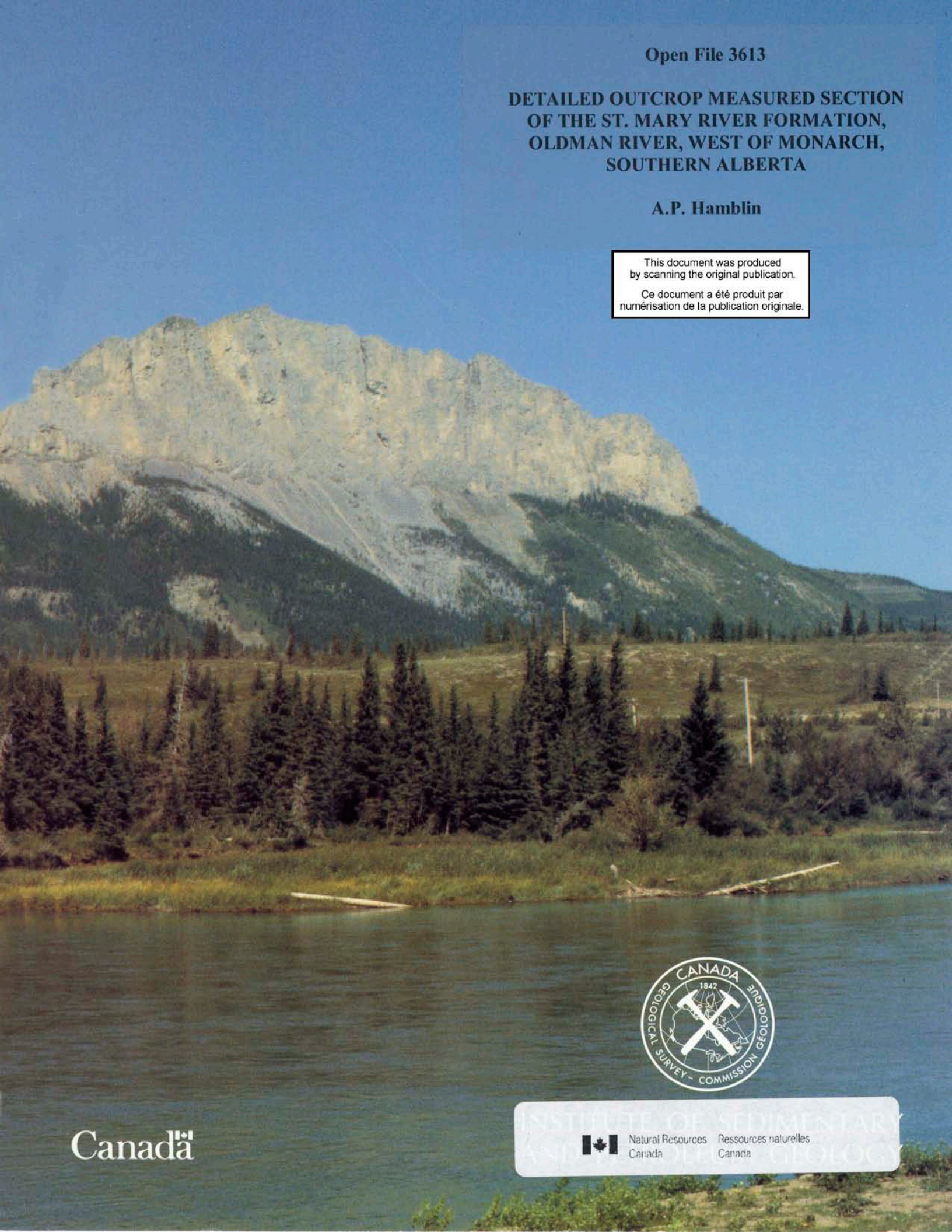
Open File 3613

DETAILED OUTCROP MEASURED SECTION OF THE ST. MARY RIVER FORMATION, OLDMAN RIVER, WEST OF MONARCH, SOUTHERN ALBERTA

A.P. Hamblin



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DETAILED OUTCROP MEASURED SECTION OF THE ST. MARY RIVER FORMATION, OLDMAN RIVER, WEST OF MONARCH, SOUTHERN ALBERTA

By A.P. Hamblin

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INTRODUCTION

The enclosed measured outcrop description section represents a partially complete succession through the Maastrichtian-age St. Mary River Formation. The nearly continuous outcrop, located about 200 km south-southeast of Calgary (Fig. 1), is one of the most complete surface records of these strata in the Plains portion of the basin. It includes about 530 m of the St. Mary River Formation. Beds exposed at this location were briefly examined by Williams and Dyer (1930), Russell and Landes (1940) and Tozer (1952), concentrating particularly on the St. Mary River/Willow Creek contact. Nadon (1991) provided detailed descriptions and paleocurrent data for individual channel sandstones throughout this outcrop area, but no complete measured section or direct stratigraphic correlation to surrounding surface and subsurface occurrences.

Background geological information on the St. Mary River Formation, Edmonton Group and Bearpaw Formation, both in surface and subsurface, were summarized in Hamblin (1998a, 1998b, 1998c). In addition, information pertinent to the petroleum geology, discovered reserves and hydrocarbon potential of the strata of the Edmonton Group was detailed by Hamblin and Lee (1997). Further outcrop and subsurface studies of the Edmonton, and related St. Mary River Formation, are currently in progress.

