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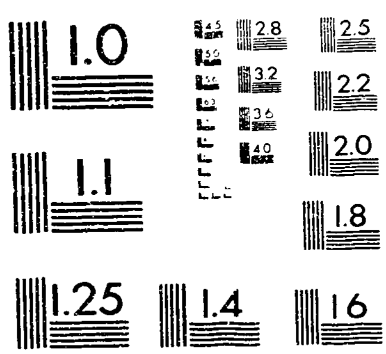

UNIVERSITY OF ALBERTA

STRATIGRAPHY AND SEDIMENTOLOGY OF THE LOWER CRETACEOUS MANNVILLE GROUP IN THE JENNER-SUFFIELD AREA, SOUTHEAST ALBERTA

BY

RHEA L. KARVONEN

A thesis

submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the Degree of MASTER OF SCIENCE

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Braithwaite (1955, p.339)

"The world is not made up of empirical facts with the addition of the laws of nature: what we call the laws of nature are conceptual devices by which we organize our empirical knowledge and predict the future. From this point of view any general hypothesis whose consequences are confirmed by experience is a valuable intellectual device; and the profitable use of such a hypothesis does not presuppose that it will not at some future time be subsumed under some more general hypothesis in a more widely applicable deductive system, nor that the facts that it explains will not some time be explicable by a quite different hypothesis in another deductive system."

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled STRATIGRAPHY AND SEDIMENTOLOGY OF THE MANNVILLE GROUP IN THE JENNER-SUFFIELD AREA, SOUTHEAST ALBERTA submitted by RHEA L. KARVONEN in partial fulfilment of the equirements for the degree of MASTER OF SCIENCE.

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ABSTRACT

The stratigraphic and sedimentologic relationships observed in a detailed study within the Lower Cretaceous Mannville Group in the Jenner-Suffield area (T17-20, R6-8W4), southeast Alberta, are used as a base for regional paleogeographic reconstruction (T16-25, R6-13W4) in the Western Canada Basin.

The retreat of the Jurassic Swift sea from the Western Canada Basin was followed by a period of uplift and erosion (Kimmeridgian-Barremian), resulting in the development of deeply incised northwesterly flowing drainage systems. Subsequent Aptian transgression led to the backfilling of these drainage systems with fluvial and floodplain deposits of the Detrital and Ellerslie members. A sequence boundary is indicated by the exposure and erosion of Ellerslie sediments.

A flooding surface overlain by laterally extensive carbonaceous and/or limy shale occurs at the base of the Ostracode member, signifying rapid and extensive inundation by the Ostracode sea which formed a shallow, brackish water embayment in southern Alberta. Progradation of NNW-SSE trending wave-dominated shoreline comprised of quartz-rich sands marks a subsequent phase of relative regression.

Subsequent sea level(base level) fluctuations resulted in the incision and back-filling of a number of valleys in the area, in ascending order these valley fills are UM1, UM2 and UM3. Chert litharenite fluvial sandstones of the informally named UM1 unit are recognized as three 1.5-3.0 km (1-2 miles) wide, NNW-SSE trending valleys which drained northward incising

into the underlying Ostracode and Ellerslie members; this unit contains numerous oil pools. The UM2 unit is observed in the 0.5 km (1/4 mile) wide ENE-WSW trending non-reservoir feldspathic litharenite fluvial sandstones, which incises into both the Ostracode sandstone and the UM1 valley trend, forming a seal to a UM1 pool. The chert litharenite sandstone of the UM3 fluvial deposit represents the youngest valley incision event (0.8-1.5 km;1/2-1 mile wide), trending almost parallel to, and incising into, the UM1 trend. To the south the easternmost UM1 valley forms the reservoir for the Medicine Hat oil field, which contains 31800 X $10^3 m^3$ (200 mmbbl) of 15^o API gravity oil.

Estimated oil in place within the Jenner-Suffield area is approximately 84127 x $10^3 m^3$ (530 mmbbl) (recovery factor 3-6%) of 16^oAPI gravity oil. Ostracode traps are stratigraphic consisting of a sandstone buildup surrounded by impermeable coastal plain sediments. Incision by the UM1 and UM3 results in reservoir fluvial sandstones directly adjacent to and overlain by non-reservoir, genetically unrelated, continental and coastal plain sediments.

ACKNOWLEDGEMENTS

Numerous people have contributed and encouraged the development of this project.

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INTRODUCTION

Interest in the Lower Cretaceous Mannville Gro. .) as an exploration target has spanned over three decades in the Alberta Basin. Complex stratigraphy, however, has made exploration and development a difficult task.

Numerous studies have been conducted on the Mannville group with the early work of Workman (1958, 1959), Glaister (1959), Mellon and Wall (1961, 1963), Williams (1963), Rudkin (1964), Mellon (1967) to more recent work by Hopkins et al (1984), Hradsky and Griffin (1984), Hayes (1986), Tilley and Longstaffe (1984), Wanklyn (1985), Strobl (1988), Rosenthal (1988), Wood and Hopkins (1989), just to name a few. The Lower Cretaceous Mannville Group was deposited in Caldwell's (1984) Clearwater T-R Couplet, initiated in Aptian-Albian time, when the Clearwater (Boreal) Sea impinged on many portions of the southern Interior Plains (McLean and Wall, 1981).

Development of the Cretaceous epicratonic seaway occurred with the formation of a foreland basin to the east of the active orogen. The Mannville Group is part of the basal clastic wedge which developed during orogenic activity. Marine, marginal marine and fluvial sediments were deposited in the shallow seaway as the coastline migrated repeatedly in response to various influences. The complexity of the of the Mannville

Group is the result of a number of factors including sediment supply and source, relief on the underlying pre-Cretaceous unconformity, and sea level fluctuations.

This study focuses on units from the pre-Cretaceous unconformity stratigraphically upwards to selected units assigned to the upper Mannville Group in southeast Alberta. The units are placed into a paleogeographic framework by examining local sedimentologic and stratigraphic relationships.

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SEDIMENTOLOGY, ICHNOLOGY AND STRATIGRAPHY OF THE OSTRACODE MEMBER (LOWER CRETACEOUS) IN THE JENNER-SUFFIELD AREA, SOUTHEAST ALBERTA

INTRODUCTION

The Lower Cretaceous Ostracode Zone is a widespread environmentally controlled biozone which is defined in the subsurface of central and southern Alberta (Loranger, 1951; Badgley, 1952; Mellon and Wall, 1961, 1963; Glaister, 1959; Finger, 1983; Burden, 1984). Located at the top of the lower Mannville Group, this biostratigraphic zone contains numerous forms of ostracodes and molluscs, representing a mixed assemblage zone (Finger, 1983). The Ostracode Zone varies from 6 to 21m in thickness and is described as a well developed microfossil zone (biozone) which is dominated by *Metacypris persulcata* Peck and associated ostracodes, accompanied by charophytes, pelecypods, and gastropods (Loranger, 1951). Lithologically the Ostracode Zone is characteristically found in a sometimes calcareous dark grey shale, or fine grained sandstone, typically with thin beds of dark grey argillaceous limestone and pyritic bands.

The Ostracode Zone is correlative in the foothills to portions of the Calcareous Member (Glaister, 1959; Mellon, 1967) which caps the Gladstone Formation (top of the lower Blairmore Group). The Calcareous Member, however, is a lithostratigraphic unit described by Glaister (1959) as a 9 to 15m thick succession of gray argillaceous limestones, calcareous shales and buff to brown calcareous sandstones which contains gastropods, pelecypods and ostracodes.

Useful in local correlations, the Ostracode Zone is contained within sediments which were deposited during widespread southward flooding of the Boreal sea into low relief areas of central and southern Alberta. The basal shale and limy units of the Ostracode interval are easily recognizable laterally extensive markers which represent deposition within a broad shallow brackish water embayment. Deposited during Aptian time (Loranger, 1951; Mellon and Wall, 1961; Pocock, 1980; Caldwell, 1984) the Ostracode interval is representative of marine to marginal marine ('Glauconite C ', Rosenthal, 1988; Wanklyn, 1985) to estuarine (Bellshill Lake, Karvonen, 1989) environments in central Alberta to brackish in southern Alberta, and therefore represents a potential exploration target.

Within the Jenner-Suffield area the informally named Ostracode member, is proposed to be lithostratigraphically equivalent to the sediments which contain the Ostracode Zone (Loranger, 1951) as recognized in central and southern Alberta, and the Calcareous Member (Glaister, 1959) in the foothills region. Since no micropaleontology was conducted in this study, determination as to whether this lithologic unit contains/corresponds with the Ostracode Zone was not possible. The Ostracode member is comprised predominantly of two lithologies, a limy or laminated carbonaceous shale with a moderate abundance of bioturbation, and a very fine to fine grained clean mature, sublitharenite sandstone (Q:F:L ratio, 86.1:0.7:13.2, Folk, 1974). To the WSW, these sandstones laterally grade into bioturbated shales.

The purpose of this paper is to develop a depositional model for the Ostracode member in southeast Alberta, using sedimentologic, ichnologic and stratigraphic relationships. Geophysical well logs from 260 wells were studied in the Jenner-Suffield area, T17-20, R6-8W4M (Fig. II-1). Facies and facies relationships were established with the examination of 28 cores and

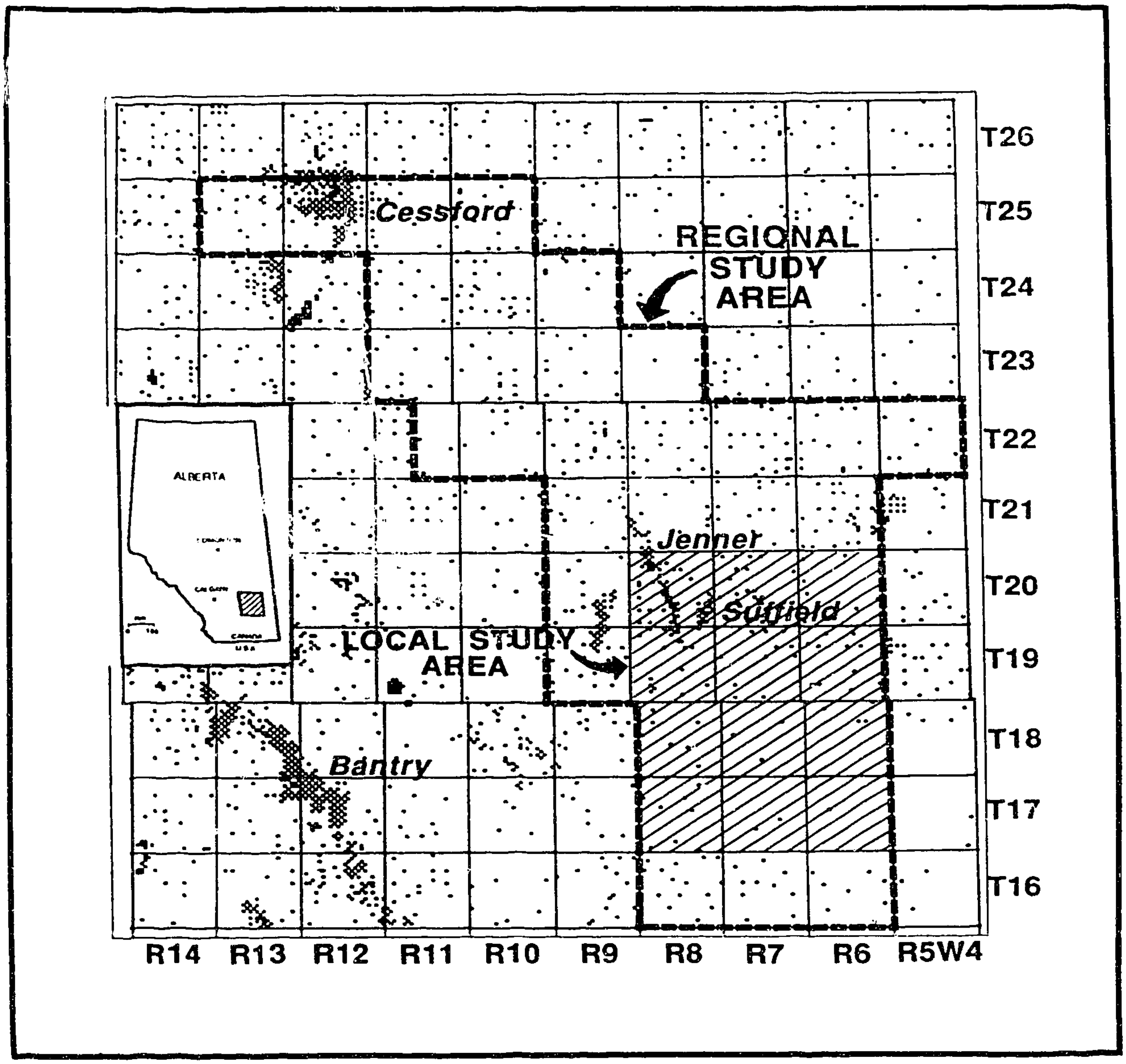


FIGURE II-1. Location Map.

mineralogy was obtained from point-counting 6 thin sections in the Ostracode interval in and around the study area. Stratigraphic relationships within the area were then determined and all data were combined into a paleogeographic and depositional framework. This framework was then expanded and applied to a more regional study area conta ithin the block of T16-25, R5-13W4M, where geophysical logs from 621 wells were used to map the unit and get a regional perspective on its distribution. Computer data were used in the area T14-30, R1-15W4 in order to map regional trends in the lower Mannville Group and get an understanding of the pre-Cretaceous surface.

Within the study area the Jenner E and Suffield A pools produce out of stratigraphic traps in the Ostracode sand.

GEOLOGIC FRAMEWORK

Early work by Glaister (1959), Williams (1963), Mellon and Wall (1963), Rudkin (1964), and Mellon (1967) recognized the division between the lower and upper Mannville Group (Fig. II-2). The upper Mannville Group consists of lithic and feldspathic sandstones, in contrast to the lower Mannville Group which is characterized by siliceous sandstones capped in some areas by the Calcareous member, the Ostracode member equivalent (Glaister, 1959).

Within the Jenner-Suffield area the quartzose Ellerslie member overlies a variable thickness of the Detrital member (Fig. II-3). The Detrital member infills lows on the pre-Cretaceous surface, and is composed of sediments sourced from the pre-Cretaceous unconformity. The quartzose sediments of the Ostracode member sit disconformably on the Ellerslie member (Fig II-4). Mississippian strata forms the subcrop within the area. The influence of the paleotopographic relief of the pre-Cretaceous surface on depositional patterns

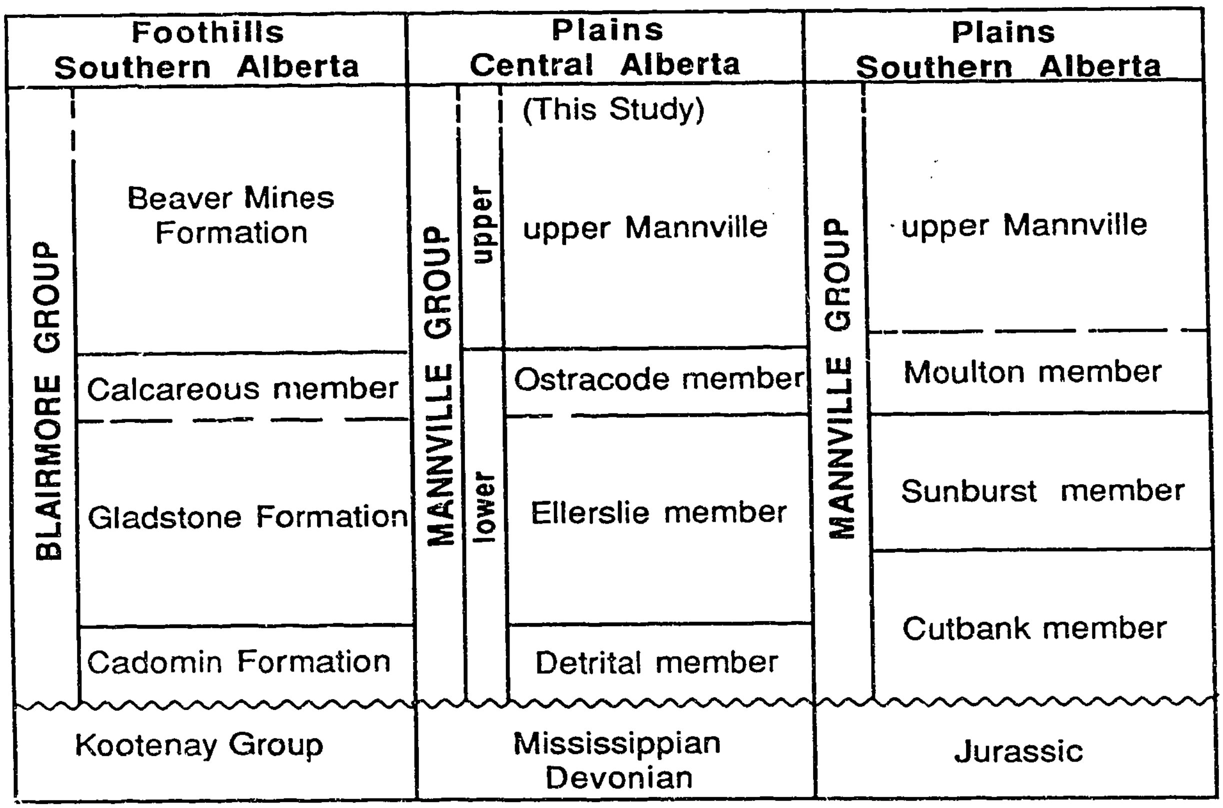


FIGURE II-2. Stratigraphic terminology and correlation chart for southern and central Alberta and the Foothills region (modified from McLean and Wall, 1981).

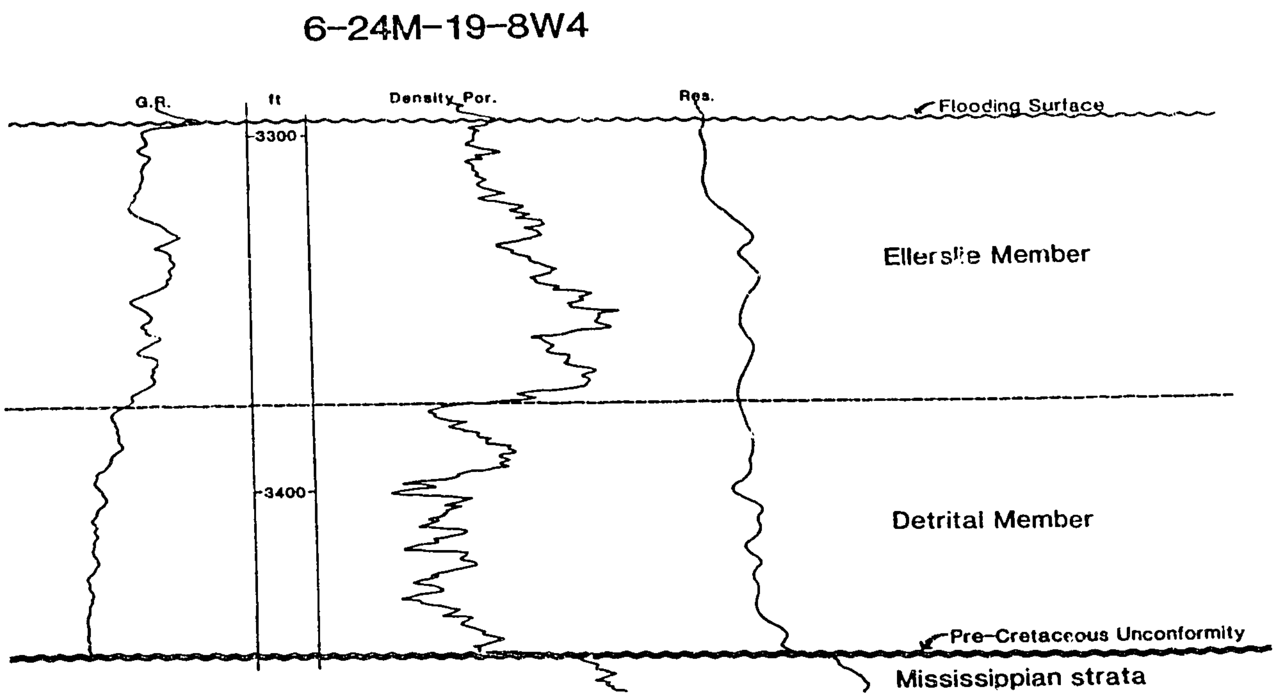


FIGURE II-3. Type log for the Ellerslie and Detrital members.

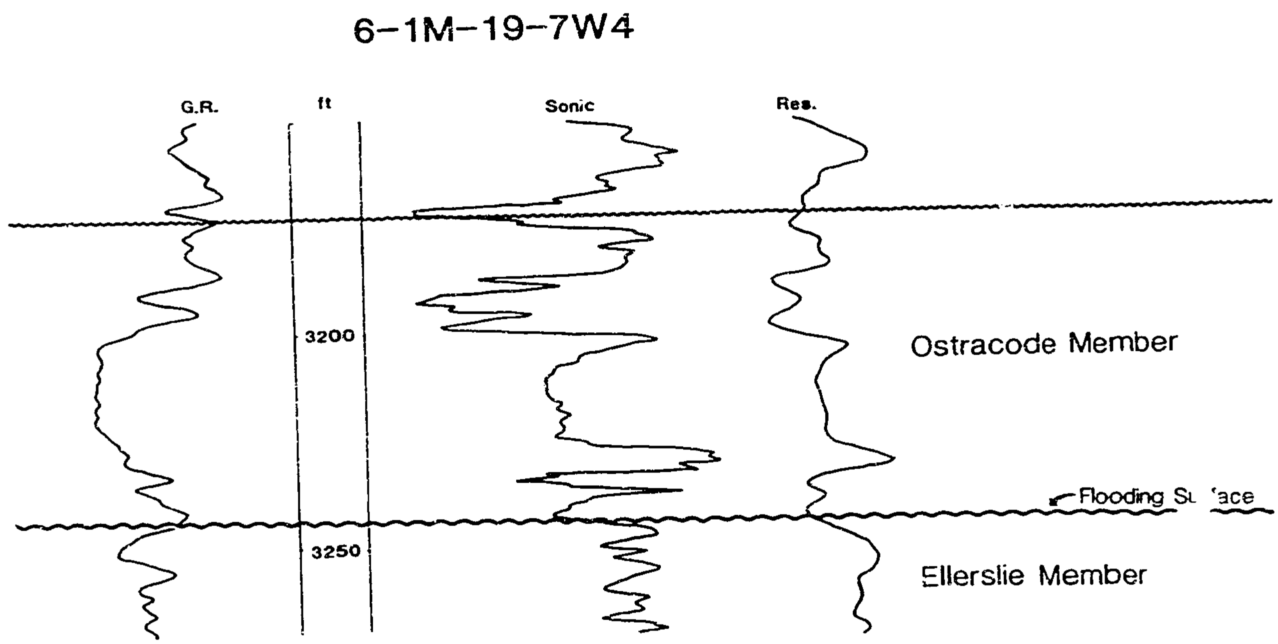


FIGURE II-4. Type log for the Ostracode member.

decreases upsection so that once upper Mannville sedimentation began, the paleotopography was significantly subdued. The Ostracode member is disconformably overlain by the lithic-rich sediments of the upper Mannville Group, which locally incises into the Ostracode member (Type 1 unconformity; Van Wagoner, 1988).

The Ostracode member is speculated to be the lithostratigraphic equivalent to the Moulton member in southern Alberta and north central Montana (Oakes, 1966), the upper portion of the Gething Formation of northeastern B.C. and the Calcareous Member (Glaister, 1959) of the Gladstone Formation in southern Alberta Foothills (McLean and Wall, 1981) (Fig. III-2). The quartzose "Home sand" recognized by Hume (1939) in the Turner Valley-Pine Creek area in the southern foothills was interpreted as a locally arenaceous phase of the Calcareous Member (Ostracode member) by Mellon (1967). In a Montana-Southern Alberta study Hayes (1986) noted fine quartzose sandstone beds with low angle cross-stratification at the top of the distinctive shale, siltstone and limestones of the Ostracode member (Calcareous Member). These sandstones are, in all likelihood, equivalent to the Jenner-Suffield sandstones representing the extension of the Ostracode sea southward of the Jenner-Suffield area. In northern Montana, Oakes (1966) recognized a similar sequence as that observed in the Jenner-Suffield area. There, the sequence consists of fine grained lacustrine and swamp deposits capped by reworked deltaic sands of the Moulton sandstone. It is speculated here that the Moulton sandstone was probably deposited by the southern arm of the Ostracode sea as it transgressed into Montana. McLean and Wall (1981) suggested that limestone beds in more southerly areas are similar in age and character to those documented by Glass and Wilkinson (1980) in the Wyoming-Idaho area of the U.S.

PREVIOUS WORK

In the Jenner-Suffield area the fine-grained quartzose Ostracode sandstone amalgamates locally with the lithic-rich upper Mannville sandstones. Previous work on the Mannville succession in southeast Alberta by Tilley and Longstaffe (1984), Holmes and Rivard (1976) and Herbaly (1974) did not recognize the Ostracode sequence as described of this paper, but instead grouped the Ostracode sandstone with the upper Mannville sandstones into the 'Glauconitic sandstone'. The Glauconitic sandstone was assigned to a dune origin by Herbaly (1974) and to a barrier island origin by Tilley and Longstaffe (1984) and Holmes and Rivard (1976), with the Ostracode sandstone forming the lower shoreface of this thick barrier succession. The author disagrees with these interpretations, and proposes instead that the Ostracode sand is itself a distinct barrier deposit, subsequently incised by genetically unrelated upper Mannville fluvial valley deposits.

In the Countess area, directly west of Jenner-Suffield in R16W4, Farshori (1983) described the Ostracode member as shales interbedded with limestone and siltstone grading upwards into fine to medium grained white sandstones. Farshori (1984) considered the Ostracode beds in southern Alberta to be representative of lacustrine deposition, as favored by continuous lateral beds, palynological data, faunal assemblages, primary structures and a coarsening upwards sequence. In the subsurface of southwest Alberta, the Calcareous Member, is composed of bentonites, marls and fossil limestones, disconformably overlying the Cutbank Member (James, 1985).

REGIONAL PALEOGEOGRAPHY

Deposition of the Ostracode member throughout much of central and southern Alberta represents the southward transgression of the Boreal sea within the Alberta Foreland Basin. With this transgression, the relatively low topographic relief and slope resulted in the formation of an extensive shallow embayment which probably continued southward into Montana (Hopkins, 1980; McLean and Wall, 1981). Previously existing paleovalleys were flooded, resulting in the formation of small bays and estuaries until the topographic highs were also eventually flooded. The southeastern deposit of the Ostracode member is relatively thin compared with that observed to the west and in central Alberta. This unit, deposited along the eastern flank of the embayment is thought to represent one flooding event in the overall transgressive-regressive Ostracode couplet (transgressive and highstand systems tracts; Van Wagoner, 1988).

SEDIMENTOLOGY/ICHNOLOGY

A number of facies and subfacies have been delineated within the Ostracode Member based on core examination (Fig. II-5). Mississippian strata form the subcrop within the area (Plate II-1a), and is overlain by the Detrital member. The Detrital member sediments are sourced predominantly from the underlying Mississippian strata (Plate II-1b)and are typically comprised of a chert breccia with angular clasts up to 7cm in diameter in a poorly sorted sandstone matrix. No structures were recognized in the Detrital which is interpreted as a valley deposit chaotically filled due to slumping of Paleozoic valley walls. The chert breccias of the Detrital grade upwards into the clay-

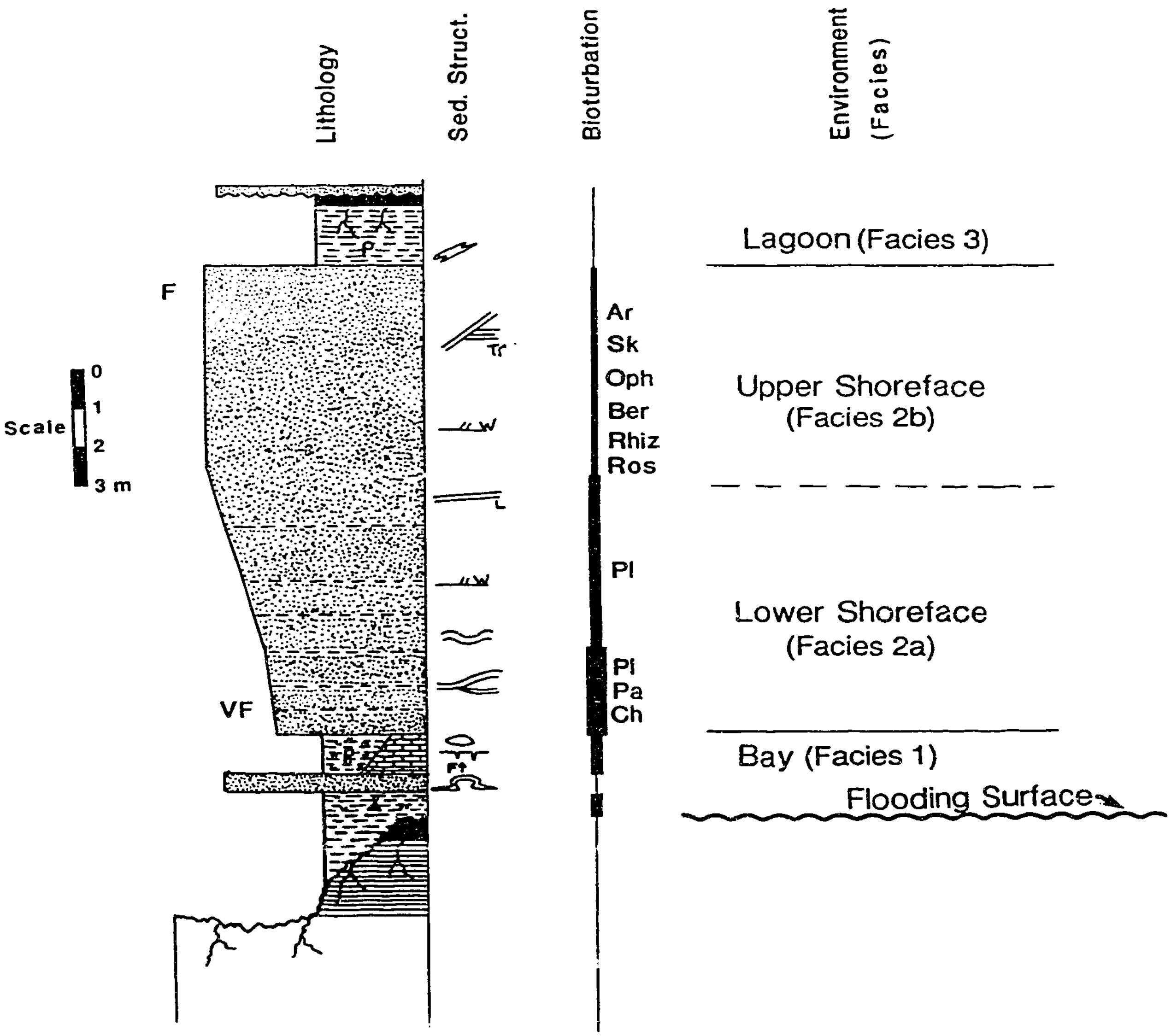


FIGURE II-5. Composite core litholog for the Ostracode member.

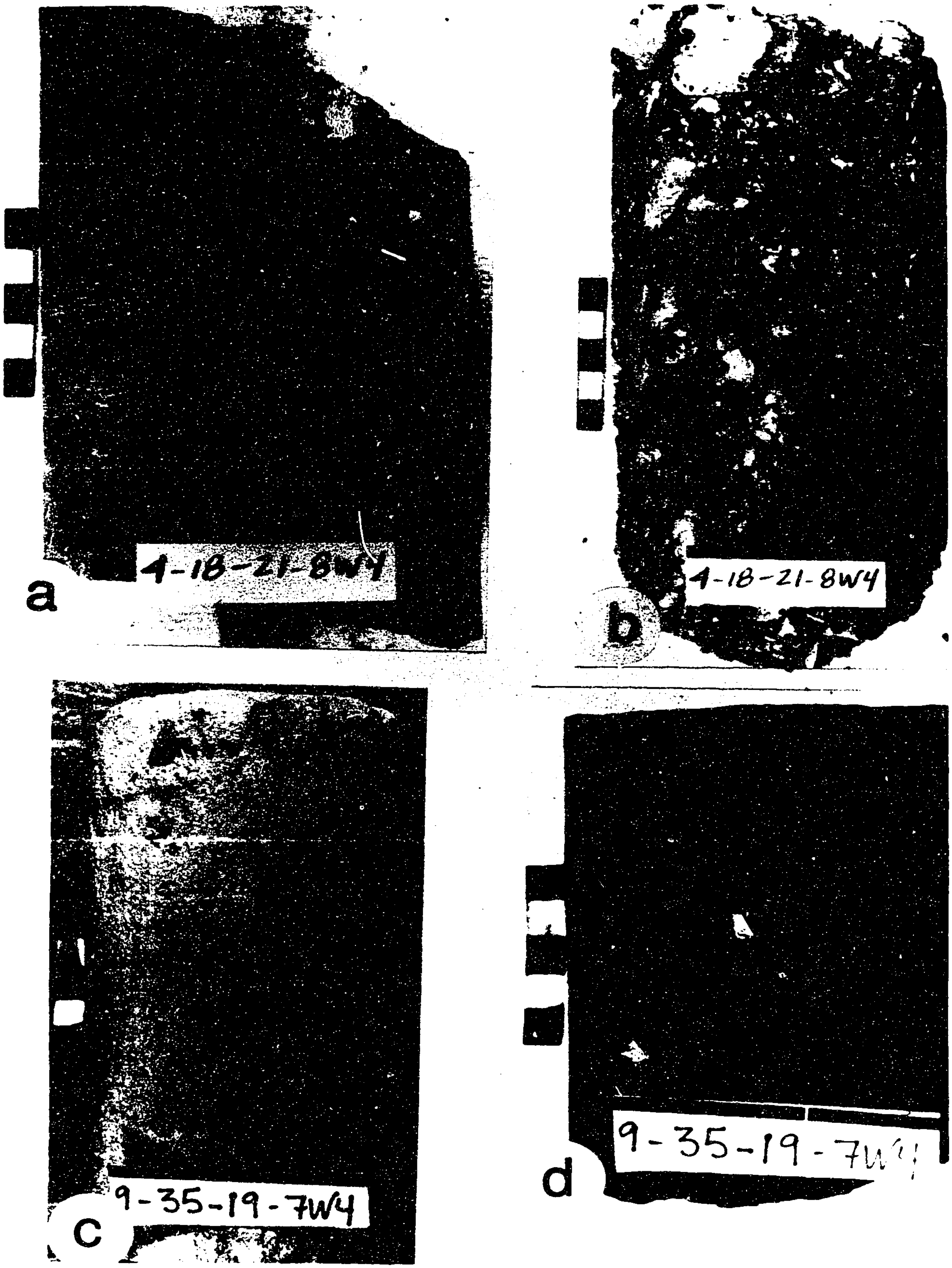
PLATE II-1

a). 4-18-21-8W4: Mississippian strata underlying the pre-Cretaceous unconformity (scale increments in cm).

b). 4-18-21-8W4: The Detrital member, sourced mainly from the underlying Mississippian strata.

c). 9-35-19-7W4 (depth: 3232 ft): Clay rich massive sandstones of the Ellerslie member.

d). 9-35-19-7W4 (depth: 3187 ft): Ostracode member facies 1a showing fine sandstone/siltstone laminations in carbonaceous shale.


a
4-18-21-8W4
b
4-18-21-8W4
c
9-35-19-7W4
d
9-35-19-7W4

rich, medium-grained, quartzose sandstones of the Ellerslie member. Sedimentary structures where discernable include soft sediment deformation, slumping, microfaulting and high angle cross-stratification. The Ellerslie member is interpreted as a fluvial deposit. The Ostracode member sits disconformably on Ellerslie sediments which in its upper portions consists of a paleosol, coal or white rooted homogeneous sandstone/ siltstone (Plate ll-1c). The contact between the Ostracode and Ellerslie members represents a flooding surface. The Ostracode member is disconformably overlain by upper Mannville Group sediments which in many cases incise into the Ostracode sediments.

Facies 1

Three subfacies are recognized in facies 1 which disconformably overlies Ellerslie sediments.

Subfacies 1a: Subfacies 1a is characterized by black carbonaceous shale (Plate ll-1d), with lenticular siltstone of very fine grained sandstone beds, which typically fine upwards. Pyritic lamination or replacement of burrows is common. Syneresis cracks are also noted within this subfacies. Bioturbation is moderate to common in abundance, typified by *Planolites*, *Chondrites*, and *Gyrolithes*. This subfacies has a variable thickness ranging from 0.3m to 2+m, and sharply overlies Ellerslie sediments.

Subfacies 1b: Pyritic grey calcareous siltstone/shale comprise subfacies 1b. Bioturbation is common characterized by the ichnogenera *Planolites* and *Thalassinoides*. A typical thickness is 10-25cm. The upper and lower contacts vary from sharp to gradational.

Subfacies 1c: This subfacies is typically comprised of a cream coloured, homogeneous bed of sandstone, chert pebbles (Plate ll-2a), shale clasts

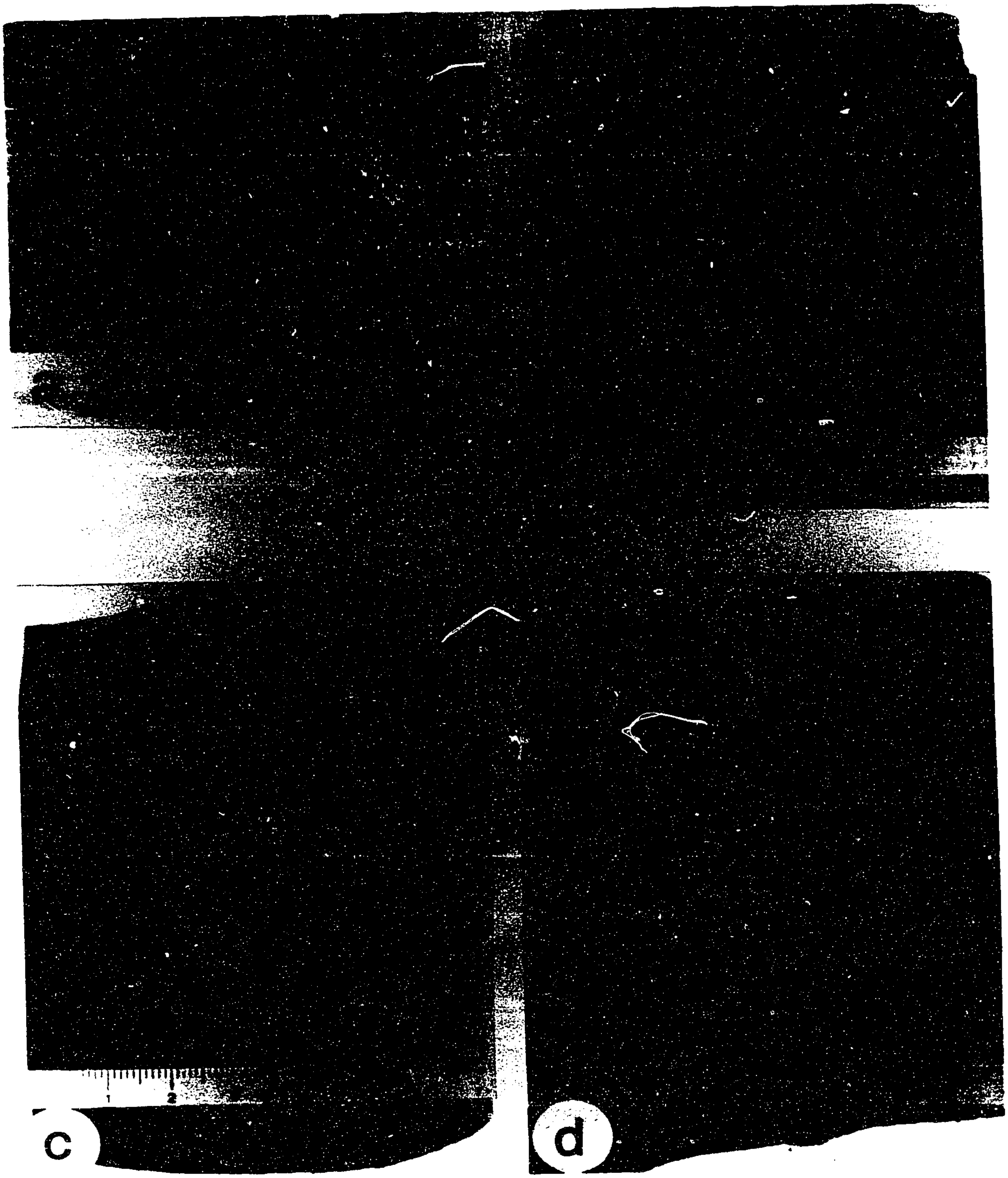
PLATE 11-2

a). 14-23-20-8W4 (depth: 945.2 m): Ostracode member facies 1c. In this case the pebbly sandstone occurs at the base of the shoreface sucession (scale increments in cm).

b).14-23-20-8W4 (depth: 944 m): Ostracode member facies 2a. Wave ripples draped with shale exhibiting syneresis cracks.

c). 14-23-20-8W4 (depth: 939.5 m): Ostracode member facies 2a. Very fine grained sandstones exhibiting wave ripple stratification.

d). 12-32-20-8W4 (depth: 3105 ft): Ostracode member facies 2a. Hummocky cross-stratified very fine grained sandstone with a bioturbated shale bed containing the burrows *Planolites* (large arrow) and *Chondrites* (small arrow).


1
2
c
d

(similar in appearance to Ellerslie sediments) mixture. There are signs of soft-sediment deformation. This unit is on average 0.6m in thickness and typically has sharp lower and upper contacts.

Facies 2

This facies sharply overlies Facies 1. This coarsening upwards unit is comprised of litharenites (Q:F:L ratio; 86.1:0.7:13.2, Folk, 1974) (Fig. ll-6), and has an average thickness of 9 meters.

Subfacies 2a: Subfacies 2a is characterized by very fine to lower fine grained sandstone commonly with organic and shale laminations and associated pyrite. Syneresis cracks (Plate ll-2c) are observed in this subfacies. Sedimentary structures include wave ripples (Plate ll-2b), hummocky cross stratification (Plate ll-c,d), and low angle stratification. Bioturbation is common to abundant with the ichnogenera *Planolites*, *Paleophycus* and *Chondrites* (Plate ll-2d). The lower contact is typically sharp with a gradational upper contact

Subfacies 2b: Subfacies 2b is comprised of sandstone with a grain size typically ranges from lower fine to lower medium. Rare to moderate bioturbation is observed, with a relatively high diversity of ichnogenera including *Rosselia*, *Bergauria*, *Rhizocorallium*, *Ophiomorpha*, *Skolithos*, *Arenicolites*. Sedimentary structures include wave ripples and high angle cross stratification (Plate ll-3a,b). Pyrite is commonly observed in the sandstone. This subfacies has aggradational lower contact with subfacies 2a and a sharp to gradational upper contact with facies 3.

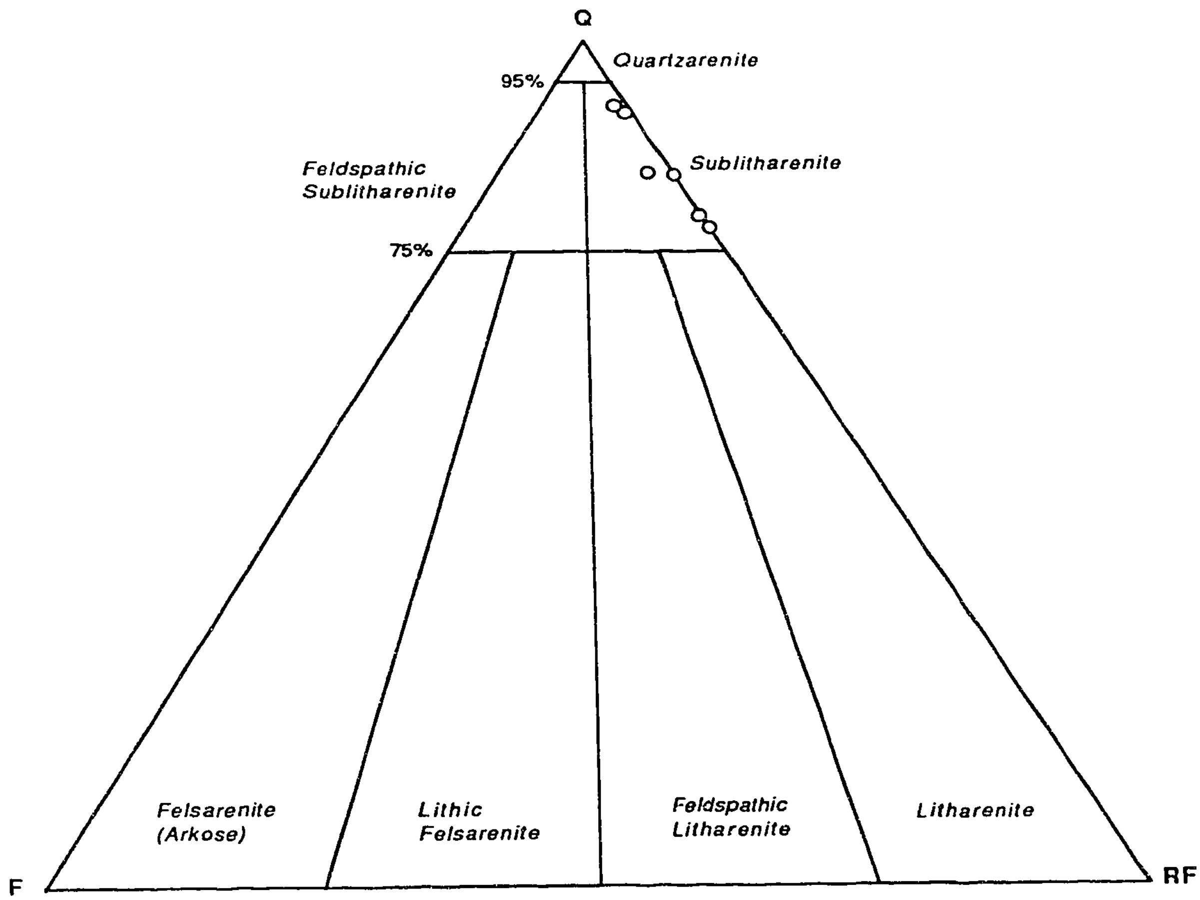


FIGURE II-6. Ternary diagram plotting Ostracode sandstones (based on Folk, 1980).

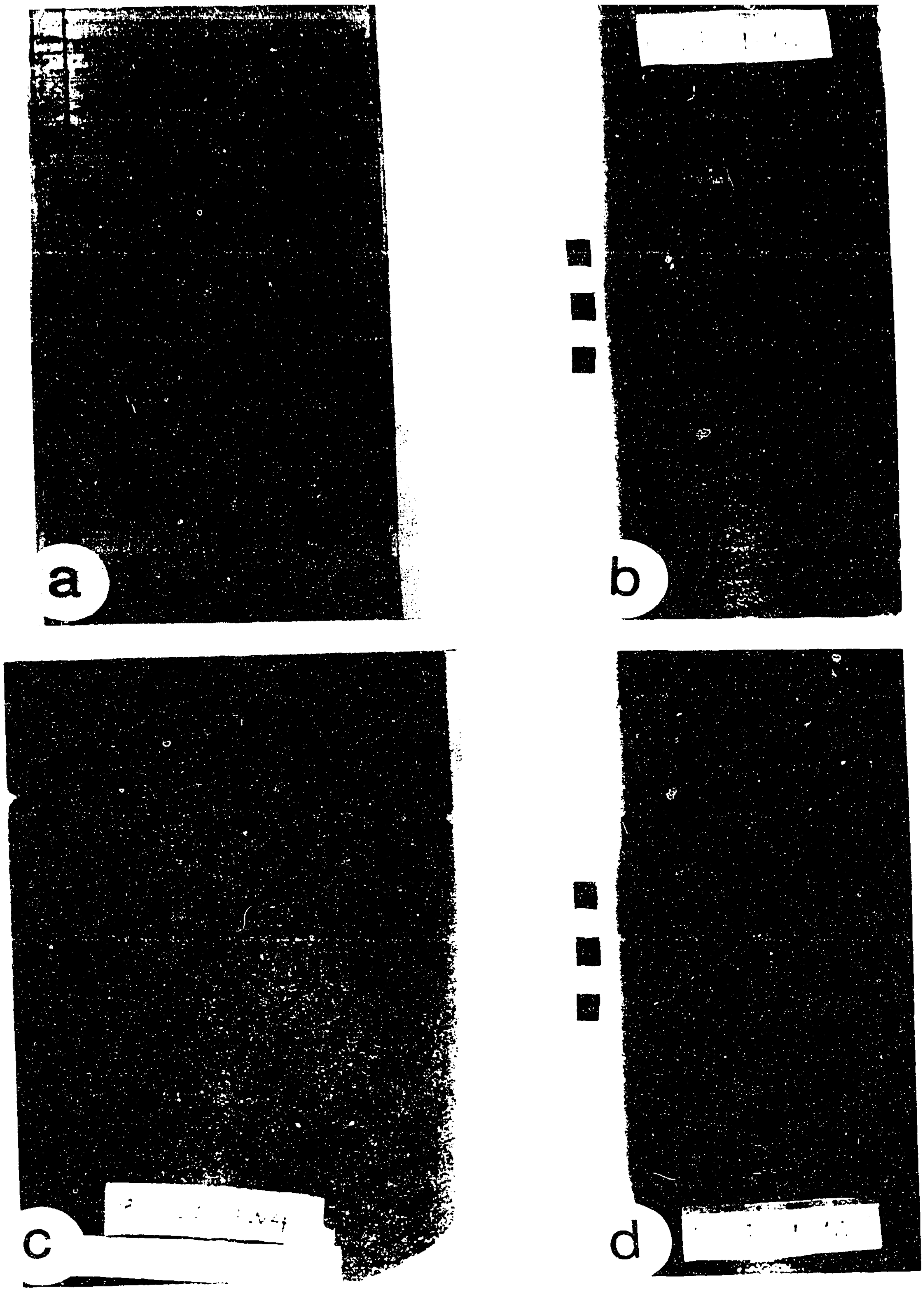
PLATE II-3

a). 6-34-19-8W4 (depth: 3303.5 ft): Ostracode member facies 2b. Partial oil saturation highlights high angle cross-stratification (scale increments in cm).

b). 10-24-19-9W4 (depth: 3275.2 ft): Ostracode member facies 2b. High angle cross-stratified sandstones with fine shale laminations.

c). 8-3-20-7W4 (depth: 3109 ft): Ostracode member facies 4. Fine grained sandstone containing *Skolithos* (small arrow) and *Paleophycus* (large arrow).

d). 10-24-19-9W4 (depth 3270 ft): Ostracode member facies 5. Bioturbated siltstone and shale.


a
b
c
d

Facies 3

Pyritic shale with high organic content (laminations and debris) and thin coal beds characterize this facies. Rooting is commonly observed in this unit, which has an average thickness of 2 m. The lower contact with subfacies 2b is sharp to gradational, with a gradational upper contact.

Facies 4

Facies 4 is typified by very fine to fine grained sand which has abundant organic laminations and debris. Bioturbation is common with the ichnogenera *Planolites*, *Paleophycus*, *Skolithos* (Plate II-3c). Wave ripples and high angle cross stratification are typical sedimentary structures in this unit which reaches up to 6 m in thickness. Lower and upper contacts are sharp and gradational, respectively, with facies 3 above and below.

Facies 5

Interbedded/laminated sandstone, siltstone, and mudstone are typical of facies 5. Low angle stratification is observed where it is not destroyed by bioturbation. Organic debris, siderite and pyrite are observed. Bioturbation is common to abundant (Plate II-3d) with the ichnogenera, *Planolites*, *Skolithos*, *Teichichnus*, *Rhizocorallium*, *Paleophycus*, and *Chondrites*.

Discussion

Facies 1

Subfacies 1a: Subfacies 1a consists predominantly of carbonaceous shale, which is indicative of an environment with variable low energy conditions.

Shales were deposited during quiet water conditions, or by traction transport and deposition of floccules and fecal pellets during lower current velocity phases (Potter et al, 1980). Carbonaceous material was probably sourced from transgressed marshes, or peat swamps. Thin lenticular sandstone beds and fining upward beds, indicate energy fluctuation, possibly related to storm activity or seasonal variations. The presence of syneresis cracks is the result of contraction of swelling clays due to salinity fluctuations (Burst, 1965), indicating deposition in a brackish water setting. Ichnogenera identified are commonly of low diversity and moderate to low abundance, which may indicate a stressed environment (salinity fluctuations?). *Chondrites* and *Planolites* are deposit feeding organisms, while the ethology of *Gyrolithes* probably represents a dwelling structure produced by an annelid which burrows in order to retreat from rapid bottom-water salinity fluctuations (Ranger and Pemberton, 1989; Gernant, 1972).

Subfacies 1b: This facies is interpreted to have been deposited in a low energy environment. The calcareous nature of this facies is very characteristic of basal Ostracode sediments all over central and southern Alberta (ie. Hradsky and Griffin, 1984; Farshori, 1983; Hopkins et al, 1982). Calcareous beds may represent recrystallized shell fragments which may be concentrated in a transgressive situation as noted by Weimer (1984) or they may represent deposition in a shallow bay with low clastic input and therefore represent primary carbonate formation. Bioturbation is low in abundance and diversity. *Planolites* and *Thalassinoides* are structures produced by the activities by deposit feeding organisms.

Subfacies 1c: This subfacies has sharp lower and upper contacts, and may be found in subfacies 1a or directly underlying facies 2a. Poor sorting and variable grain size characterize this subfacies. Some of the sediment appears to be sourced from the underlying Ellerslie. The presence of soft sediment deformation may indicate rapid deposition of this subfacies, causing possible pore pressure differences resulting in liquifaction or slumping. This subfacies is thought to represent a transgressive lag.

Facies 1 is thought to have been deposited under transgressive conditions in a broad, shallow, quiet water, brackish bay, with periodic storm/wave action. This facies sharply overlies the Ellerslie member, a contact which represents a sequence boundary/flooding surface. Ichnologically this facies is representative of the *Cruziana* ichnofacies (Seilacher, 1963; Pemberton and Frey, 1984). However the low diversity and abundances are indicative of stressful environmental conditions, such as salinity fluctuations.

Previous interpretations of the Ostracode member/Calcareous member lithology represented by facies 1 was one of fresh water lacustrine deposition in southern Alberta (Glaister, 1959; McLean and Wall, 1981; Farshori,1984) and Montana (Hopkins, 1985). Other authors have noted a mixed brackish-fresh assemblage (Mellon and Wall, 1963; McLean and Wall, 1981; Finger, 1983). and other information like the presence of bioturbation, which was noted by Mellon (1967), McLean and Wall (1981), syneresis cracks, and the presence of pyrite, all indicate brackish deposition probably occurred into southern Alberta. According to Berner et al (1979) it is rare for freshwater lakes to have high enough concentrations of sulfate to form pyrite, which tends to be associated with brackish to marine waters

Facies 2

Subfacies 2a: The sediments of subfacies 2a are interpreted as lower shoreface deposits, deposited in the shoaling-breaker zone (Reinson, 1984) of a nearshore environment. The presence of hummocky cross stratification is probably indicative of storm activity. Wave ripples are formed due to oscillatory flow which occurs during wave action. Wave ripples are common structures in modern shoreface deposits such as the coast of California (Howard and Reineck, 1981) and Oregon (Clifton et al, 1971). Low angle stratification could possibly result on a bar crest where waves are large enough to break and extend down the sides of the bars such as that observed in the moderate energy nearshore of Northern Padre Island, Texas (Hill and Hunter, 1976). Bioturbation by such ichnogenera as *Planolites*, *Palaeophycus*, and *Chondrites* is predominantly representative of behavior of deposit feeding organisms, typically represented by the *Cruziana* ichnofacies. The low to moderate abundance may be due to stressful conditions such as brackish conditions, as also indicated by the presence of syneresis cracks.

Subfacies 2b: Subfacies 2b consists of fine grained sandstone. High angle cross stratification may have resulted from the migration of megaripples. High angle cross-stratification is typically near the top of the succession, indicating relatively high energy conditions. The presence of high energy cross-stratification is noted, for example,in the upper shoreface along the Oregon coast by Clifton et al (1971). The presence of wave ripples is indicative of oscillatory flow. This association of ripple and cross stratification is also observed in the bar-trough system of Padre Island, as produced by wave and current action on fine grained sandstone (Hill and Hunter, 1976). Bioturbation is typically representative of dwelling structures or suspension feeding activities, with *Rhizocorallium* reflecting deposit feeding activities. This assemblage of ichnogenera, with low abundance and moderate diversity is typical of the *Skolithos* ichnofacies. The *Skolithos* ichnofacies is thought to be representative of relatively high energy conditions and fluctuating depositional rates. The substrates would tend to be clean and well sorted. Subfacies 2b is interpreted to represent an upper shoreface deposit.

Facies 2 is representative of deposition in a wave dominated progradational barrier system. The transition from subfacies 2a to 2b represents a shoaling upwards, which can be seen with the change from lower energy physical and biogenic structures contained in subfacies 2a to the coarser grained sandstones. These display physical structures indicative of a higher energy environment and the transition to predominantly suspension feeding organisms as indicated by the trace fossils. Foreshore deposits may be present but were not recognized in core, or they may not be preserved.

Tilley (1982) recovered the dinoflagellates *Muderongia sp.* and *Ctenidodinium* from the Ostracode member (Facies 1 and 2). This low species diversity was interpreted to indicate a restricted marine environment of low salinity. This supports the interpretation of this paper that the Ostracode member was deposited within a brackish embayment formed by a transgression of the Ostracode sea .

Facies 3

Facies 3 is [illegible]ded by a sharp to gradational lower contact and a gradational upper contact. The shales which predominate in this facies were probably deposited from suspension and are representative of low energy conditions. High organic content and rooting at the top of the unit is thought to be indicative of nearby peat swamps and/or marshes. This facies is interpreted as a lagoonal deposit.

Facies 4

This facies is characterized by organic rich sands which have a sharp lower contact. Wave ripples are indicative of oscillatory flow while high angle cross stratification may have been produced with the movement of sandwaves/ megaripples under higher energy conditions. Biogenic reworking of these sands occurred with the return of quiet water conditions. *Planolites* and *Palaeophycus* represent the behavior of a deposit feeder and a dwelling structure respectively. This facies is interpreted as a washover lobe deposit.

Washover sediments are deposited on the landward side of the barrier by storm activity, coalescing in an apron behind the barrier and extending into the fine grained lagoonal sediments, where biogenic reworking typically occurs. Washover sediments form an important constituent of the lagoonal deposit, as exemplified on Padre Island, Texas by Fisk (1959).

Facies 5

Facies 5 is characterized by interbedded sandstone, siltstone and mudstone, with a low organic content. Ichnogenera are dominated by deposit feeding organism traces, where organisms are moderately abundant and have a relatively high diversity. The dominance of deposit feeding structures and the abundance/diversity of the ichnogenera places this assemblage into a *Cruziana* ichnofacies. This facies is thought to represent an offshore deposit.

STRATIGRAPHY

The shoreface sands of the Ostracode member produce a distinctive coarsening upwards log profile (Fig. II-4) (Fig. II-7). Ostracode member sandstones average 9m thickness reaching a maximum thickness of 24m. The

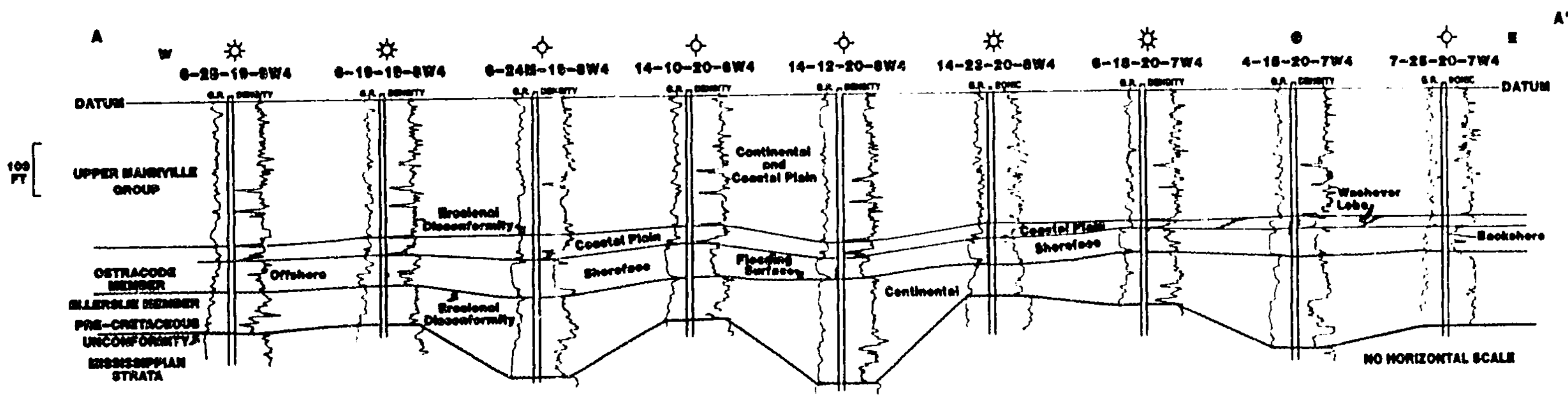


FIGURE II-7. Stratigraphic cross-section A-A' (datum: top of Mannville).

base of the Ostracode member is typically an easily recognized stratigraphic contact since the finer transgressive shales or limy sediments (Facies 1) are drastically different from the underlying clay rich sands or paleosols of the Ellerslie member. Hopkins et al (1982) proposed that in central Alberta the smectite rich Bantry shale, located at the base of the Ostracode member, was a reworked ash layer derived from contemporaneously deposited volcanic sediments to the west. A horizon equivalent to the Bantry shale is recognized in the study area (Facies 1), is characterized on geophysical logs by low resistivity and high spontaneous potential values common to mudstones, but it has distinctively suppressed gamma ray values and high density porosity values. It is proposed that the Bantry shale is not a time marker, but a transgressive shale marker, with its composition inherent in its origin.

To the east the Ostracode barrier sandstones grade laterally into the swamp and lagoonal deposits of the backshore. There is also a local buildup (Facies 4) in the study area on the top of the main Ostracode barrier forming a portion of the Suffield A Pool reservoir. Core and stratigraphic observations indicate that this buildup (Facies 4) is a washover deposit. To the west the barrier sands (Facies 2) grade laterally into the bioturbated shales and siltstones of the offshore (Facies 5). The Ostracode barrier is similar to the UA-5 sandstone, Wyoming, studied by McCubbin and Brady (1969). A coal typically caps the coarsening upwards unit and the overlying lagoonal deposits (Facies 3). Overlying the coal are a series of interbedded shales, siltstones and carbonaceous rich sediments interpreted as coastal plain deposits. This blanket of coastal plain sediments overlies the Ostracode interval throughout the area.

The Ostracode member is incised in the Jenner-Suffield area by lithic upper Mannville valleys of fluvial origin. The Ostracode barrier sandstone and the sandstones of the upper Mannville valley fill, previously grouped as one depositional system by such workers as Tilley and Longstaffe (1984) and Holmes and Rivard (1976), are interpreted to have been deposited as the result of different depositional systems/sequences (see Chapter 3). This situation of an fluvially incised shoreface is very similar to the example documented by Harms (1966) and Exum and Harms (1968) in the Dakota Group 'J' interval in Wyoming.

MAPPING

The Ostracode member disconformably overlies the Ellerslie member. An isopach map of the Ellerslie and Detrital members (Fig. II-8) reflects the paleotopography on the pre-Cretaceous surface. Isopach thicks reflect the numerous valley systems that developed on this surface, subsequently infilled with the fluvial sediments of the Ellerslie and Detrital members. The Suffield P pool (Fig. II-9) produces out of one of these Ellerslie member valley deposits. A regional computer generated isopach map of the Mannville Group T14-30, R 1-15W4M (Fig. II-10) indicates the drainage system which developed during lower Mannville time. Drainage flowed to the west off a number of easterly paleohighs, eventually joining a more NW flowing system.

The barrier sands of the Ostracode member trend NNW-SSE, with a known length of over 104km (65 miles) and an average width of 26km (16 miles) (Fig. II-11). There are two thick trends, possibly representing barrier step out which may have occurred while the barrier was keeping pace with a relative sea level drop. Although the Ostracode barrier appears to have a sheet-like or blanket morphology, it is most probably a sequence of separate off-lapping sandstone bodies ie. parasequences. Stacking of parasequences was probably limited as it appears that the system regressed at a relatively rapid rate with

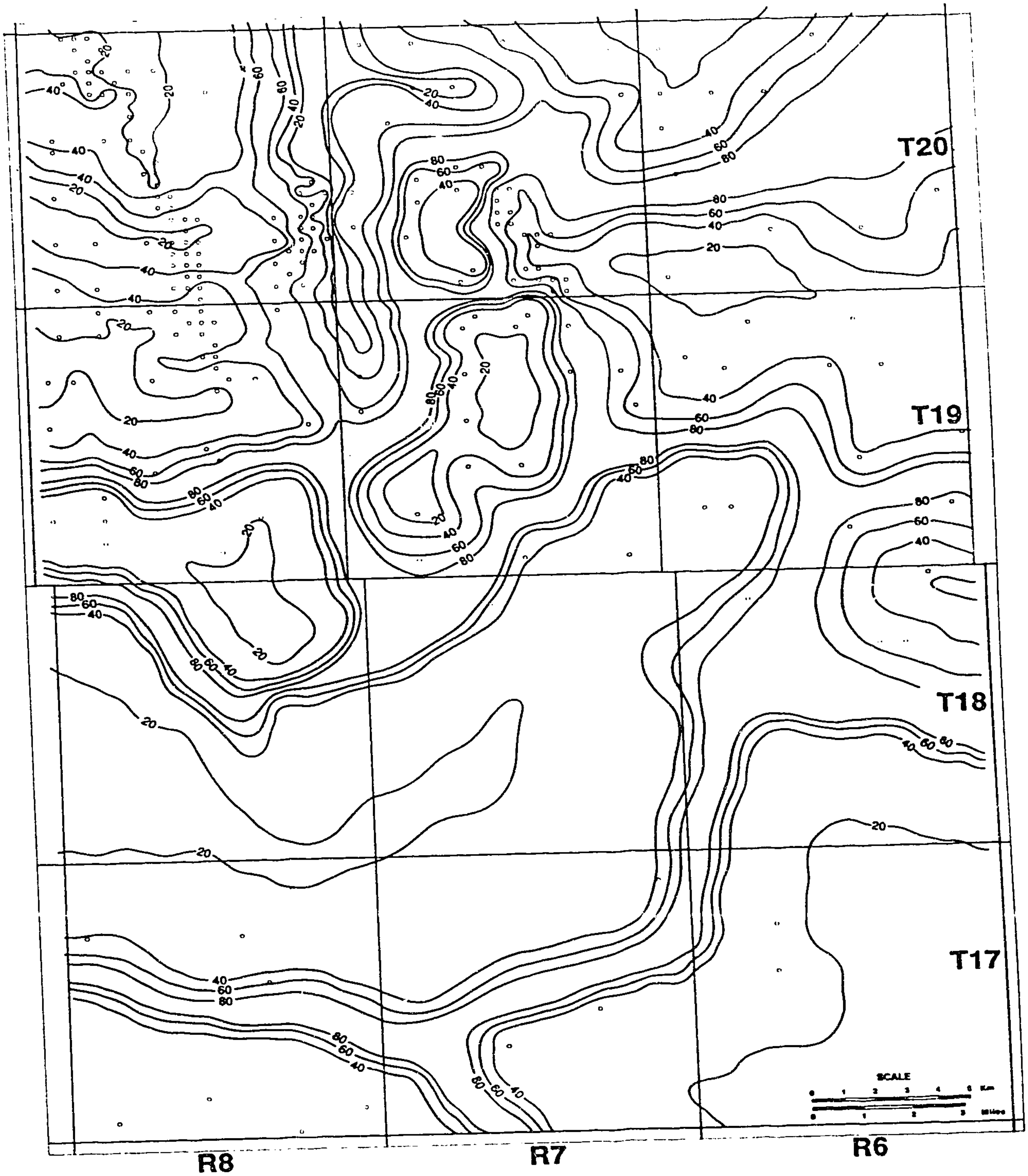


FIGURE II-8. Isopach map of the Ellerslie and Detrital members in T17-20, R 6-8W4; note the thicks in the isopach which correspond to valleys on the pre-Cretaceous surface (contour interval 20m).

