowed. 59.

SHALE: siltstone, and sandstone. Shale, dark-gray, 80 percent of unit. Siltstone and fine-grained sandstone, light-gray, weathers rusty brown, calcareous; 0.5- to 2-in.-thick beds, finely laminated, plane-bedded; horizontal burrows on bedding surfaces. 58.

SANDSTONE: light-gray, fine- to coarse-grained, quartz- and chert-rich "salt-and-pepper," very calcareous; trough crossbeds several feet across; tabular cross-beds in upper 2 ft. About 1 ft below top, sandstone is very corase grained and contains 4-in.-thick zone of dark-gray mudstone rip-up clasts. 57.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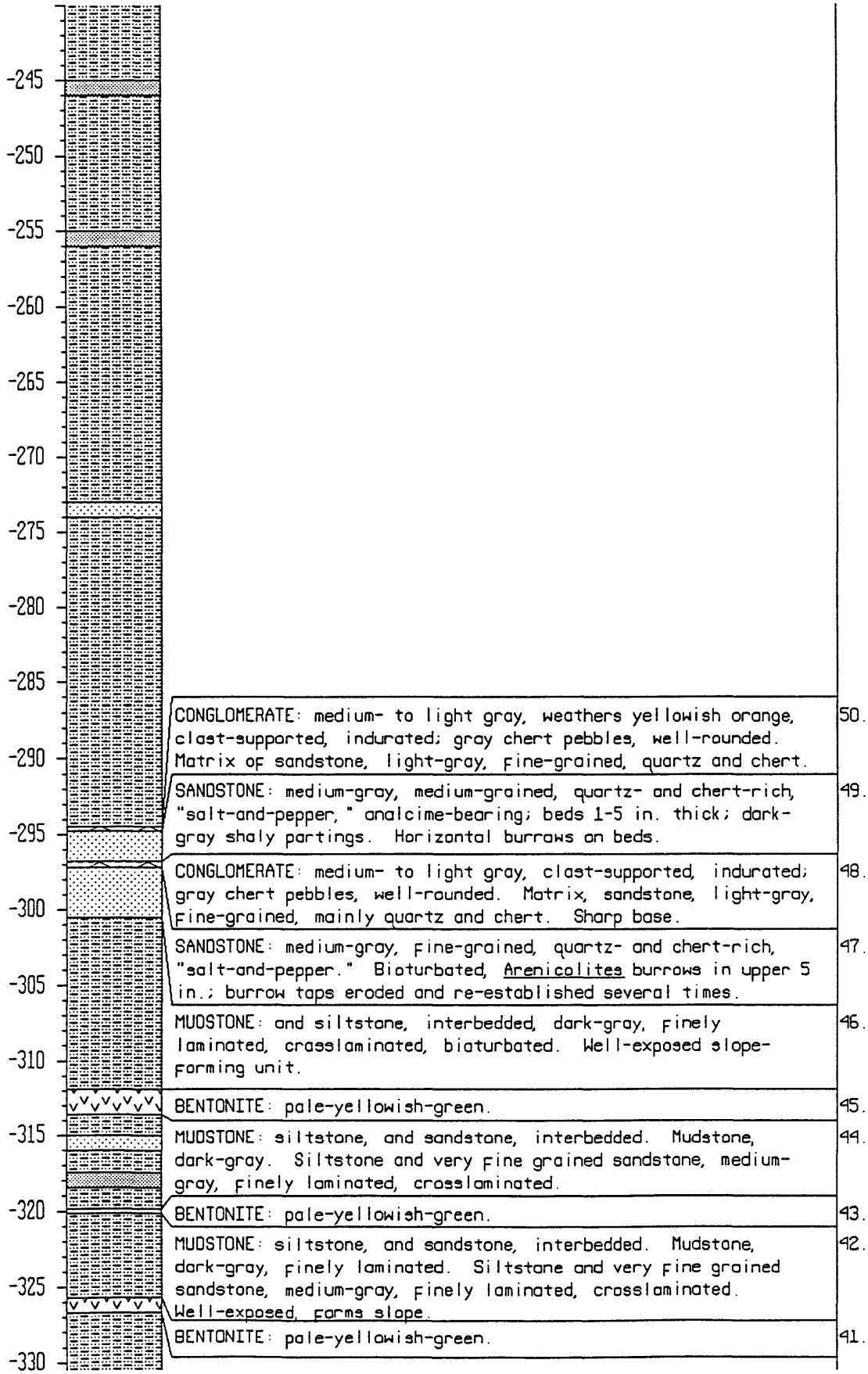
SANDSTONE: yellowish gray, fine-grained, medium-bedded, plane-bedded.
56.
SANDSTONE: yellowish gray, fine-grained, thin-bedded, plane-bedded, flaggy, laminae up to 0.1 in. thick; contains carbonaceous plant debris.
55.
SANDSTONE: yellowish gray, fine-grained, thin-bedded, plane-bedded, laminae up to 0.1 in. thick; rubbly weathering, probably burrowed. Poorly exposed.
54.
SANDSTONE: yellowish gray, fine-grained, thin-bedded, plane-bedded, flaggy, laminae up to 0.1 in. thick.
53.
COVERED: probably mudstone.
52.
MUDSTONE: and minor interbeds of siltstone and sandstone. Mudstone, dark-gray, about 80 percent of unit. Siltstone and fine-grained sandstone, light-gray, weathers rusty brown, very calcareous; fine planar laminations, local crosslaminations; abundant horizontal burrows on bedding surfaces.