The exposures are good to excellent, are scattered along 20 km of the Oldman River (Fig. 1) in a line oblique to the strike of the bedding and reveal portions of most of the ~530 m of stratigraphic thickness. The outcrops are located in Twp. 9-10, Rge 23-25W4. Together, the exposed sections cover about 410 m of the succession, with a large gap only in the lower 1/3 of the unit, here estimated at about 90 m (Fig. 2). Paleocurrent data, suggesting dominant direction of sediment dispersal, is summarized in Figure 3. A subsurface Gamma Ray-Sonic log from a nearby well to the west is also included for comparison to the outcrops (Fig. 4).

SUMMARY OF SEDIMENTOLOGY AND STRATIGRAPHY

The exposed section of Maastrichtian rocks detailed here covers about 410 metres of the succession, missing only a 90 m interval in the lower third, and several very minor intervals elsewhere (Fig. 2). The basal contact of the St. Mary River Formation is exposed at the Monarch Fault Zone, 3 km south of the village of Monarch, where it overlies marine shale of the Bearpaw Formation. The upper contact is exposed at the northward bend of the river, 6 km north of the village of Pearce, where the lowest beds of the overlying Willow Creek Formation appear.

Bearpaw Formation

The Bearpaw Formation, as exposed here, consists of grey to dark grey silty mudstone, slightly coarsening-upward, with abundant bioturbation. Only the uppermost few metres is present.

St. Mary River Formation

The St. Mary River Formation is generally characterized by thinly interbedded siltstone, very fine to medium sandstone and minor carbonaceous shale to coal. The lower 60 m exposed here (Fig. 2a) includes alternating very fine to fine sandstone, grey burrowed siltstone with gastropod shells, minor greenish grey pedogenic siltstone and numerous seams of coal and carbonaceous mudstone. These facies are similar to those commonly associated with the lower

Horseshoe Canyon Formation to the north (see Hamblin, 1998b)and the lower portion of the St. Mary River Formation as exposed near Little Bow Provincial Park (see Hamblin, 1998a). This is interpreted as a shoreline-related transitional succession, with significant marine influence at the 30 m and the 40 m levels. No significant shoreface deposits are preserved here, although this section is approximately correlative to the Blood Reserve Formation of the southernmost Foothills (see Hamblin, 1998b). This exposure is followed by a covered interval, estimated at about 90 m in thickness (Fig. 1, 2a,b).

The succeeding section, from about 150 m to about 455 m (fig. 2b-e), consists of a monotonous succession of thinly interbedded greenish grey pedogenic siltstone, sharp-based fining-upward fine to medium sandstone, with sideritic concretion horizons and minor thin bentonite beds. Roots and dinosaur footprints are common, but thin carbonaceous mudstones are rare. These facies are typical of the St. Mary River Formation throughout its area of distribution in the southern Plains and Foothills (see Hamblin, 1998b). These sediments are interpreted as the result of floodplain deposition in a non-marine setting. Some sandstone units are thick, multi storied, have erosional bases and are characterised by abundant trough and ripple cross bedding. These are interpreted as significant channel deposits. Abundant paleocurrent data suggests dominant sediment dispersal toward the northeast (Fig. 3), a conclusion similar to that of Nadon (1991). Indications of some possible marine (or open lacustrine?) influence are present in the 305-330 m level: presence of *Ophiomorpha* and other vertical burrows, hummocky cross stratification, and thin coarsening-upward sequences. These features, positioned at approximately 2/3 from the base of the formation, are in a similar position to that of the Drumheller Marine Tongue of the Horseshoe Canyon Formation to the north.

From about 455 m to 533 m represents the upper 78 m of the St. Mary River Formation. It includes interbedded thick fine to medium sandstones, lesser greenish grey pedogenic siltstone, and abundant thin carbonaceous mudstones. Roots are ubiquitous. Sideritic concretion horizons are absent. These facies are more reminiscent of the Horseshoe Canyon Formation to the north. Paleocurrent data indicate sediment dispersal was much more variable than in the previous unit including transport to the northeast, southeast, northwest and southwest. These deposits are interpreted to represent floodplain deposition, with re-establishment of conditions favourable to preservation of peat accumulation. Ten metres below the upper contact a white, trough cross bedded sandstone with large vertical tree roots is present, approximately correlative to the well-known Whitemud Formation of southeastern and central Alberta. In the upper 10 m are two distinct dark grey to brownish, laminated, bentonitic mudstone units which are very similar to the well-known Battle Formation of southeastern and central Alberta.

Willow Creek Formation

Only about 10 m of the overlying Willow Creek Formation is poorly exposed at this location. Bright green shale alternates with whitish very fine to fine sandstone.

INTERPRETATION

Comparison of the surface and subsurface sections (Fig. 4), and with the section near Carmangay (Hamblin 1998a), suggests that the intertonguing of St. Mary River-type facies of the south with Horseshoe Canyon-type facies of the north occurs in a definable and stratigraphically organized fashion at this latitude. Horseshoe Canyon-type facies (pale grey thick channel

sandstones interbedded with burrowed marine-brackish mudstone, abundant coals and carbonaceous shales, and lesser pedogenic siltstone) are prevalent in the lower ~70 m and the upper ~80 m. However, strata of the intervening ~350 m are dominated by St. Mary River-type facies (greenish grey pedogenic siltstone with abundant caliche/paleosol horizons and roots, interbedded with thin grey to buff sandstones and rare thin carbonaceous shales). Here, at the latitude of Twp 10, the Horseshoe Canyon-like units are thinner and less organic-rich than those at the latitude of Twp 14 near Carmangay (see Hamblin 1998a). Conversely, the St. Mary River-like facies are more dominant.

This stratigraphic arrangement may be interpreted as representing a N-S climatic trend (more humid to the north, more arid to the south; first expounded by Jerzykiewicz and Sweet, 1988) which shifted first northward, then southward through the time of Maastrichtian deposition. Conversely, it may be the result of the large-scale intertonguing of two different clastic wedges in this area which had different depositional styles, sediment sources and patterns of sediment dispersal. A third possibility is a relation to transgressive-regressive patterns. A combination of all three is possible.