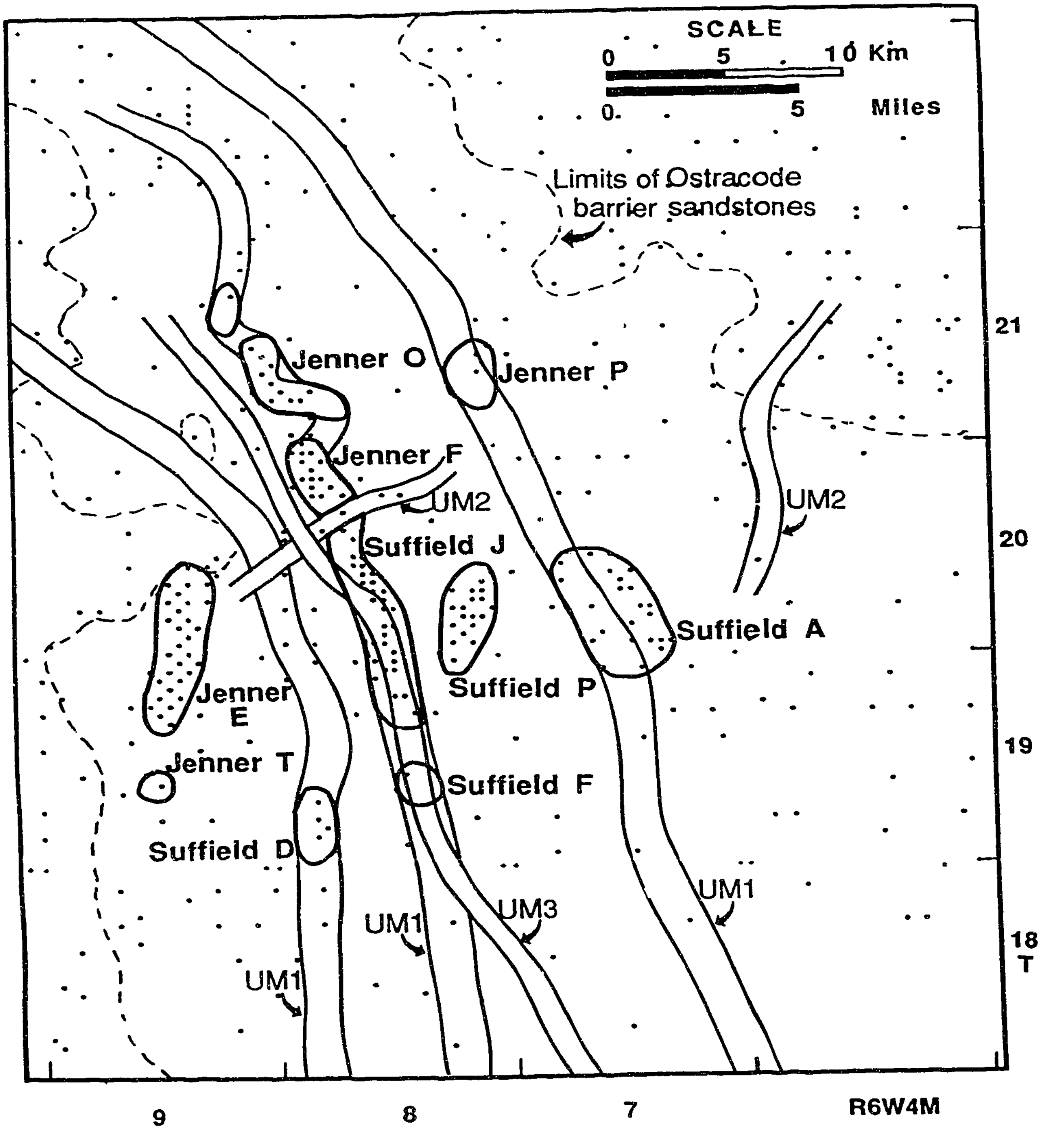


FIGURE II-9. Hydrocarbon distribution map for the Jenner-Suffield area.

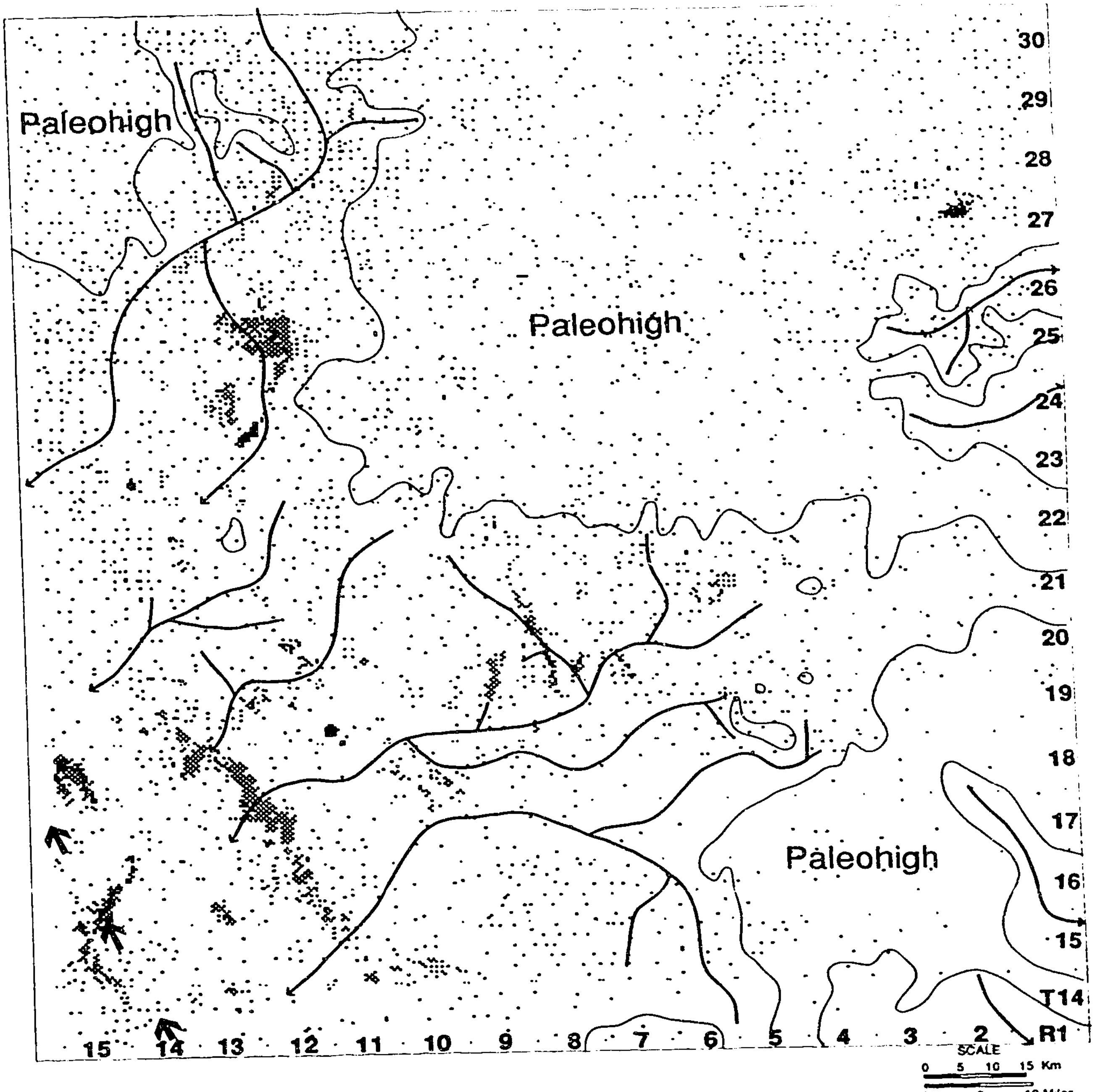


FIGURE II-10. Regional map, T14-30, R1-15W4, showing the inferred paleodrainage during Ellerslie/Detrital deposition (Aptian), based on a Mannville Group isopach.

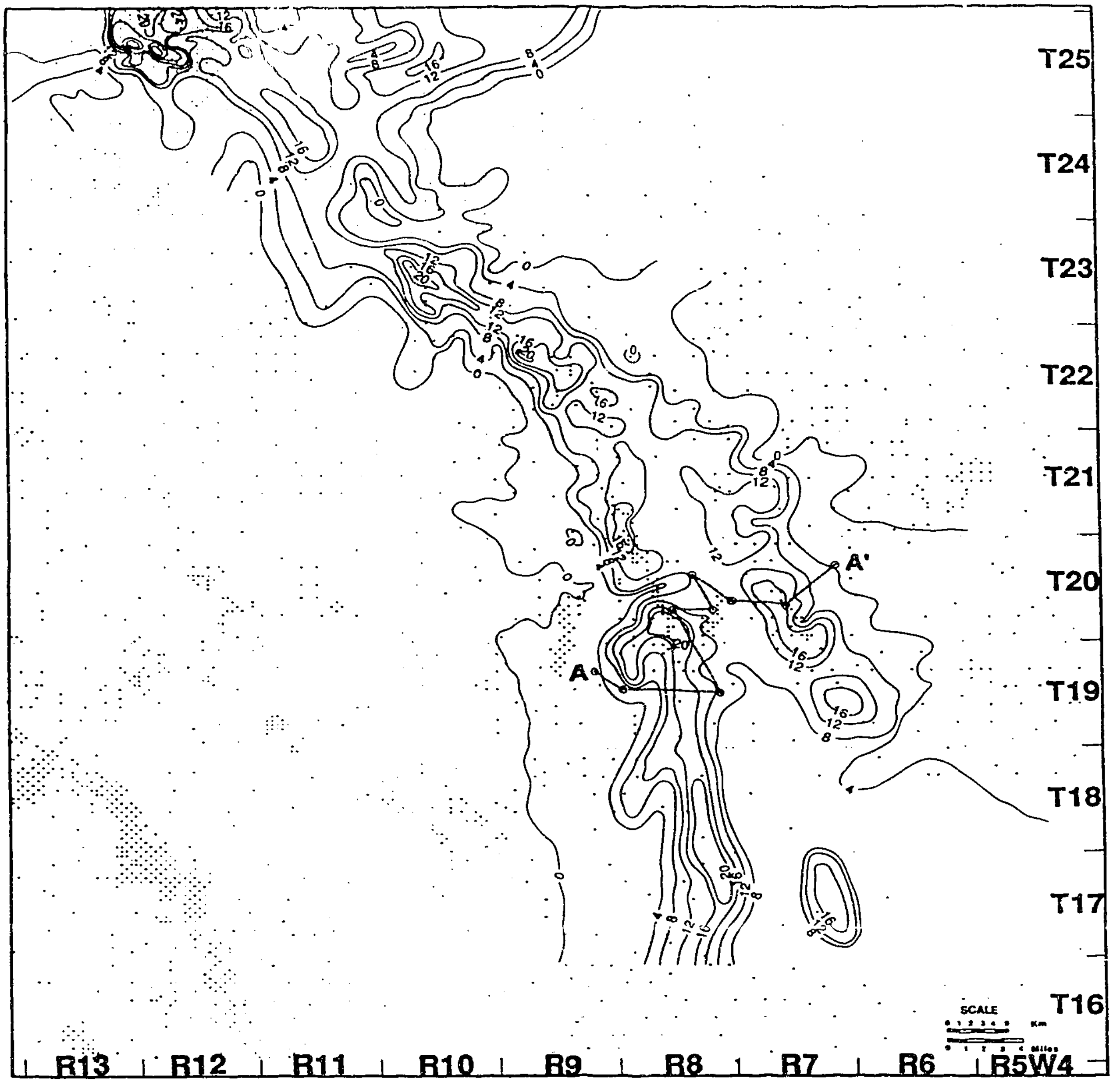


FIGURE II-11. Net sandstone isopach map for the Ostracode member from T17-25, R5-13W4. Note the two sandstone buildups in the Jenner-Suffield area (T19-20,R6-8W4), and the distinct thickening of the sands to the north in the Cessford area (T25, R11-12W4), which is interpreted to have been the deltaic source for sediments to the south (Contour interval 4 m).

the barrier actually stepping out at one point to keep up with falling relative sea level. The easternmost sandstone trend has in the area of T20, R7 another sandstone unit stacked on it (Fig. II-12). This sandstone unit reaches about 6 m in thickness (Facies 4) and is interpreted to be a later feature, a washover lobe associated with the western bar, which seems to comprise the main shoreline trend. A number of north-south trending spit-like features are observed on the western (seaward) margin of the barrier. The Jenner E pool is contained in one of these sandstone buildups which are interpreted as wave-formed offshore spits on the seaward side of the barrier.

There is a thinning of the Mannville Group to the east, and the Ostracode member becomes unrecognizable. These areas to the east are thought to represent paleohighs which dictated the coastal morphology and the limits of the Ostracode transgression. Within T23-24, R9-10, the Ostracode sandstone rests directly on the Paleozoic unconformity, possibly indicating coastal erosion of the paleohighs during the Ostracode transgression. To the north, in the Cessford area (T25, R12), the Ostracode sandstone thickens and begins to stack vertically. This is thought to represent a deltaic complex which probably sourced the barrier sands to the south.

PALEOGEOGRAPHIC SUMMARY/SPECULATION

The Ostracode member represents the first widespread transgression with in the Mannville Group into central and southern Alberta. A relative rise in sea level in Aptian time resulted in the flooding of vast low relief areas to the south by the Boreal sea. The result was the development of a broad, shallow, brackish water embayment which extended into Alberta and Saskatchewan, with its southern limits somewhere in Montana (Christopher, 1980; Hopkins,

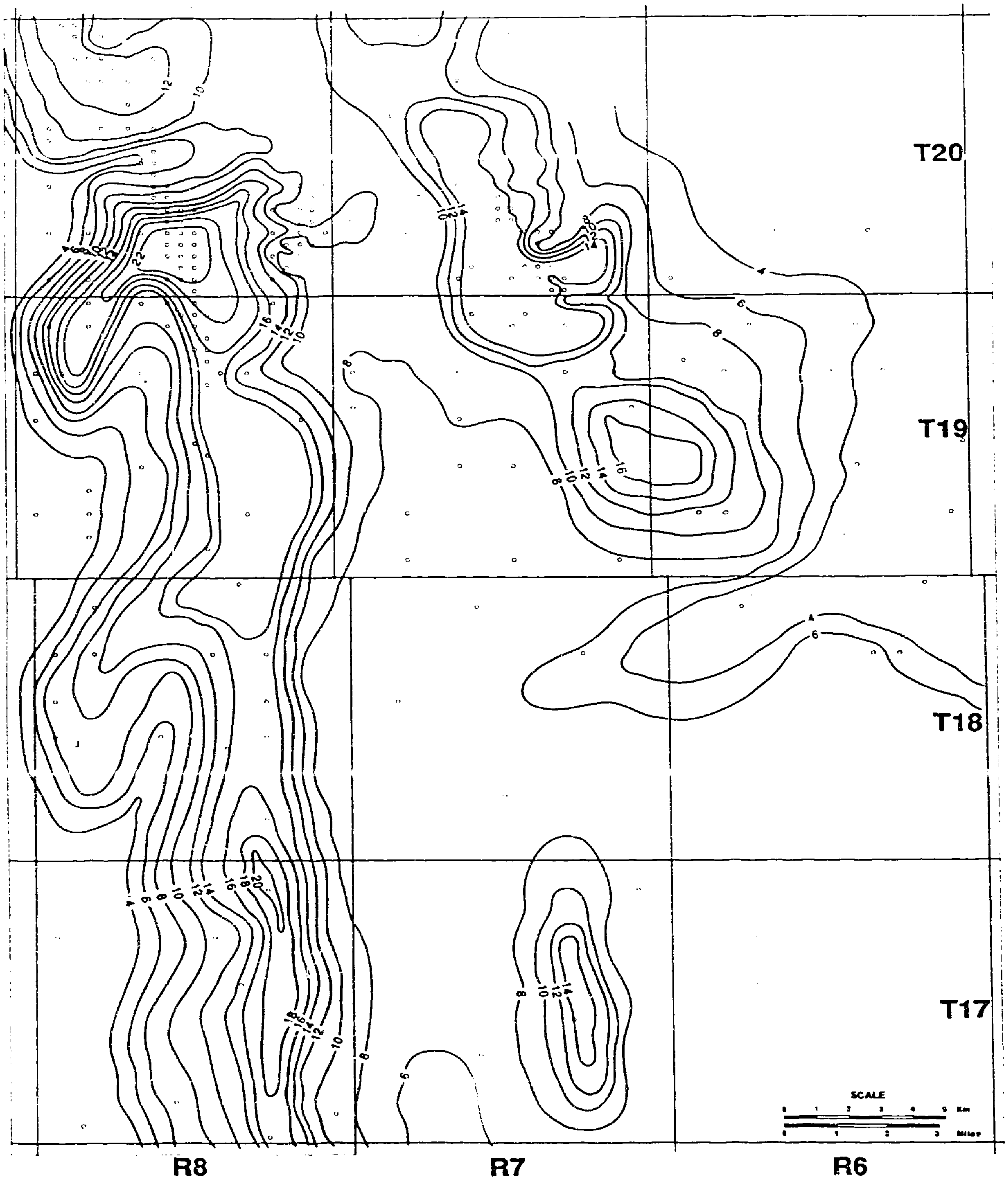


FIGURE II-12. Net sandstone isopach of the Ostracode memberin T17-20, R6-8W4. Note the 'spit-like' features on the west side of the western sandstone buildup (contour interval 2 m).

1980; McLean and Wall, 1981). Taylor and Walker (1984) placed the minimum southward extent of the Ostracode sea around Calgary, T24. This seaway may have continued even further south along the mountain front, and into Montana; equivalent shorelines to those observed the Jenner-Suffield area may have developed in Montana .

In southeast Alberta previously existing paleohighs (Fig. II-10) dictated the coastal morphology, and limited the eastward transgression of the Boreal sea (Fig. II-13). During this time fine grained carbonaceous and calcareous bay sediments (Facies 1) were deposited over the previously exposed Ellerslie Member (flooding surface). This transgression consists of only one flooding event in south Alberta, but transgressive oscillation is evidenced in central (Rosenthal, 1988) and southwest Alberta (Little Bow, Hopkins et al, 1982) by a thicker, multiple basal Ostracode shale and limestone units. No sooner had the Boreal sea reached its maximum limits when it began to retreat. A relative drop or still stand in sea level then resulted in the westward progradation of the quartzose barrier sands (Facies 2) of the Ostracode member (Fig. II-14). These sands were deposited in a wave dominated setting in a NNW-SSE shore parallel trend. This progradation is thought to have eroded certain portions of the underlying Facies 1, the fine grained bay sediments. Some of the sand bodies may have been localized by erosional depressions on the Ellerslie. The barrier stepped out at one point in a westward direction in order to keep pace with the retreating Boreal sea. This unprotected shoreline was greatly influenced by waves and longshore drift. Numerous 'spit-like' sandstone features finger off the barrier on the west side from north to south. One of these spit-like features contains the Jenner E pool. A well developed washover lobe (Facies 4) also formed at this time. Sediments were moved from the north and arrived via longshore drift where

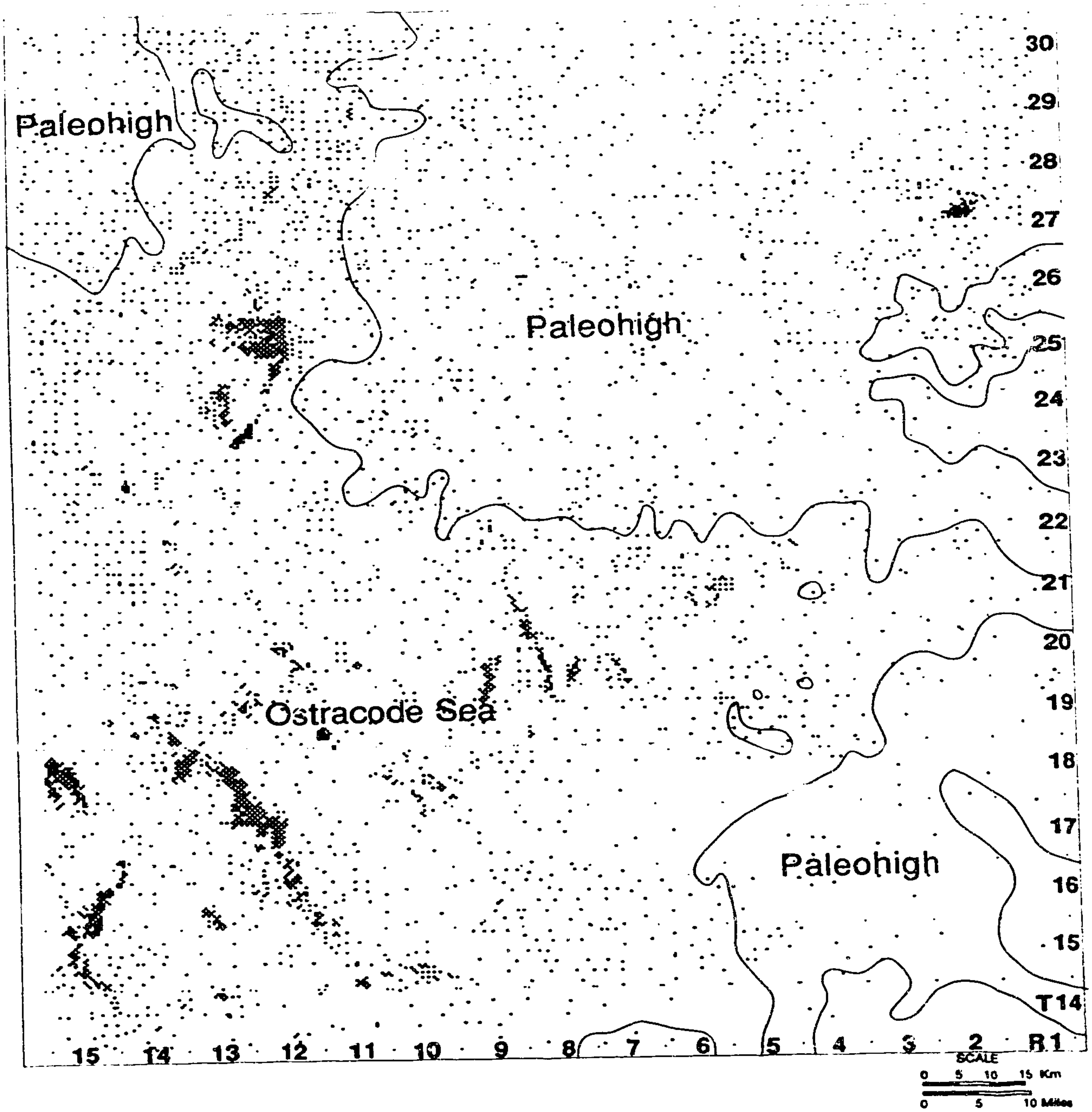


FIGURE II-13. Regional map, T14-30, R1-15W4, showing the inferred coastal morphology after maximum transgression of the Ostracode sea.

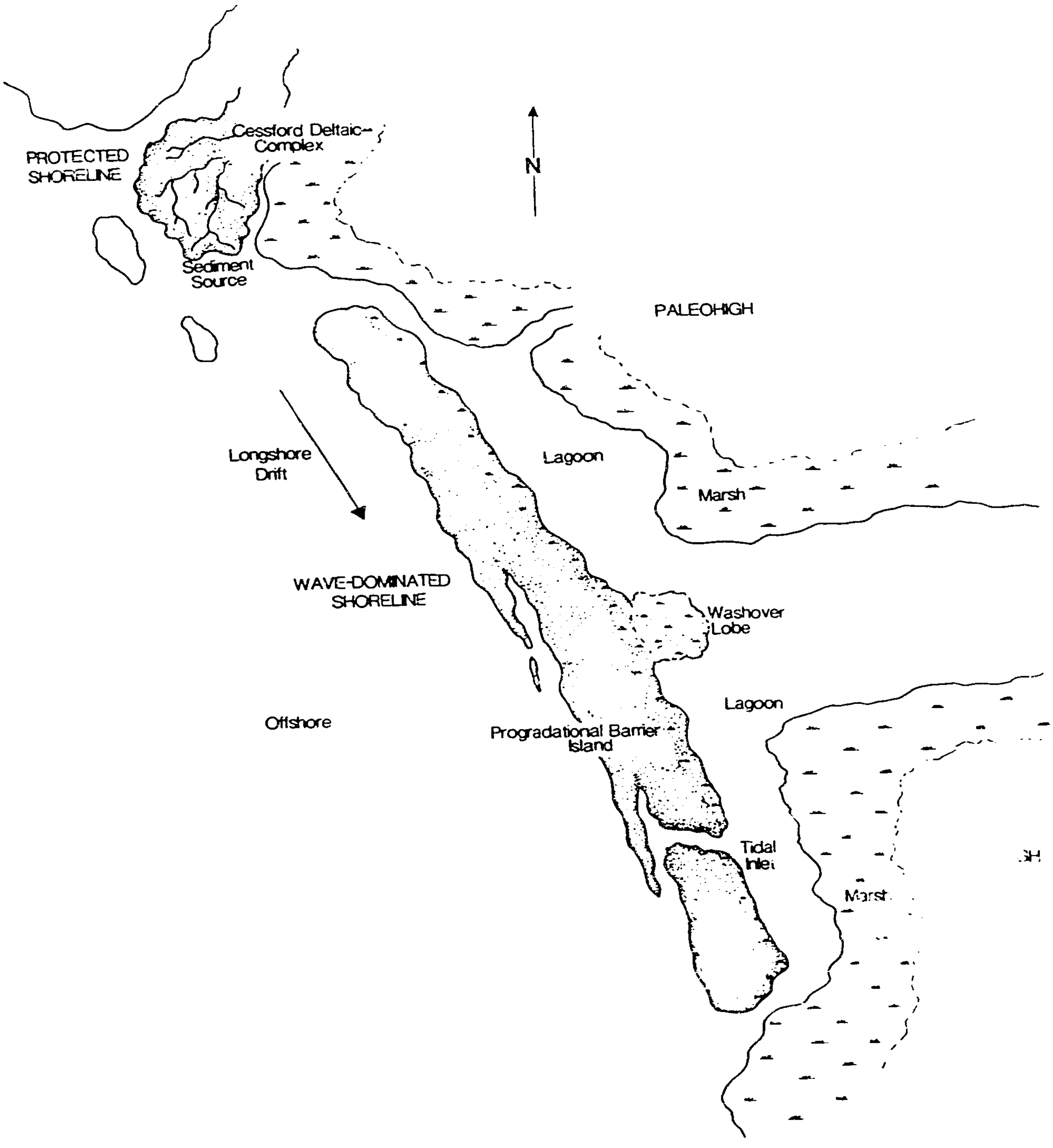


FIGURE II-14. Paleogeographic reconstruction of Ostracode member deposition (approximate scale: 1cm=6miles).

they were deposited (Fig. II-14). Westward the barrier sands grade laterally into bioturbated shales and siltstones of the offshore. Behind the barrier a quiet water lagoon and swamp (Facies 3) developed. Progradation was completed in southern Alberta with the capping of this sequence with coastal plain sediments.

Figure 15 is a paleogeographic sketch illustrating the speculated coastal configuration of the Ostracode basin in Alberta; this embayment probably extended into Montana. Coastlines developed within the embayment, such as the Cessford deltaic complex, the Jenner-Suffield barrier, the Home sand to the west (Hume, 1939),and the Moulton shoreline in Montana (Oakes, 1966). It is also speculated here that the Bellshill valley system (Karvonen, 1989) sourced the Cessford delta.

HYDROCARBON POTENTIAL

The Ostracode barrier sands represent potential stratigraphic traps with considerable regional extent as they buildup and are overlain by shales, coals and siltstones of the coastal plain. Laterally adjacent sediments also represent potential seals; in the west these consist of non-reservoir bioturbated shales and siltstones of the offshore; to the east shaley sediments of the backshore and coastal plain.

Presently known fields within the study area include the Jenner E pool, a spit or offshore bar, and the Suffield A pool, a washover lobe (includes production out of the UM1 unit)(Fig. II-9). The Jenner E pool has an initial volume of oil in place of 3810 x 10^3 m^3 (24 mmbbl) of 927 kg/m^3 (15^oAPI) gravity oil. Ostracode reservoir sandstones in the Jenner E pool have an average porosity of 29.7% and permeability of 1521 millidarcies.

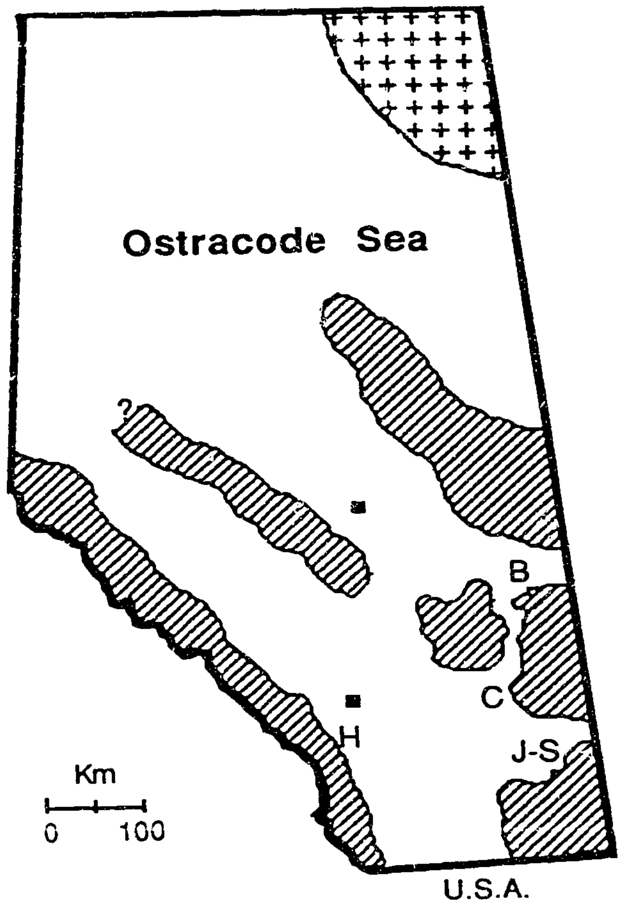


FIGURE II-15. Paleogeographic sketch showing the extent of transgression of the Ostracode sea, B:Bellshill Lake, J-S: Jenner-Suffield, C: Cessford, H: Home, (modified from McLean and Wall, 1981; Jackson, 1985; Hayes, 1986; Karvonen, 1989).

Exploration previously concentrated on the thick sandstones associated with incised valley fill sands which scour into the Ostracode member (see Chapter 3) (Fig. II-9). These thick sandstones were previously interpreted as barrier sands (Tilley and Longstaffe, 1984; Holmes and Rivard, 1976). With exploration concentrating on the thick sandstones, this laterally extensive barrier sandstone deposit, which has considerable potential, has been overlooked. These sands have been traced to the north up to Cessford, where they are thought to form part of the Cessford oil reservoir.

Interpretation of the genesis and geomorphology of a sandstone body is critical where further exploration and development is ongoing. Knowledge of the configuration of the Ostracode basin at the time of maximum transgression improves the chance of finding equivalent shoreline deposits.

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THE UPPER MANNVILLE GROUP IN SOUTHEAST ALBERTA: AN EXAMPLE OF MULTIPLE INCISED VALLEY FILL DEPOSITS

INTRODUCTION

Incised valley deposits have been recognized in the ancient record since the early work of Harms (1966) and Exum and Harms (1968). However the application of the concept of valley incision related to a sequence stratigraphy has been recognized for less than a decade (Weimer,1984). Within the Alberta basin this type of deposit probably accounts for much more of the stratigraphic column than previously realized (ie. James, 1985; Reinson, 1988; Strobl, 1988). The recognition of these 'events' as related to relative sea level fall is important since these depositional systems usually have excellent reservoir potential. Valleys may be backfilled with sediments ranging from marine, to estuarine to fluvial in origin resulting in stratigraphic or combined structural-stratigraphic traps.

In southern Alberta, the Lower Cretaceous Mannville group contains numerous highly productive reservoirs (E R C B, 1987), many of which are now interpreted as estuarine or fluvially filled valleys (ie. Little Bow: Wood and Hopkins, 1989, R. Rahmani, pers. comm; Countess: Farshori, 1983; Taber-Turin: Hradsky and Griffin, 1984; and Medicine River: Strobl, 1988). The Jenner-Suffield fields are located in southeastern Alberta on the NW flank of the Sweetgrass arch, a positive structural feature rising in central Montana and continuing into the Alberta plains where it meets the southward plunging North Battleford arch (Herbaly, 1974).

During much of early Albian time, the southern coastline of the Boreal Sea was located in central and northern Alberta. In southeast Alberta, in the

Jenner-Suffield area (T18-21, R7-9W4)(Fig. III-1), time equivalent fluvially filled valley deposits are recognized. They are in all likelihood the drainage system that fed coastal progradational shoreline systems located to the north. Lateral and vertical changes from genetically unrelated porous point bar valley fill sandstones to non-reservoir fine grained interbedded siltstone, claystone and coals of coastal/floodplain deposits provide an excellent trapping mechanism for petroleum. Differential compaction further enhances the stratigraphic trap. The Jenner-Suffield upper Mannville pools contain total estimated oil in place of approximately 71429 X $10^3 m^3$ (450 mmbbl) of 959 kg/m^3(16^o API) gravity oil.

The data base for the local study area T17-20, R 6-8W4M includes geophysical well logs from 305 wells, core logged from 85 wells and point counting of 24 thin sections. Data from this area served to establish sedimentologic and stratigraphic relationships for the various units. This knowledge was then expanded and applied to a more regional study area contained within the block of T4-25, R3-13W4M, where geophysical logs from more than 960 wells were used in order to map the units and get a regional perpective on their distribution.

The object of this paper is to develop an integrated depositional model for the informal upper Mannville units UM1, UM2 and UM3, using stratigraphic, sedimentologic and reservoir data.

PREVIOUS WORK

Selected studies on the Mannville Group in southern Alberta include: Workman (1958), Herbaly (1974), Holmes and Rivard (1976), Farshori(1983), Hradsky and Griffin (1984), Tilley and Longstaffe (1984).

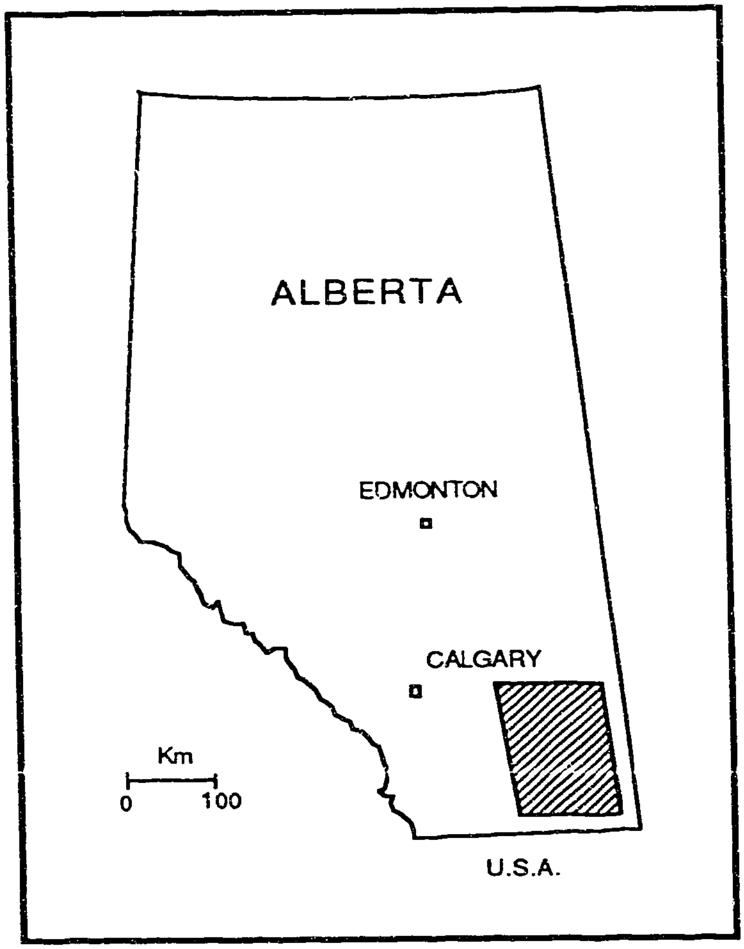


FIGURE III-1. Location map.

The sandstone deposits in the Jenner-Suffield area have previously been referred to as the 'Glauconitic sandstone' by a number of authors including Herbaly (1974) and Tilley and Longstaffe (1984). In this study, numerous different depositional systems are interpreted as responsible for this sandstone accumulation, hence the term 'Glauconitic sandstone' is not appropriate. Instead these genetically mixed sandstones are assigned to the upper Mannville Group.

Early work by Glaister (1959), Williams (1963), Mellon and Wall(1964), Rudkin (1964), and Mellon (1967) recognized the division between the lower and upper Mannville Group. The upper Mannville Group including the Jenner sandstones is composed of lithic and feldspathic sandstones unlike the lower Mannville Group which is characterized by siliceous sandstones capped in some areas by the Calcareous Member (Ostracode member equivalent) (Glaister, 1959).

Numerous interpretations for the upper Mannville reservoir sandstones at Jenner-Suffield have been proposed since the discovery of hydrocarbons in the Jenner O pool in 1952 (Holmes and Rivard, 1976), the Jenner F pool in 1965 and the Suffield J pool in 1977 (E R C B, 1987). Herbaly (1974) proposed that the Jenner trend represents a dune deposit. Holmes and Rivard (1976) and Tilley and Longstaffe (1984) interpreted the thick reservoir sands (up to 45 m in thickness) in the Jenner-Suffield area as marine barrier sands. This paper will provide an alternative explanation for the genesis of the thick 'Glauconitic sandstone' in the area.

STRATIGRAPHY

Within the study area Mississippian strata form the subcrop beneath the pre-Cretaceous Unconformity (Fig. III-2). Considerable relief can be developed on this surface, with the chert breccias of the Detrital Member sourced mainly from the pre-Cretaceous surface, infilling low-lying areas. Overlying the Detrital is the siliceous clay-rich sandstones of the Ellerslie Member which is disconformably overlain by the Ostracode member. The Ostracode member, which is typically comprised of quartz-rich sandstones, is in turn overlain by the upper Mannville Group. In the study area the upper Mannville Group sits disconformably on the Ostracode member where a number of informally named lithic-rich sandstone units are recognized. They are in ascending order, the UM1, UM2 and UM3. Each is separated by an erosional disconformity at their base (Type 1 sequence boundary; Van Wagoner et al, 1988).

SEDIMENTOLOGIC AND STRATIGRAPHIC RELATIONSHIPS

The three informally named units named above have been delineated within the upper Mannville Group based on sedimentologic evidence and stratigraphic relationships (Fig. III-3). Each unit is interpreted to represent a valley fill deposit. These valleys have been traced regionally as shown in Figure III-4.

It must be kept in mind that when rivers are confined to valleys, information regarding the dimensions of the ancient channel may be destroyed by channel adjustment. A valley deposit must be looked at as one

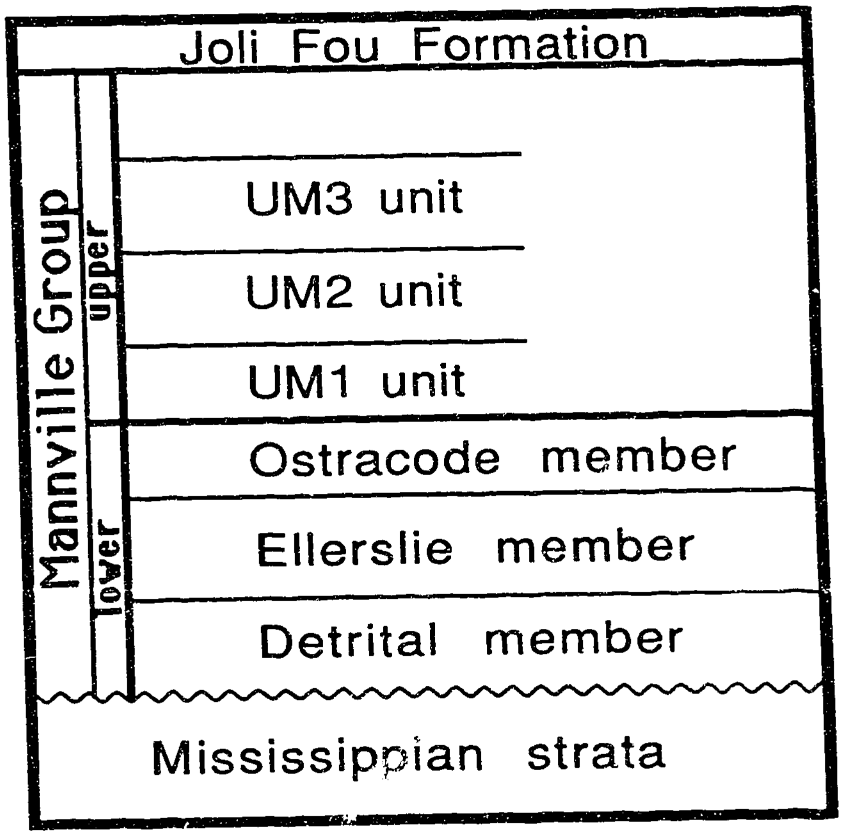


FIGURE III-2. Stratigraphic chart.

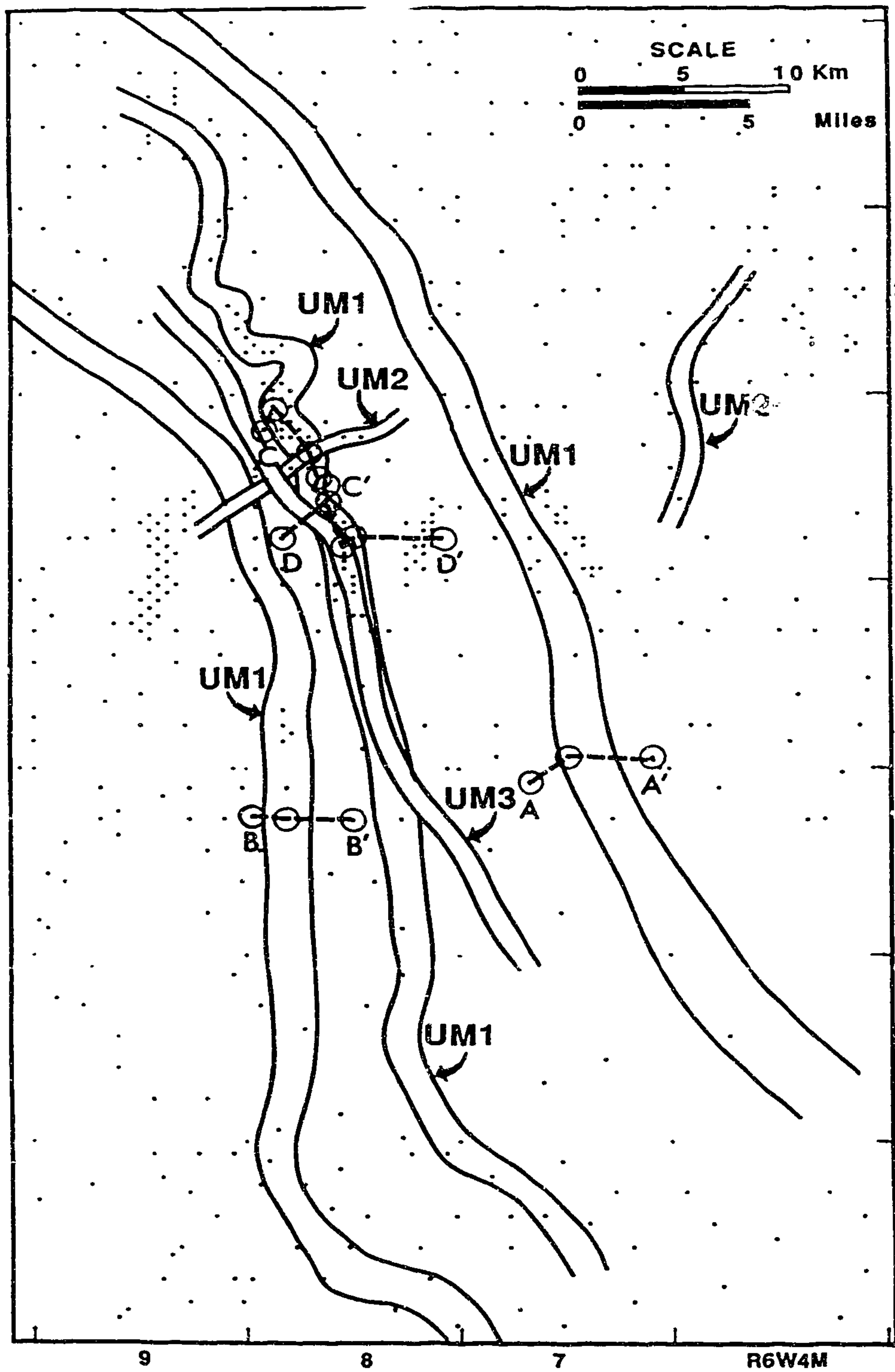


FIGURE III-3. Valley incision map (Cross-section location map).

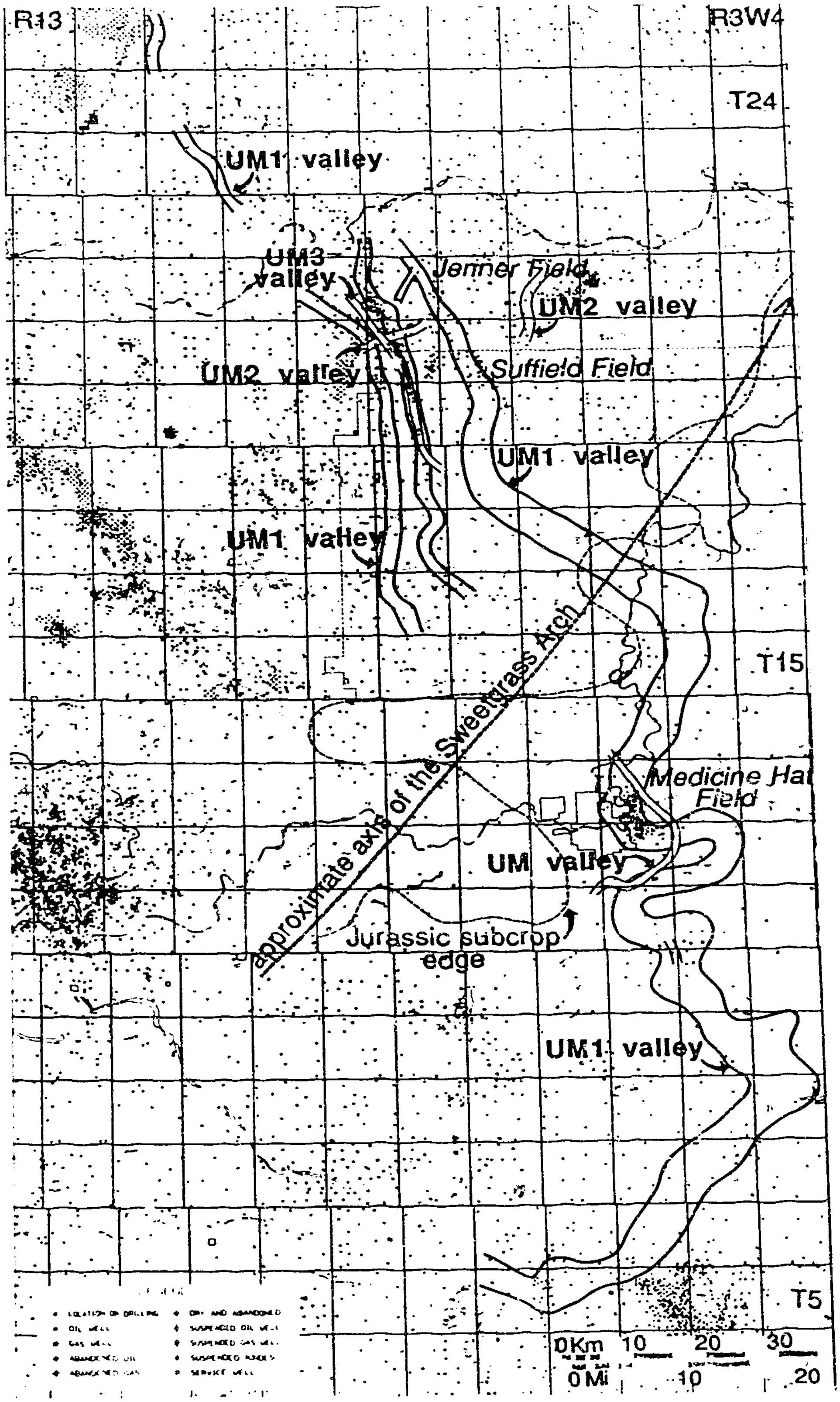


FIGURE III-4. Regional valley incision events.

unit containing the deposits recording the evolution of a stream through time.

UM1 Deposit

VALLEY MORPHOLOGY

Mapping and cross sections of this unit indicate an initial incision event which was subsequently infilled with UM1 sediments (Fig. III-5).

A general alluvial channel classification by Galloway (1977) and Schumm (1977) is used here since the valley fill will reflect the characteristics of the channels which are contained within the valley (Fig. III-6). This classification is based on morphology and fill, since the relative proportions of bedload (sand and gravel) and suspended load (silts and clays) dictate the channel/valley morphology (Schumm, 1981). After this general classification, further delineation as to the specific type of channel model that appear to characterize the deposits will be made (ie: braided, meandering). Channel modelling of any kind can only be general since model classification requires a detailed description of vertical and lateral sedimentologic successions that cannot be obtained in the subsurface.

There appears to be no relationship between the UM1 deposit and the laterally adjacent coastal plain sediments of the Ostracode member which are characterized by interbedded coals, siltstones and shales (Fig. III-7). Three NNW-SSE trending UM1 valleys are recognized, scouring into the coastal plain sediments, the underlying, mineralogically different Ostracode barrier deposit (Tilley and Longstaffe's Facies 6) and occasionally the Ellerslie Member (Fig. III-8). The UM1 deposits are interpreted as fluvial backfill deposits in an incised valley. In intervalley areas the disconformity

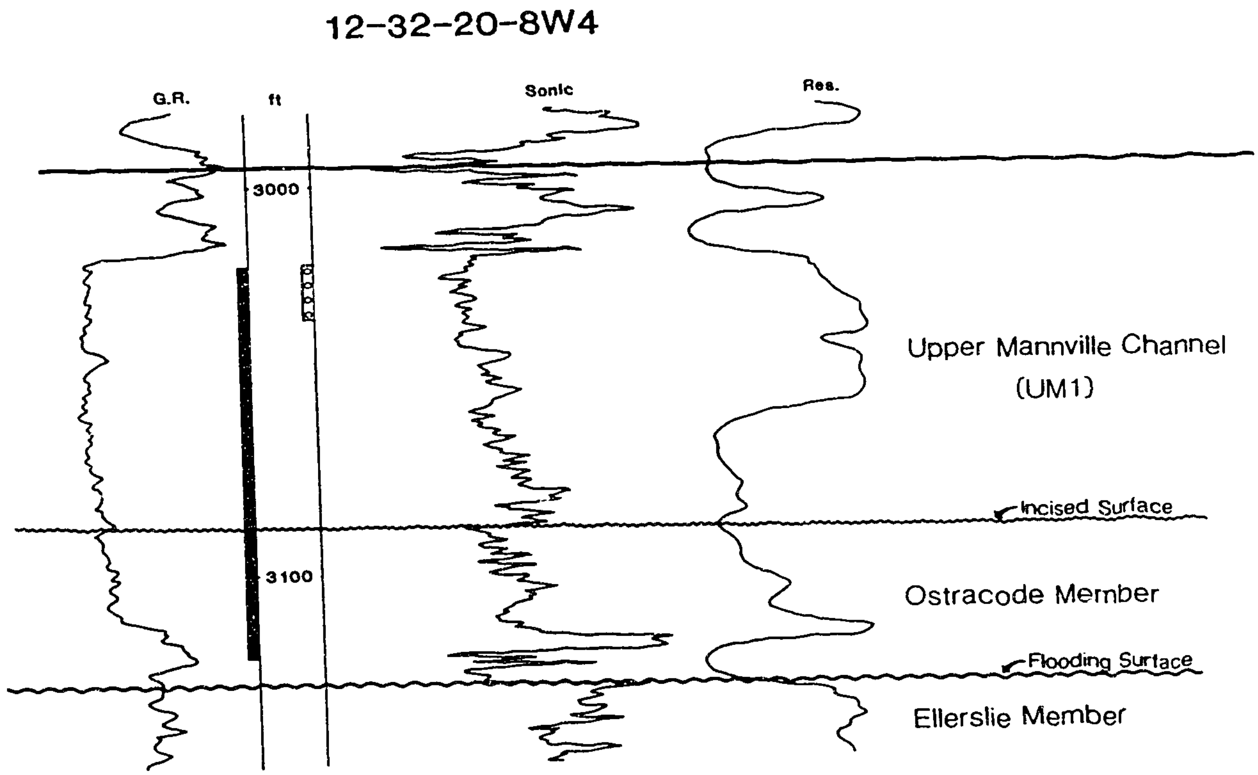


FIGURE III-5. UM1 type log profile.

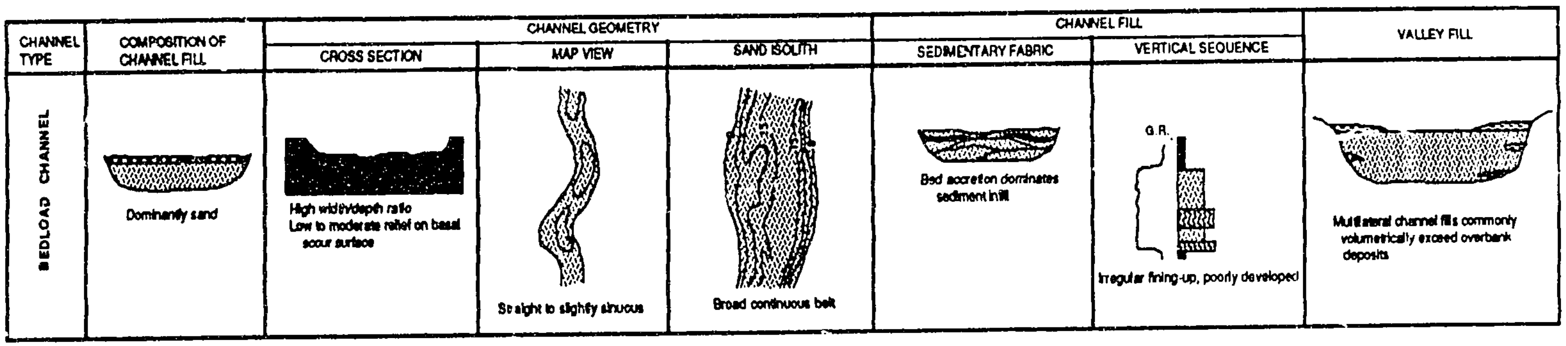


FIGURE III-6. Morphologic and sedimentologic characteristics of a bedload channel and valley fill (modified from Galloway, 1977 and Schumm, 1977).

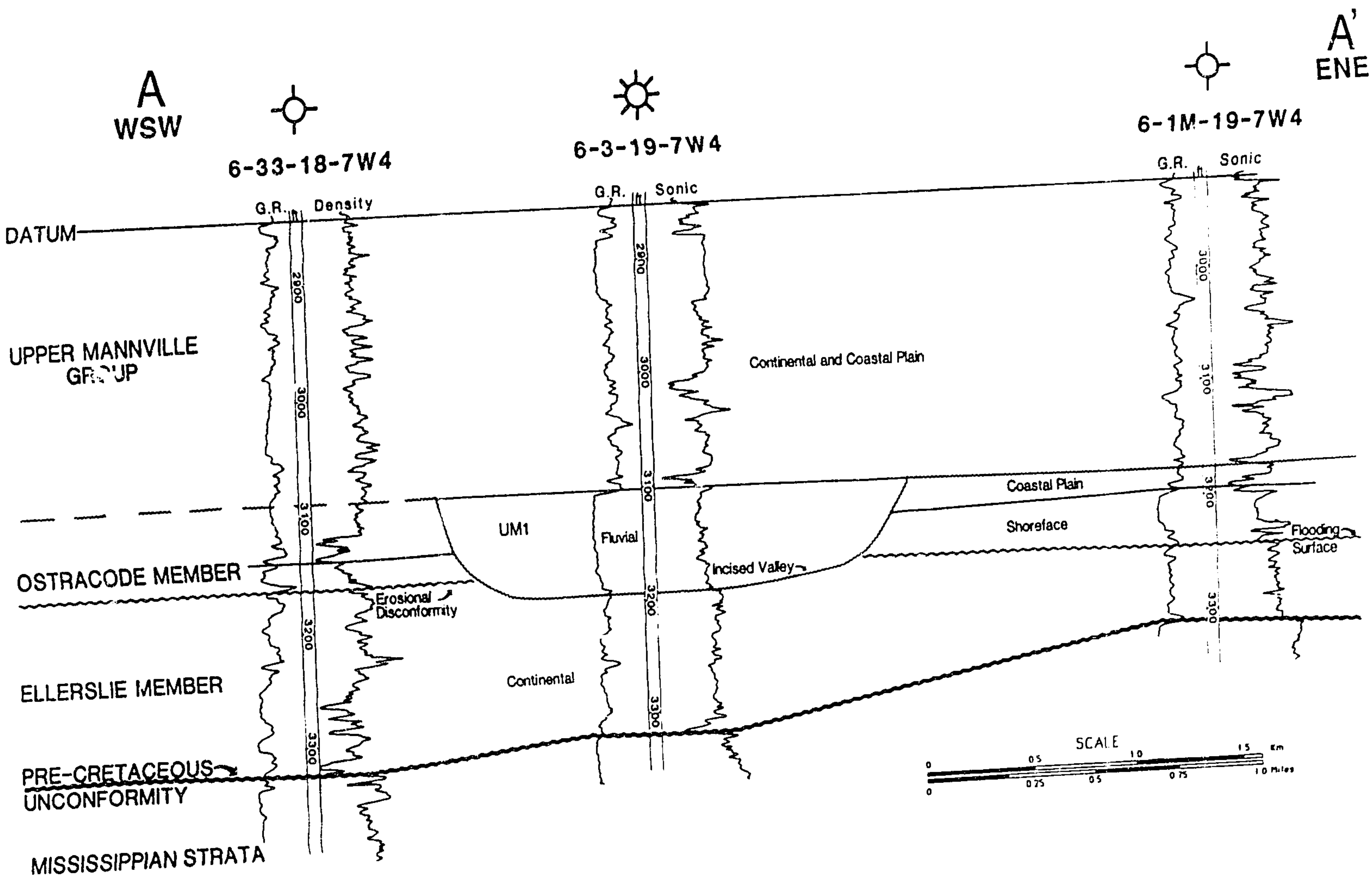


FIGURE III-7. Stratigraphic cross-section A-A' (datum: top of Mannville).

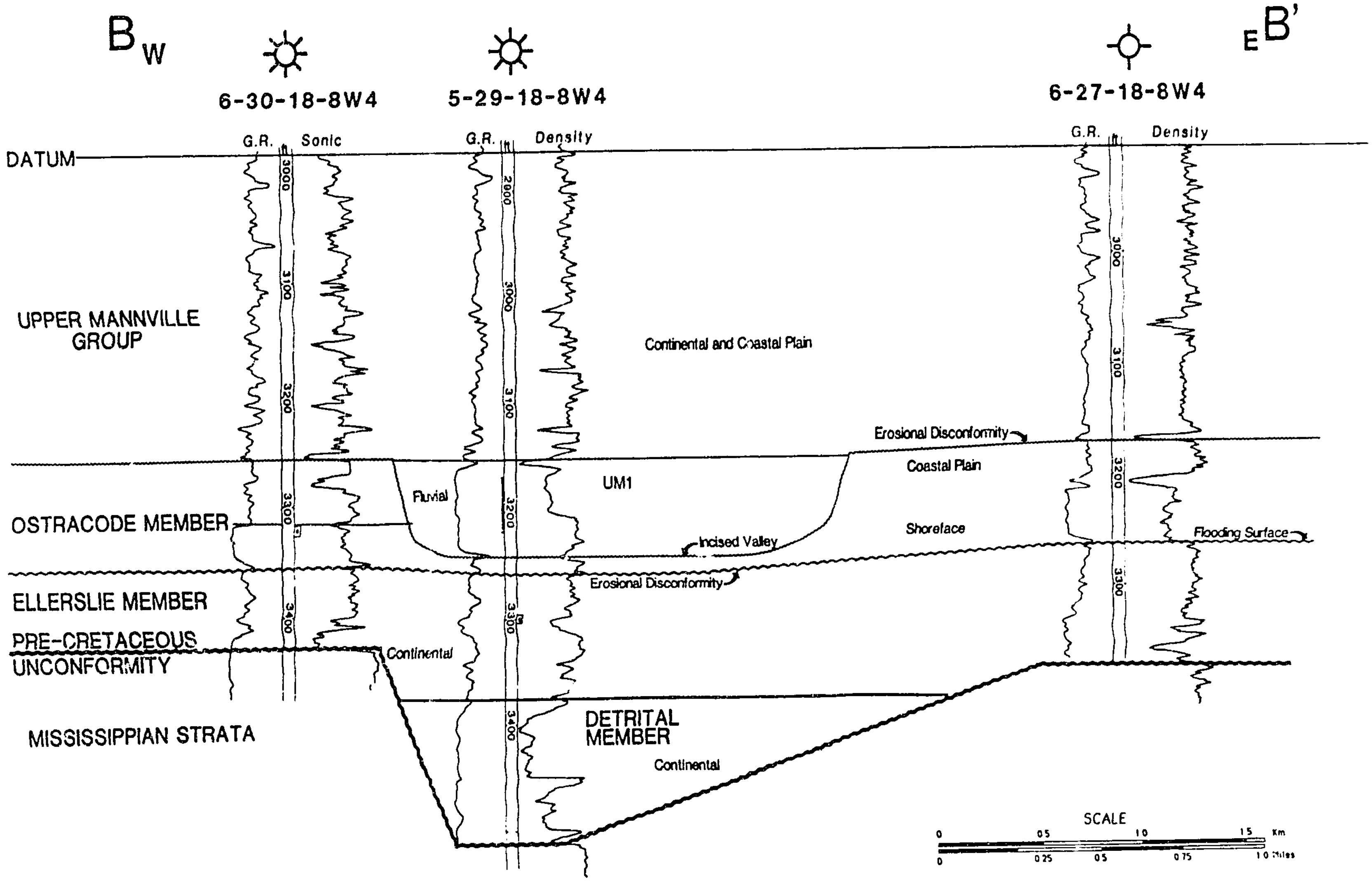


FIGURE III-8. *Stratigraphic cross-section B-B' (datum: top of Mannville).*

associated with valley incision is typically marked by a coal. Incision transforms the floodplain into a terrace which may be marked by a coal or a paleosol.

In the Lower Cretaceous Dakota Group in the Denver basin, Nebraska, this situation of fluvially incised shoreface deposit, both of different mineralogy, is similar to that observed in the marine Ft Collins Member and the upper fluvial valley fill of the Horsetooth Member (15 m/50 ft thick) documented by Harms (1966), Exum and Harms (1968), MacKenzie (1975), and Land and Weimer (1978). This Horsetooth incision event has recently been correlated to the incision at the base of the Encinal Canyon Member to the southwest in the San Juan Basin, Colorado by Aubrey (1989).

The UM1 valleys are on average 1.5 to 3.0 km (1-2 miles) wide (Fig. III-4), and range from straight to sinuous in morphology. Average thickness of the UM1 unit is 20-25m, and a high width to depth ratio 2400m/20m ≈120:1 is typical of the valleys. Sandstone within the valley forms a broad continuous belt. Low to moderate relief is associated with the base of the scour surface, a variation in scour depth along the valley length is no more than 10m. Local variations cannot be determined with the available well density. These valleys are proposed to have contained predominantly bedload channels. Muddier portions have been recognized in some areas within the valleys.

The size (depth and width) of these sandstone deposits is a strong line of evidence that they are valley deposits, not the product of a single channel which would tend to be of a much lesser magnitude (Schumm, 1977). Hradsky and Griffin (1984) note that incision of the Oldman and Bow rivers responding to isostatic rebound following Pleistocene glaciation resulted in valleys up to 3 km wide and 40 m deep. Present day Peace River valley is approximately 3.2 km wide, with the Oldman valley 1-2 km in width.

The easternmost UM1 valley has been traced through the Medicine Hat oilfield to the south, to the Manyberries area (Twp5), a distance of about 160 km (100miles) (Fig. III-4). The morphology of the valley and the nature of the fill changes as it is traced from south to north. In the Medicine Hat area the UM1 valley is typically 6.5 to 8 km (4 to 5 miles) in width with an average thickness of 15 to 20 m. To the north, the valley narrows to about 1.5 to 3 km (1 to 2 miles) in width and deepens to about 20 to 25 m. The valley fill tends to get sandier to the north. Fining upwards successions and abandoned channels are more readily recognized in the Medicine Hat area, possibly due to less vertical stacking of channels. In the Medicine Hat area the valley incises into lower Mannville continental sediments and bottoms out on a resistant paleosol shale which marks the unconformity at the top of the Jurassic sequence, probably resulting in the widening of the valley since it could no longer downcut. The narrowing of the valley to the north may be the result of an increased gradient or the fact that the scoured substrate changes to continental sediments of the lower Mannville Group versus the marine shales of the Jurassic Rierdon which forms the subcrop beneath the sub-Jurassic unconformity (easier to incise to the north?).

Variation on the relatively straight morphology can be seen as sharp meander bends along the valley, such as that observed in the area between the Jenner O and F pools. This sharp meander morphology is also seen in the Medicine Hat field to the south (T12, R4W4). Experimental work by Gardner (1975) showed how incised meanders form during an incision event (Fig. II-9). After the initial drop in base level, headward erosion occurs up the meander pattern. As this incision migrates upstream the downstream

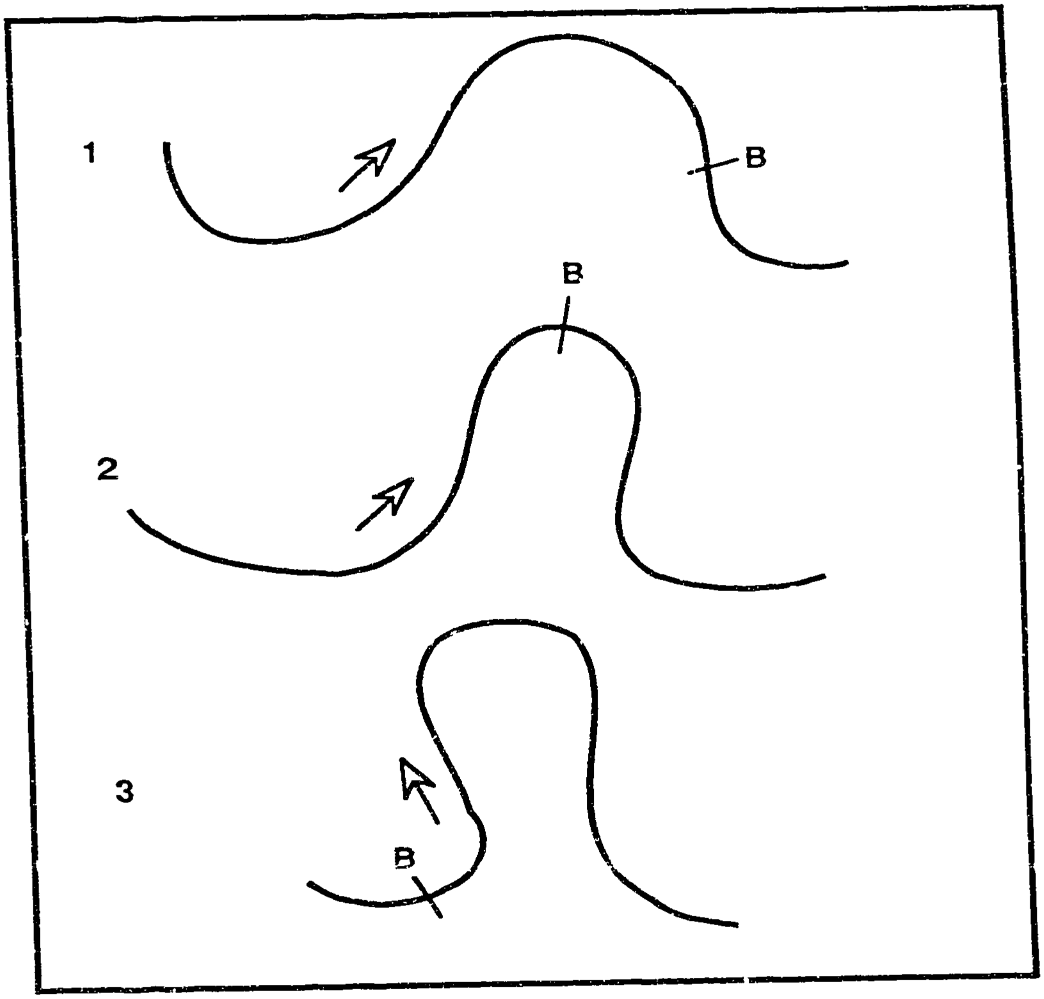


FIGURE III-9. Development of incised meander during base level drop. The letter B indicates the location at which the channel incises bedrock (modified from Gardner, 1975 and Schumm, 1977).

limb of the meander hits bedrock first and is fixed in position. The upstream limb of the meander, still on alluvium, continues to migrate downstream as a part of a normal meander pattern and deformation of the meander loop occurs. This process is probably responsible for the deformed incised meanders observed on the San Juan River (Schumm, 1977). Incised meanders probably occur along the lengths of many upper Mannville valley networks in the Alberta Basin and represent potential hydrocarbon traps.

The UM1 fluvial systems are thought to have supplied sediment to a coastline in central and/or northern Alberta. The drainage basin (source area) is speculated to be located in the tectonically active areas in the NW United States. A relative sea level drop resulted in the incision of this drainage network. A subsequent relative rise in sea level may have resulted in the backfilling of the valley with fluvial sediments.