51.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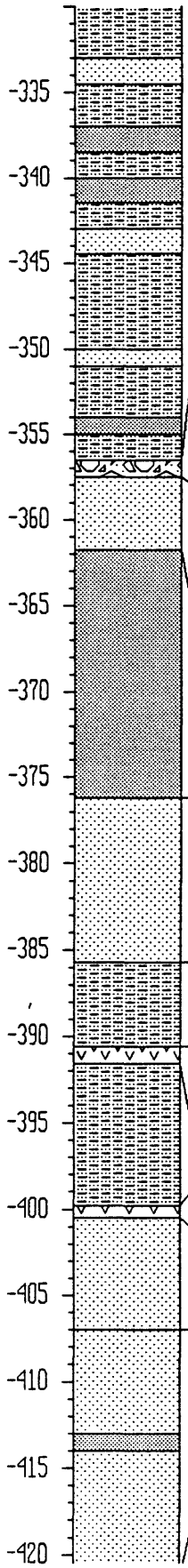
CONGLOMERATE: medium- to light gray, weathers yellowish orange, clast-supported, indurated; gray chert pebbles, well-rounded. Matrix of sandstone, light-gray, fine-grained, quartz and chert.
50.
SANDSTONE: medium-gray, medium-grained, quartz- and chert-rich, "salt-and-pepper," analcime-bearing; beds 1-5 in. thick; dark-gray shaly partings. Horizontal burrows on beds.
49.
CONGLOMERATE: medium- to light gray, clast-supported, indurated; gray chert pebbles, well-rounded. Matrix, sandstone, light-gray, fine-grained, mainly quartz and chert. Sharp base.
48.
SANDSTONE: medium-gray, fine-grained, quartz- and chert-rich, "salt-and-pepper." Bioturbated, Arenicolites burrows in upper 5 in.; burrow tops eroded and re-established several times.
47.
MUDSTONE: and siltstone, interbedded, dark-gray, finely laminated, crosslaminated, bioturbated. Well-exposed slope-forming unit.
46.
BENTONITE: pale-yellowish-green.
45.
MUDSTONE: siltstone, and sandstone, interbedded. Mudstone, dark-gray. Siltstone and very fine grained sandstone, medium-gray, finely laminated, crosslaminated.
44.
BENTONITE: pale-yellowish-green.
43.
MUDSTONE: siltstone, and sandstone, interbedded. Mudstone, dark-gray, finely laminated. Siltstone and very fine grained sandstone, medium-gray, finely laminated, crosslaminated. Well-exposed, forms slope.
42.
BENTONITE: pale-yellowish-green.
41.



