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STRATIGRAPHIC RECONNIASSANCE

OF THE

LIARD RIVER BASIN

1968



By: R. D. Ferguson

Interpretation of Faunal Communities
and Environments by Dr. J. P. A. Noble

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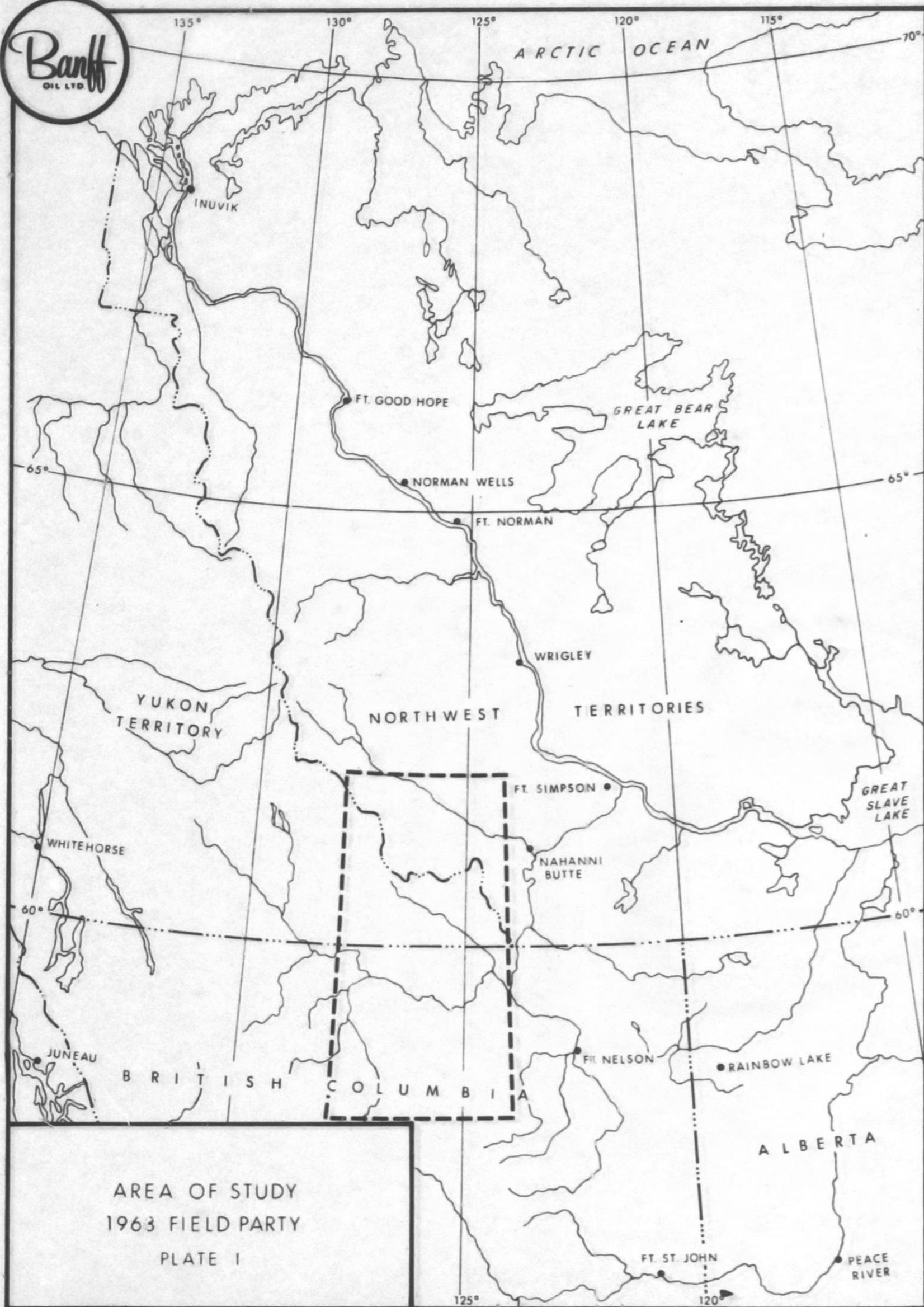
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INTRODUCTION

The study was begun in the Toad River area of Northeast British Columbia and extended northward through the Caribou Hills, Crow River and Beaver River areas to the South Nahanni area of the southern Mackenzie Mountains, a region which can be broadly referred to as the Liard Basin.

The field work was undertaken with a number of specific objectives in mind. Foremost among these were: to examine the nature of the Nahanni Shale-out where good exposures could be found; to trace the shale-out line into Northeast British Columbia and look for evidence of shale re-entrant east of the main shale basin; to examine the Nahanni/Besa River contact to determine if a major unconformity exists on top of the Nahanni; and to resolve the correlation problems between the Nahanni and Arnica Formations of the southern Mackenzie Mountains and the Dunedin and Stone Formations of Northeast British Columbia.

A considerable amount of information was obtained from micro and macropaleontological studies carried out by Drs. W. K. Braun, J. LeFevre and J. P. A. Noble. Geochemical studies on samples collected were done by Dr. J. L. Rumeau at the Centre de Recherches of S.N.P.A., in Pau, France.



PERSONNEL AND EQUIPMENT

The party consisted of geologists Dr. J. P. A. Noble of the University of New Brunswick; Dr. Jean LeFevre of S.N.P.A., Pau, France; Bas Groeneweg and R. D. Ferguson of Banff Oil Ltd. Assistants were: Ed Kozbial, a Banff Oil geological technician and Pierre Archambault, a student from Drummondville, Quebec.

A great loss was suffered as a result of a helicopter accident that occurred while flying Banff personnel on a field trip at Jasper the day before the party was to leave for the field. While attempting to take-off for a ferry flight from Jasper to Miette, the Jet Ranger helicopter struck a wire and crashed. The pilot, Alden (Mac) MacAlister, died after being rushed to the Jasper Hospital. He was an extremely competent and careful pilot, well respected throughout the industry. He had done an excellent job for us the previous year.

Injured in the crash were Messrs. Dave Barss, Mike Roop and Dr. J. P. A. Noble. In spite of being injured in the accident Dr. Noble joined us in the field for the last two weeks of field work.

The helicopter obtained after the accident was a Bell G-3B-2, ably piloted by Doug Ward. The engineer, Mel O'Reiley, proved not only willing and competent as an engineer, but also did an expert job as a cook.

REGIONAL CORRELATIONS

Correlation of Nahanni and Hume Formations:

The relationship of the Nahanni to the Hume of the Norman Wells area was discussed in the report on the 1967 stratigraphic reconnaissance program and will be discussed only briefly here.

Essentially the top and bottom of the Nahanni and Hume Formations are equivalents. The top of the Nahanni, where not eroded, may be marked by the presence of the Leiorhynchus castanea bed which is a distinct boundary at Norman Wells. The castanea bed was found at Trench Lake in 1967 (WB-11) and on the Ram River in 1968 (JN-1). Erosion, of either pre-Upper Devonian or recent age, has removed the top most beds of the Nahanni in most sections measured.

The base of the Nahanni Formation is variable as it grades into shaly Headless Formation as one approaches the shale basin to the west. The Schuchertella adoceta zone, which is found in the lower 1/3 or lower 135 feet of the Hume at Norman Wells, is also found in the lower 1/3 of the Nahanni/Headless interval in the southern Mackenzie Mountains.

Correlation with the Keg River Formation

The relationship of the Nahanni to the Keg River of Northern Alberta is not as easily determined. No diagnostic macrofauna has been reported from the Keg River in Northern Alberta in the subsurface and, as yet, there is no published

CORRELATION CHART WITH ZONE FAUNAS

PERIOD	STAGE	NORMAN WELLS AREA			SOUTHERN MACKENZIE MOUNTAINS		GREAT SLAVE LAKE NWT		NORTHWEST ALBERTA		NORTHEAST BRITISH COLUMBIA	
		CANOL	FAUNAL ZONES (lost zones of Braun)	MACRO	ROCK UNIT	FAUNAL ZONE	ROCK UNIT	FAUNAL ZONE	ROCK UNIT	FAUNAL ZONE	ROCK UNIT	FAUNAL ZONE
DEVONIAN	DEVONIAN	UNNAMED BEDS		h								
		KEE SCARP	Leiorhynchus hippocastanea Warrenella timetia Stringocephalus	f e4 e3 e2 e1			SLAVE POINT WATT MTN.	Timetia Chara	SLAVE POINT		SLAVE POINT WATT MTN.	Stringocephalus
		HARE INDIAN	Abundant Tentaculites	d	ROOT RIVER (REEF)?	Stringocephalus	HORN RIVER SHALE PRES. QUILLE BARRIER SULPHUR POINT NYARLING (MUSKEG)	Stringocephalus burtini Leiorhynchus castanea	SULPHUR POINT MUSKEG		SULPHUR POINT KLUA SHALE	Stringocephalus
		HUME	Leiorhynchus castanea Billingsastrea verrilli Schuchertella adoceta	c b	NAHANNI HEADLESS	Leiorhynchus castanea Billingsastrea verrilli Schuchertella adoceta	LONELY BAY (KEG RIVER) U. CHINCHAGA	Atrypa arctica Caranotina dysmorphostratia	KEG RIVER U. CHINCHAGA		DUNEDIN	Leiorhynchus castanea Billingsastrea verrilli Schuchertella adoceta
		BEAR ROCK		a	LANDRY / MANETOE / FUNERAL	Warrenella sp. A Two holed assicle	L. CHINCHAGA MIRAGE POINT (COLD LAKE) ERNESTINA LAKE	Welleria meadowlakensis Planetophyllum planetum	L CHINCHAGA COLD LAKE ERNESTINA LAKE	Welleria meadowlakensis Planetophyllum planetum	STONE (ARNICA) WOKKPASH	
	MIDDLE DEVONIAN				ARNICA							
					CAMSELL							
	LOWER DEVONIAN				DELORME	Gypidula pelagica Monograptus yukonensis Monograptus nilsonni					MUNCHO - McCONNELL	
SILURIAN												
ORDOVICIAN		RONNING	Halysites		WHITTAKER	Halysites						
			Tetragraptus Halysites Catenipora Bighornia	U M L	MT. KINDLE	Halysites Catenipora Bighornia	CHEDABUCTO LAKE	Halysites Streptolasma Catenipora Bighornia				
MIDDLE CAMBRIAN					SUNBLOOD	Isograptus cadeus	LA MARTRE FALLS	Diplograptus				
LOWER CAMBRIAN		SALINE RIVER			MTN.							
		McDOUGAL GROUP			MT. CAP MT. CLARK		OLD FORT ISLAND	Trilobites				

data on the microfauna in subsurface. However, Dr. W. K. Braun at the University of Saskatchewan is, at present, attempting to determine the precise correlation of the Keg River to the Nahanni from Ostracods but results to date have not been conclusive. Only the Upper Keg River has been worked on as yet and only "b" ostracods found. Other wells are to be looked at presently. On this project he is sponsored by the Institute of Sedimentary and Petroleum Geology.

A paper recently published by Craig et al (1967) describes four Keg River outcrop sections in the Slave River area. They show that the "a", "b" and "c" ostracod fauna of Braun are present in the Keg River Formation in outcrop, as well as the A. arctica fauna of Crickmay.

The authors state that "Clearly, the carbonates at these four stations are lithologically and faunally related. It is an easy matter to correlate the carbonates section at these outcrops both microfaunally and lithologically with the lower part of the Keg River Formation in the subsurface". However, they do not list the microfauna in subsurface which support this statement.

Two observations must be made concerning the above quotations. Firstly, the presence of the "a" ostracod fauna with the A. arctica fauna is anomalous in that the "a" fauna is a restricted fauna according to Braun and would not be expected with the open marine A. arctica fauna.

Secondly, a serious question is posed concerning the ranges of the two fauna when the "a" fauna and the A. arctica fauna are reported to occur together. The "a" ostracod fauna is believed to be restricted to basal Hume or uppermost Gossage or Landry. The A. arctica fauna on the other hand is considered by Crickmay to be uppermost Hume. It would appear that either the ranges of one or both of these fauna are greater than expected or that the ostracod assemblage identified is not truly the "a" fauna of Braun. A mis-identification would be possible due to the fact that the pictures of the fauna have not as yet been published by Dr. Braun.

A second occurrence of the A. arctica fauna in the Keg River platform was reported by Dr. G. O. Raasch from an examination of the Iskut Little Buffalo Falls well. He reported A. arctica within 61 feet of the top of the Chinchaga.

Based originally on stratigraphic evidence, we had equated the Keg River with the upper part of the Nahanni. The occurrence of the arctica fauna in the base of the Keg River provides confirmation although the lower range of the species identified from the A. arctica suite, i.e. Disquamata arctica (Warren), or the older name "Atrypa arctica", is not as limited as the Leiorhynchus castanea species referred to earlier. Further support to the above interpretation will be given in the discussion of the Chinchaga.

Correlation with Dunedin Formation

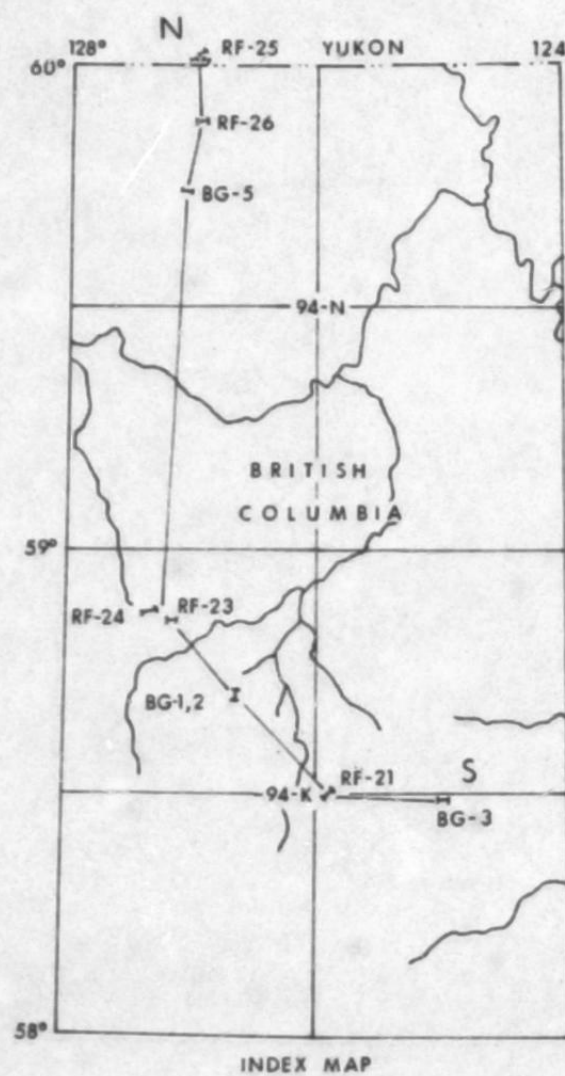
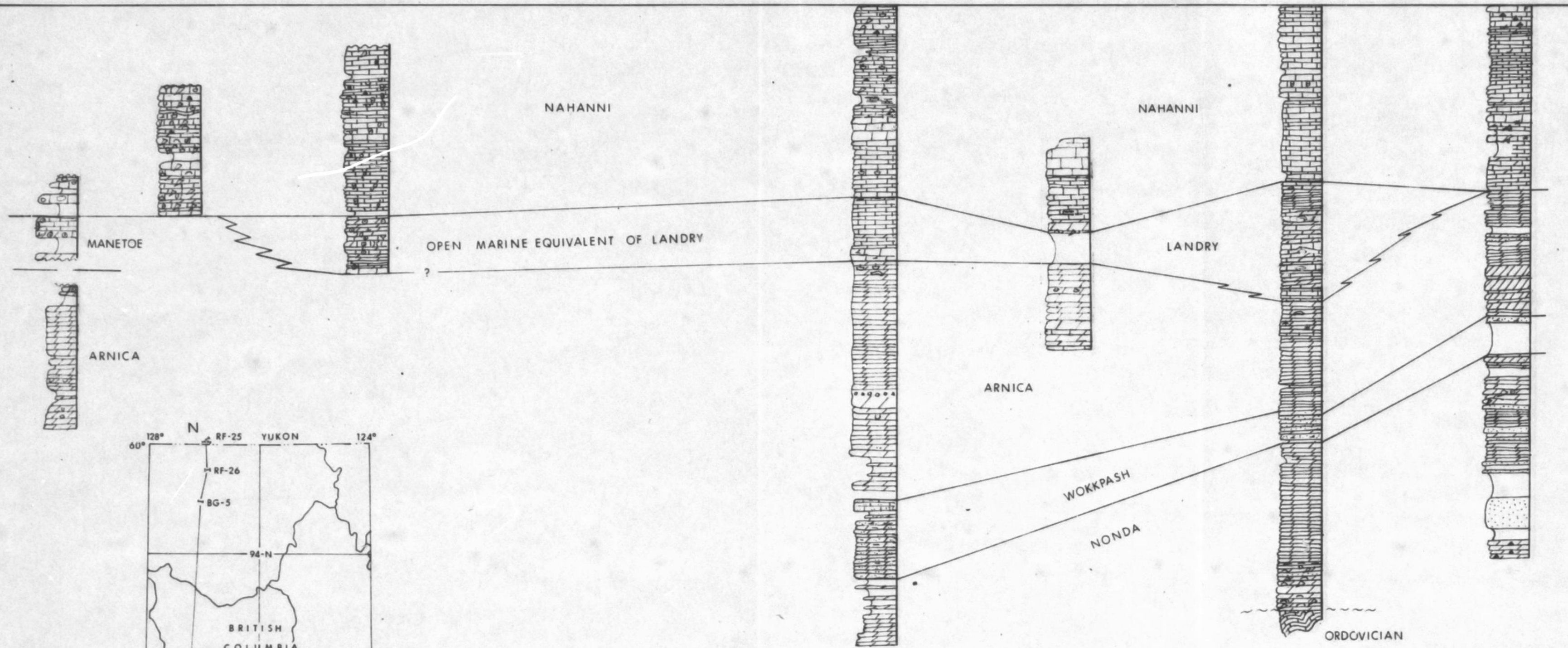
Correlation of the Nahanni with the Dunedin of Northeast British Columbia is confounded by the lack of conclusive faunal control, as well as, the lack of good stratigraphic markers.

The Dunedin Formation was named by Dr. Gordon Taylor of the Geological Survey of Canada (in press) for the sequence of limestones of Middle Devonian age that overlies the dolomite of the Stone Formation in the Macdonald Creek area of Northeast British Columbia. No diagnostic fauna was available at that time to define either the upper or lower limits of the formation. It was felt, therefore, that a new formation name should be used, as the relationship to the Nahanni and to the Keg River was not known.

With later work, the Geological Survey of Canada was able to determine the age of the top of the limestone sequence in the Toad River area. Leiorhynchus castanea was found at the top of the sequence in outcrops near Muncho Lake (Dr. Taylor, personal communication). This very diagnostic fossil confirms that the top of the Dunedin in this area is equivalent in age to the top of the Nahanni.

The base of the Dunedin was taken at the top of the dolomites of the Middle Devonian "Stone" Formation also named by Taylor. The base is not marked by a distinct fauna but rather by the transition from limestone to dolomite. Although the Schuchertella adoceta species has been found in the Dunedin, it does not appear to be as restricted in range in the Dunedin

N. RF-25 CROW RIVER 9 mi. RF-26 N. CARIBOU RGE. 14 mi. BG-5 CARIBOU HILLS 59 mi. RF-23, 24 S. E. MUNCHO LK. 15 mi. BG-1,2 YASH CREEK 18 mi. RF-21 WOKKPASH CREEK 16 mi. BG-3 MOUNT MARY HENRY S.



STRATIGRAPHIC CROSS SECTION

MOUNT MARY HENRY to CROW RIVER

INTERPRETED BY: R.D.F.	CONTOUR INTERVAL:
DATE: Jan., 1971	SCALE: Vert. 1" = 500' Hor. 1" = 8 mi.
REVISED:	FILE NO.:

as it is in the Nahanni and Hume Formations, where it is found only in the lower third of those formations.

S. adoceta was found at BG-5, in the Caribou Hills, within the upper half of the limestone unit. The Geological Survey of Canada has found S. adoceta or S. cf adoceta at three locations in the Caribou Hills, at 200 feet, 297 feet and 580 feet below the top, (Taylor, personal communication). Also at BG-5, Noble has identified Billingsastrea verrilli zone fauna from above the Schuchertella adoceta occurrence and Braun has identified his "b" zone ostracods also from the upper half of the carbonate.

It must be concluded from the above that the upper beds of the Nahanni are either absent by truncation or non-deposition, or are represented by shale in the Caribou Hills.

Another, even higher occurrence of Schuchertella adoceta is also reported by Taylor in the North Caribou Hills. Here S. adoceta was found within 12 feet of the top of the carbonate/shale contact. We believe this section resembles the Crow River section, RF-25, in which only the lower 200 feet of Nahanni is present.

We have conclusive evidence, mentioned above, to support the correlation of the top of the Nahanni with the top of the Dunedin where an uneroded top is found.

We have been less successful in determining the age of the basal beds of the Dunedin. We believe that Landry equivalent

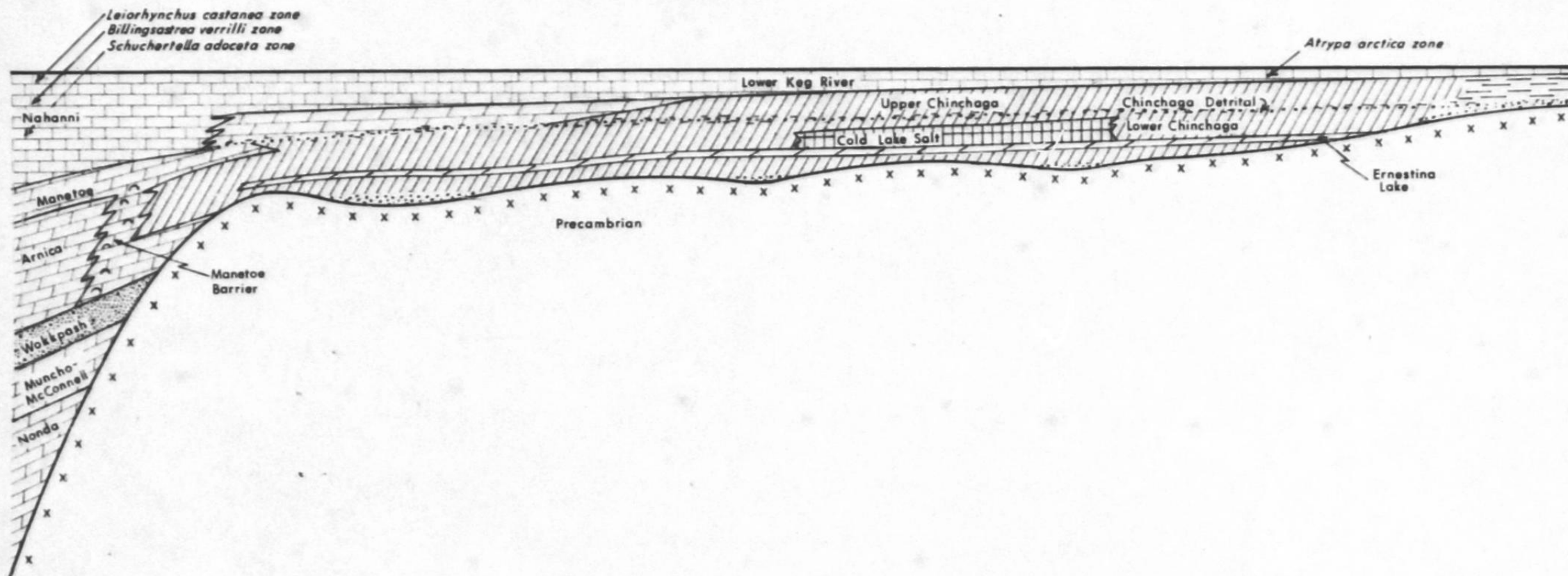
TOAD
RIVER

EVIE
LAKE

RAINBOW
AREA

LITTLE BUFFALO
RIVER

CLEARWATER
RIVER



SCHEMATIC CROSS SECTION AT END OF LOWER KEG RIVER TIME

SCALE: Vert - 1" = 1000'
Hor. - none

R. D. F., 1970

beds may be included in the Dunedin based on the following evidence:

Both the Landry/Arnica contact and the Dunedin/Stone contact are gradational in their respective areas.