VALLEY FILL

Sedimentology

The sandstones which comprise the UM1 unit are chert litharenites (Q:F:L ratio of 56:0.3:43.7, Folk,1974). This sequence typically fines upwards from a chert pebble conglomerate (Plate III-1a, b) or medium grained sandstone to a fine grained sandstone at the top (Fig. III-10). Mud is rarely observed probably due to a general lack of mud in the sediment supply. Gamma ray log profiles of the UM1 are typically blocky and do not show a fining upwards trend (Fig. III-5). This is expected since the fining up in the valley deposits is due to a loss of the pebble or coarse sand component which would not be observed on a Gamma ray trace, but is usually recognizable on the Spontaneous Potential profile. The lack of both a 'nice' fining upward succession and a predictable sequence of sedimentary structures is not

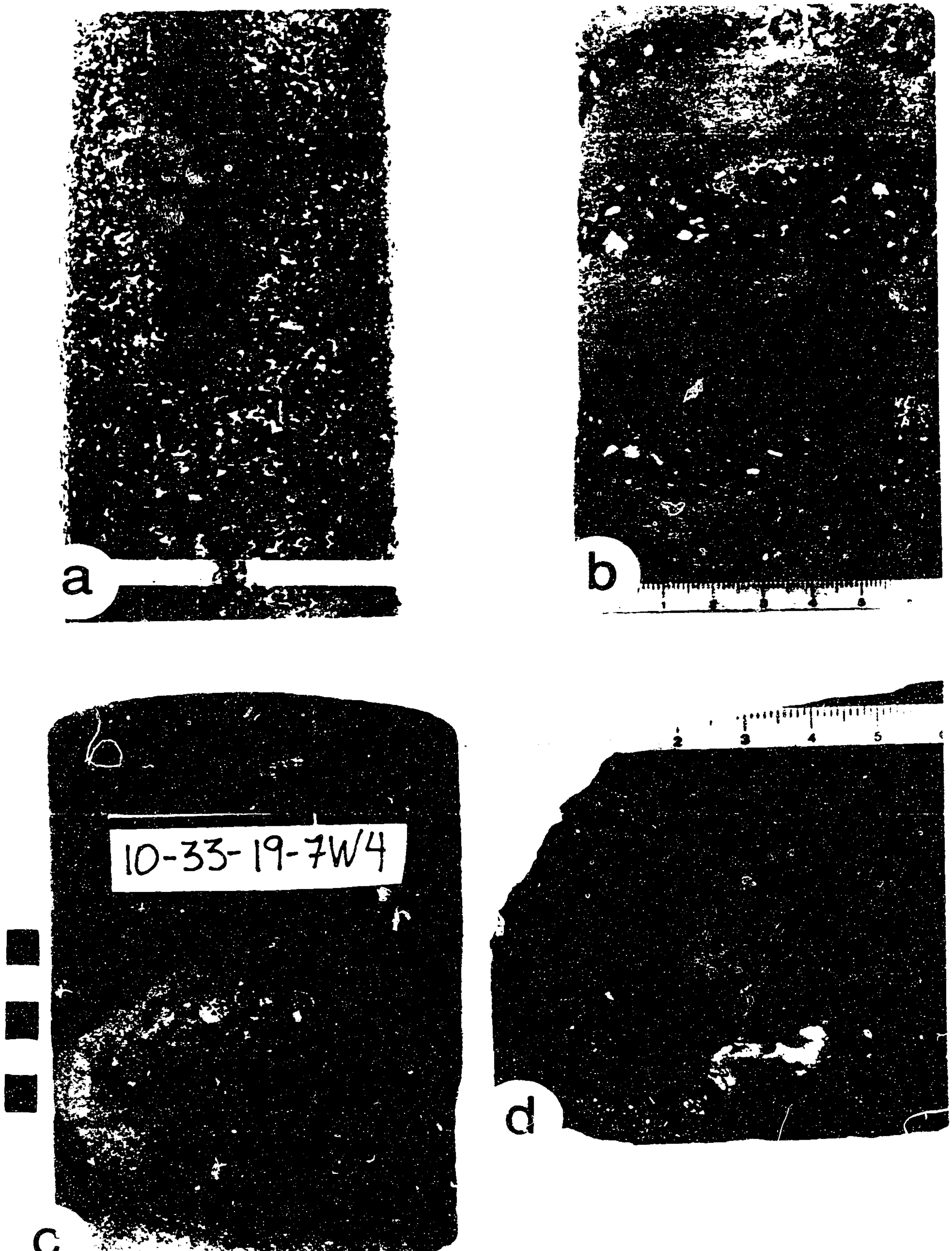
PLATE III-1

a). 5-29-18-8W4 (depth: 3212 ft): Massive chert pebble conglomerate containing no matrix and abundant calcite cement in the UM1 unit (scale increments in cm).

b). 10-17-20-7W4 (depth: 3180 ft): Interbedded medium grained sandstone and chert pebble conglomerate exhibiting high angle cross-stratification in the UM1 unit.

c). 10-33-19-7W4 (depth: 3164 ft): Clasts at the base of UM1 containing gastropod fragments (from the underlying Ostracode member).

d). 12-32-20-8W4 (depth: 3091 ft): Base of the UM1 containing some clasts and exhibiting low angle cross-stratification


a
b
c
d
10-33-19-7W4
2
3
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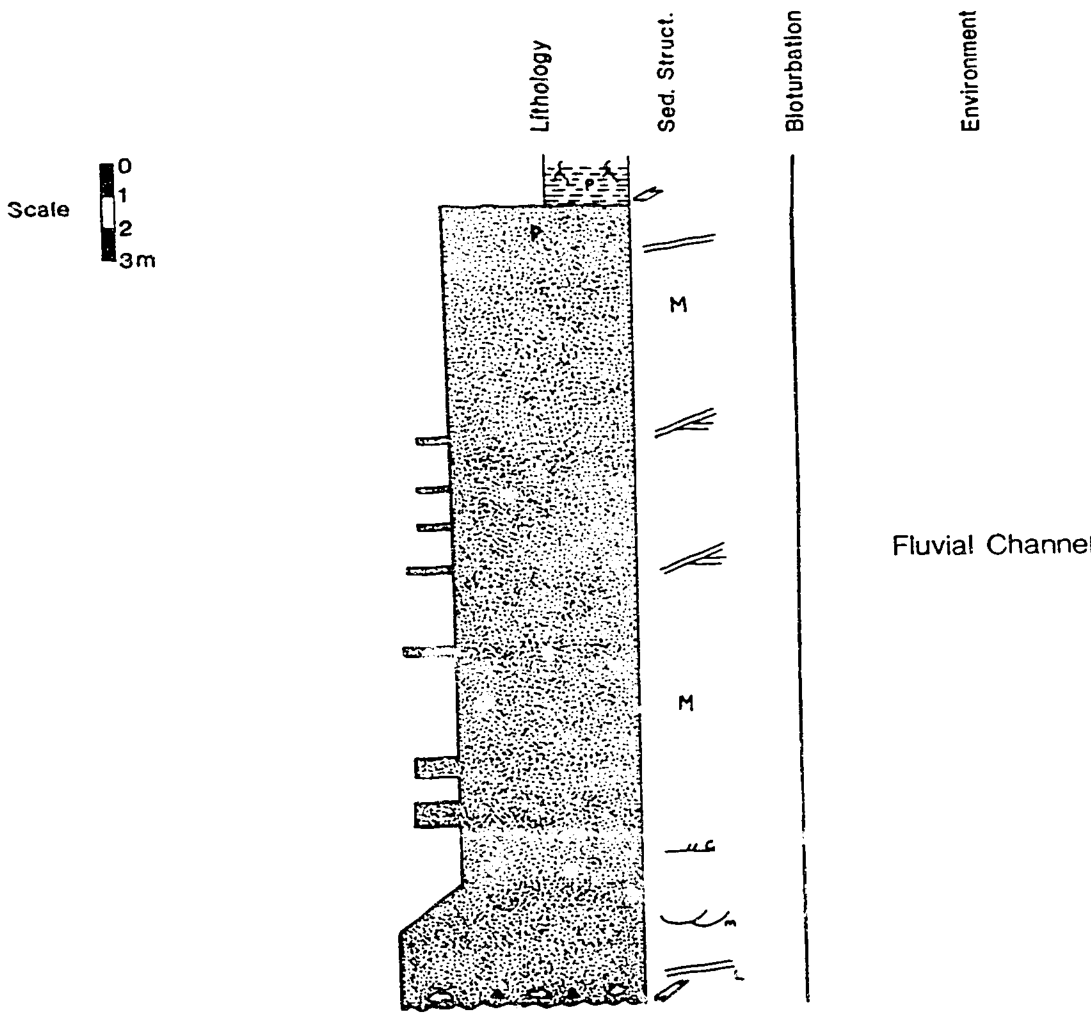


FIGURE III-10. Composite core litholog for the UM1 unit.

surprising, and should be expected in a valley succession. The deposit does not represent one meander point bar deposit but a series of vertically stacked channel deposits representative of successive truncation and deposition. Facies classification would be of little use in this case.

Occasional to common matrix supported pebbles and coarse grained sandstones were observed indicating periods of higher energy. The UM1 unit is typically sandy with minor amounts of mud observed in core, indicating little suspended load deposition. Core typically does not penetrate the base of the unit. When it does, a sharp scour base is observed where this unit sits disconformably on the underlying more quartzose sandstone (Q:F:L ratio of 86.1:0.7:13.2) of the Ostracode member. Wood fragments/ organic debris, calcareous sandstone clasts with gastropod fragments (Plate lll-1c, d), and coarse grained sediments typically form a lag at the base of the UM1 unit. Sedimentary structures such as low- to high-angle cross-stratification, current ripples, and low-angle parallel laminations all indicate sediment transport by traction. In the lower portions (ie. the lower half) of the sequence interbedded coarse grained sandstone/chert pebble conglomerate and medium grained sandstone typically exhibits low to moderate angle cross-stratification (Plate lll-1a, 1c), trough cross-stratification (Plate lll-2b), some high angle cross-stratification, and scour and fill structures. In well 5-29-18-8W4 matrix free chert pebble conglomerates reach 14 m in thickness, massive in nature (Plate lll-1a) or exhibiting low-angle cross-stratification. These deposits are thought to reflect various channel bars (longitudinal, transverse and marginal) in a braided fluvial system. Upper portions of the UM1 unit tend to be sandier with less coarse component than lower in the unit. Medium to fine grained sandstones exhibit low to high angle cross-stratification, or they may be massive in nature. These upper deposits are

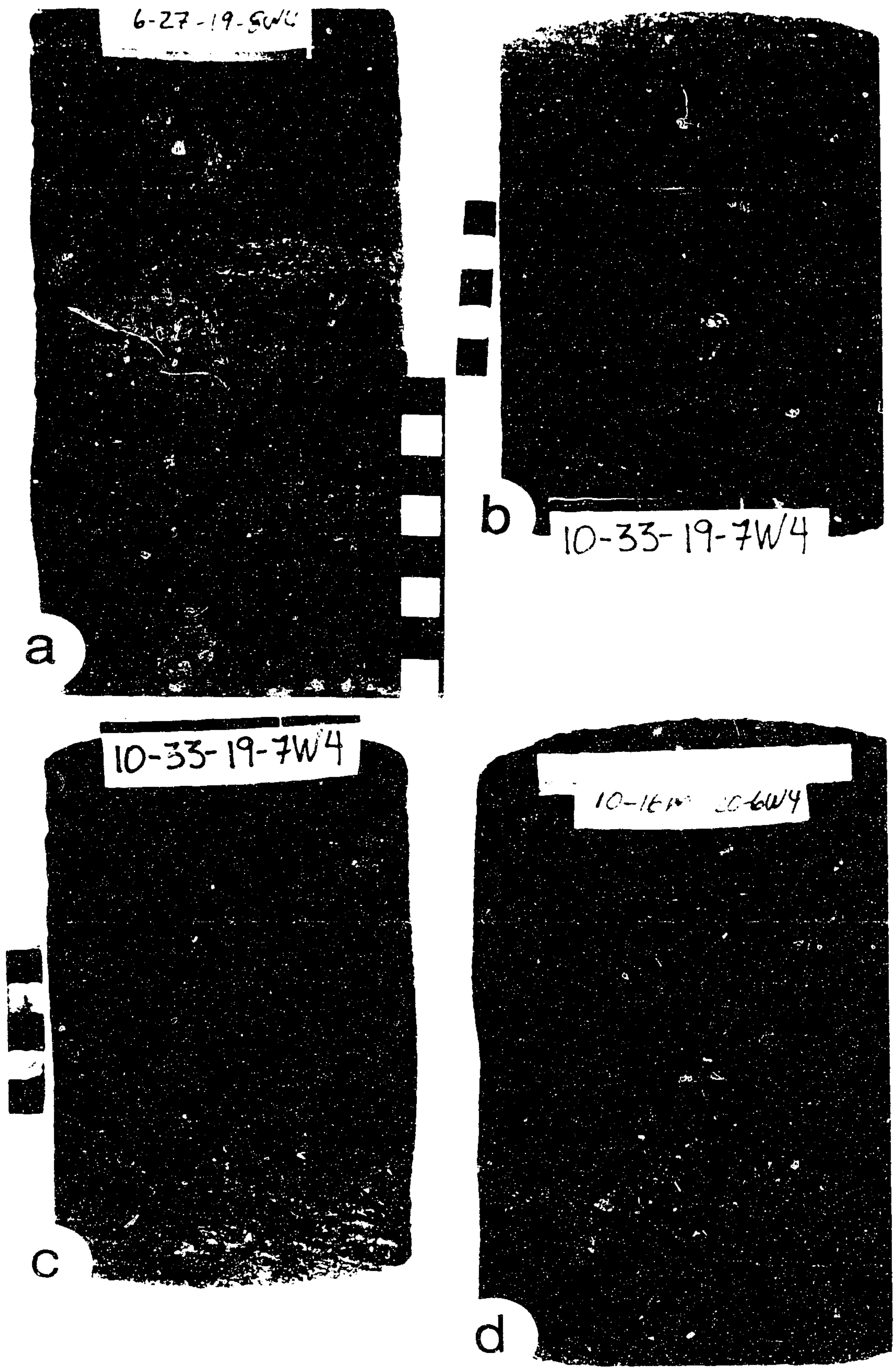
PLATE III-2

a). 6-27-19-8W4 (depth: 3162.5 ft): Interbedded very coarse to coarse grained sandstone and fine grained sandstone displaying high angle cross-stratification in the UM1 unit (scale increments in cm).

b). 10-33-19-7W4 (depth: 3146.5 ft): Trough cross-stratification in the UM1 unit.

c). 10-33-19-7W4 (depth: 3146.5 ft): High angle cross-stratification in the UM1 unit.

d). 10-16-20-[illegible]W4 (depth: 3045 ft): Coarse grain filled unlined burrow near the top of the UM1 unit.


a
b
10-33-19-7W4
10-33-19-7W4
c
d

thought to represent a shift in the system with deposition now occurring in a meandering river system. Occasional unlined vertical burrows (*Skolithos*) are recognized on bedding planes due to grain size differences in the upper portions of the unit (Plate III-2d). It has not been ruled out that the uppermost portions of the UM1 valley fill could have an estuarine influence. The top of the UM1 unit is characteristically rooted and is overlain by interbedded siltstones, shales and coals with minor bioturbation. Tilley and Longstaffe (1982) recovered the dinoflagellates *Muderongia sp.* and *Ctenidodinium* from the Ostracode member. This low species diversity was interpreted to indicate a restricted marine environment of low salinity. This supports the interpretation of this paper that the Ostracode member was deposited within a brackish embayment formed by a transgression of the Ostracode sea (see Chapter 2). Spores and pollen when found included *Minerisporites, Erlansonsporites* and *Arcellites* (Tilley and Longstaffe, 1982) were recovered from the upper Mannville deposits indicating continental conditions; no dinoflagellates were recovered. The influence of the lack of mud in the upper Mannville valley deposits must be recognized as an influence on palynological recoveries.

The high sand content, low relief of scour and linear geometry of the valley indicates that the channels contained within them were probably bedload channels as described by Galloway (1977). Just as sediment load influences the morphology and fill of a channel, the same is true for valley fill deposits representing successive truncation and deposition (Fig. III-6). A high ratio of channel sandstone to fine grained floodplain deposits would suggest low sinuosity channels, where the river migrates across the floodplain more frequently eroding vertically accreted floodplain deposits. The sediment source will determine the valley fill, which in the UM1 is dominantly sand and gravel. The coarse component at the base and the dominance of sandstone in the upper portion of the valley sequence seem to indicate a change in energy and/or rates of deposition upsection. It is proposed that as the UM1 valley infilled channel deposition changed from braided at the base to meandering near the top. The incision of a stream results in the supply of large quantities of sediment that can overwhelm the transporting capacity of the channel and periods of aggradation take place interrupting the degradational process (Schumm, 1981). Experimental work by Schumm (1977) actually demonstrated that with the infilling of a valley this type of succession from braided to meandering can be expected.

With the initial drop in base level incision typically occurs at the mouth of the basin and as erosion progresses upstream the main channel transports increasing volumes of sediment, resulting in deposition and the formation of a braided stream. As the river adjusts to the new base level, sediment load decreases and new phase of channel erosion occurs, forming a low alluvial terrace or floodplain. This decrease in bedload and therefore gradient, then results in a more defined meandering type channel. Braiding and meandering are commonly interrelated. Coleman (1969) showed that the Bahmaputra River in its lower reaches was 100 years ago a typical meandering stream but is now braided due to an increase in discharge. This trend from braided to meandering is also present in the Mississippi River valley deposit (Fisk, 1944). The Mississippi valley was filled with sediments which grade upwards from coarse sands and gravels of a braided system through sands and silts of a meandering system. Braiding and meandering may occur in the same river along its length at the same time, depending on gradient and sediment discharge (Schumm and Lichty, 1963; Schumm, 1977; Galloway,1981; Schumm,1981).

In the UM1 valleys the coarse grained braided deposits, when present, are typically sharply overlain by the medium to fine grained sandstones of the meandering deposits (point bar), so it is speculated that the terrace which may have developed during the valley infill was eroded. Some aggradation of these coarse grained basal deposits may have occurred while base level was still falling/ fluctuating.

It is speculated that the UM1 deposits are probably equivalent to the Glauconite Member as described elsewhere (Farshori, 1983; Hradsky and Griffin,1984; James,1985; Rosenthal,1988; Strobl,1988). The Glauconite channels in the Taber-Turin area documented by Hradsky and Griffin (1984) are of low sinuousity and are up to 3km wide and 40m deep and cut into the underlying Ostracode and Taber deposits. Hradsky and Griffin (1984) also recognized a later Mannville (post-Glauconitic channel event) which is possibly equivalent to the UM3 unit in the Jenner-Suffield area.

Mineralogy

A total [illegible] thin sections were point counted for the various units including the Ostracode member . Grain size was considered, and a consistent sand size fine-medium range was used, with the coarse grain sizes being excluded since the result was an anomalously high lithic component. Using a fine to medium grain size cutoff, 10 thin sections were plotted in the UM units (Fig. lll-11).

A total of 5 thin sections were point counted (approximately 250 points) and plotted for the UM1 in order to quantitatively determine the mineralogy of the UM1 sandstone. The UM1 unit contains significantly more lithic (including chert) rock fragments than the underlying more quartzose Ostracode member (Plate lll-3). The sand grains tend to be subangular to

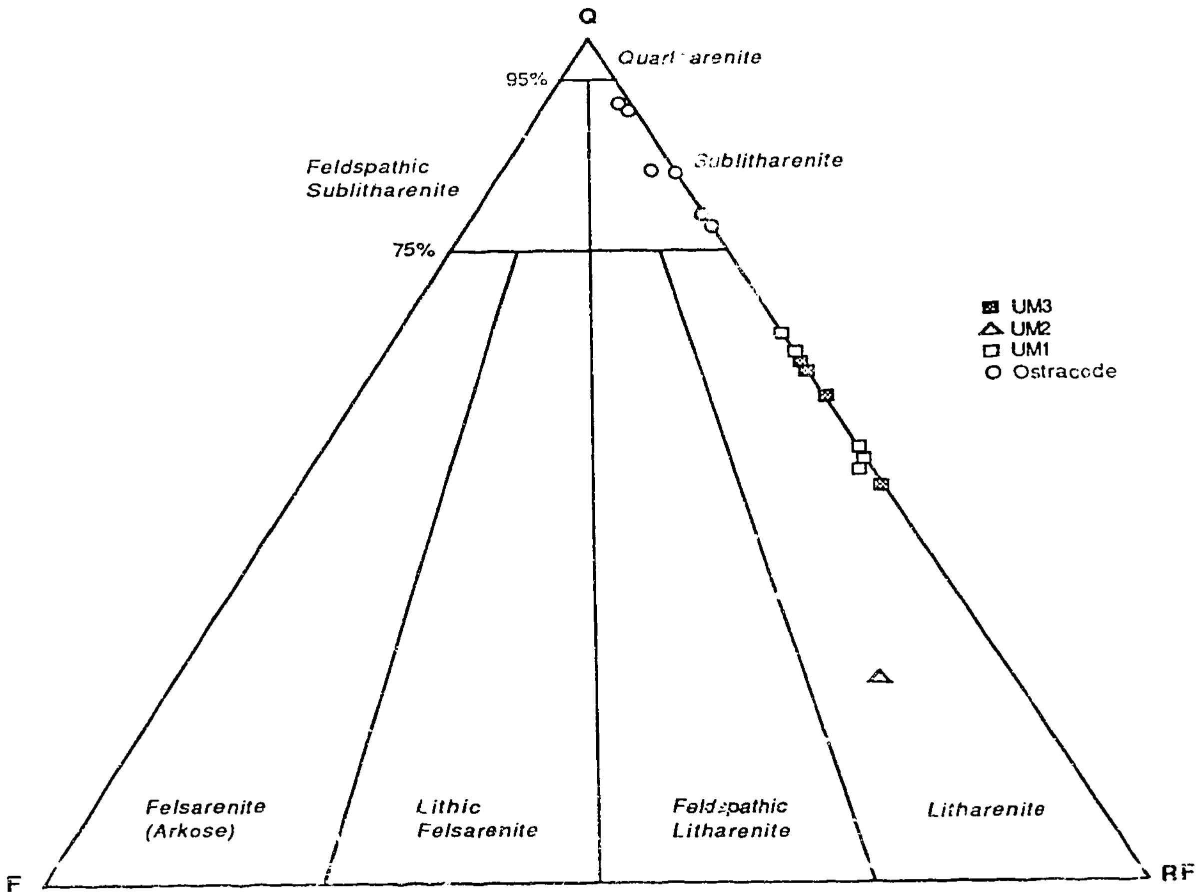


FIGURE III-11. Ternary plot (from Folk, 1980) showing the representative mineralogy of the Ostracode member, the UM1unit, UM2 unit, and UM3 unit.

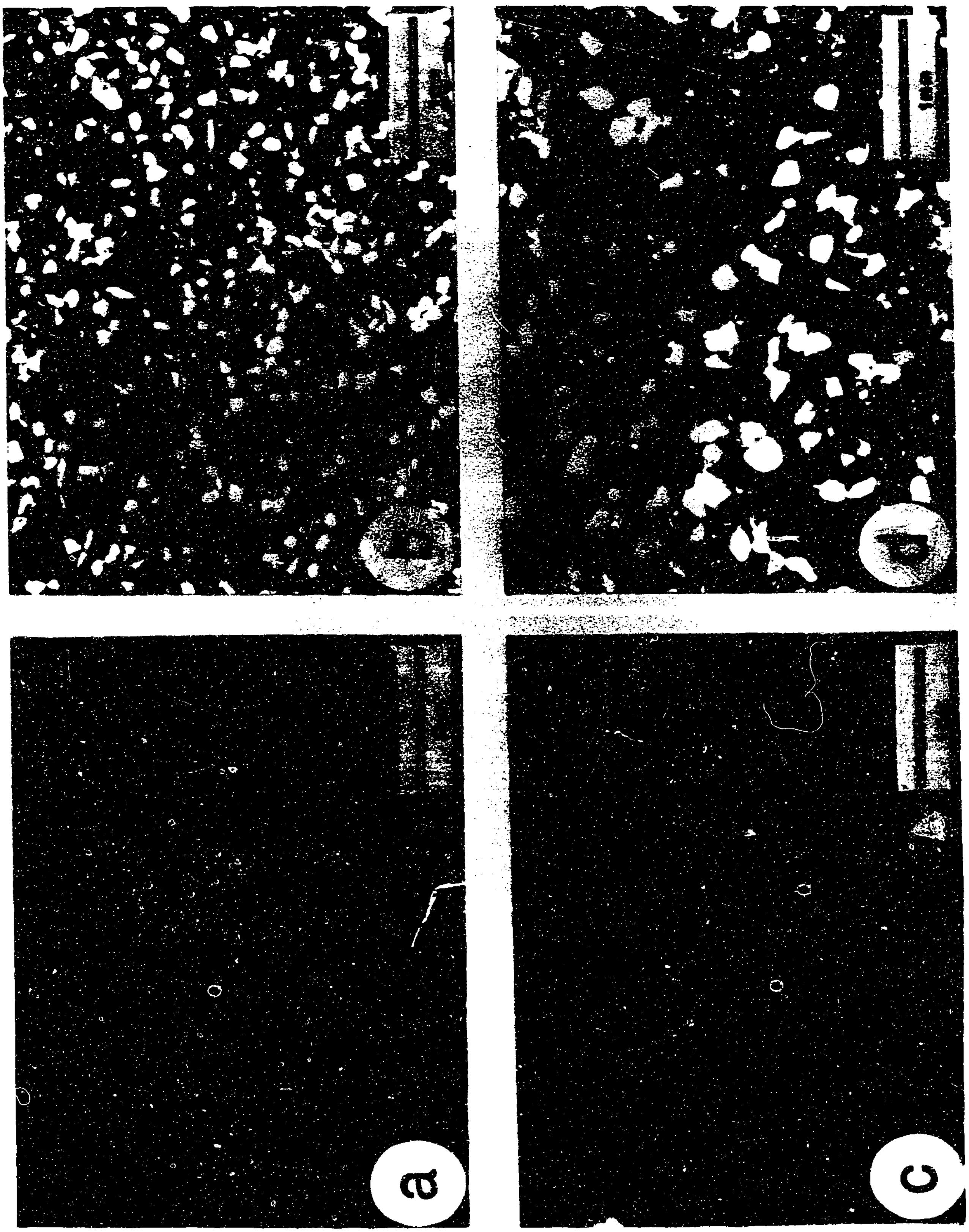
PLATE III-[illegible]

a). 10-10-21-8W4 (depth: 3100 ft): Ostracode sandstone (plane polars)(Q-quartz, P-porosity).

b). 10-10-21-8W4 (depth: 3100 ft): Ostracode sandstone (cross polars).

c). 12-32-20-8W4 (depth: 3171.5 ft): UM1 unit (plane polars)(C-chert, Q-quartz).

d). 12-32-20-8W4 (depth: 3171.5 ft): UM1 unit (cross polars).



subrounded in nature with common clay cement (Kaolinite, Chlorite) and occasional quartz overgrowths. Calcite forms a cement in certain beds and zones, and the control on this cementation is unknown (recognizable on geophysical logs)

The dominant detrital components are quartz and lithic rock fragments dominated by chert, and minor feldspar. As previously mentioned the sandstones which comprise the UM1 unit are chert litharenites (Q:F:L ratio of 56:0.3:43.7, Folk,1974), and this enables distinction from the underlying Ostracode member which is more quartzose (Q:F:L ratio of 86.1:0.7:13.2).

The quartz grains are typically single crystals of the plutonic/common variety. The genetic classification noted by Folk (1974) was used to determine quartz types. Some minor amounts of metamorphic, stretched and schistose types were observed. Chert is considered with the lithic component, even though is is composed of microcrystalline quartz. The chert is chiefly microcrystalline mosaic in nature, although chalcedony is also observed. Chert is probably derived from an original carbonate source, and many times ghost/remnant fossil textures are recognized, especially in the coarser grains.

Minor amounts of metamorphic and volcanic rock fragments were observed, along with sedimentary fragments of claystone (typically deformed). Volcanic rock fragments were mainly in the form of porphyritic or acidic grains, all of which were quite fine grained. This fine grained nature of the volcanics made it difficult at times to distinguish them from microcrystalline chert and therefore the amount of volcanics may be under-represented. Accessories observed include epidote, pyroxene, sphene, and authigenic pyrite. Rare feldspar of plagioclase composition was observed.

UM2 Deposit

VALLEY MORPHOLOGY

UM2 deposits are typically 20-25m thick. No stratigraphic relationships are present between the UM2 deposits and adjacent sediments. UM2 valleys incise into the Ostracode Member, but also cross-cut UM1 deposits (Figs. III-12, III-13). Two UM2 valleys are recognized within the area trending ENE-WSW and are characteristically 0.5 km wide (1/4 mile). These valleys can only be followed for a maximum of 6.5-11 km (4-7 miles) within the study area due to poor well control (Fig. III-3). From the data available the UM2 valleys look straight to slightly sinuous in morphology, with a depth to width ratio of 500m/20m=25:1. Variability of scour cannot be determined.

UM2 valley deposits are interpreted as fluvial channels, which backfilled an incised valley during a relative sea level rise. These channels probably flowed to the ENE.

VALLEY FILL

Sedimentology

Sedimentological descriptions are based on the only core interval that exists in the study area. The UM2 unit is comprised of litharenites (Q:F:L ratio; 23.5:13:63.5) which have a higher feldspar content than the UM1 sands (Fig. III-11). Grain size ranges from lower medium to upper medium (1-2 ø) sand with zones of organic laminations and/or common organic debris. Organic laminations could be indicative of fluctuating current velocities or chemical conditions, where organic debris settles out of suspension. Siderite is commonly observed and is typically associated with

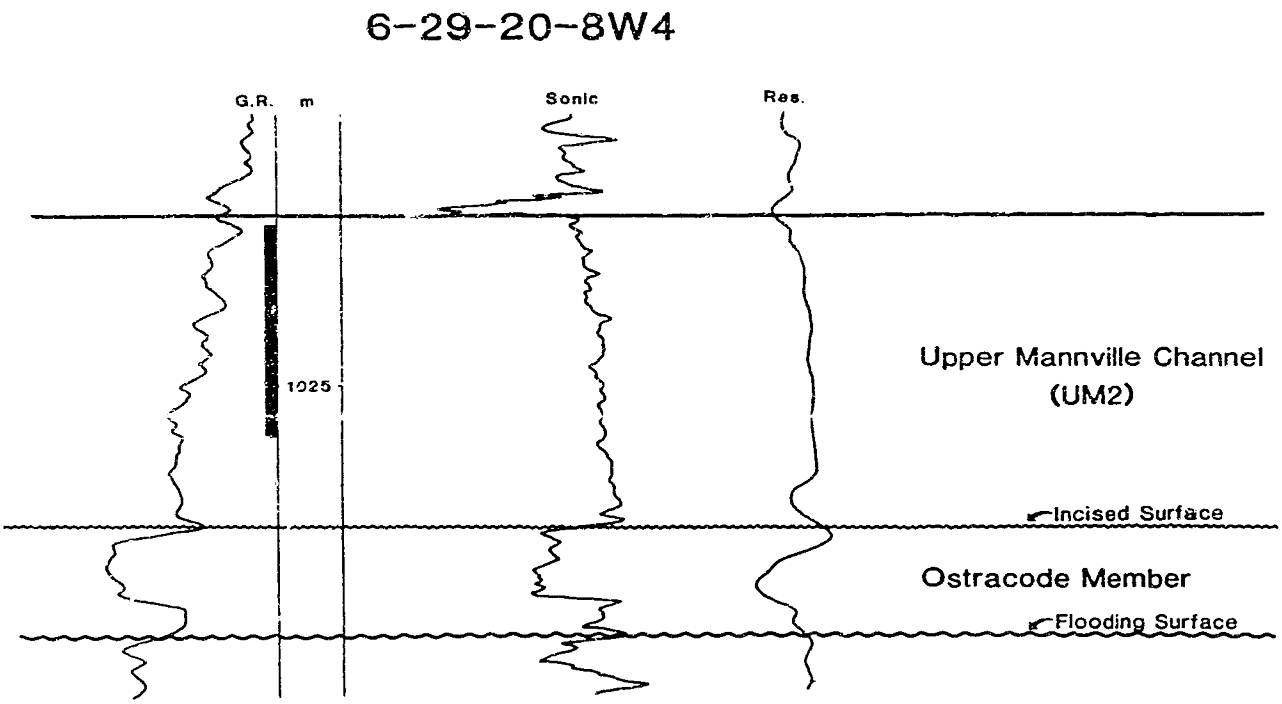


FIGURE III-12. UM2 type log profile.

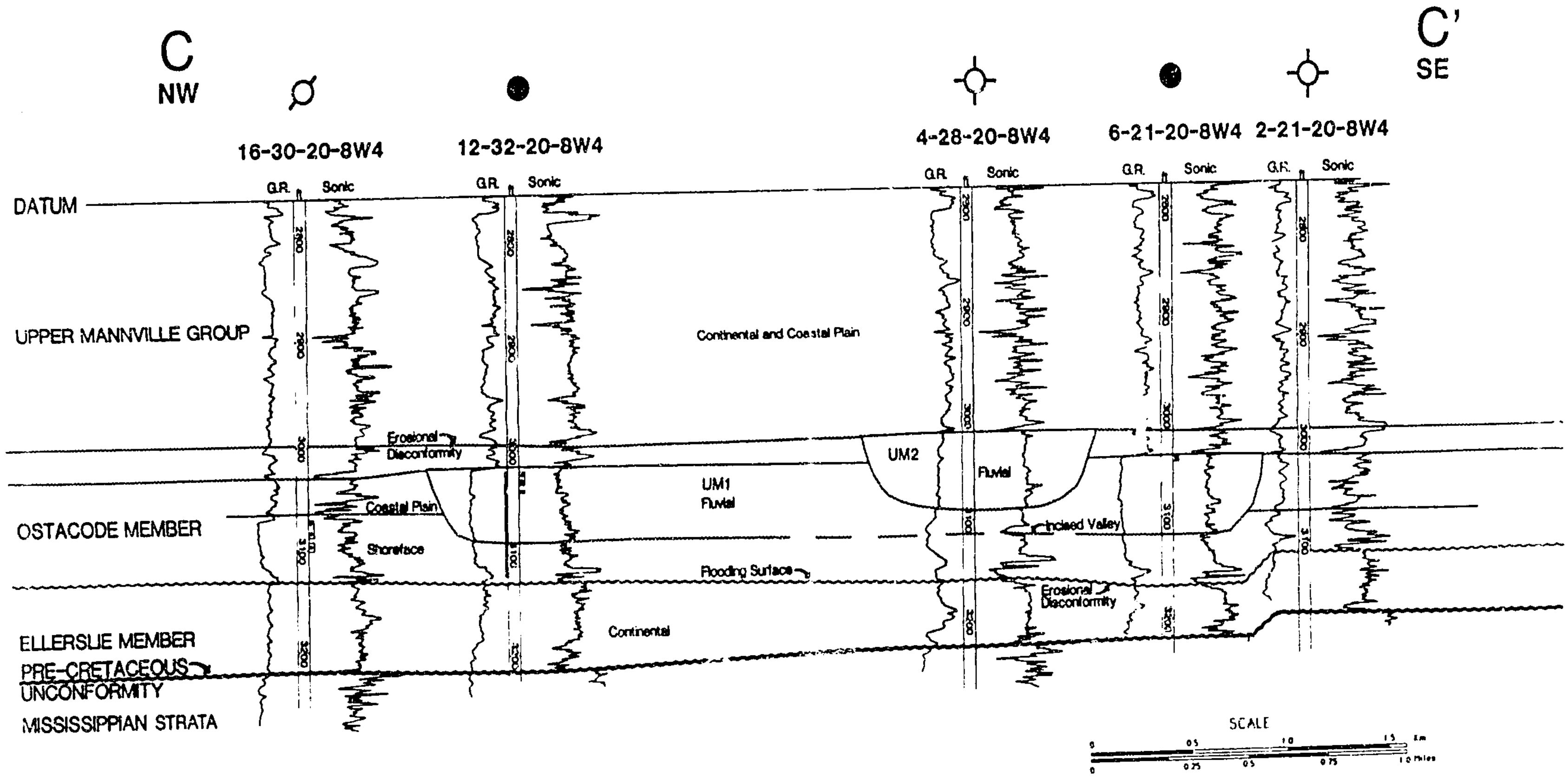


FIGURE III-13. Stratigraphic cross-section C-C' (datum: top of Mannville).

the organic material. Low-angle stratification is the dominant sedimentary structure. The sequence fines upwards and feldspar alteration to clays has reduced porosity and permeability of the sands.

The UM2 log profile is readily identifiable (Fig. III-12) because the alteration of feldspar to clay in these sands results in a low density porosity, high Gamma Ray and suppressed resistivity profile.

Mineralogy

Only one cored interval exists within the UM2 unit, and one representative thin section was point counted (approximately 250 points) in order to determine the mineralogy of the unit (Fig. III-12) (Plate III-4a). The grain size of the thin section sample was medium grained. The sand grains tend to be angular to subangular in shape. Low porosity and permeability is apparent in thin section, and corresponds to the non-reservoir nature observed in core and on logs. Compaction of soft lithic grains, poor sorting on a thin section scale, the presence of clay in the pores and pore throats, a high lithic content, and the angularity of the grains all indicate the relative immaturity of the sandstones of the UM2 (Plate III-4a). A Q:F:L ratio for the UM2 is 23.5:13:63.5. It contains relatively more feldspar, less chert and more of the remaining lithic component-volcanic, sedimentary and metamorphic- than the UM1 valley fill.

Quartz grains are typically single crystals of plutonic/common origin. Some schistose (metamorphic) quartz is also observed. Metamorphic fragments and chert are also dominant, with some volcanic fragments. Sedimentary rock fragments (locally derived claystone) are observed and are typically deformed. In most cases the clays have altered to siderite. Feldspar is observed and is of the Plagioclase group. Albite twinning is

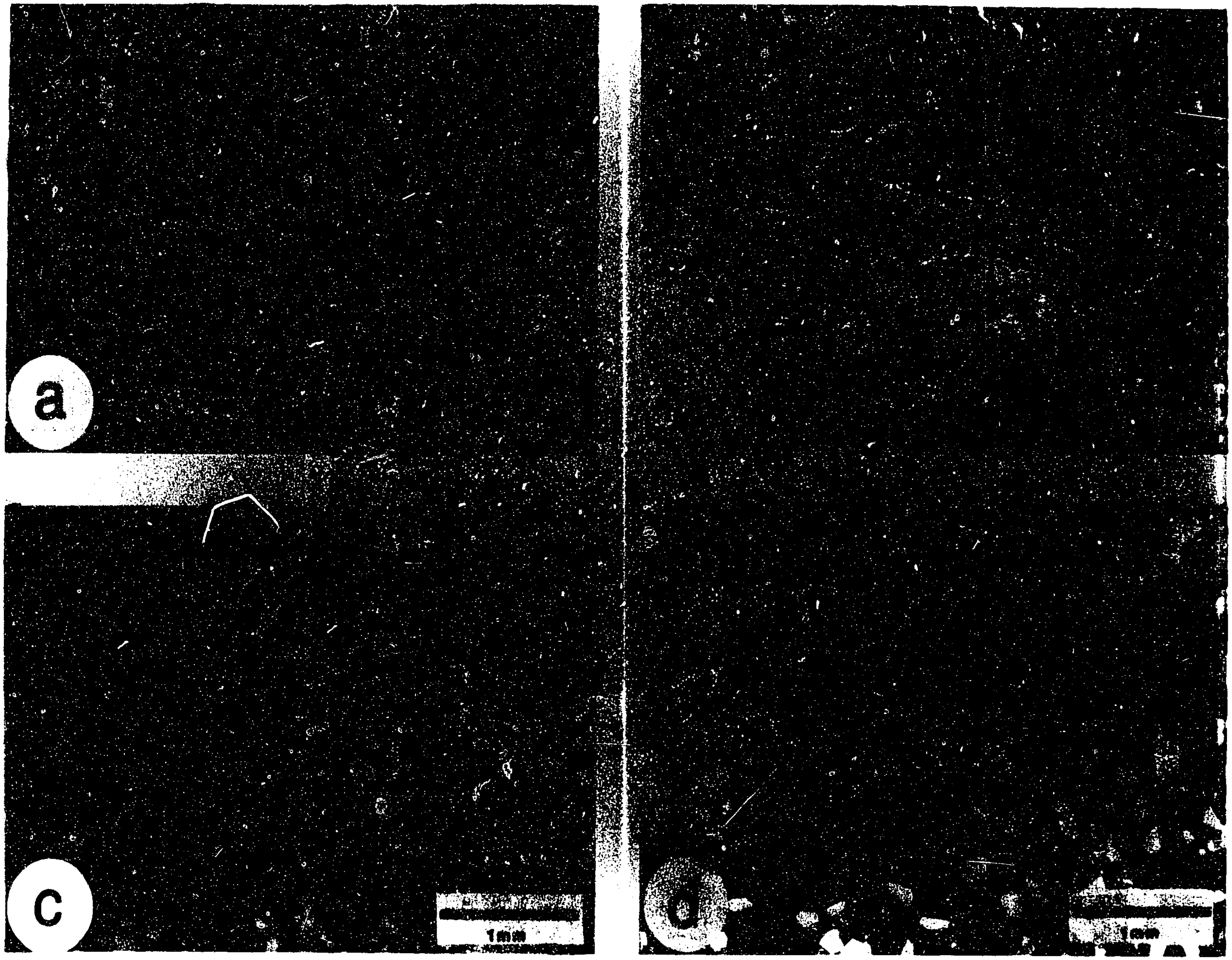
PLATE III-4

a). 6-29-20-6W4 (depth: 1030 m): UM2 unit (plane polars). Note the tight nature of the sandstone (F-feldspar, O-organics, Q-quartz, V-volcanics).

b). 6-29-20-6W4 (depth: 1030 m): UM2 unit (cross polars) Feldspar with alteration to siderite, calcite and clay thereby reducing the porosity and permeability of the unit (F-feldspar).

c). 16-9-20-8W4 (depth: 2996 ft): UM3 unit (plane polars)(C_i-iron stained chert, Q-quartz).

d). 08/5-10-20-8W4 (depth: 918.5): UM3 unit (cross polars).


a
c
1mm
d
1mm

common, and feldspars typically show some alteration to clay, probably kaolinite, or sometimes with the more calcic rich feldspars to calcite (Plate lll-4b). Accessories include mica (muscovite) and zircon.

Cement is typically clay, probably kaolinite. The kaolinite is developed as plates but more commonly as granular aggregates. Siderite cement and granular siderite (altered from clay and organics) is commonly observed. The presence and association of siderite and organic debris, could represent changing oxygenation and pH conditions (ie. lower than that for glauconite formation). Under these conditions the organic debris is preserved and siderite formation occurs during or shortly after deposition.

UM3 Deposit

VALLEY MORPHOLOGY

Core and well control is limited to the Suffield J Pool where the UM3 unit amalgamates with the UM1 unit (Fig. lll-14). Similarity in mineralogy and log signature to the UM1 unit makes the base of the UM3 valley difficult to determine. This sandstone belt trends parallel to and incises into the UM1 unit and is typically 1.0 to 1.5 km (1/2 to 1 mile)wide (Fig. lll-3). No stratigraphic relationship could be discerned between the UM3 and laterally adjacent continental and coastal plain sediments (Fig. lll-15). Amalgamation of the UM3, the UM1 and the Ostracode member results in reservoir thicknesses up to 45m. The superposition of the UM3 valley on the central UM1 valley is not odd and in fact fluvial/channel systems typically do persists in the same location as exemplified by the superposition of Holocene rivers on older fluvial axes on the Gulf coastal plain, Texas (Galloway, 1981).

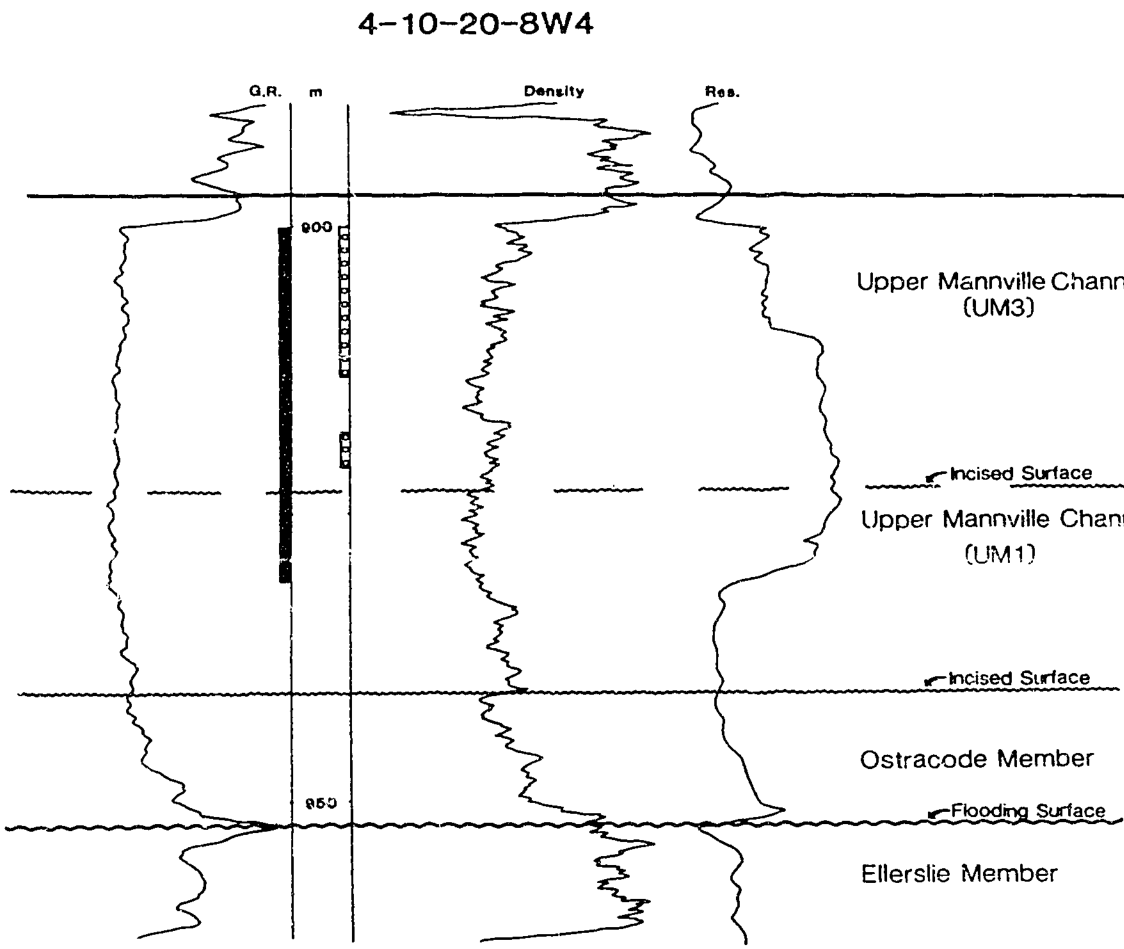


FIGURE III-14. UM3 type log profile.

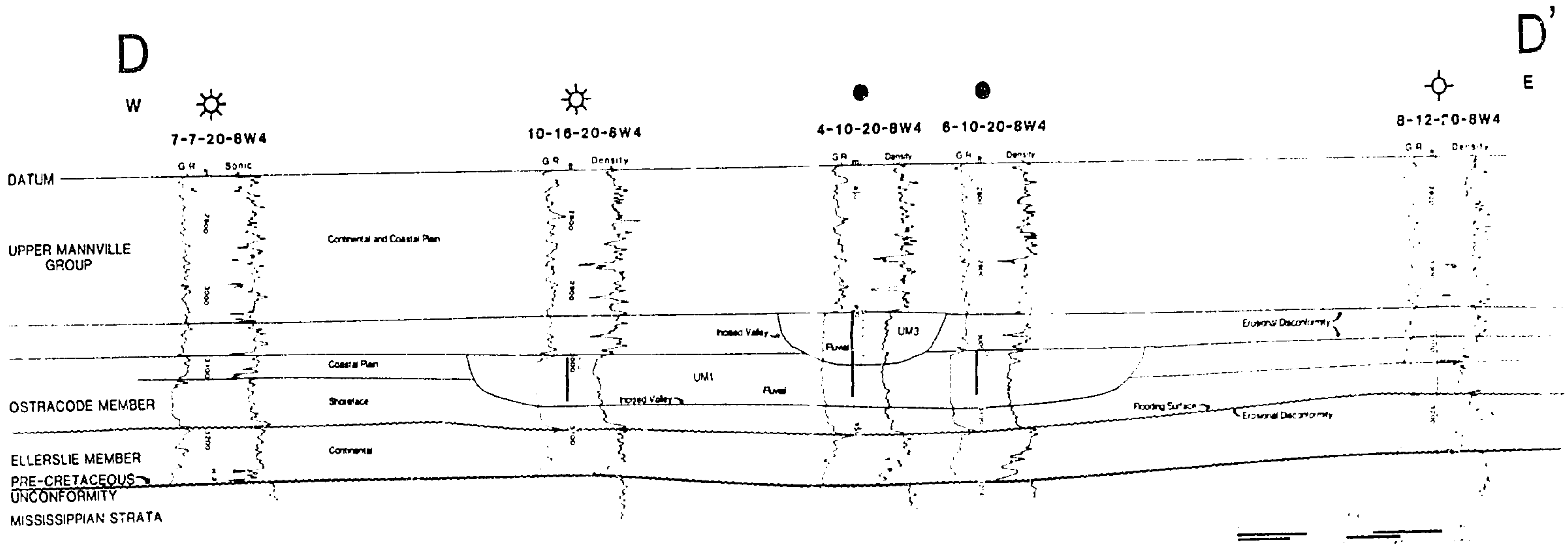


FIGURE III-15. Stratigraphic cross-section D-D' (datum: top of Mannville).

The UM3 is interpreted as a valley fill fluvial deposit. This valley trends to the NW, and is observed again north of the field in the well 2-12-21-9W4 The valley is straight in morphology, and forms a broad continuous belt of sandstone. The depth of scour is speculative, so the valley width to depth ratio cannot be determined. Here the UM3 scours into continental and coastal plain sediments (no underlying UM1). This valley probably drained to the NW.

VALLEY FILL

Sedimentology

Chert litharenite sandstones (Q:F:L ratio of 56.8:0:43.3) comprise the UM3 unit. This deposit is characterized by either 1) a number of 5-10m thick fining upward cycles or 2) one continuous deposit of constant grain size, 26m in thickness (typically medium to fine grained sand) (Fig. lll-16). The presence of coarser grained sand laminations within a fine grained sand is a common feature indicating fluctuating energy levels. Sedimentary structures include low- to high-angle cross-stratification (Plate lll-5a) and low-angle planar stratification, though commonly high-angle cross-stratification is dominant. These structures are indicative of bedload transport of sand waves and megaripples by unidirectional currents. Massive sandstones are also common in the UM3 unit, possibly indicating high rates of deposition, where sand is deposited directly out of suspension (Plate lll-5b). The UM3 valley fill is interpreted to be predominantly comprised of meander point bar deposits. The base of the UM3 is usually difficult to determine in core (Plate lll-5c) and especially on logs, due to the similarity

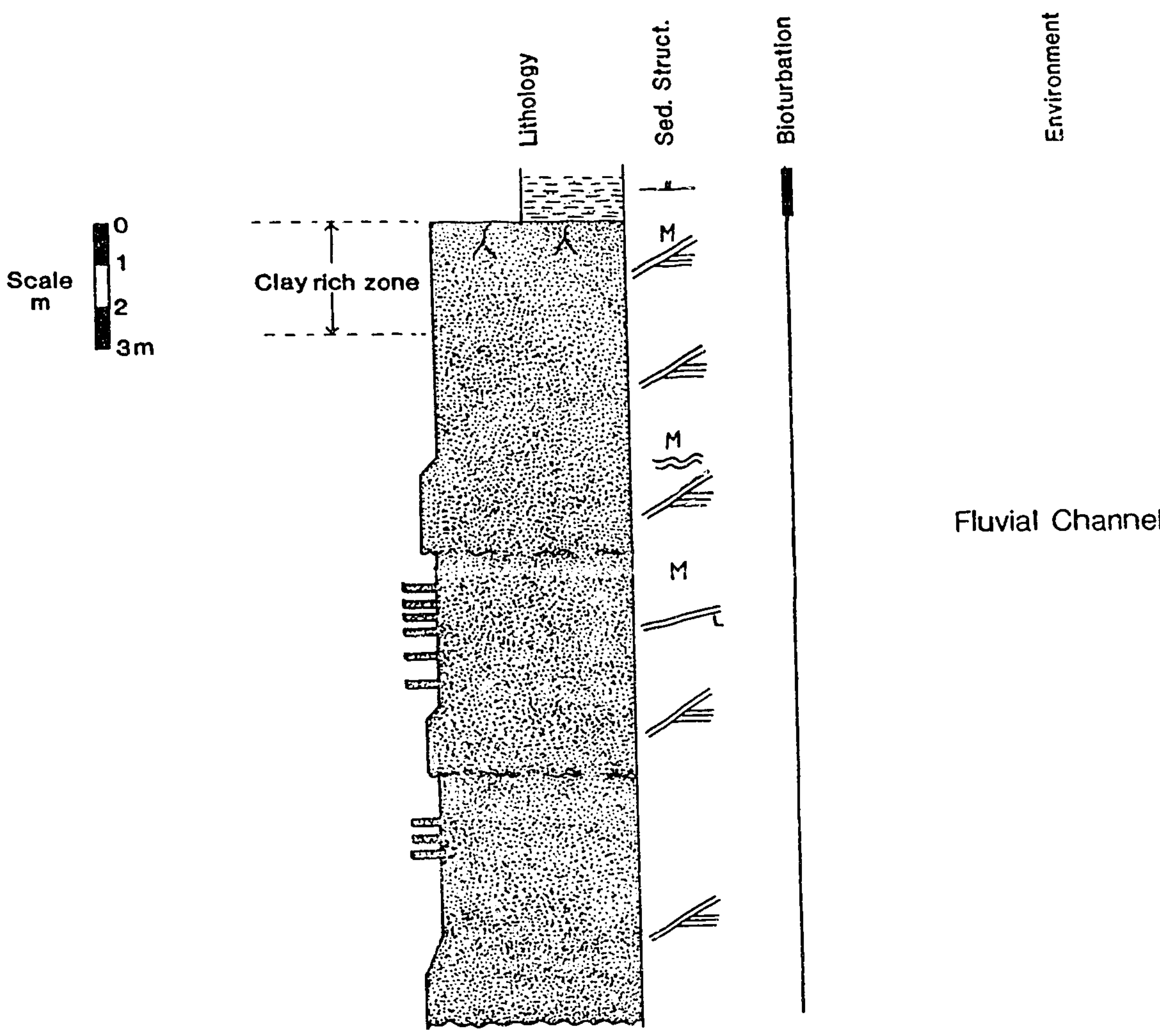


FIGURE III-16. Composite core litholog for the UM3 unit.

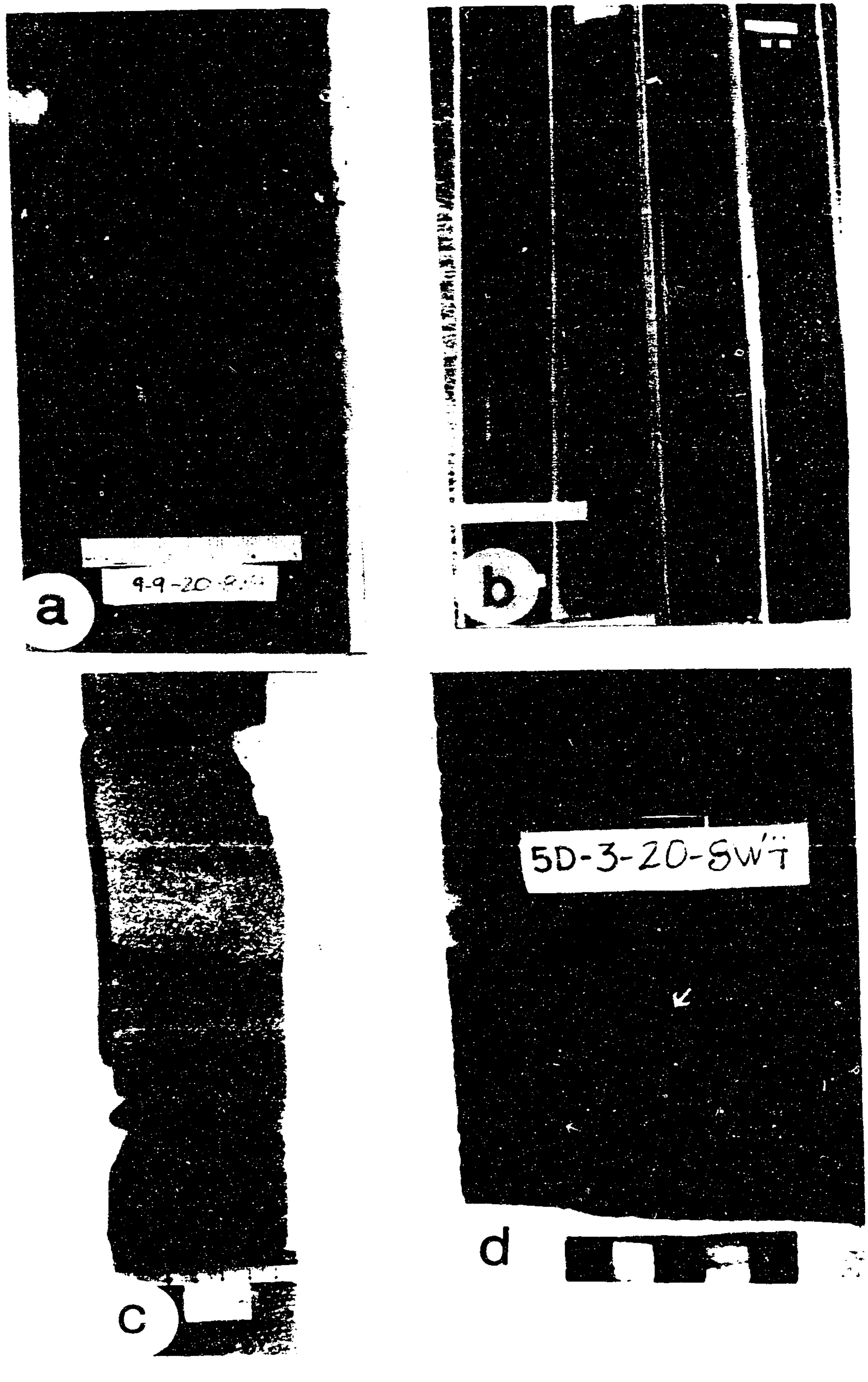
PLATE III-5

a). 9-9-20-8W4 (depth: 916 m): Oil saturated fine grained sandstone exhibiting high angle cross-stratification in the UM3 unit (scale increments in cm).

b). 1-16-20-8W4 (depth: 905.4-908.3 m): Oil saturated fine-to medium-grained sandstone, massive in nature with some high angle cross-stratification in the UM3 unit.

c). 12-10-20-8W4 (depth: 920.5 m): Base of the UM3 unit.

d). 5D-3-20-8W4 (depth: 912.5 m): Current ripples (large arrow) and *Teichichnus* burrows (small arrow) in the sediments overlying the UM3 unit.


a
b
c
d

in mineralogy, lithology and depositional environment with the underlying UM1 unit.

Typically clay-rich sandstone is interbedded with clean sandstone (emphasized by differences in oil saturation) in the upper portions of the UM3 unit (Plate lll-6a, b, and c). In the top 5-10m (average) of the unit, a clay-rich zone with low or patchy oil saturation is observed. This clay-rich unit is typified by interbedded clean and clay-rich sandstone displaying soft-sediment deformation features such as slumps, small folds and microfaulting, along with pebbles, sandstone clasts, and root casts. These soft-sediment deformation features are noted by Coleman (1969) to be rather common in natural levee deposits mainly due to liquefaction and flow. Distribution of the clay is interpreted as depositionally controlled. Tilley and Longstaffe (1984) identified the clay as kaolinite, and assigned a detrital origin. This interpretation would agree with the interpretation of this study that this clay-rich zone is probably the product of a vegetated floodplain or levee which capped the channel sequence. This is similar to the sequence observed in the fluvial sandstone of the Nubia sequence in Egypt (Klitzsch et al, 1979 in Harms et al, 1975).

Sharply overlying the UM3 is a horizontally bedded finely laminated siltstone/ claystone and organic laminations with occasional sandstone beds, rare climbing ripples, and containing pyrite, shale clasts, and root casts; it is rarely bioturbated (Plate lll-5d and 6d). This deposit is interpreted to be a floodplain deposit which caps the valley sequence or a lacustrine deposit developed after the valley was infilled. According to Reineck and Singh (1980) floodplain deposits are generally characterized by horizontally bedded fine sand alternating with laminated mud layers. In more sandy areas, sequences of climbing ripple bedding capped by mud layers are

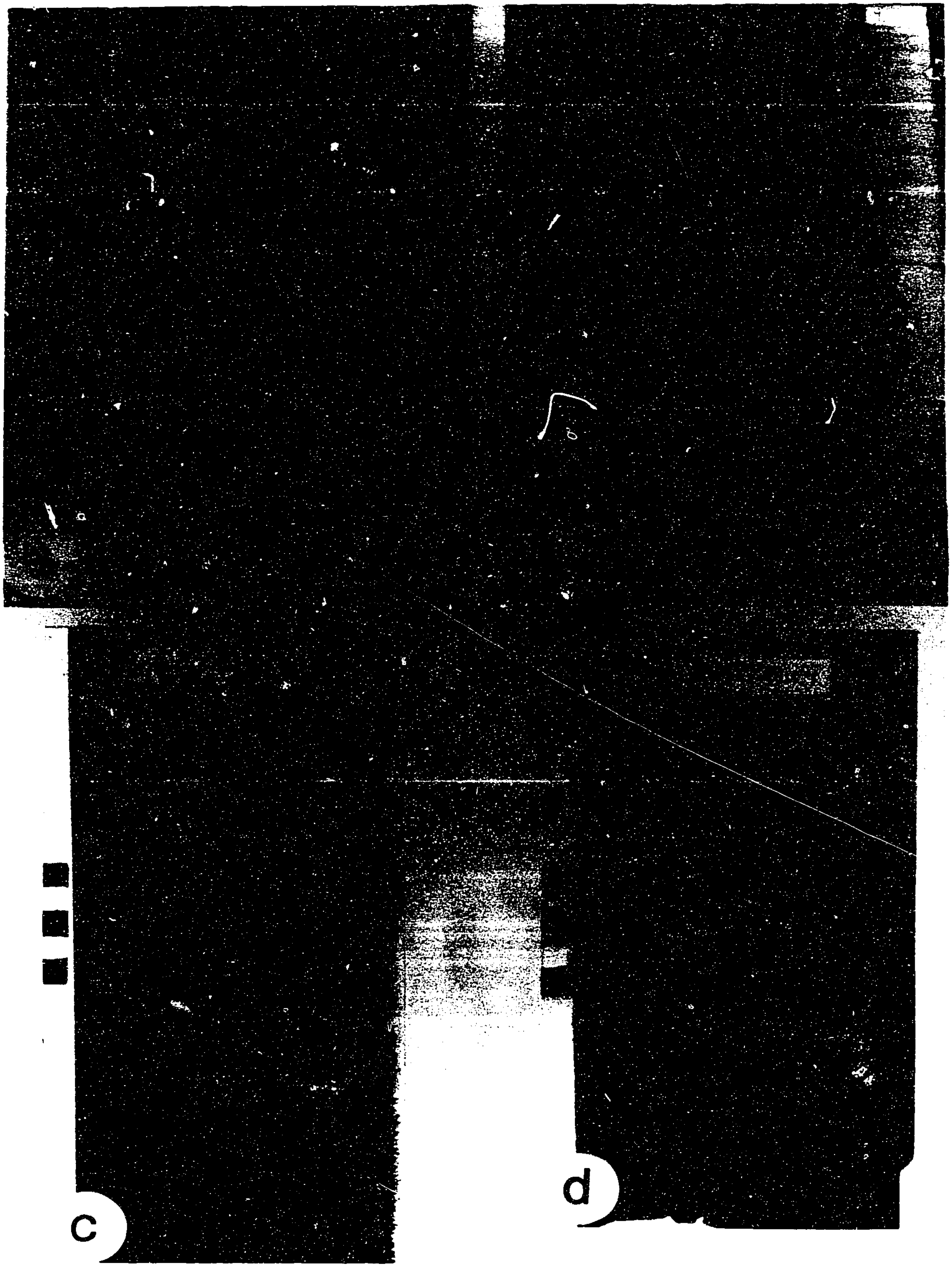
PLATE III-6

a). 5D-3-20-8W4 (depth: 920-923 m): High angle cross-stratified point- bar sandstones grading upwards into the clay rich sandstones of a levee deposit (UM3) (scale increments in cm).

b). 5D-3-20-8W4 (depth: 917-920 m): Clay-rich levee sandstones of the UM3 sharply overlain by fine grained lacustrine or bay deposits (organic rich laminations).

c). 5D-3-20-8W4 (depth: 920.5 m): Close-up of the clay-rich levee sediments. Note the soft-sediment deformation.

d). 5D-3-20-8W4 (depth: 917.7 m):Close-up of the sharp(erosional) upper contact between the UM3 and the overlying lacustrine/bay sediments.


c
d

present. Occasionally thin mud layers are intercalated and often show penecontemporaneous deformation structures.

The clay-rich zone which is associated with the UM3 deposit results in a reduced K_{max} in core analysis. The reduced oil saturation can usually be observed on the resistivity log profile (Fig. lll-14).

Mineralogy

Mineralogy was obtained by point counting 4 thin sections (approximately 250 points) in the UM3 (Plate lll-4c, d). Medium grain size sandstones were used for consistency. The UM3 has a Q:F:L ratio of 60:0:40 (Fig. lll-11). Comparatively the UM1 and UM3 have similar ratios. However a qualitative evaluation of the UM3 showed that there is a difference in the UM1 and UM3 mineralogy. A predominant iron stain was recognized in the UM3 unit. This staining especially affects the lithic fragments, while 'clean' chert (that chert formed in limestones) is not affected. This iron was probably sourced from the silicified argillaceous and volcanic fragments (Lerbekmo, Pers. comm.). These silicified fragments were grouped with chert in the point counting, although it is now realized that this is misleading. Siliceous rock fragments show the microcrystalline texture typical of chert but they tend to have other minerals such as micas, hematite etc. These siliceous rock fragments since they are not comprised of just chert are prone to later alteration and are highlighted by the staining. Qualitatively, therefore, the UM3 has relatively less 'clean' chert and a higher amount of silicified lithic component, comprised mainly of sedimentary and volcanic rock fragments, than the UM1 which is dominated by 'clean' chert.

Sand grains are subangular to subrounded. Cement is typically clay, namely kaolinite (see Tilley and Longstaffe, 1984). Shale clasts compacted and deformed also reduce porosity and permeability.

Quartz is predominantly the plutonic/common variety. Some recrystallized metamorphic quartz was also observed. Chert was commonly microcrystalline, and ghost textures were occasionally observed. Chalcedony was also present in minor amounts. Included as chert are the silicified argillaceous and volcanic rock fragments. As mentioned above they are typically iron stained and 'dirty', and they may show some signs of deformation due to compaction. The lithic component in the UM3 sandstone is about 40%. The lithic component in the UM3 is comprised of chert, sedimentary, volcanic and minor metamorphic rock fragments. Sedimentary rock fragments are typically claystone and siltstone, probably locally derived, and they commonly show signs of deformation. Feldspar is observed in minor amounts, is probably predominantly of the plagioclase group and commonly shows signs of alteration. Accessory minerals include epidote, and lesser amounts of tourmaline and pyroxene. Authigenic pyrite is also noted. Other cements include minor quartz overgrowths and calcite cemented beds.