MUDSTONE: siltstone and sandstone, interbedded. Mudstone, dark-gray, finely laminated. Siltstone and very fine grained sandstone, medium-gray; noncalcareous, chiefly quartz, chert, and feldspar, some mottles of analcime; finely laminated and and crosslaminated; contains clayey laminae. Well-exposed, forms slope. 40.

CONGLOMERATE: chert pebbles, medium- to light gray, well-rounded, clast-supported, noncalcareous. Matrix of sandstone, fine- to medium-grained, mainly quartz and chert. Well-cemented, caps a ledge. 39.

SANDSTONE: gray-green, fine-grained, quartz, chert, and feldspar; weathered surface locally mottled medium-gray due to alteration of feldspar to analcime; thin- to medium-bedded; lower half rubbly. Forms ledge. 38.

SILTSTONE: dark-gray, beds about 0.5 in. thick, burrow structures are mottled medium-gray. Poorly exposed, forms slope. 37.

SANDSTONE: gray-green fine-grained, thin-bedded, wispy cross-laminated; weathered surface mottled medium-gray with analcime. Forms slope. 36.

MUDSTONE: dark-gray, thin-bedded, finely laminated; sparse .01-in.-thick laminae of siltstone, light-gray. 35.

BENTONITE: pale-yellowish-green. 34.

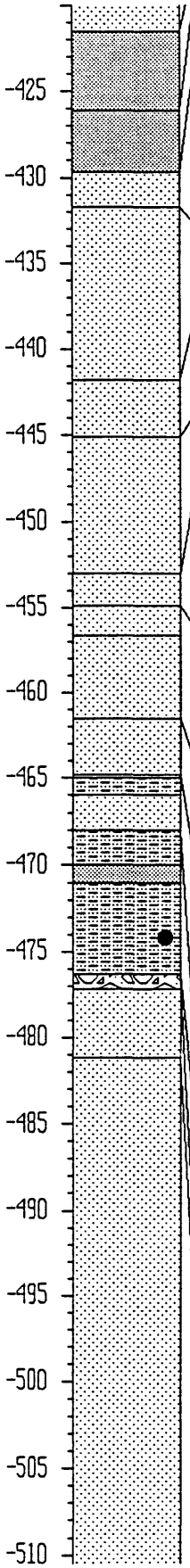
MUDSTONE: dark-gray, thin-bedded, finely laminated. 33.

BENTONITE: pale-yellowish-green. 32.

SANDSTONE: gray-green, fine-grained, quartz, chert, and feldspar, weathered surface has medium-gray mottles of analcime; thin- to medium-bedded. Forms ledge. 31.

SANDSTONE: light-gray, fine-grained, thin-bedded, ripple crosslaminated, mainly quartz, chert, and feldspar; weathered surface shows medium-gray mottles of analcime. Dark-gray partings and local thin interbeds of mudstone. Forms ledge. 30.

SILTSTONE: gray-green, thin-bedded, weathers rubbly. 29.



SILTSTONE: medium-gray, thin beds about 0.5 in. thick, thoroughly bioturbated, weathers rubbly. Forms slope. — 28.

SANDSTONE: medium-gray, fine-grained, uppermost part very fine grained to siltstone; mainly quartz, chert, and feldspar; some medium-gray mottles of analcime; medium-bedded, planar to slightly undulatory beds, finely laminated. Dark-gray shaly partings. Forms ledge. — 27.

SANDSTONE: light-gray, fine-grained, quartz, chert and feldspar; medium-gray mottles of analcime evident on weathered surface; thin-bedded, dark-gray clayey partings. Poorly exposed, forms slope. — 26.

SANDSTONE: medium-gray, fine-grained, medium-bedded; laminae are planar to slightly undulatory. Weathered surface mottled medium-gray with analcime. Shaly partings. Forms ledge. — 25.