HYDROCARBON POTENTIAL

Further work is required to resolve the regional-scale stratigraphic architecture of the Maastrichtian deposits of southern Alberta. This may be important because a limited number of gas pools are known in the Horseshoe Canyon to the north, although relatively little exploration has ever been targeted directly toward these units. However, vast areas of Alberta shallowly underlain by these units are essentially unexplored at this stratigraphic level, and may offer undiscovered pools of modest size, low pressure, but inexpensive exploration costs.

LIST OF FIGURES

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519

Twp 11

Twp 10

1515-540m

460-515m

410-460m

365-410m

Oldman R.

approximate outcrop top St. Mary River Fm.
approximate outcrop base Willow Creek Fm.

350-365 m

340-350 m

340°
8°w

approximate strike and dip of beds

≈ 60-150m covered interval

150-205m

45-60m

225-340m

approximate outcrop base St. Mary River Fm.
approximate outcrop top Beaverhill Lake Fm.

23

Monarch

Pearce

3

new Highway construction

Twp 10

Twp 9

Oldman R.

0-45m

0 5km

Rge 25w4 | Rge 24w4

Rge 24w4 | Rge 23w4

FIGURE 1

FIGURE 1

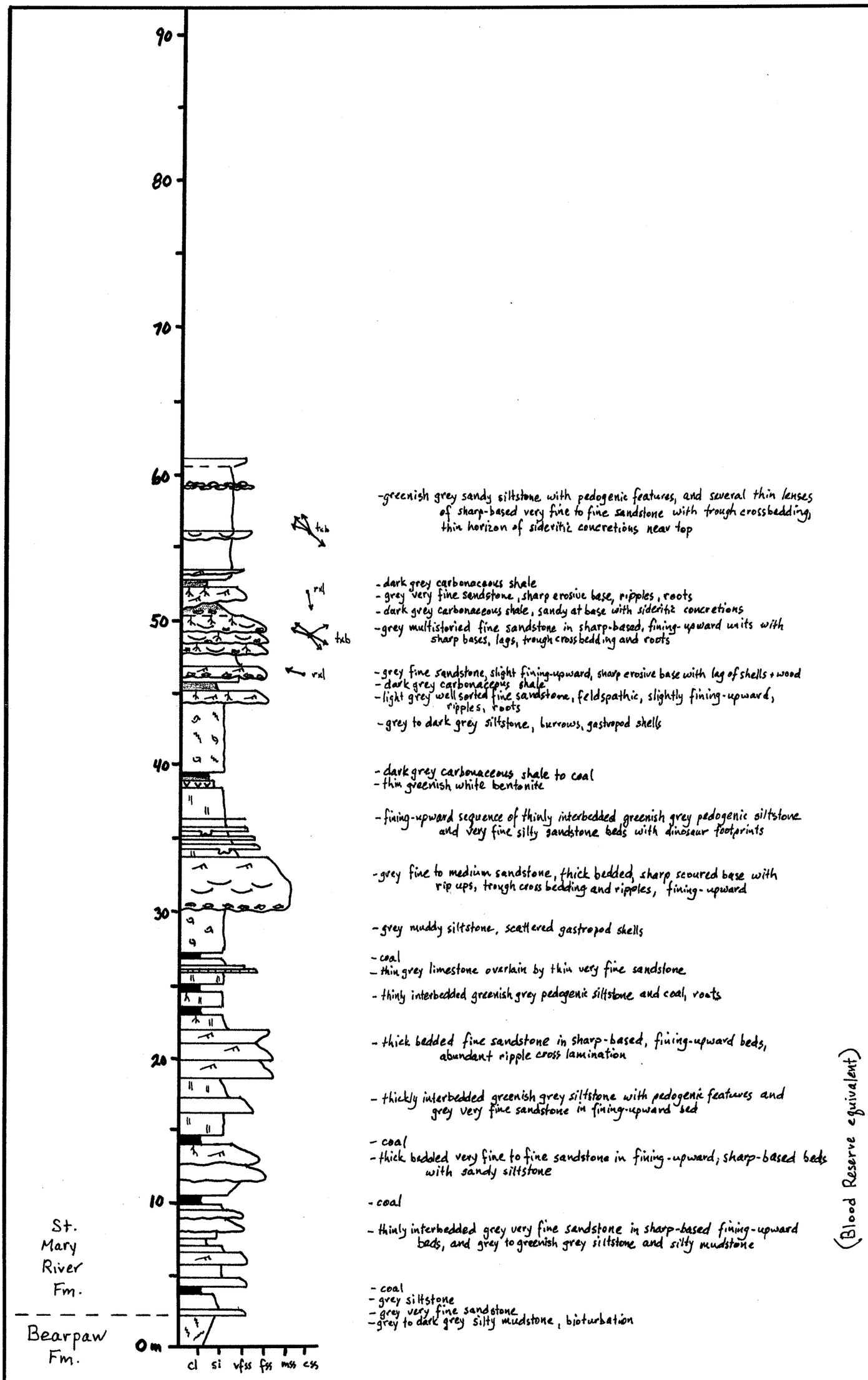
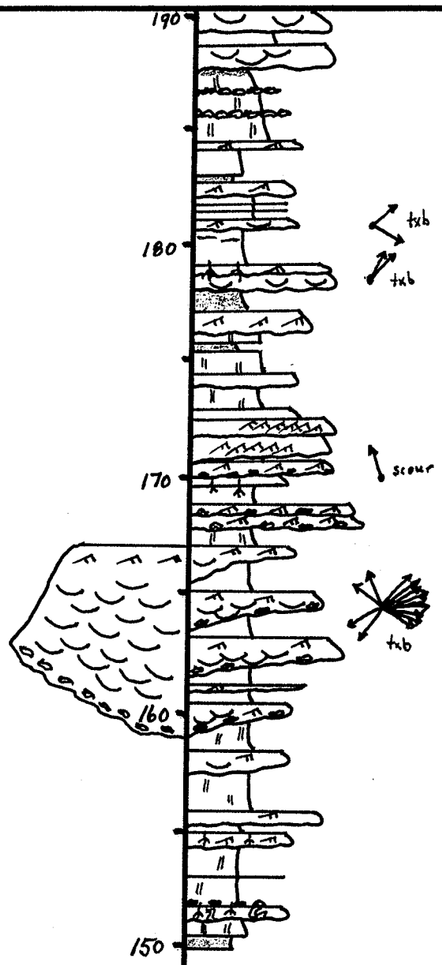