HYDROCARBON DISTRIBUTION

Numerous heavy oil (959 kg/m^3-16° API) pools are contained within the Mannville Group in the Jenner-Suffield area (Fig. III-17). This paper focuses on the Jenner O, Jenner F and Suffield J pools, where reservoirs are present in the UM1 and UM3 valley fill sands (Table III-1). The incisive nature of these systems points toward stratigraphic entrapment, which is the

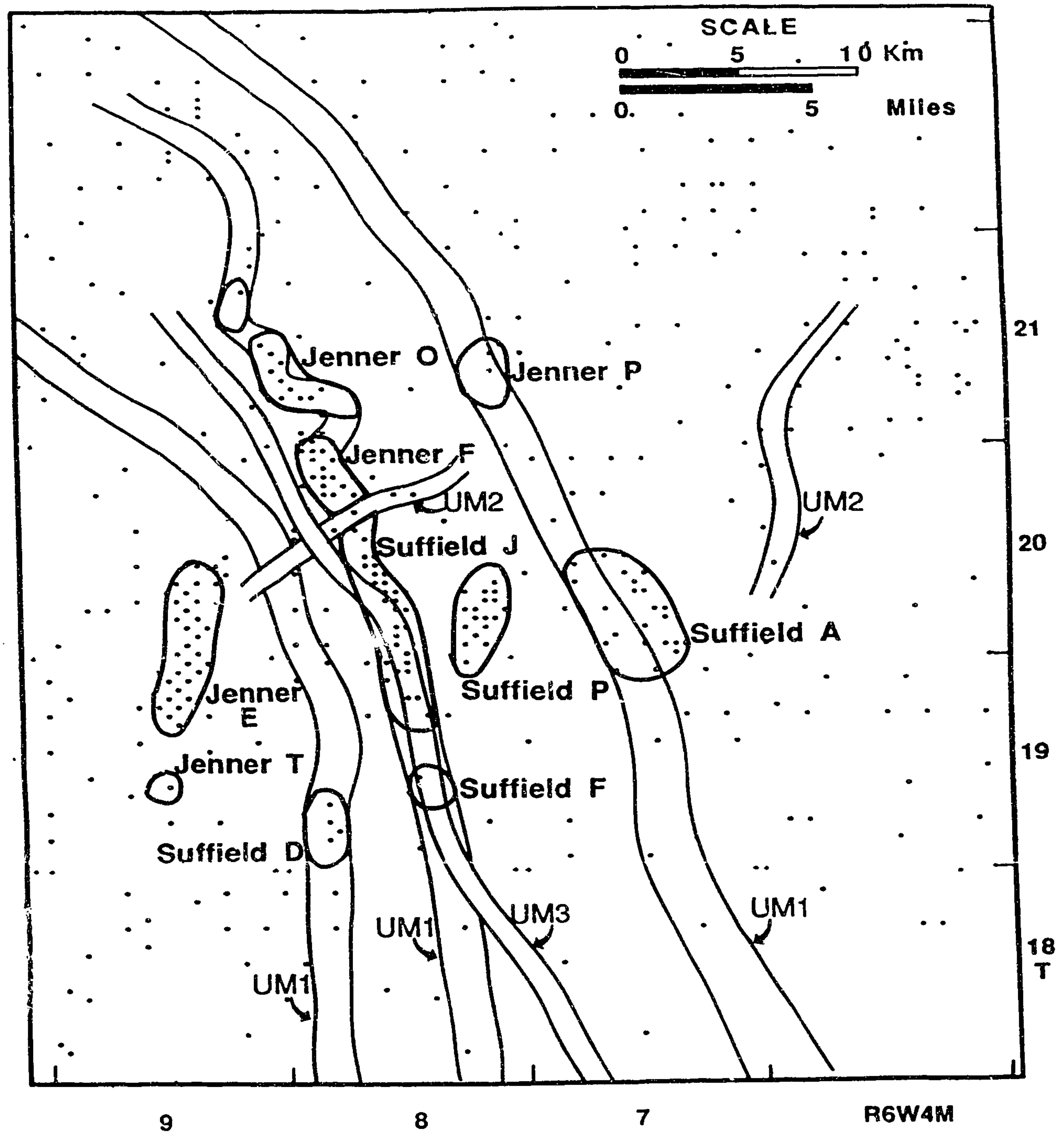


FIGURE III-17. Hydrocarbon distribution map for the Jenner-Suffield area.

JENNER E POOL

Initial Volume in Place: 3810.0 X 10^3m^3 (24 MMBBL)
Initial Established Reserves: 953.0 X 10^3m^3 (6 MMBBL)
Cumulative Production: 753.6 X 10^3m^3 (4.7 MMBBL)
Remaining Established Reserves: 199.4 X 10^3m^3 (1.2 MMBBL)
Porosity: 29.7% Permeability: 1521md
Discovery Year: 1964
Producing Unit: Ostracode member

JENNER F POOL

Initial Volume in Place: 4 260.0 X 10^3m^3 (26.8 MMBBL)
Initial Established Reserves: 170.0 X 10^3m^3 (1.1 MMBBL)
Cumulative Production: 148.2 X 10^3m^3 (934 MBBL)
Remaining Established Reserves: 21.8 X 10^3m^3 (137 MBBL)
Porosity: 26% Permeability: 385md
Discovery Year: 1965
Producing Unit: UM1

JENNER O POOL

Initial Volume in Place: 5 550.0 X 10^3m^3 (35 MMBBL)
Initial Established Reserves: 278 X 10^3m^3 (1.8 MMBBL)
Cumulative Production:99.8 X 10^3m^3 (629 MBBL)
Remaining Established Reserves:178.2 X 10^3m^3 (1.1 MMBBL)
Porosity: 26%
Discovery Year: 1972
Producing Unit: UM1

SUFFIELD A POOL

Initial Volume in Place: 20 800.0 X 10^3m^3 (131 MMBBL)
Initial Established Reserves: 208.0 X 10^3m^3 (1.3 MMBBL)
Cumulative Production: 66.9 X 10^3m^3 (421 MBBL)
Remaining Established Reserves: 141.1 X 10^3m^3 (889 MBBL)
Porosity: 25%
Discovery Year: 1976
Producing Unit: UM1+ Ostracode member

SUFFIELD P POOL

Initial Volume in Place: 1 660.0 X 10^3m^3 (10.5 MMBBL)
Initial Established Reserves: 166.0 X 10^3m^3 (1.1 MMBBL)
Cumulative Production: 93.7 X 10^3m^3 (590 MBBL)
Remaining Established Reserves: 72.3 X 10^3m^3 (459 MBBL)
Porosity: 24%
Discovery Year: 1976
Producing Unit: Ellerslie member

SUFFIELD J POOL

Initial Volume in Place: 40 100.0 X $103m^3$ (253 MMBBL)
Initial Established Reserves: 1203 X 10^3m^3 (75.8MMBBL)
Cumulative Production: 531 X $103m^3$ (3.4MMBBL)
Remaining Established Reserves: 671.2 X 10^3m^3 (4.2 MMBBL)
Porosity: 25%
Discovery Year: 1977
Producing Unit: UM1+ UM3

TABLE III-1. Reservoir data for the Jenner-Suffield area.

case in these three pools (Figs. lll-18-22). Sand filled valleys with laterally and vertically adjacent fine-grained sediments of the continental and coastal plain constitute the reservoir and trap, respectively. Other pools in the UM1 include the Suffield A pool (combined Ostracode and UM1 pool) (Table lll-1) and a number of smaller pools such as the Jenner LM P and UM P, the Jenner N, Jenner M, Suffield F, and Suffield D. The eastern most UM1 valley also produces to the south in the Medicine Hat area (T12, R5W4) (Fig. lll-4). The Medicine Hat field is located in the fluvial sandstones of a UM1 incised valley, which trends approximately north-south and can be traced from Manyberries to the south to Jenner/ Suffield to the north. Lateral seal to the reservoir is provided by a lithic non-reservoir upper Mannville valley deposit.

The Jenner O Pool (Fig. lll-23) is within the central UM1 valley. Some pay is also in the adjacent Ostracode sandstone. This pool was discovered in 1952 (Holmes and Rivard, 1976) and delineated in 1972 (Table 1). The reservoir sands of the UM1 have an average porosity of 26% with an initial estimated volume in place of 5550.0 x $10^3 m^3$ (35mmbbl) (primary recovery 5%) (reservoir data from E R C B, 1987). North of the Jenner O Pool in the UM1 trend, a one well pool is observed. The lateral seal for this pool is thought to be a muddy zone within the channel, (Fig. lll-23). The barrier between these two pools is not known.

Along strike to the south is the Jenner F Pool(Fig. lll-24), which was discovered in 1965 (Table lll-1). Average porosity is 26% with permeabilities of about 360md. Initial estimated volume of oil in place is 4260.0 x 10^3 m^3 (26.8mmbbl) (primary recovery 5%). The lateral seal between the O and F pools is speculated to be due to non-communication between point bar

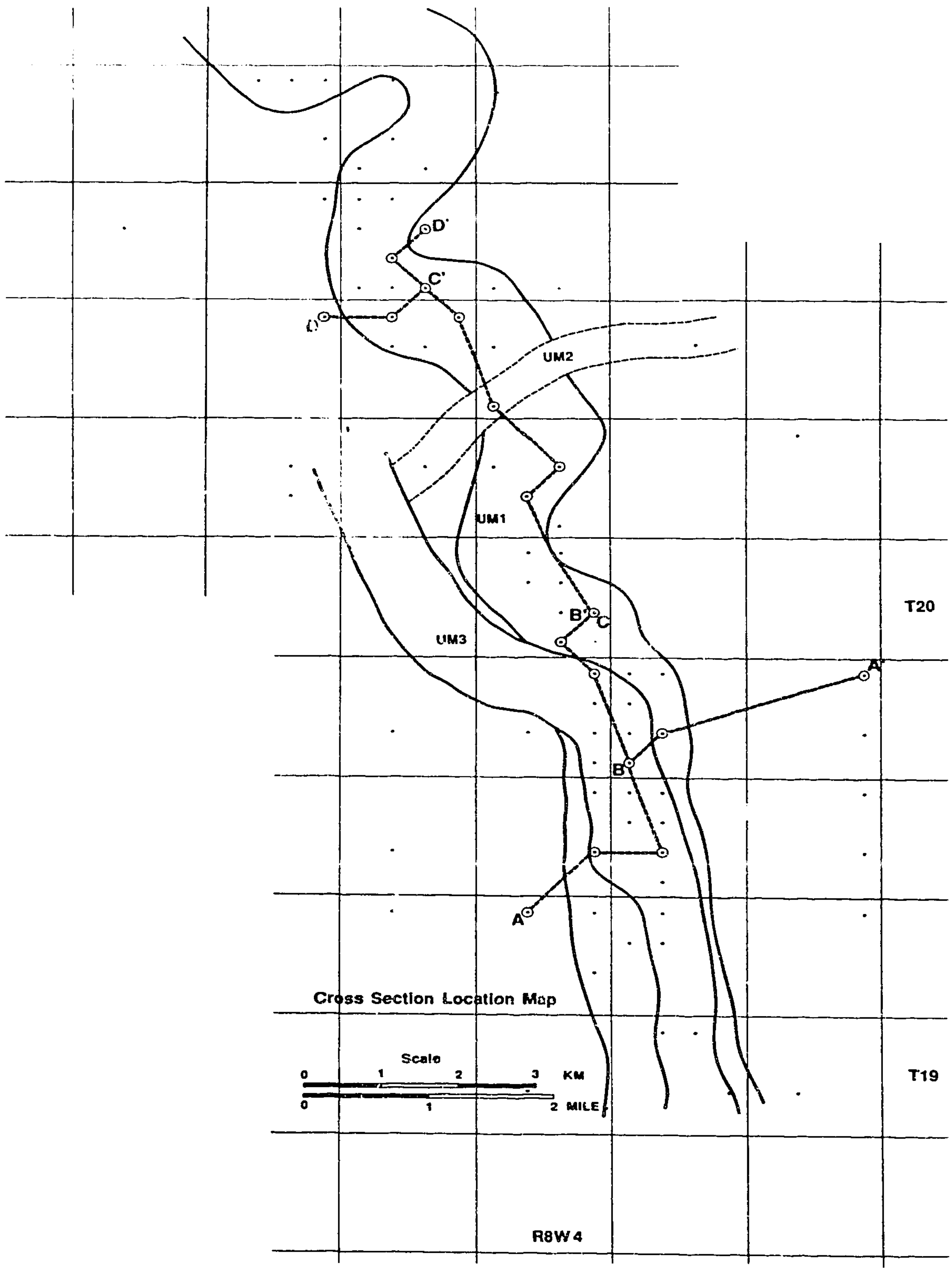


FIGURE III-18. Structural cross-section location map.

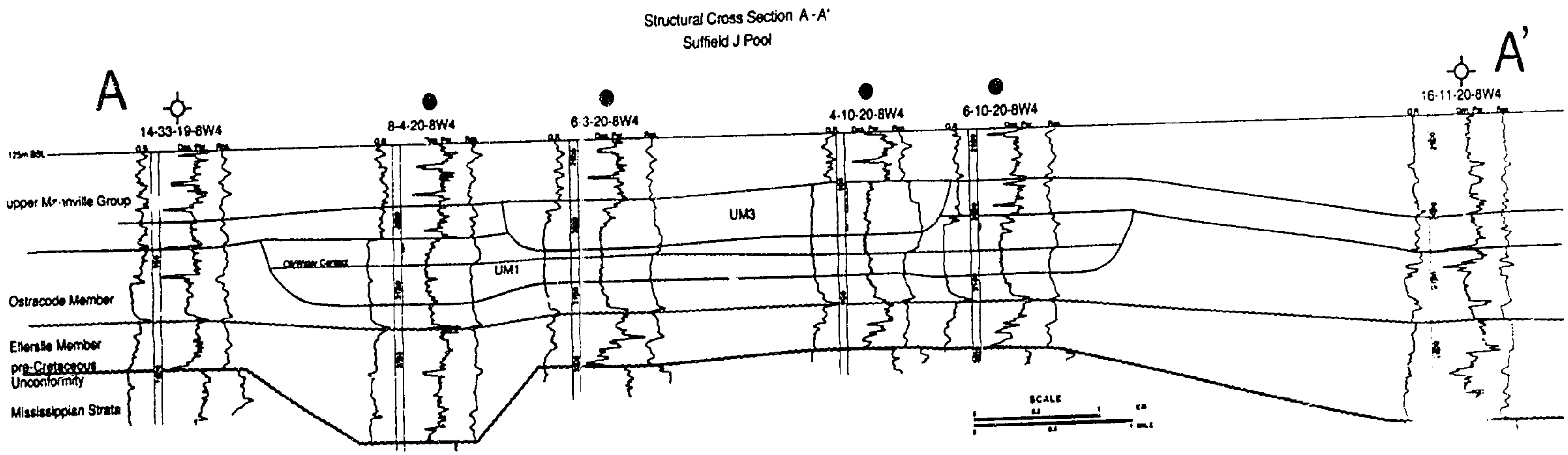


FIGURE III-19. Structural cross-section A-A'.

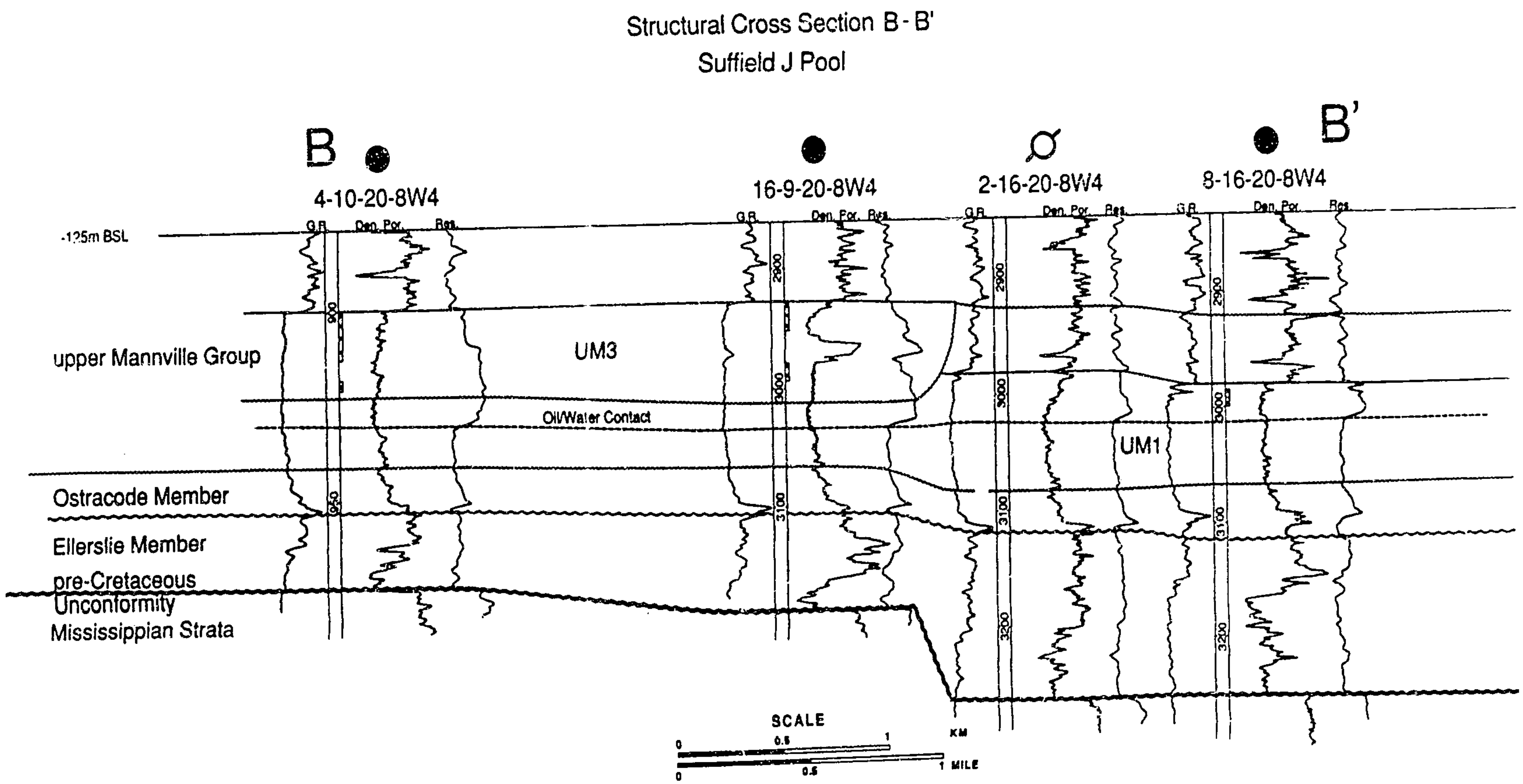


FIGURE III-20. Structural cross-section B-B'.

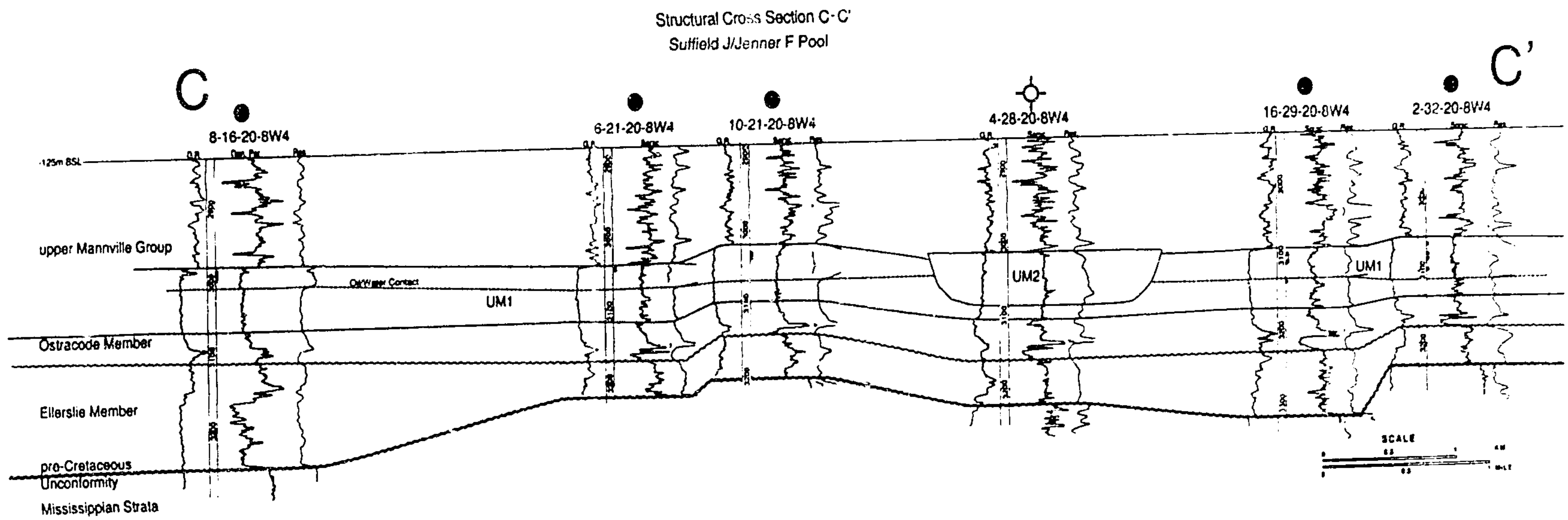


FIGURE III-21. Structural cross-section C-C'.

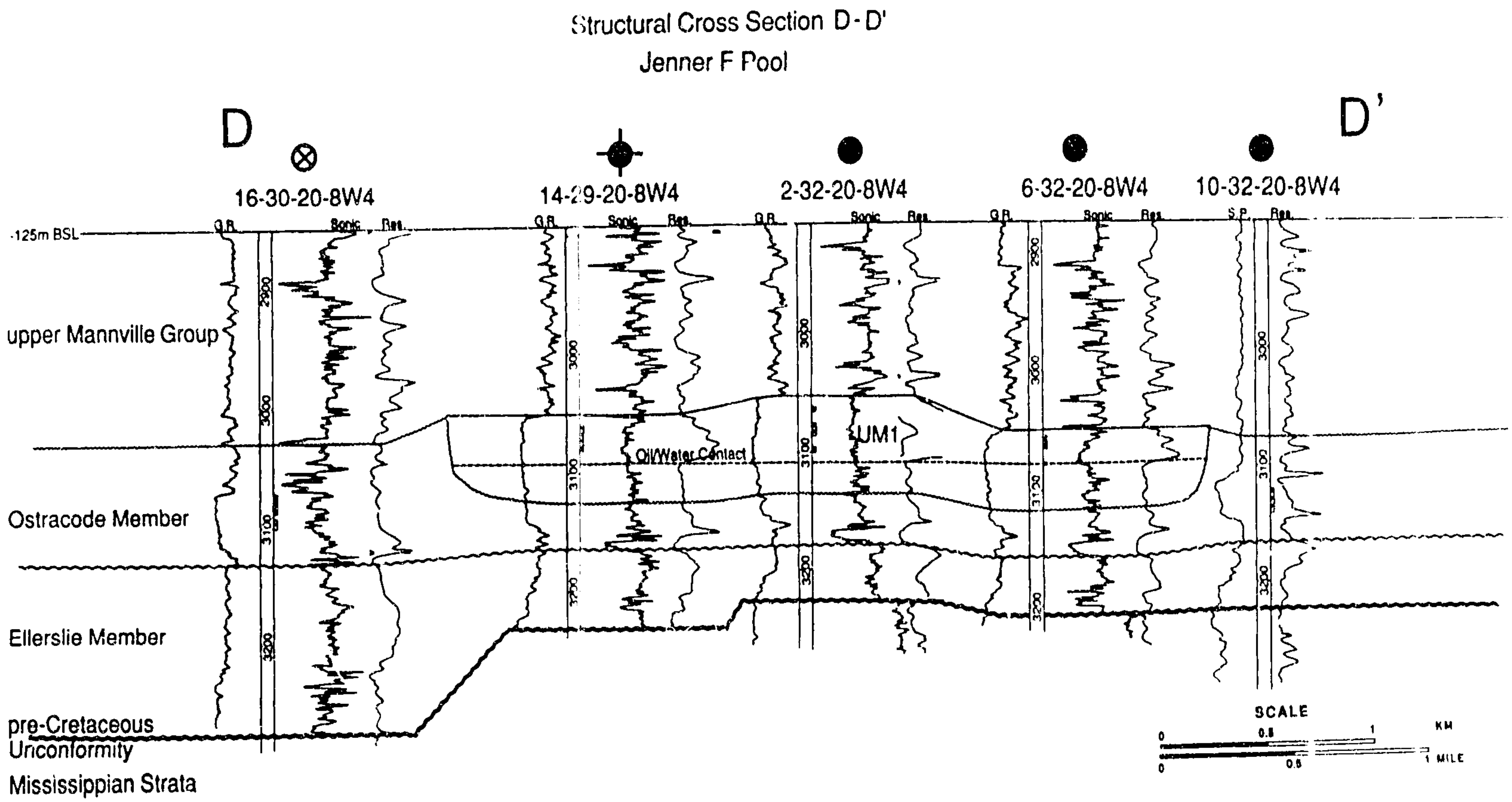


FIGURE III-22. Structural cross-section D-D'.

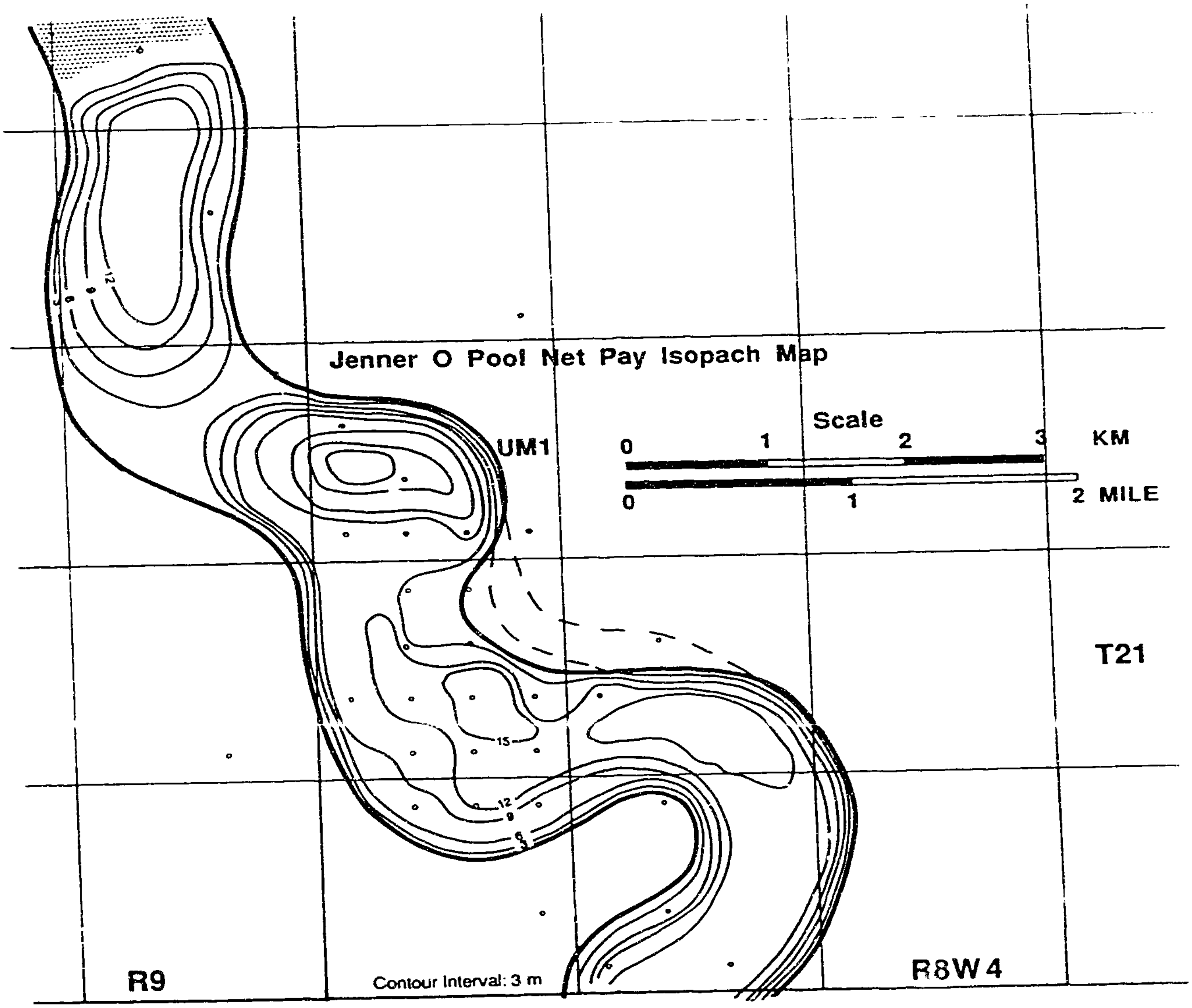


FIGURE III-23. Jenner O pool net pay map.

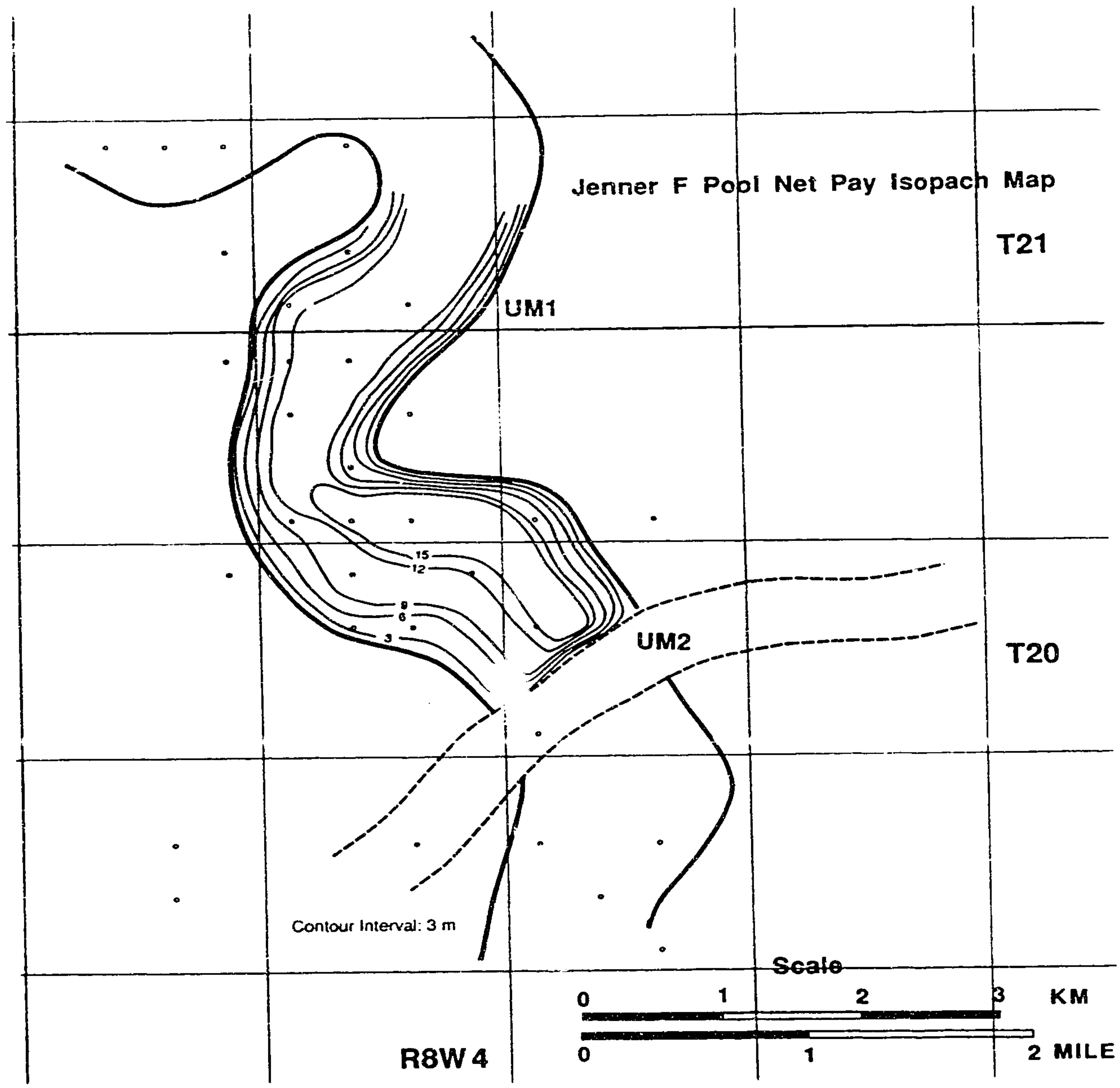


FIGURE III-24. Jenner F pool net pay map.

deposits, possibly related to the nature of the sharp meander bend and/or point bar thinning.

Suffield J Pool reservoir sands have an average porosity of 25%, with an initial volume of oil in place of 40100 x 10^3 m^3 (253mmbbl) (primary recovery 3%). The Suffield J Pool was discovered in 1977. The UM2 unit forms a partial updip seal to the Suffield J Pool which produces from the UM1 and UM3 sands (Table III-1) (Fig. III-25 a and b). Where the UM1 and UM3 sands amalgamate maximum pay thicknesses are about 21m. Within the UM1, maximum pay is >15m. The UM3 valley diverges to the NW.

Significant hydrocarbon potential exists for the UM1 and UM3 units. These valleys are part of a drainage network, and therefore the potential exists for hydrocarbon accumulations along the sandstone trends. The easternmost UM1 valley, for example, has been traced through a number of oilfields including the Medicine Hat field. The other two UM1 valleys and the UM3 valley have not been traced outside the Jenner-Suffield area.

SUMMARY/DISCUSSION

Summary

Figure III-26 summarizes the stratigraphic relationships observed in the area. A sudden drop in relative sea level and the corresponding drop in stream base level resulted in the incision of a number of 1.5-3.0 km wide (1-2miles) NNW-SSE trending valleys which incise into the underlying Ostracode barrier and coastal plain deposit. These fluvially dominated valley systems sourced a coastline to the NW. The ensuing rise in sea level resulted in the backfilling of these valleys, observed as the chert-rich sandstones of the UM1 unit. Another younger incision and backfill event is

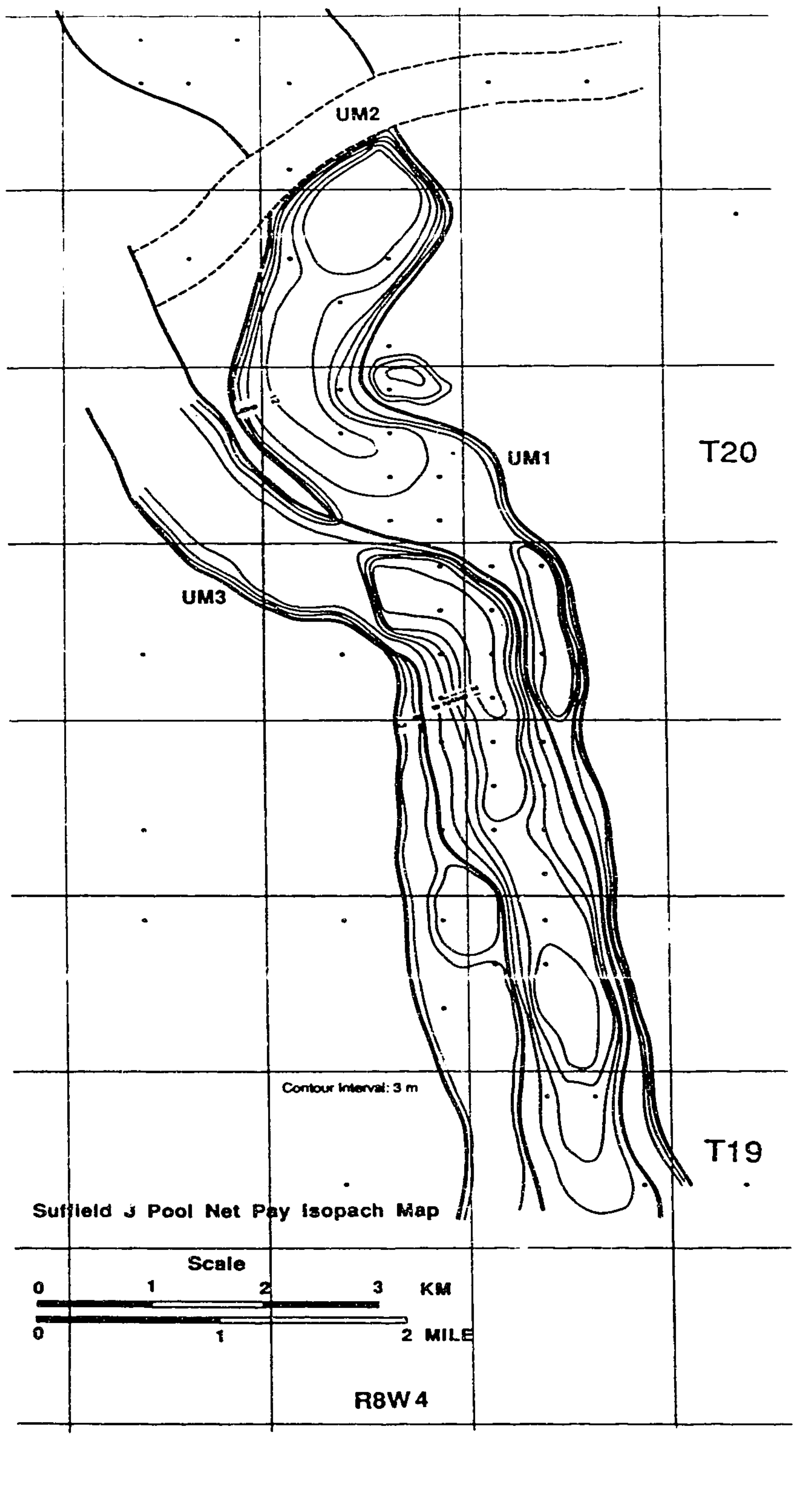


FIGURE III-25. a) Suffield J pool net pay map.

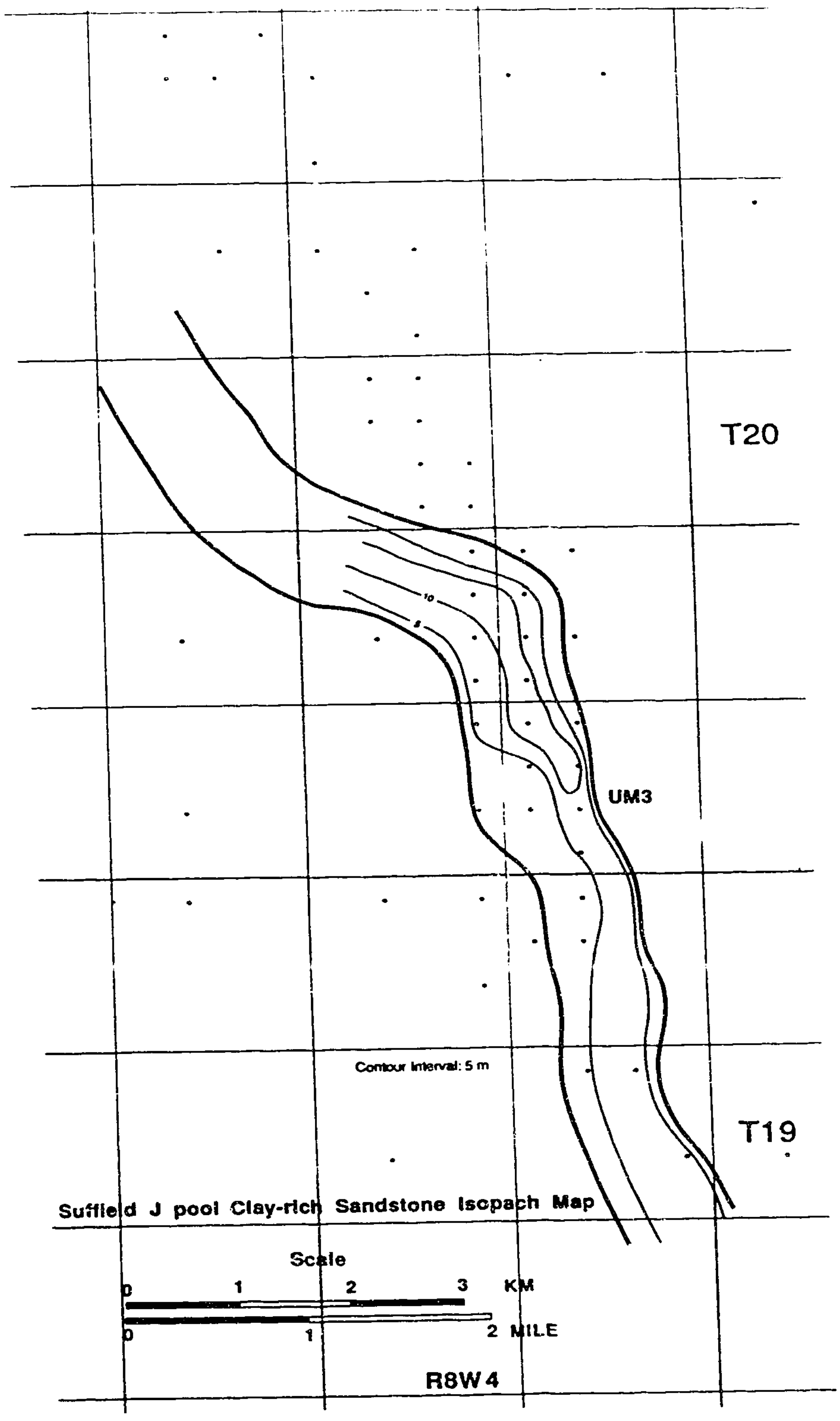


FIGURE III-25. b) Suffield J pool clay rich sandstone isopach.

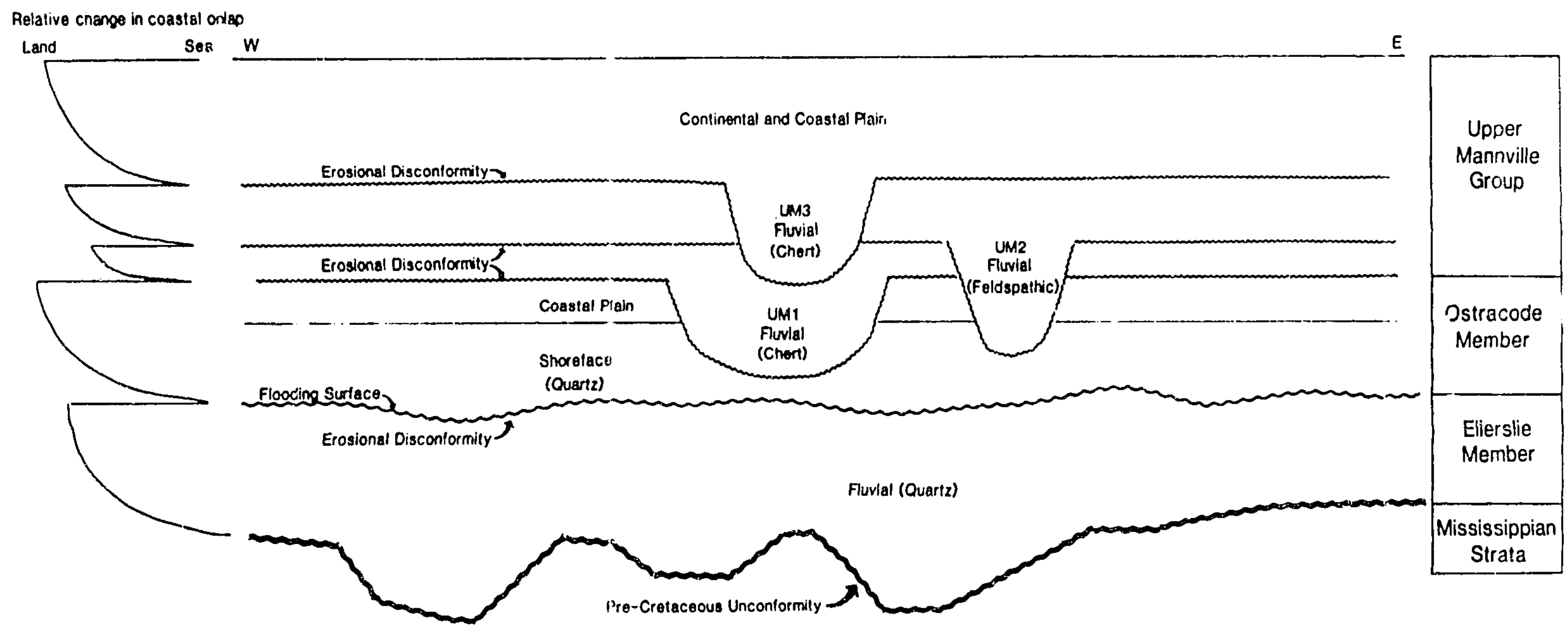


FIGURE III-26. Schematic W-E cross-section summarizing the stratigraphic relationships in the Jenner-Suffield area.

observed in the more feldspathic sands of the UM2 unit. These valleys are approximately 0.5 km (1/4 mile) in width and trend WSW-ENE. The UM2 valley system incises into the underlying Ostracode Member and the UM1 unit where it trends almost perpendicular to the UM1 trend. The UM2 fluvially dominated valleys probably sourced a coastline to the ENE possibly in Saskatchewan (D. Smith, Pers. Comm.). The chert-rich sandstones of the UM3 unit represents the youngest valley incision event (1.0 to 1.5 km/1/2 to 1 mile wide), which trend almost parallel to the UM1 valley sandstones. The UM3 valley incises into the UM1 sandstones and previously deposited highstand continental and coastal plain deposits. A subsequent relative rise in base level resulted in the backfilling of the incised valley with fluvial sediments.

Mineralogically each of these sandstone unit are distinctive, but comparison to other studies (ie. Young and Doig, 1986) and correlation on this basis is very speculative. Drainage divides may exist, additional source areas, and marine (reworking) to non-marine environments makes correlation difficult.

Architecture

The valley fill deposits of the upper Mannville within the Jenner-Suffield area reflect mainly bedload channel deposition. Schumm (1977) used the bedload streams of Kansas and Texas as examples of the resulting valley-fill stratigraphy. A thin veneer of fine grained floodplain deposits typically caps a thick cross-bedded sand and gravel deposit (Fig III-6). Although a floodplain may form with overbank flooding and vertical accretion, lateral migration of the channel may erode/ rework the floodplain deposits as shown by Schumm and Lichty (1963). In bedload channels floodplain deposits have a low preservation potential and within a valley this factor is compounded by subsequent channel migration and stacking. In the valley of the Canadian River in Texas, a thin veneer a few feet thick of floodplain sediment covers 46 m (150 ft) of clean sand and gravel. The valley deposits of the Colorado River, Texas is another example of bedload channel infill of a valley (Galloway, 1981). Ancient examples of bedload valleys include the Mississippian Berea Sandstone (Pepper et al, 1954; Schumm, 1977) and the Lower Cretaceous 'J' interval (Harms, 1966, Exum and Harm, 1968). Mineralogy was also used both cases to help distinguish the valley fill from the surrounding strata.

Localization and orientation

The upper Mannville valleys observed in the Jenner-Suffield area do not appear to have been topographically controlled to any great extent by the relief on the pre-Cretaceous unconformity. Infill of Detrital and Ellerslie sediments seems to have subdued much of the paleotopography by upper Mannville time. Salt solution and related faulting is not observed regionally since there is no substantial thickening of the Mannville Group where the valleys are located which would indicate syndepositional subsidence. The Prairie Evaporite underlies the area (Tilley and Longstaffe, 1984), and local salt solution should not be ruled out. The straight nature of these valleys is not considered unusual since these valleys are bedload in nature, and also during incision a relatively high gradient and high sediment input would undoubtedly produce a straight morphology. More sinuous valleys such as that observed at Little Bow (Hermanson, 1982; Hopkins et al, 1982; Wood and Hopkins, 1989) suggests that, along with other factors, these were mixed load channel deposits. The influence of the substrate lithology on the morphology of the incised valley is difficult to determine. The easternmost

UM1 valley which changes morphologically along strike, is probably influenced by the change in substrate from more resistant lower Mannville continental sediments and Jurassic shales in the south to the less resistant continental sediments of the lower Mannville group to the north. Other factors may be an relative increase in gradient or decrease in sediment load to the north.

Although active during the deposition of the overlying Colorado Group (Herbaly, 1974) the Sweetgrass arch is not considered to have been active during Mannville deposition. Since one of the UM1 valleys crosses over the axis of the arch, and considering the orientation of the UM1 and UM3 valleys, with their source areas lying much further to the south. Drainage patterns and source areas in pre-middle Albian may have reached as far south as Arizona, New Mexico, and Texas as noted by McGookey (1972) (Fig. 14). Source area and tectonic activity determined the orientation of these valleys.

Orientation of many of the Mannville valleys in the foreland basin is typically parallel to the Cordillera mountain front (ie. this study; Williams, 1963; McLean and Wall, 1981; Hayes, 1983; Jackson, 1985) similar to that observed in the Himalayas. Here drainage within the aggrading molasse basin is mainly longitudinal with respect to the active structural features, except flanking the mountain front where active but short transverse streams supply sediment to the main longitudinal rivers (Eisbacher et al, 1974).

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CONCLUSIONS/SUMMARY

Examination of the Mannville Group within the Jenner-Suffield area of southeast Alberta has delineated numerous depositional systems which evolved within the Alberta foreland basin.

Regional erosion spanning at least 40 million years (Hayes,1983) took place with the retreat of the Jurassic Swift sea from the Interior Plains due to major tectonic activity to the west. Significant topographic relief developed on the erosive surface with the incision of numerous valley systems, such as the Spirit River (McLean, 1977), Edmonton, St Paul (Williams, 1963), and Cutbank (Hayes (1983, 1986) valleys. These valleys contained major fluviatile systems that drained the Interior Plains to the northwest.

Isopachous mapping of the Mannville Group in southeast Alberta reflects the paleotopographic relief on this erosive surface which is up to 70m. Westerly drainage off the paleohighs fed a larger valley system which drained to the NW, eventually joining the Spirit River valley system. A relative rise in sea level (base level) resulted in the back-filling of valleys depositing Detrital and Ellerslie fluvial sediments, respectively, in the study area. Clay rich, rooted sediments or paleosols are located at the top of the quartzose Ellerslie member. The overlying exposure surface is thought to represent an sequence boundary. A flooding surface is also represented by this sequence boundary, with the deposition of the basal limy and carbonaceous shales of the Ostracode member. These basal sediments are representative of the inundation of much of central and southern Alberta by the Ostracode sea which deposited sediments in a broad shallow, brackish water embayment. The paleohighs located to the east, now dictated the coastal morphology, with the prevailing coastline trending NNW-SSE. No sooner did the Ostracode sea reach its maximum transgressive limits when it began to retreat. A relative sea level drop or still stand resulted in the progradation of a quartzose (Q:F:L ratio 86.1:0.7:13.2) barrier sand of the Ostracode member. It is speculated that the Cessford deltaic complex, located to the NNW, supplied sediments southeastward via longshore drift to this wave dominated barrier. This regional barrier sandstone has a known length of 104 km, an average width of 16 km and an average thickness of 9 m. To the east the Ostracode barrier sandstones grade laterally into swamp and lagoonal deposits of the backshore. To the west the barrier sands grade laterally into the bioturbated shales and siltstones of the offshore. The barrier itself has a number of ridges possibly indicating barrier stepout. A number of 'spit' like features are also recognized, one of which contains the Jenner E pool. The Suffield A pool is partly contained in washover sands which buildup above the main barrier itself. This buildup is incised by one of the upper Mannville UM1 valleys, and is structurally high enough to form part of the Suffield A

Subsequent sea level (base level) fluctuations resulted in the incision and back-filling of a number of valleys in the area, in ascending order UM1, UM2 and UM3. Chert litharenite fluvial sandstones (Q:F:L ratio

56:0.3:43.7) of the informally named UM1 unit are recognized as three 1.5-3.0 km (1-2 mile) wide, NNW-SSE trending valleys which incised into the underlying Ostracode and Ellerslie members as they drained northward. Average thickness of the UM1 is 20-25 m. The easternmost UM1 valley has been traced for over 100 km (60 miles) from T4 to T21. The UM1 valleys are interpreted to have contained bedload fluvial channels, resulting in a predominantly sand filled valley with a minor amount of overbank fines. The UM1 unit appears to grade from braided deposits at the base to meandering type deposits at the top. With the initial drop in base level, high volumes of sediment were produced resulting in the formation of a braided stream. As the river adjusted to the new base level, sediment load and gradient decreases resulting in a more meandering type channel. The UM1 unit contains numerous oilfields in the Jenner-Suffield area such as the Jenner O, Jenner F, and Suffield J pools. In the Medicine Hat area located in T12, R5W4 the easternmost UM1 valley forms the reservoir.

The UM2 unit is observed in the 0.5 km (1/4 mile) wide ENE-WSW trending non-reservoir feldspathic litharenite fluvial sandstones , which incises into both the Ostracode sandstone and the UM1 valley trend, forming a seal to a UM1 pool. The UM2 valleys probably sourced a coastline to the ENE probably in Saskatchewan (D. Smith, Pers. Comm.).

The chert litharenite sandstone of the UM3 fluvial deposit represents the youngest valley incision event 1.0-1.5 km (1/2-1 mile wide). The UM3 valley trends almost parallel to, and incises into, the UM1 trend, and into previously deposited highstand continental and coastal plain deposits.

Estimated oil in place within the Jenner-Suffield area is approximately 84127.0 x 10^3 m^3 (530 mmbbl) (recovery factor 3-6%) of 16^0API gravity oil. Ostracode traps usually consist of a sandstone buildup surrounded by non-reservoir coastal plain sediments. Incision by the UM1 and UM3 results in reservoir fluvial sandstones directly adjacent to and overlain by non-reservoir, genetically unrelated, continental and coastal plain sediments.

Exploration potential for the UM1 and UM3 units is represented in the recognition of these systems as drainage networks. These valleys represent potential hydrocarbon reservoirs if they are traced along strike. The regional Ostracode barrier sandstone also represents an important exploration target. Previously ignored for the thick UM valley deposits, the Ostracode sand is a clean, fine grained sand with excellent reservoir potential if followed regionally.

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APPENDIX 1

LEGEND

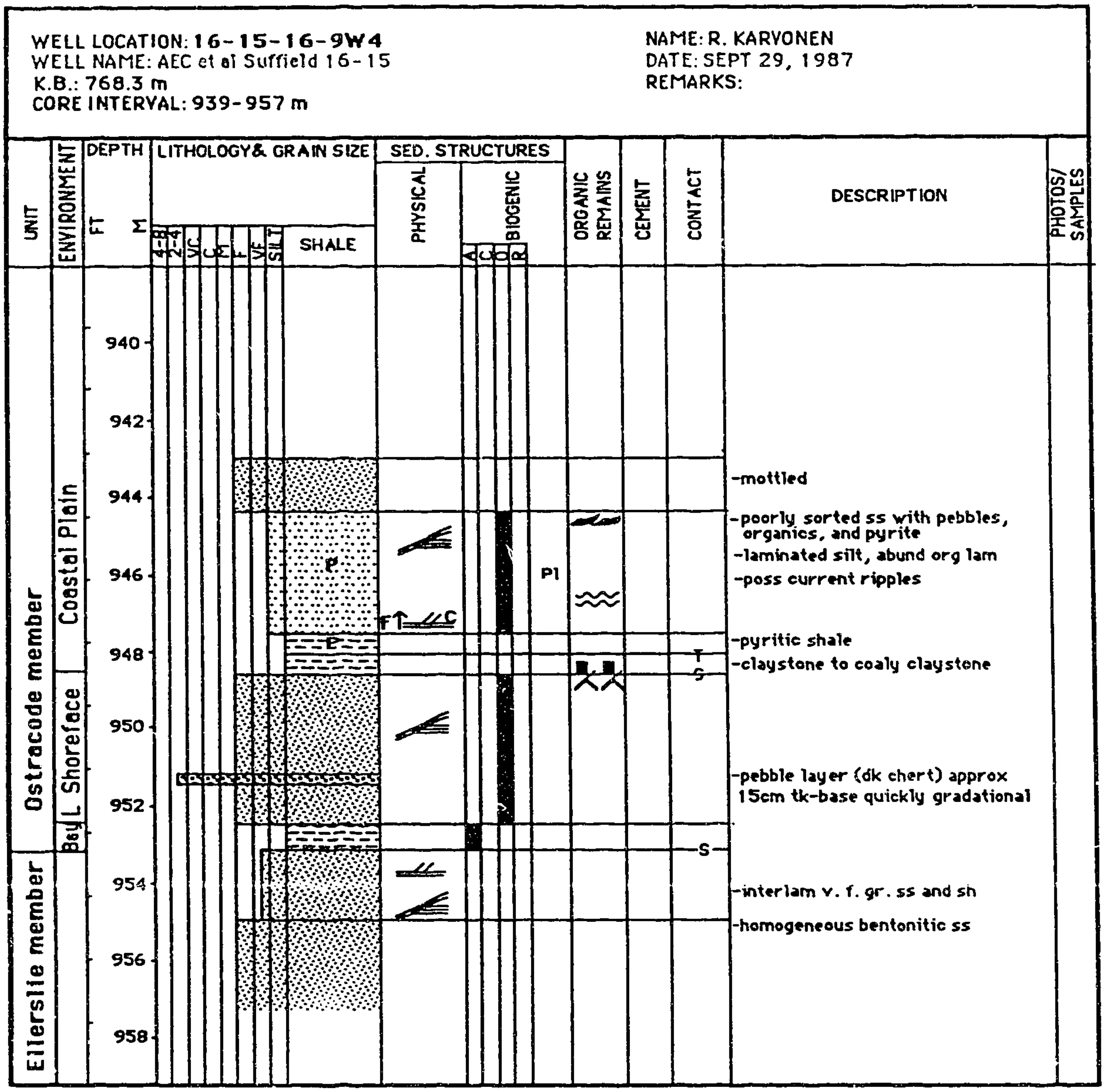
- CLAST
- COAL CHIPS
- CONTACT Sc-Scour
  - S-Sharp
  - T-transitional
- RIPPLE STRATIFICATION W-wave
  - C-current
- F↑ FINING UPWARD LAM/BED
- HIGH ANGLE CROSS-STRATIFICATION
- HORIZONTAL STRATIFICATION
- HUMMOCKY CROSS-STRATIFICATION
- M MASSIVE
- MICROFAULTING
- LENTICULAR BEDDING
- LOW ANGLE CROSS-STRATIFICATION
- LOW ANGLE STRATIFICATION
- ORGANIC DEBRIS
- ORGANIC LAMINATIONS
- SCOUR AND FILL
- SHALE CLASTS
- SOFT SEDIMENT DEFORMATION
- SYNERESIS CRACKS
- TROUGH CROSS-STRATIFICATION
- WAVY BEDDING
- WOOD FRAGMENT

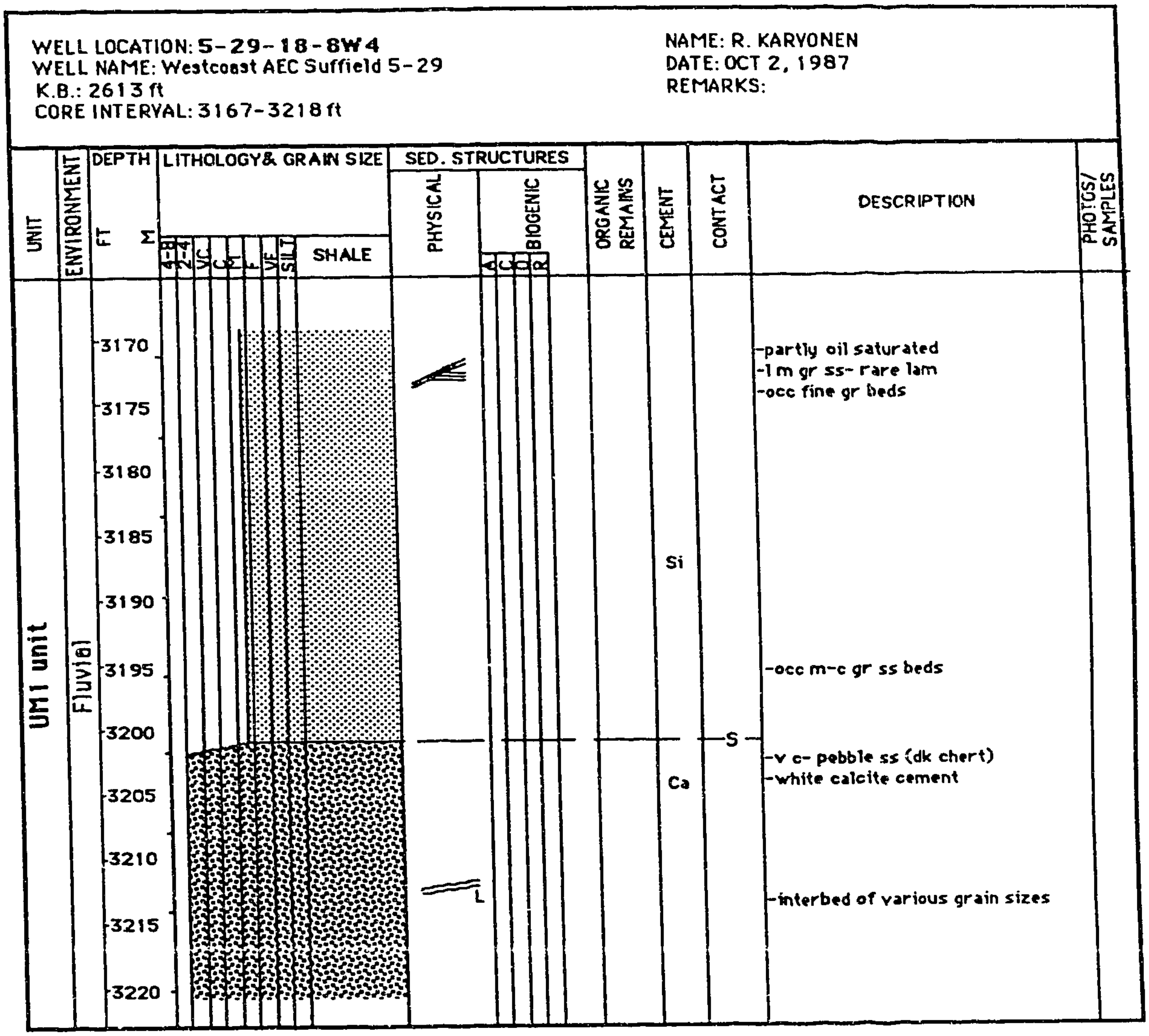
BIOGENIC STRUCTURES

Ar	Arenicolites
Ber	Bergauria
Ch	Chondrites
Con	Conichnus
Oph	Ophiomorpha
Pa	Paleophycus
Pl	Planolites
Rhiz	Rhizocorallium
Ro	Rosselia
Sk	Skolithos
Tei	Teichichnus
Th	Thalassinoides

MISCELLANEOUS

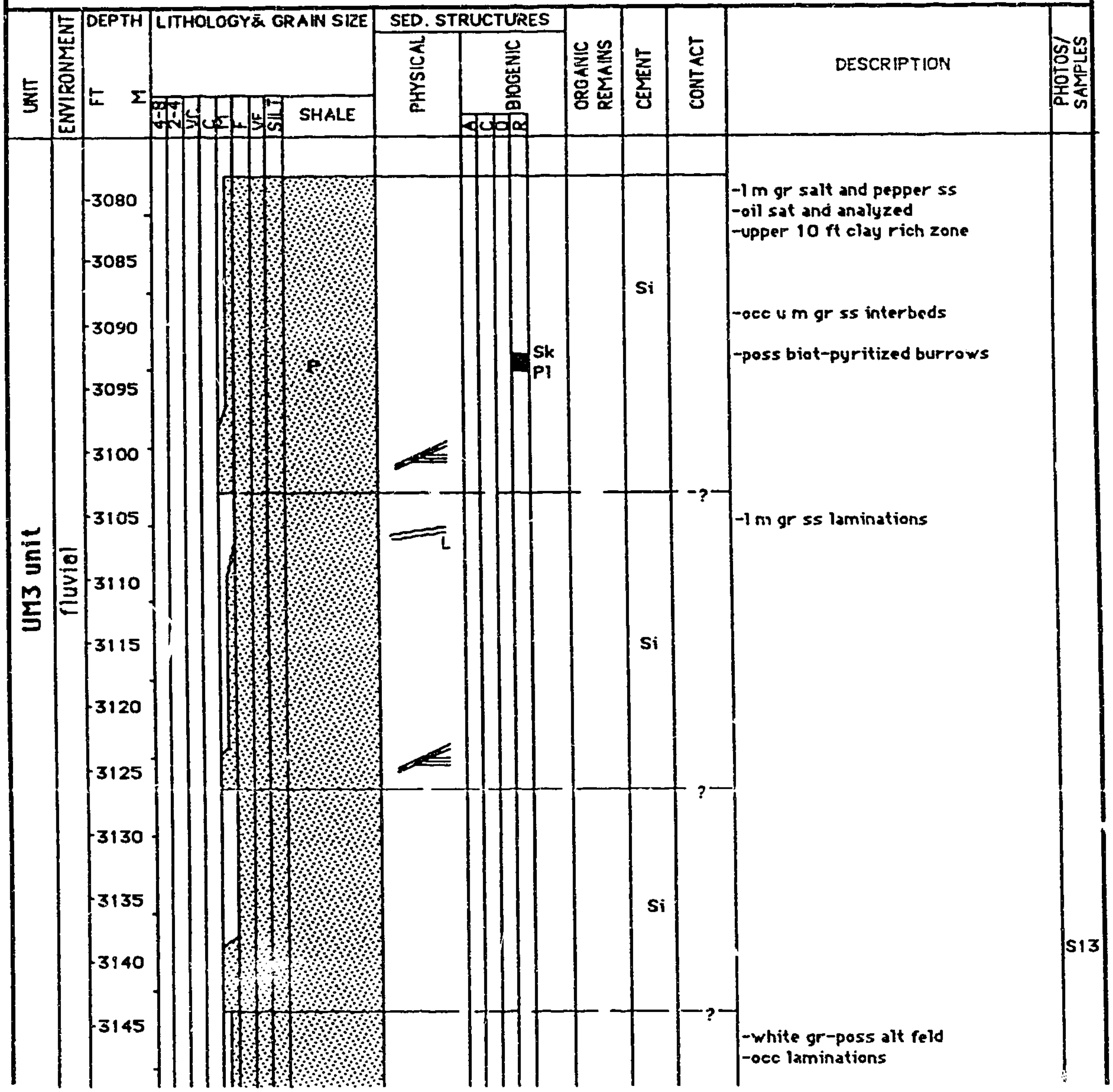
Si	Silica
Ca	Calcite
S	Siderite
P	Pyrite

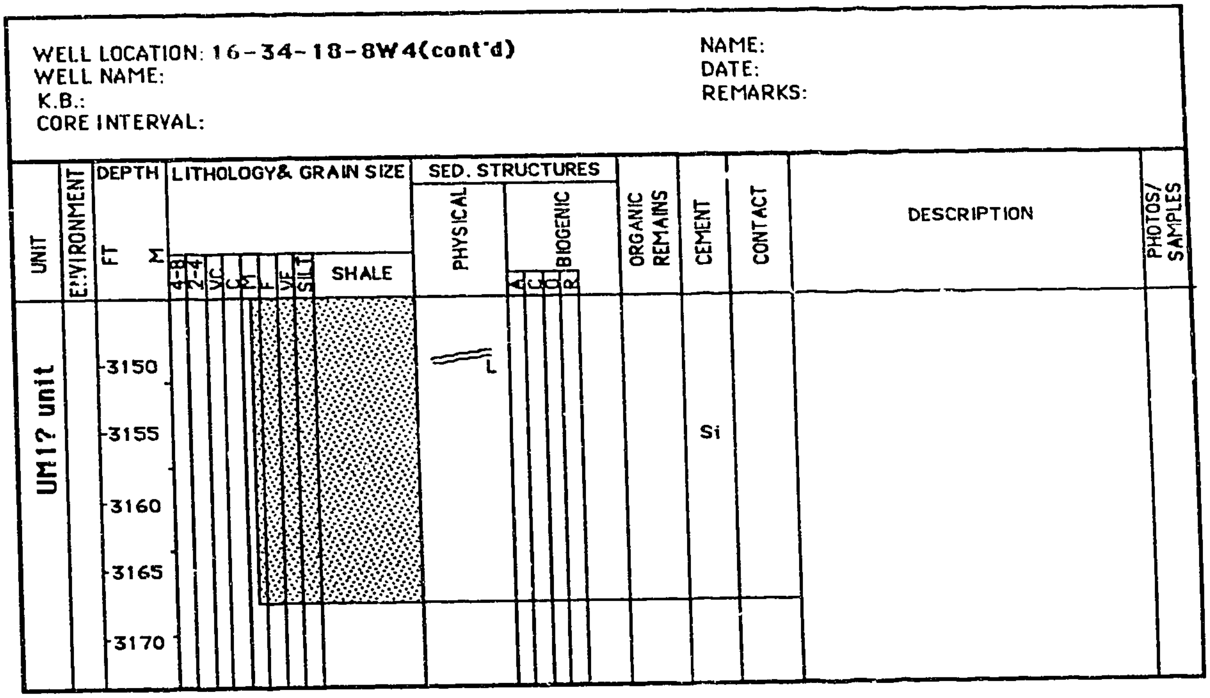

WELL LOCATION: 16-15-16-9W4
WELL NAME: AEC et al Suffield 16-15
K.B.: 768.3 m
CORE INTERVAL: 939-957 m
NAME: R. KARVONEN
DATE: SEPT 29, 1987
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
4-8
2-4
VC
C
M
F
VF
SILT
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
A
C
O
R
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
940
942
944
946
948
950
952
954
956
958
Ostracode member
Ellerslie member
Coastal Plain
L Shoreface
Bay
Pl
T
S
S
-mottled
-poorly sorted ss with pebbles, organics, and pyrite
-laminated silt, abund org lam
-poss current ripples
-pyritic shale
-claystone to coaly claystone
-pebble layer (dk chert) approx 15cm tk-base quickly gradational
-interlam v. f. gr. ss and sh
-homogeneous bentonitic ss