SANDSTONE: light-gray fine-grained thin-bedded; weathered surface mottled medium-gray with analcime. Partings of dark-gray mudstone. Forms slope. — 24.

SANDSTONE: medium-gray, very fine grained, thin- to medium-bedded, ripple crosslaminated and trough crossbeds. Some strata burrowed, rubbly, weather to a rough surface. Capped by dark-gray mudstone bed, less than 1 in. thick, undulatory. — 23.

SANDSTONE: and mudstone, interbedded. Some sandstone beds light-gray, fine-grained, thin-bedded, finely laminated, including dark-gray mudstone laminae. Other sandstone beds medium-gray, fine-grained, thin-bedded, clayey, cherty, "salt-and-pepper," analcime-bearing. Mudstone, dark-gray, thin-bedded, finely laminated. — 22-21.

SANDSTONE: medium-gray, very fine grained, medium- to thick-bedded; quartz, chert, feldspar, and analcime(?); ripple cross-laminated and tabular crossbeds. Some strata are burrowed. — 20.

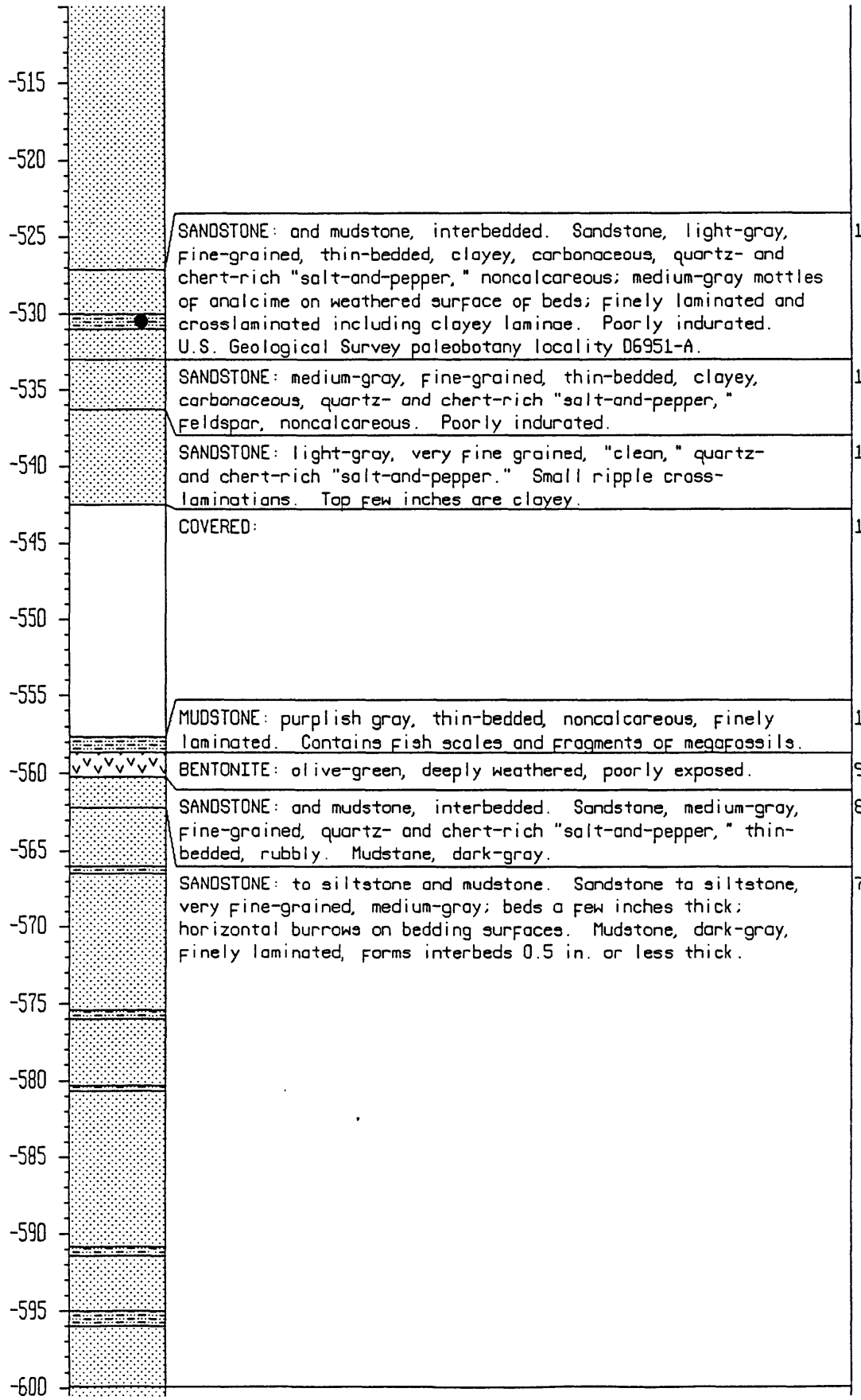
SANDSTONE: and mudstone, interbedded. Some sandstone beds light- to medium-gray, fine-grained, quartz, chert, feldspar, and analcime; thin-bedded, crosslaminated, finely laminated. Other sandstone beds medium-gray, fine-grained, thin-bedded, clayey, quartz- and chert-rich "salt-and-pepper;" poorly indurated. Mudstone, dark-gray, thin-bedded, finely laminated. — 19.