Both the Landry and the basal beds of the Dunedin are generally unfossiliferous. One exception is RF-21 which contained an abundance of algal structure in the lower part. Although algae are not common in the Landry, the equivalent Manetoe Formation contains an abundance of laminates which are believe to be of algal origin. A second exception is seen in BG-5 where the basal limestone beds contain an open marine brachiopod fauna. The Landry age is indicated by two-holed crinoids but the typical "restricted limestone" are absent. Apparently, this is an open marine equivalent of the typically restricted Landry facies.

Finally, the position of *Schuchertella adoceta* 600 feet above the base of the limestone strongly supports the conclusion that beds older than Nahanni are included in the Dunedin Formation.

The Stone (or Arnica) Formation

The Stone Formation was named by Dr. Taylor (in press) also, for the sequence of unfossiliferous dolomites which underly the Dunedin and overly the Wokkpash sandstones, Lower Devonian Muncho McConnel or Silurian Nonda Fromations, depending on the area. The top is believed to be a transitional contact in the

Toad River area but the base is well defined by the Wokkpash sandstone.

The lithology of the Stone is very similar to that of the Arnica with the exception of the very prominent banding found in the Arnica of the Mackenzie Mountains. Both are generally a very finely crystalline, medium to thickly bedded dolomite with little or non fauna. Only rarely is anything but crinoids found in either. These similarities plus its stratigraphic position give strong support to equating the two formations. We would, therefore, recommend dropping the name "Stone Formation" and using Arnica Formation for the Middle Devonian dolomite unit.

THE CHINCHAGA FORMATION

The Chinchaga Formation was named by Law (1955), for the sequence of anhydrites and anhydritic dolomites and sandstone that underly the Keg River and overly the Red Beds which mark the base of the Elk Point group. The Chinchaga was divided into an upper and lower member by Belyea and Norris (1962). The lower member consists of mainly anhydrite, dolomite and sandstone. The upper member is mainly an anhydritic dolomite with interbedded anhydrite and an underlying clastic unit generally called the middle Chinchaga clastic.

Belyea (1970) has demonstrated that this middle Chinchaga clastic overlies an unconformity and various units underlying can

be seen to be truncated in an easterly direction.

The clastic break, which has for some time been considered a reliable correlating marker, can be traced throughout northern Alberta, Northeast British Columbia and throughout most of the Mackenzie Valley (Plates 3, 4 & 5). It was cored in the Imp. Arrowhead I-46 well and there appears to be a soft green shale infilling the leached surface of the Landry Formation. A similar green shale break has been reported by Blake Brady at the base of the Headless from a number of sections in the Southern Mackenzie Mountains. Where not found, it may be that it is concealed by a covered interval.

Faunal control on the age of beds just overlying the clastic break was obtained in subsurface from the Imp. Netla F-73 well which is located about 12 miles southwest of the Arrowhead I-46 well mentioned above. The distinctive lower Hume (or Nahanni) indicator, "Schuchertella adoceta" was found at 7,547 feet in an open marine limestone, only 43 feet above the clastic marker. As the lithology remains the same down to the clastic unit, there is no doubt that the Nahanni extends down to the clastic break and is, therefore, the marine equivalent of the Upper Chinchaga evaporites.

Although the above mentioned evidence is conclusive, we have other evidence based on a few brachiopods found in a dolomite near the middle of the Chinchaga in outcrop south of Great Slave Lake. Dr. A.W. Norris (personal communication) has

identified one species as Caranatina dysmorphostrotia, a species representing the Billingsastrea verrilli zone of the Hume or Nahanni Formations. This occurrence of the B. verrilli fauna in the Chinchaga plus the presence of the Atrypa arctica fauna in the basal Keg River at Little Buffalo River (see Plate 3), give further conclusive evidence that both the Upper Chinchaga and at least the Keg River platform are represented by the Nahanni in the Mackenzie Mountains.

We, therefore, have a regular progression from west to east with open marine limestones deposited near the mountain front going abruptly to an evaporitic facies, which also changes facies as it onlaps the Canadian Shield in the east, and is represented there by the shales, siltstones and sandy dolomites of the McLean River Formation. A schematic diagram showing this relationship is seen in Plate 7.

THE NAHANNI SHALE-OUT

The broad shallow shelf carbonates of Nahanni age that extend from the Canadian Shield westward for about 350 miles were known to pass into shales along the more or less north - south extension of the Road River basin, (Lenz and Jackson, 1964; Douglas and Norris, 1960; Brady, personal communication). After doing some reconnaissance in the Meilleur Creek area, we were able to locate some good exposures where the facies change could not only be conclusively demonstrated but could also be examined in detail to determine

the paleontological, as well as, lithological changes that occur.

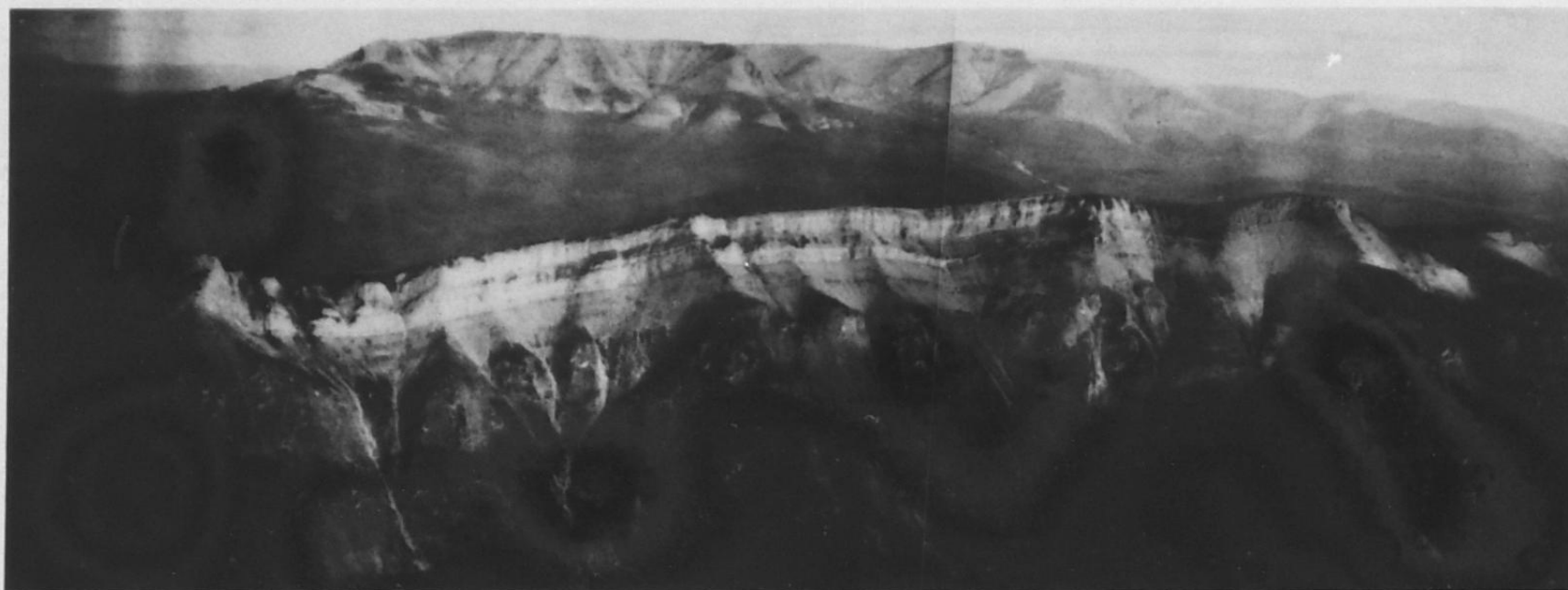
Indisputable physical evidence of the shale-out is shown in the photo, Plate 8. The thick section of shelf carbonate goes to a basinal shale within about three miles in a north - south direction in a local embayment in this area.

In an east - west direction, Plate 9, the transition is traced from a near shore carbonate position at WB-16 along a gently dipping platform to a shelf margin position at RF-32 and into the basin at RF-30.

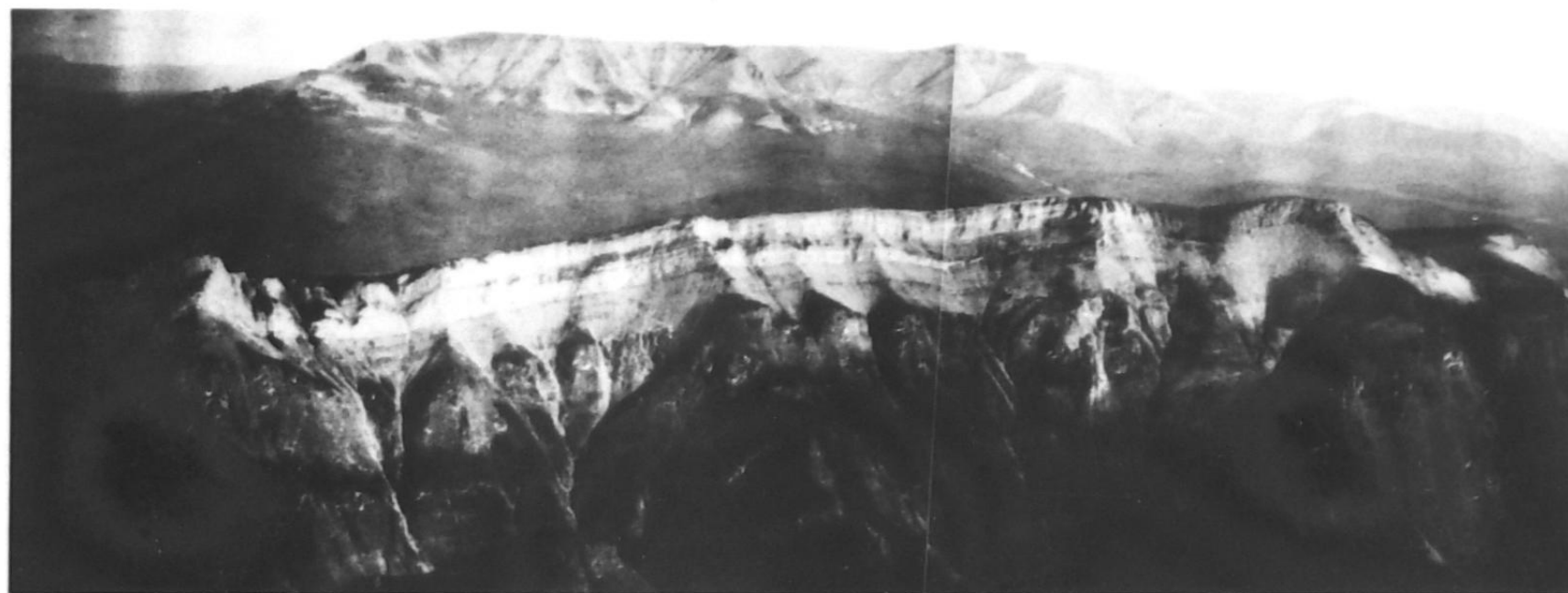
Although the most diagnostic faunas were not present in these sections, there was sufficient representation of the established faunal zones. I.e. L. castanea, B. verrilli and S. adoceta zones, that correlation was confirmed even across the shelf to basin transition.

A fourth zone was established by Dr. Noble, the Warrenella species 1 zone which underlies the adoceta zone. Warrenella species 1 is very common throughout the southern Mackenzie Mountains and Dr. Noble feels it is readily distinguished from younger Warrenellas. It is generally found near the top of the Funeral shales.

Some difficulty was encountered in precise correlations from the shelf into the basin as the changes in bathymetry apparently also caused a change in fauna as well. Specifically, the difficulty arose in precise correlations between sections RF-28, RF-30 and RF-32.



NAHANNI SHALE-OUT
Photograph by R.D. Ferguson



NAHANNI SHALE-OUT

Photograph by R.D. Ferguson

Considering firstly the correlation of RF-30 and 32, section RF-32 contains abundant specimens of the genus Warrenella from near the base of the section to the top. Three species which Dr. Noble refers to as 2, 3 and 4 are found, with species 2 and 3 being dominant in the upper half species 4 occurring only near the top. In RF-30, species 2 and 3 occur in the middle and upper part of the section but species 4 was not collected. Lower down, however, Warrenella species 1 was found, this being the species which elsewhere is commonly found in the upper part of the Funeral and below the Schuchertella adoceta zone.

The sections are also correlated reasonably well in the upper part by the characteristic fauna of the Billingsastrea verrilli zone, i.e. Hadorhynchia sp. 1, Spinulicosta stainbrooki, Spinatrypa coriacea, Syringopora sp. 1 etc. These forms occur in both sections in the upper 800 feet.

Correlation with the Beaver River section, RF-28 is more difficult.

Large samples of the shales overlying the carbonate were taken but did not yield any diagnostic microfauna. Macrofauna was collected diligently but the more diagnostic species were absent. However, three criteria, in ascending order of importance, are discussed below.

Firstly, the lithology of the carbonates is the typical light to medium grey, coarse crystalline, highly crinoidal, massive dolomite found in the Manetoe throughout the southern

Mackenzie Mountains. It is no doubt the product of the recrystallization of a relatively fossiliferous, somewhat porous limestone.

Although the conditions necessary to produce a Manetoe-type dolomite were present at different times, those conditions appear to have been most prevalent in late Eifelian time, just prior to the Headless transgression.

Secondly, both the coarsely crystallized dolomite and the few feet of coarse grained, crinoidal, variably dolomitized limestone contain an abundance of two-holed crinoids. We recognize that the two-holed crinoid does not have a very restricted range, that it may be as old as Gedinian but almost surely it is not younger than Eifelian. In fact, to our knowledge, it has been found anywhere within the Nahanni/Headless sequence.

Thirdly, and perhaps most significantly, a single specimen of Warrenella species 1 was collected from the top of the carbonates, just below the shales. This species is almost surely pre-Headless according to Dr. Noble, who has studied extensively the many Warrenellas found in the Mackenzie Mountains.

On the basis of the foregoing, plus the fact that we have traced the Nahanni shale-out in this direction, we feel confident that the carbonate at RF-28 is truly Manetoe and not recrystallized Nahanni.

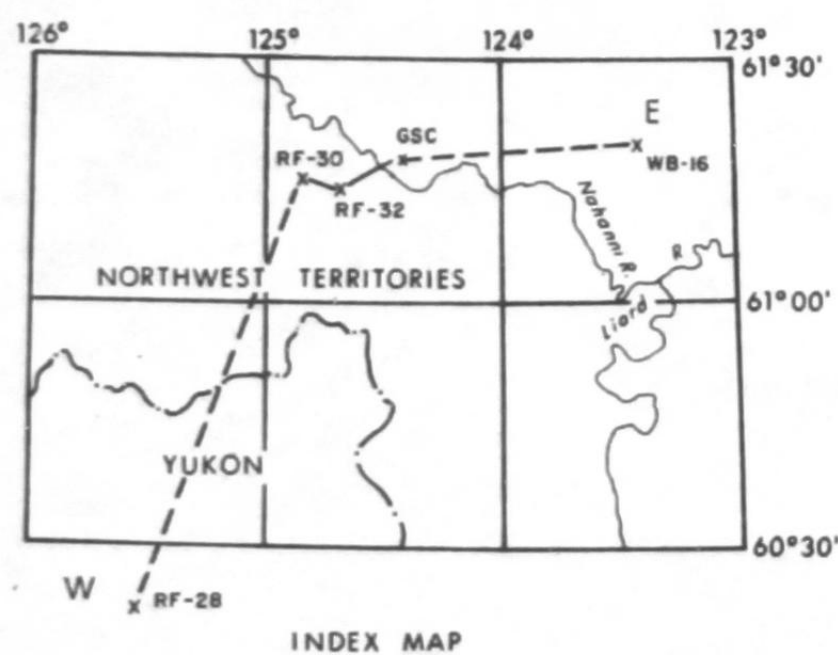
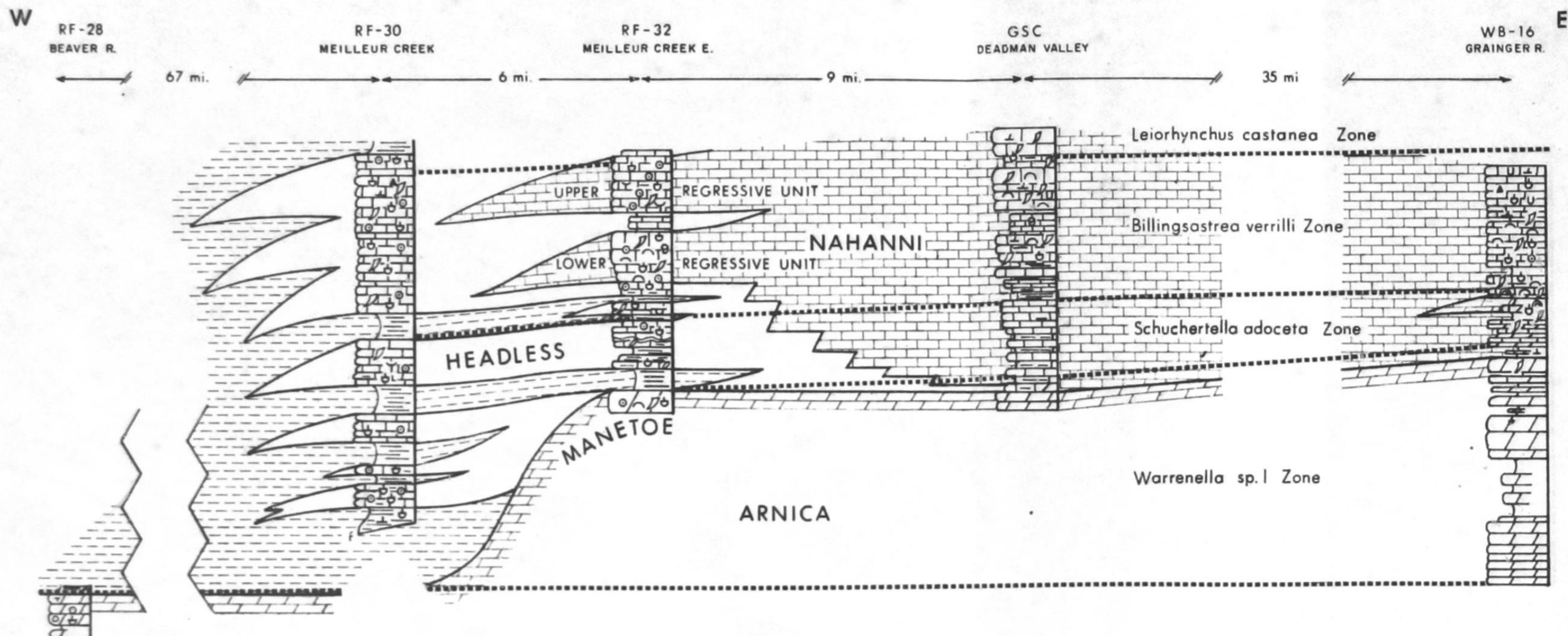
Faunal Communities and Indicated Depositional Environments

After examining the abundant fauna obtained near the shelf margin, Dr. Noble found that although there was some mixing of the fossil assemblages he was, nevertheless, able to recognize several fossil communities. These communities were probably not transported to any significant extent, we believe, as evidenced by the lack of fragmentation and disarticulation of valves of the brachiopods and by the high percentage of micrite in the matrix. The distribution of the principal faunal communities across the shelf to basin transition is shown in Plate 10. The main components of each community are summarized in Plate 9, along with tentative environmental interpretations made from an analysis of each member of the faunal communities and of their associated sediments. A general discussion by Dr. Noble of these communities follows:

Massive Stromatoporoid-Coral Biofacies

Limestone, slightly argillaceous, often dolomitic with irregular mottling. Some silicification. Limestone variable but predominantly micrites with minor fossiliferous micrites and pelmicrites. Bedding thin to thick or massive, often irregular and lensoid.

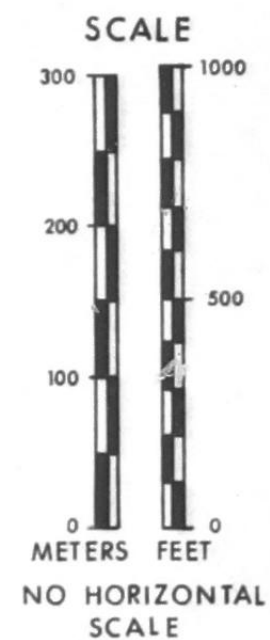
This biofacies is characterized by a fauna of corals and stromatoporoids, many of which make up reefoid masses on a small scale. *Amphipora* is common in some beds; *Spongophyllids*, *Socialophyllum*, *Xystriophyllum*, *Leptoinophyllum*, *Alveolites*,



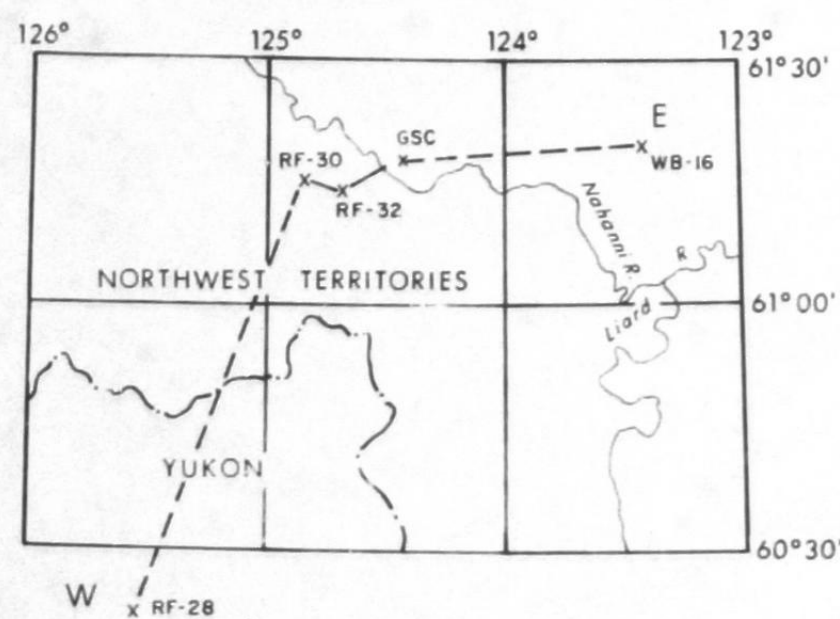
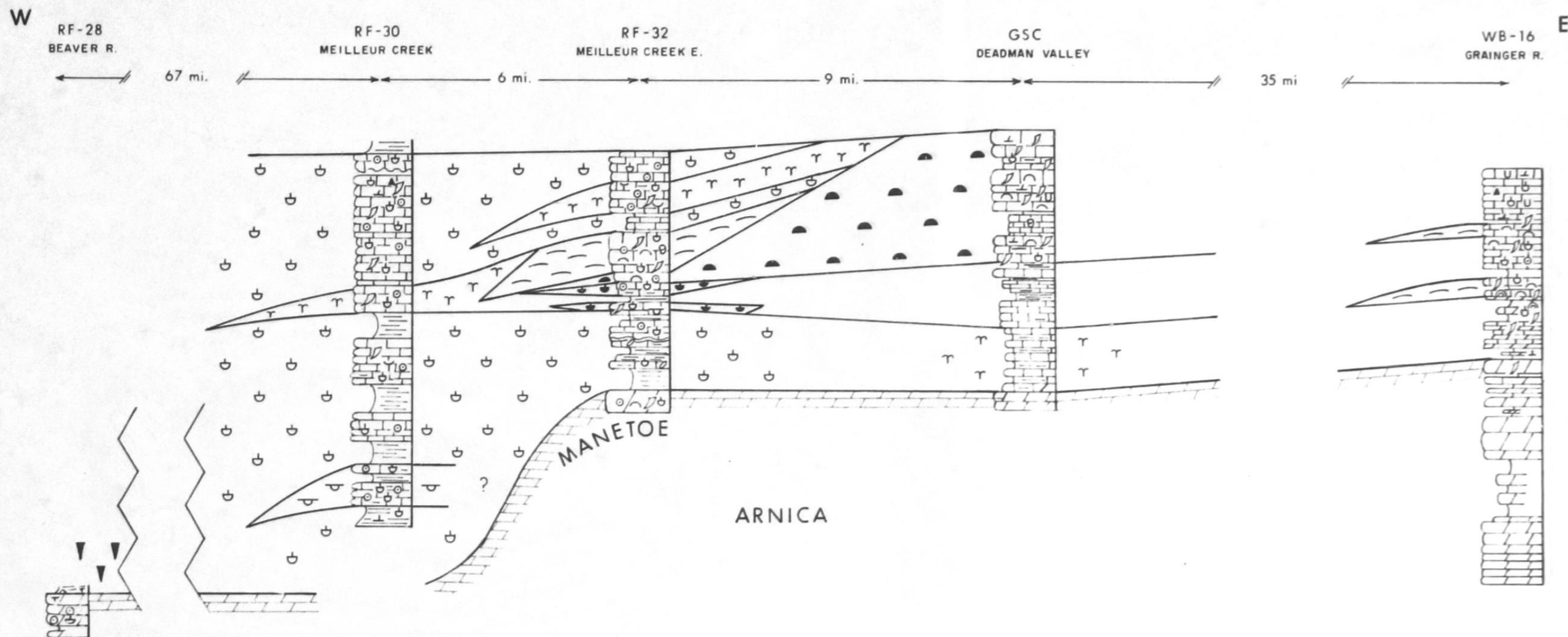
LEGEND