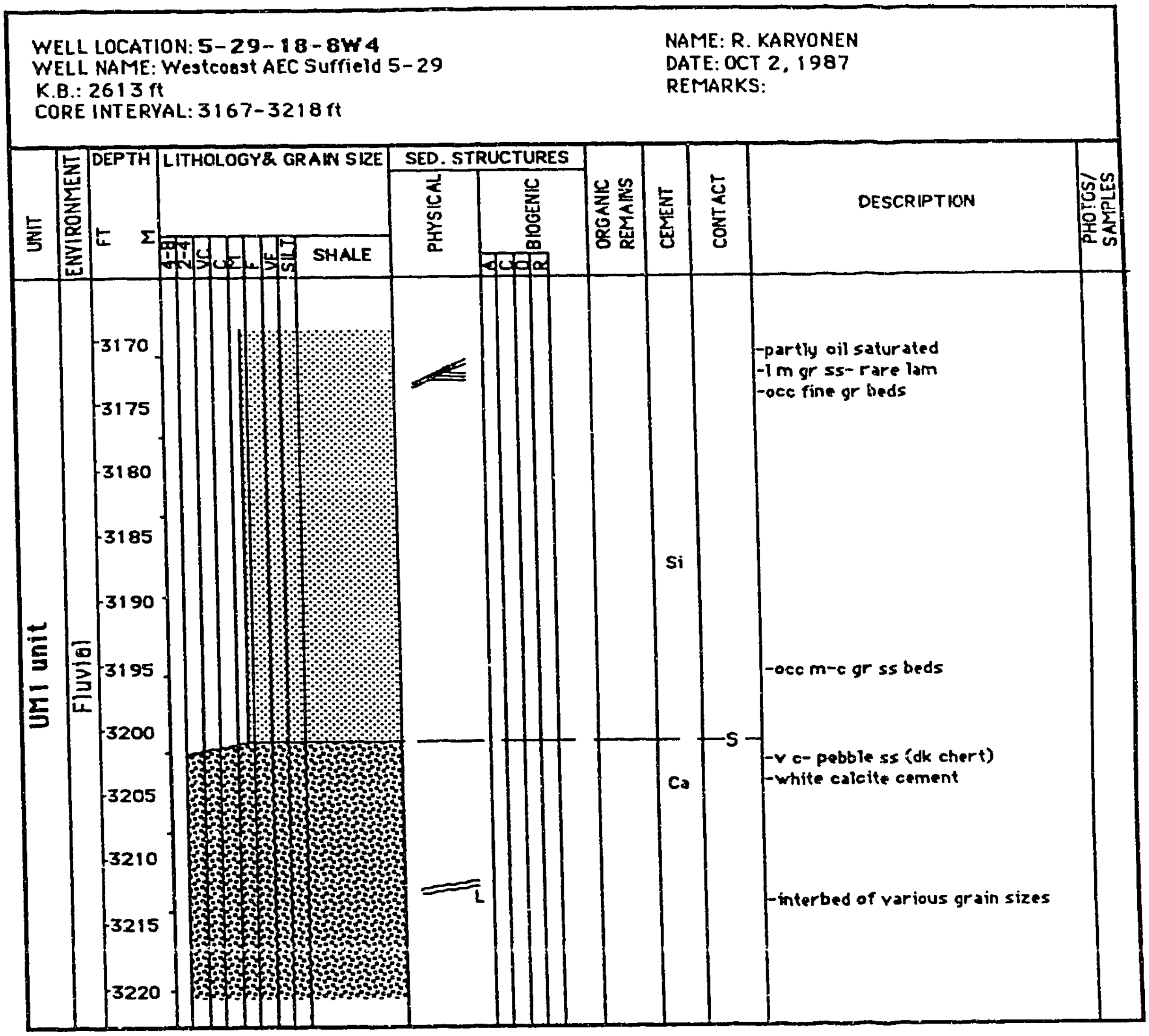

WELL LOCATION: 5-29-18-8W4
WELL NAME: Westcoast AEC Suffield 5-29
K.B.: 2613 ft
CORE INTERVAL: 3167-3218 ft
NAME: R. KARVONEN
DATE: OCT 2, 1987
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
4-8
2-4
VC
C
M
F
VF
SILT
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
A
C
O
R
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
3170
3175
3180
3185
3190
3195
3200
3205
3210
3215
3220
UM1 unit
Fluvial
-partly oil saturated
-1 m gr ss- rare lam
-occ fine gr beds
Si
-occ m-c gr ss beds
S
-v c- pebble ss (dk chert)
-white calcite cement
Ca
L
-interbed of various grain sizes

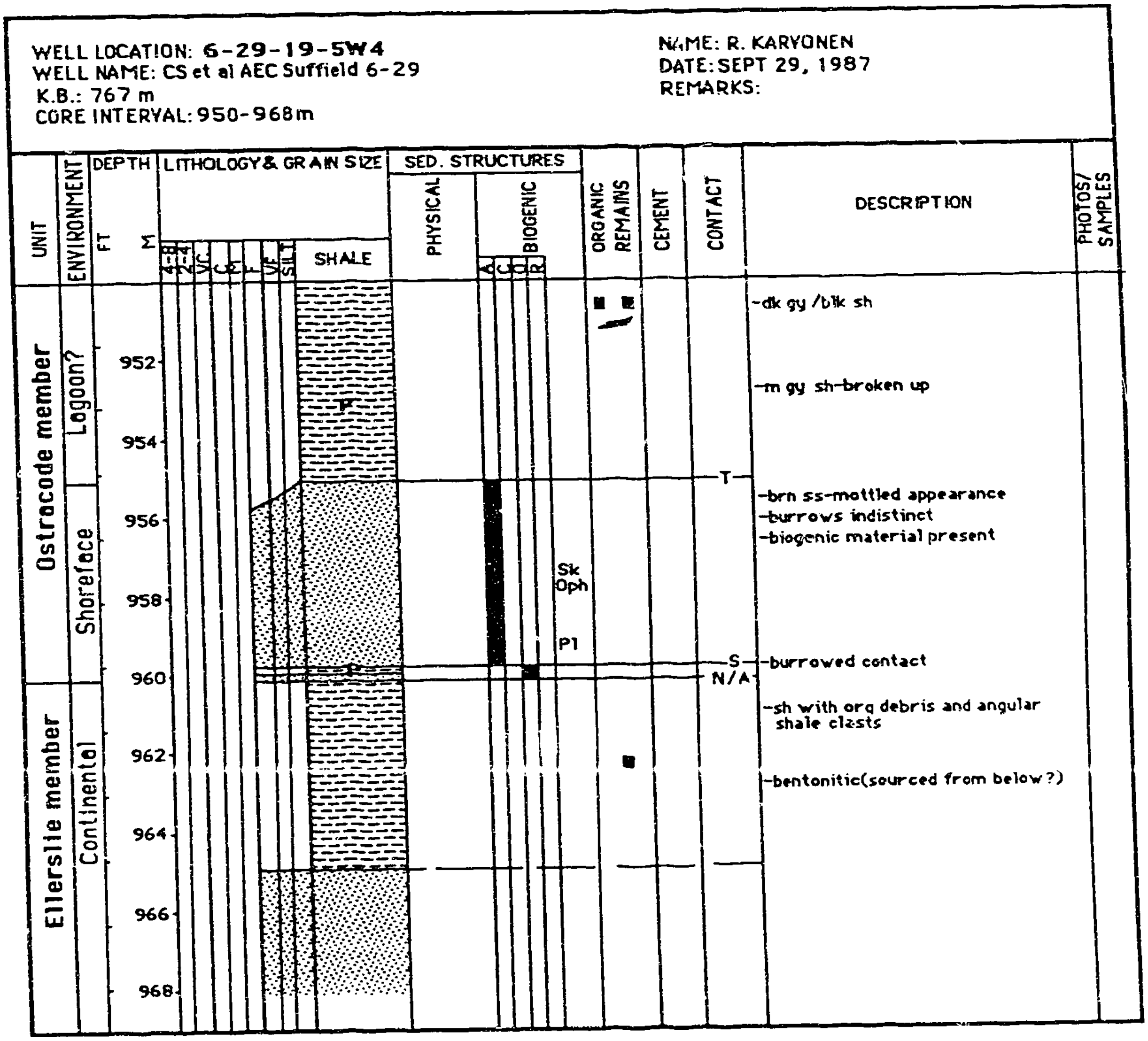
WELL LOCATION: 16-34-18-8W4
WELL NAME: Westcoast AEC Suffield 16-34
K.B.: 2590ft
CORE INTERVAL: 3078-3167ft

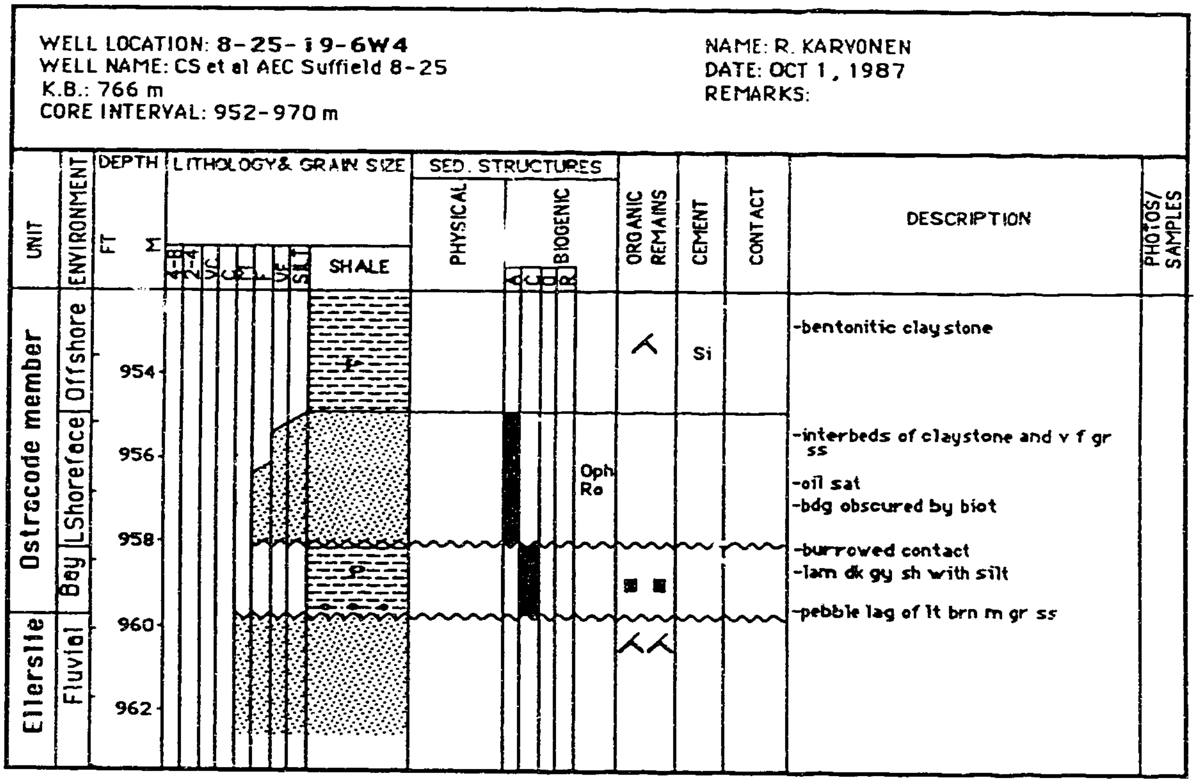
NAME: R. Karvonen
DATE: Jan 7, 1988
REMARKS: Poor core

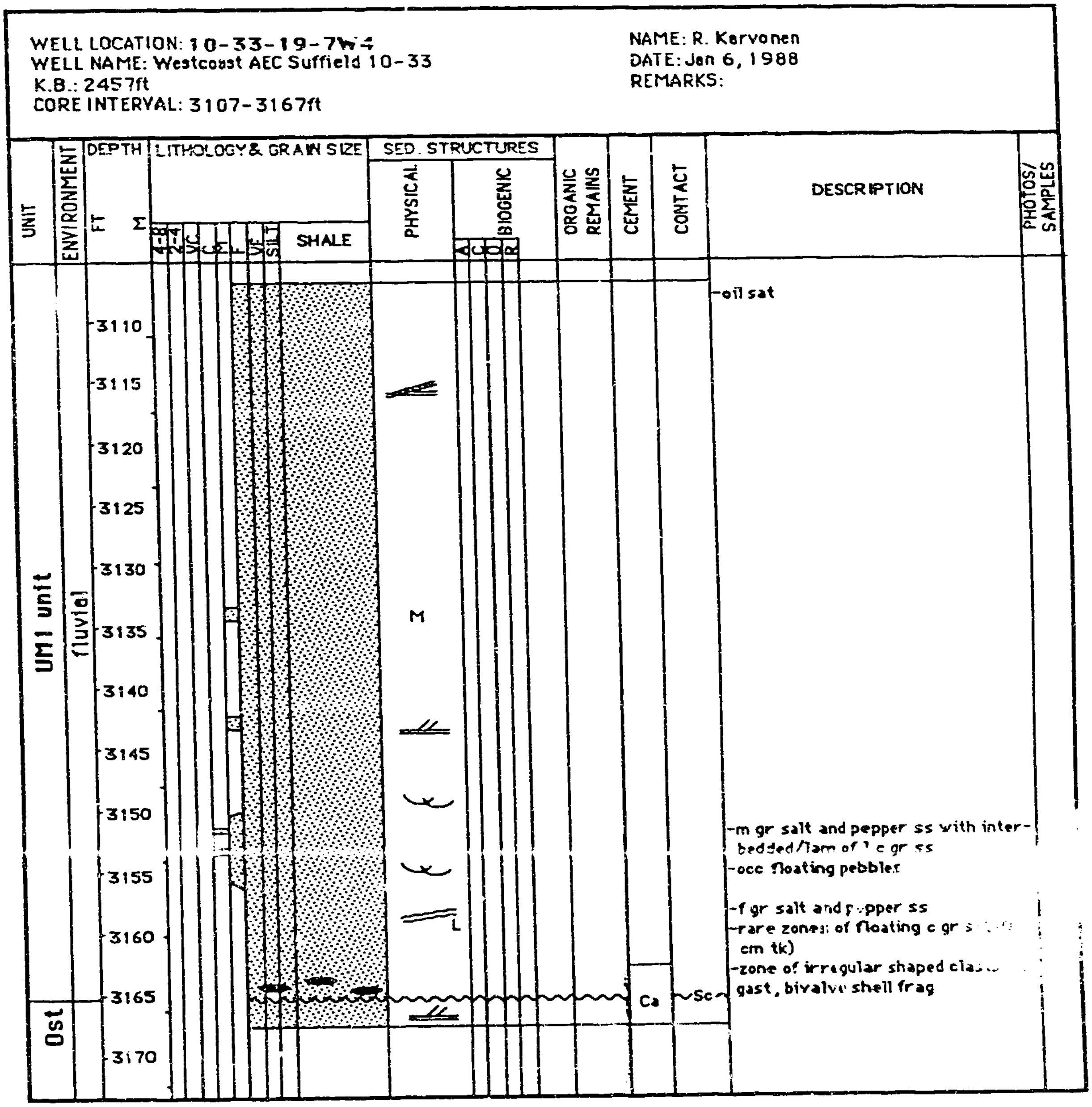



WELL LOCATION: 16-34-18-8W4(cont'd)
WELL NAME:
K.B.:
CORE INTERVAL:
NAME:
DATE:
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY& GRAIN SIZE
4-8
2-4
VC
C
M
F
VF
SILT
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
A
C
O
R
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
UM1? unit
3150
3155
3160
3165
3170
L
Si


WELL LOCATION: 5-29-18-8W4
WELL NAME: Westcoast AEC Suffield 5-29
K.B.: 2613 ft
CORE INTERVAL: 3167-3218 ft
NAME: R. KARVONEN
DATE: OCT 2, 1987
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
4-8
2-4
VC
C
M
F
VF
SILT
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
A
C
O
R
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
UM1 unit
Fluvial
3170
3175
3180
3185
3190
3195
3200
3205
3210
3215
3220
Si
Ca
S
L
-partly oil saturated
-1 m gr ss- rare lam
-occ fine gr beds
-occ m-c gr ss beds
-v c- pebble ss (dk chert)
-white calcite cement
-interbed of various grain sizes

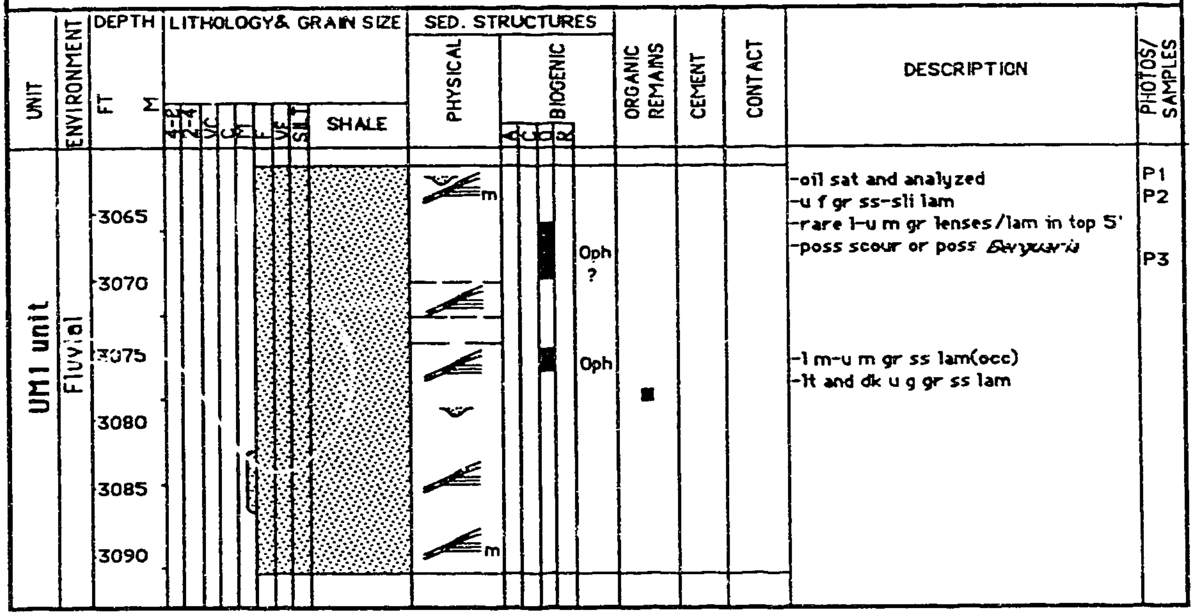

WELL LOCATION: 6-29-19-5W4
WELL NAME: CS et al AEC Suffield 6-29
K.B.: 767 m
CORE INTERVAL: 950-968m
NAME: R. KARYONEN
DATE: SEPT 29, 1987
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
Ostracode member
Ellerslie member
Lagoon?
Shoreface
Continental
952
954
956
958
960
962
964
966
968
Sk
Oph
Pl
T
S
N/A
-dk gy /blk sh
-m gy sh-broken up
-brn ss-mottled appearance
-burrows indistinct
-biogenic material present
-burrowed contact
-sh with org debris and angular shale clasts
-bentonitic(sourced from below?)

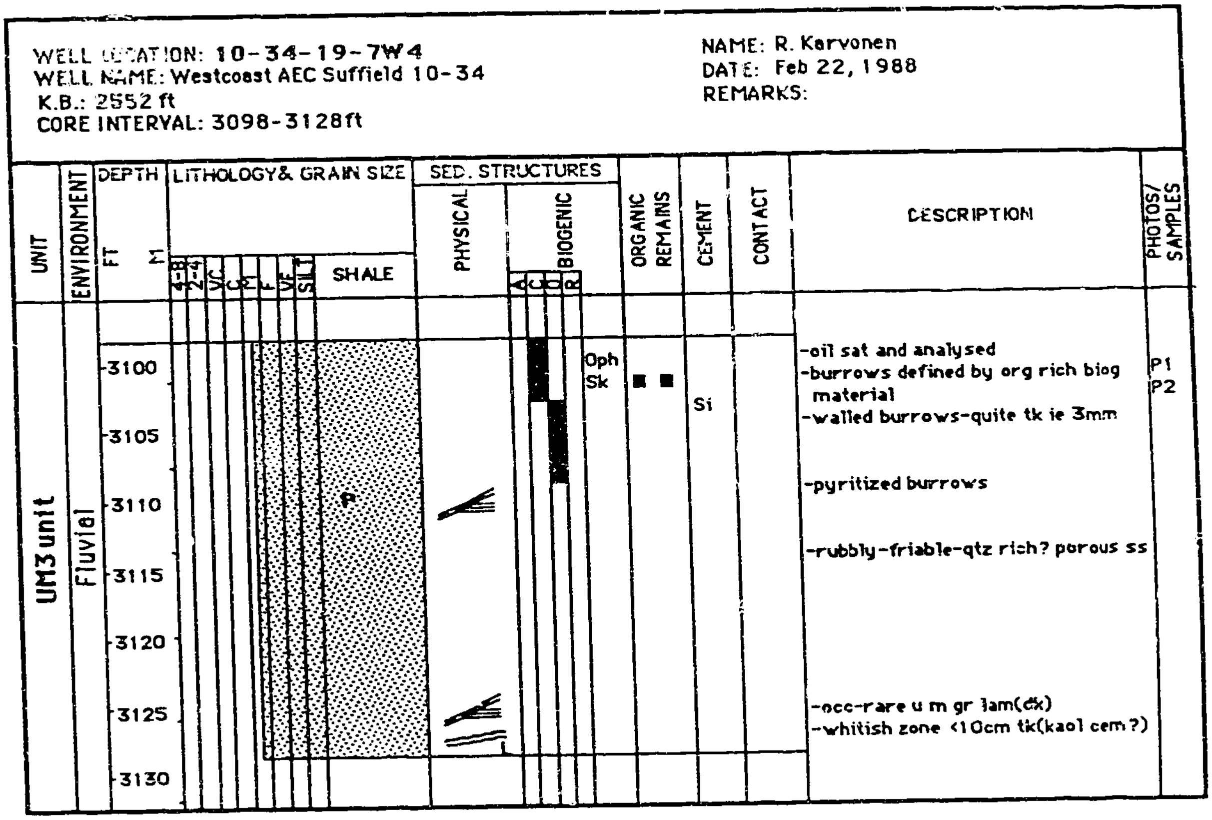

WELL LOCATION: 8-25-19-6W4
WELL NAME: CS et al AEC Suffield 8-25
K.B.: 766 m
CORE INTERVAL: 952-970 m
NAME: R. KARVONEN
DATE: OCT 1, 1987
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
Ostracode member
Ellerslie
Offshore
LShoreface
Bay
Fluvial
954
956
958
960
962
Si
Oph
Ro
-bentonitic claystone
-interbeds of claystone and v f gr ss
-oil sat
-bdg obscured by biot
-burrowed contact
-lam dk gy sh with silt
-pebble lag of lt brn m gr ss

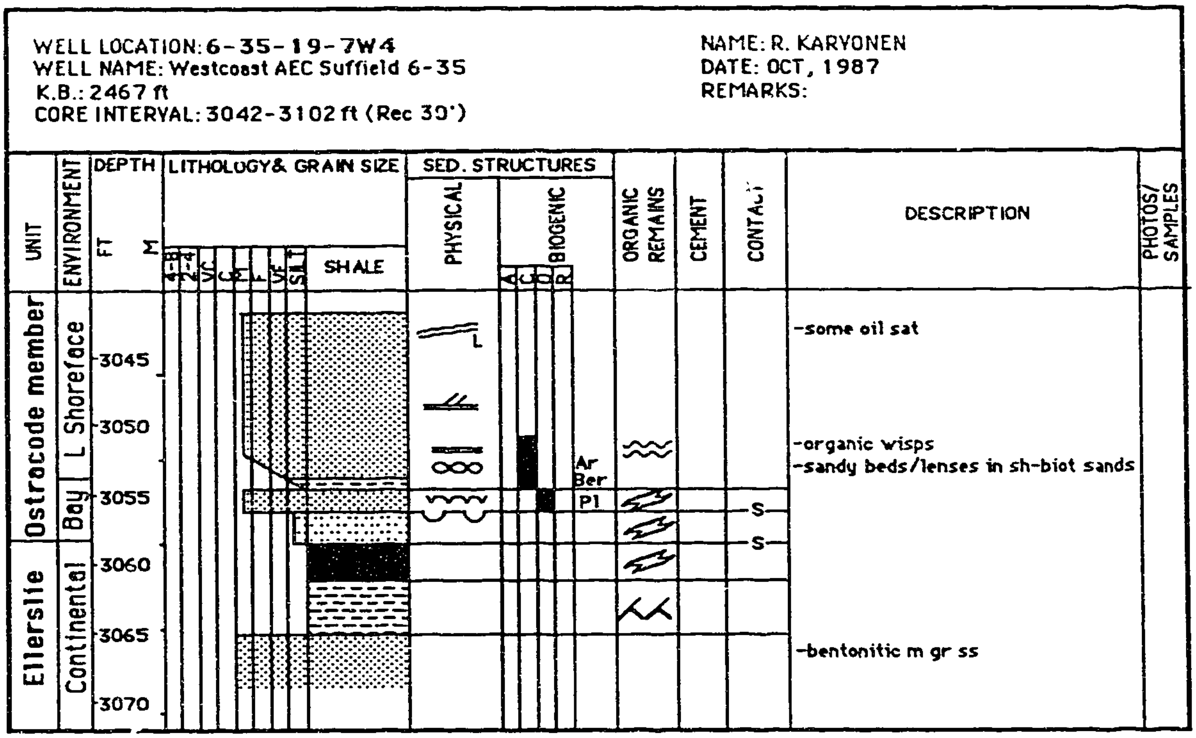

WELL LOCATION: 10-33-19-7W4
WELL NAME: Westcoast AEC Suffield 10-33
K.B.: 2457ft
CORE INTERVAL: 3107-3167ft
NAME: R. Karvonen
DATE: Jan 6, 1988
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
VC
C
M
F
VF
SILT
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
A
C
O
R
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
3110
3115
3120
3125
3130
3135
3140
3145
3150
3155
3160
3165
3170
UM1 unit
fluvial
Ost
M
L
Ca
Sc
-oil sat
-m gr salt and pepper ss with inter-
bedded/lam of c gr ss
-occ floating pebbles
-f gr salt and pepper ss
-rare zones of floating c gr
cm tk)
-zone of irregular shaped clas
gast, bivalve shell frag

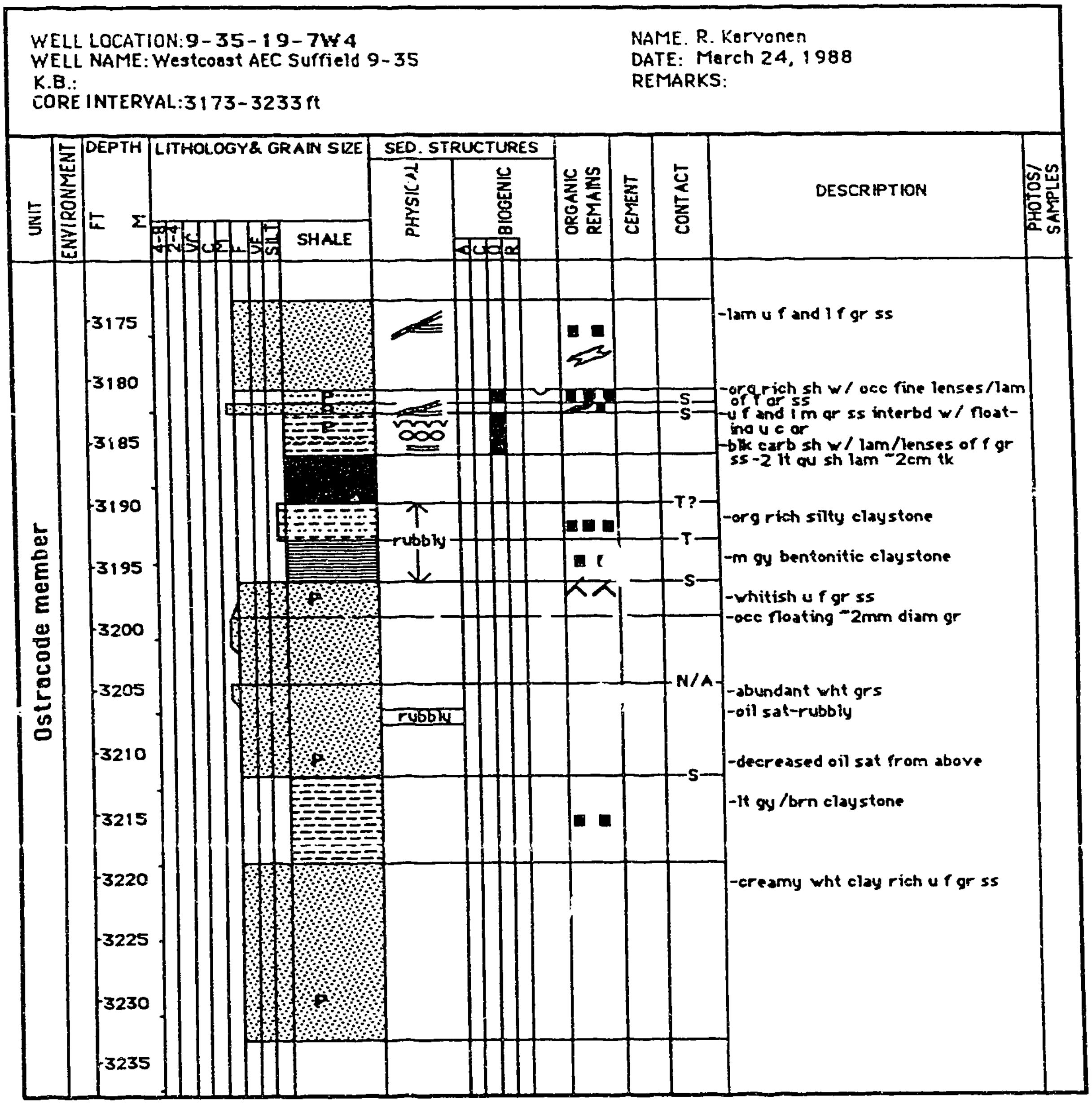
WELL LOCATION: 6-34M-19-7W4
WELL NAME: Westcoast AEC Suffield 6-34M
K.B.: 2489 ft
CORE INTERVAL: 3061-3091ft

NAME: R. Karvonen
DATE: March 22, 1988
REMARKS:



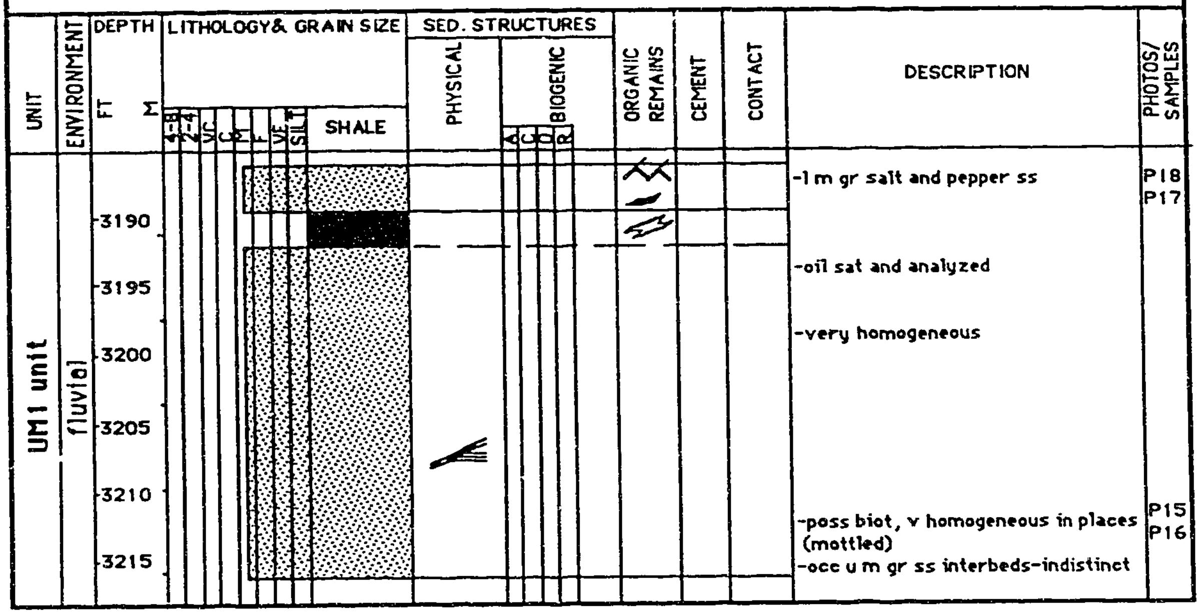

WELL LOCATION: 10-34-19-7W4
WELL NAME: Westcoast AEC Suffield 10-34
K.B.: 2552 ft
CORE INTERVAL: 3098-3128ft
NAME: R. Karvonen
DATE: Feb 22, 1988
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT M
LITHOLOGY& GRAIN SIZE
4-8
2-4
VC
C
M
F
VF
SILT
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
A
C
O
R
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
UM3 unit
Fluvial
3100
3105
3110
3115
3120
3125
3130
Oph
Sk
Si
P
-oil sat and analysed
-burrows defined by org rich biog material
-walled burrows-quite tk ie 3mm
-pyritized burrows
-rubbly-friable-qtz rich? porous ss
-occ-rare u m gr lam(dk)
-whitish zone <10cm tk(kaol cem?)
P1
P2

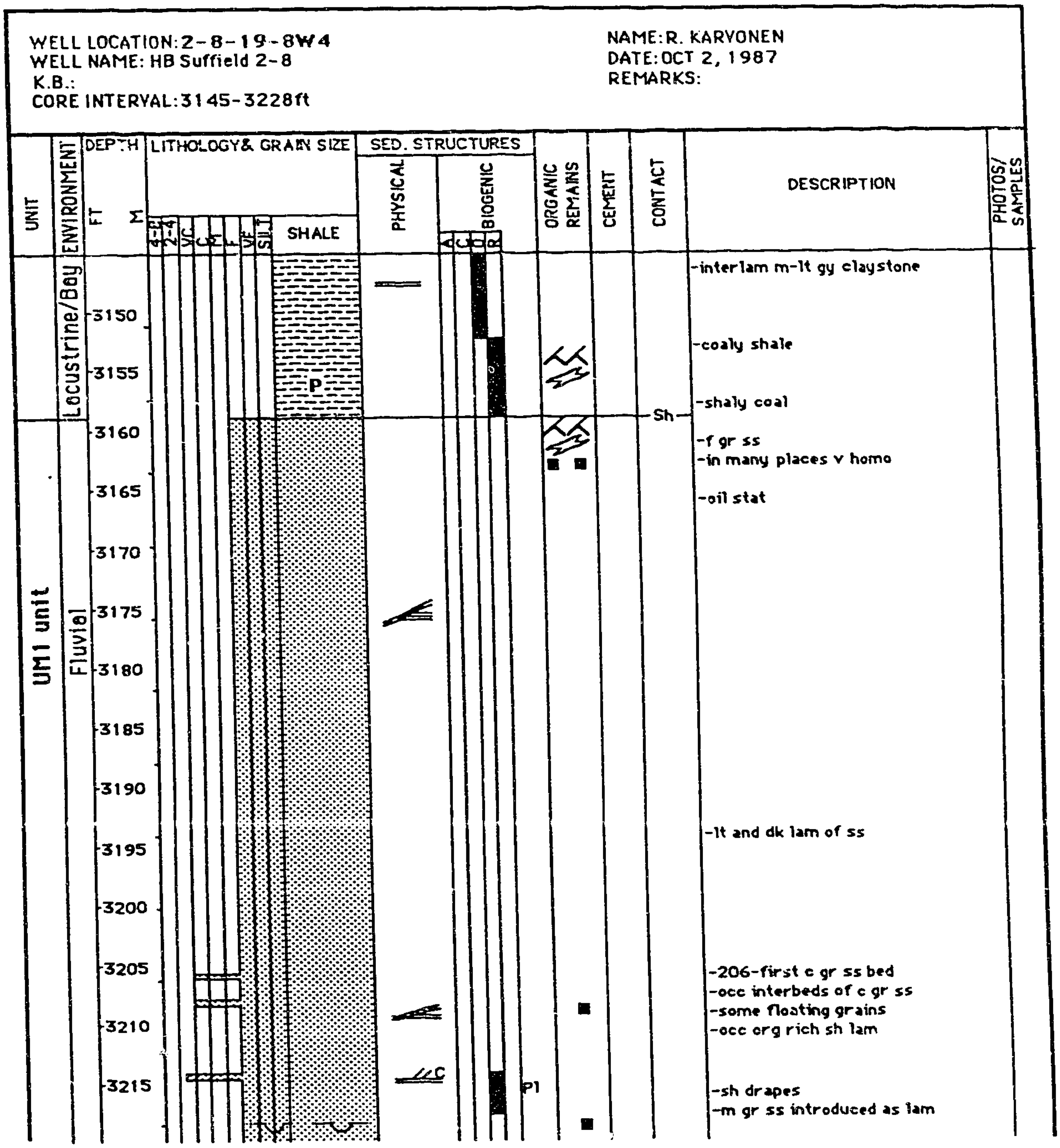

WELL LOCATION: 6-35-19-7W4
WELL NAME: Westcoast AEC Suffield 6-35
K.B.: 2467 ft
CORE INTERVAL: 3042-3102 ft (Rec 30')
NAME: R. KARYONEN
DATE: OCT, 1987
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY& GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
DESCRIPTION
PHOTOS/ SAMPLES
Ostracode member
Ellerslie
L Shoreface
Bay
Continental
3045
3050
3055
3060
3065
3070
Ar
Ber
Pl
S
S
-some oil sat
-organic wisps
-sandy beds/lenses in sh-biot sands
-bentonitic m gr ss

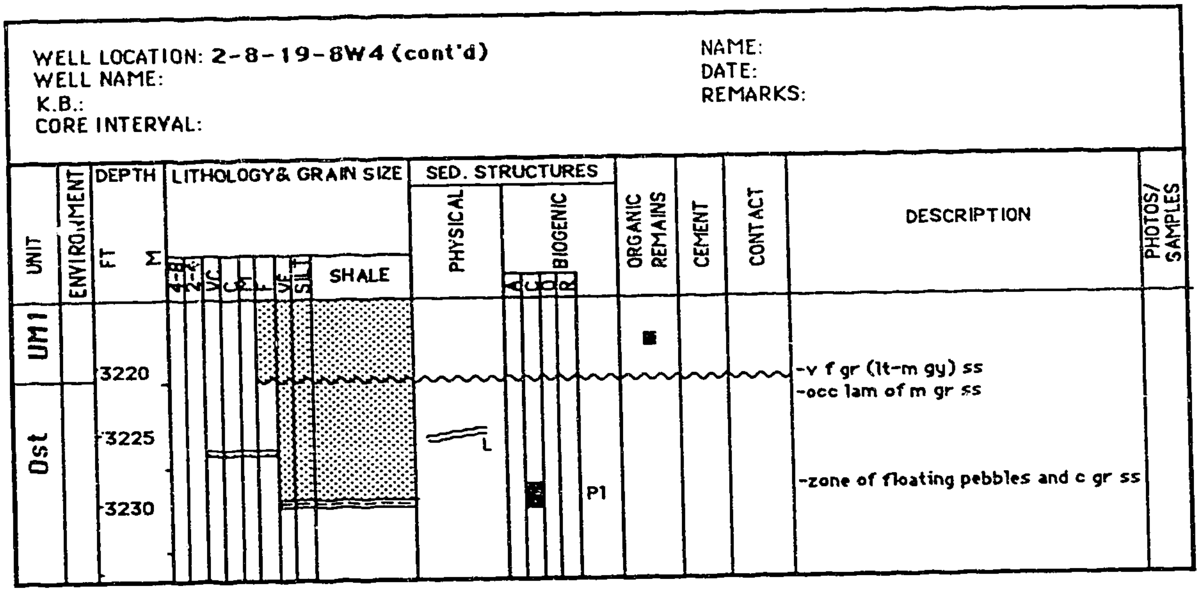

WELL LOCATION: 9-35-19-7W4
WELL NAME: Westcoast AEC Suffield 9-35
K.B.:
CORE INTERVAL: 3173-3233 ft
NAME. R. Karvonen
DATE: March 24, 1988
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT M
LITHOLOGY & GRAIN SIZE
4-8
2-4
VC
C
M
F
VF
SILT
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
A
C
O
R
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
Ostracode member
3175
3180
3185
3190
3195
3200
3205
3210
3215
3220
3225
3230
3235
rubbly
rubbly
S
S
T?
T
S
N/A
S
-lam u f and l f gr ss
-org rich sh w/ occ fine lenses/lam of f gr ss
-u f and l m gr ss interbd w/ floating u c gr
-blk carb sh w/ lam/lenses of f gr ss -2 lt gy sh lam ~2cm tk
-org rich silty claystone
-m gy bentonitic claystone
-whitish u f gr ss
-occ floating ~2mm diam gr
-abundant wht grs
-oil sat-rubbly
-decreased oil sat from above
-lt gy/brn claystone
-creamy wht clay rich u f gr ss

WELL LOCATION: 14-5-19-8W4
WELL NAME: Westcoast AEC Suffield 14-5
K.B.: 2621ft
CORE INTERVAL: 3186-3216ft

NAME: R. Karvonen
DATE: Jan 7, 1988
REMARKS:

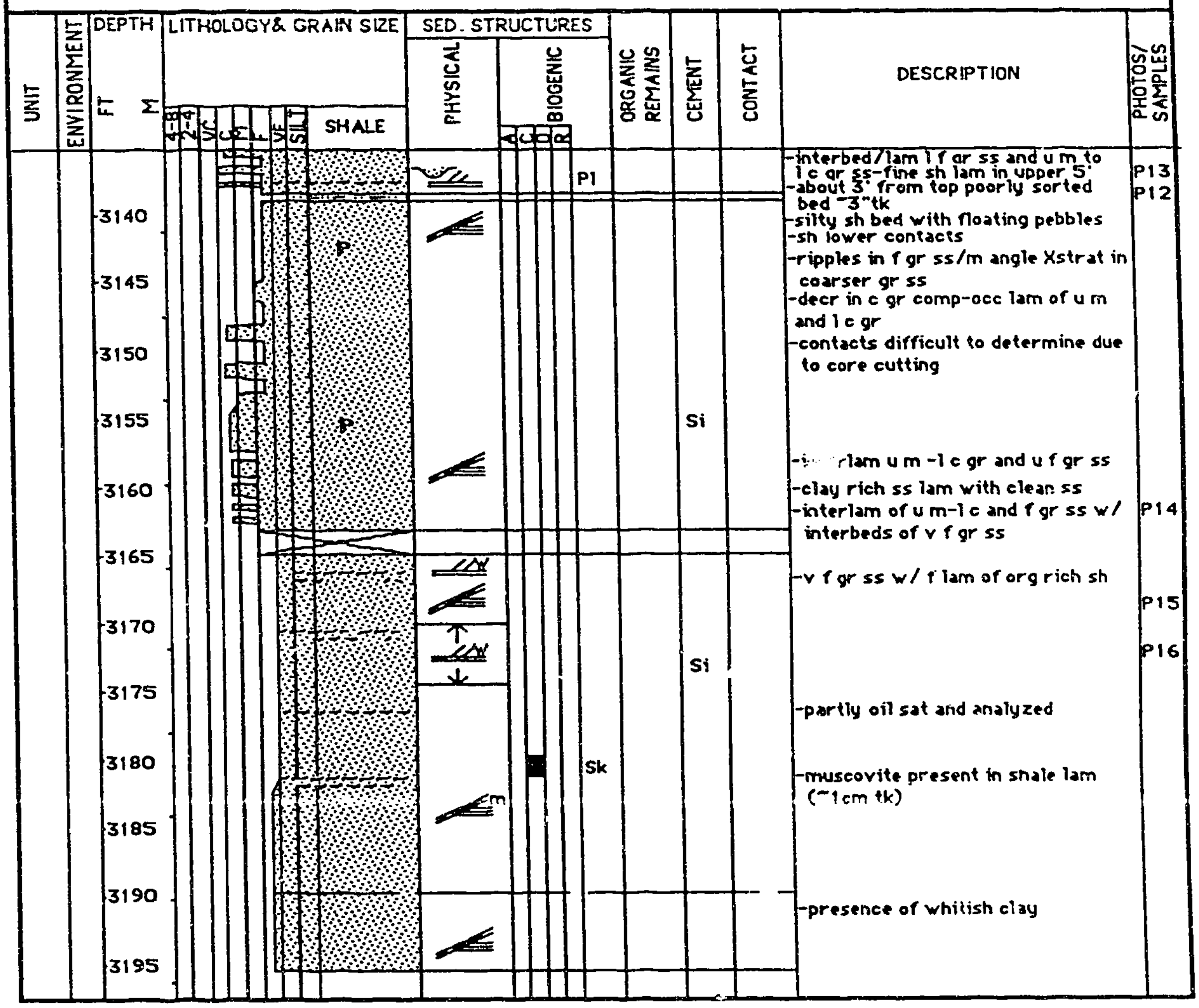



WELL LOCATION: 2-8-19-8W4
WELL NAME: HB Suffield 2-8
K.B.:
CORE INTERVAL: 3145-3228ft
NAME: R. KARVONEN
DATE: OCT 2, 1987
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
SHALE
SILT
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
Lacustrine/Bay
UM1 unit
Fluvial
3150
3155
3160
3165
3170
3175
3180
3185
3190
3195
3200
3205
3210
3215
P
Sh
P1
-interlam m-lt gy claystone
-coaly shale
-shaly coal
-f gr ss
-in many places v homo
-oil stat
-lt and dk lam of ss
-206-first c gr ss bed
-occ interbeds of c gr ss
-some floating grains
-occ org rich sh lam
-sh drapes
-m gr ss introduced as lam


WELL LOCATION: 2-8-19-8W4 (cont'd)
WELL NAME:
K.B.:
CORE INTERVAL:
NAME:
DATE:
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY& GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
UM1
Ost
3220
3225
3230
L
P1
-v f gr (lt-m gy) ss
-occ lam of m gr ss
-zone of floating pebbles and c gr ss

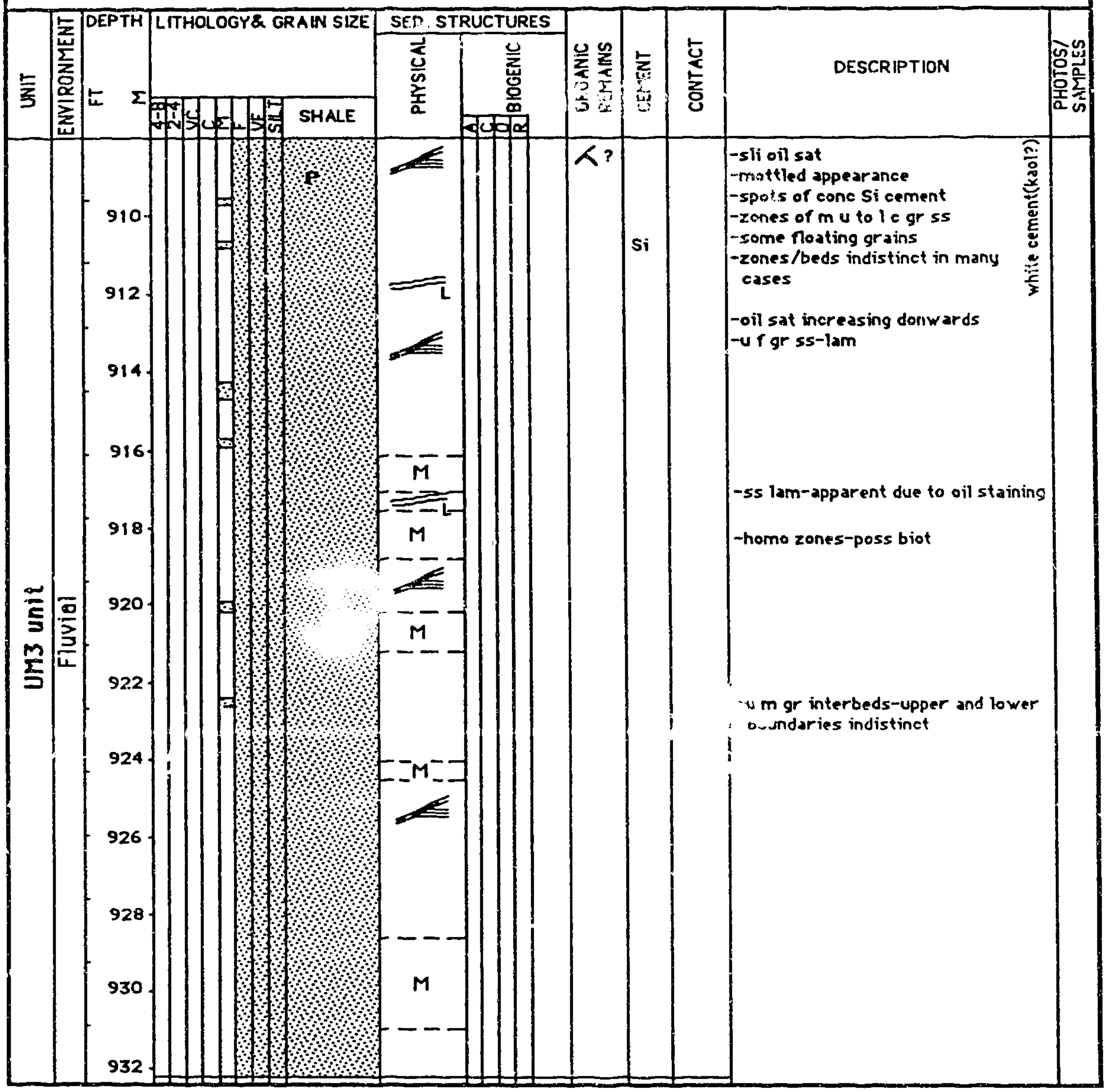
WELL LOCATION: 6-27-19-8W4
WELL NAME:
K.B.:
CORE INTERVAL: 3135-3195'

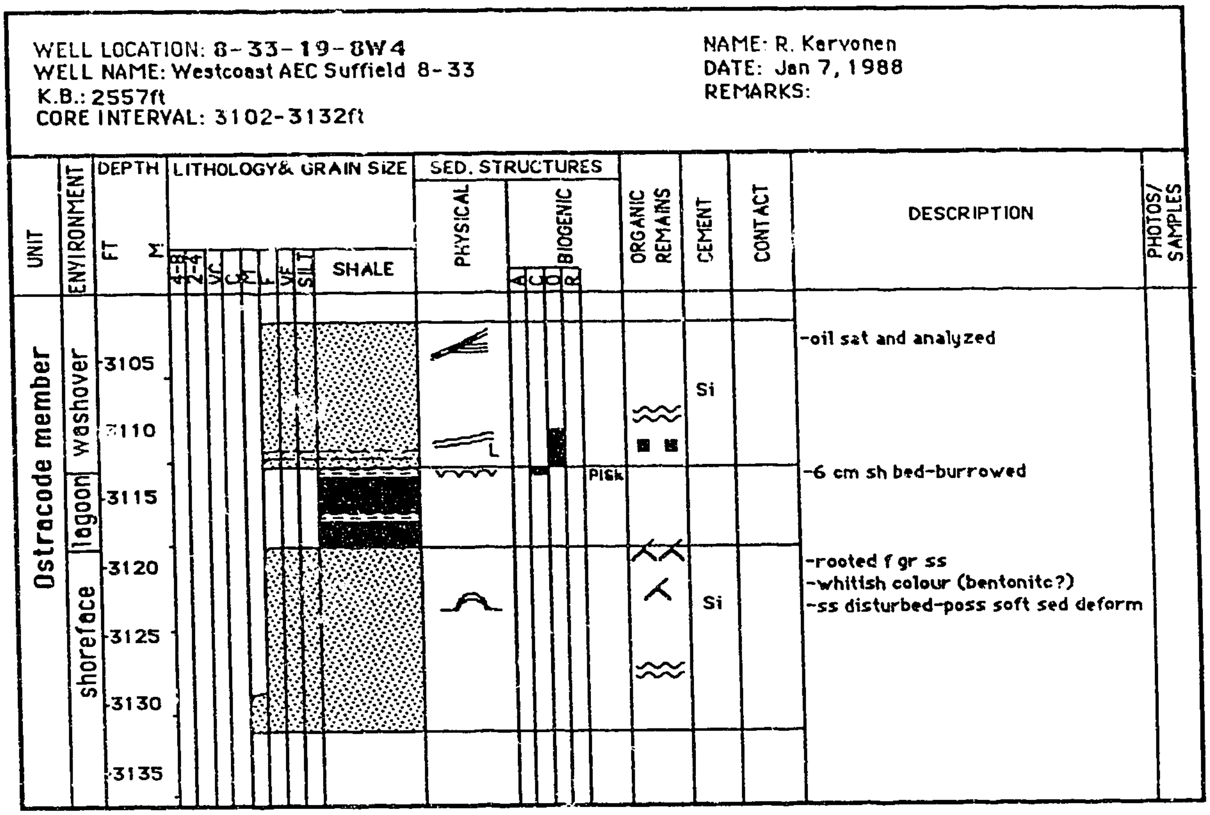
NAME: R. Karvonen
DATE: March 25, 1988
REMARKS:

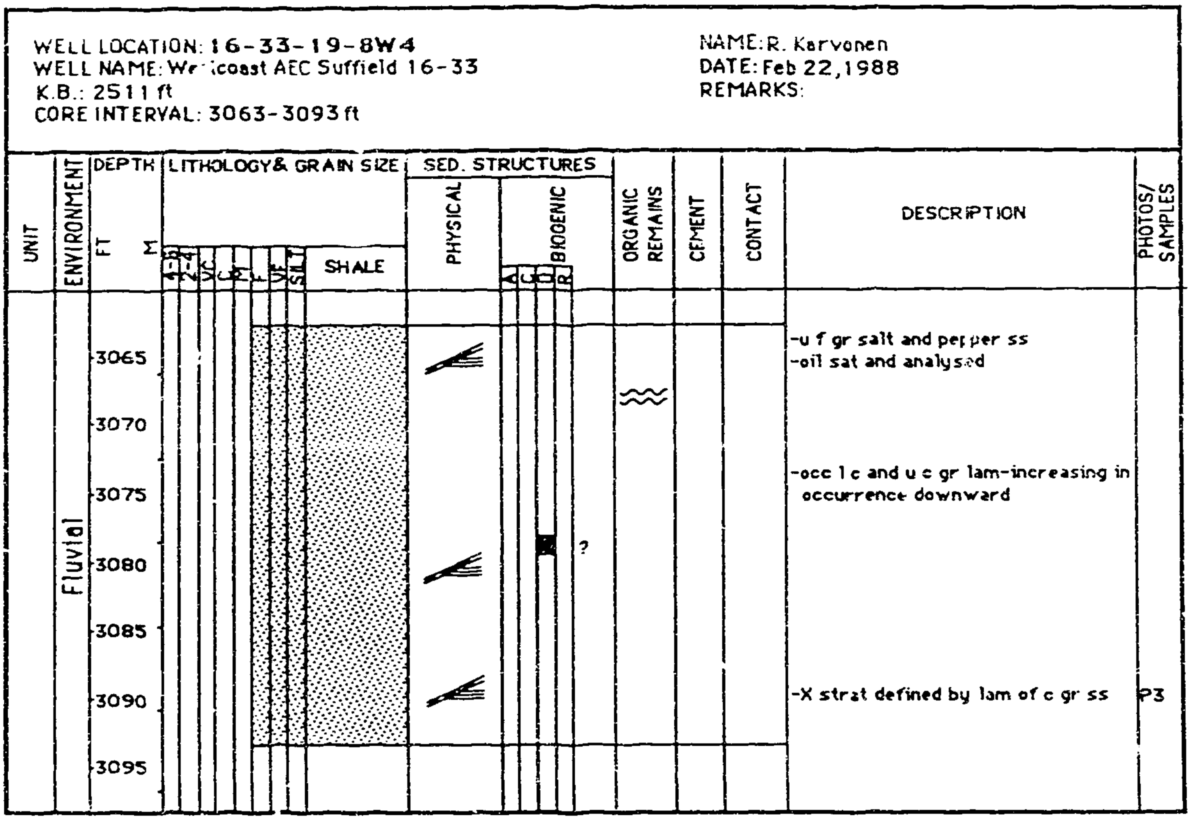


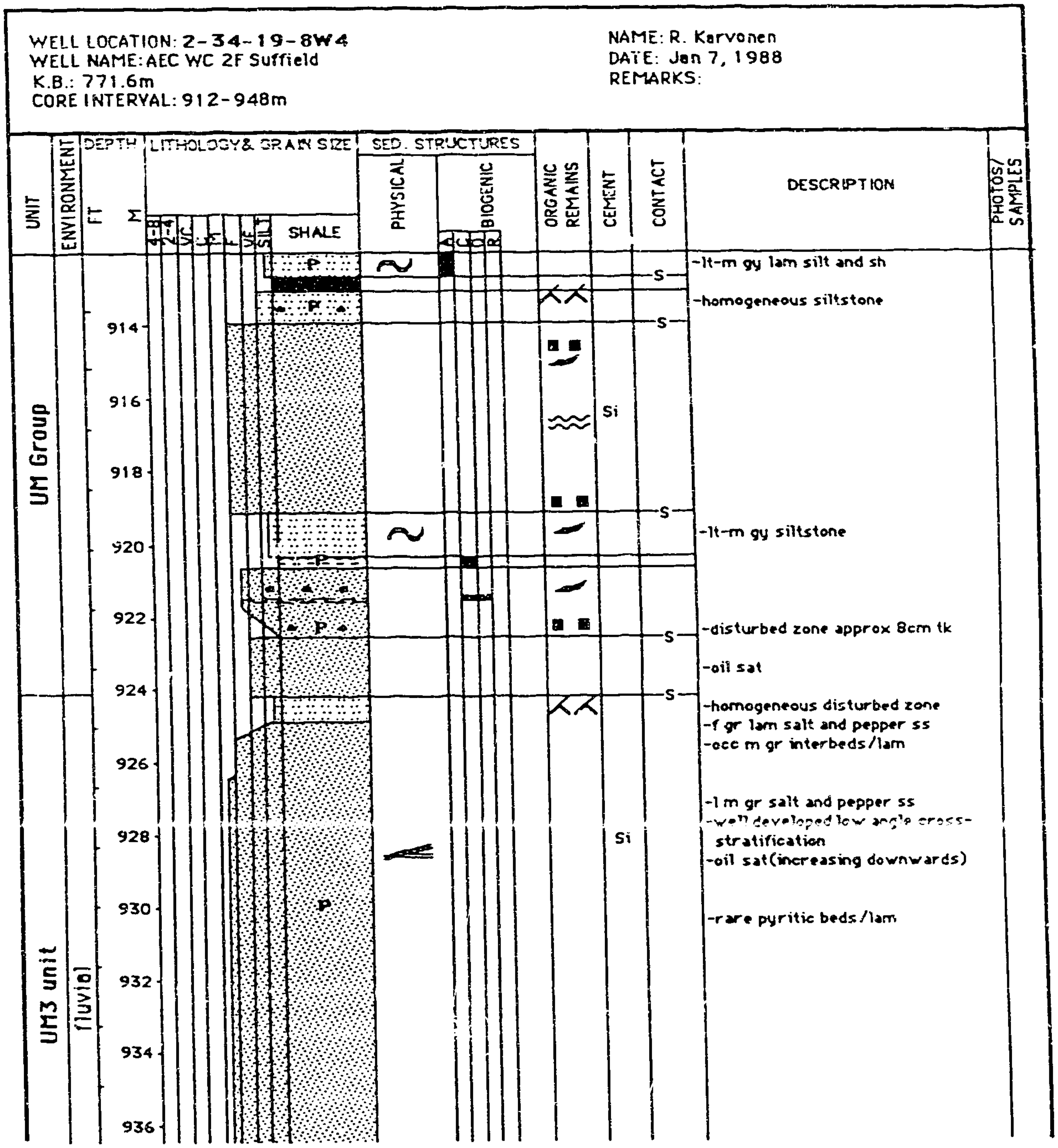
WELL LOCATION: **108-27-19-8W4**
WELL NAME: AEC WC 10B Suffield 10-27
K.B.: 764.8m
CORE INTERVAL: 908-932m

NAME: R. Kar\'\.cn
DATE: Feb 23, 1988
REMARKS: Slabbed core



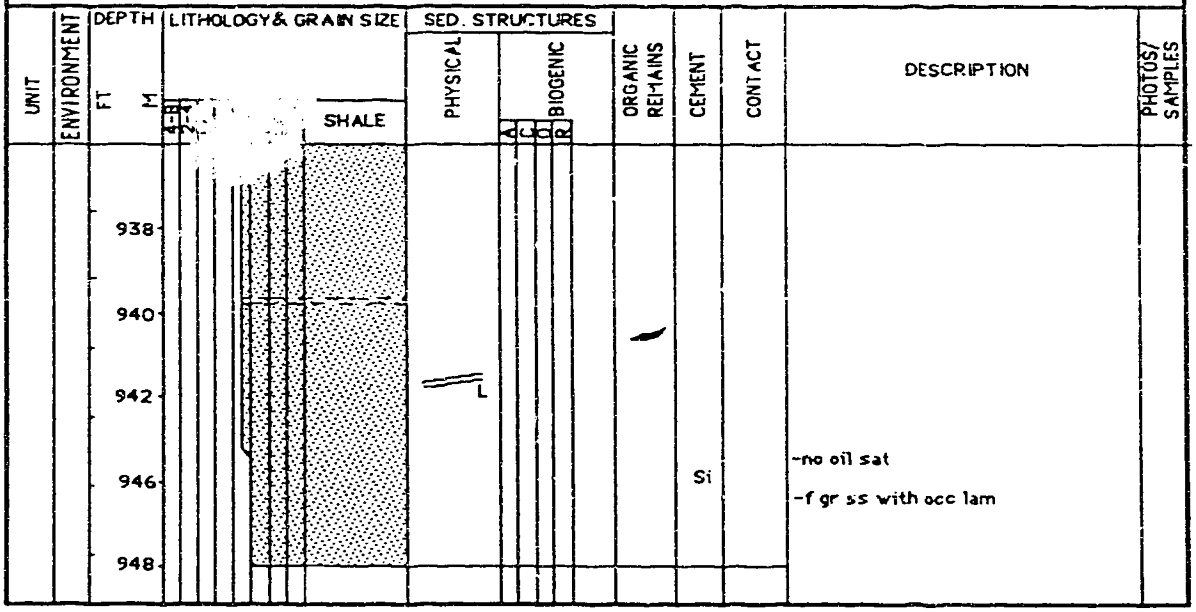

WELL LOCATION: 8-33-19-8W4
WELL NAME: Westcoast AEC Suffield 8-33
K.B.: 2557ft
CORE INTERVAL: 3102-3132ft
NAME: R. Karvonen
DATE: Jan 7, 1988
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
VC
C
M
F
VF
SILT
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
A
C
O
R
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
Ostracode member
washover
lagoon
shoreface
3105
3110
3115
3120
3125
3130
3135
L
Pisk
Si
Si
-oil sat and analyzed
-6 cm sh bed-burrowed
-rooted f gr ss
-whitish colour (bentonite?)
-ss disturbed-poss soft sed deform


WELL LOCATION: 16-33-19-8W4
WELL NAME: Wr·:coast AEC Suffield 16-33
K.B.: 2511 ft
CORE INTERVAL: 3063-3093 ft
NAME: R. Karvonen
DATE: Feb 22, 1988
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/SAMPLES
Fluvial
3065
3070
3075
3080
3085
3090
3095
?
-u f gr salt and pepper ss
-oil sat and analysed
-occ l c and u c gr lam-increasing in occurrence downward
-X strat defined by lam of c gr ss
P3


WELL LOCATION: 2-34-19-8W4
WELL NAME: AEC WC 2F Suffield
K.B.: 771.6m
CORE INTERVAL: 912-948m
NAME: R. Karvonen
DATE: Jan 7, 1988
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
UM Group
UM3 unit
fluvial
914
916
918
920
922
924
926
928
930
932
934
936
Si
Si
S
-lt-m gy lam silt and sh
-homogeneous siltstone
-lt-m gy siltstone
-disturbed zone approx 8cm tk
-oil sat
-homogeneous disturbed zone
-f gr lam salt and pepper ss
-occ m gr interbeds/lam
-l m gr salt and pepper ss
-well developed low angle cross-stratification
-oil sat(increasing downwards)
-rare pyritic beds/lam

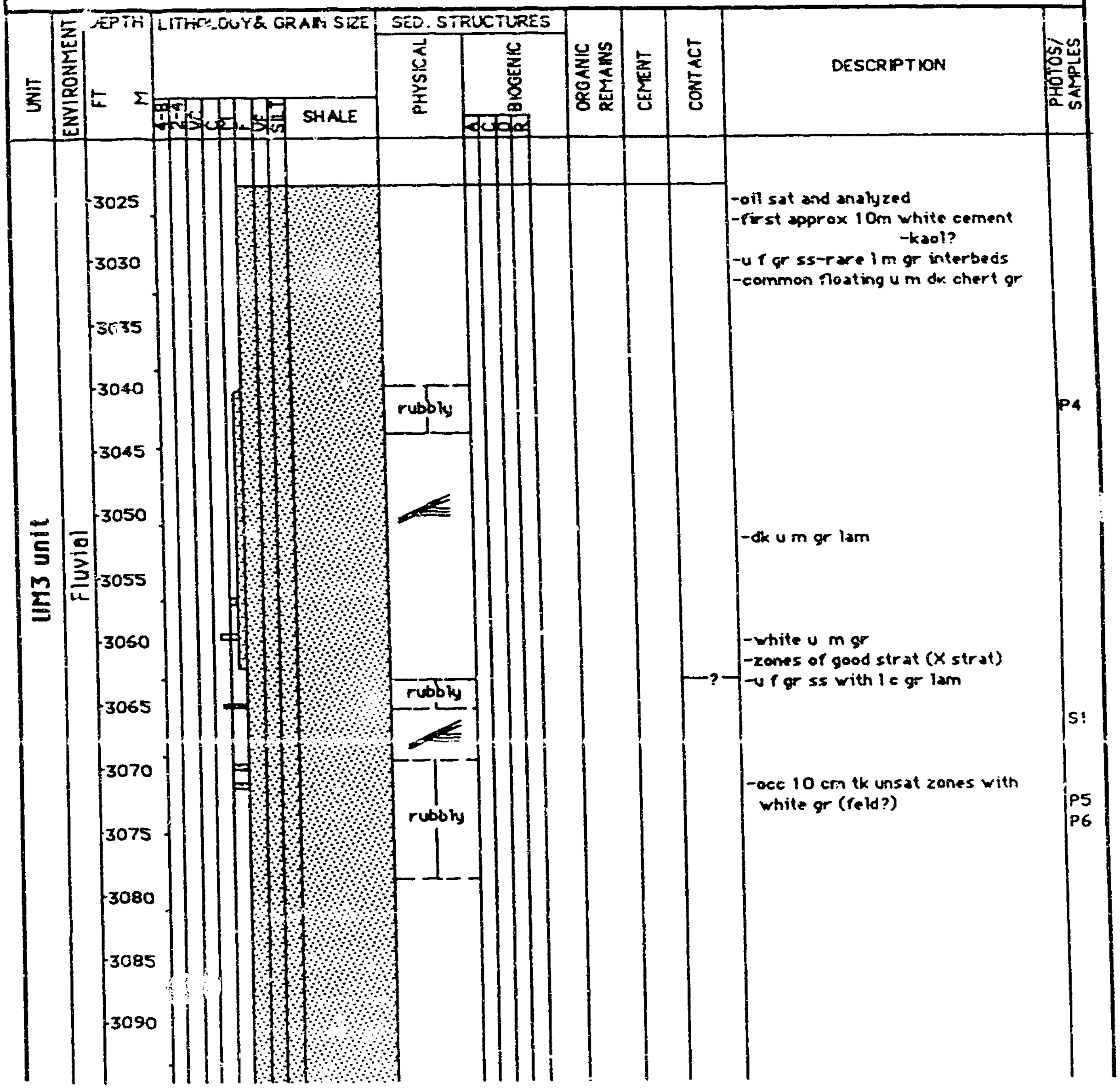
WELL LOCATION. 2-34-19-8W4(cont'd)
WELL NAME:
K.B.:
CORE INTERVAL:

NAME: R. Karvonen
DATE: Jan 7, 1988
REMARKS:



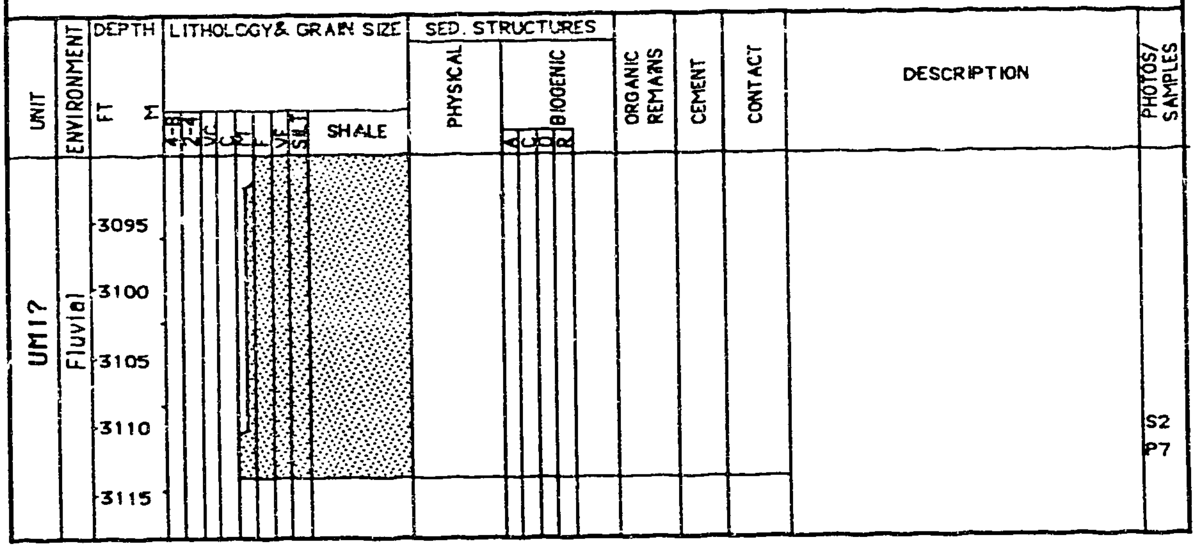
WELL LOCATION: 6-34-19-8W4
WELL NAME: Westcoast AEC Suffield 6-34M
K.B.: 252[illegible]
CORE INTERVAL: 3024-3114 ft

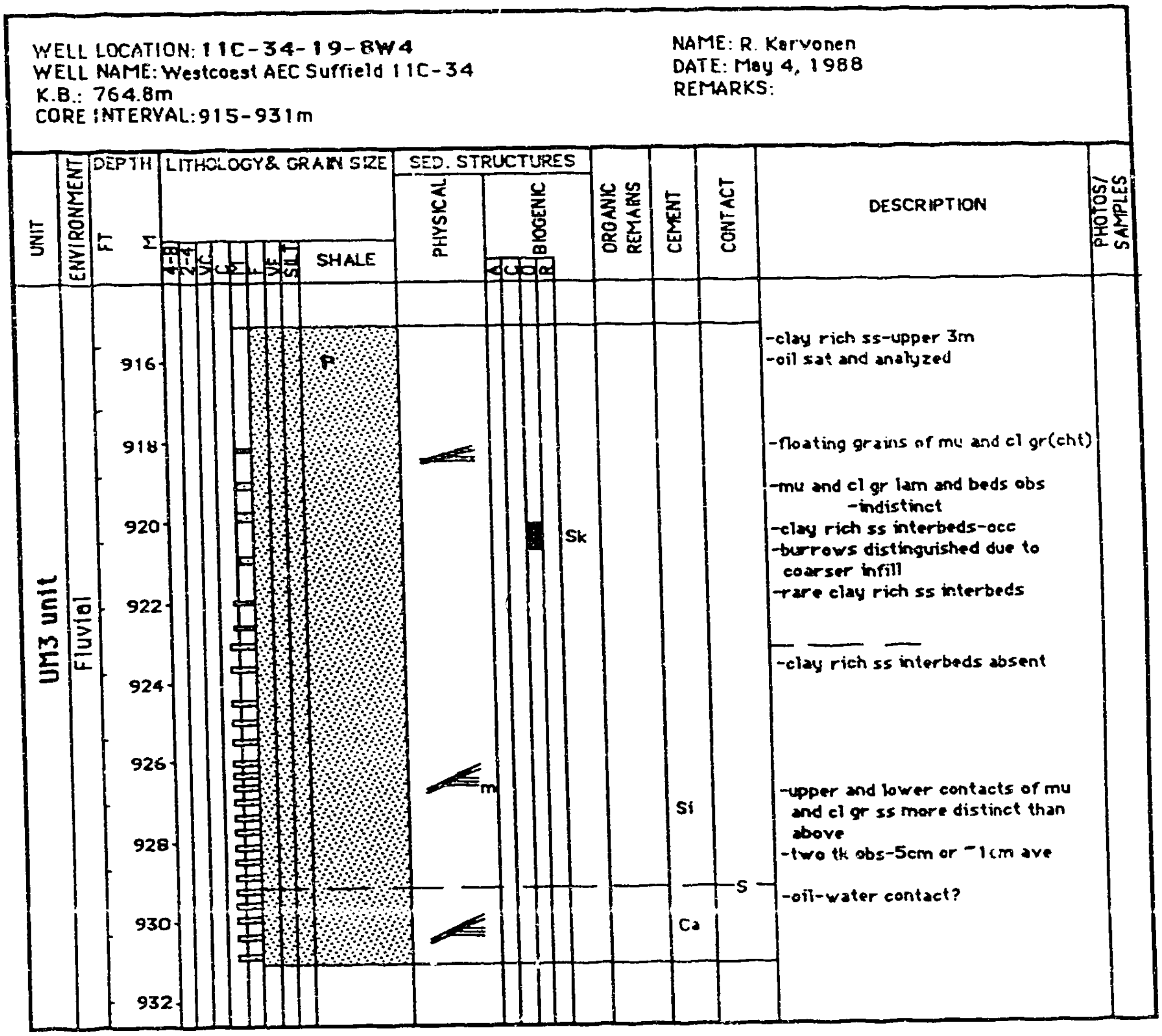
NAME: R. Karvonen
DATE: Feb 22, 1988
REMARKS: V rubbly in places
high % of wht gr-alt chert/feld?