MUDSTONE: and siltstone, interbedded. Mudstone, dark-gray. Siltstone, medium-gray, thin-bedded, finely laminated. U.S. Geological Survey paleobotany locality D6951-B. — 18.

CONGLOMERATE: medium- to light-gray, chert pebbles, well-rounded, clast-supported. Matrix of sandstone, fine- to coarse-grained, quartz and chert. Sharp base cuts underlying sandstone. Well-cemented, indurated, forms ledge. — 17.

SANDSTONE: pale-brown, fine-grained, quartz- and chert-rich "salt-and-pepper." Forms single bed. — 16.

SANDSTONE: light-gray, fine-grained; mainly quartz, chert, and feldspar, calcareous; thin-bedded. Weathered surface mottled medium-gray with analcime. Contains fish scales, Ophiomorpha(?). — 15.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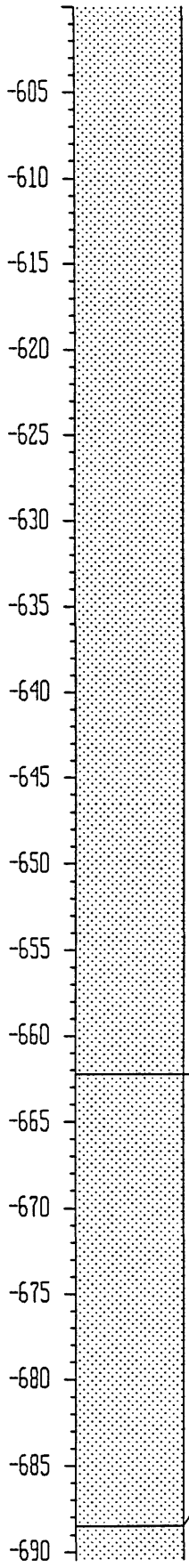
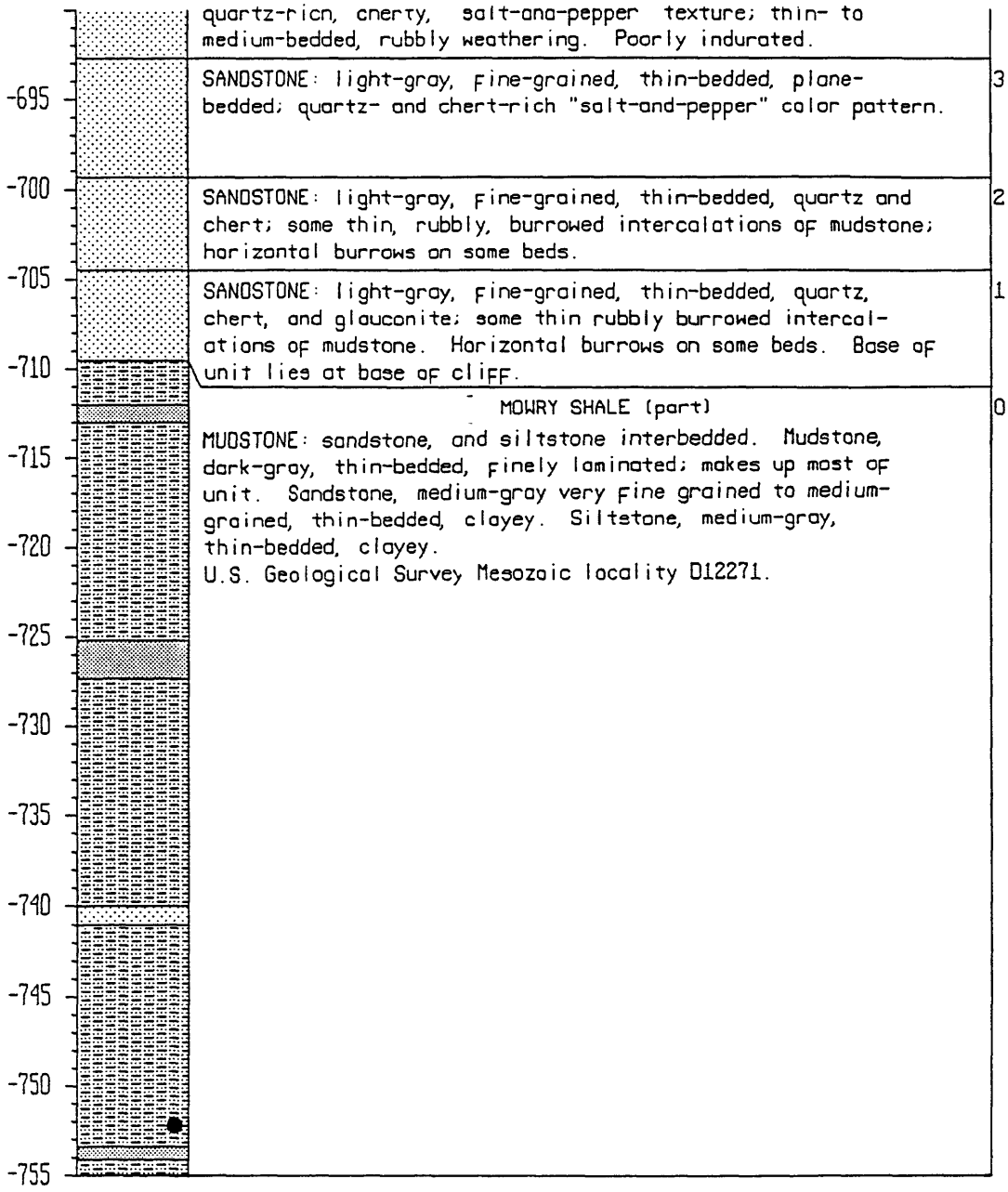
SANDSTONE: and mudstone, interbedded. Sandstone, light-gray, fine-grained, thin-bedded, clayey, carbonaceous, quartz- and chert-rich "salt-and-pepper," noncalcareous; medium-gray mottles of analcime on weathered surface of beds; finely laminated and crosslaminated including clayey laminae. Poorly indurated. U.S. Geological Survey paleobotany locality D6951-A.
14.
SANDSTONE: medium-gray, fine-grained, thin-bedded, clayey, carbonaceous, quartz- and chert-rich "salt-and-pepper," feldspar, noncalcareous. Poorly indurated.
13.
SANDSTONE: light-gray, very fine grained, "clean," quartz- and chert-rich "salt-and-pepper." Small ripple cross-laminations. Top few inches are clayey.
12.
COVERED:
11.
MUDSTONE: purplish gray, thin-bedded, noncalcareous, finely laminated. Contains fish scales and fragments of megafossils.
10.
BENTONITE: olive-green, deeply weathered, poorly exposed.
9.
SANDSTONE: and mudstone, interbedded. Sandstone, medium-gray, fine-grained, quartz- and chert-rich "salt-and-pepper," thin-bedded, rubbly. Mudstone, dark-gray.
8.
SANDSTONE: to siltstone and mudstone. Sandstone to siltstone, very fine-grained, medium-gray; beds a few inches thick; horizontal burrows on bedding surfaces. Mudstone, dark-gray, finely laminated, forms interbeds 0.5 in. or less thick.
7.