FIGURE 2(a)

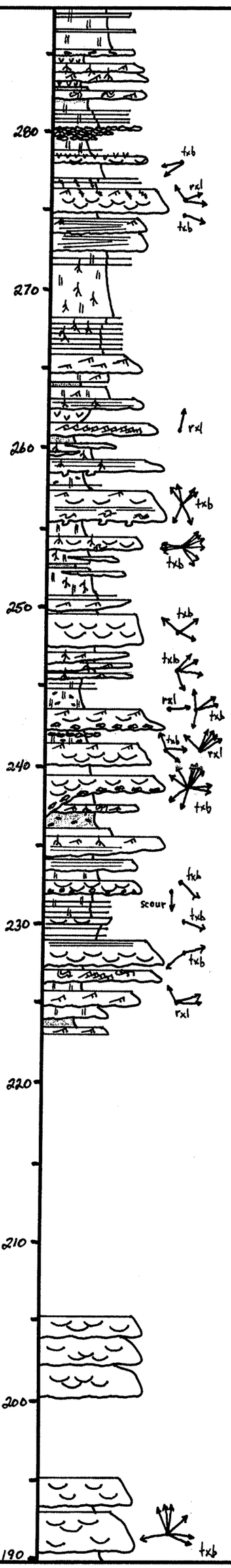
FIGURE 2 (a)



- greenish grey pedogenic siltstone, several horizons of sideritic concretions, carbonaceous shale at top
- grey very fine sandstone, ripples
- greenish grey pedogenic muddy siltstone, thin carbonaceous shale at base
- thinly interbedded grey very fine sandstone and siltstone, sharp erosive bases, trough cross bedded and rippled
- grey silty mudstone, carbonaceous streaks at top
- grey multistoried fine sandstone, sharp erosive base, fining-upward, trough cross bedding, ripples, roots
- carbonaceous shale
- grey fine sandstone, sharp base, fining-upward, rippled
- greenish grey pedogenic siltstone, thin carbonaceous shale near top
- grey fine sandstone, sharp base
- greenish grey pedogenic siltstone
- light grey multistoried fine sandstone with sharp erosional bases, separated by thin discontinuous siltstone lenses, coaly rip-ups, ripples and climbing ripples
- greenish grey siltstone and silty very fine sandstone, roots
- grey fine to medium sandstone, several stacked beds with erosional bases, ripups, fining-upward, rippled
- greenish grey sandy siltstone, pedogenic
- light grey very fine to medium sandstone, in several thick beds with sharp erosional bases and ripups separated by lenses of greenish grey siltstone – to west these all merge to form one thick 8m sandstone bed – trough cross bedded and rippled throughout
- greenish grey pedogenic siltstone
- light grey very fine sandstone, sharp scoured base, rippled
- greenish grey muddy siltstone, pedogenic
- several thin light grey very fine to fine sandstone beds, sharp erosive bases, fining-upward, roots, low angle lamination and ripples
- greenish grey silty mudstone, pedogenic
- greenish grey very fine sandstone, erosive base, roots, contorted lamination
- greenish grey silty mudstone, pedogenic
- dark grey carbonaceous shale

FIGURE 2 (b)

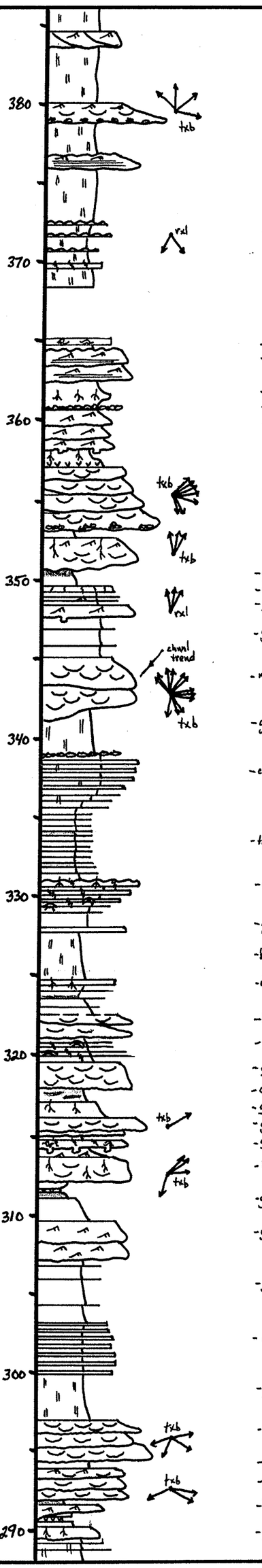
FIGURE 2(b)