- ⊙ Crinoid
- ⊕ Brachiopod
- ⌒ Stromatoporoid
- U Amphipora
- Y Bryzoa
- ⌒ Algae
- Ostracod
- ⊖ Gastropod
- ⌒ Pelecypod
- ⌒ Coral
- ▲ Chert

- Limestone
- Dolomite
- Shale
- Shale and Limestone



LITHOLOGIC CROSS SECTION ACROSS SHELF TO BASIN TRANSITION



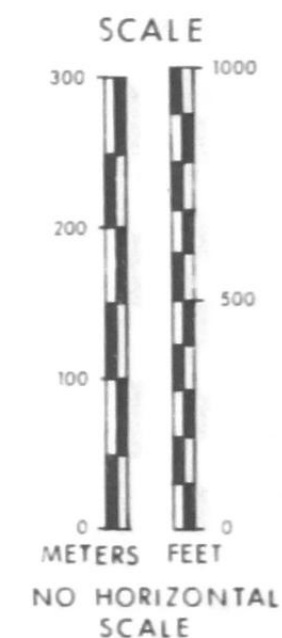
INDEX MAP

LOG SYMBOLS

- ⊙ Crinoid
- ⊕ Brachiopod
- ⌒ Stromatoporoid
- u Amphipora
- Y Bryzoa
- ⌒ Algae
- Ostracod
- ⊖ Gastropod
- ⌒ Pelecypod
- ⌒ Coral
- ▲ Chert

FAUNAL COMMUNITY

- MASSIVE STROMATOPOROID - CORAL COMMUNITY
- LAMINAR STROMATOPOROID - CORAL COMMUNITY
- BRANCHING TABULATE CORAL COMMUNITY
- WARRENELLA RHYNCHONELLID COMMUNITY
- SPINULICOSTA - ATRYPID COMMUNITY
- EMANUELLA - PELECYPOD COMMUNITY
- PELAGIC COMMUNITY
- DOLOMITE LIMESTONE SHALE

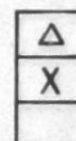


DISTRIBUTION OF FAUNAL COMMUNITIES ACROSS SHELF TO BASIN TRANSITION

MAIN COMPONENTS OF FAUNAL COMMUNITIES WITH ENVIRONMENTAL INTERPRETATION

COMMUNITY	MASSIVE STROMS	BRANCHING STROMS	LAMINAR STROMS	MASSIVE TABULATE CORALS	BRANCHING TABULATE CORALS	LAMINAR TABULATE CORALS	MASSIVE RUGOSE CORALS	FASCICULATE RUGOSE CORALS	SOLITARY RUGOSE CORALS	BRACHIOPODS	CRINOIDS	GASTROPODS	PELECYPODS	TRILOBITES	OSTRACODS	BRYOZOA	CRICOONARIDS	AMMONOIDS	
MASSIVE STROM. - CORAL				X	X		X	X	X	X	X	X							OUTER SHELF - SLIGHTLY RESTRICTED
SPINULICOSTA - ATRYPID					X				X	△	X	X		X					OUTER SHELF - SLIGHTLY RESTRICTED
LAMINAR STROM	X		△	△		△	X		X	X	X			X	X				SHELF EDGE
SYRINGOPORA - SPINULICOSTA	X	X			△		X			X	X	X							SHELF EDGE
BRANCHING TABULATE CORAL	X	△		X	△		X		X	X	X	X			X				SHELF EDGE - SHOAL
ATRYPA - BRYOZOA					X					△	X	X				△			SHELF EDGE - SHOAL
WARRENELLA - RYNCHONELLID									X	△	△	X	X	X	X		X		SLOPE - BASIN
EMANUELLA - PELECYPOD										△			△	X	X				SLOPE - BASIN
LINGULA										△							△	X	BASIN
PELAGIC										X	X				X		△	△	BASIN

KEY



△ MAJOR COMPONENTS
 X MINOR COMPONENTS
 ABSENT OR RARE

Favosites and Thamnopora and fasciculate corals of various genera occur but are not common. Gastropods, crinoids and brachiopods are of less importance.

This community is typically seen in the upper part of the Nahanni Formation on the outer shelf but a little behind the edge, (Plate 10).

In view of the stromatoporoids, coral heads and reefal masses and relatively minor percentages of fragmented shells, this biofacies must have been deposited in a shallow water environment free from the influence of terrigenous material. The limestones, however, are almost entirely micrites and pelmicrites indicating rather low energy conditions, and together with the interbedded dolomites and on the whole, rather sparse fauna, indicate a shallow area of slightly restricted circulation, possibly behind a shoaling area at the edge of the shelf immediately to the west. This biofacies may be compared with the facies of the Manlius Formation of New York state which Laporte (1968) regards as having formed in a slightly restricted environment behind crinoidal bars of the Coeymans Formation.

Spinulicosta-Atrypid Community

Limestone, argillaceous in part, micrites, fossiliferous micrites and some pelmicrites and biomicrites. Sparites rare. Thin to medium nodular bedding.

Spinulicosta stainbrookii and atrypids are the common elements of this mixed assemblage. Other productids include

Productella; spiriferids may be present, especially Emanuella, and occasional gastropods and small solitary rugose corals and small branching tabulate corals. Crinoid ossicles and trilobite fragments also occur. The fauna, however, is dominated by brachiopods, especially Spinulicosta stainbrooki, Atrypa aperanta, Spinatrypa coriacea and other atrypids.

This community is closely associated with both the Massive Stromatoporoid Biofacies and the Laminar Stromatoporoid Biofacies and may be observed at the edge of the shelf or back from the edge in a position interpreted as slightly restricted outer shelf.

This interpretation is supported by the fact that the atrypids are mostly the spinaceous types which according to Copper (1967) are found in relatively quiet water lagoonal environments.

Laminar Stromatoporoid Community

Limestones, traces of argillaceous content, slightly dolomitic with irregular chert lenses and a partially silicified fauna. Limestones are predominantly micrites with occasional pelmicrites, intramicrites and biomicrites. Bedding is thick-bedded to massive and regular.

Fauna consists of mainly small laminar stromatoporoids and laminar and small massive tabulate corals, especially Favosites. Massive colonial corals and stromatoporoids and solitary rugose corals are dispersed through the biofacies but are rare. A few scattered brachiopods (partially fragmented)

included Spinulicosta and Emanuella; trilobite fragments, such as Otarium sp. and a few ostracods and crinoids, occur sporadically.

The fauna and sediments of this biofacies and its position relative to other biofacies are consistent with a postulated sub-turbulent (Lecompte, 1956) shoal environment at the outer edge of the shelf.

Branching Tabulate Coral Community

Limestones, slightly argillaceous, dolomitic in part. Biomicrites and pelmicrites dominant with minor sparry calcarenites. This community is dominated by small branching colonies of Favosites and Amphipora coenostea concentrated in certain bedding planes. Other corals which occur frequently in this community are Xystriophyllum, Leptoinophyllum and various genera of tabulate corals. A few massive stromatoporoids may also be present, and these are often partially silicified. Scattered brachiopods, crinoids, gastropods and ostracods are usually present and many of the brachiopods are at least partially fragmented. Brachiopods include Cyrtina, Carinata dysmorphostrotia, Emanuella, Schizophoria, Atrypa and Biconostrophia.

Syringopora-Spinulicosta Community

This community has many of the same elements as the Branching Tabulate Coral Community including Favosites, similar brachiopods and a similar sedimentary matrix. However, Syringopora is the dominant coral, Spinulicosta is common and ostracods are rare.

The *Atrypa*-Bryozoa Community is well-developed throughout the Liard-Nahanni area in a broad zone approximately at the boundary of the carbonate and shale provinces. In spite of its association with a strong terrigenous component it is apparently not really a basinal community. The associated calcarenites indicate a relatively high energy environment, and the association of cemented suspension feeders and pedunculate suspension feeders and vagrant browsers (probably on algae) indicate a relatively shallow water environment.

Furthermore, sedimentary structures have been observed (e.g. ripple bedding and mudcracks) in the sediments associated with this community, tending to confirm the above interpretation of a fairly high energy shallow water environment, possibly the shelf edge or upper slope.

Warrenella-Rhynchonellid Community

Limestone, argillaceous, with some shaly interbeds, rarely dolomitic. Micrites and biomicrites common, some calcisiltites and rare calcarenites. Bedding thin-medium, very often nodular, occasionally platy.

Abundant brachiopods, especially Warrenella, Atrypa, Hadorrhynchia, Schuchertella, Spinulicosta, Spinatrypa, Productella, Emanuella and other Spiriferids. Crinoids are common, prolific in some beds, and trilobites (especially pygidia), solitary rugose corals, pelecypods and gastropods are scattered throughout. Cricoconariids occur in traces and ostracods are common in some beds.

Both these communities are found in a position between the Massive Stromatoporoid-Coral Biofacies and the Warrenella-Atrypa community and apparently represent a transitional environment, somewhat similar to the sub-turbulent environment of Lecompte (1956). This environment may, therefore, be designated as shelf edge.

Atrypa-Bryozoa Community

Limestones, with shaly interbeds. Calcarenites and calcisiltites are much more common than in other Communities, and calcarenites include biosparites, as well as, biomicrites and intramicrites.

This is a community dominated by brachiopods, especially Atrypids and Schizophorids, but characterized also by abundant bryozoa, a few very small Favositids, gastropods and some Emanuellas. Spinatrypa, Productella, Schuchertella, Camerotoechia and Spinulicosta also occur sporadically. This community is not as well developed in any of the sections shown in the biofacies cross-section, as it is in section somewhat further north from this area where it is a typical development of the Headless Formation. Closely associated with this community are some beds with abundant gastropods and a few atrypids. These gastropods (pleurotomarids) were most likely vagrant browsers on vegetable matter and indicate an environment with algal growth and of limited depth.

Lingula Community

Shales, buff weathering, platy bedded, pyritic, with rare interbeds of thin limestone, argillaceous and silty. This is a characteristic Funeral Formation facies. The limestones include calcisiltites, micrites and minor biomicrites. The fauna is considerably impoverished but Lingula is often abundant on some bedding planes and occasionally crushed Atrypas, and small rhynchonellids, and sporadic occurrences of Novakia, Styliolina and Tentaculites and small orthoconic nautiloids and goniatites may be observed.

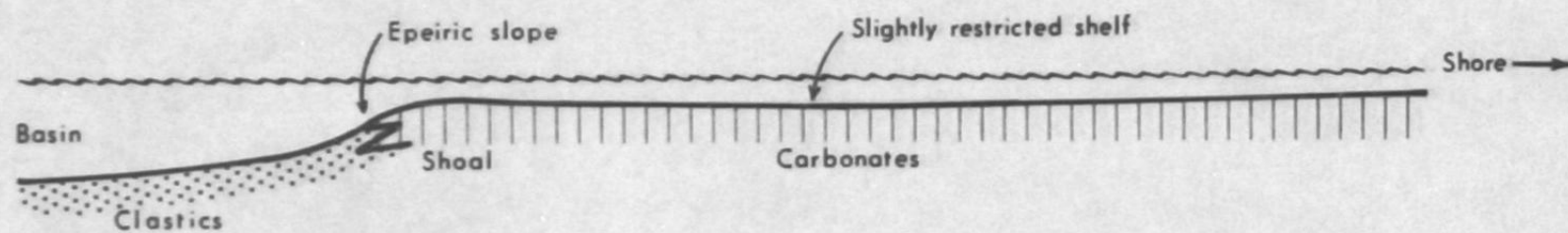
This community is commonly closely associated with the pelagic community and contains itself a fauna which is partly pelagic. These observations together with the fact that the rock in which it is found is usually a very regularly bedded platy shale, imply a relatively deep water environment. It is true that most well documented ecologic studies on Lingula in the past have indicated that Lingula is, more often than not, a littoral shallow water genus (e.g. Ziegler 1965, Bretsky 1968, Paine 1970) with an affinity of conditions of somewhat less than normal salinity. Paine's studies off the California coast indicate, however, that some modern lingulids are very abundant on a muddy substrata in deeper water, below wave-base. Also, Bulman (1964) cites examples from the Lower Paleozoics of the Welsh geosyncline where abundant very small Lingulas are associated with graptolites and other pelagic elements of a deep-water facies. He suggests that these tiny inarticulate brachiopods may actually be the pelagic larval

This is a very common development in sections RF-30 and RF-32 (Plate 10) and in other parts of the Liard-Nahanni area where it appears to be confined to a rather narrow belt approximately at the boundary of the carbonate and shale provinces. Stromatoporoids and colonial rugose corals are notably absent and the prolific brachiopod fauna dominated by Warrenella and Atrypa is much less fragmented and disarticulated than are the brachiopods in the Atrypa-Bryozoa community described above. It appears, therefore, to be a lower energy deeper water community of the slope.

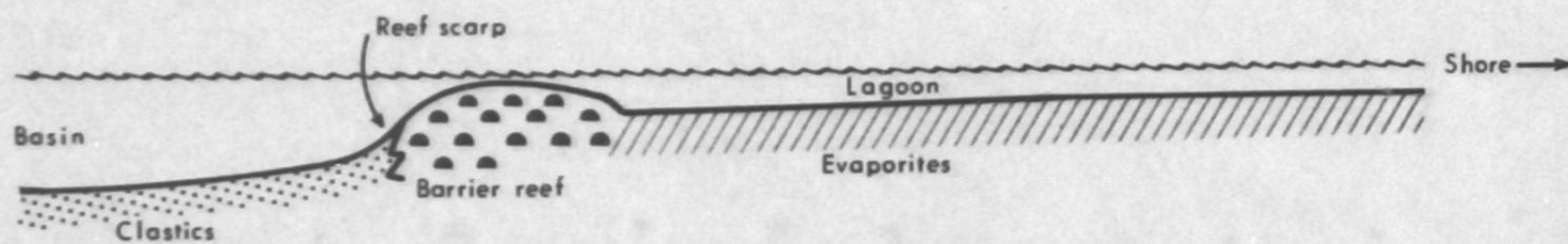
Emanuella-Pelecypod Community

Shales, very calcareous, often platy, intimately interbedded with shaly limestones. The fauna includes numerous Emanuellas, often in lensoid brachiopod coquinas, and scattered pelecypods, especially Paracyclas and Paleoneilo. Paleoneilo was probably a burrowing deposit feeder as were all the nuculoid bivalves and Paracyclas was also probably infaunal. Trilobite fragments (e.g. Dechenella), ostracods and indeterminate brachiopod fragments including spiriferids are also found in this community.

This is probably very nearly a true fossil community with few transported elements. The environment was clearly one of marked turbidity, and relatively low energy, indicating perhaps a basinal or lower slope environment.



NAHANNI TIME



MANETOE TIME

MODELS OF SHELF - BASIN TRANSITIONS
DURING NAHANNI AND MANETOE TIME

an east-west direction demand that this interpretation be made.

We have drawn models for both the Nahanni and Manetoe shelf edges (Plate 12) and will discuss these in turn.

At the Nahanni shelf edge, we have shown that, although minor in a regional sense, there were transgressions and regressions over a distance of 2 or 3 miles based on both faunal and lithologic criteria. Shoaling developed near the edge but there is no indication that a true barrier existed at this time. Although slight restrictions no doubt were developed behind the area of shoaling there is no indication of evaporites developing as a result of this minor restriction. The clastics to the west no doubt represent a basinal facies and this is confirmed by the basinal fauna.

The Nahanni shelf to basin transition no doubt took place across a moderately steep edge, something in the order of a few degrees in contrast to fraction of a degree for the slope of the shelf to the east.

At the Manetoe edge, we find a much more abrupt edge and essentially no interfingering occurs. At a number of localities faint relicts of stromatoporoids, corals and algal laminites can be observed in positions either known to be or believed to be at the carbonate edge. We believe that the carbonate edge was reefal and dipped off steeply into the basin. The reef may have been a broad complex but in any case it no doubt formed the barrier that contained the evaporites to the east.

stages of the near shore benthonic adult Lingula, and quotes Dr. J. Wickstead (personal communication) as having observed such larvae in modern tropical oceans where the Lingula larvae are much larger than those found near shore.

The populations found in the uneral Shales of the Liard-Nahanni area could well fit the larvae hypothesis because they are almost always very small forms. On the basis of this plus an associated fauna dominated by pelagic organisms, it is concluded that the Lingula community of this area is a relatively deep water or basinal association.

Pelagic Community

Shales, calcareous, often platy bedded, with infrequent limestone interbeds. Limestones variable, include micrites, fossiliferous micrites, calcisiltites, and rare calcarenites. Pyrite common.

Fauna largely pelagic including Tentaculites, Stylolina, Novakia, Agoniatites, Anarcestes, other goniatites, crinoids, orthoconic nautiloids and a few brachiopods and ostracods.

The almost complete absence of a benthonic fauna from this marine community and the characteristics of the sediments together suggests a deep basinal water environment.

Paleoslopes of the Nahanni and Manetoe Shelf Edges

There is little doubt that the regional paleoslope throughout the Middle Devonian was westward, both from an analysis of the sediments and from regional isopachs (Plates 13, 14, 15 and 16 in pocket). Also the changes in fauna in

Conclusion

Re-Correlations

We believe that we have adequately demonstrated the relationship of the Nahanni to the Keg River, Dunedin and Upper Chinchaga Formation. The basal beds of the open marine Nahanni limestones are no doubt the stratigraphic equivalent of the evaporitic, Upper Chinchaga Formation. Subsurface geologists have for some time confused the picture by using the name "Chinchaga" for not only the evaporitic sequence but also the open marine limestone sequence. This is clearly a breach of the stratigraphic code and we, therefore, recommend that the name "Chinchaga" be restricted to the lithologic unit as originally named. We would recommend that the terminology from the southern Northwest Territories be extended into Northeast British Columbia, and that the term Nahanni be used for the open marine limestone above the detrital. We believe that the only purpose served by retaining the name "Dunedin Formation" would be to have a name available for outcrop sections where the clastic unit is not discernable and one suspects that the limestone sequence may include Landry, as well as, Nahanni beds.

Similarly, we would recommend that "Arnica" be used in preference to "Stone" Formation as there appears to be little doubt that the "Stone" and "Arnica" Formations are equivalents. The Arnica and Landry Formations would therefore, be used for the dolomite and limestone equivalents of the evaporitic lower Chinchaga.

Nahanni Shale-out and Its Relationship to a Possible Shale
Re-entrant in Northeast British Columbia

We have conclusively demonstrated at least in the area of study, that the shale-out of the Nahanni takes place from the bottom upwards rather than from the top downwards as postulated by others. It takes place relatively rapidly with only minor transgressions and regressions, although still not as abruptly as the shale-out of the Manetoe Formation.

Because of the foregoing and also certain faunal criteria discussed previously, we believe that there is little evidence for a major shale re-entrant previously postulated. The thinning observed on isopachs appears more likely due to depositional thinning or to pre-upper Devonian erosion.

Pre-Upper Devonian Unconformity

The strongest evidence for a pre-Upper Devonian unconformity is the occurrence of lower or middle Nahanni fauna near the top of the Nahanni with a shale contact above. As discussed previously, this occurs in the Caribou Hills at BG-5 and at 2 localities examined by the Geological Survey of Canada in the same area. Although one might argue that the range of the specific fauna may be greater than previously indicated, we have found all 3 indicators, i.e. Schuchertella adoceta, the Billingsastrea verrilli zone and the ostracod "b" zone to have a fairly limited range and would, therefore, prefer the truncation theory as the solution.

Lithofacies

Lithofacies studies were done on several of the sections as indicated by the detail shown on the logs, i.e. RF-21, RF-26, RF-30, RF-32 ----- BG-3, BG-5, BG-6, BG-7 and BG-8.

Except in the case of RF-32 and the Geological Survey of Canada section in Deadman's Valley, no true reefal material was encountered in the Nahanni Formation. In Northeast British Columbia, lithology was generally that of a shallow shelf carbonate with a fairly scarce open marine brachiopod fauna and a few poorly preserved ostracods. The coralliferous zones often found in the Mackenzie Mountains were generally not found in the sections south of the Caribou Hills. The lack of fauna at least in parts of the Nahanni in this area resembles a similar condition typically found in the Landry of the Mackenzie Mountains.

Without more extensive control and more detailed work such as microfacies studies being done on this material we are reluctant to draw conclusions that might place the Toad River area in an unfavourable light. However, our incomplete information at present would indicate that areas from Redfern Lake south and the Caribou Hills north are more favourable than the area in between.

We would recommend that a microfacies study be undertaken encompassing the Nahanni, Headless, Funeral and Landry lithologies in sections from the Redstone Range to Toad River to outline areas of shoal or reef developments, zones indicating

restricted environments, basinal facies etc. It is possible that detailed work of this sort might also improve our understanding of the depositional picture of the Landry which we believe to have occurred on a very shallow quiet shelf resulting in a limestone either barren or with a very restricted fauna of only poorly preserved ostracods.

It is possible, also that a microfacies study might confirm that the Manetoe was derived from a reefal or high energy limestone as described in the 1967 report.

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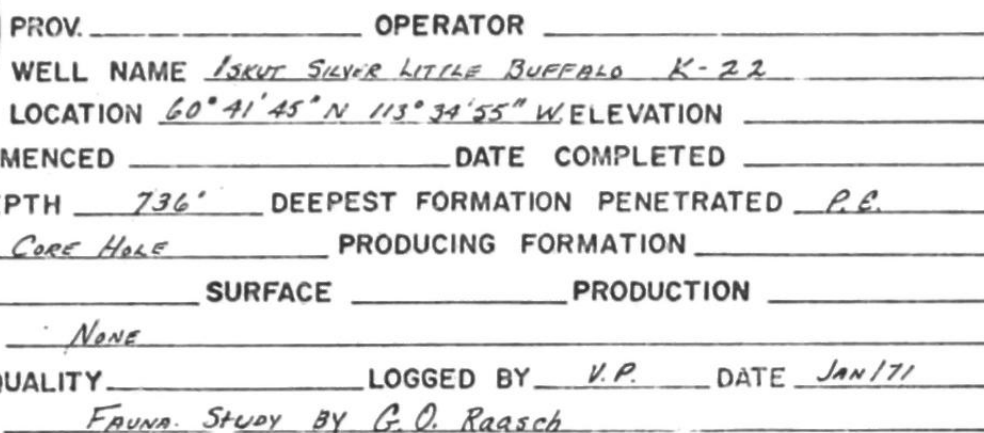
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APPENDIX



DEPTH	UNIT	DESCRIPTION
0-100'	MIDDLE PINE PT. EQUIV.	Dol., lt. gy. br. - lt. brn. f. xln. arg. bands. Few crin., small brachs.
100-130'	LOWER KEG RIVER (Atrypa arctica zone)	Ls., arg., micula, pt. nod. in marl. mtx. Atrypa & crin. oss. Marl. Ls., mottled gy., arg. Atrypa pectimbrata Crickmay. Ls., a.o. Atrypa sp., misc. brachs., lg. gast., crin. oss., ost. ^{secondary} Atrypa pectimbrata, gast. few post. strom. crin. joints.
130-200'	LOWER KEG RIVER (Atrypa arctica zone)	Ls., nod., arg. interst. Atrypa arctica, gast., post. strom., cf. Micro- -plasma fongi, Cystophyllid & br. corals in lower pt. Ls., arg., Ab. crin. f. gast., Macrochieling near base, Cystoph. cor. fr. A.a. w/ crin., gast., brach. (Atrypa), ost., sponge spic., ooc. A.o. w/ Microplasma fongi, brachs., pos. Vertumnia, Macrochellina. A.a., more nod. Sol. rug. cor., Atrypa a., crin. tab. strom. alg. A.a. Crin., sm. alg. masses.
200-300'	LOWER KEG RIVER (Atrypa arctica zone)	A.a. Crin., rare Atrypa. A.a. brecciated. Few sm. gast. & brach. Alveolites, Cyst. cor., Ls., chalky, nod., arg. Gast., pelecypods, Emanuella merstoides & Ls., dolomitic, f. xln. Coenites? & Echinocoelia? Ls., Dol. No fos.
300-350'	UPPER CHINCHAGA	Anhy., mass., brn. gy. Anhy., lamin.
350-400'	UPPER CHINCHAGA	Anhy., banded
400-430'	UPPER CHINCHAGA	Anhy., more arg.
430-470'	UPPER CHINCHAGA	Anhy., clay bands.
470-500'	UPPER CHINCHAGA	Anhy., brecc.
500-530'	UPPER CHINCHAGA	Anhy., folded & faulted.
530-560'	UPPER CHINCHAGA	Anhy., banded. dk & lt; clay, anhydritic, breccia
560-570'	UPPER CHINCHAGA	
570-600'	UPPER CHINCHAGA	
600-610'	UPPER CHINCHAGA	Anhy., brown-red & green.
610-615'	UPPER CHINCHAGA	Red rock Breccia: Clay mts., silty, clayst. frags., anhy. clasts Soft clay.
615-620'	UPPER CHINCHAGA	Anhy., lam. - banded, brecc. brecc.
620-630'	UPPER CHINCHAGA	Anhy., dol., mas.
630-640'	UPPER CHINCHAGA	Dolomite, f. xln., earthy, rexl. Plantophyllum, small gast., ost?
640-650'	UPPER CHINCHAGA	Poor sample. Use & gast? Atrypa., crin.
650-660'	UPPER CHINCHAGA	Anhy., dolomitic, banded.
660-670'	UPPER CHINCHAGA	Clay, gy & red, clastics of dol & gypsum. From Ernestina?
670-680'	UPPER CHINCHAGA	Anhy., pink-yy, salt sol.
680-690'	UPPER CHINCHAGA	Dol., gy - oxidized red, bands. fal. anhy. w/ satin spar. Halite band at 676'
690-700'	UPPER CHINCHAGA	Ss., clean, wh., w/ gngy. clay.
700-710'	UPPER CHINCHAGA	Ss., core lost because not cemented.
710-720'	UPPER CHINCHAGA	Porphyry, kaolinized - Knife edge contact w/ bed above.
720-736 TO	UPPER CHINCHAGA	Porphyry, feldspar vis. entirely kaolinized.