SANDSTONE: light-gray, quartz, some chert, "salt-and-pepper" texture, glauconitic, fine-grained; trough crossbeds as much as 3 ft across, crossbed sets 10-15 in. thick in upper part, thicker in lower part. Top of unit forms top of cliff. 6.

SANDSTONE: light-gray, fine-grained, quartz, sparse glauconite; fine planar laminations, beds 3 ft or more thick. Uppermost part has 5-in.-thick beds, rippled, with more glauconite than in lower beds; vertical burrows, about 0.1 in. diameter and 10 in. high, cylindrical. 5.

SANDSTONE: medium-gray, fine- to medium-grained, glauconitic, 4.



quartz-rich, cherty, salt-and-pepper texture; thin- to medium-bedded, rubbly weathering. Poorly indurated.

SANDSTONE: light-gray, fine-grained, thin-bedded, plane-bedded; quartz- and chert-rich "salt-and-pepper" color pattern. 3.

SANDSTONE: light-gray, fine-grained, thin-bedded, quartz and chert; some thin, rubbly, burrowed intercalations of mudstone; horizontal burrows on some beds. 2.

SANDSTONE: light-gray, fine-grained, thin-bedded, quartz, chert, and glauconite; some thin rubbly burrowed intercalations of mudstone. Horizontal burrows on some beds. Base of unit lies at base of cliff. 1.

MOWRY SHALE (part) 0.

MUDSTONE: sandstone, and siltstone interbedded. Mudstone, dark-gray, thin-bedded, finely laminated; makes up most of unit. Sandstone, medium-gray very fine grained to medium-grained, thin-bedded, clayey. Siltstone, medium-gray, thin-bedded, clayey.
U.S. Geological Survey Mesozoic locality D12271.

Table 1. Lists of fossils collected from McLeod measured section. Stratigraphic position of each collection is indicated by solid circle in graphic log; locality number is in adjacent text.

PALYNOMORPHS
(identified by D.J. Nichols)

Locality D6951-B

Baltisphaeridium sp.
Camarozonosporites sp.
Cicatricosisporites hallei
Cicatricosisporites sp.
Corollina sp.
Cribroperidinium edwardsii
Cyathidites sp.
Deflandrea sp.
Gleicheniidites spp.
Oligosphaeridium sp.
Ovoidinium verrucosum
Palaeohystrichophora infusorioides
Pityosporites sp.
Quadripollis krempii
Dinocysts, unidentified

Locality D6951-A

Appendicisporites sp.
Baltisphaeridium sp.
Camarozonosporites sp.
Cicatricosisporites hallei
Corollina sp.
Costatoperforosporites foveolatus
Cupuliferoidaepollenites sp.
Cyathidites sp.
Gleicheniidites spp.
Ischyosporites sp.
Oligosphaeridium pulcherrimum
Ovoidinium verrucosum
Palaeohystrichophora infusorioides
Phyllocladidites sp.
Pityosporites sp.
Pterospermella sp.
Spiniferites sp.
Taurocusporites sp.
Angiosperm tetrads, unidentified
Dinocysts, unidentified

MOLLUSKS
(identified by W.A. Cobban)

Locality D12271

Neogastroplites sp.

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