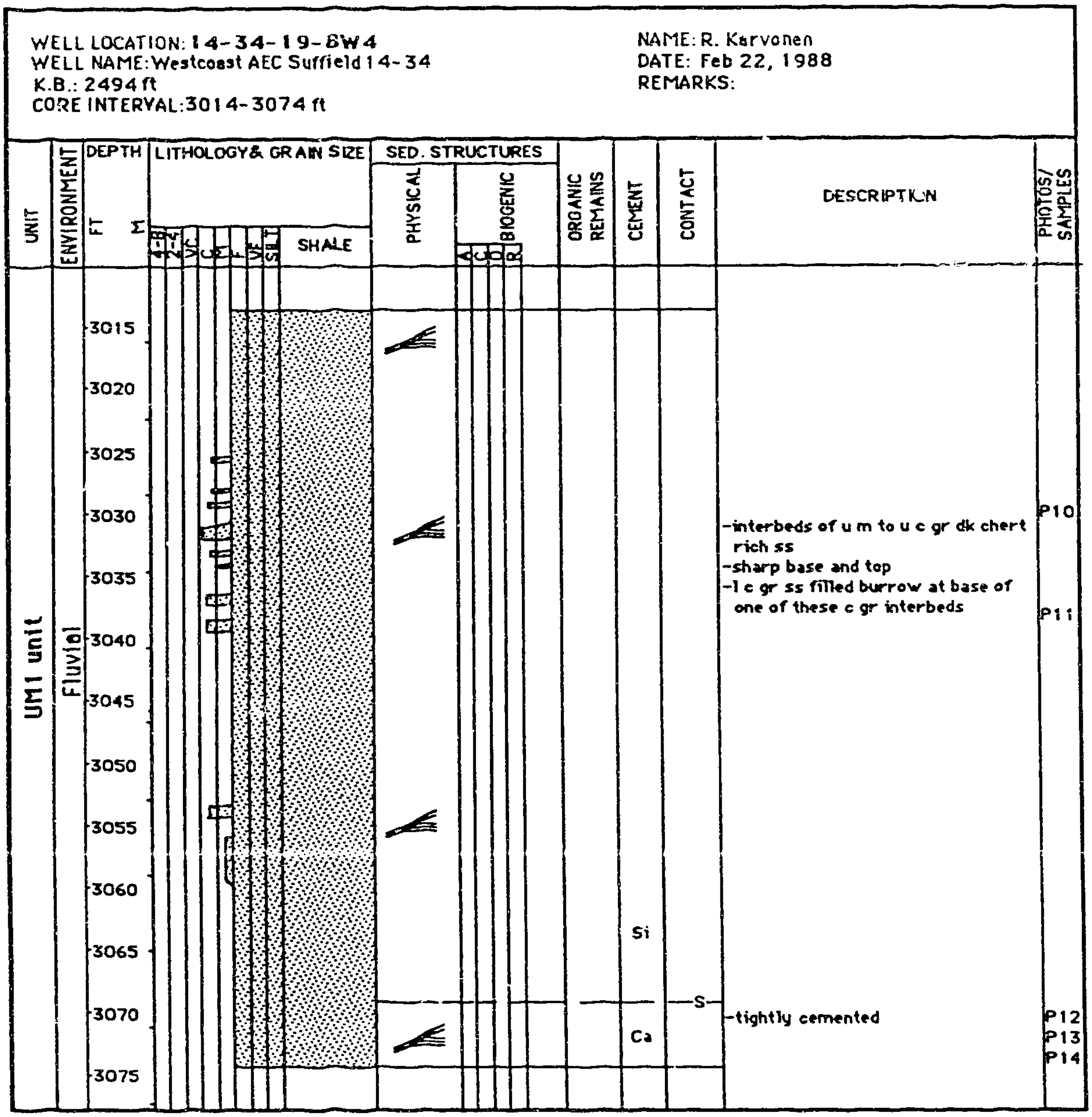


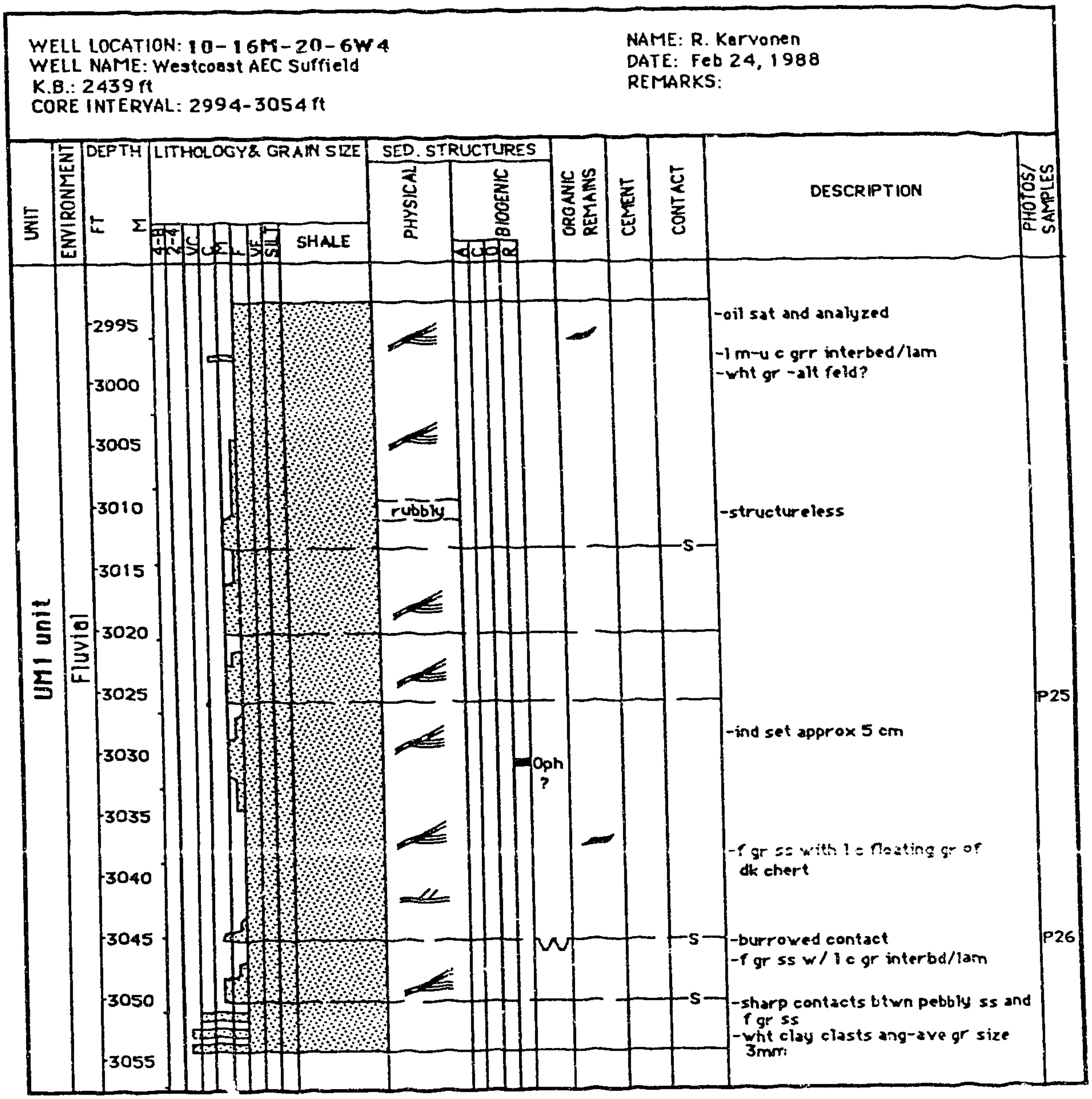
WELL LOCATION: 6-34-19-8W4(cont'd)
WELL NAME:
K.B.:
CORE INTERVAL: 3024-3114ft

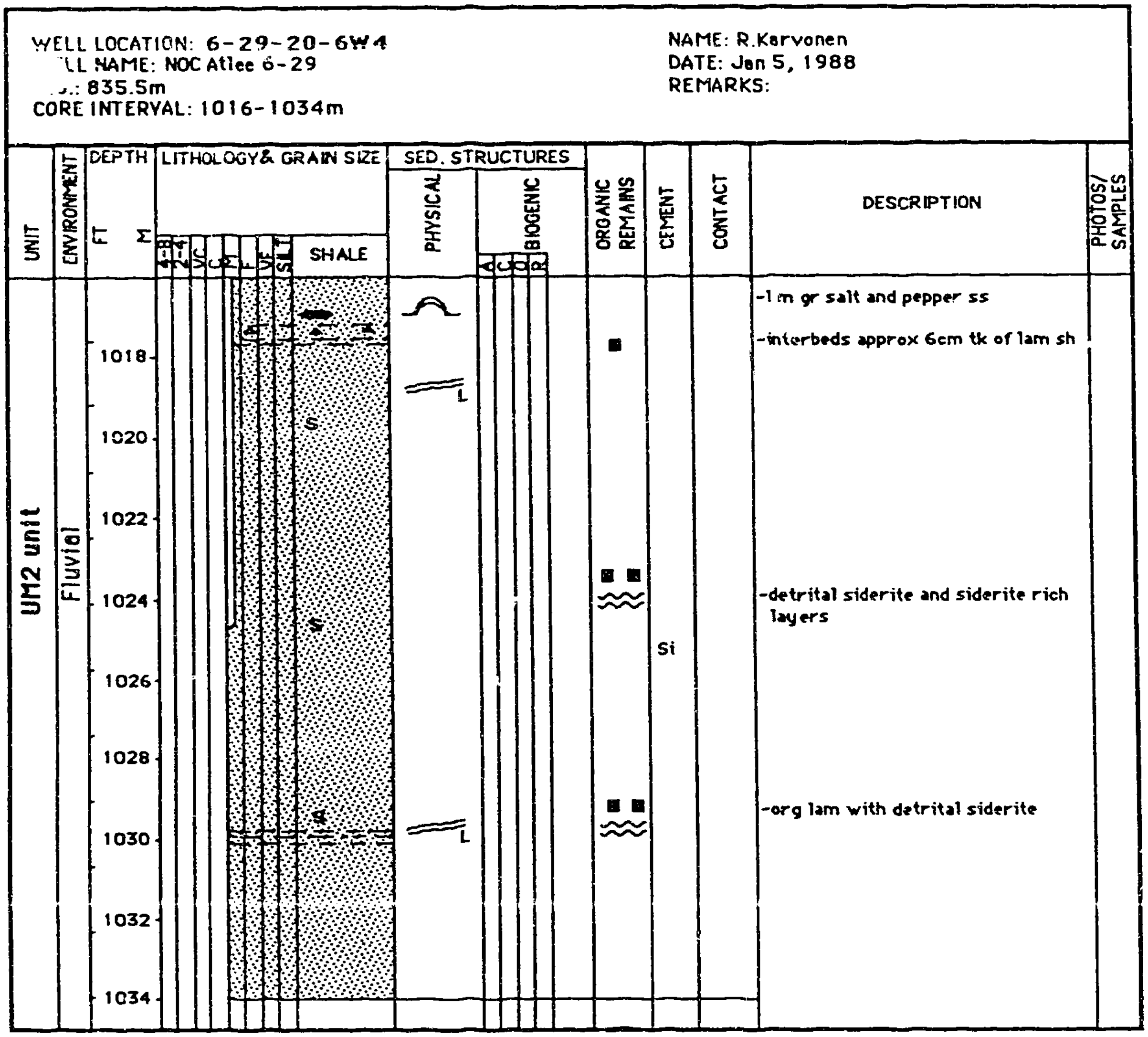
NAME:
DATE:
REMARKS:

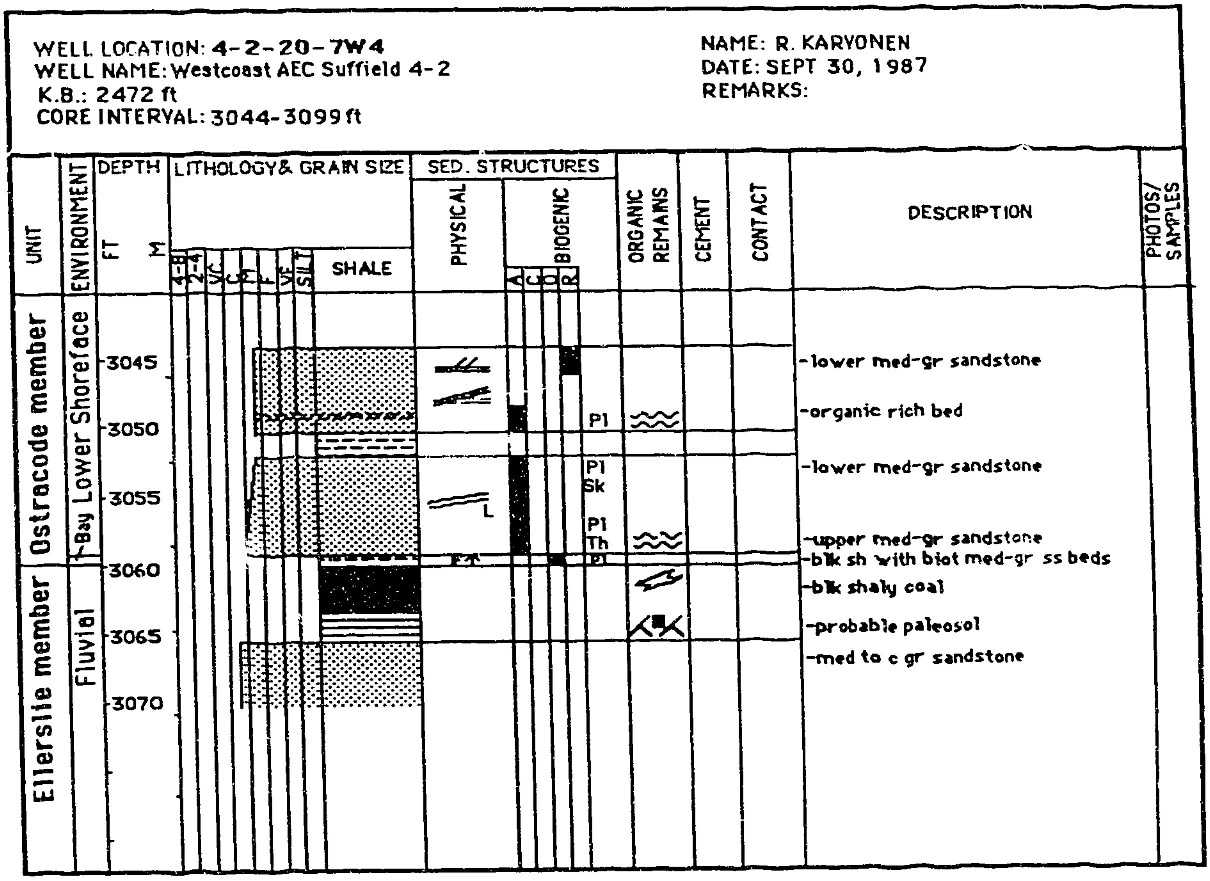


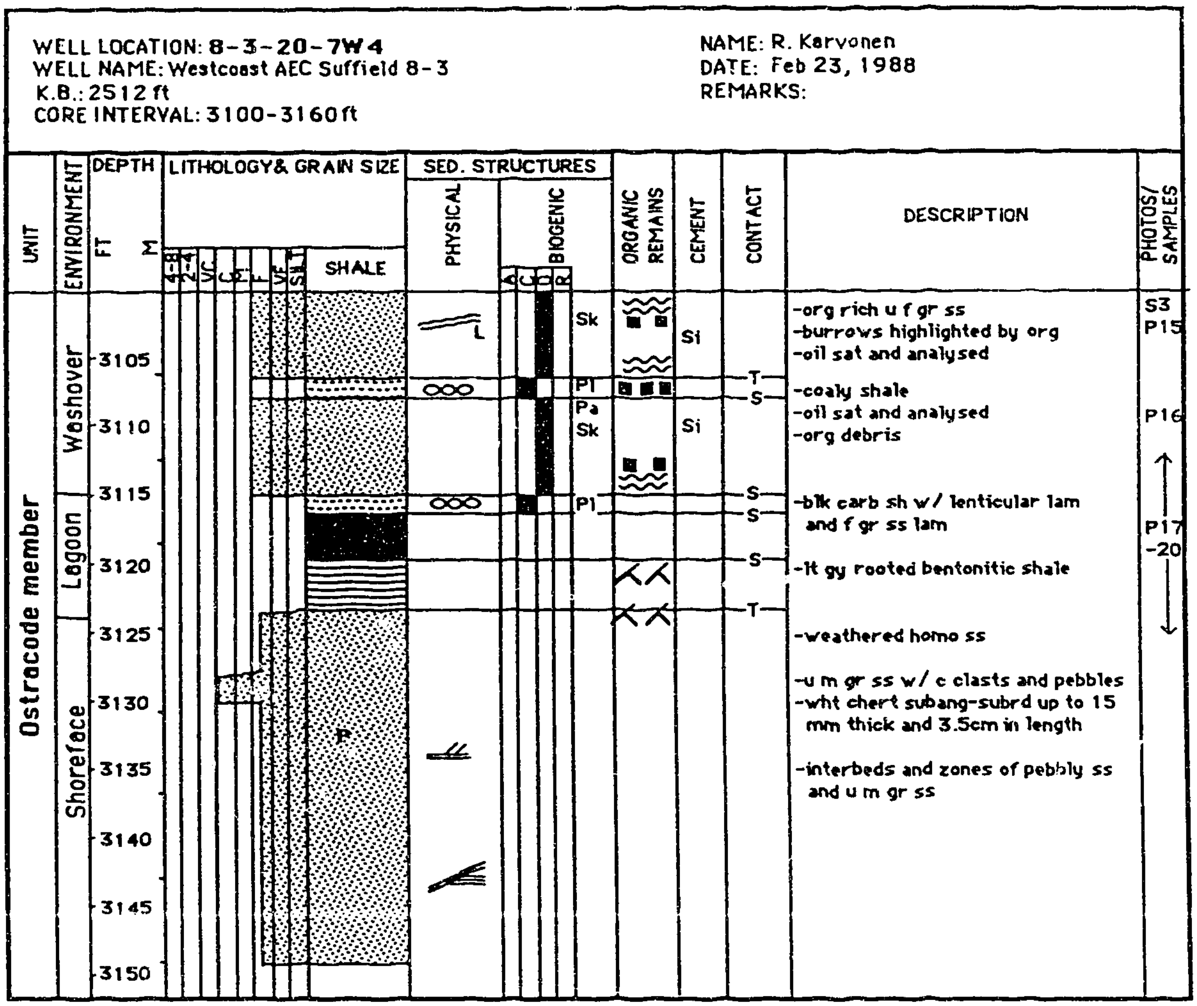

WELL LOCATION: 11C-34-19-8W4
WELL NAME: Westcoest AEC Suffield 11C-34
K.B.: 764.8m
CORE INTERVAL: 915-931m
NAME: R. Karvonen
DATE: May 4, 1988
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
UM3 unit
Fluvial
916
918
920
922
924
926
928
930
932
Sk
Si
Ca
S
-clay rich ss-upper 3m
-oil sat and analyzed
-floating grains of mu and cl gr(cht)
-mu and cl gr lam and beds obs
-indistinct
-clay rich ss interbeds-occ
-burrows distinguished due to coarser infill
-rare clay rich ss interbeds
-clay rich ss interbeds absent
-upper and lower contacts of mu and cl gr ss more distinct than above
-two tk obs-5cm or ~1cm ave
-oil-water contact?

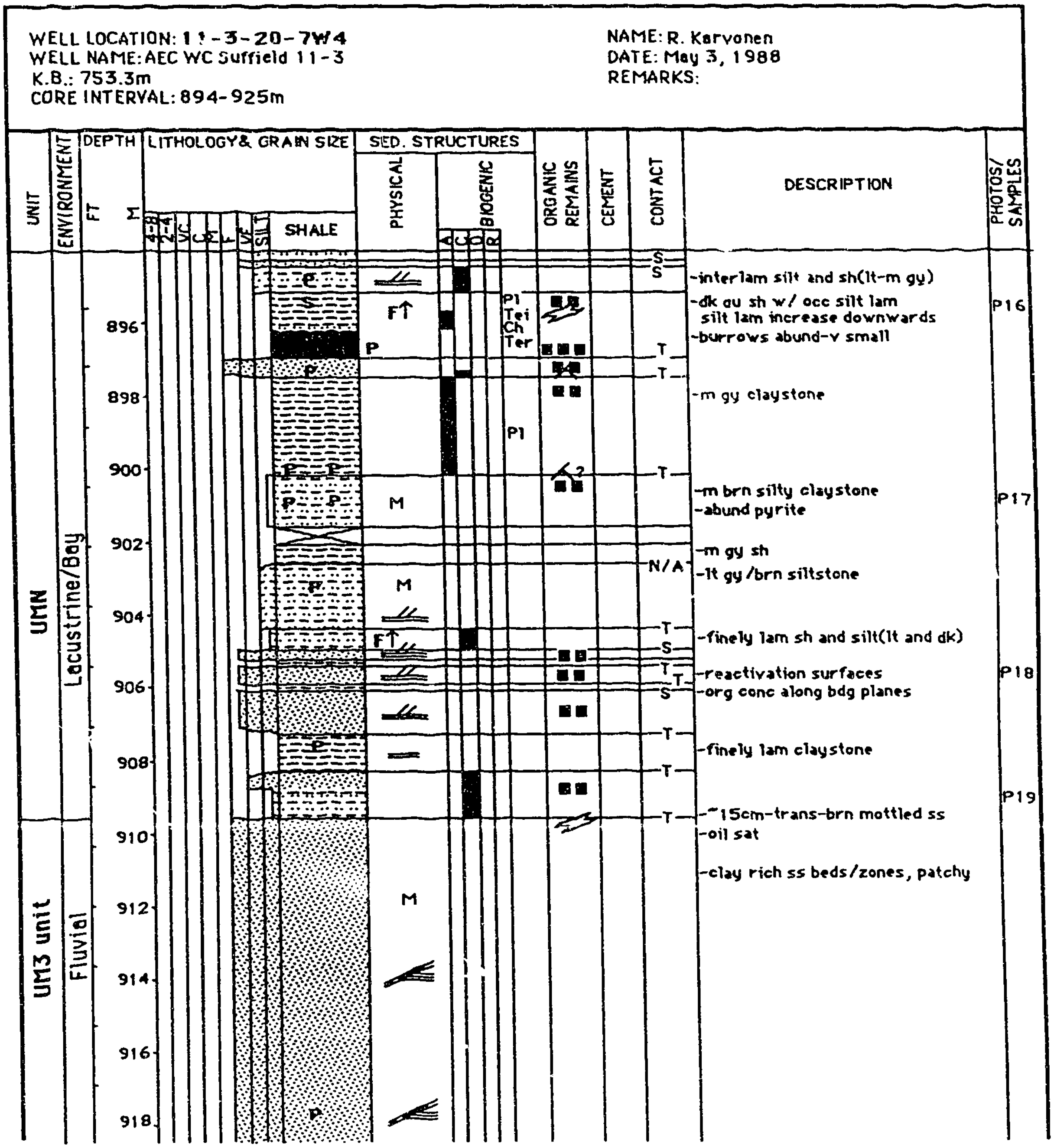

WELL LOCATION: 14-34-19-8W4
WELL NAME: Westcoast AEC Suffield 14-34
K.B.: 2494 ft
CORE INTERVAL: 3014-3074 ft
NAME: R. Karvonen
DATE: Feb 22, 1988
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT M
LITHOLOGY & GRAIN SIZE
4-8
2-4
VC
C
M
F
VF
SILT
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
A
C
O
R
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
UM1 unit
Fluvial
3015
3020
3025
3030
3035
3040
3045
3050
3055
3060
3065
3070
3075
-interbeds of u m to u c gr dk chert rich ss
-sharp base and top
-1 c gr ss filled burrow at base of one of these c gr interbeds
P10
P11
Si
S
-tightly cemented
Ca
P12
P13
P14

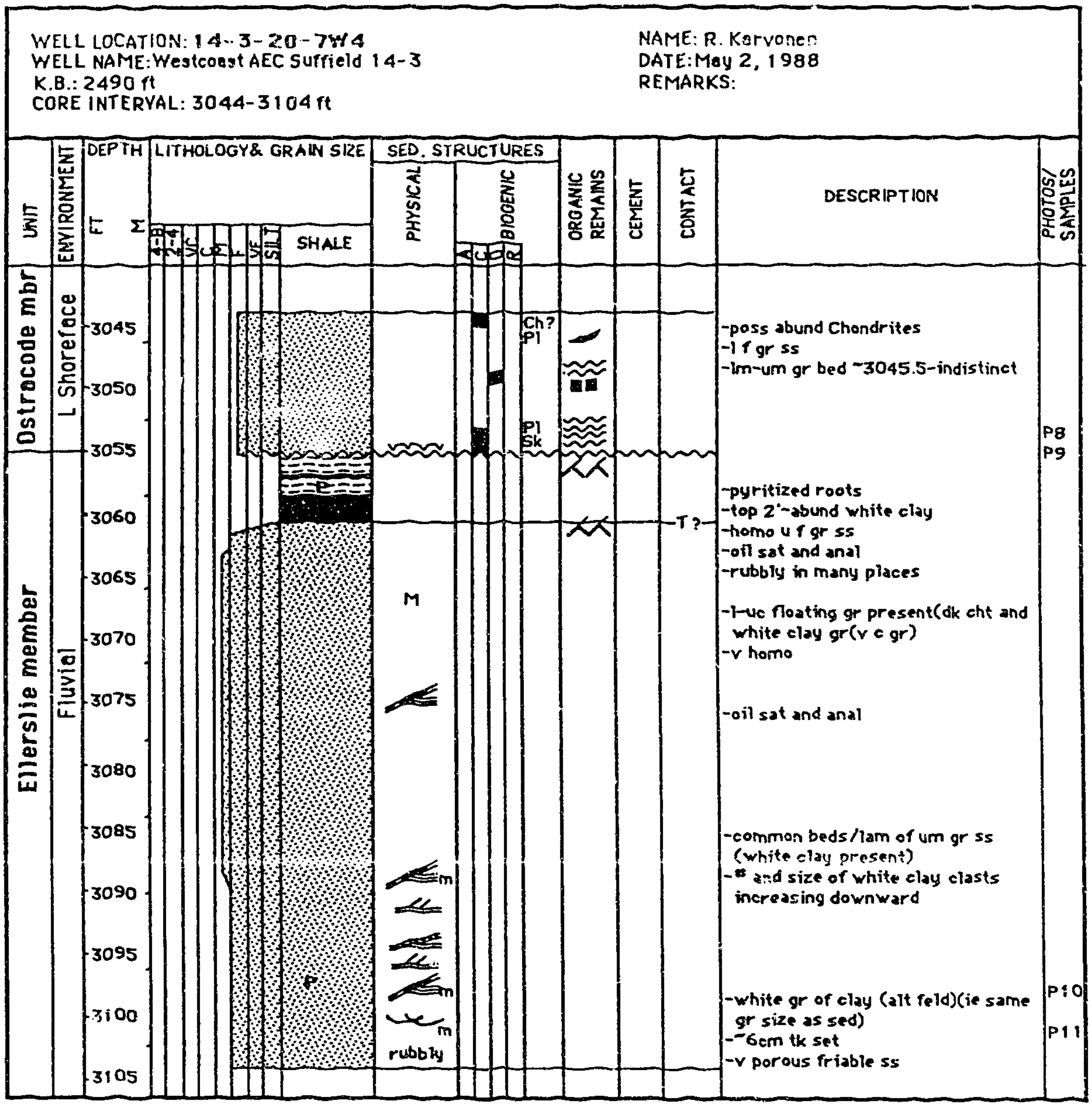

WELL LOCATION: 10-16M-20-6W4
WELL NAME: Westcoast AEC Suffield
K.B.: 2439 ft
CORE INTERVAL: 2994-3054 ft
NAME: R. Karvonen
DATE: Feb 24, 1988
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY& GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
UM1 unit
Fluvial
2995
3000
3005
3010
3015
3020
3025
3030
3035
3040
3045
3050
3055
rubbly
Oph ?
S
S
S
-oil sat and analyzed
-1 m-u c grr interbed/lam
-wht gr -alt feld?
-structureless
-ind set approx 5 cm
-f gr ss with 1 c floating gr of dk chert
-burrowed contact
-f gr ss w/ 1 c gr interbd/lam
-sharp contacts btwn pebbly ss and f gr ss
-wht clay clasts ang-ave gr size 3mm
P25
P26

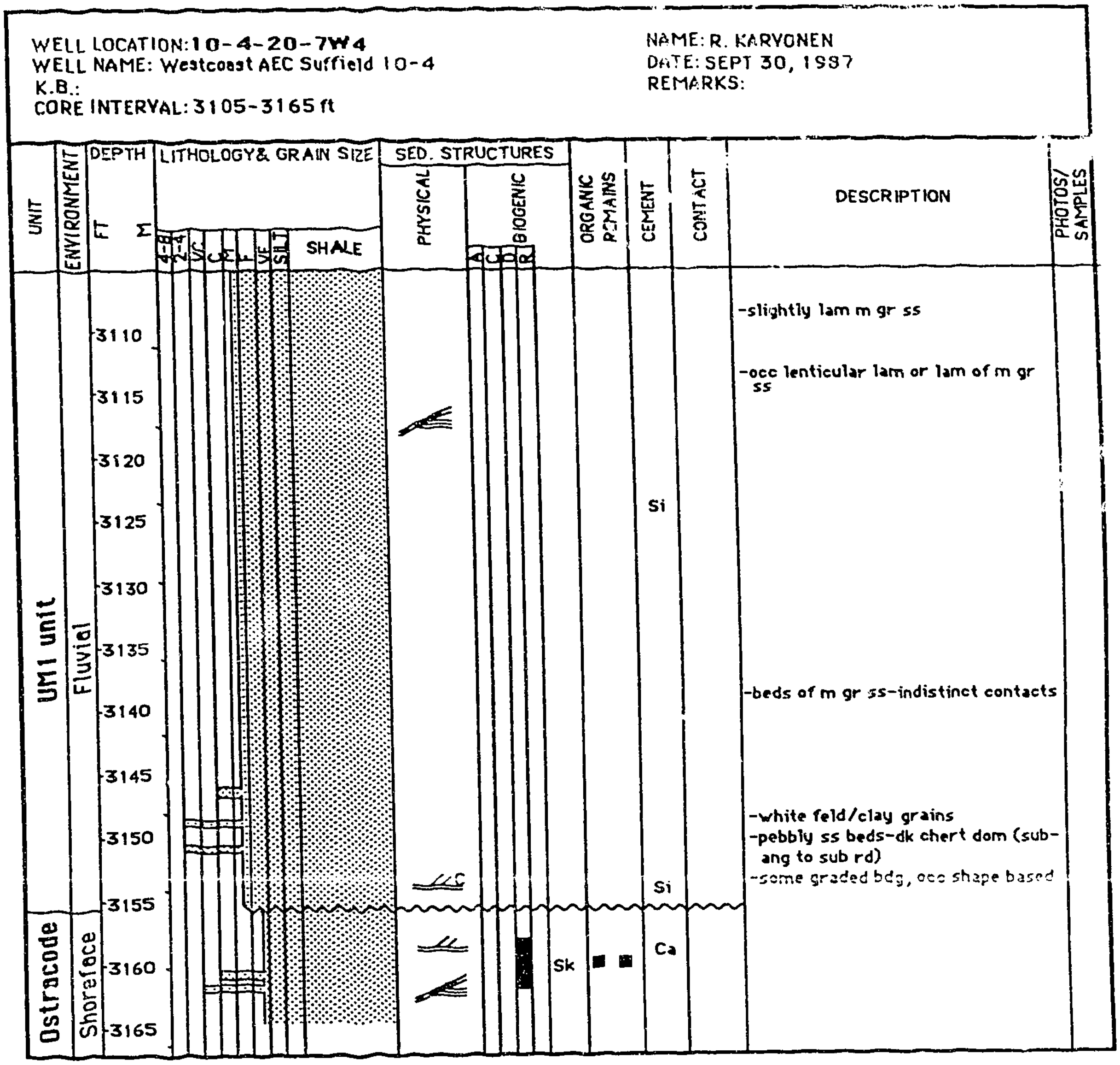

WELL LOCATION: 6-29-20-6W4
LL NAME: NOC Atlee 6-29
: 835.5m
CORE INTERVAL: 1016-1034m
NAME: R.Karvonen
DATE: Jan 5, 1988
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT M
LITHOLOGY & GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
UM2 unit
Fluvial
1018
1020
1022
1024
1026
1028
1030
1032
1034
Si
-1 m gr salt and pepper ss
-interbeds approx 6cm tk of lam sh
-detrital siderite and siderite rich layers
-org lam with detrital siderite

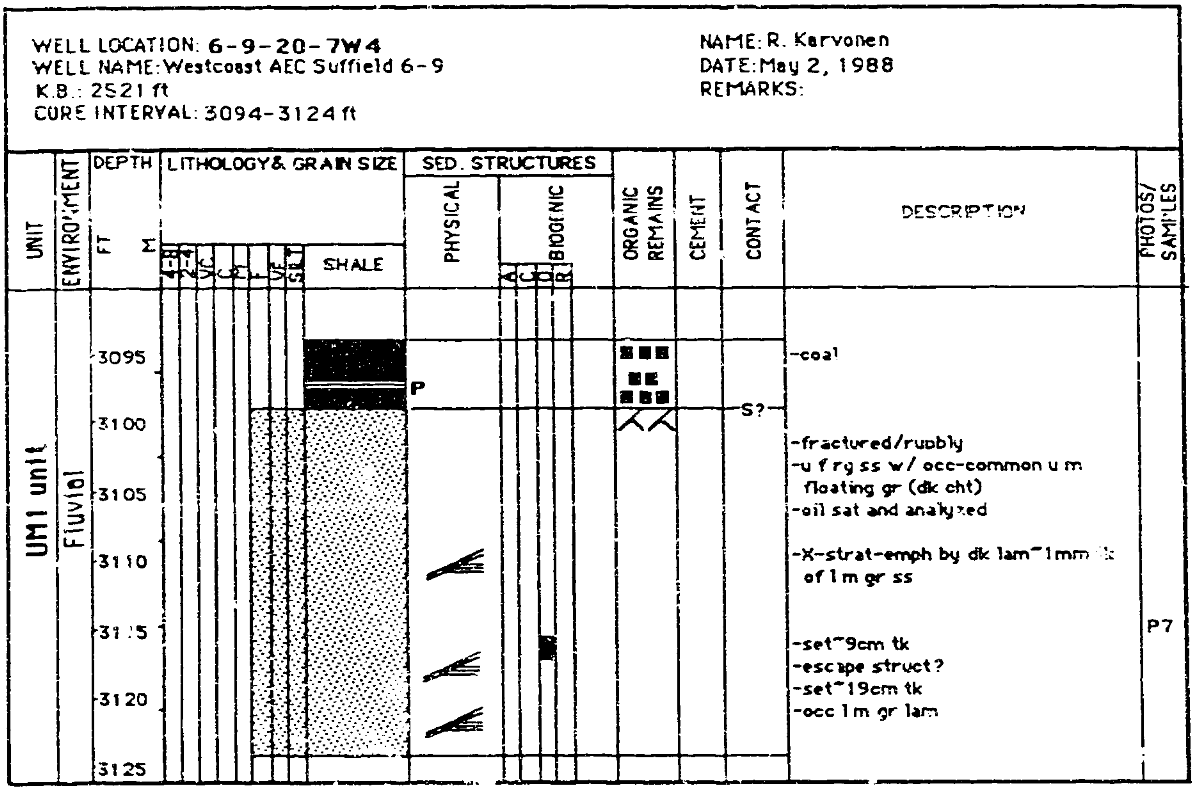

WELL LOCATION: 4-2-20-7W4
WELL NAME: Westcoast AEC Suffield 4-2
K.B.: 2472 ft
CORE INTERVAL: 3044-3099 ft
NAME: R. KARVONEN
DATE: SEPT 30, 1987
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
Ostracode member
Ellerslie member
Bay
Lower Shoreface
Fluvial
3045
3050
3055
3060
3065
3070
Pl
Sk
Th
-lower med-gr sandstone
-organic rich bed
-lower med-gr sandstone
-upper med-gr sandstone
-blk sh with biot med-gr ss beds
-blk shaly coal
-probable paleosol
-med to c gr sandstone

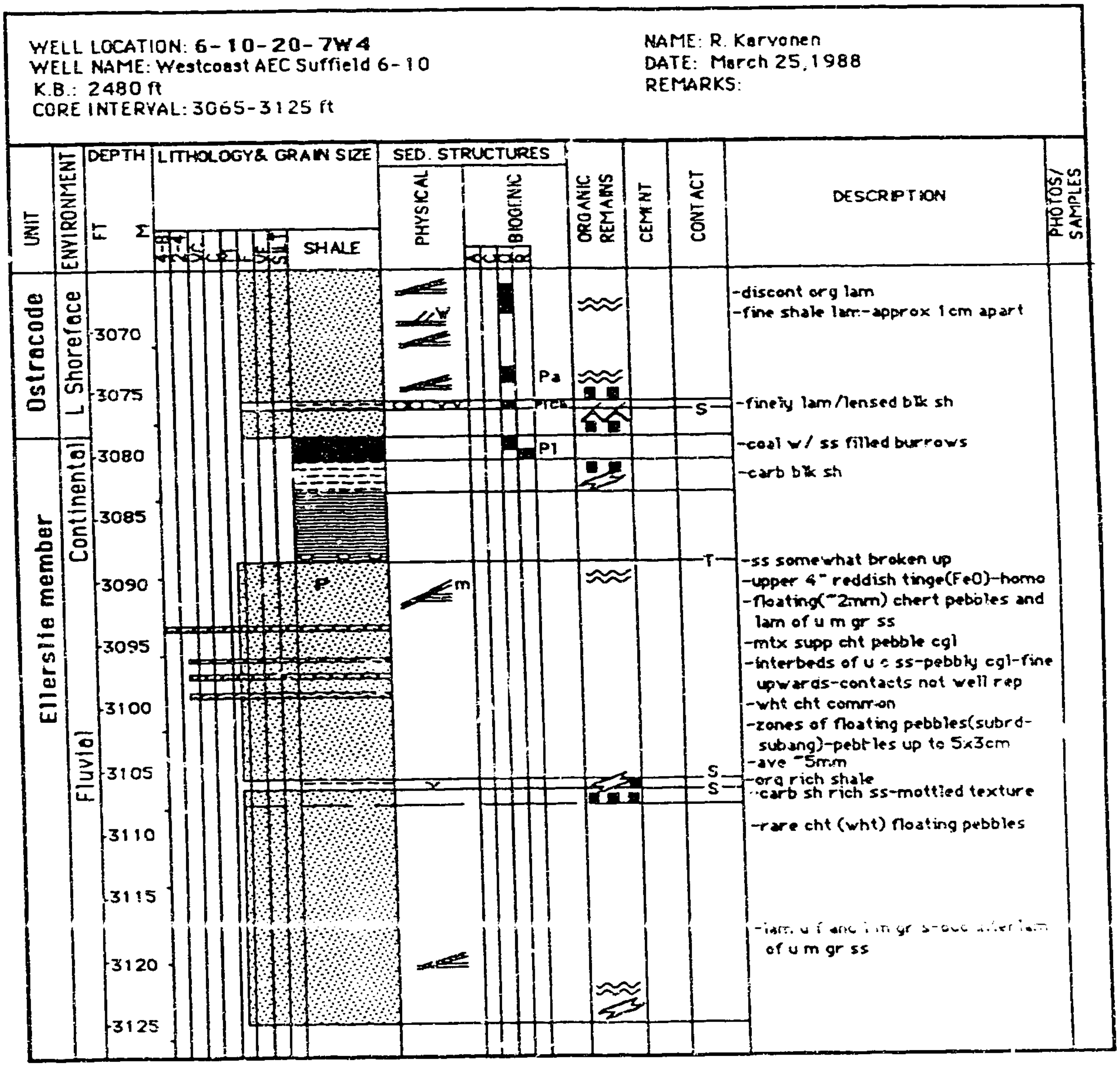

WELL LOCATION: 8-3-20-7W4
WELL NAME: Westcoast AEC Suffield 8-3
K.B.: 2512 ft
CORE INTERVAL: 3100-3160ft
NAME: R. Karvonen
DATE: Feb 23, 1988
REMARKS:
UNIT
ENVIRONMENT
DEPTH FT M
LITHOLOGY & GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
Ostracode member
Washover
Lagoon
Shoreface
3105
3110
3115
3120
3125
3130
3135
3140
3145
3150
Sk
Pl
Pa
Sk
Pl
Si
Si
T
S
S
S
S
T
-org rich u f gr ss
-burrows highlighted by org
-oil sat and analysed
-coaly shale
-oil sat and analysed
-org debris
-blk carb sh w/ lenticular lam and f gr ss lam
-lt gy rooted bentonitic shale
-weathered homo ss
-u m gr ss w/ c clasts and pebbles
-wht chert subang-subrd up to 15 mm thick and 3.5cm in length
-interbeds and zones of pebbly ss and u m gr ss
S3
P15
P16
P17
-20

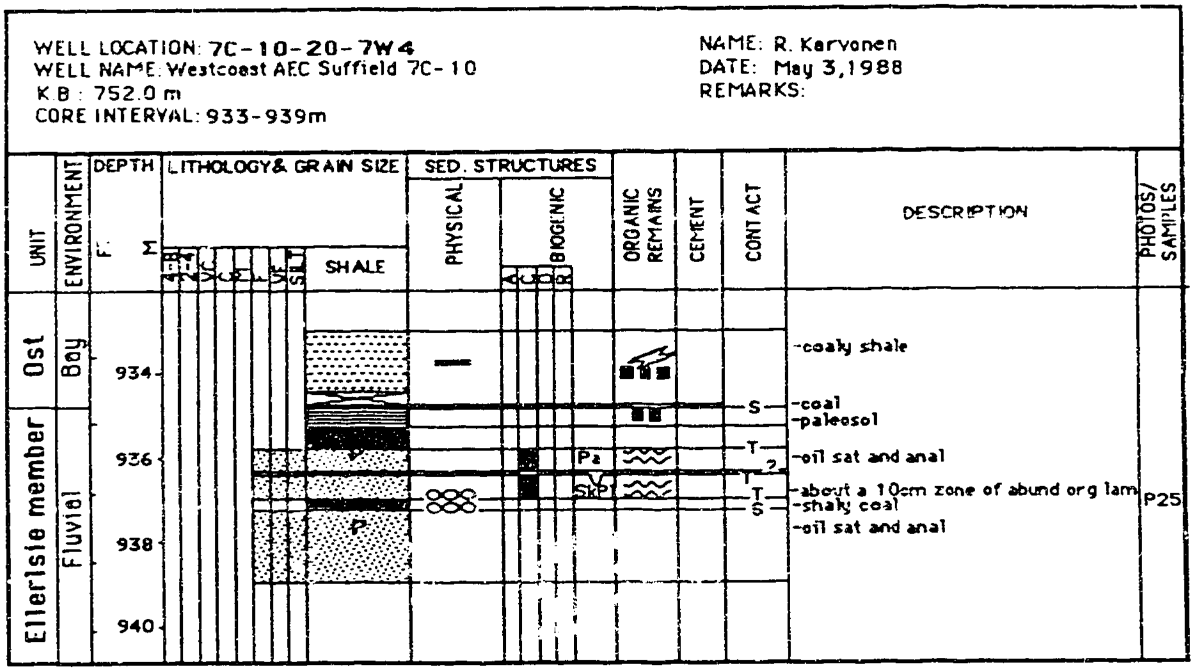

WELL LOCATION: 11-3-20-7W4
WELL NAME: AEC WC Suffield 11-3
K.B.: 753.3m
CORE INTERVAL: 894-925m
NAME: R. Karvonen
DATE: May 3, 1988
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
896
898
900
902
904
906
908
910
912
914
916
918
UMN
Lacustrine/Bay
UM3 unit
Fluvial
-interlam silt and sh(lt-m gy)
-dk gy sh w/ occ silt lam
silt lam increase downwards
-burrows abund-v small
-m gy claystone
-m brn silty claystone
-abund pyrite
-m gy sh
-lt gy/brn siltstone
-finely lam sh and silt(lt and dk)
-reactivation surfaces
-org conc along bdg planes
-finely lam claystone
-~15cm-trans-brn mottled ss
-oil sat
-clay rich ss beds/zones, patchy
P16
P17
P18
P19
Pl
Tei
Ch
Ter
M
N/A

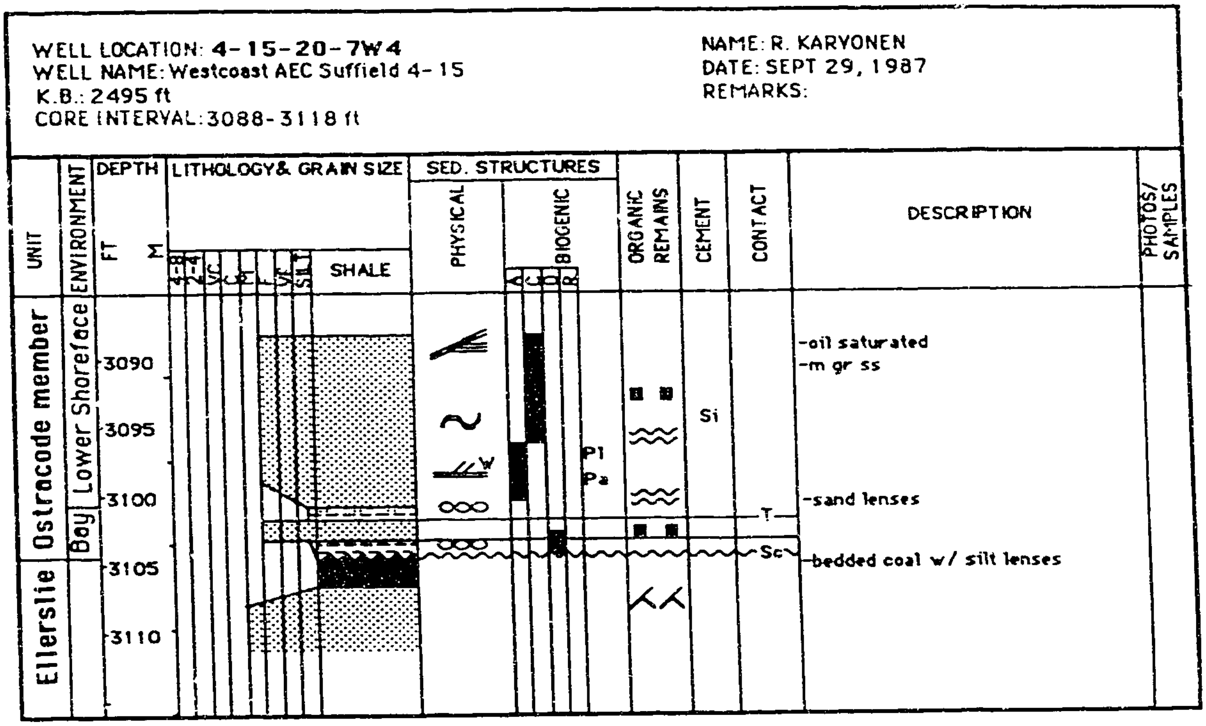

WELL LOCATION: 14-3-20-7W4
WELL NAME: Westcoast AEC Suffield 14-3
K.B.: 2490 ft
CORE INTERVAL: 3044-3104 ft
NAME: R. Karvonen
DATE: May 2, 1988
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT M
LITHOLOGY & GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
Ostracode mbr
L Shoreface
Ellerslie member
Fluvial
3045
3050
3055
3060
3065
3070
3075
3080
3085
3090
3095
3100
3105
Ch?
Pl
Sk
M
m
rubbly
T?
-poss abund Chondrites
-l f gr ss
-lm-um gr bed ~3045.5-indistinct
-pyritized roots
-top 2'-abund white clay
-homo u f gr ss
-oil sat and anal
-rubbly in many places
-l-uc floating gr present(dk cht and white clay gr(v c gr)
-v homo
-oil sat and anal
-common beds/lam of um gr ss (white clay present)
-# and size of white clay clasts increasing downward
-white gr of clay (alt feld)(ie same gr size as sed)
-~6cm tk set
-v porous friable ss
P8
P9
P10
P11


WELL LOCATION: 10-4-20-7W4
WELL NAME: Westcoast AEC Suffield 10-4
K.B.:
CORE INTERVAL: 3105-3165 ft
NAME: R. KARYONEN
DATE: SEPT 30, 1987
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
UM1 unit
Fluvial
Ostracode
Shoreface
3110
3115
3120
3125
3130
3135
3140
3145
3150
3155
3160
3165
Si
Si
Ca
Sk
-slightly lam m gr ss
-occ lenticular lam or lam of m gr ss
-beds of m gr ss-indistinct contacts
-white feld/clay grains
-pebbly ss beds-dk chert dom (sub-ang to sub rd)
-some graded bdg, occ shape based


WELL LOCATION: 6-9-20-7W4
WELL NAME: Westcoast AEC Suffield 6-9
K.B.: 2521 ft
CORE INTERVAL: 3094-3124 ft
NAME: R. Karvonen
DATE: May 2, 1988
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
UM1 unit
Fluvial
3095
3100
3105
3110
3120
3125
P
S?
-coal
-fractured/rubbly
-u f rg ss w/ occ-common u m floating gr (dk cht)
-oil sat and analyzed
-X-strat-emph by dk lam~1mm
of 1 m gr ss
-set~9cm tk
-escape struct?
-set~19cm tk
-occ 1 m gr lam
P7

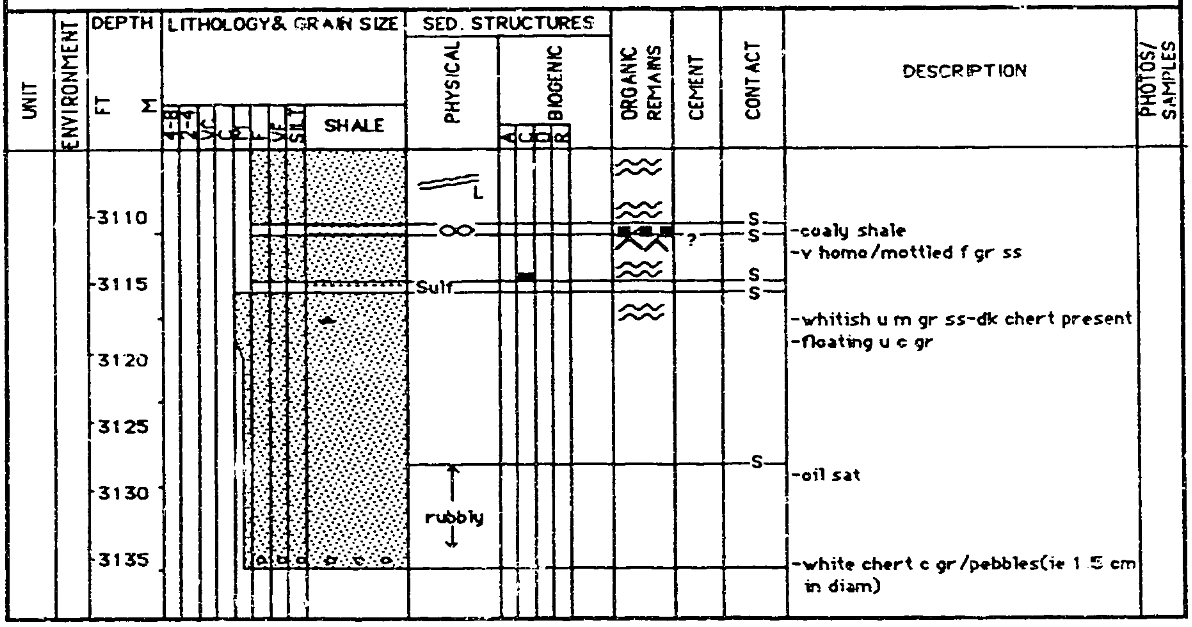

WELL LOCATION: 6-10-20-7W4
WELL NAME: Westcoast AEC Suffield 6-10
K.B.: 2480 ft
CORE INTERVAL: 3065-3125 ft
NAME: R. Karvonen
DATE: March 25, 1988
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY& GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
Ostracode
L Shoreface
Ellerslie member
Continental
Fluvial
3070
3075
3080
3085
3090
3095
3100
3105
3110
3115
3120
3125
Pa
P1
S
T
S
S
-discont org lam
-fine shale lam-approx 1cm apart
-finely lam/lensed blk sh
-coal w/ ss filled burrows
-carb blk sh
-ss somewhat broken up
-upper 4" reddish tinge(FeO)-homo
-floating(~2mm) chert pebbles and lam of u m gr ss
-mtx supp cht pebble cgl
-interbeds of u c ss-pebbly cgl-fine upwards-contacts not well rep
-wht cht common
-zones of floating pebbles(subrd-subang)-pebbles up to 5x3cm
-ave ~5mm
-org rich shale
-carb sh rich ss-mottled texture
-rare cht (wht) floating pebbles
of u m gr ss

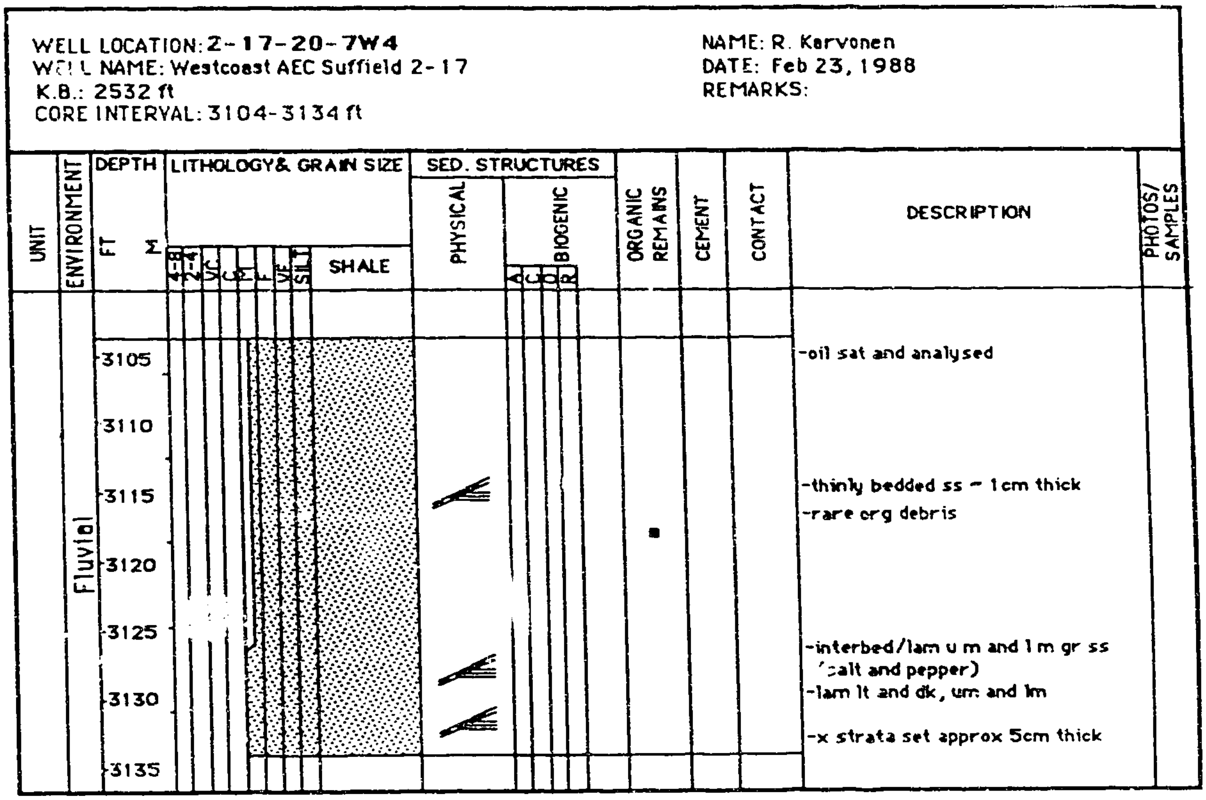

WELL LOCATION: 7C-10-20-7W4
WELL NAME: Westcoast AEC Suffield 7C-10
K.B: 752.0 m
CORE INTERVAL: 933-939m
NAME: R. Karvonen
DATE: May 3,1988
REMARKS:
UNIT
ENVIRONMENT
DEPTH
LITHOLOGY& GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
Ost
Bay
Ellerisle member
Fluvial
934
936
938
940
-coaly shale
-coal
-paleosol
-oil sat and anal
-about a 10cm zone of abund org lam
-shaly coal
-oil sat and anal
P25


WELL LOCATION: 4-15-20-7W4
WELL NAME: Westcoast AEC Suffield 4-15
K.B.: 2495 ft
CORE INTERVAL: 3088-3118 ft
NAME: R. KARYONEN
DATE: SEPT 29, 1987
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
Ostracode member
Ellerslie
Lower Shoreface
Bay
3090
3095
3100
3105
3110
Pl
Pa
Si
T
Sc
-oil saturated
-m gr ss
-sand lenses
-bedded coal w/ silt lenses

WELL LOCATION: 8-16-20-7W4
WELL NAME: Westcoast nEC Suffield 8-16
K.B.:
CORE INTERVAL: 3105-3135 ft

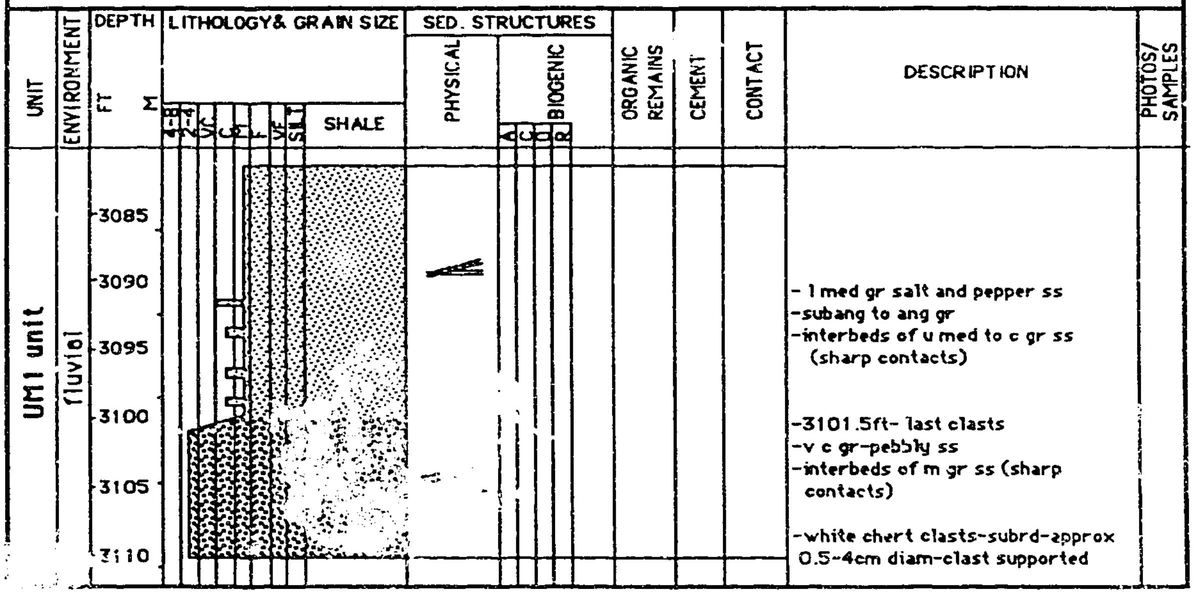
NAME: R. Karvonen
DATE: Feb 23, 1988
REMARKS:

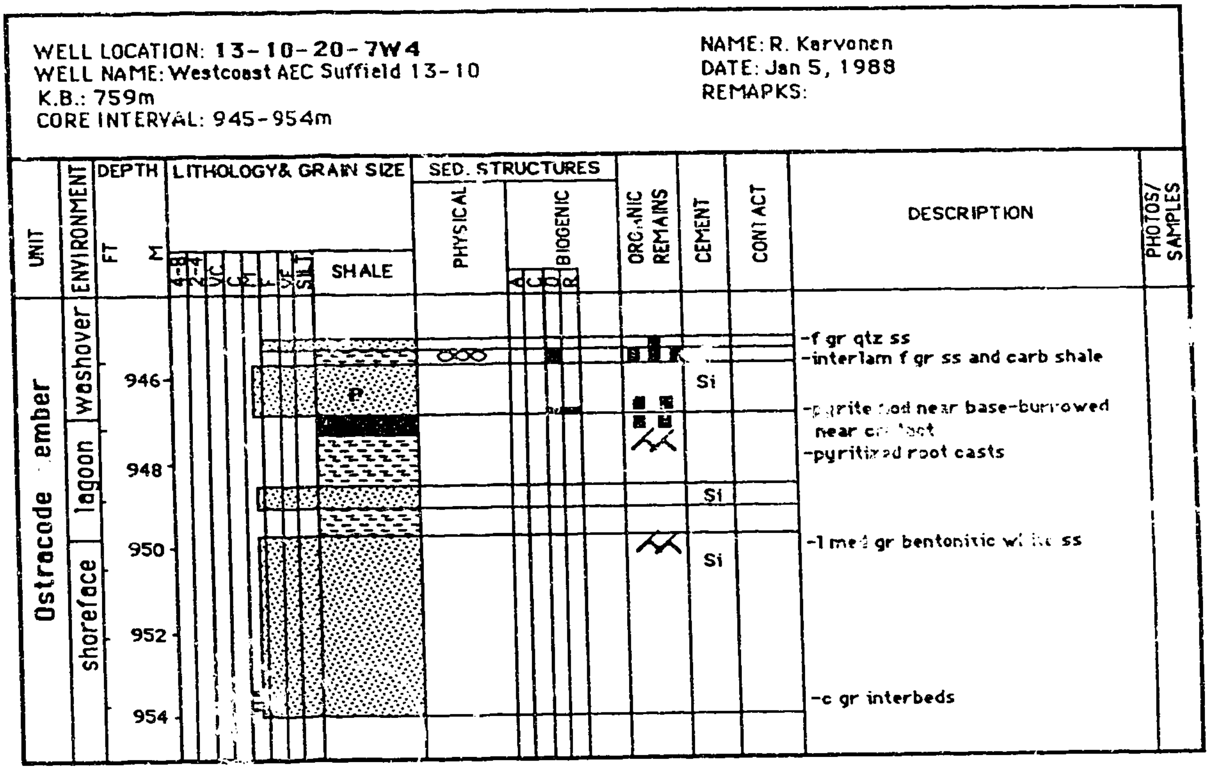



WELL LOCATION: 2-17-20-7W4
WELL NAME: Westcoast AEC Suffield 2-17
K.B.: 2532 ft
CORE INTERVAL: 3104-3134 ft
NAME: R. Karvonen
DATE: Feb 23, 1988
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT M
LITHOLOGY & GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
Fluvial
3105
3110
3115
3120
3125
3130
3135
-oil sat and analysed
-thinly bedded ss ~ 1cm thick
-rare org debris
-interbed/lam u m and l m gr ss (salt and pepper)
-lam lt and dk, um and lm
-x strata set approx 5cm thick

WELL LOCATION: **6-3-20-7W4**
WELL NAME: Westcoast AEC Suffield 6-3
K.B.: 2477ft
CORE INTERVAL: 3082-3110ft

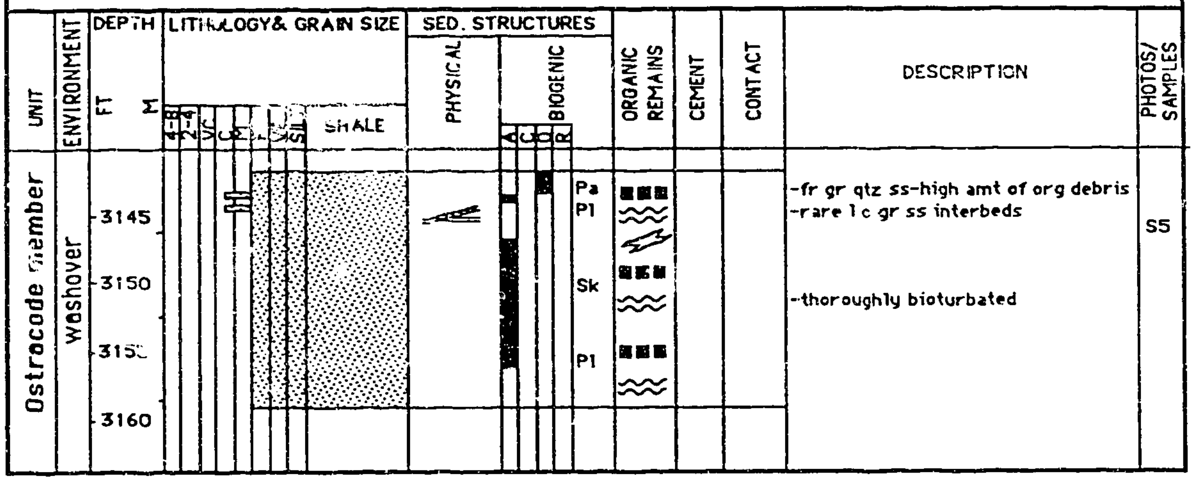
NAME: R. Karvonen
DATE: Jan 4, 1988
REMARKS:




WELL LOCATION: 13-10-20-7W4
WELL NAME: Westcoast AEC Suffield 13-10
K.B.: 759m
CORE INTERVAL: 945-954m
NAME: R. Karvonen
DATE: Jan 5, 1988
REMAPKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY& GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
Ostracode Member
washover
lagoon
shoreface
946
948
950
952
954
Si
Si
Si
-f gr qtz ss
-interlam f gr ss and carb shale
-pyritized root casts
-c gr interbeds

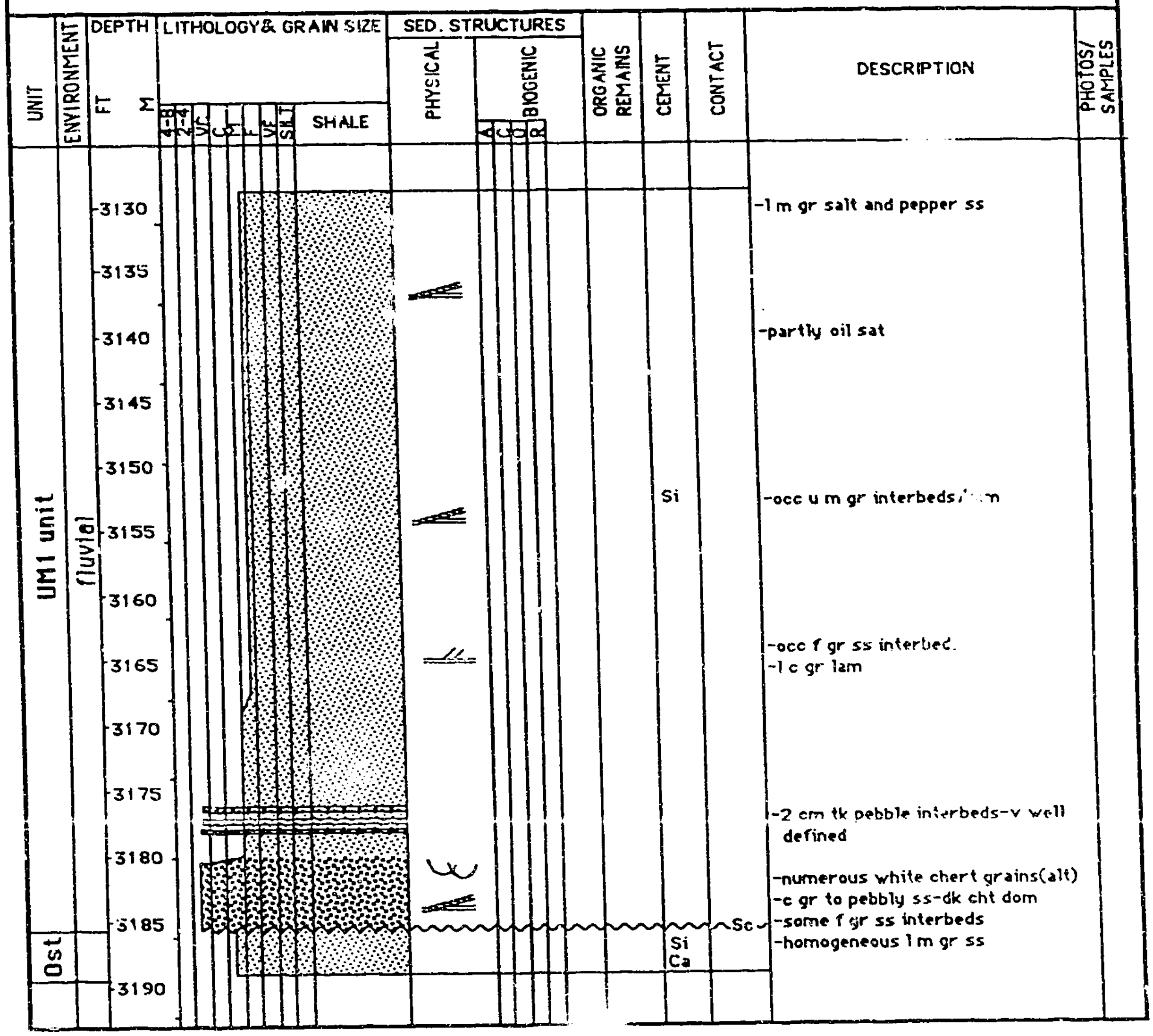
WELL LOCATION: 14-10-20-7W4
WELL NAME: Westcoast AEC Suffield 14-10
K.B.: 2546ft
CORE INTERVAL: 3142-3159ft

NAME: R. Karvonen
DATE: Jan 5, 1988
REMARKS:



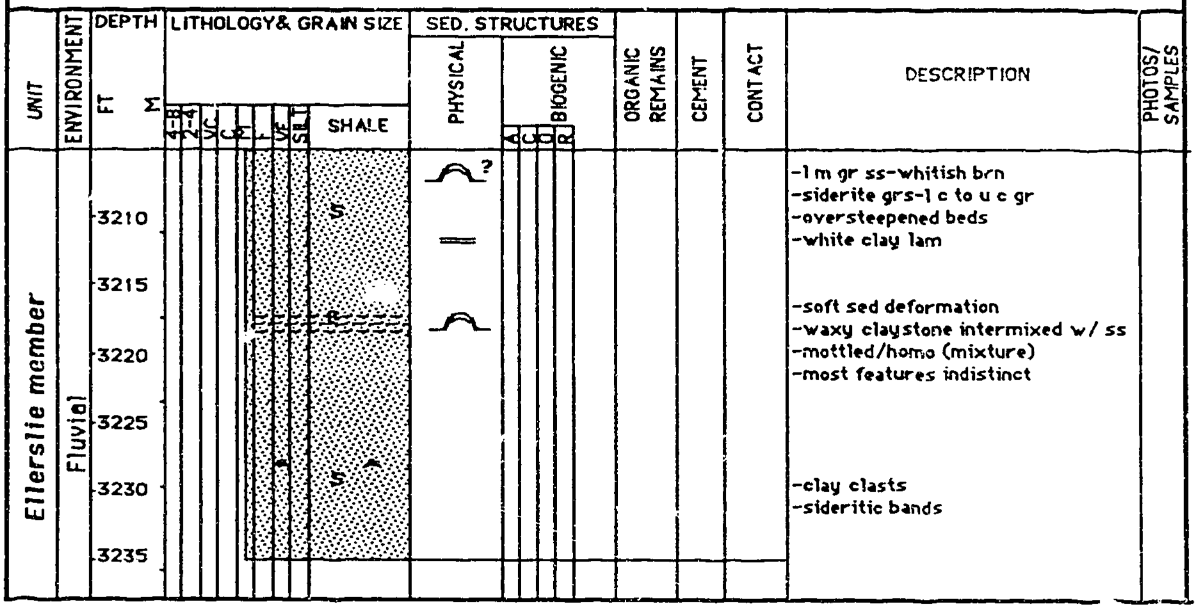
WELL LOCATION: **10-17-20-7W4**
WELL NAME: Westcoast AEC Suffield 10-17
K.B.: 2559ft
CORE INTERVAL: 3129-3189ft

NAME: R. Karvonen
DATE: Jan 4, 1988
REMARKS:



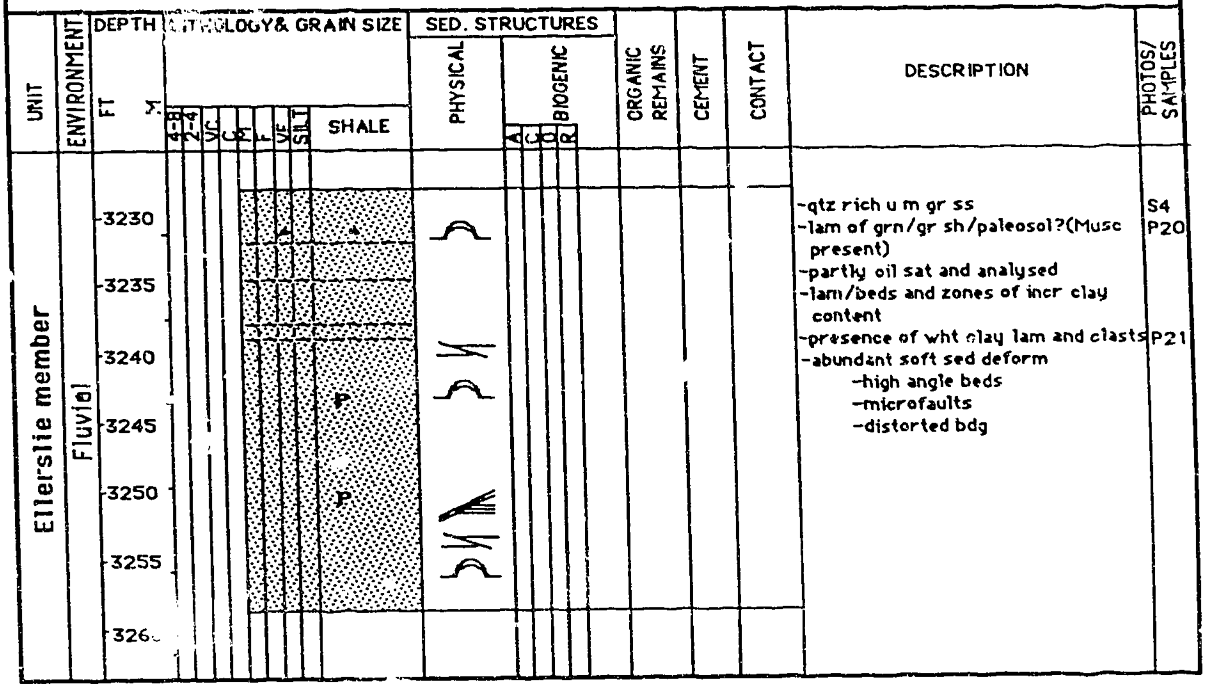
WELL LOCATION: 6-1-20-8W4
WELL NAME: Westcoast AEC Suffield 6-1
K.B.: 2528 ft
CORE INTERVAL: 3205-3235 ft

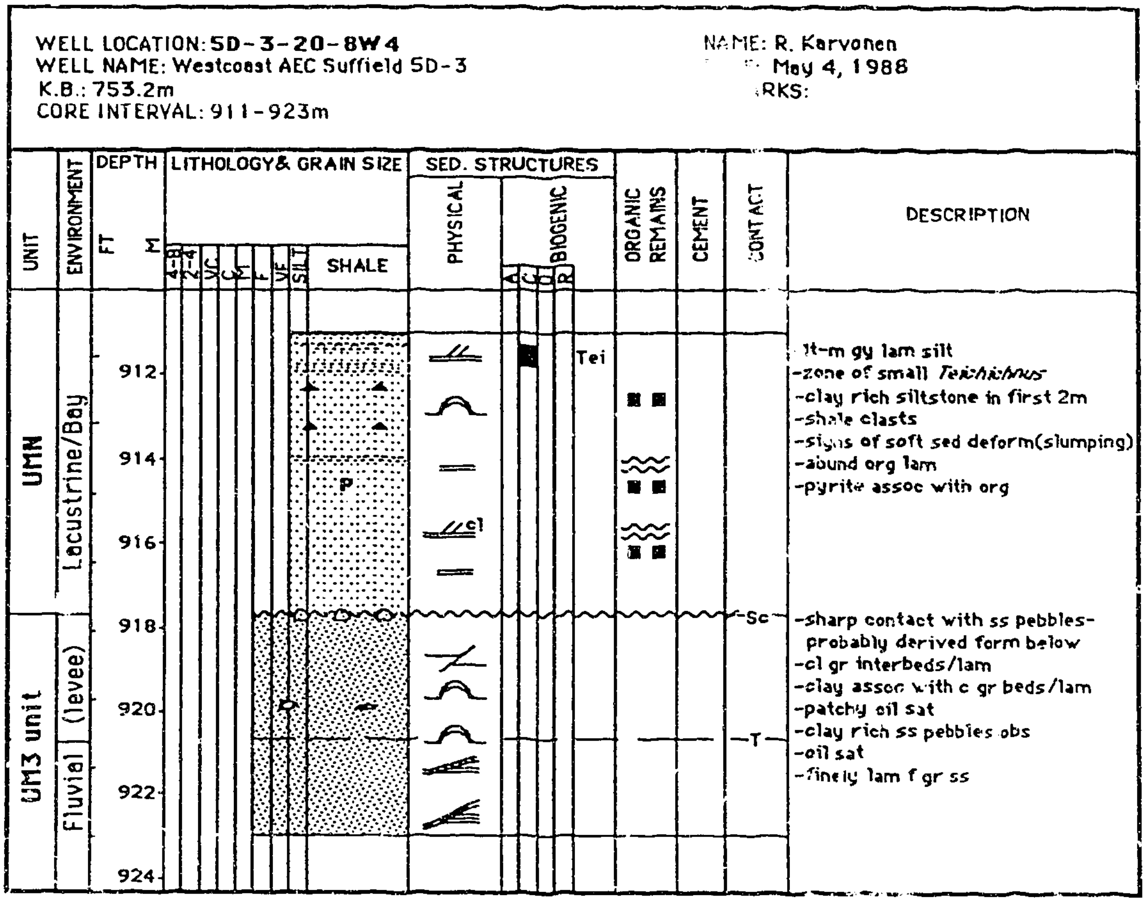
NAME: R. Karvonen
DATE: March 23, 1988
REMARKS:

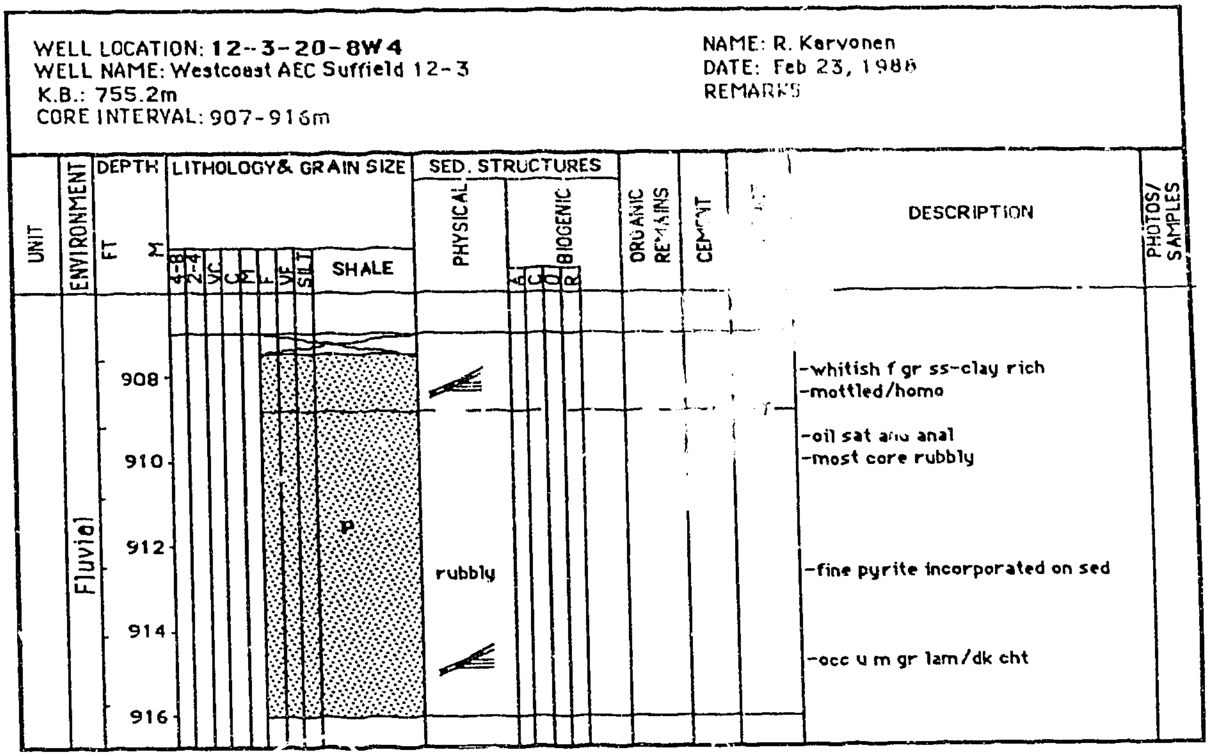


WELL LOCATION: 8-2-20-8W4
WELL NAME: Westcoast AEC Suffield 8-2
K.B.: 2548 ft
CORE INTERVAL: 3228-3258 ft

NAME: R. Karvonen
DATE: Feb 24, 1988
REMARKS:

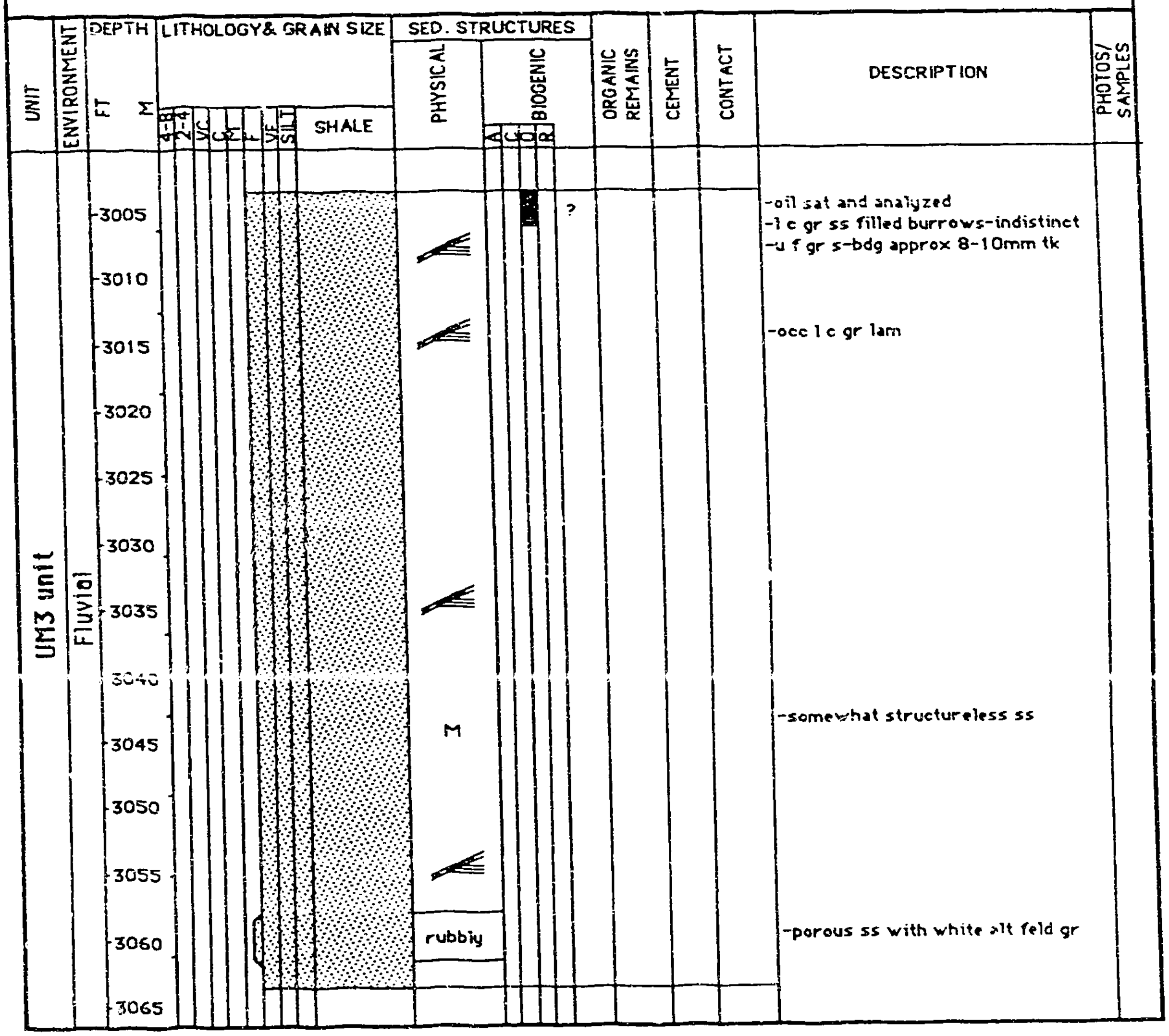



WELL LOCATION: SD-3-20-8W4
WELL NAME: Westcoast AEC Suffield SD-3
K.B.: 753.2m
CORE INTERVAL: 911-923m
NAME: R. Karvonen
May 4, 1988
RKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
VC
C
M
F
VF
SILT
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
A
C
R
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
UMN
Lacustrine/Bay
UM3 unit
Fluvial (levee)
912
914
916
918
920
922
924
P
cl
Tei
Sc
T
lt-m gy lam silt
-zone of small Teichichnus
-clay rich siltstone in first 2m
-shale clasts
-signs of soft sed deform(slumping)
-abund org lam
-pyrite assoc with org
-sharp contact with ss pebbles-
probably derived form below
-cl gr interbeds/lam
-clay assoc with c gr beds/lam
-patchy oil sat
-clay rich ss pebbles obs
-oil sat
-finely lam f gr ss


WELL LOCATION: 12-3-20-8W4
WELL NAME: Westcoast AEC Suffield 12-3
K.B.: 755.2m
CORE INTERVAL: 907-916m
NAME: R. Karvonen
DATE: Feb 23, 1986
REMARKS
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY& GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
DESCRIPTION
PHOTOS/ SAMPLES
Fluvial
908
910
912
914
916
rubbly
-whitish f gr ss-clay rich
-mottled/homo
-oil sat and anal
-most core rubbly
-fine pyrite incorporated on sed
-occ u m gr lam/dk cht

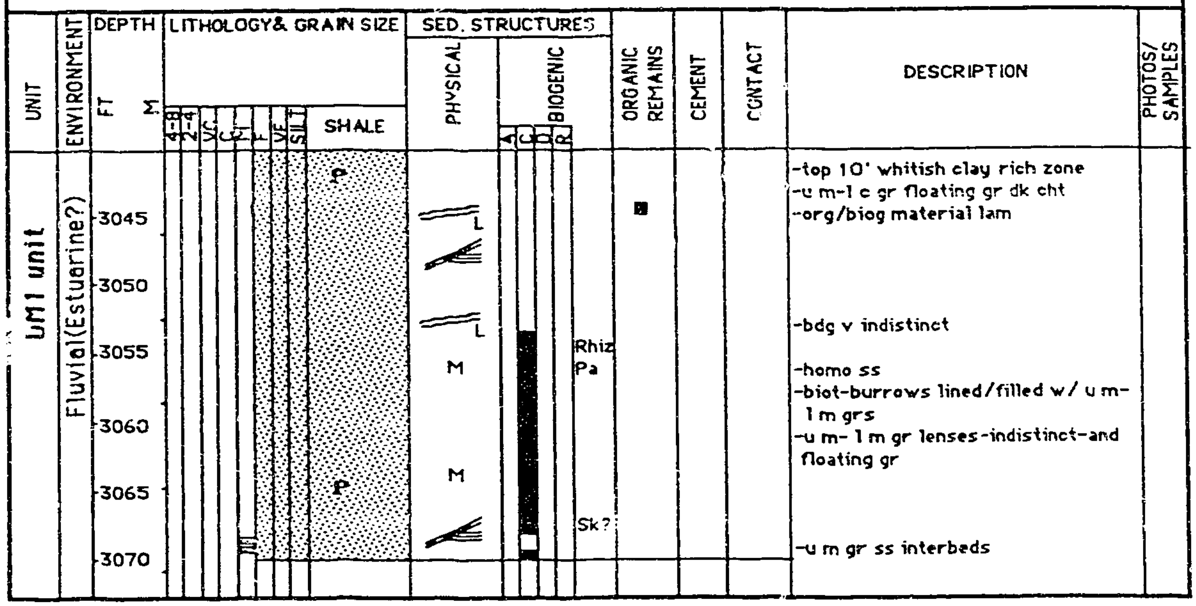
WELL LOCATION: **14-3-20-8W4**
WELL NAME: Westcoast AEC Suffield 14-3
K.B.: 2460 ft
CORE INTERVAL: 3003-3063 ft

NAME: R. Karvonen
DATE: March 25, 1988
REMARKS:



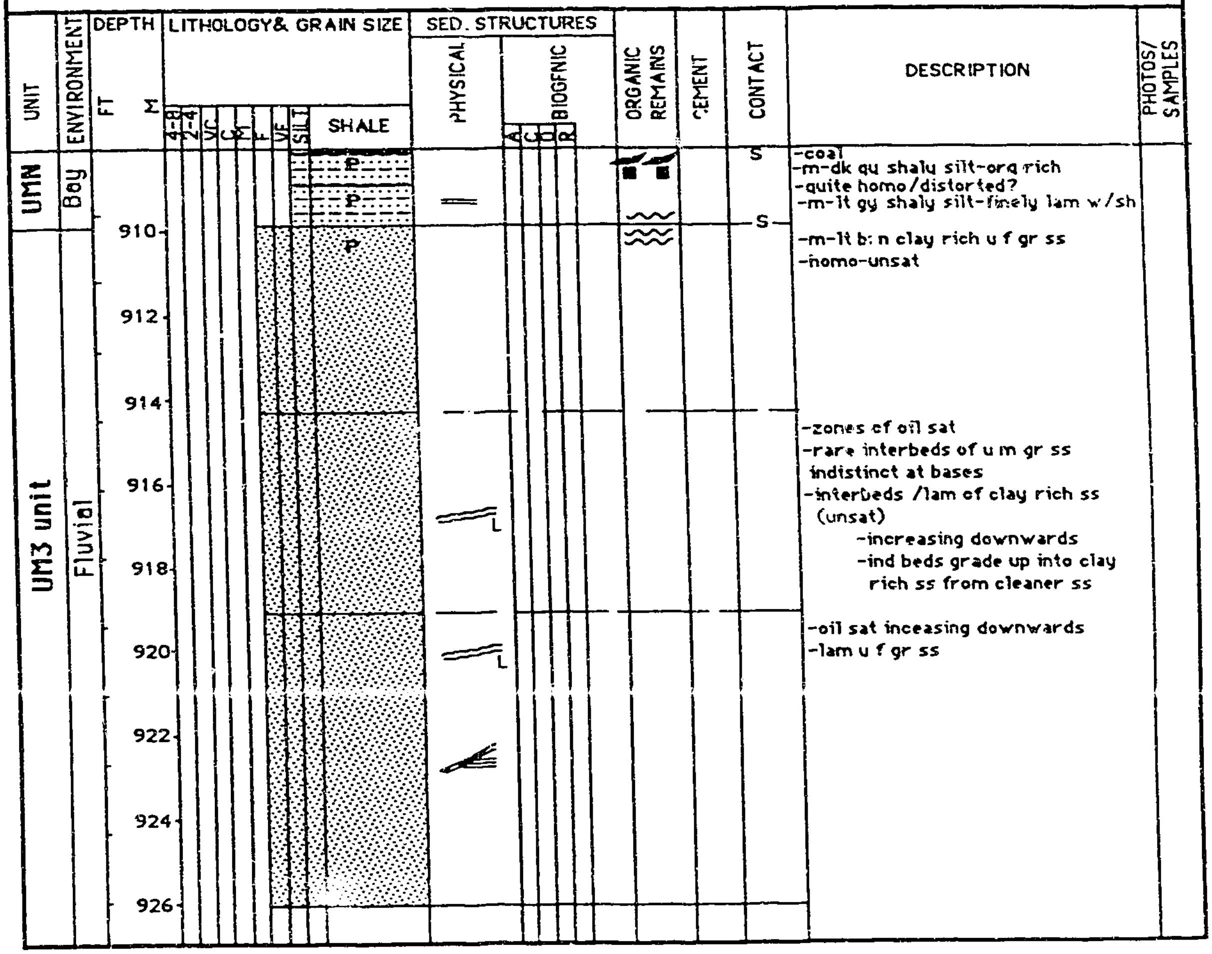
WELL LOCATION: 8-4-20-8W4
WELL NAME: Westcoast AEC Suffield 8-4
K.B.: 2485 ft
CORE INTERVAL: 3040-3070 ft

NAME: R. Karvonen
DATE: March 23, 1988
REMARKS:



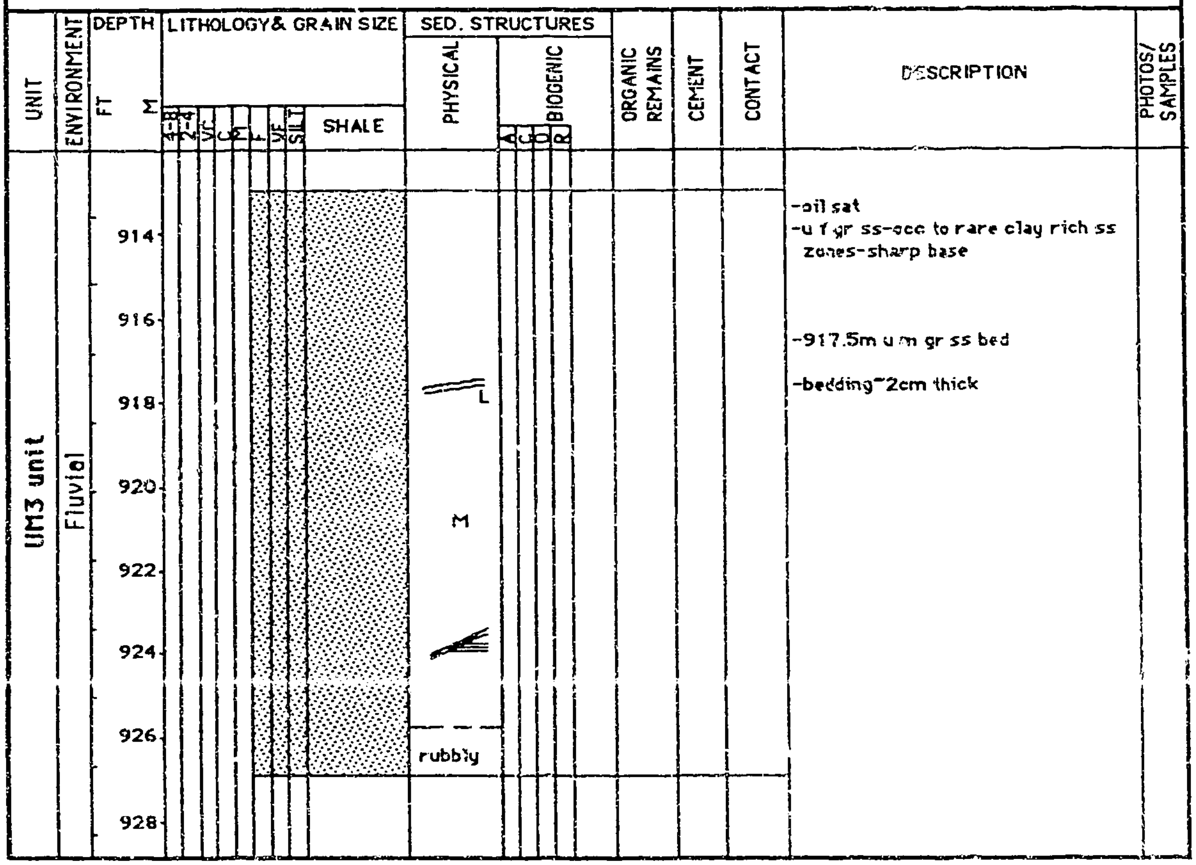
WELL LOCATION: 03/16H-4-20-8W4
WELL NAME: AEC WC 16H Suffield 16-4
K.B.: 754m
CORE INTERVAL: 908-926m

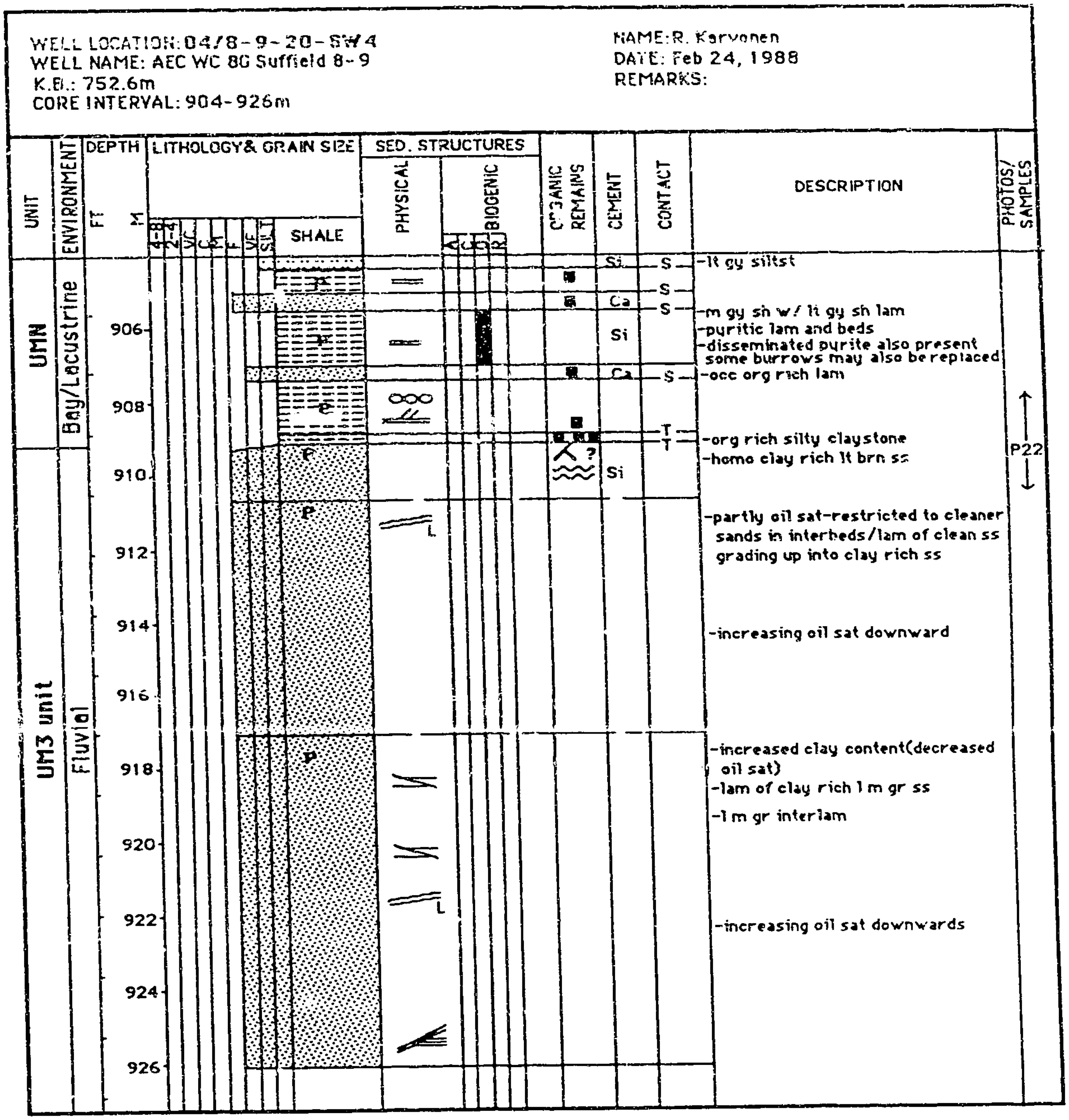
NAME: R. Karvonen
DATE: Feb 24, 1988
REMARKS:



WELL LOCATION: 02/1-9-20-6W4
WELL NAME: AEC WC 10 Suffield 1-9
K.B.: 753.1m
CORE INTERVAL: 913-927m

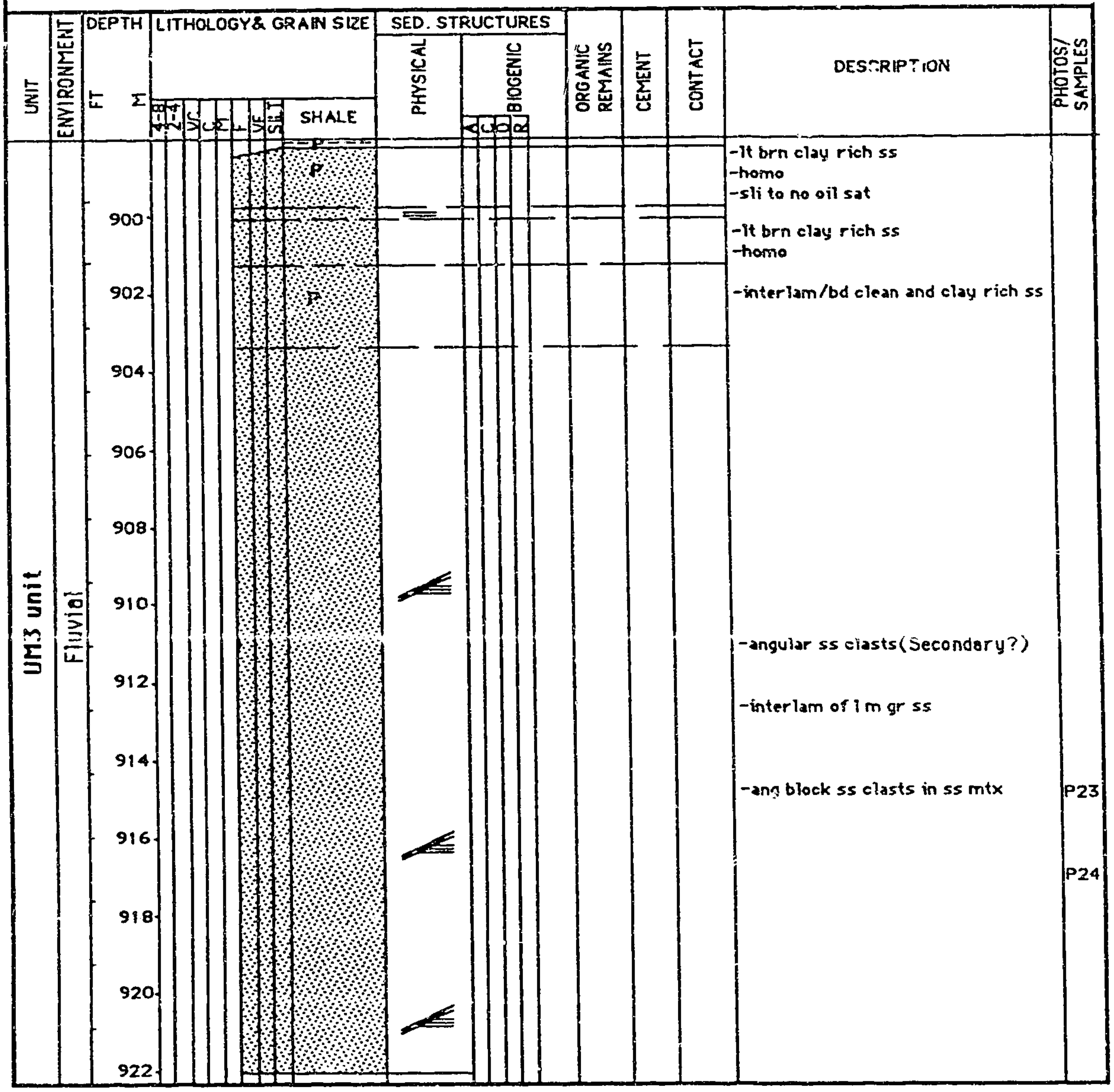
NAME: R. Karvonen
DATE: March 23, 1988
REMARKS: Very poor core, very little to distinguish-rubbly.




WELL LOCATION: 04/8-9-20-SW4
WELL NAME: AEC WC 8G Suffield 8-9
K.B.: 752.6m
CORE INTERVAL: 904-926m
NAME: R. Karvonen
DATE: Feb 24, 1988
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY& GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
UMN
Bay/Lacustrine
UM3 unit
Fluvial
906
908
910
912
914
916
918
920
922
924
926
Si
Ca
Si
Ca
Si
S
S
S
S
T
T
-lt gy siltst
-m gy sh w/ lt gy sh lam
-pyritic lam and beds
-disseminated pyrite also present
some burrows may also be replaced
-occ org rich lam
-org rich silty claystone
-homo clay rich lt brn ss
-partly oil sat-restricted to cleaner sands in interbeds/lam of clean ss grading up into clay rich ss
-increasing oil sat downward
-increased clay content(decreased oil sat)
-lam of clay rich 1 m gr ss
-1 m gr interlam
-increasing oil sat downwards
P22

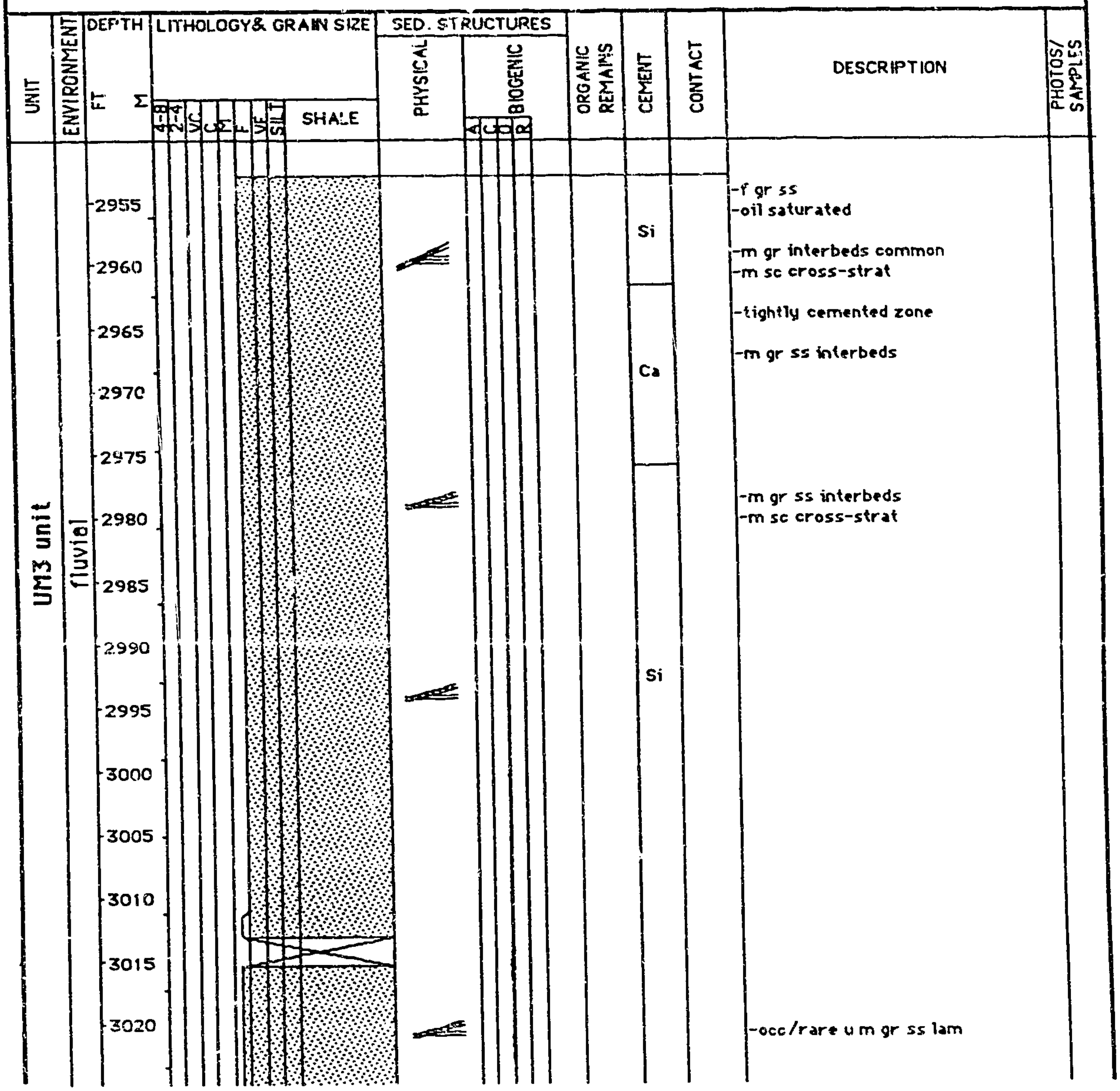
WELL LOCATION: 9-9-20-8W4
WELL NAME: AEC WC 9B Suffield
K.B.: 747 m
CORE INTERVAL: 898-922m

NAME: R. Karvonen
DATE: Feb 24, 1988
REMARKS:



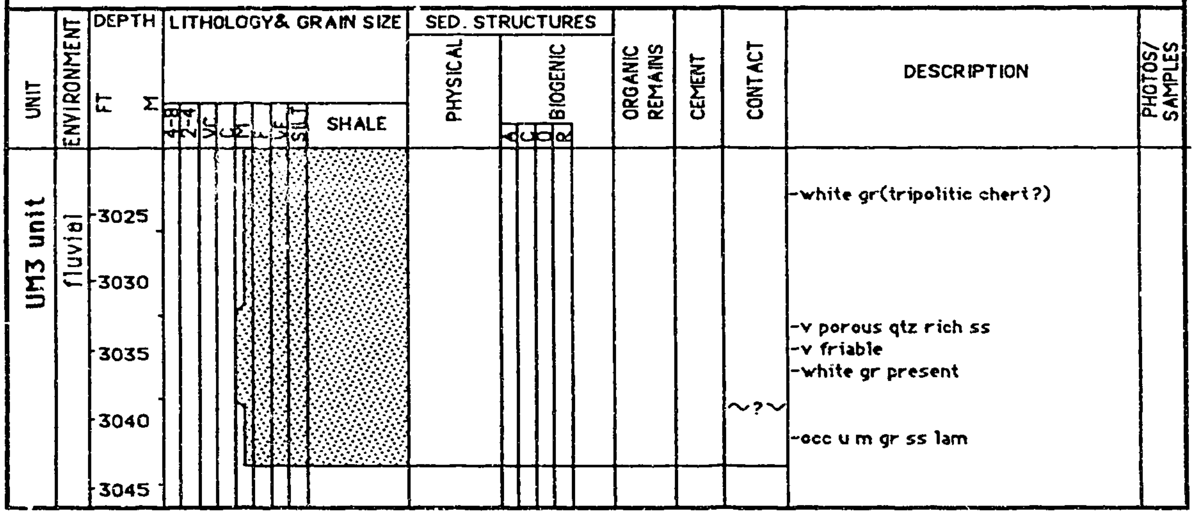
WELL LOCATION: 16-9-20-8W4
WELL NAME: Westcoasr AEC Suffield 16-9
K.B.: 2841 ft
CORE INTERVAL: 2953-3042 ft

NAME: R. Karvonen
DATE: Jan 6, 1988
REMARKS:



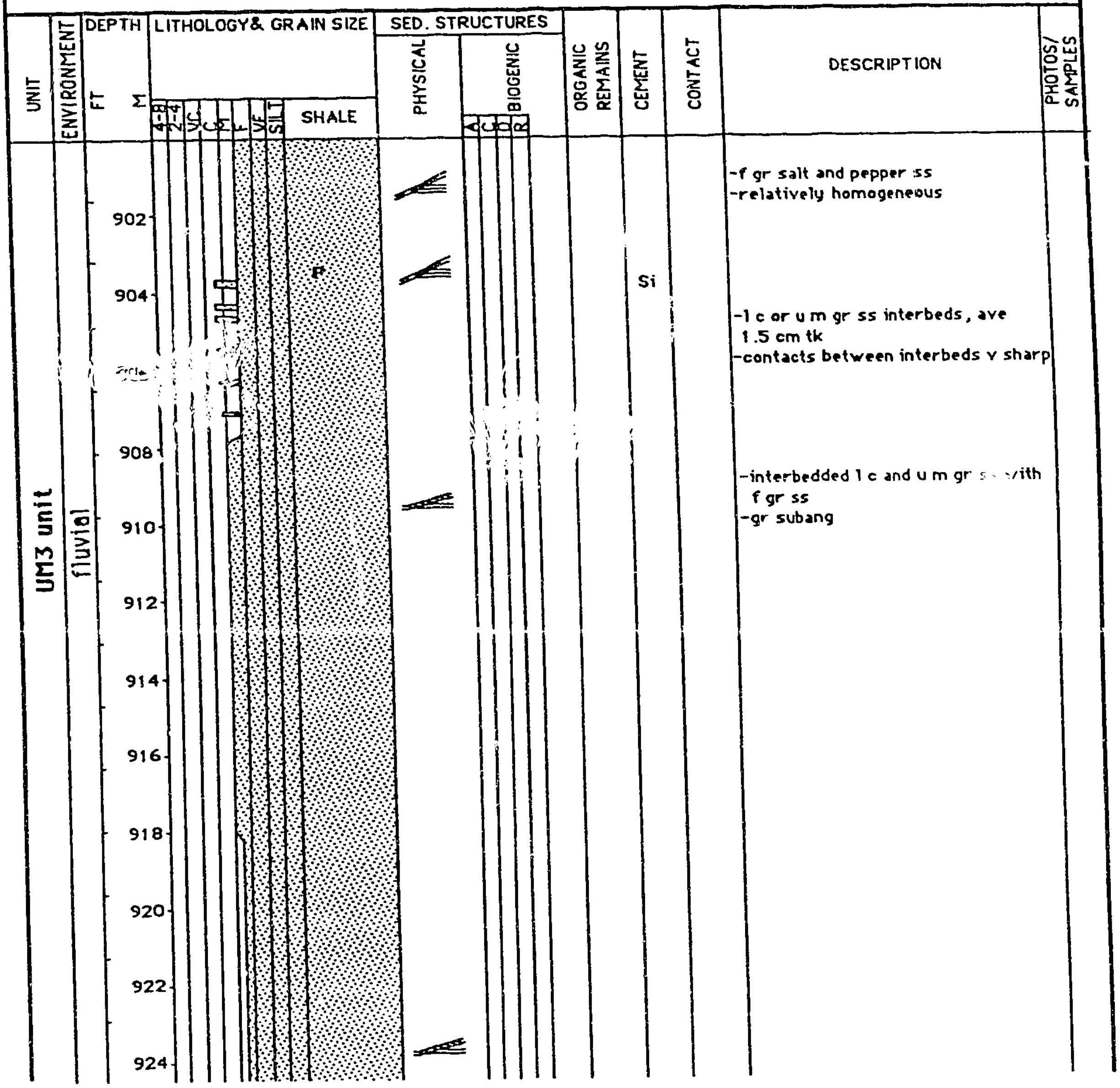
WELL LOCATION: **16-9-20-8W4(cont'd)**
WELL NAME:
K.B.:
CORE INTERVAL:

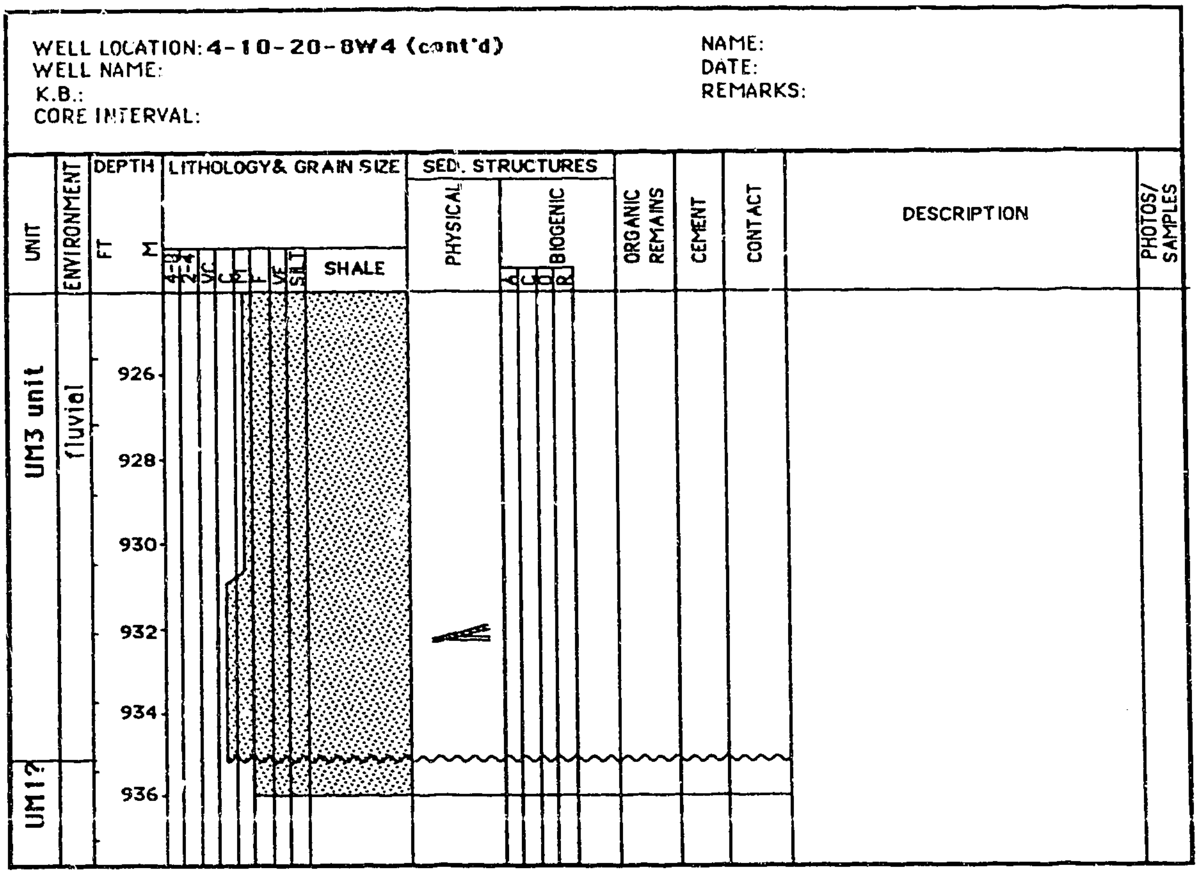
NAME:
DATE:
REMARKS:

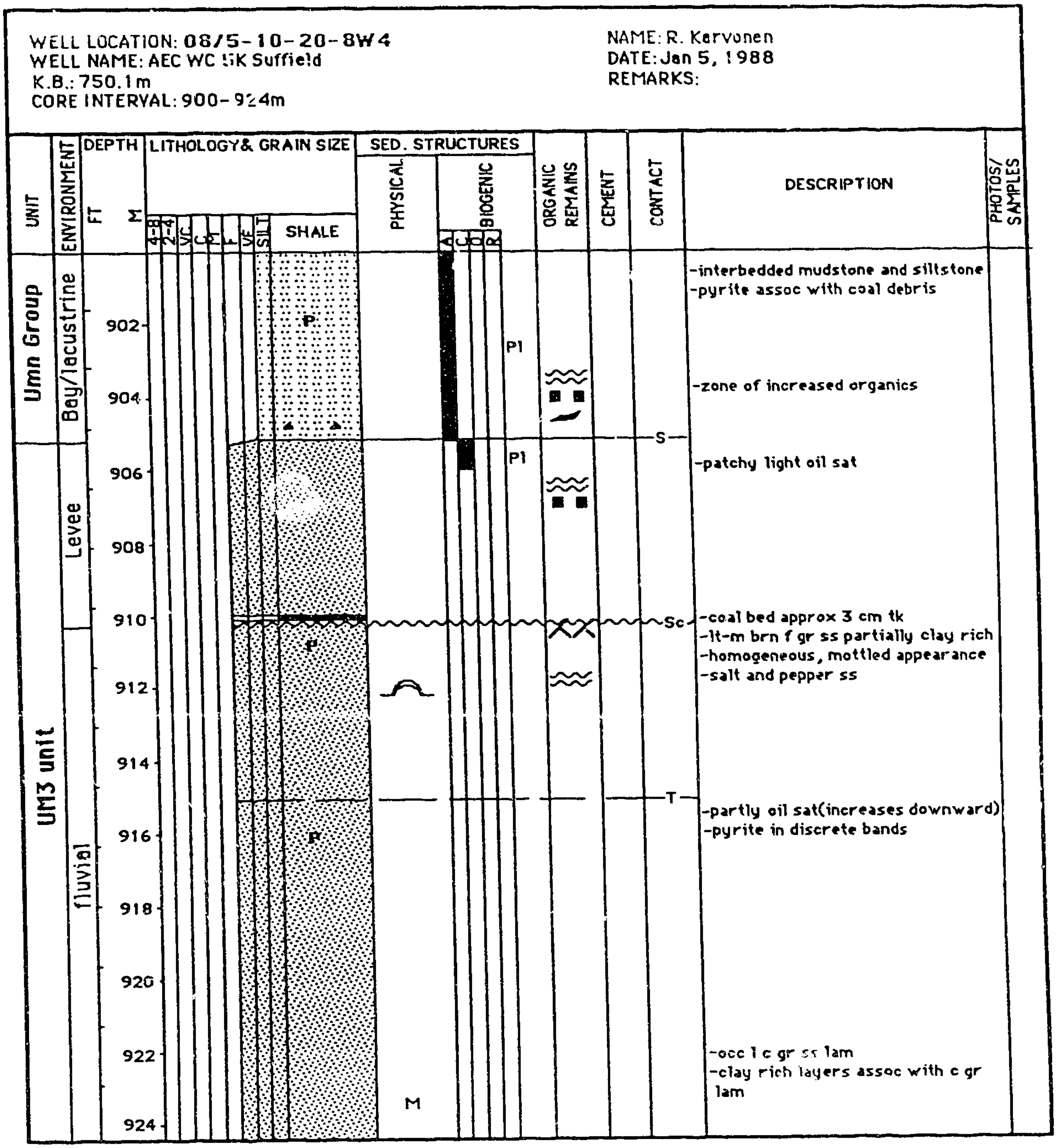


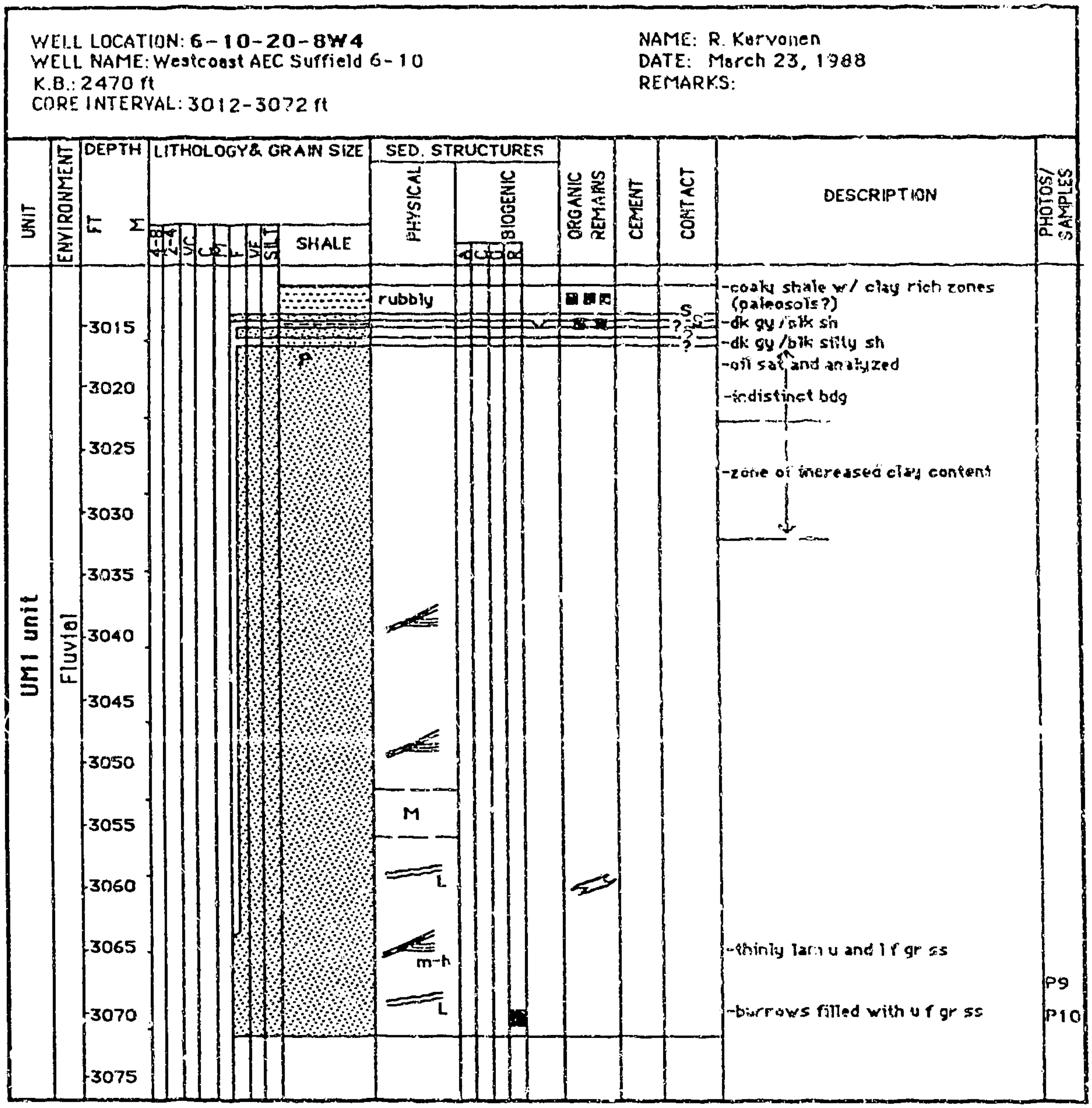
WELL LOCATION: 4-10-20-8W4
WELL NAME: Westcoast AEC Suffield
K.B.: 753.3 m
CORE INTERVAL: 900-936m

NAME: R. Kervonen
DATE: Jan 4, 1989
REMARKS:



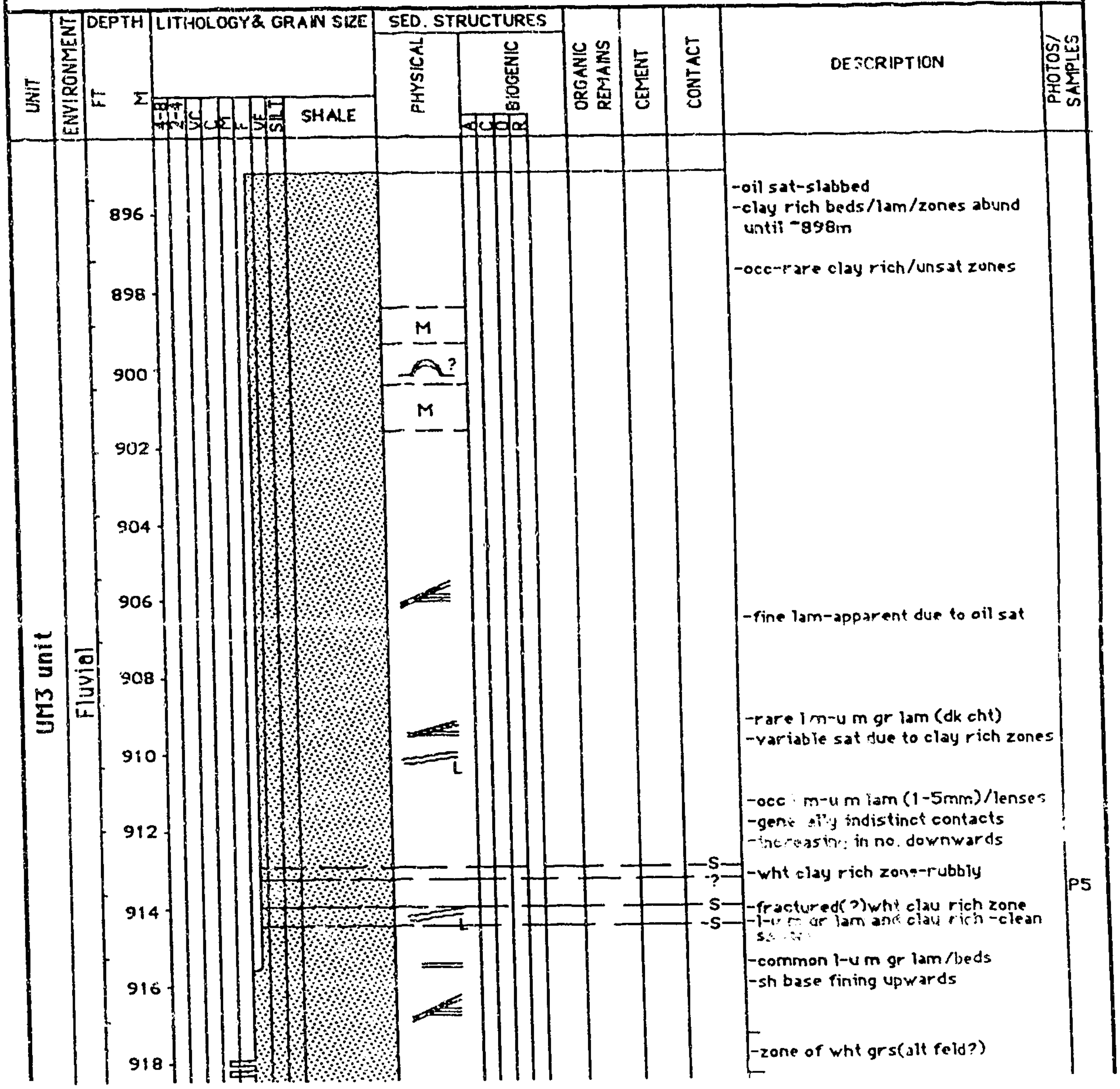

WELL LOCATION: 4-10-20-8W4 (cont'd)
WELL NAME:
K.B.:
CORE INTERVAL:
NAME:
DATE:
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
UM3 unit
fluvial
UM1?
926
928
930
932
934
936


WELL LOCATION: 08/5-10-20-8W4
WELL NAME: AEC WC SK Suffield
K.B.: 750.1m
CORE INTERVAL: 900-924m
NAME: R. Karvonen
DATE: Jan 5, 1988
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
SHALE
SILT
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
Umn Group
Bay/lacustrine
Levee
fluvial
UM3 unit
902
904
906
908
910
912
914
916
918
920
922
924
P1
P1
S
Sc
T
M
-interbedded mudstone and siltstone
-pyrite assoc with coal debris
-zone of increased organics
-patchy light oil sat
-coal bed approx 3 cm tk
-lt-m brn f gr ss partially clay rich
-homogeneous, mottled appearance
-salt and pepper ss
-partly oil sat(increases downward)
-pyrite in discrete bands
-occ 1 c gr ss lam
-clay rich layers assoc with c gr lam


WELL LOCATION: 6-10-20-8W4
WELL NAME: Westcoast AEC Suffield 6-10
K.B.: 2470 ft
CORE INTERVAL: 3012-3072 ft
NAME: R. Kervonen
DATE: March 23, 1988
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY& GRAIN SIZE
VC
C
M
F
VF
SILT
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
A
C
U
R
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
UM1 unit
Fluvial
3015
3020
3025
3030
3035
3040
3045
3050
3055
3060
3065
3070
3075
rubbly
M
L
m-h
L
S
?
?
-coaly shale w/ clay rich zones (paleosols?)
-dk gy /blk sh
-dk gy /blk silty sh
-oil sat and analyzed
-indistinct bdg
-zone of increased clay content
-thinly lam u and l f gr ss
-burrows filled with u f gr ss
P9
P10

WELL LOCATION: 12-10-20-8W4
WELL NAME: Westcoast AEC Suffield 12-10
K.B.: 747.9m
CORE INTERVAL: 895-922m

NAME: R. Korvonen
DATE: March 22, 1988
REMARKS:



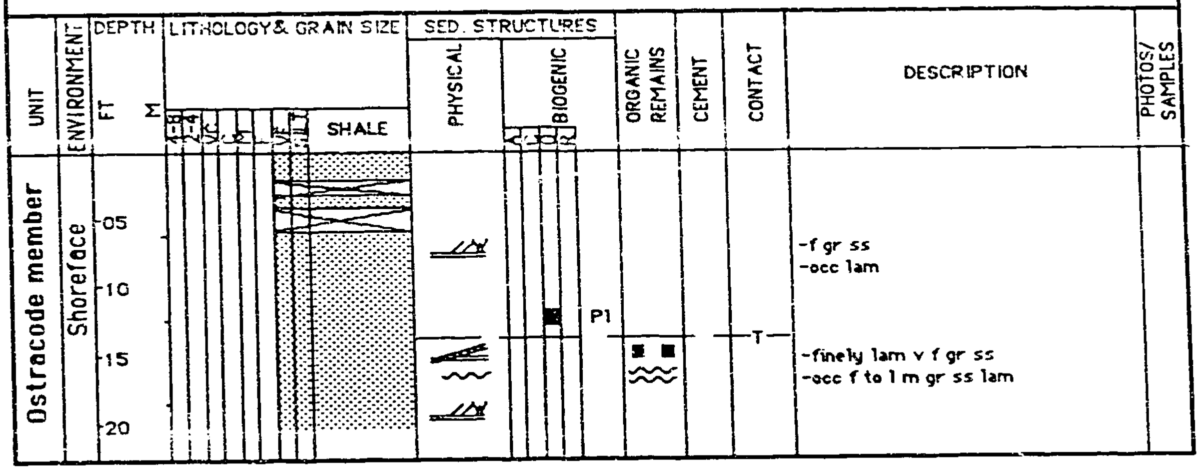
WELL LOCATION: **12-10-20-8W4 (cont'd)**
WELL NAME:
K.B.:
CORE INTERVAL:

NAME:
DATE:
REMARKS:

UNIT	ENVIRONMENT	DEPTH FT M	LITHOLOGY & GRAIN SIZE	SED. STRUCTURES PHYSICAL	SED. STRUCTURES BIOGENIC	ORGANIC REMAINS	CEMENT	CONTACT	DESCRIPTION	PHOTOS/ SAMPLES
UM3	Fluvial	920							-dk cht abundant -sm sc trough strat -sli lam	
								Sc		
UM1	Fluvial	922		L					-finely lam ss -dk(org rich) and lt lam -sli oil sat	P6

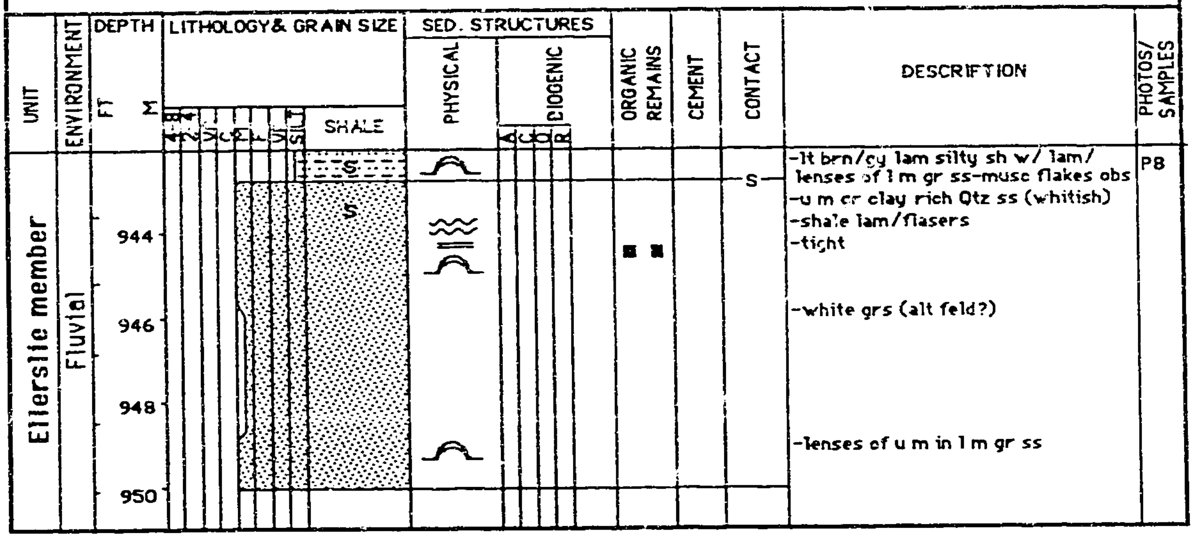
WELL LOCATION: **14-12-20-8W4**
WELL NAME: Westcoast AEC Suffield 14-12
K.B.:
CORE INTERVAL: offset

NAME: R. KARYON
DATE: SEPT 30, 1987
REMARKS:



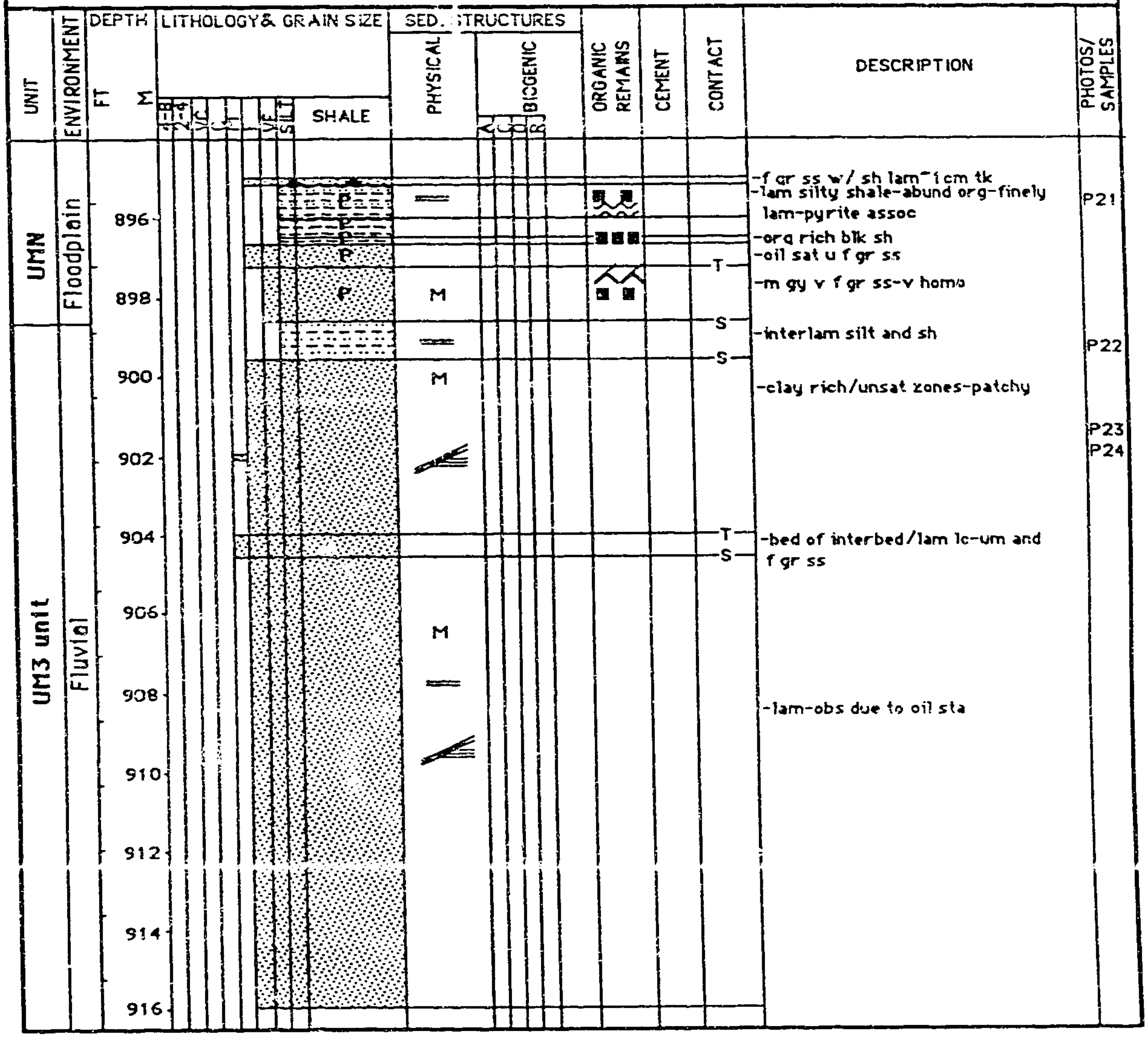
WELL LOCATION: 15C-12-20-8W4
WELL NAME: Westcoast AEC Suffield 15-12
K.B.: 742.1 m
CORE INTERVAL: 942-950 m

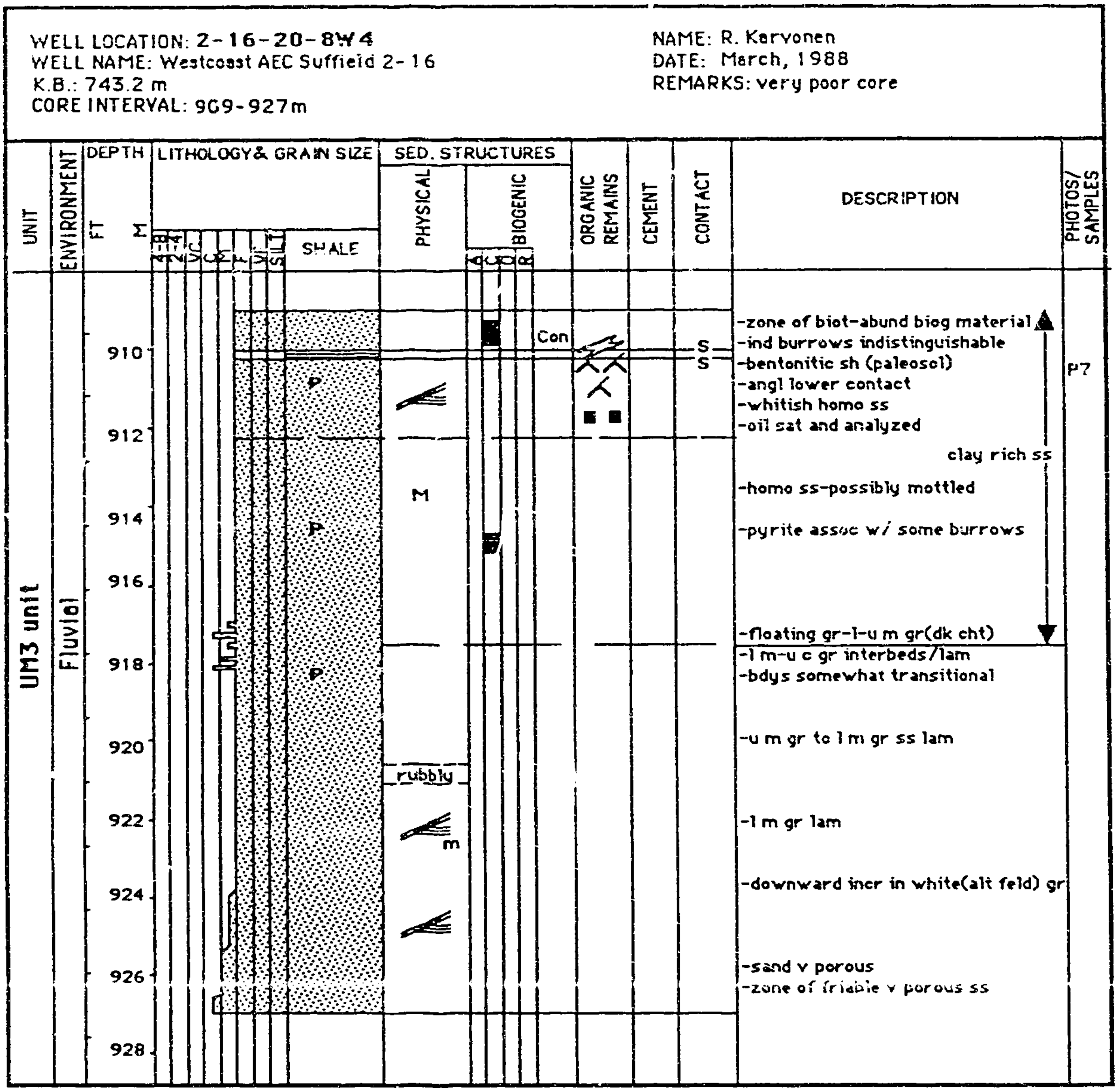
NAME: R. Karvonen
DATE: March 23, 1988
REMARKS:

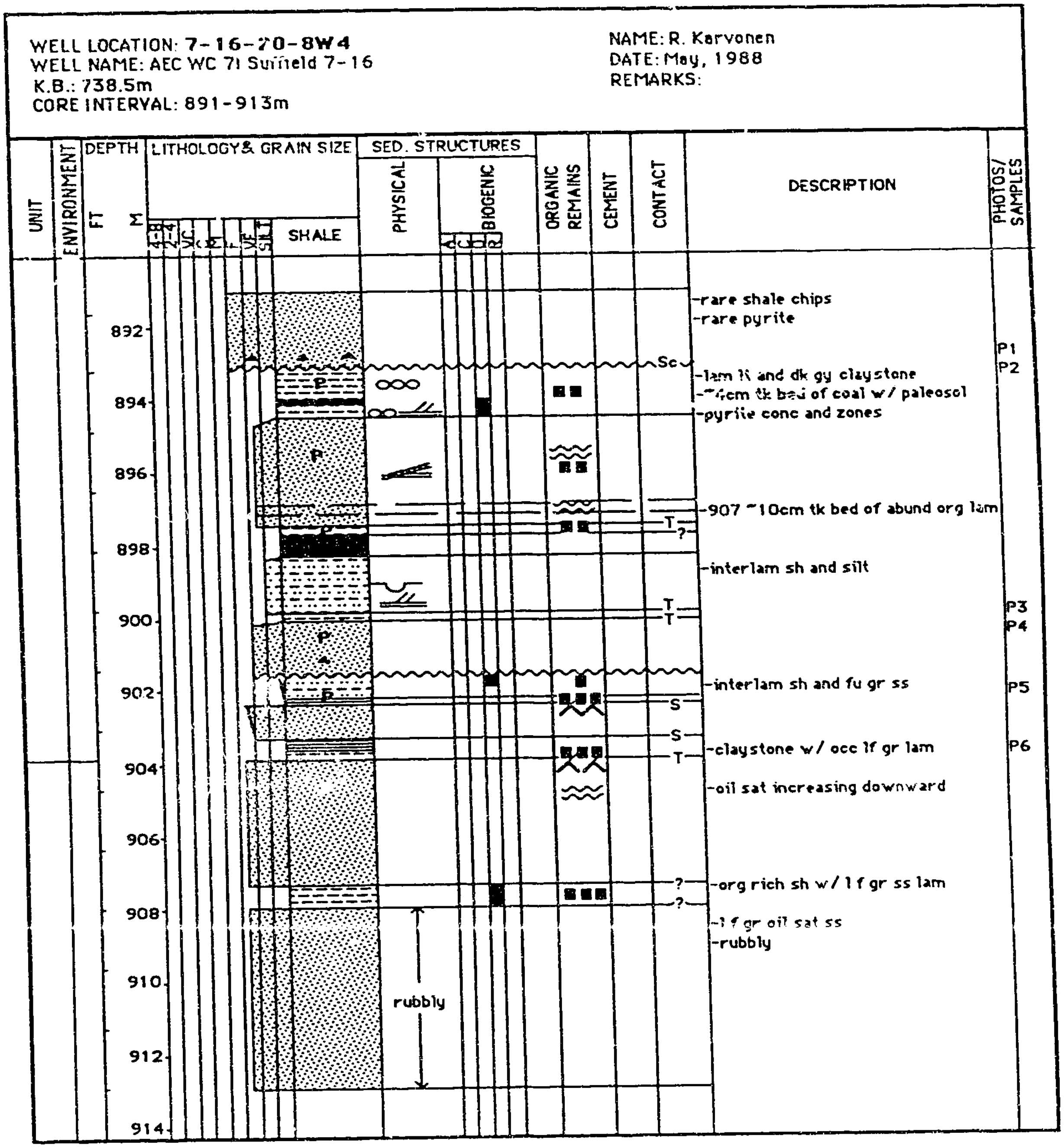


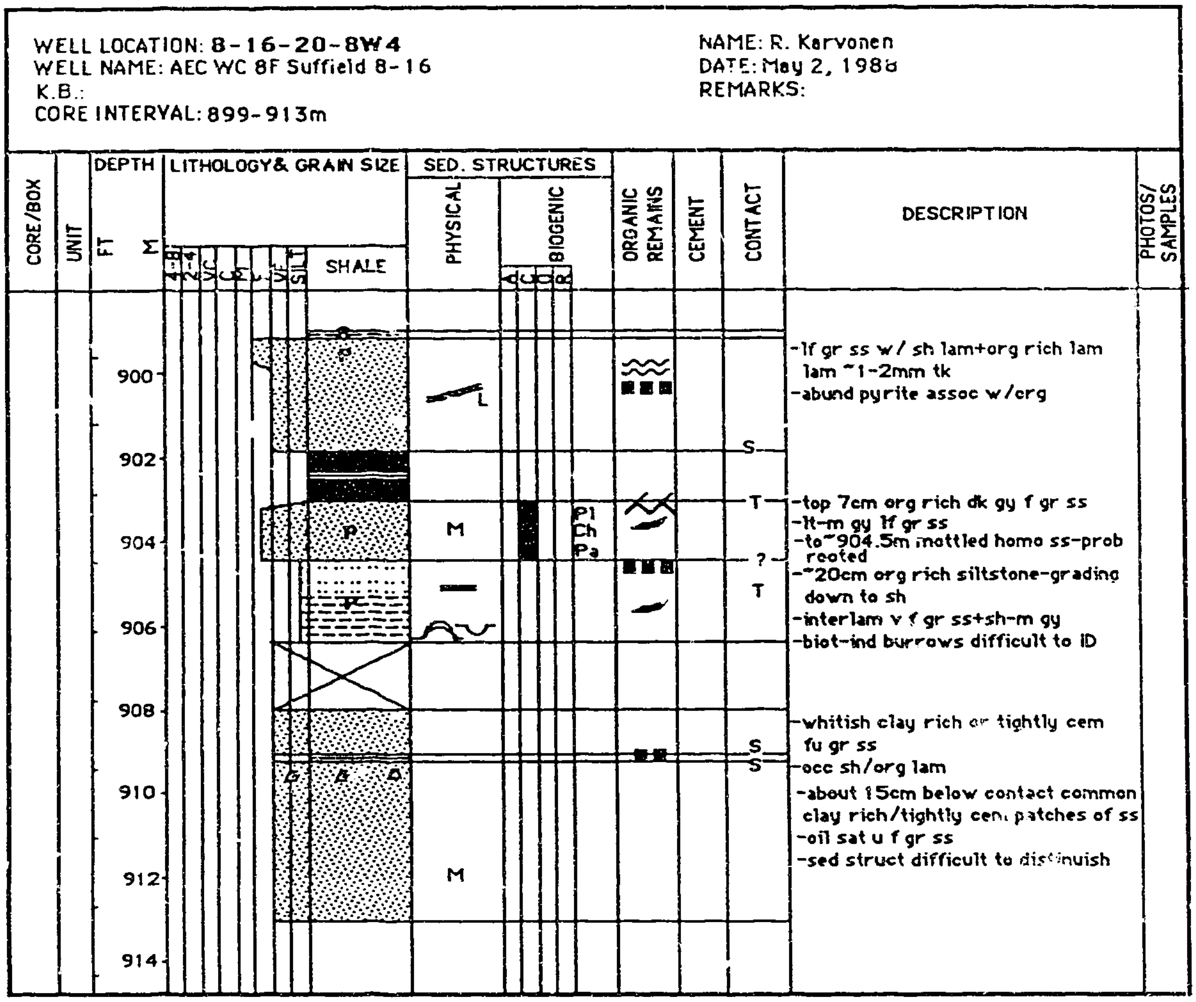
WELL LOCATION: 1-16-20-8W4
WELL NAME: AEC WC 1A Suffield 1-16
K.B.: 742.5m
CORE INTERVAL: 895-916m

NAME: R. Kervonen
DATE: May 3, 1988
REMARKS:



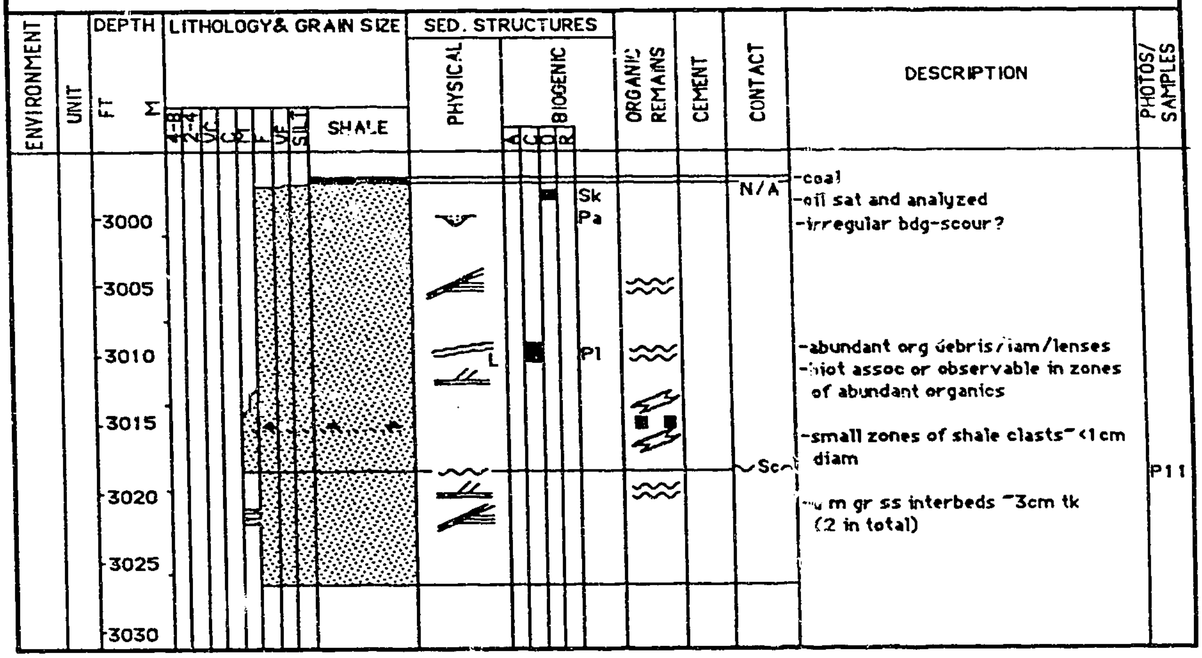

WELL LOCATION: 2-16-20-8W4
WELL NAME: Westcoast AEC Suffield 2-16
K.B.: 743.2 m
CORE INTERVAL: 909-927m
NAME: R. Karvonen
DATE: March, 1988
REMARKS: very poor core
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
SHALE
SILT
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
UM3 unit
Fluvial
910
912
914
916
918
920
922
924
926
928
Con
rubbly
M
m
S
S
P7
-zone of biot-abund biog material
-ind burrows indistinguishable
-bentonitic sh (paleosol)
-angl lower contact
-whitish homo ss
-oil sat and analyzed
clay rich ss
-homo ss-possibly mottled
-pyrite assoc w/ some burrows
-floating gr-l-u m gr(dk cht)
-l m-u c gr interbeds/lam
-bdys somewhat transitional
-u m gr to l m gr ss lam
-l m gr lam
-downward incr in white(alt feld) gr
-sand v porous
-zone of friable v porous ss

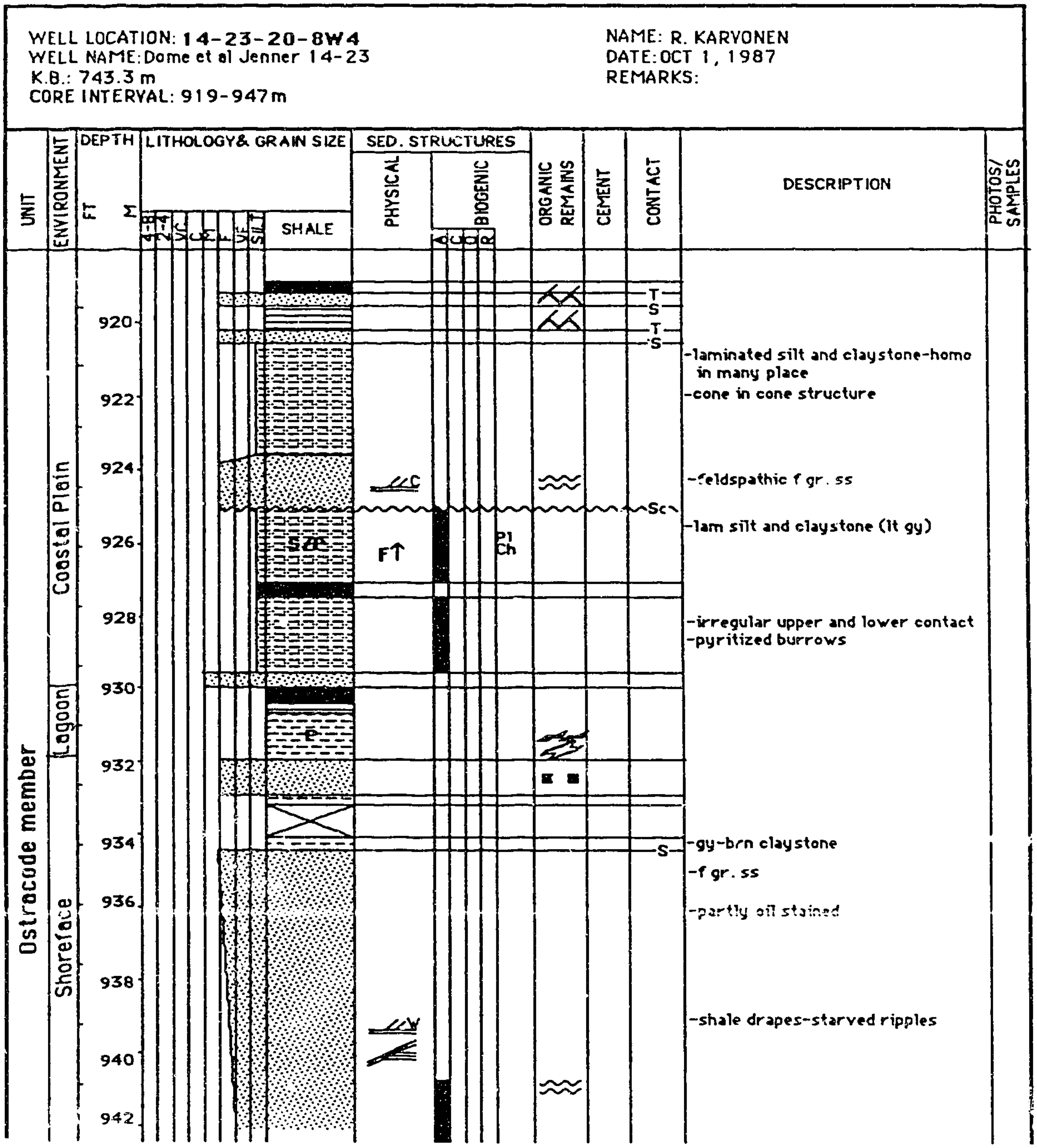

WELL LOCATION: 7-16-70-8W4
WELL NAME: AEC WC 71 Suffield 7-16
K.B.: 738.5m
CORE INTERVAL: 891-913m
NAME: R. Karvonen
DATE: May, 1988
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
892
894
896
898
900
902
904
906
908
910
912
914
-rare shale chips
-rare pyrite
-lam lt and dk gy claystone
-pyrite conc and zones
-907 ~10cm tk bed of abund org lam
-interlam sh and silt
-interlam sh and fu gr ss
-claystone w/ occ lf gr lam
-oil sat increasing downward
-org rich sh w/ 1 f gr ss lam
-rubbly
rubbly
P1
P2
P3
P4
P5
P6

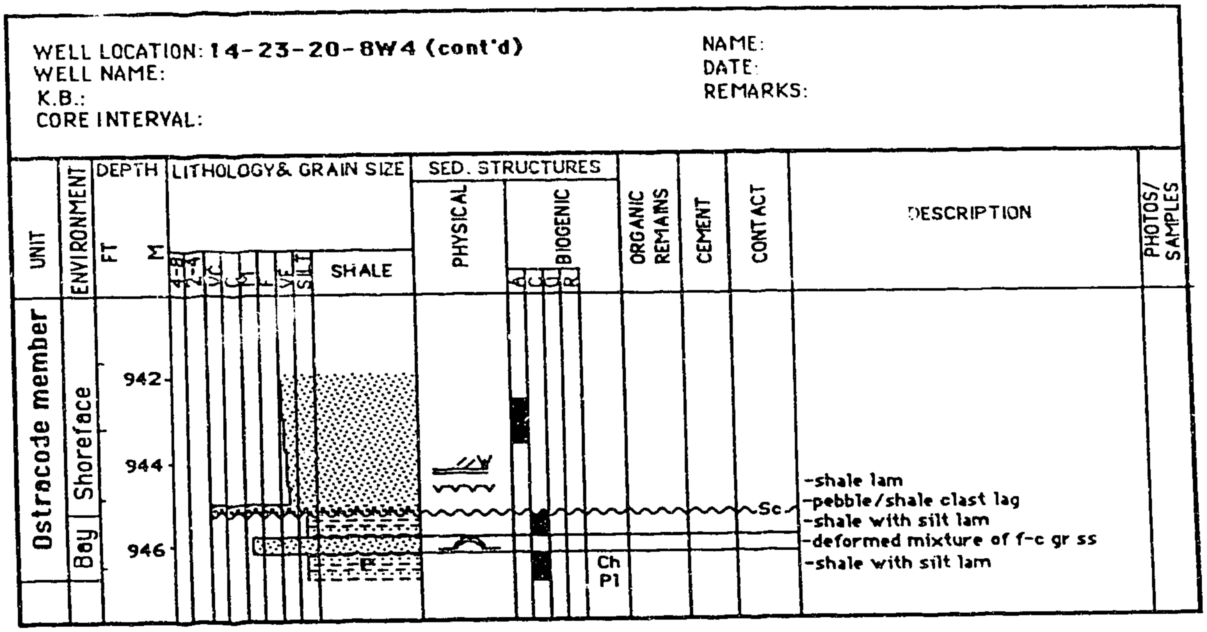

WELL LOCATION: 8-16-20-8W4
WELL NAME: AEC WC 8F Suffield 8-16
K.B.:
CORE INTERVAL: 899-913m
NAME: R. Karvonen
DATE: May 2, 1988
REMARKS:
CORE/BOX
UNIT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
900
902
904
906
908
910
912
914
L
M
M
Pl
Ch
Pa
S
T
?
T
S
S
-lf gr ss w/ sh lam+org rich lam
lam ~1-2mm tk
-abund pyrite assoc w/org
-top 7cm org rich dk gy f gr ss
-lt-m gy lf gr ss
-to ~904.5m mottled homo ss-prob rooted
-~20cm org rich siltstone-grading down to sh
-interlam v f gr ss+sh-m gy
-biot-ind burrows difficult to ID
-whitish clay rich or tightly cem fu gr ss
-occ sh/org lam
-about 15cm below contact common clay rich/tightly cem patches of ss
-oil sat u f gr ss
-sed struct difficult to distinuish

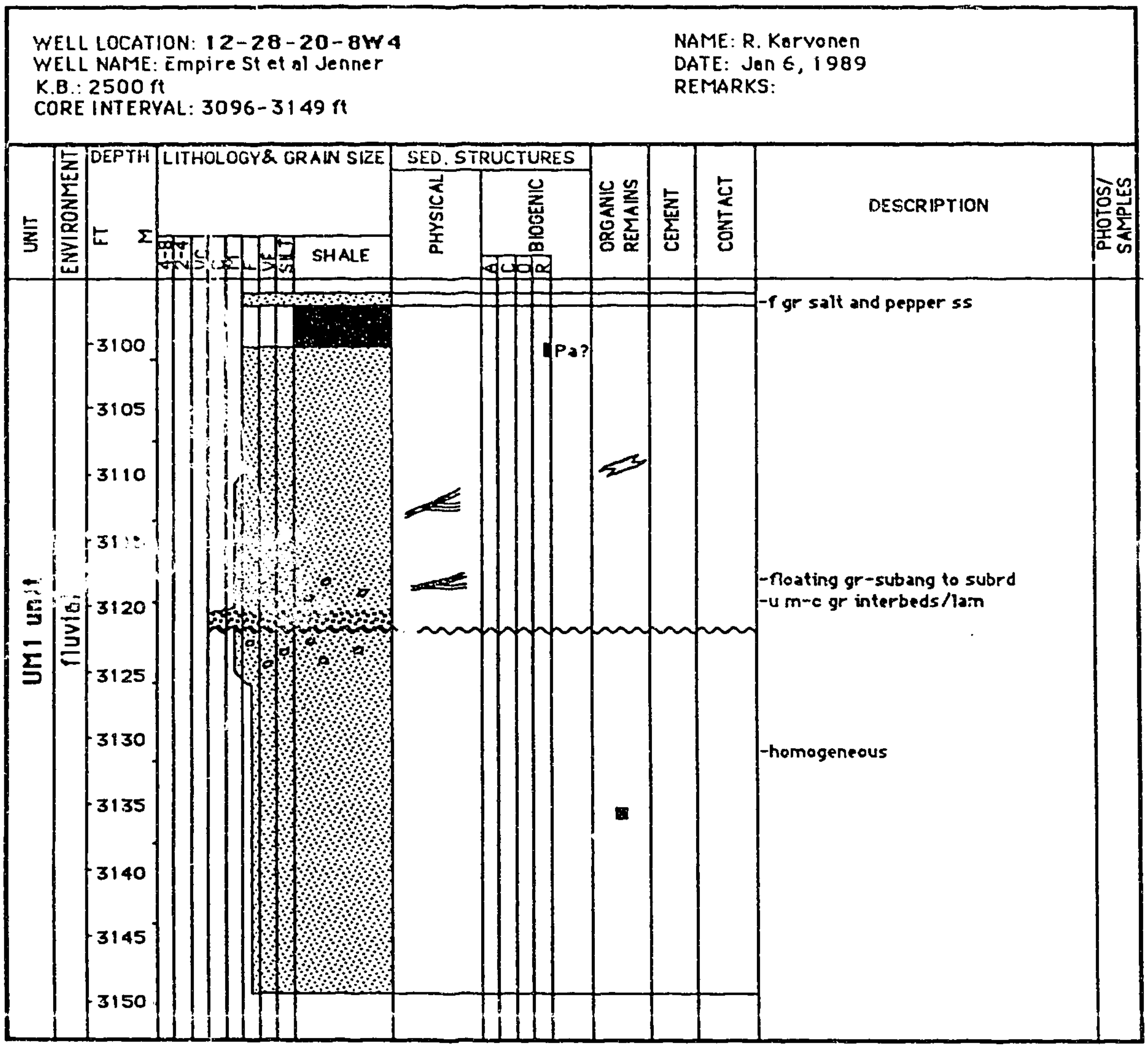
WELL LOCATION: 8-16-20-8W4
WELL NAME: Westcoast AEC Suffield 8-16
K.B.: 2422 ft
CORE INTERVAL: 2997-3027 ft (log 2987-3017)

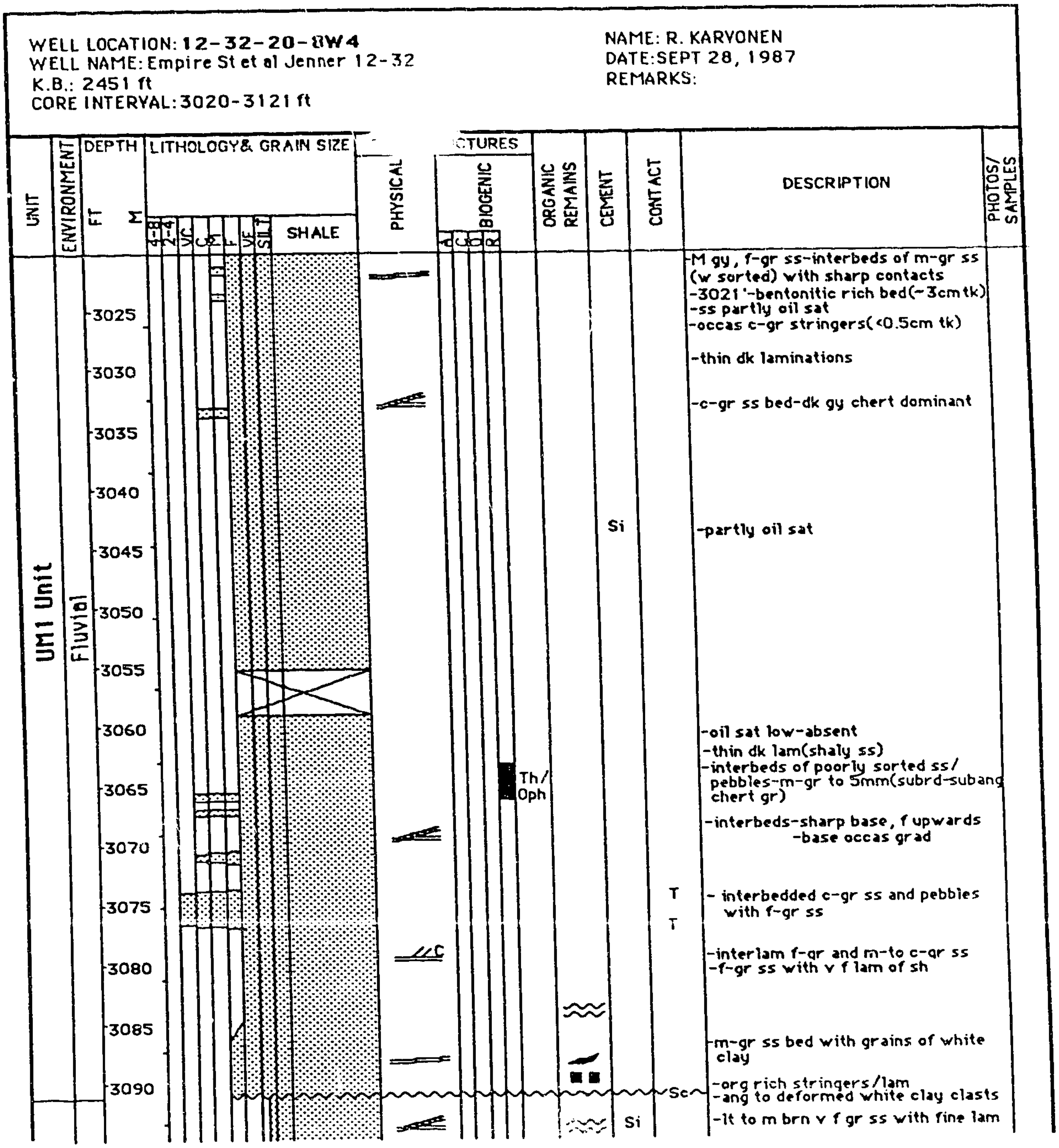
NAME: R. Karvonen
DATE: March 23, 1988
REMARKS:

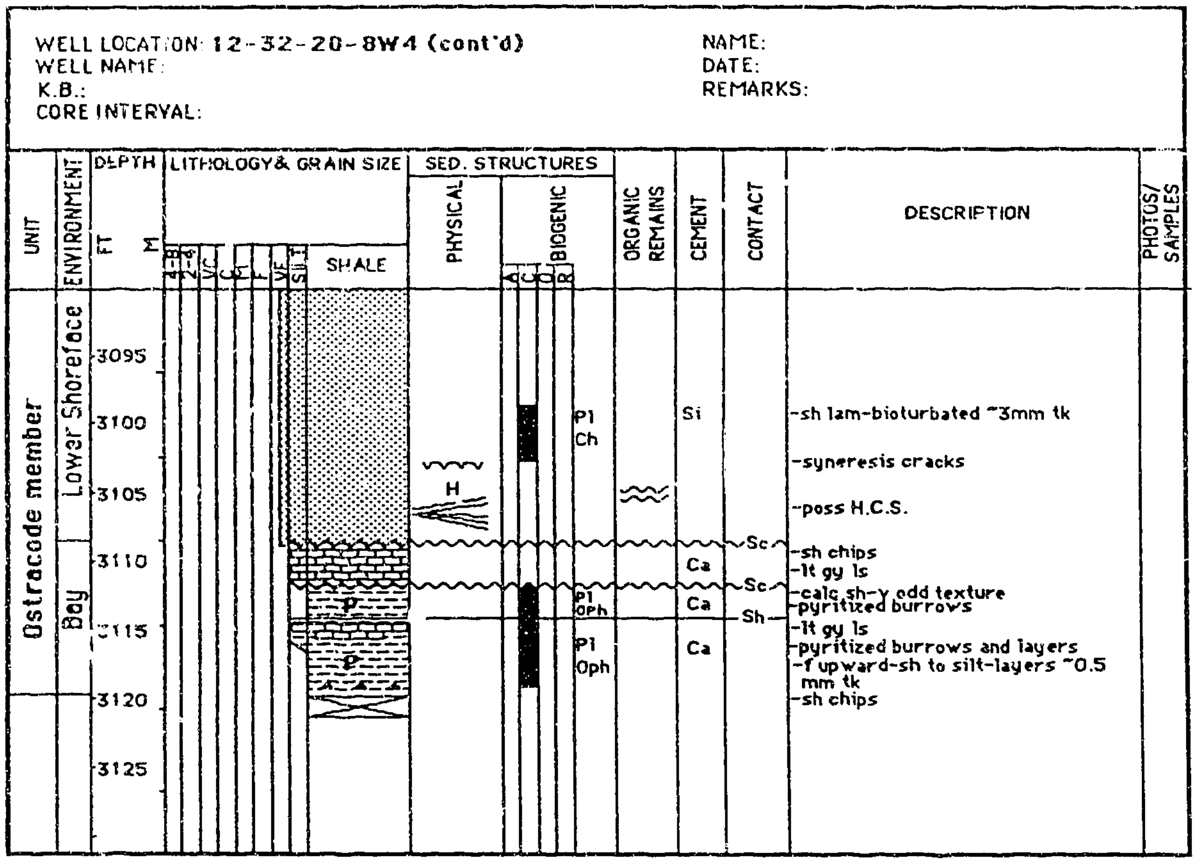



WELL LOCATION: 14-23-20-8W4
WELL NAME: Dome et al Jenner 14-23
K.B.: 743.3 m
CORE INTERVAL: 919-947m
NAME: R. KARVONEN
DATE: OCT 1, 1987
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
SHALE
SILT
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
Ostracode member
Coastal Plain
Lagoon
Shoreface
920
922
924
926
928
930
932
934
936
938
940
942
T
S
T
S
Sc
FT
Pl
Ch
-laminated silt and claystone-homo in many place
-cone in cone structure
-feldspathic f gr. ss
-lam silt and claystone (lt gy)
-irregular upper and lower contact
-pyritized burrows
-gy-brn claystone
-f gr. ss
-partly oil stained
-shale drapes-starved ripples


WELL LOCATION: 14-23-20-8W4 (cont'd)
WELL NAME:
K.B.:
CORE INTERVAL:
NAME:
DATE:
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
4-8
2-4
VC
C
M
F
VF
SILT
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
A
C
U
R
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
Ostracode member
Shoreface
Bay
942
944
946
Sc
Ch
Pl
-shale lam
-pebble/shale clast lag
-shale with silt lam
-deformed mixture of f-c gr ss
-shale with silt lam

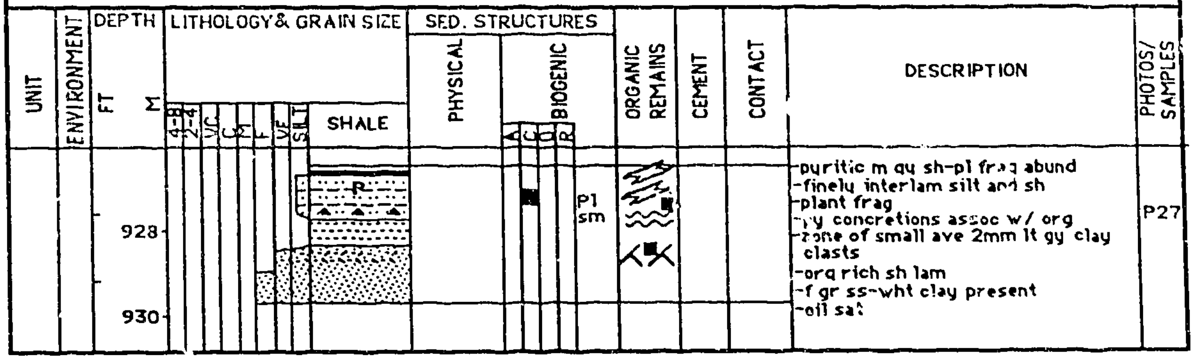

WELL LOCATION: 12-28-20-8W4
WELL NAME: Empire St et al Jenner
K.B.: 2500 ft
CORE INTERVAL: 3096-3149 ft
NAME: R. Karvonen
DATE: Jan 6, 1989
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
3100
3105
3110
3120
3125
3130
3135
3140
3145
3150
Pa?
-f gr salt and pepper ss
-floating gr-subang to subrd
-u m-c gr interbeds/lam
-homogeneous

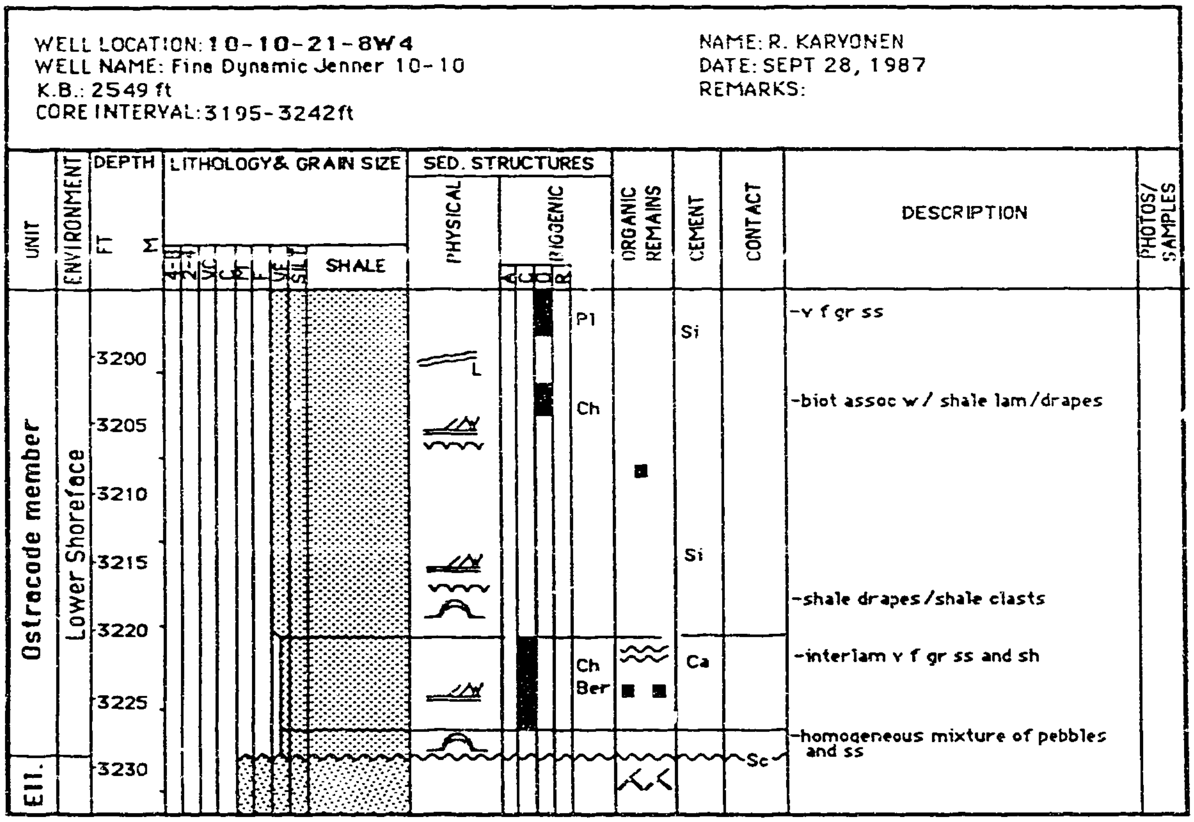

WELL LOCATION: 12-32-20-8W4
WELL NAME: Empire St et al Jenner 12-32
K.B.: 2451 ft
CORE INTERVAL: 3020-3121 ft
NAME: R. KARVONEN
DATE: SEPT 28, 1987
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY& GRAIN SIZE
SHALE
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
UM1 Unit
Fluvial
3025
3030
3035
3040
3045
3050
3055
3060
3065
3070
3075
3080
3085
3090
Th/ Oph
Si
T
T
Sc
Si
-M gy, f-gr ss-interbeds of m-gr ss (w sorted) with sharp contacts
-3021'-bentonitic rich bed(~3cm tk)
-ss partly oil sat
-occas c-gr stringers(<0.5cm tk)
-thin dk laminations
-c-gr ss bed-dk gy chert dominant
-partly oil sat
-oil sat low-absent
-thin dk lam(shaly ss)
-interbeds of poorly sorted ss/ pebbles-m-gr to 5mm(subrd-subang chert gr)
-interbeds-sharp base, f upwards -base occas grad
- interbedded c-gr ss and pebbles with f-gr ss
-interlam f-gr and m-to c-gr ss
-f-gr ss with v f lam of sh
-m-gr ss bed with grains of white clay
-org rich stringers/lam
-ang to deformed white clay clasts
-lt to m brn v f gr ss with fine lam


WELL LOCATION: 12-32-20-8W4 (cont'd)
WELL NAME:
K.B.:
CORE INTERVAL:
NAME:
DATE:
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
Ostracode member
Lower Shoreface
Bay
3095
3100
3105
3110
3115
3120
3125
H
P1
Ch
P1
Oph
P1
Oph
Si
Ca
Ca
Ca
Sc
Sc
Sh
-sh lam-bioturbated ~3mm tk
-syneresis cracks
-poss H.C.S.
-sh chips
-lt gy ls
-calc sh-y odd texture
-pyritized burrows
-lt gy ls
-pyritized burrows and layers
-f upward-sh to silt-layers ~0.5 mm tk
-sh chips

WELL LOCATION: **13-32-20-8W4**
WELL NAME: Kaiser et al Jenner 13-32
K.B.: 753 m
CORE INTERVAL: 926.6-929.6 m

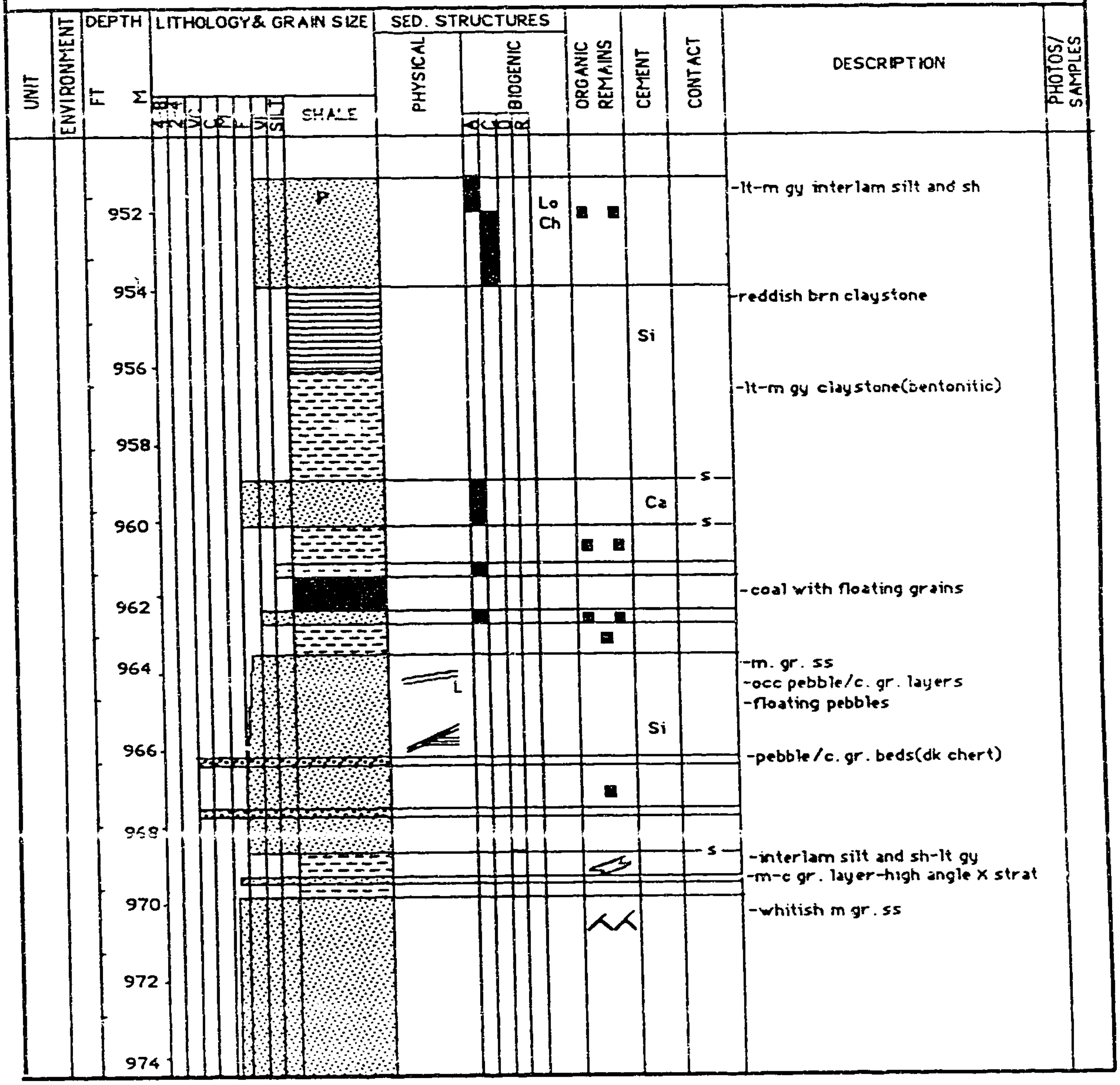
NAME: R. Karvonen
DATE: Feb 25, 1988
REMARKS:

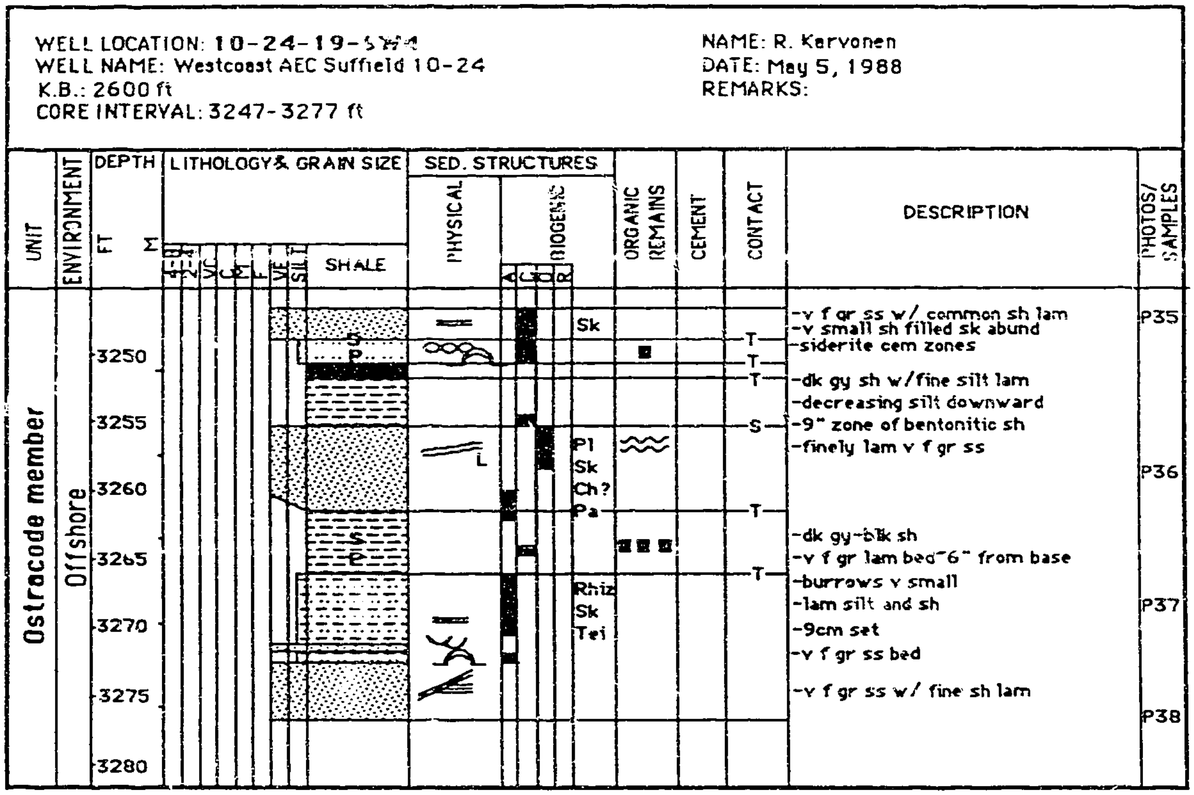


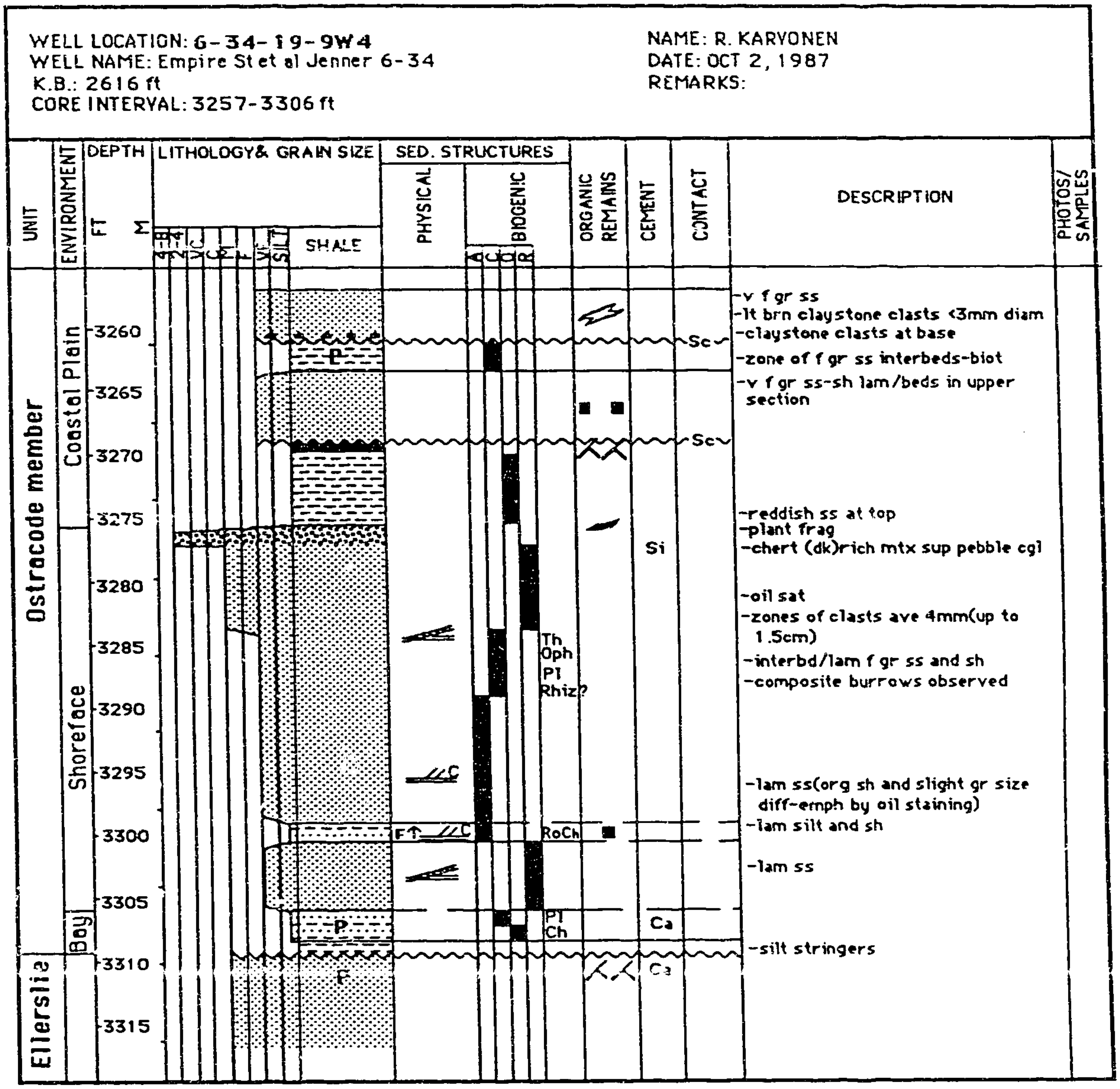

WELL LOCATION: 10-10-21-8W4
WELL NAME: Fine Dynamic Jenner 10-10
K.B.: 2549 ft
CORE INTERVAL: 3195-3242ft
NAME: R. KARYONEN
DATE: SEPT 28, 1987
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT M
LITHOLOGY& GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
Ostracode member
Lower Shoreface
Ell.
3200
3205
3210
3215
3220
3225
3230
L
Pl
Ch
Ch
Ber
Si
Si
Ca
Sc
-v f gr ss
-biot assoc w/ shale lam/drapes
-shale drapes/shale clasts
-interlam v f gr ss and sh
-homogeneous mixture of pebbles and ss

WELL LOCATION: 8-15-16-9W4
WELL NAME: Canso et al AEC Suffield 8-15
K.B.: 778 m
CORE INTERVAL: 951-974 m

NAME: R. KARYONEN
DATE: OCT 1, 1987
REMARKS: -most of this core was very rubbly

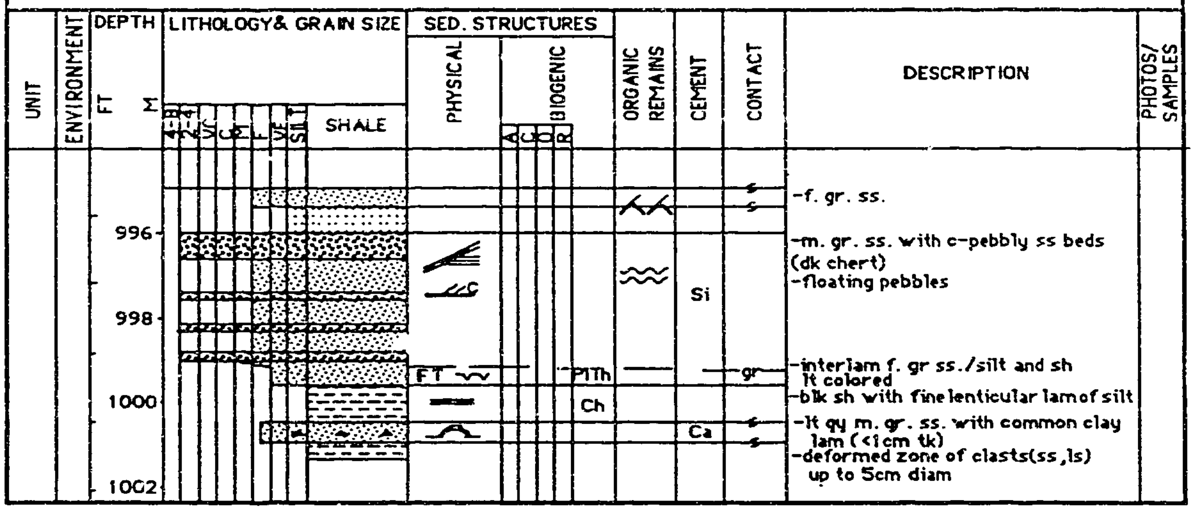


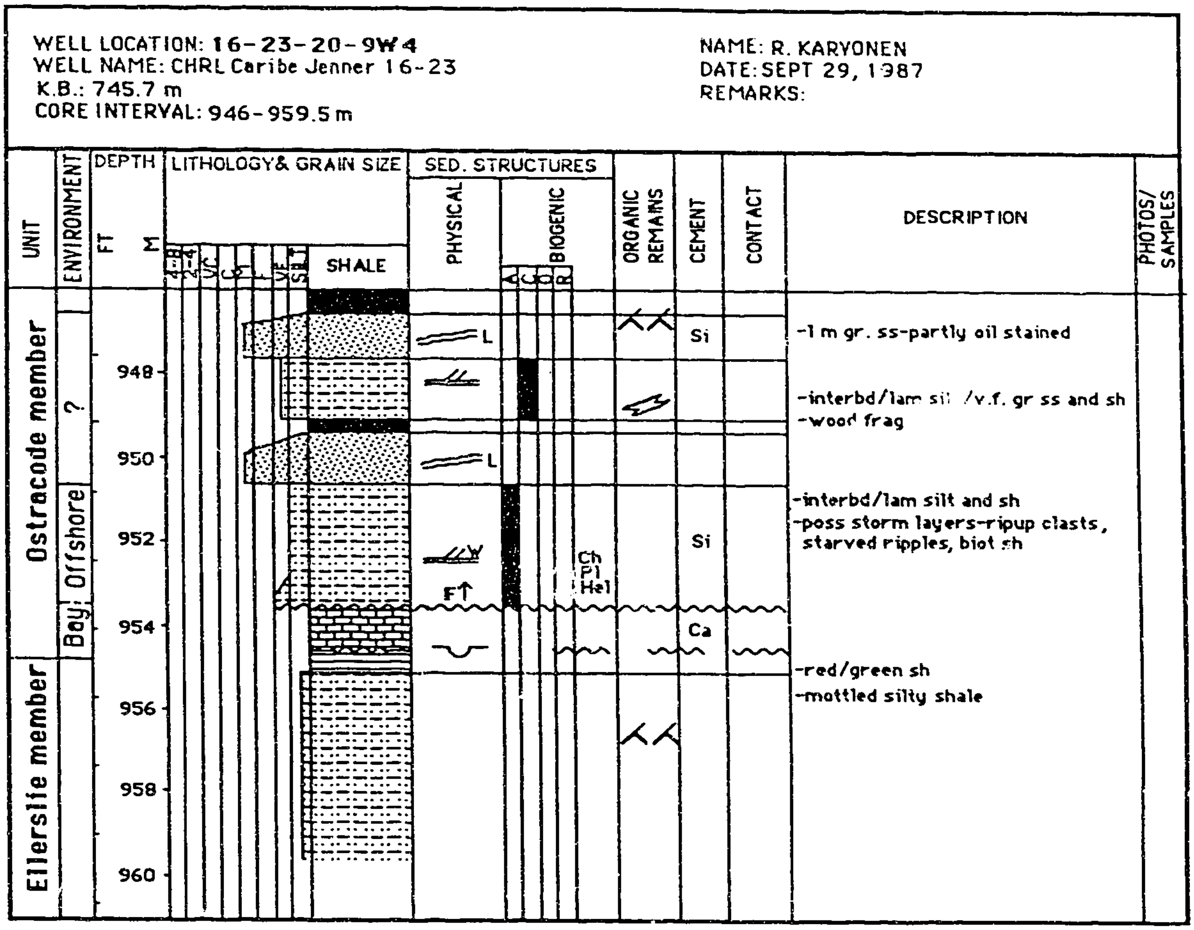

WELL LOCATION: 10-24-19-5W4
WELL NAME: Westcoast AEC Suffield 10-24
K.B.: 2600 ft
CORE INTERVAL: 3247-3277 ft
NAME: R. Karvonen
DATE: May 5, 1988
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
Ostracode member
Offshore
3250
3255
3260
3265
3270
3275
3280
Sk
Pl
Sk
Ch?
Pa
Rhiz
Sk
Tei
-v f gr ss w/ common sh lam
-v small sh filled sk abund
-siderite cem zones
-dk gy sh w/fine silt lam
-decreasing silt downward
-9" zone of bentonitic sh
-finely lam v f gr ss
-dk gy-blk sh
-v f gr lam bed~6" from base
-burrows v small
-lam silt and sh
-9cm set
-v f gr ss bed
-v f gr ss w/ fine sh lam
P35
P36
P37
P38


WELL LOCATION: 6-34-19-9W4
WELL NAME: Empire St et al Jenner 6-34
K.B.: 2616 ft
CORE INTERVAL: 3257-3306 ft
NAME: R. KARVONEN
DATE: OCT 2, 1987
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT M
LITHOLOGY& GRAIN SIZE
SHALE
SILT
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
Ostracode member
Ellerslie
Coastal Plain
Shoreface
Bay
3260
3265
3270
3275
3280
3285
3290
3295
3300
3305
3310
3315
Sc
Si
Ca
Th
Oph
Pl
Rhiz?
RoCh
Pl
Ch
-v f gr ss
-lt brn claystone clasts <3mm diam
-claystone clasts at base
-zone of f gr ss interbeds-biot
-v f gr ss-sh lam/beds in upper section
-reddish ss at top
-plant frag
-chert (dk)rich mtx sup pebble cgl
-oil sat
-zones of clasts ave 4mm(up to 1.5cm)
-interbd/lam f gr ss and sh
-composite burrows observed
-lam ss(org sh and slight gr size diff-emph by oil staining)
-lam silt and sh
-lam ss
-silt stringers

WELL LOCATION: 8-36-19-9W4
WELL NAME: Westcoast AEC Suffield 8-36
K.B.: 800.6m
CORE INTERVAL: 995-1001m

NAME: R. KARVONEN
DATE: SEPT 30, 1987
REMARKS:




WELL LOCATION: 16-23-20-9W4
WELL NAME: CHRL Caribe Jenner 16-23
K.B.: 745.7 m
CORE INTERVAL: 946-959.5 m
NAME: R. KARYONEN
DATE: SEPT 29, 1987
REMARKS:
UNIT
ENVIRONMENT
DEPTH
FT
M
LITHOLOGY & GRAIN SIZE
SHALE
SED. STRUCTURES
PHYSICAL
BIOGENIC
ORGANIC REMAINS
CEMENT
CONTACT
DESCRIPTION
PHOTOS/ SAMPLES
Ostracode member
Ellerslie member
?
Bay; Offshore
948
950
952
954
956
958
960
L
L
W
F
Ch
Pl
Hel
Si
Si
Ca
-1 m gr. ss-partly oil stained
-interbd/lam sil /v.f. gr ss and sh
-woo frag
-interbd/lam silt and sh
-poss storm layers-ripup clasts,
starved ripples, biot sh
-red/green sh
-mottled silty shale