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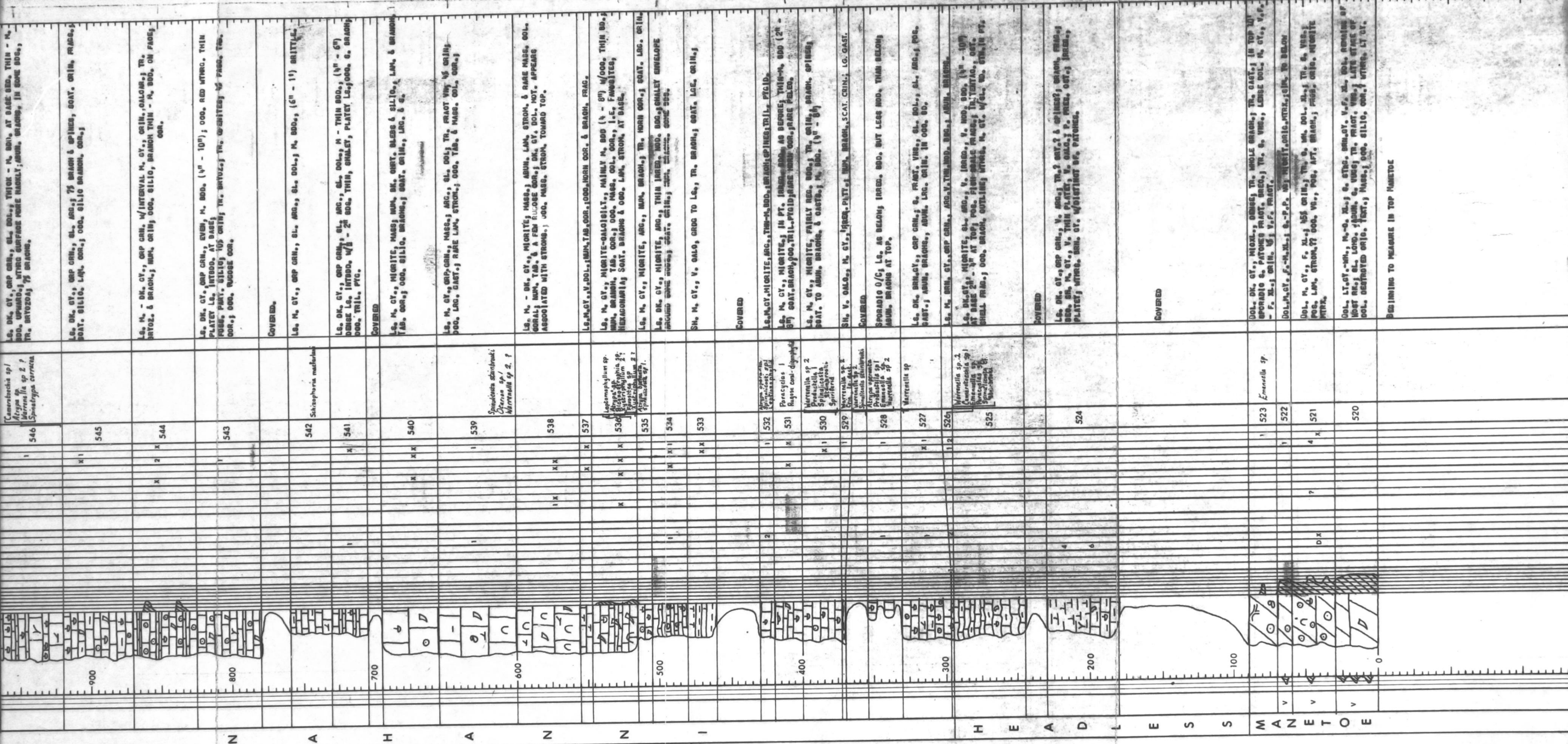
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MINERAL CRYSTALS
FRACTURES (WITH INFILL)
MICROMICACEOUS

X - 0 - 2 %	6 - 50 - 60 %
1 - 2 - 10 %	7 - 60 - 70 %
2 - 10 - 20 %	8 - 70 - 80 %
3 - 20 - 30 %	9 - 80 - 90 %
4 - 30 - 40 %	10 - 90 - 100 %
5 - 40 - 50 %	

1 of



Camerothia sp.
Atrypa sp.
Merrellia sp. 2?
Spirifer sp.
Spirifer sp.

N A H A N Z I

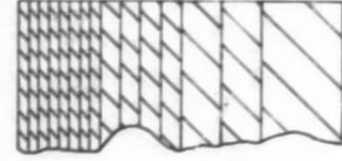
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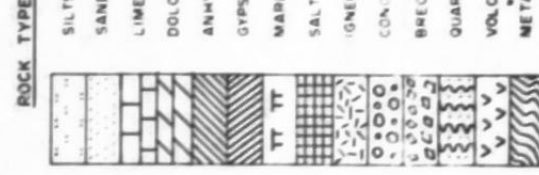


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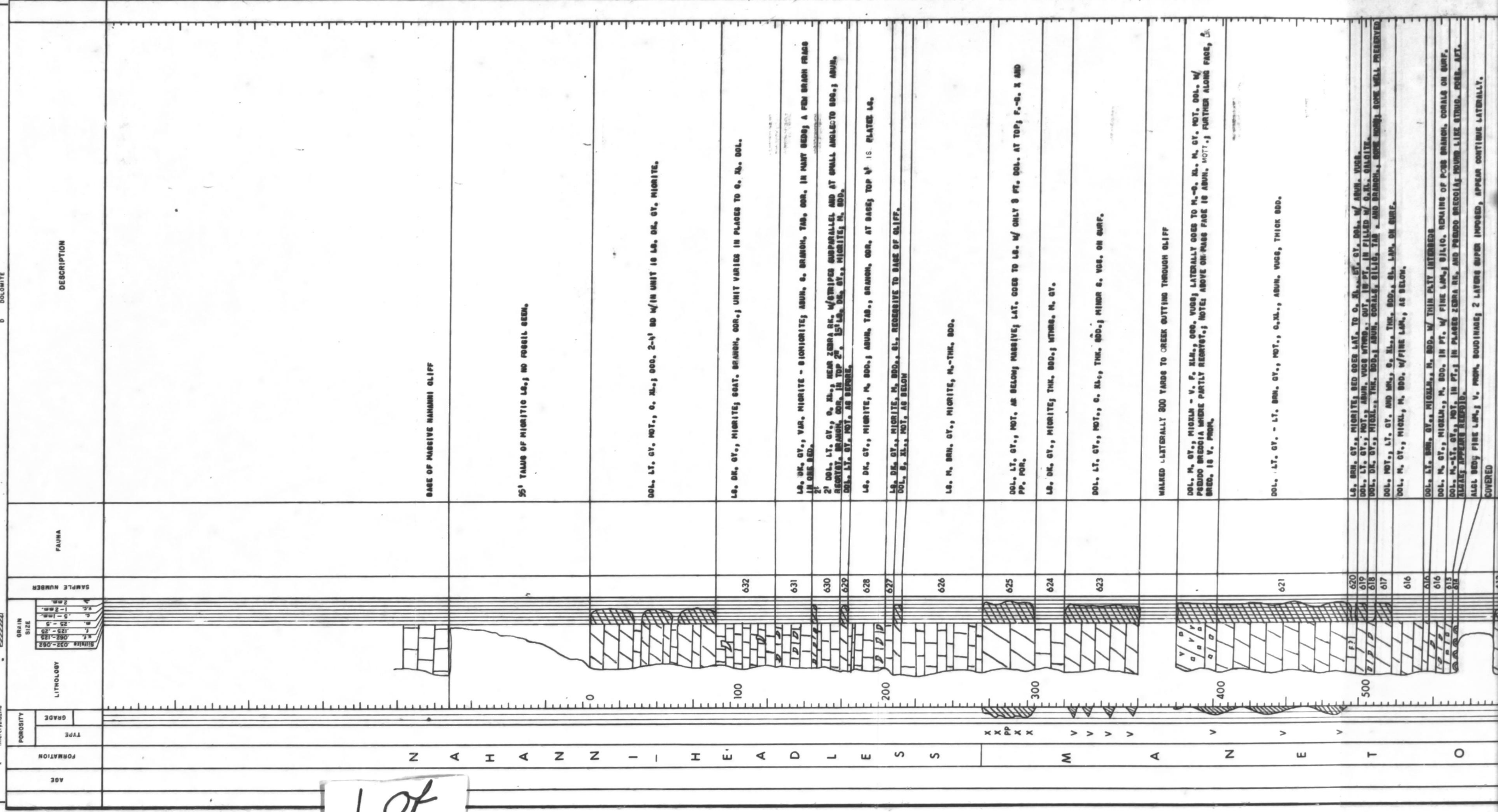
LOCATION FIRST CANYON, SOUTH NAHANNI R., N.W.T.
COORDINATES: LAT. N 61°15'30" LONG. W 124°19'
MAP AREA VIRGINIA FALLS
FIELD PARTY LIARD BASIN YEAR 1968
FORMATIONS ARNICA - NAHANNI
THICKNESS MEASURED 1020' MEASURED BY R.D. Ferguson & P. Archambault

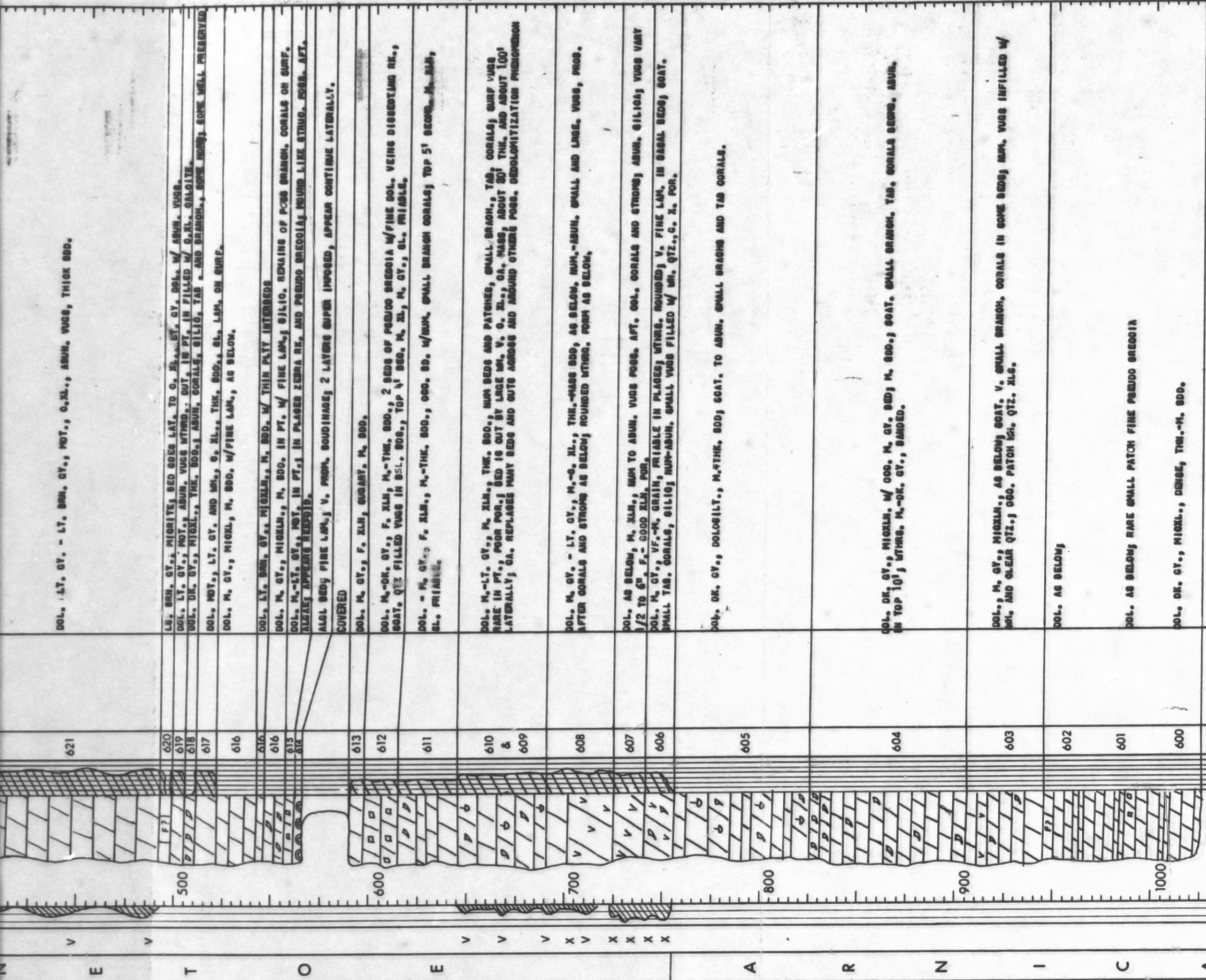


Porosity Type
Vugs
Dip
Fracture
Entry
Intergranular



Accessory Crystals
A Anhydrite
C Calcite
D Dolomite





DOL. LT. CV. - LT. BRN. CV. MOT., O. XL., ABUN. VUGS, THICK BED.

LS. BRN. CV., MICRITIC, BED SOFT LAT. TO O. XL., LT. CV. DOL. W/ ABUN. VUGS.

DOL. LT. CV., MOT., ABUN. VUGS WITHED. CUT. IN PT. IN FILLED W/ G.R. SILICITE.

DOL. OK. CV., MIDDLE, THK. BED, ABUN. CORALS, SILIC, TAB. AND BRANCH., SOME HORN, SOME WELL PRESERVED.

DOL. MOT., LT. CV. AND M., O. XL., THK. BED, SIL. LAM. ON SURF.

DOL. M. CV., MICEL, M. BED, W/FINE LAM., AS BELOW.

DOL. LT. BRN. CV., MICEL, M. BED, W/ THIN PLTY INTERBEDS.

DOL. M. CV., MICEL, M. BED, IN PT. W/ FINE LAM., SILIC. REMAINS OF FOS BRANCH, CORALS OR SURF.

DOL. M.-LT. CV., MOT., IN PT. IN PLACES ZENIA RE. AND PSEUDO BRECCIA, ROUND LIKE ITUNG. POSS. ART. BEARS APPARENT REEDS.

ALSO BEDS FINE LAM., V. FROM, BOUNDARIES, 2 LAYERS SUPER IMPROVED, SPEAR CONTINUE LATERALLY.

COVERED

DOL. M. CV., F. XL., QUARTZ, M. BED.

DOL. M.-OK. CV., F. XL., M.-THK. BED, 2 BEDS OF PSEUDO BRECCIA W/FINE DOL. VEINS DISSECTING RE., SEAT. QZ FILLING VUGS IN SIL. BED., TOP M. XL., M. CV., SIL. FRAGILE.

DOL. M. CV., F. XL., M.-THK. BED, 80. W/ABUN. SMALL BRANCH CORALS, TOP 5' SECT. M. XL., SIL. FRAGILE.

DOL. M.-LT. CV., M. XL., THK. BED, MUM BEDS AND PATCHES, SMALL BRANCH, TAB. CORALS, SURF VUGS RARE IN PT., POOR FOR, BED IS CUT BY LARGE M. V. O. XL., O. XL., GR. MASS, ABOUT 80' THK. AND ABOUT 100' LATERALLY, O. XL. REPLACES MUM BEDS AND CUTS ACROSS AND AROUND OTHERS POSS. DECOLONIZATION PHENOMENON.

DOL. M. CV., - LT. CV., M.-O. XL., THK.-MASS BED, AS BELOW, MUM.-ABUN. SMALL AND LARGE VUGS, POSS. AFTER CORALS AND STRONG AS BELOW, ROUNDED WITHED. FORM AS BELOW.

DOL. AS BELOW, M. XL., MUM TO ABUN. VUGS POSS. ART. DOL. CORALS AND STRONG, ABUN. SILIC, VUGS VARY 1/2 TO 6" F. GOOD XL., POSS.

DOL. M. CV., V.-M. GRAIN, FRAGILE IN PLACES, WITHED. ROUNDED, V. FINE LAM. IN BASAL BEDS, SEAT. SMALL TAB. CORALS, SILIC, MUM-ABUN. SMALL VUGS FILLED W/ M. QZ., O. XL. FOR.

DOL. OK. CV., DOLOMIT., M.-THK. BED, SEAT. TO ABUN. SMALL BRANCH AND TAB CORALS.

DOL. OK. CV., MICEL, W/ OOL. M. CV. BED, M. BED, SEAT. SMALL BRANCH, TAB. CORALS BEDS. ABUN. ON TOP 10', WITHED. M.-OK. CV., BANNED.

DOL. M. CV., MICEL, W/ OOL. M. CV. BED, SEAT. V. SMALL BRANCH, CORALS IN SOME BEDS, MUM. VUGS FILLED W/ M. AND CLEAR QZ., OOL. PATCH M. QZ. XL.

DOL. AS BELOW,

DOL. AS BELOW, RARE SMALL PATCH FINE PSEUDO BRECCIA

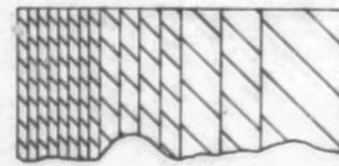
DOL. OK. CV., MICEL., DENSE, THK.-M. BED.

NOTES LANDED ON SAND BAR AND CLIMBED FROM BASE. BEGINNING TO MEASURE NEAR TOP OF SECTION.



STRATIGRAPHIC SECTION NO. BG 18268

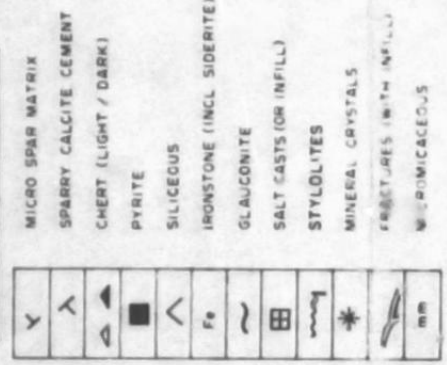
LOCATION YASH CREEK, B.C.
COORDINATES: LAT. 58° 44' LONG. 125° 18'
MAP AREA TUCHODI LAKES
FIELD PARTY LIARD RIVER BASIN YEAR 1968
FORMATIONS ARNICA - NAHANNI
THICKNESS MEASURED 1050' MEASURED BY B. Groeneweg, E. Kozbial



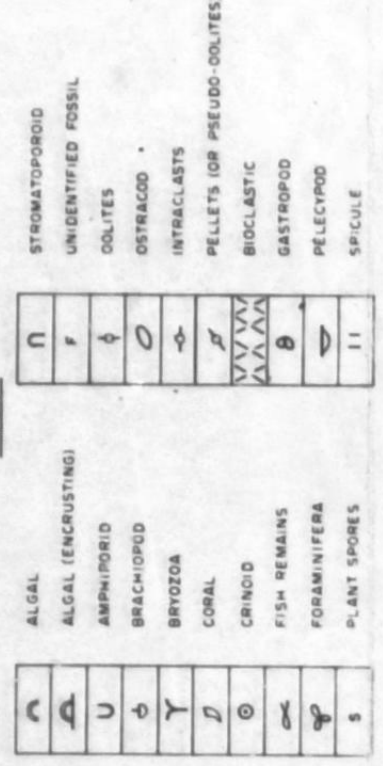
ROCK TYPE



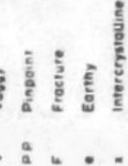
ACCESSORIES & COMBINATIONS



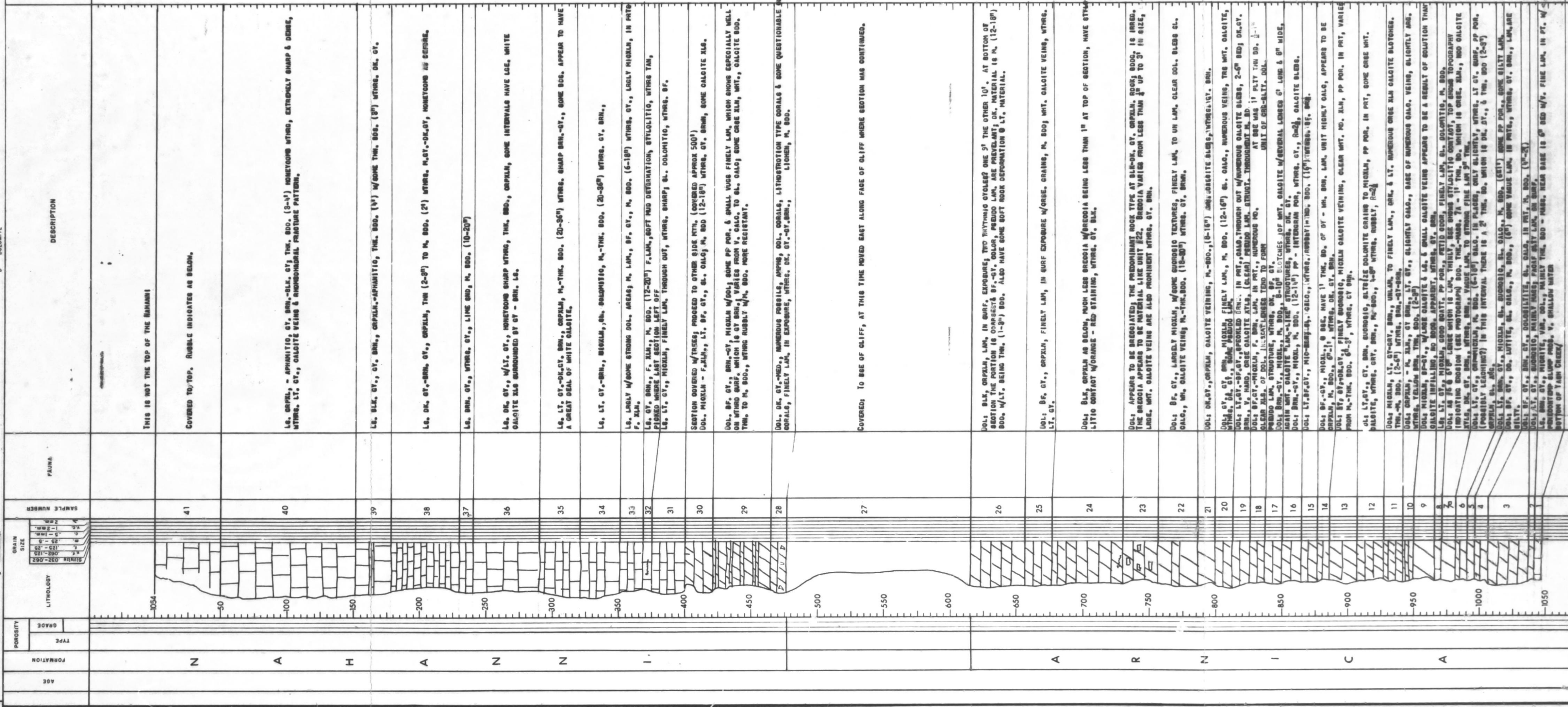
FOSSILS



POROSITY TYPE



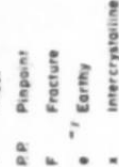
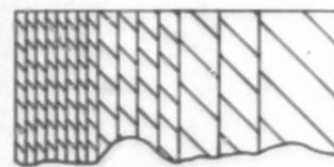
ACCESSORY CRYSTALS