- greenish grey pedogenic siltstone, few thin very fine sandstone beds
- grey silty fine sandstone, large wood fragments
- light grey claystone bentonite
- grey fine sandstone, rippled, rooted.
- light grey claystone bentonite
- grey fine sandstone, rippled, dinosaur footprints, contorted lamination
- thinly interbedded greenish grey pedogenic siltstone and very fine sandstone, carbonaceous at top
- lens of sideritic concretions, sharp irregular top, roots, fractures, slickensides – calcrete
- greenish grey pedogenic silty mudstone
- grey fine sandstone, trough cross bedded, several thin bentonite beds
- greenish grey siltstone
- light grey fine to medium sandstone, sharp base, fining-upward to siltstone, trough cross bedding, ripples, abundant vertical + horizontal burrows in upper 1 m including Ophiomorpha
- light grey fine sandstone in 2 sharp based beds, low angle lamination and ripples
- greenish grey very sandy siltstone, pedogenic, brecciated, calcareous, sideritic sandstone beds near top, roots
- thinly interbedded very fine sandstone and greenish grey siltstone, long roots
- light grey very fine to fine sandstone, sharp base, fining-upward, rippled
- greenish grey sandy siltstone, pedogenic, rippled, carbonaceous shale lens
- grey fine sandstone, horizontal and low angle lamination, roots at top
- light grey silty bentonite, coarsening-upward
- light grey fine to medium sandstone, fining-upward, climbing ripples
- dark grey carbonaceous shale
- greenish grey siltstone, roots, thin very fine sandstone lenses
- light grey fine to medium sandstone, sharp base with ball+pillow, roots, horizontal lamination
- greenish grey pedogenic silty mudstone, fining-upward; carbonaceous fragments
- light grey fine to medium sandstone, erosive base with ball+pillow, fining-upward, horizontal lamination, trough cross bedding, minor ripples
- greenish grey pedogenic siltstone
- rusty weathering fine sandstone, calcareous, roots, contorted lamination
- greenish grey pedogenic silty mudstone, roots throughout, thin carbonaceous shale near top, minor very fine sandstone lenses
- grey very fine sandstone, lens shape
- light grey fine sandstone, sharp erosive base, trough cross bedded, carbonaceous flakes
- interbedded very fine to fine sandstone and sandy siltstone, sharp erosional bases, sandstone beds merge to west, trough cross beds, ripples, roots
- greenish grey silty mudstone, pedogenic; carbonaceous fragments, several siltstone lenses with sharp irregular tops
- grey fine sandstone, fining-upward, erosive base with coarse lag and rip-ups, trough cross bedded, ripples
- greenish grey silty mudstone, pedogenic, carbonaceous, sideritic concretion bed
- light grey fine sandstone, erosive base with lag, fining-upward, trough cross bedded
- grey carbonaceous shale, silty streaks
- buff fine to medium sandstone, deeply incised to west, fining-upward, trough cross bedded
- dark grey carbonaceous sandy siltstone with thin fine sandstone and greenish sandy siltstone, roots, wood fragments, contorted lamination
- grey fine to medium sandstone lenses encased in greenish grey pedogenic sandy siltstone, erosive bases, horizontal lamination, roots,
- buff fine sandstone, erosive base with caliche rip ups and linear scours
- thinly interbedded pedogenic siltstone and very fine sandstone
- slightly coarsening-upward sequence of greenish sandy siltstone and silty very fine sandstone
- light grey fine to medium sandstone, calcareous, erosive base, trough cross bedded
- light grey feldspathic fine to medium sandstone encased in greenish pedogenic clayey siltstone, climbing ripples, contorted lamination
- light grey very fine to fine sandstone, fining-upward, sharp base, rippled
- greenish grey silty very fine sandstone, pedogenic, rippled, with carbonaceous shale
- grey multistoried fine sandstone, thick bedded, brownish weathering, sharp bases and fining-upward, trough cross bedded
- grey multistoried fine to very fine sandstone, brownish weathering, in thick sharp based beds each fining-upward and separated by thin carbonaceous sandy siltstone to silty very fine sandstone, trough cross bedded

FIGURE 2 (c)

FIGURE 2 (c)