STRATIGRAPHIC SECTION NO.BG.3-68

LOCATION MOUNT MARY HENRY, B.C.
COORDINATES: LAT. 58° 28' LONG. 124° 30'
MAP AREA TUCHODI LAKES
FIELD PARTY LIARD RIVER BASIN FIELD PARTY YEAR 1968
FORMATIONS BESA RIVER - SILURIAN NONDA
THICKNESS MEASURED 2686' MEASURED BY B.Groeneweg, E.Korbiel, J.de Foye

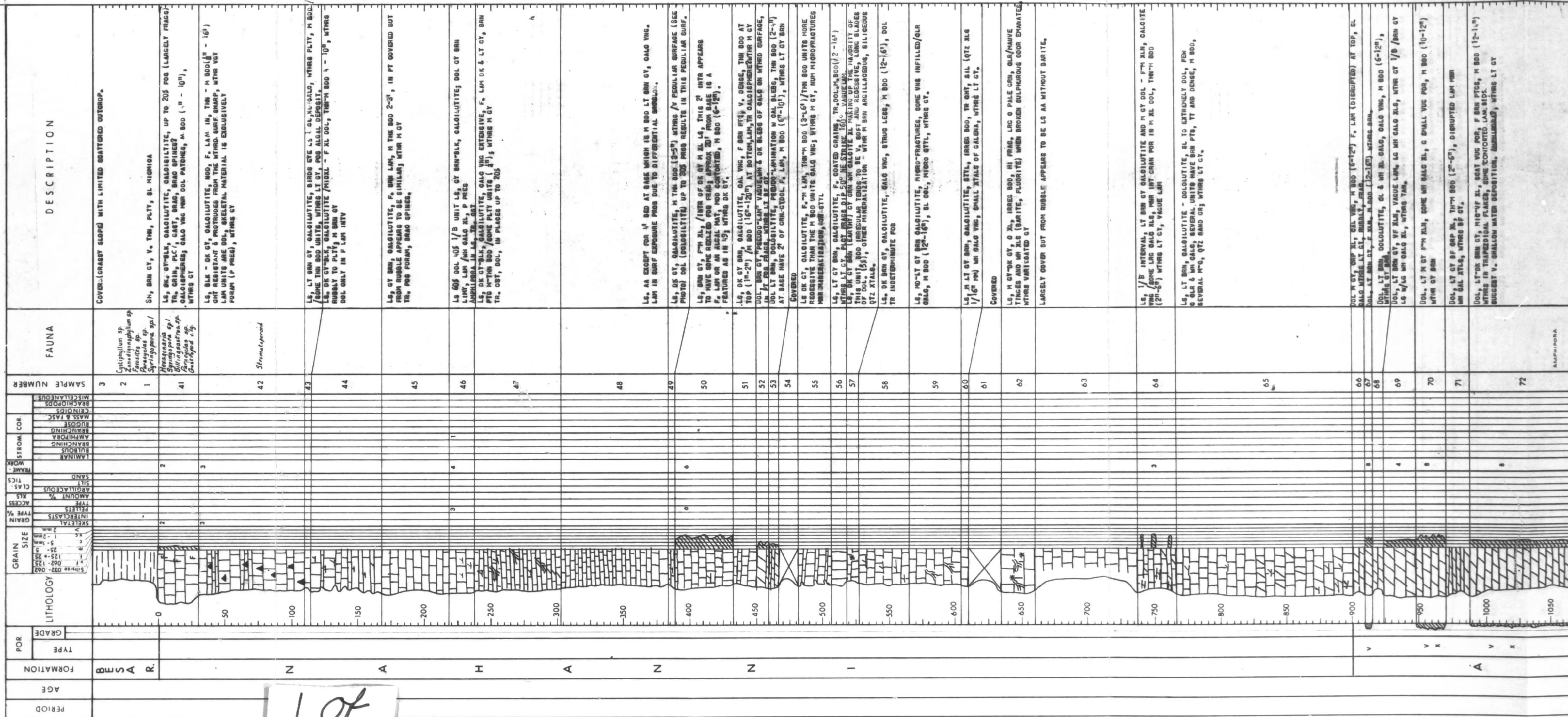


Percentage:
1 - 0 - 10 %
2 - 10 - 20 %
3 - 20 - 30 %
4 - 30 - 40 %
5 - 40 - 50 %
6 - 50 - 60 %
7 - 60 - 70 %
8 - 70 - 80 %
9 - 80 - 90 %
10 - 90 - 100 %

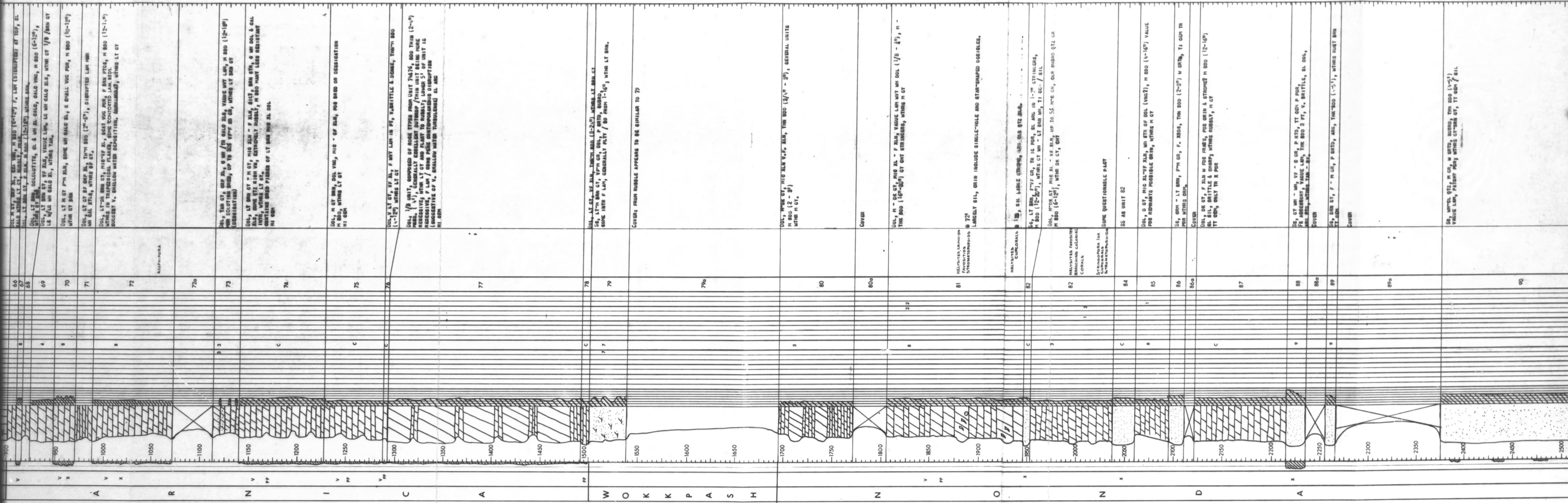
DEPTH OF WATER
1 - SUBARIAL
2 - INTERTIDAL
3 - 10' - SHALLOW SUB-TIDAL TO DEEPEST BASINAL

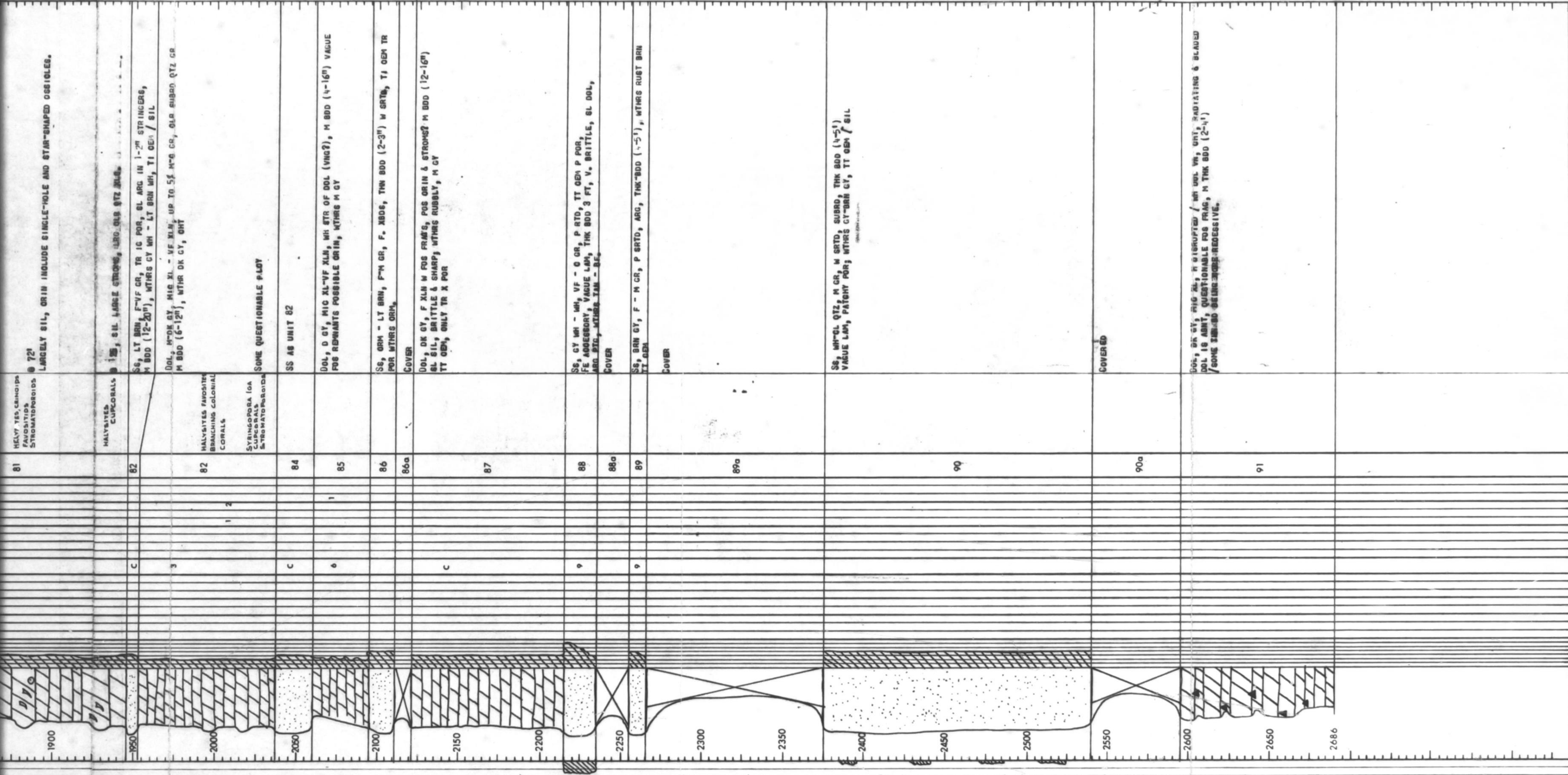
ACCESSORY CRYSTALS
A ANHYDRITE
C CALCITE
D DOLOMITE

STROMATOPORO
UNIDENTIFIED FOSSIL
CORALS
OSTRACODS
INTRALASTS
PELLETS (OR PSEUDO-CORALS)
BRACHIOPOD
GASTROPOD
PELECYPOD
SPICULE

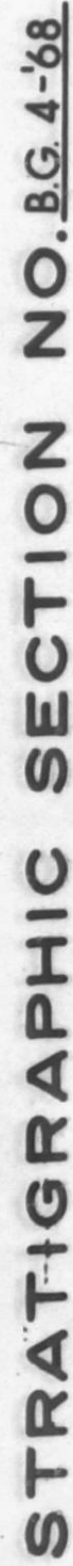


1 of

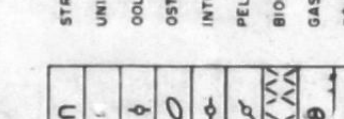




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THICKNESS MEASURED _____ 650' _____ MEASURED BY B. Groeneweg - J. LeFevre



ALS
GYPSUM
QUARTZ

SUM
RTZ

TION

100

	A
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2115/139

STRATIGRAPHIC SECTION NO. B.G. 5-68

LOCATION CARIBOU HILLS, B.C.

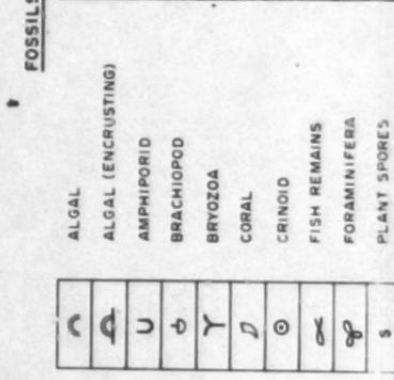
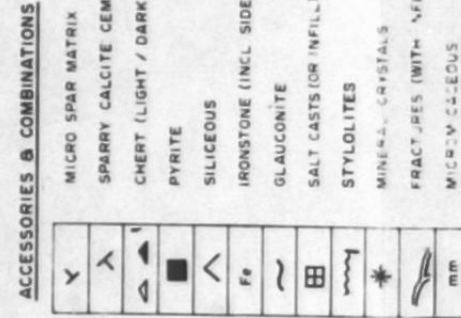
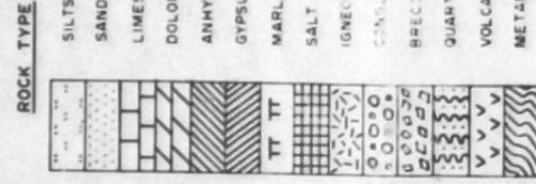
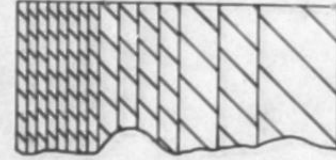
COORDINATES: LAT. 59°44' LONG. 124°30'

MAP AREA TOAD RIVER

FIELD PARTY LIARD RIVER BASIN

FORMATIONS LANDRY EQUIVALENT - BASAL BESA RIVER

THICKNESS MEASURED 1108' MEASURED BY B.Groeneweg & J.le Fevre



POROSITY TYPE
V Vary
PP Pore
F Fracture
E Earth
I Interstitial

Percentage
1 - 0-10 %
2 - 10-20 %
3 - 20-30 %
4 - 30-40 %
5 - 40-50 %

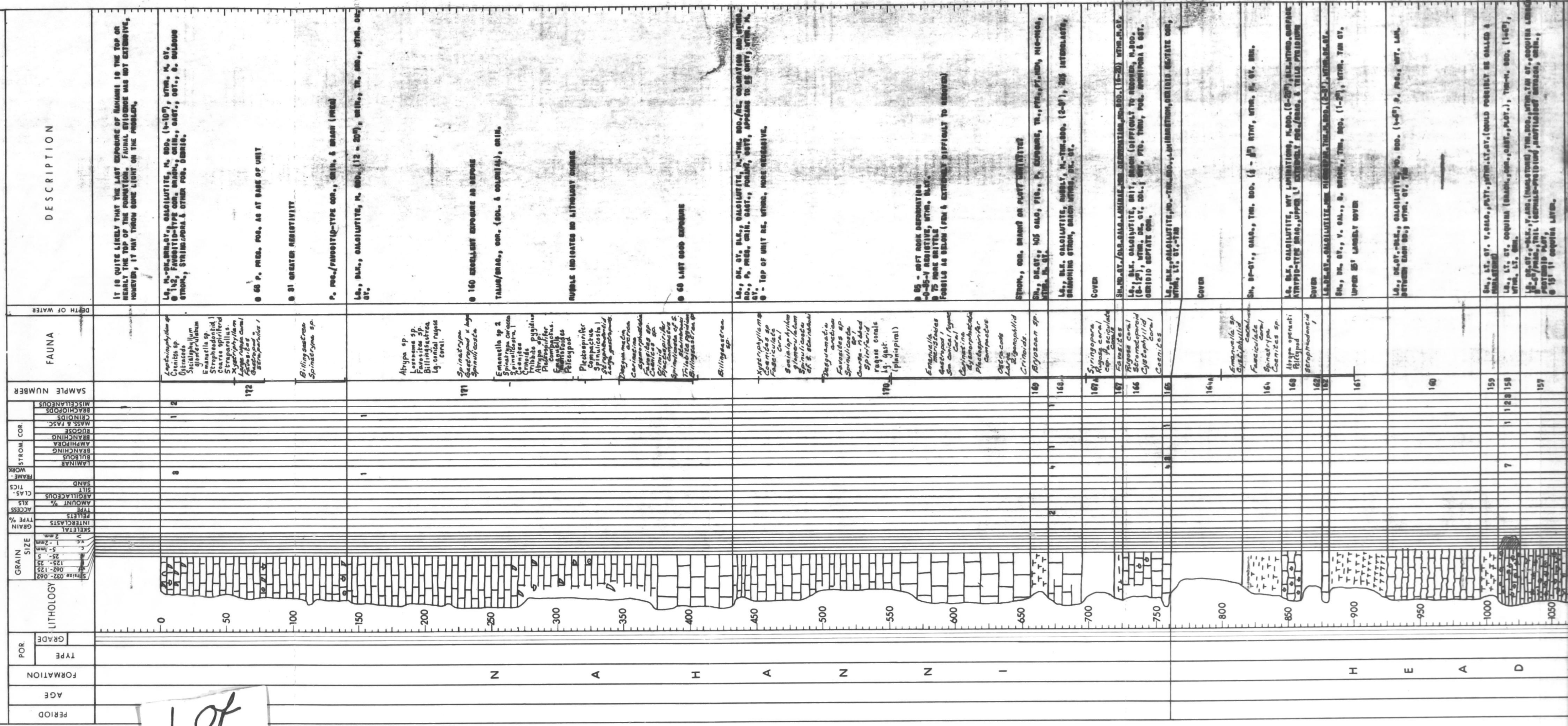
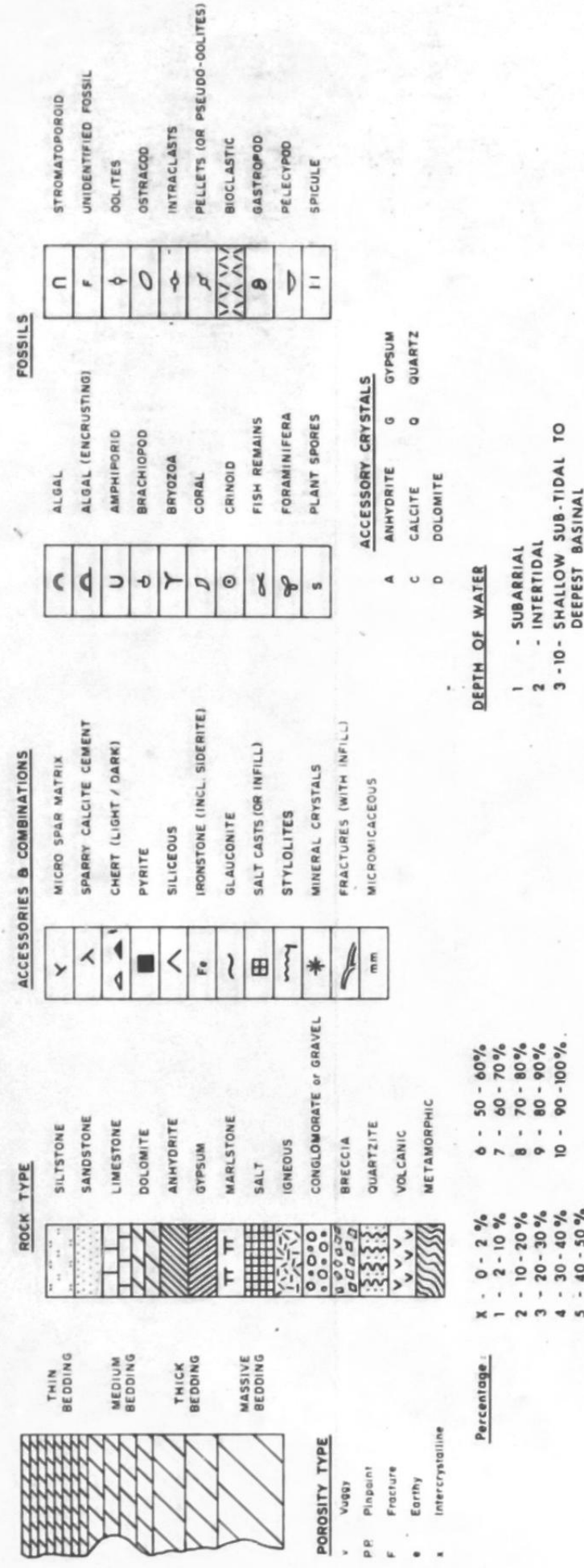
DEPTH OF WATER
1 - SUBARIAL
2 - INTERTIDAL
3 - 10- SHALLOW SUB-TIDAL TO DEEPEST BASINAL

ACCESSORY CRYSTALS
A ANHYDRITE
C CALCITE
D DOLOMITE
G GYPSUM
O QUARTZ

PERIOD	AGE	FORMATION	POR. TYPE	LITHOLOGY	GRAIN SIZE	ACCESS. TYPE %	CLAS. TICS	WAGE	STROM. COR.	SAMPLE NUMBER	FAUNA	DESCRIPTION
		BESA R.								144		SH, BLK, MISTHICA PLTY, TIN BD, FLS, FE STN, THRU WTBALTY QY-BF RUST, FRAG
										143		LS, BLK, MISTHICA PLTY, TIN BD, FLS, FE STN, THRU WTBALTY QY-BF RUST, FRAG
										142		LS, BLK, MISTHICA PLTY, TIN BD, FLS, FE STN, THRU WTBALTY QY-BF RUST, FRAG
										141		LS, BLK, MISTHICA PLTY, TIN BD, FLS, FE STN, THRU WTBALTY QY-BF RUST, FRAG
										140		LS, BLK, MISTHICA PLTY, TIN BD, FLS, FE STN, THRU WTBALTY QY-BF RUST, FRAG
										139		LS, BLK, MISTHICA PLTY, TIN BD, FLS, FE STN, THRU WTBALTY QY-BF RUST, FRAG
										138		LS, BLK, MISTHICA PLTY, TIN BD, FLS, FE STN, THRU WTBALTY QY-BF RUST, FRAG
										137		LS, BLK, MISTHICA PLTY, TIN BD, FLS, FE STN, THRU WTBALTY QY-BF RUST, FRAG
										136		LS, BLK, MISTHICA PLTY, TIN BD, FLS, FE STN, THRU WTBALTY QY-BF RUST, FRAG
										135		LS, BLK, MISTHICA PLTY, TIN BD, FLS, FE STN, THRU WTBALTY QY-BF RUST, FRAG



LOCATION _____ TUNDRA RIDGE, N.W.T.
COORDINATES: LAT. _____ 61° 52' _____ LONG. _____ 124° 58' _____
MAP AREA _____ VIRGINIA FALLS _____
FIELD PARTY _____ LIARD RIVER BASIN _____ YEAR _____ 1968
FORMATIONS _____ TOP ARNICA _____ NAHANNI _____
THICKNESS, MEASURED _____ 2878' _____ MEASURED BY B. Groeneweg, E. Kozbial _____

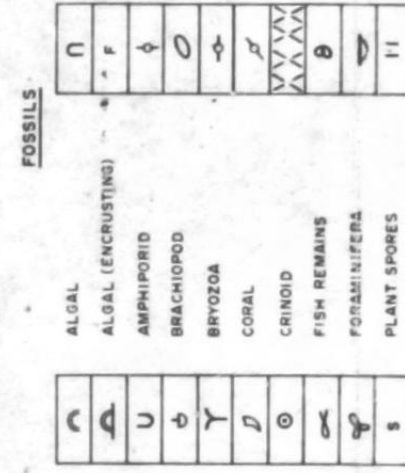
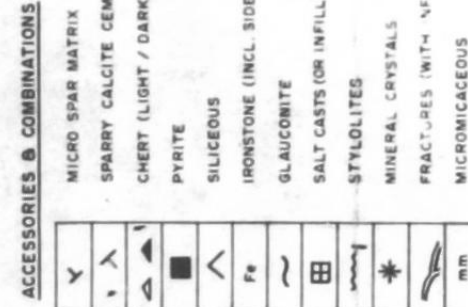
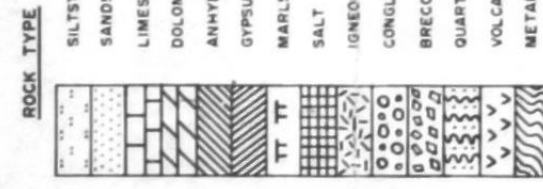
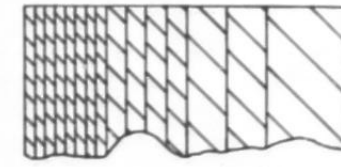






STRATIGRAPHIC SECTION NO. B.G-7-68

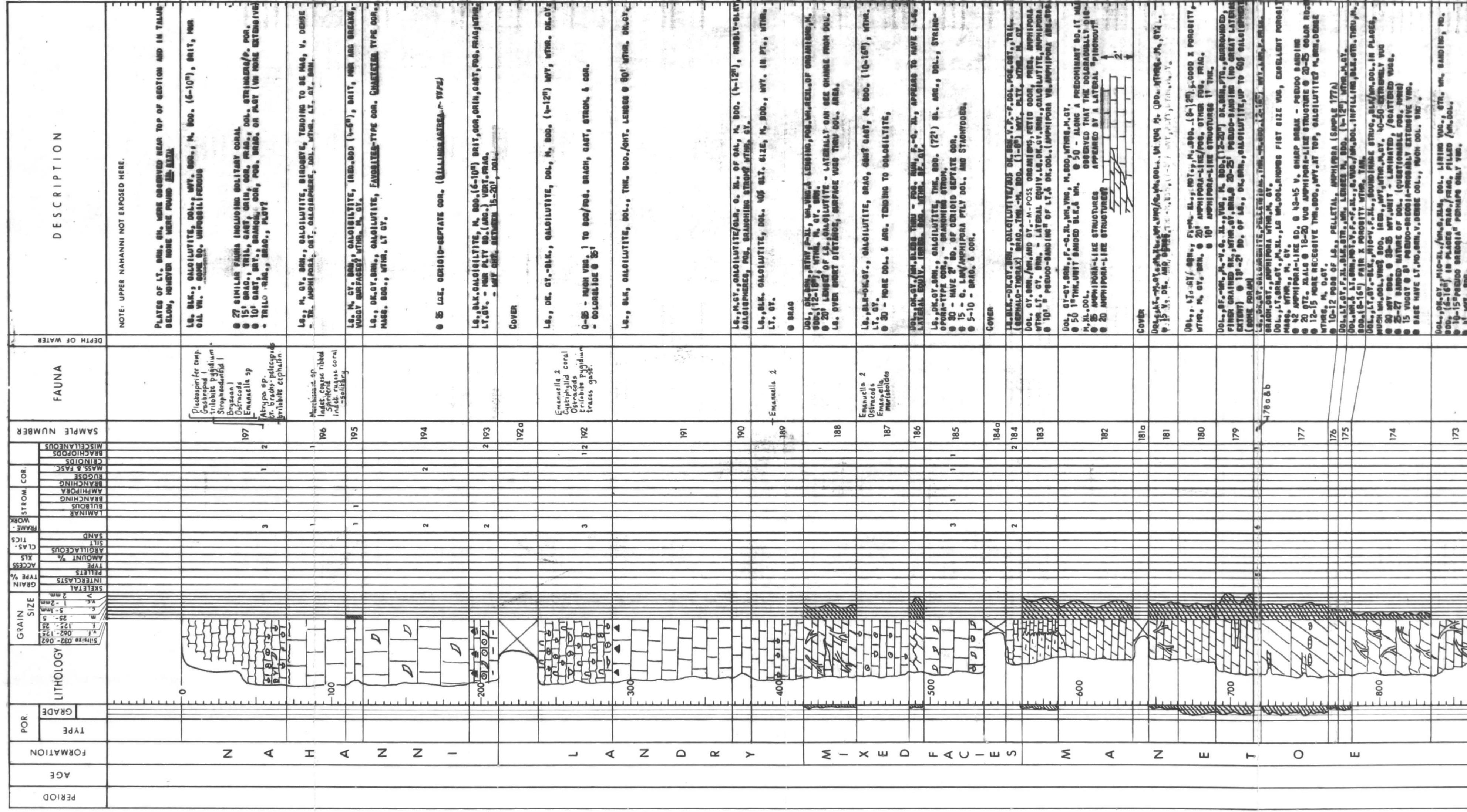
LOCATION N. of LAFFERTY CREEK S.E. of NAHANNI PLATEAU, NWT
COORDINATES: LAT. 61°29' LONG. 124°15'
MAP AREA VIRGINIA FALLS
FIELD PARTY LIARD BASIN FIELD PARTY YEAR 1968
FORMATIONS MANETOE - NAHANNI
THICKNESS MEASURED 865' MEASURED BY B. GROENEWEG, J. LEFEVRE

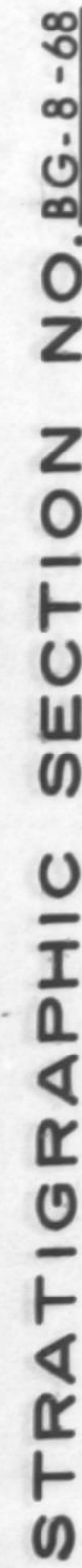


POROSIITY TYPE
V Vary
PP Pinpoint
FF Fracture
E Earth
I Inter crystalline

Percentage
1 - 0 - 10 %
2 - 10 - 20 %
3 - 20 - 30 %
4 - 30 - 40 %
5 - 40 - 50 %

DEPTH OF WATER
1 - SUBARIAL
2 - INTERTIDAL
3 - 10' - SHALLOW SUB-TIDAL TO DEEPEST BASINAL



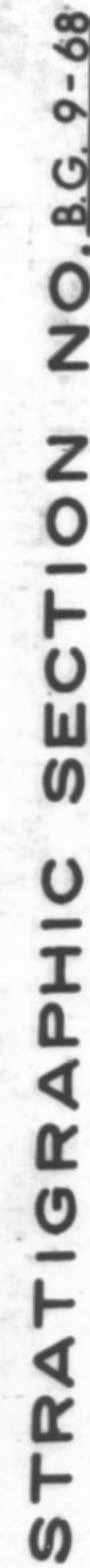


COORDINATES: LAT. 61° 41' LONG. 124° 27'

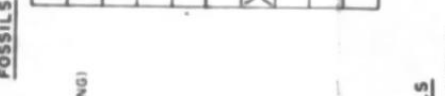
FIELD PARTY — LIARD RIVER BASIN

THICKNESS MEASURED _____ MEASURED BY B. Groeneweg, J. Le Fevre

ice brachs.

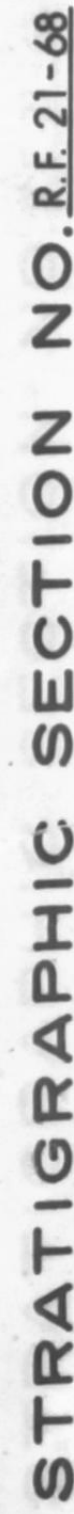


THICKNESS MEASURED _____ 780' _____ MEASURED BY B. Groeneweg & J. le Fevre



ACCESS

DESCRIPTION



THICKNESS MEASURED _____ 2975' MEASURED BY R.D. Ferguson, J. Le Fevre



CONGLOMERATE or GRAVEL

BRECCIA

QUARTZITE

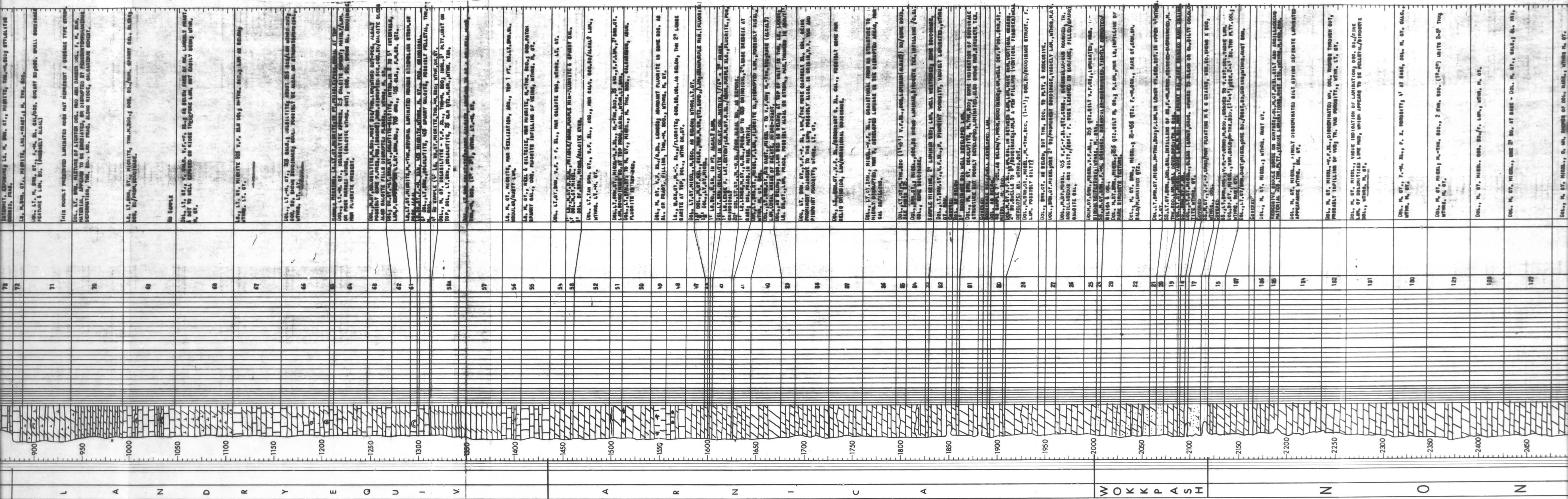
VOLCANIC

METAMORPHIC

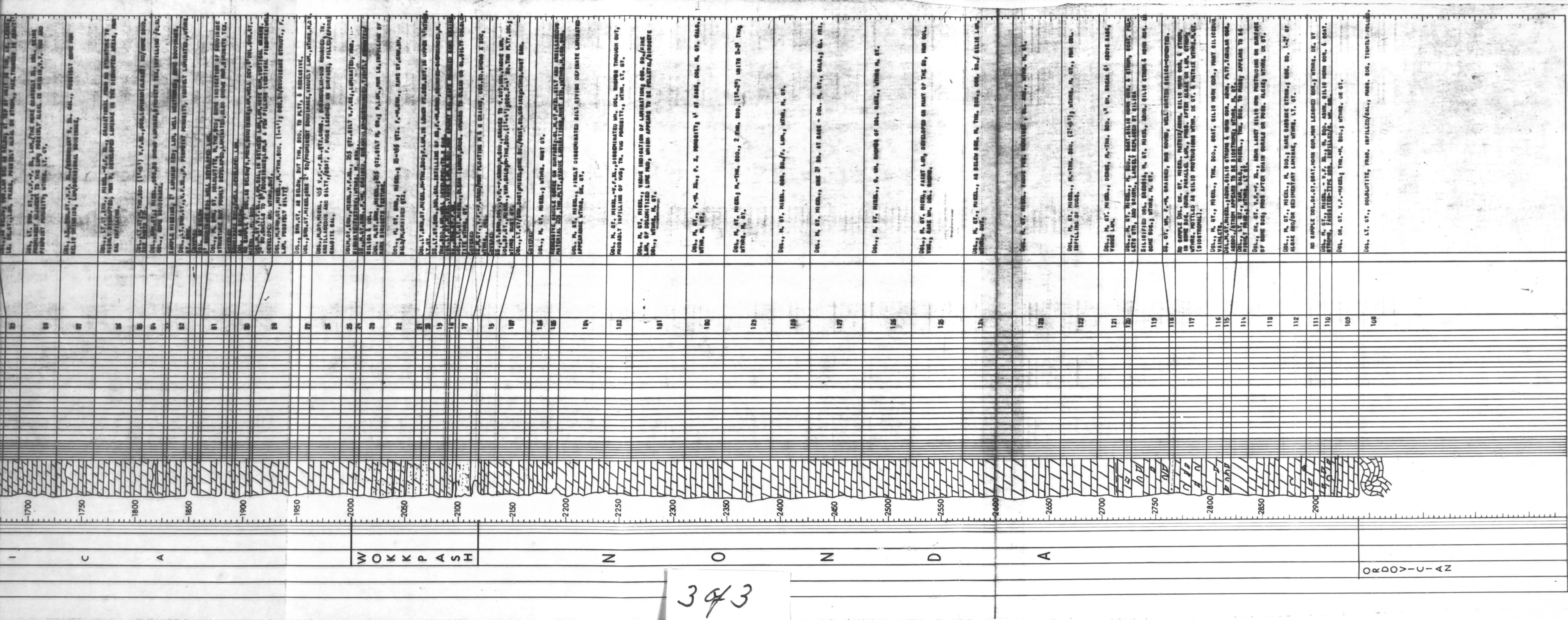
DEPTH OF WATER

1 - SUBARRIAL
2 - INTERTIDAL
3 - 10 - SHALLOW SUB-TIDAL TO
DEEPEST BASINAL

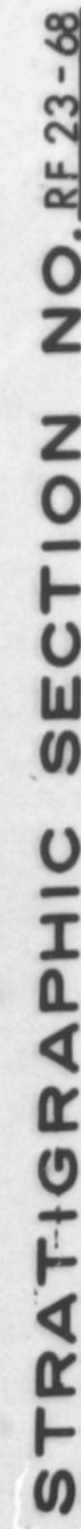
1 of



2a

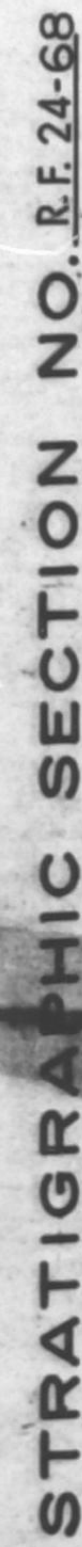


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THICKNESS MEASURED _____ 2370' MEASURED BY R.D. Ferguson, E. Kozbial

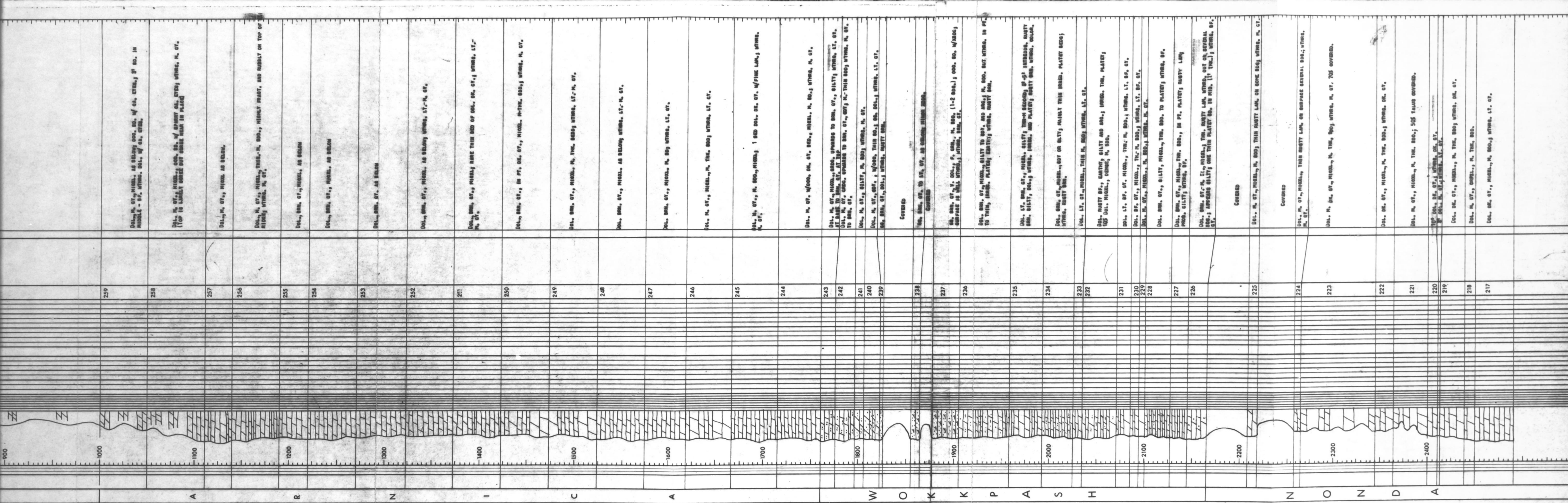
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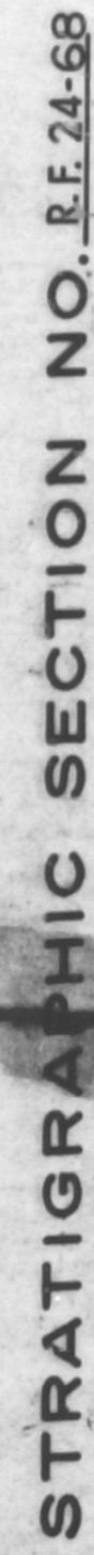


THICKNESS MEASURED 2420 MEASURED BY R.D.F. P. Archambault



1 of





LOCATION S.E. MUNCH LK #2, B.C.

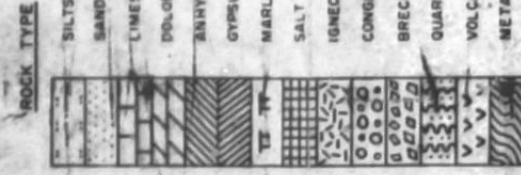
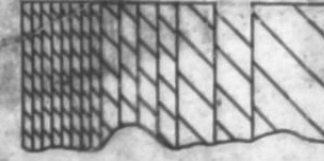
COORDINATES: LAT. 56° 47' 45" N. LONG. 125° 38' 30" W.

MAP AREA TUCHODI LAKES (94 K)

FIELD PARTY	LIARD	BASIN	YEAR
			1968

FORMATIONS NONDW - NAHANNI

THICKNESS MEASURED 2420' MEASURED BY R.D.F. & Archambault

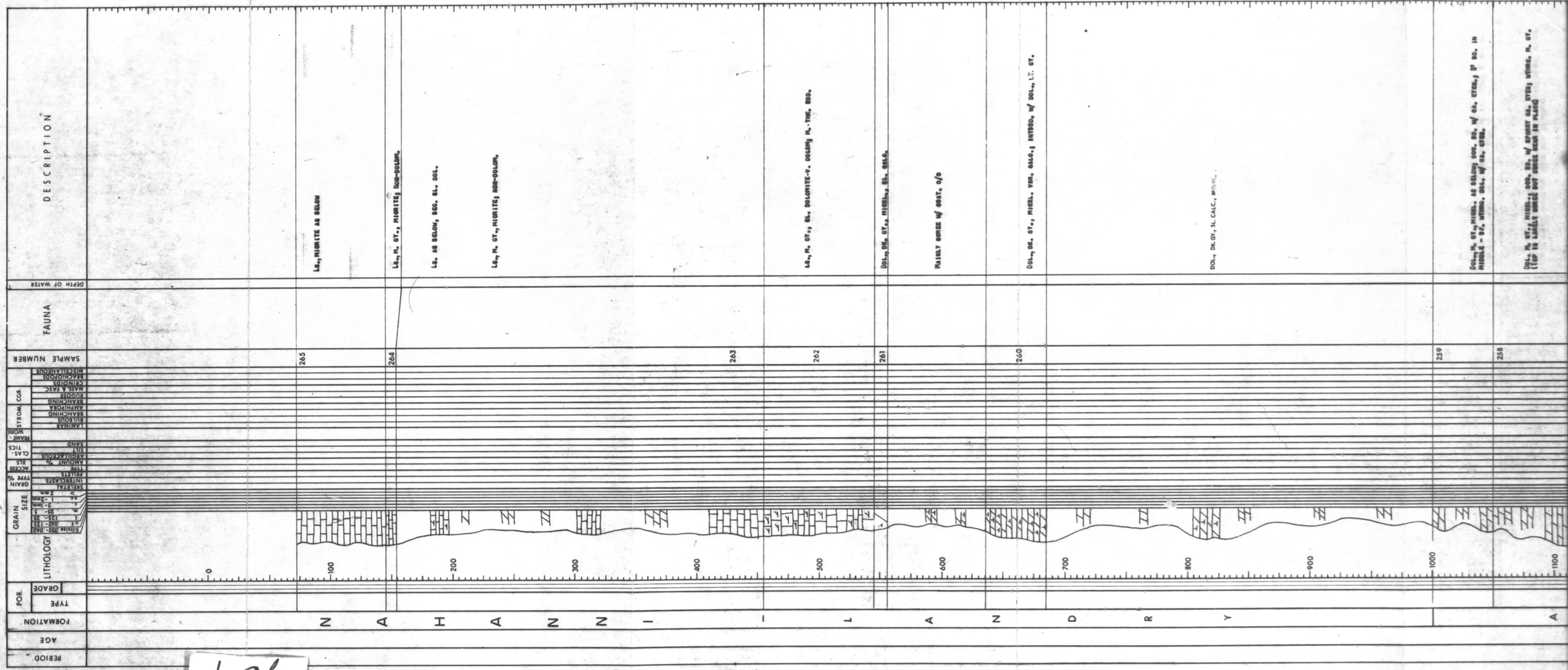


pp. Pinpoint
F Fracture
e. Earth
x Interconversion

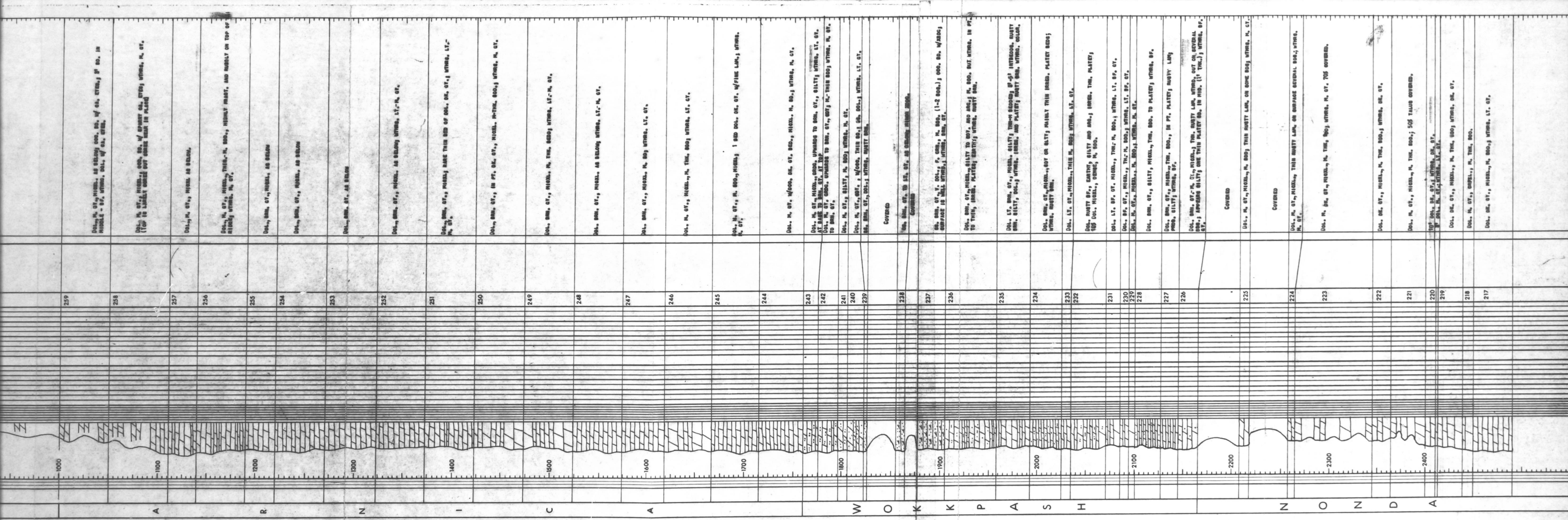
Percentage: 1 - 0-10% 2 - 10-20% 3 - 20-30% 4 - 30-40% 5 - 40-50% 6 - 50-60% 7 - 60-70% 8 - 70-80% 9 - 80-90% 10 - 90-100%