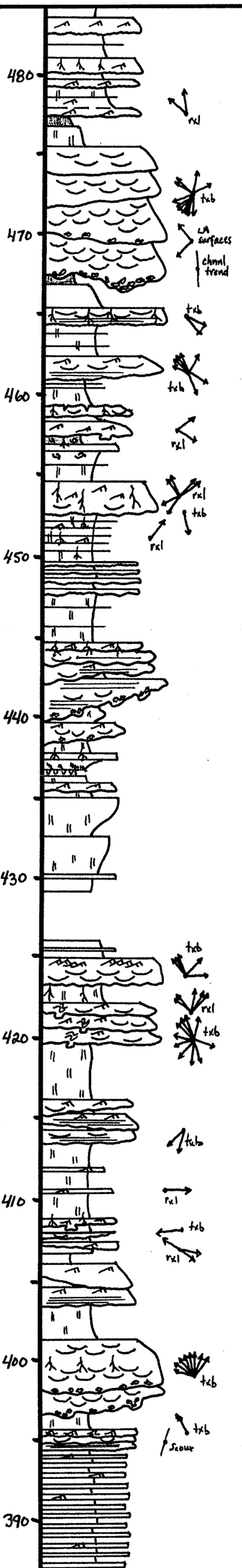


- greenish grey pedogenic siltstone, poorly exposed
- grey very fine sandstone, sharp base, lateral accretion surfaces, rippled top
- greenish grey pedogenic siltstone,
- white weathering very fine to medium sandstone, fining-upward, sharp base with rip-ups, large trough cross beds, rippled top, forms prominent ledge
- greenish grey pedogenic siltstone, fractures, rubbly weathering
- white weathering fine sandstone, fining-upward, sharp base, horizontal lamination
- greenish grey pedogenic siltstone, poorly exposed
- greenish grey pedogenic siltstone with thin very fine sandstone lenses, rippled
- rusty weathering calcrete horizon, vertical roots or burrows
- greenish grey pedogenic siltstone
- calcareous very fine sandstone and greenish grey pedogenic siltstone
- multistoried very fine to fine sandstone, erosional bases, sharp rippled top with fossil dinosaur droppings, horizontal lamination + ripples
- greenish grey pedogenic siltstone, thin rooted sandy zone in middle
- rusty weathering calcrete bed, fractured
- multistoried very fine sandstone in sharp based fining-upward beds, dinosaur footprints on base
- greenish grey siltstone, roots, coaly streaks, thin bentonite bed
- multistoried fine to medium sandstone, feldspathic, thick bedded, erosional base with localized lags of caliche nodules, trough crossbedded, separated into multiple sandstone beds to N
- greenish grey muddy siltstone grading up into dark grey carbonaceous shale
- rusty weathering calcrete bed, fractured, sharp top.
- grey fine sandstone fining-upward to siltstone, erosive base with dinosaur footprint, ripples and climbing ripples
- greenish grey sandy siltstone, few thin very fine sandstone beds
- multistoried fine sandstone, erosive incised base, slightly fining-upward, lens shaped units, trough crossbedded
- grey pedogenic siltstone, massive
- coarsening-upward sequence of grey fine sandstone and greenish grey pedogenic siltstone, irregular sideritic calcrete horizon at top
- thinly interbedded green muddy siltstone and greenish grey siltstone, few thin carbonaceous beds
- coarsening-upward sequence of grey fine to medium sandstone and sandy siltstone, low angle and hummocky cross stratification, ripples, roots, vertical burrows throughout
- grey fine sandstone, rusty weathering, sharp base + top
- bright green muddy siltstone, pedogenic, poorly exposed
- interbedded greenish grey very fine sandstone and pedogenic siltstone, roots, one thin carbonaceous shale, one thin calcrete bed
- buff fine sandstone, multistoried, erosional base, lens shapes, trough cross bedded
- thinly interbedded sandy siltstone and fine to medium sandstone, low angle and hummocky cross stratification, abundant *Ophiomorpha* burrows
- grey fine sandstone, fining-upward, erosive base, trough crossbedded
- dark grey muddy siltstone, carbonaceous streaks.
- grey silty very fine sandstone, roots
- grey multistoried fine sandstone, erosive bases, troughcrossbedded, convolute lamination
- grey fine sandstone, ball + pillow, vertical burrows including *Ophiomorpha*
- buff fine sandstone fining-upward to silty very fine sandstone, broad shallow troughs and ripples at top, roots
- greenish grey pedogenic siltstone, fining-upward, thin carbonaceous shale beds and several thin greenish bentonites near top
- greenish grey fine sandstone, multistoried, fining-upward, erosive bases, rippled
- grey siltstone, few thin very fine sandstone beds
- thinly interbedded very fine sandstone and siltstone
- greenish grey pedogenic siltstone
- buff fine to medium sandstone, multistoried, erosive bases, lenses of medium sand, fining-upward, trough cross bedded
- dark greenish grey pedogenic sandy siltstone
- grey fine sandstone, multistoried, erosive bases, large troughs, rippled top
- interbedded silty mudstone and carbonaceous shale and pale greenish bentonite and very fine sandstone with erosive base and ripples
- grey very fine sandstone, fining-upward, roots

(? Drumheller Marine Tongue equivalent ?)

FIGURE 2(d)

FIGURE 2(d)



- grey fine sandstone, sharp base, rippled
- greenish grey sandy siltstone, thin very fine sandstone in middle
- grey fine sandstone, minor ripples, roots through entire thickness
- interbedded grey fine sandstone and grey very sandy siltstone, pedogenic, ripples

- dark grey carbonaceous shale
- pale grey muddy pedogenic siltstone

- multistoried grey fine to medium sandstone, thick bedded, erosional base with stepped scour pockets with large rip-ups of shale and coal, major scour surfaces, lateral accretion surfaces and trough cross-beds, thickest portion of channel at least 100 m wide x 8m deep, exposed in deep coulee

- grey siltstone, poorly exposed
- grey fine to medium sandstone, sharp flat base, horizontal lamination and trough cross beds, roots through entire thickness
- grey pedogenic siltstone

- grey fine to medium sandstone, lenticular, fining-upward, large trough cross beds, ripples
- greenish grey muddy siltstone, sideritic horizons near top
- 2 storey fine sandstone, fining-upward, erosional bases, dinosaur footprints, wood fragments, roots, desiccation cracks at top, lower rippled, upper trough cross bedded
- dark grey carbonaceous shale, laminated, roots; shell fragments
- grey very fine sandstone, gradational base, sharp top
- greenish grey siltstone, pedogenic, few thin sandy horizons, shell fragments at top

- grey fine to medium sandstone, thick bedded, erosional base, rippled, abundant long roots through entire thickness

- greenish grey rooted pedogenic siltstone with many very thin rippled sandy beds and several siderite horizons

- several thin grey fine sandstone beds separated by thin siltstone

- greenish grey pedogenic siltstone, few very thin sandy horizons

- multistoried grey fine to medium sandstone, thick bedded, well sorted, erosional base with deep scour pockets, few silty lenses to E, horizontal lamination, minor ripples + trough cross beds, long roots at top

- grey to greenish grey pedogenic sandy siltstone with very fine to fine sandstone in middle, erosive base with rip-ups, trough cross beds and ripples