DEPTH OF WATER

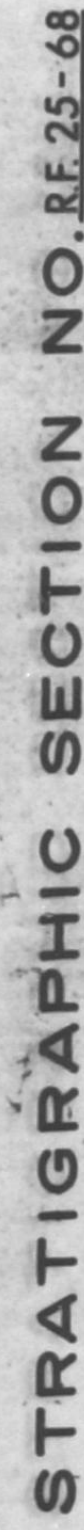
1 - SUBARRIAL
2 - INTERTIDAL
3 - 10 - SHALLOW SUB-TIDAL TO
DEEPEST BASINAL



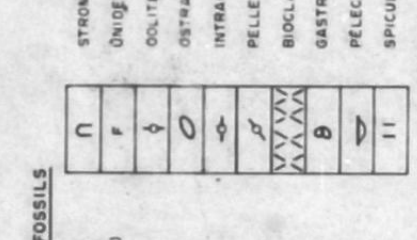
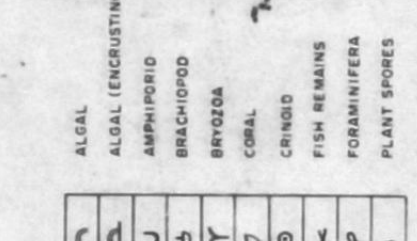
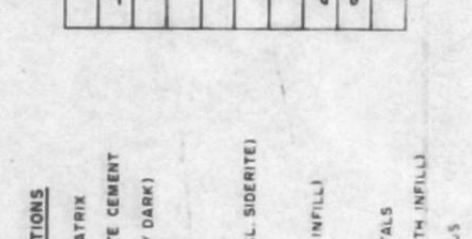
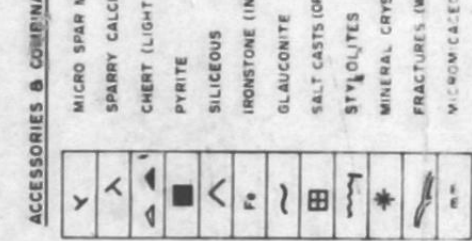
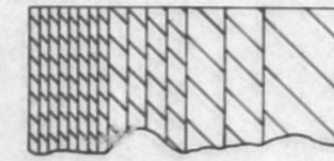
1 of



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THICKNESS MEASURED 700' MEASURED BY R.D. Ferguson & E. Kozbial

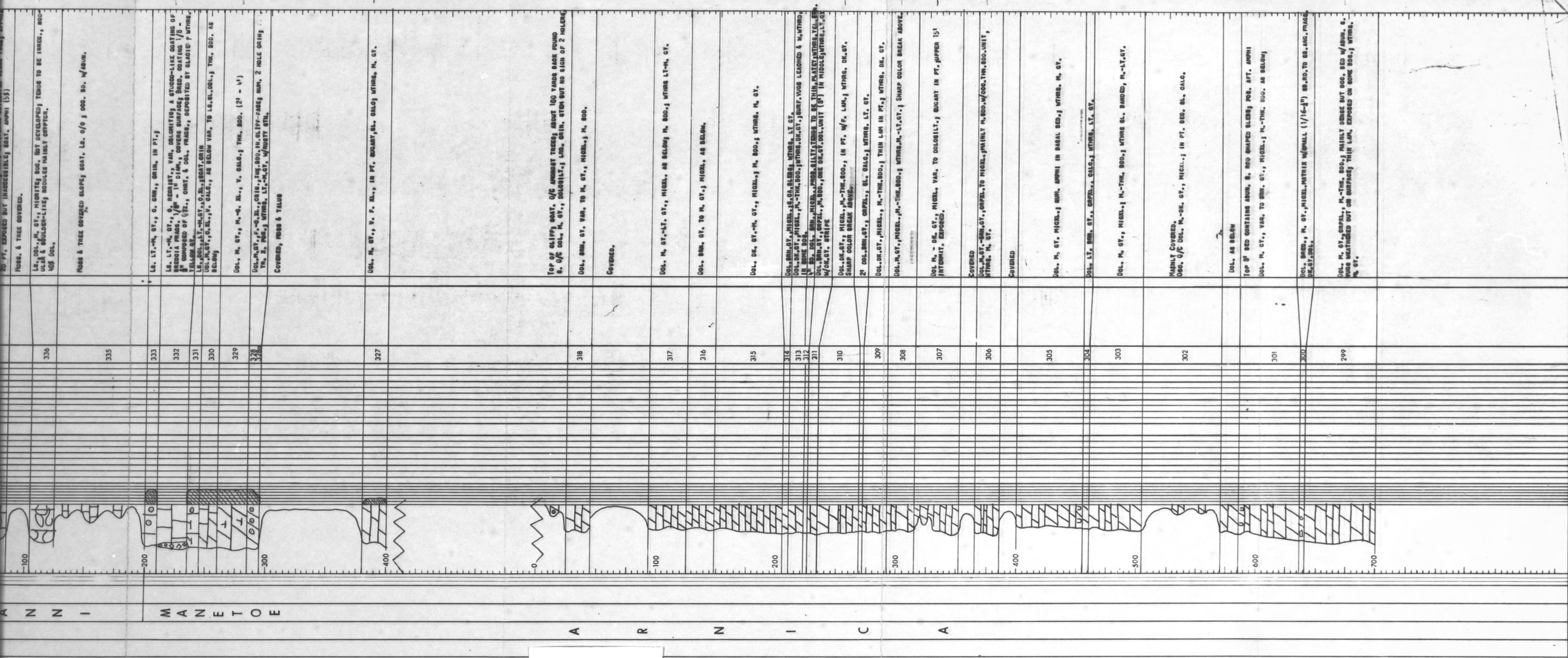


Percentage	X	0 - 2 %	6 - 50 - 60 %
1	2 - 10 %	7 - 60 - 70 %	
2	10 - 20 %	8 - 70 - 80 %	
3	20 - 30 %	9 - 80 - 90 %	
4	30 - 40 %	10 - 90 - 100 %	
5	40 - 50 %		

DEPTH OF WATER

1 - SUBARRIAL
2 - INTERTIDAL
3 - 10 - SHALLOW SUB-TIDAL TO
DEEPEST BASINAL

[illegible]



2 of 2

THICKNESS MEASURED 625'

MEASURED BY RDF, ETK, BG, JLF



IZITE
ANIC
MORPHIC

DEPTH OF WATER

1 - SUBARRIAL
2 - INTERTIDAL
3 - 10 - SHALLOW DEEP

ACCESSORY CRYSTALS	
ANHYDRITE	G
CALCITE	Q
	QUARTZ

Geological Cross-Section Data Summary:

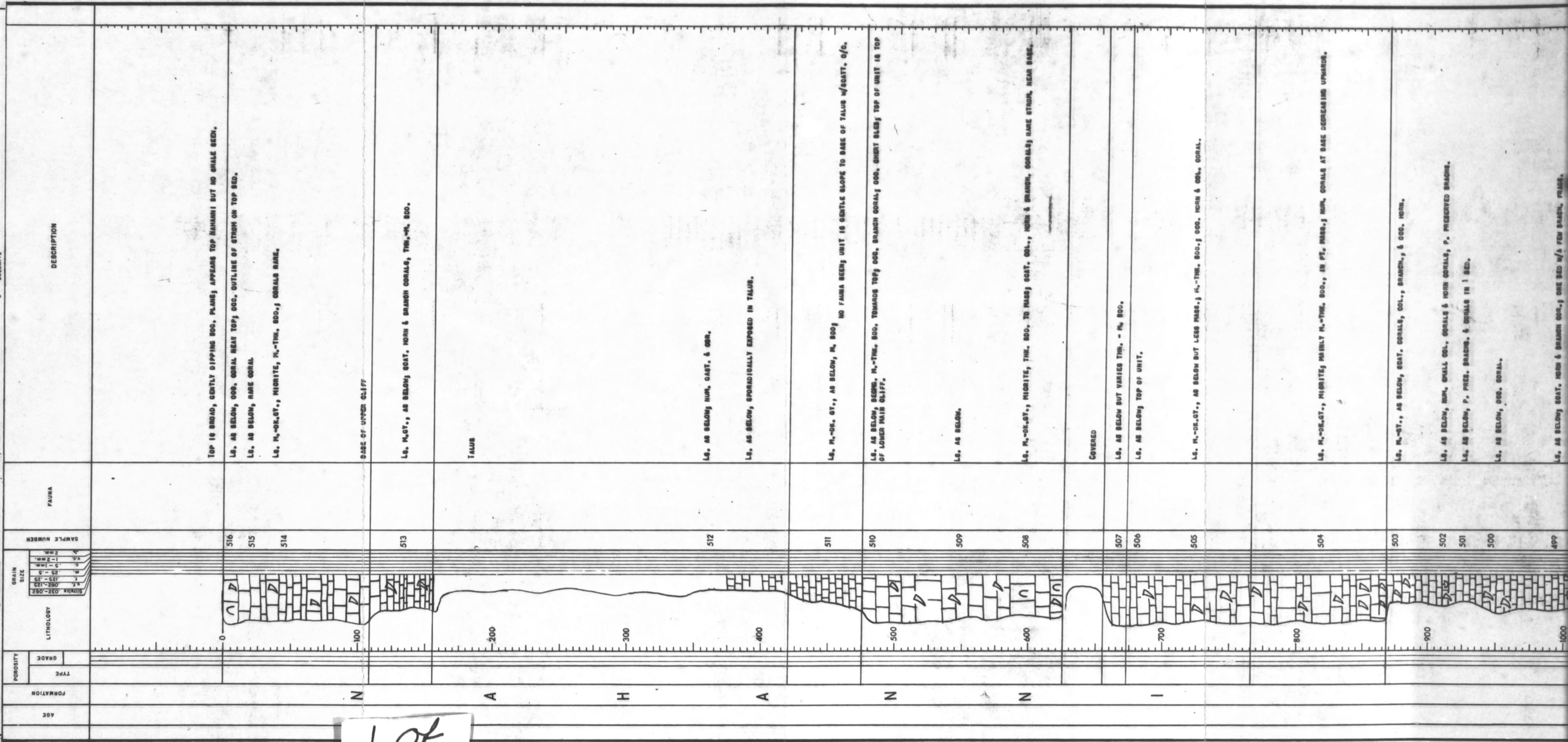
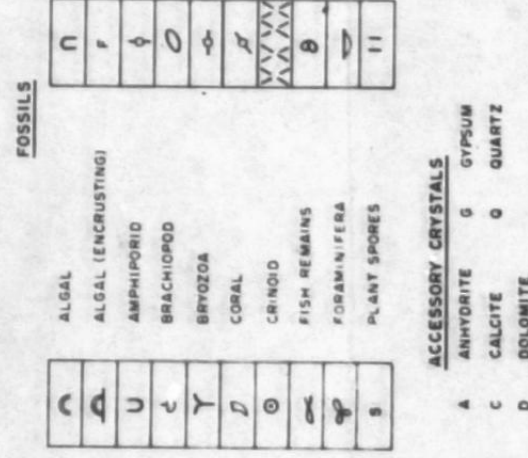
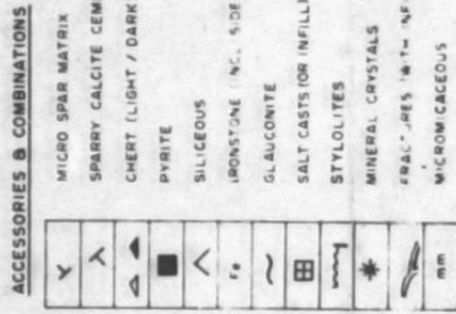
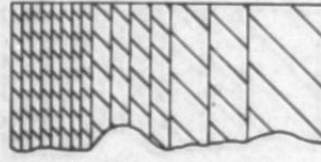
Depth (ft)	Stratigraphic Unit	Lithology	Fauna	Sample Number
0 - 25	Unit A	Sandstone, shaly	Brachiopods, Corals	372
25 - 50	Unit A	Sandstone, shaly	Brachiopods, Corals	373
50 - 100	Unit A	Sandstone, shaly	Brachiopods, Corals	374
100 - 150	Unit A	Sandstone, shaly	Brachiopods, Corals	375
150 - 200	Unit A	Sandstone, shaly	Brachiopods, Corals	376
200 - 250	Unit H	Shale, sandy	Graptolites, Brachiopods	377
250 - 300	Unit H	Shale, sandy	Graptolites, Brachiopods	378
300 - 350	Unit H	Shale, sandy	Graptolites, Brachiopods	379
350 - 400	Unit A	Sandstone, shaly	Brachiopods, Corals	380
400 - 450	Unit A	Sandstone, shaly	Brachiopods, Corals	381
450 - 500	Unit N	Limestone, shaly	Brachiopods, Corals	382
500 - 550	Unit N	Limestone, shaly	Brachiopods, Corals	383
550 - 600	Unit N	Limestone, shaly	Brachiopods, Corals	384
600 - 625	Unit N	Limestone, shaly	Brachiopods, Corals	385

The logo for Banff Oil Ltd. is a circular emblem. The word "Banff" is written in a large, stylized, cursive script. Below it, the words "OIL LTD." are written in a smaller, sans-serif, all-caps font. The entire logo is enclosed within a thin circular border.The logo for Banff Oil Ltd. is a circular emblem. The word "Banff" is written in a large, stylized, cursive script. Below it, the words "OIL LTD." are written in a smaller, sans-serif, all-caps font. The entire logo is enclosed within a thin circular border.The logo for Banff Oil Ltd. is a circular emblem. The word "Banff" is written in a large, stylized, cursive script. Below it, the words "OIL LTD." are written in a smaller, sans-serif, all-caps font. The entire logo is enclosed within a thin circular border.The logo for Banff Oil Ltd. is a circular emblem. The word "Banff" is written in a large, stylized, cursive script. Below it, the words "OIL LTD." are written in a smaller, sans-serif, all-caps font. The entire logo is enclosed within a thin circular border.

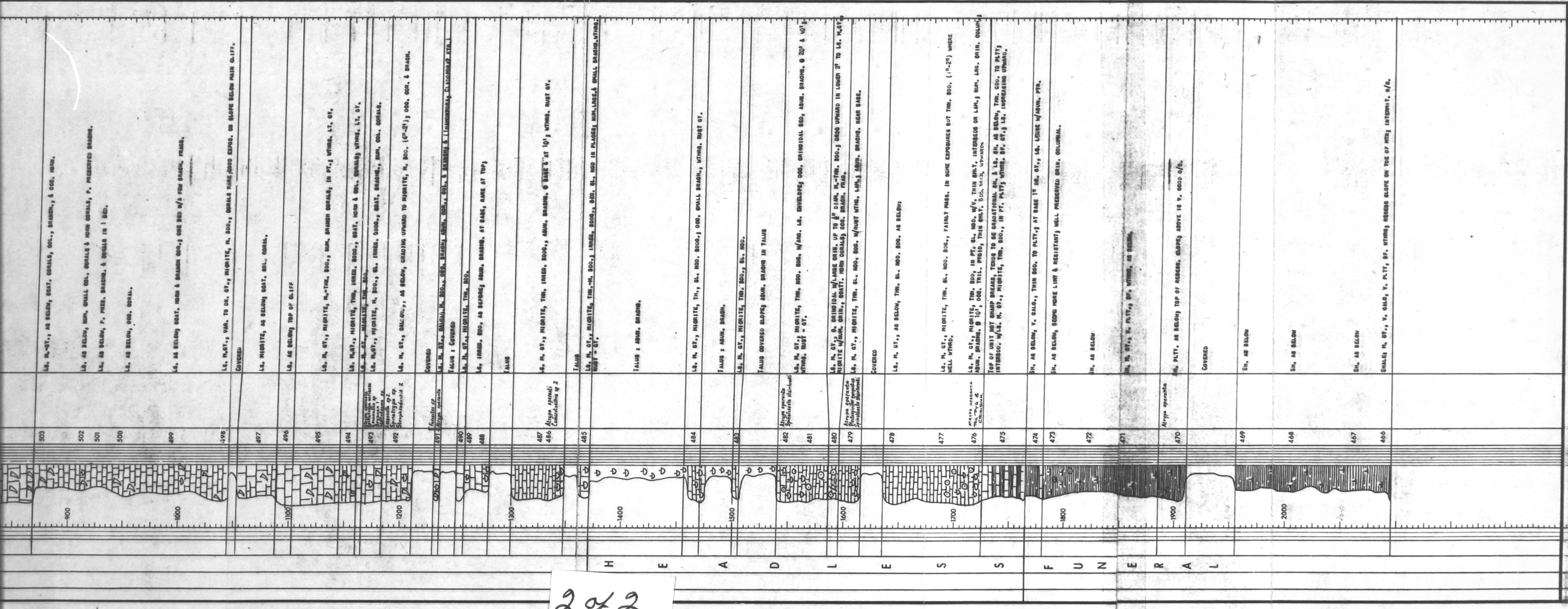


STRATIGRAPHIC SECTION NO. R.F. - 31-68

LOCATION NORTH END FUNERAL RANGE, N.W.T.
COORDINATES: LAT. N. 61°42' LONG. W. 124°59'
MAP AREA VIRGINIA FALLS
FIELD PARTY LIARD BASIN YEAR 1968
FORMATIONS FUNERAL-HEADLESS-NAHANNI
THICKNESS MEASURED 2100' MEASURED BY R.D. FERGUSON & E.I. KOZBIAL



1 of

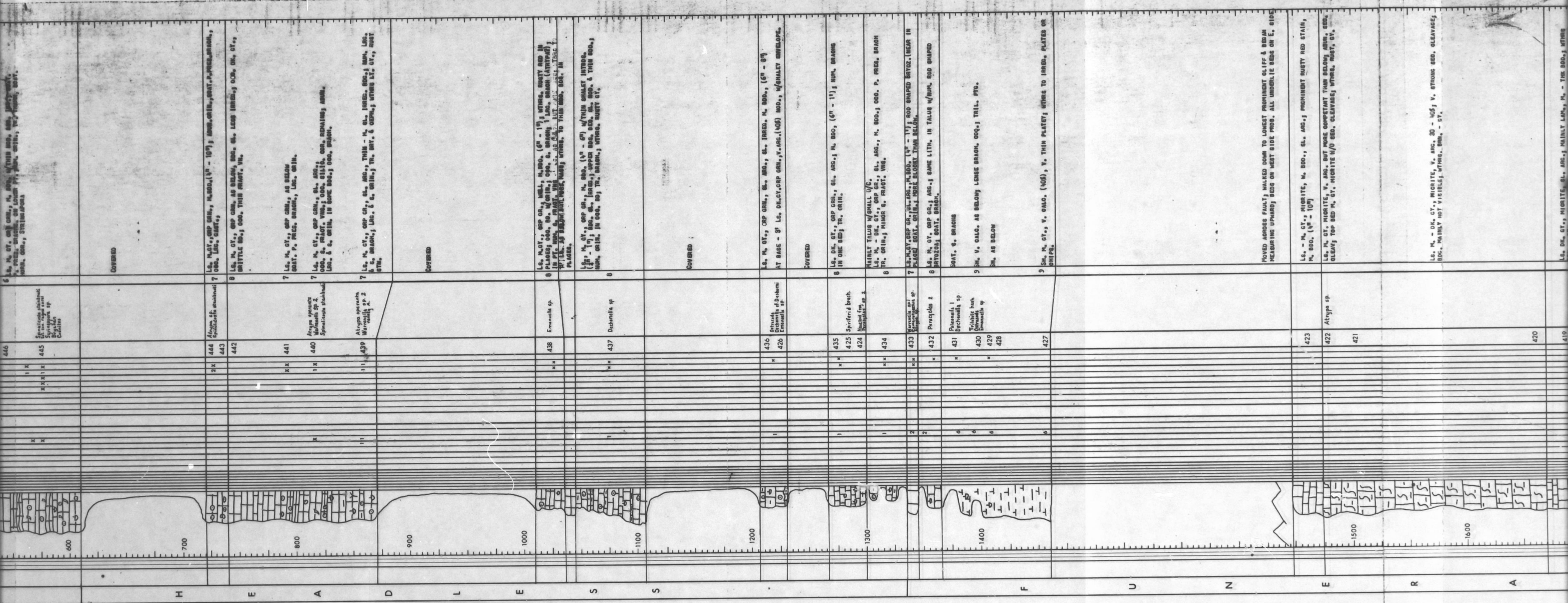


1 of

BESSA R.



BESSA R.



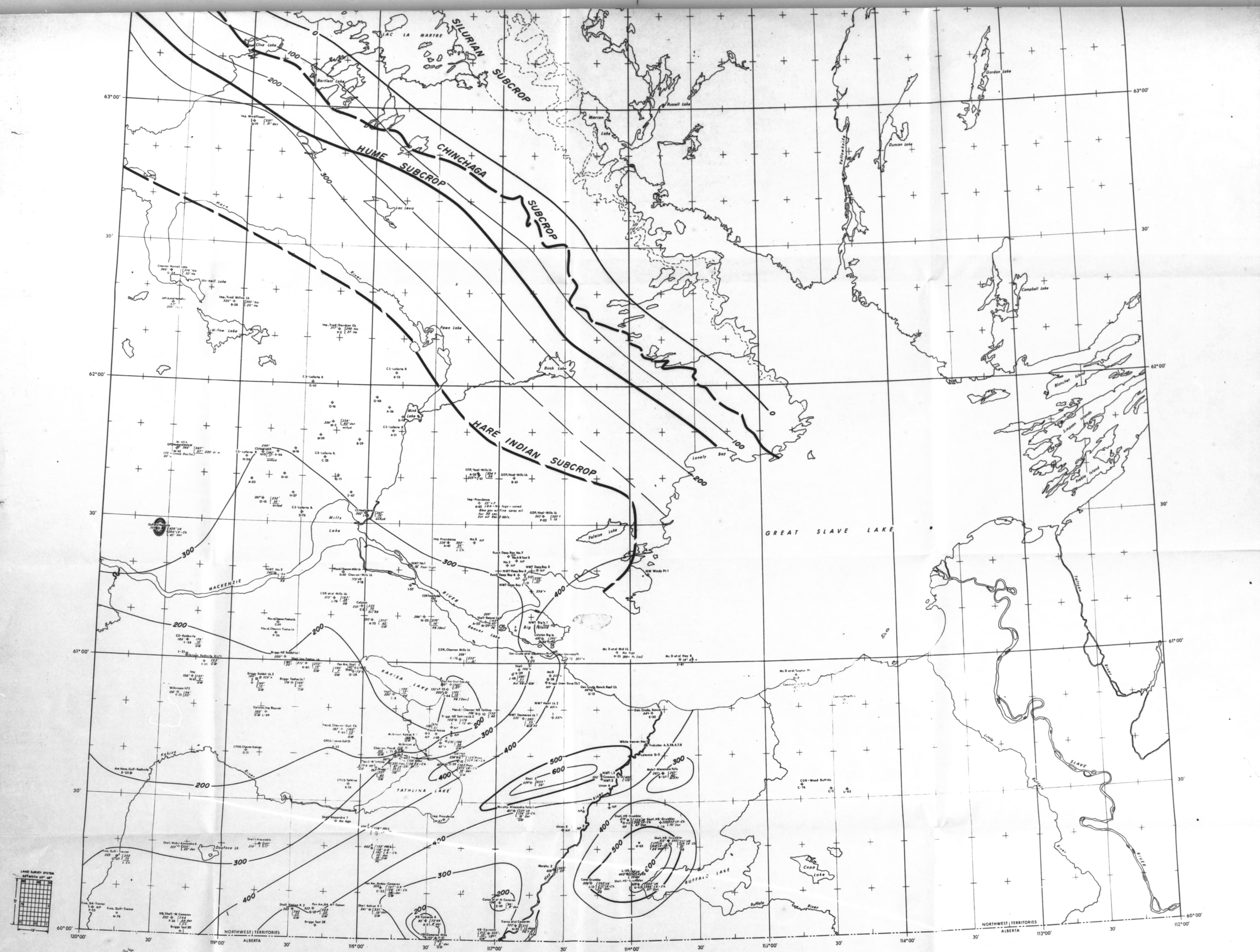




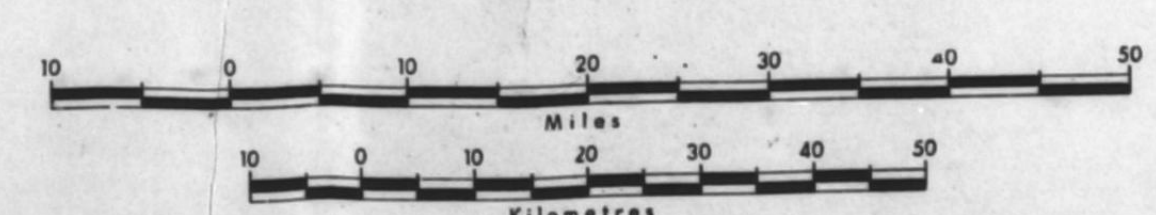


BY _____ DATE _____		SCALE _____	
REVISED: _____		CONTOUR INTERVAL: _____	
DRAFTED BY: _____		WELLS POSTED TO _____	FILE NO. ☐ X - ☐ I