- grey coarsening-upward sandy siltstone with abundant burrows at base, rooted calcrete cap
- brown silty bentonite, micaceous
- greenish grey pedogenic siltstone with grey rippled fine sandstone in middle
- coarsening-upward sequence of greenish grey sandy siltstone to silty very fine sandstone, pedogenic, calcareous cap

- coarsening-upward sequence of greenish grey sandy siltstone, pedogenic, very calcareous cap of calcrete
- grey very fine sandstone, sharp flat base + top
- grey siltstone

- grey sandy siltstone, thin very fine sandstone in middle
- grey fine to medium sandstone, feldspathic, erosional base, slightly fining-upward, trough cross bedding and climbing ripples
- greenish grey pedogenic siltstone, sandy, long roots cut off by overlying unit

- several stacked thick grey fine to medium sandstone, feldspathic, well sorted, erosional bases, dinosaur footprints, trough cross bedded, separated by thin siltstone lenses to W
- greenish grey pedogenic siltstone

- 3 stacked grey fine sandstone lenses separated by thin sandy siltstone, erosional bases, horizontal lamination, minor trough cross bedding, ripples

- greenish grey pedogenic siltstone with several thin very fine sandstone beds with sharp bases and ripples

- interbedded very fine to fine sandstone and grey siltstone, roots at top, dinosaur footprints, horizontal lamination, ripples, trough cross beds
- light grey silty mudstone, laminated, ?bentonitic ?
- grey multistoried very fine to fine sandstone, erosive bases, horizontal lamination and ripples, siltstone lens in middle

- greenish grey pedogenic siltstone

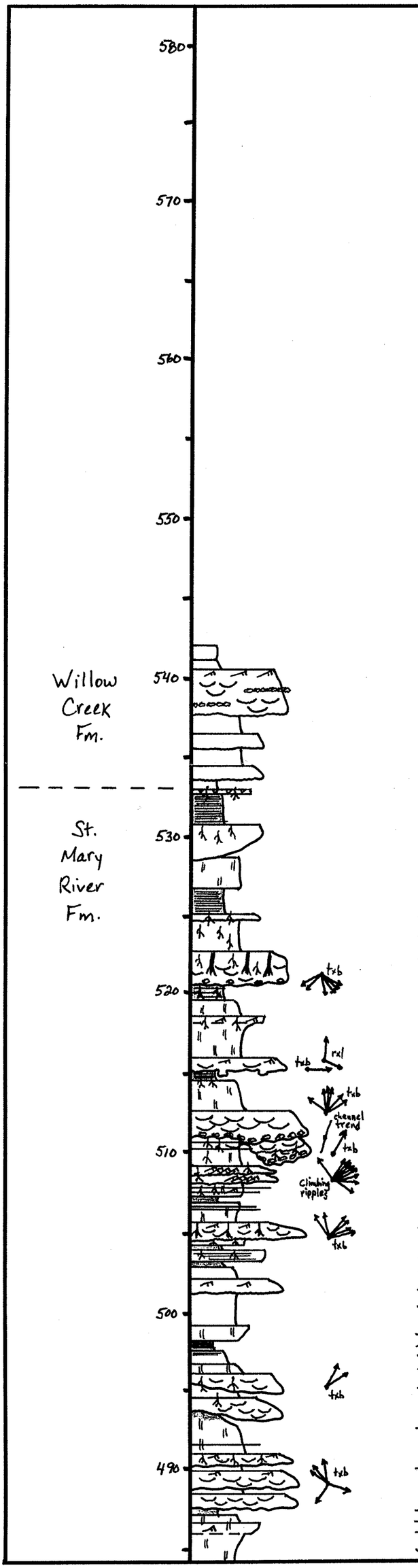
- light grey fine to medium sandstone, well sorted, thick bedded, salt+pepper, pinches out to S, erosional base with scour pockets full of rip-ups/caliche/wood/dinosaur bone, trough cross bedded, long roots in middle

- greenish grey pedogenic siltstone
- multistoried grey fine sandstone separated by shale lenses, erosional bases, trough cross bedding and ripples, calcareous cap bed

- interbedded greenish grey siltstone and very fine to fine sandstone, ripples

FIGURE 2 (e)

FIGURE 2 (e)



- grey shale, poorly exposed
- green shale, poorly exposed
- pale grey to white fine sandstone, well sorted, thick bedded, trough cross beds, minor ripples, siderite concretion horizons
- greenish grey siltstone, poorly exposed
- white very fine sandstone, poorly exposed
- greenish grey siltstone, poorly exposed
- white very fine sandstone, poorly exposed
- bright green shale, laminated
- white calcareous bentonite, nodular, roots, calcrete - tuff (Kneehills Tuff equivalent)
- dark grey to brown shale, laminated, popcorn weathering, bentonitic (Battle equivalent)
- pale greenish grey to yellow silty very fine sandstone, lenticular, sharp top, roots
- pale greenish grey pedogenic siltstone, poorly exposed
- dark grey to brown shale, laminated, popcorn weathering, bentonitic (Battle equivalent)
- pale greenish grey very fine sandstone, silty, roots, poorly exposed
- greenish grey pedogenic siltstone, sandy, roots
- pale grey fine sandstone, scour base with small rip-ups, slightly fining-upward, large trough cross beds, roots, large vertical tree roots with bark and growth rings (Whitemud equivalent)
- dark greenish grey carbonaceous silty shale, laminated, rooted, wood fragments
- greenish grey pedogenic siltstone
- grey very fine sandstone, gradational base, sharp top, roots, ripples
- greenish grey pedogenic siltstone
- grey very fine to fine sandstone, scoured base, dinosaur footprints, trough cross beds, ripples
- dark grey carbonaceous shale, laminated, roots, wood fragments
- greenish grey pedogenic siltstone
- grey fine to medium feldspathic sandstone, multistoried, deep erosive scour base with rip-ups and burrow casts cuts out underlying units, trough cross bedded, roots
- grey very fine to fine sandstone, fining-upward, roots and carbonaceous shale at top
- greenish grey pedogenic siltstone, roots
- grey very fine to fine sandstone, multistoried, separated by thin sandy siltstone lenses, climbing ripples, roots
- greenish grey pedogenic siltstone, roots, thin very fine sandstone beds especially near top, thin carbonaceous shale in middle
- white fine to medium sandstone, fining-upward, scoured base, trough cross beds and ripples, large roots through entire thickness
- greenish grey pedogenic sandy siltstone and carbonaceous shale lens
- pale grey very fine to fine sandstone, horizontal lamination, roots
- grey pedogenic siltstone, laminated and carbonaceous at top
- grey fine sandstone, sharp base, rippled
- greenish grey siltstone, poorly exposed
- greenish grey sandy siltstone, coarsening-upward, pedogenic
- dark grey to brown carbonaceous shale, laminated
- dark grey to grey silty claystone, laminated
- greenish grey pedogenic siltstone
- 2 storey fine sandstone, separated by discontinuous siltstone lens, erosive base, trough cross bedded, roots through entire thickness
- greenish grey pedogenic siltstone, few thin sandy beds, carbonaceous at top
- 3 fine to medium ss beds separated by thin siltstones, each has scoured base, trough cross beds, ripples, roots at top
- dark grey carbonaceous siltstone
- grey pedogenic siltstone
- grey silty very fine sandstone, originally rippled, gradational base, sharp top
- greenish grey pedogenic siltstone

FIGURE 2 (f)

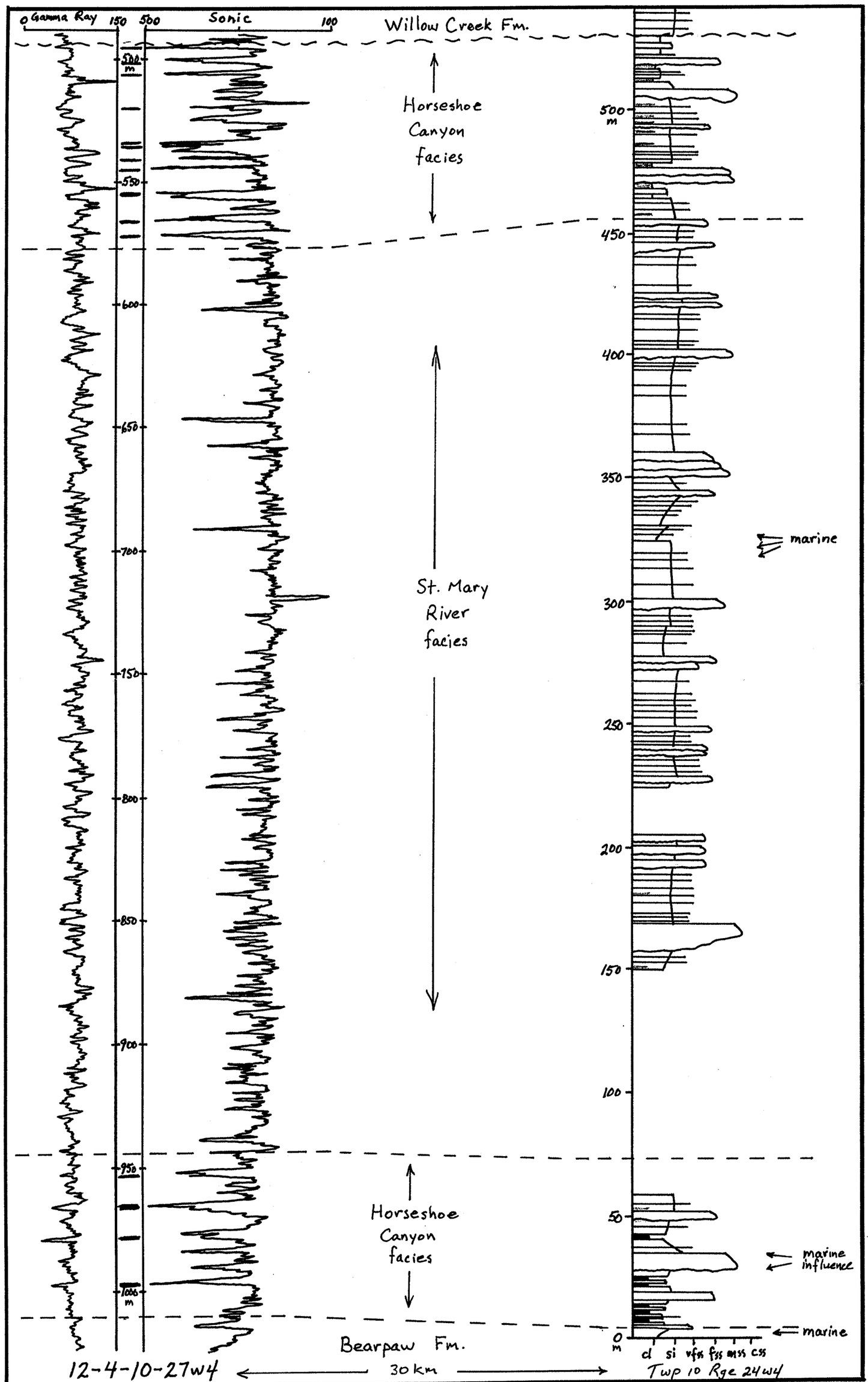


FIGURE 4

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