2 of 2



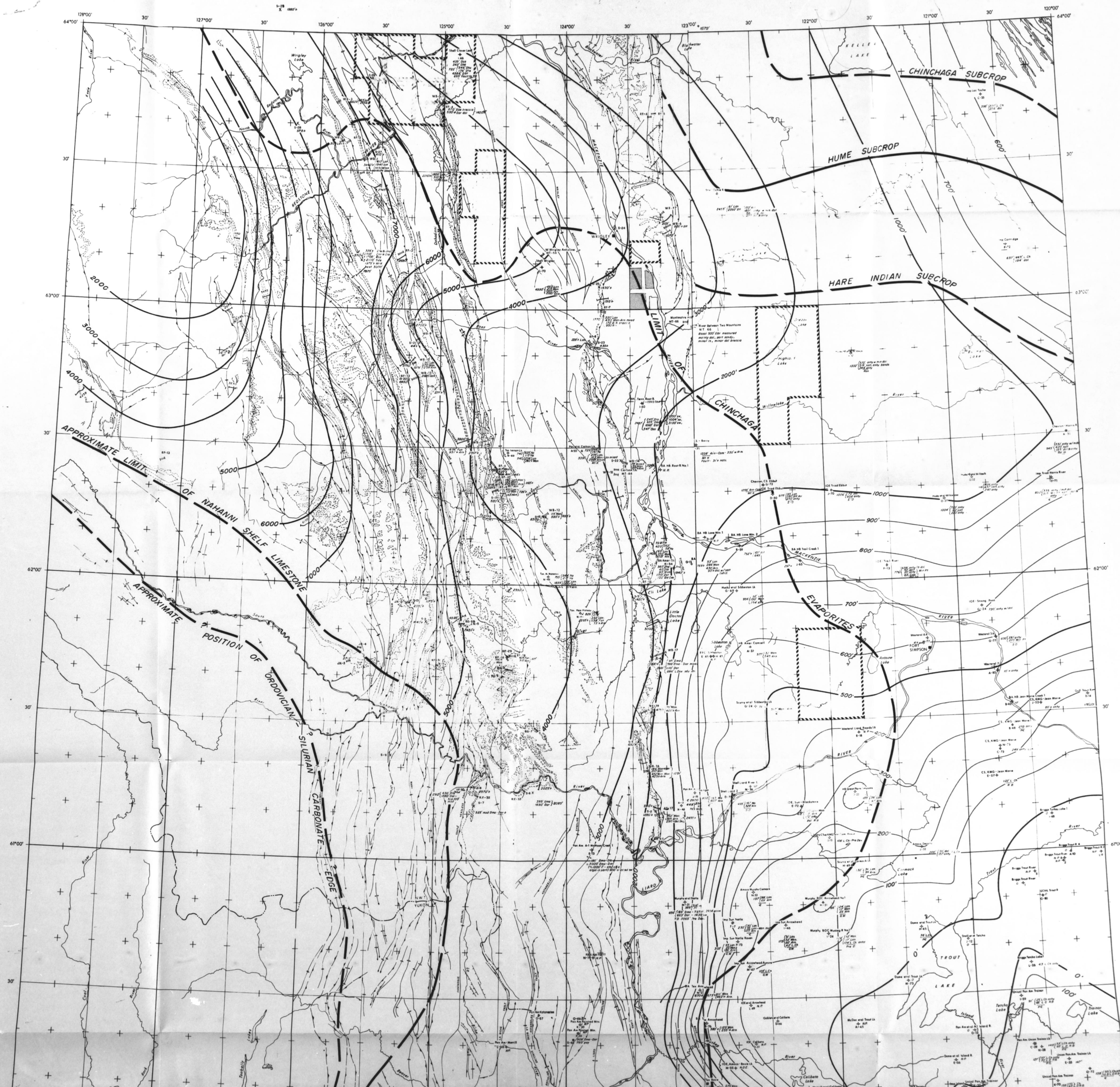
SLAVE RIVER AREA

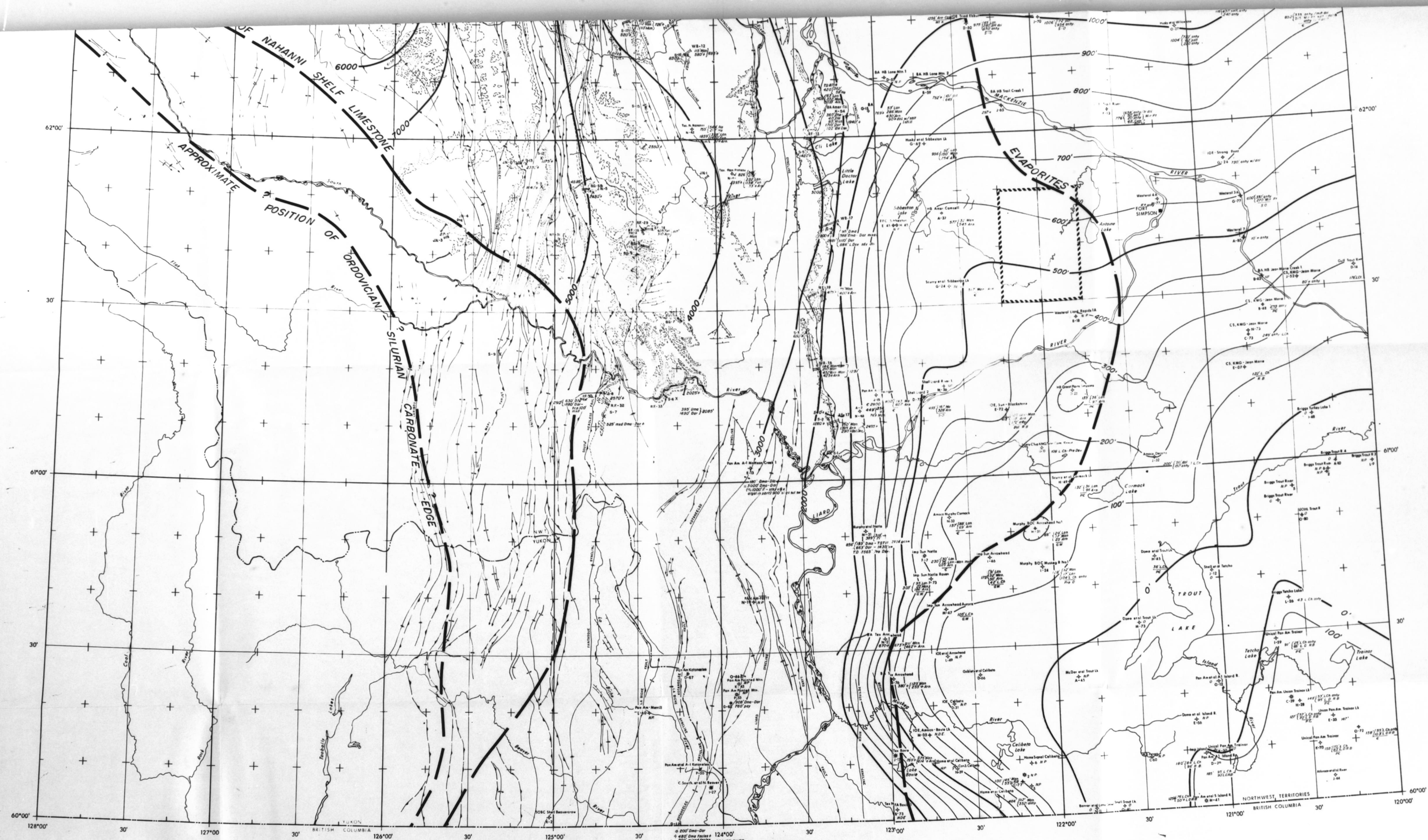


SHAGBENZIE MTS.	ST. SLAVE LAKE
NAHANNI	REP.
HEADLESS	L. NEG. RIVER
	CHINCHAGA CLSTIC

NAHANNI-HEADLESS ISOPACH

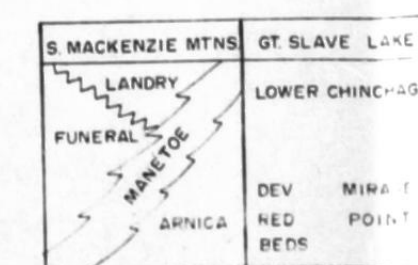
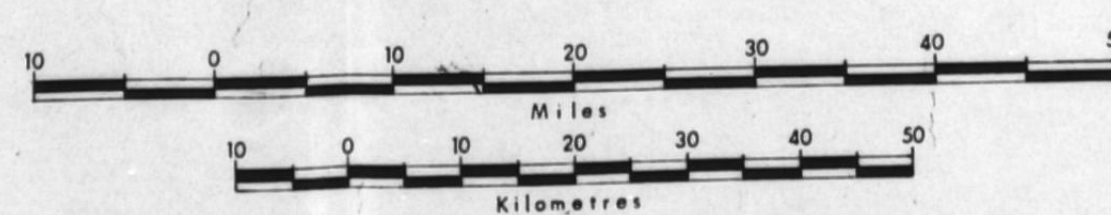
DATE: SEPT. 1970
 SCALE: 1" = 8 mi.
 MAP BY: [Name]
 CHECKED BY: [Name]
 PLATE 14





- ☐ LANDRY
- ☐ MANETOE
- ☐ ARNICA
- ☐ FUNERAL

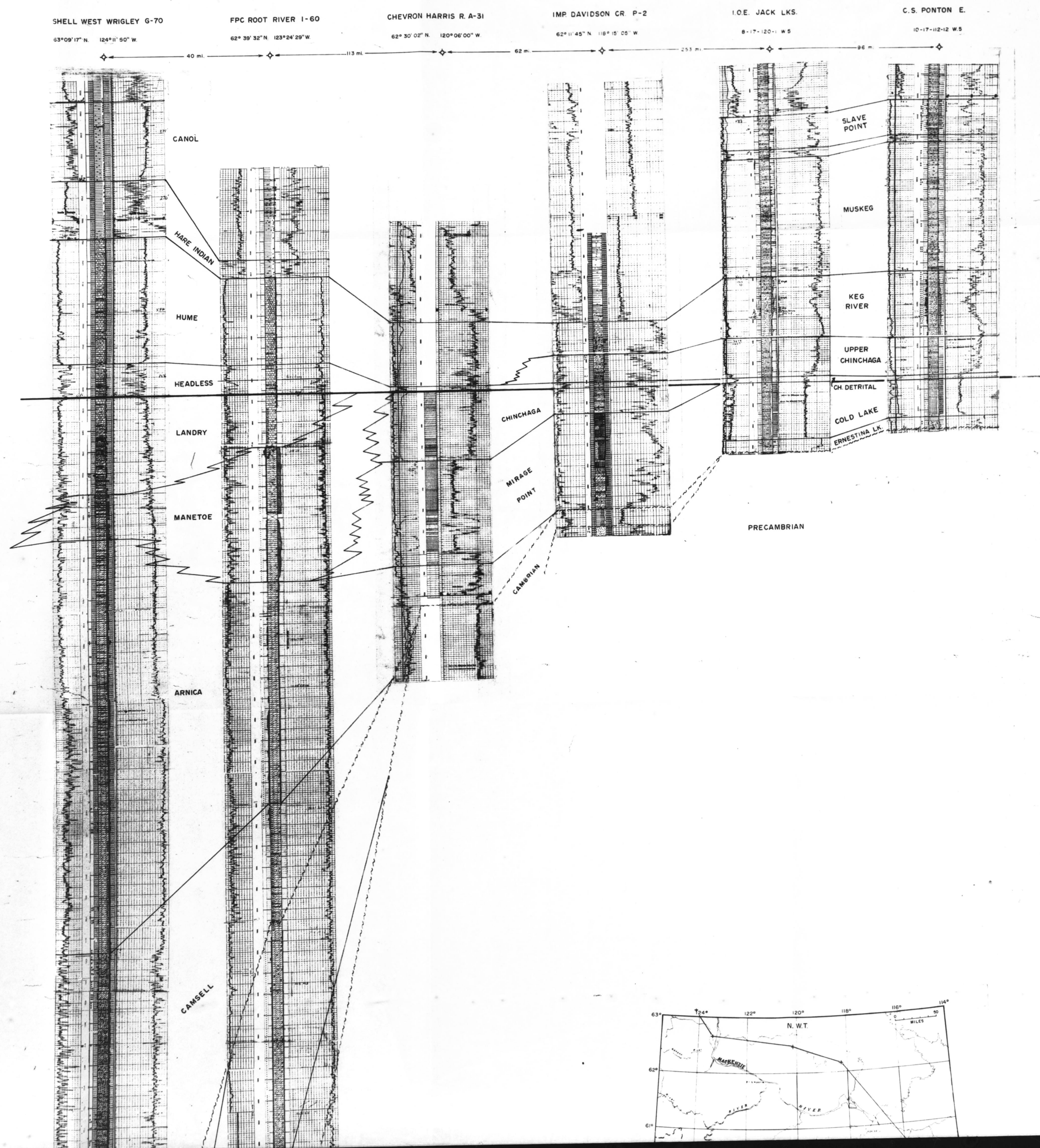
REDSTONE RIVER AREA

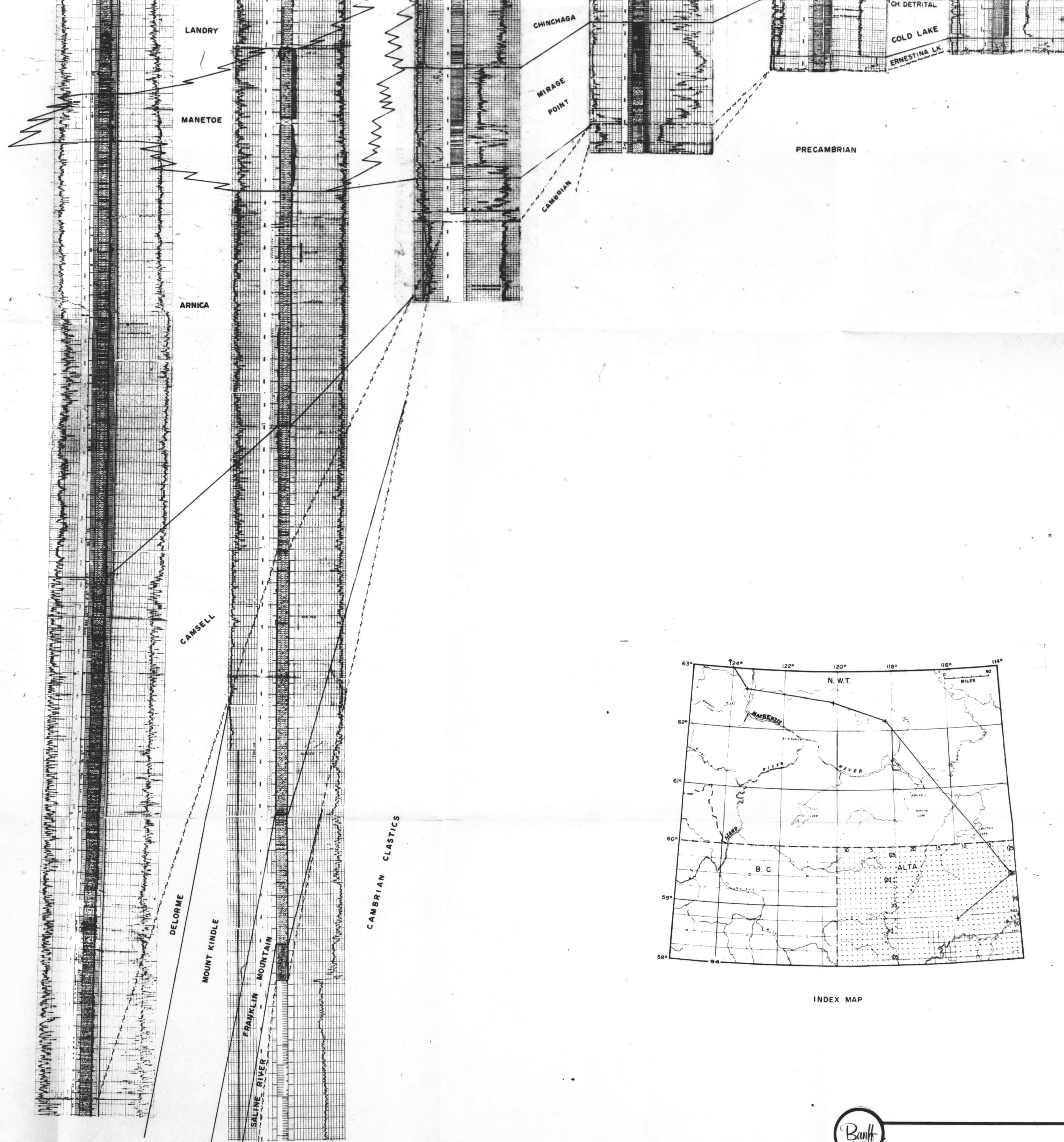


MANETOE-ARNICA-CAMELL ISOPACH

DATE	SEPT. 1970	BY	J. H. B.
REVISION		BY	
REVISION		BY	

PLATE 15

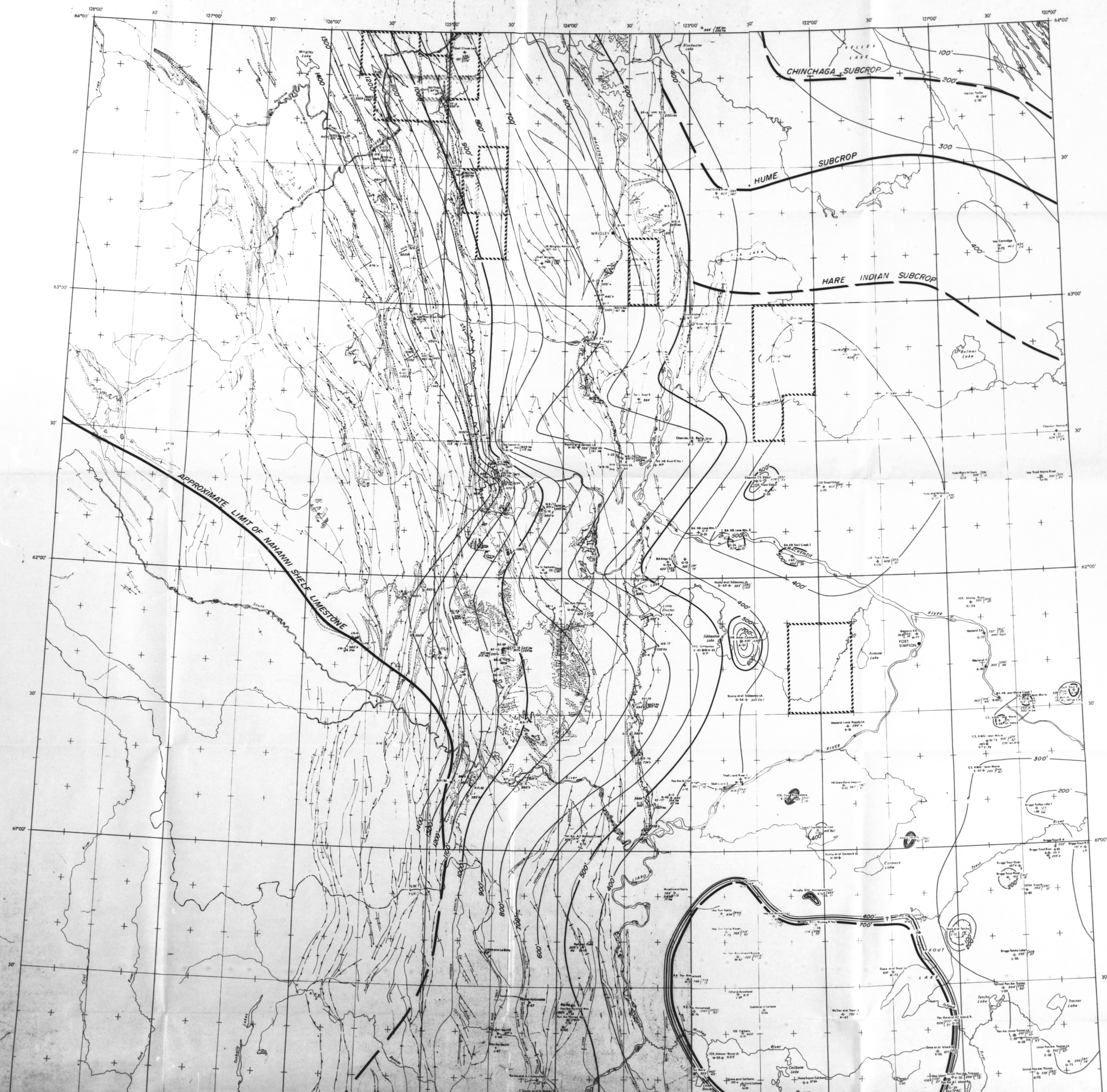


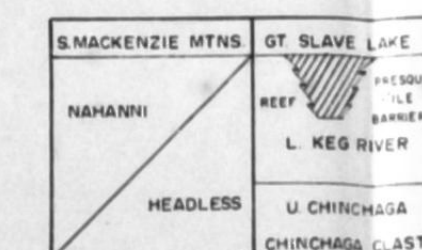
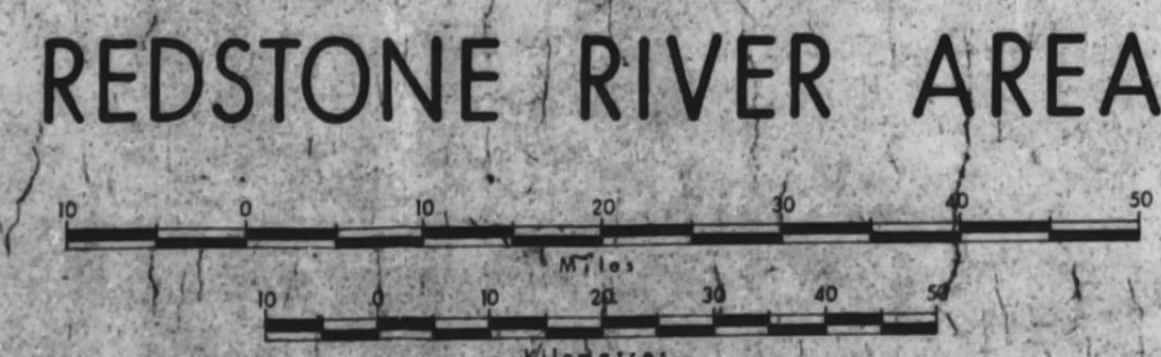


INDEX MAP

			
BY: R. D. F.	DATE: MARCH, 1970	SCALE VERT: 1"=200'	HOR: NONE
PROJECT NO:	WELLS ADJACENT TO:	CORRELATION INTERVAL:	FILE NO:
PLATE 5			

2 of 2





NAHANNI-HEADLESS ISOPACH

ST: R D F	DATE: SEPT. 1970	SCALE: 1" = 6 mi.
REVISED:		CONTOUR INTERVAL: 100 feet
DRAWN BY: [illegible]		FILE NO: [illegible]

A

PAN. AM. SHEEP CREEK

94-J-12 c-86-D
KB 3099'

GULF STATES EVIE LAKE 1

94-J-14 b-90-G
KB 1643'

PAN. AM. A-1 PHILIS

94-O-16 a-65-G
KB 1530'

HOME SIGNAL CSP CELEBETA 1

60° 03' 43" N. 122° 22' 51.29" W.
KB 1490'

IMP. NETLA RAVEN F-73

60° 42' 25" N. 122° 44' 10" W.
KB 1966'

IMP. SUN ARROWHEAD 1-46

60° 45' 37.15" N. 122° 22' 46.96" W.
KB 1905'

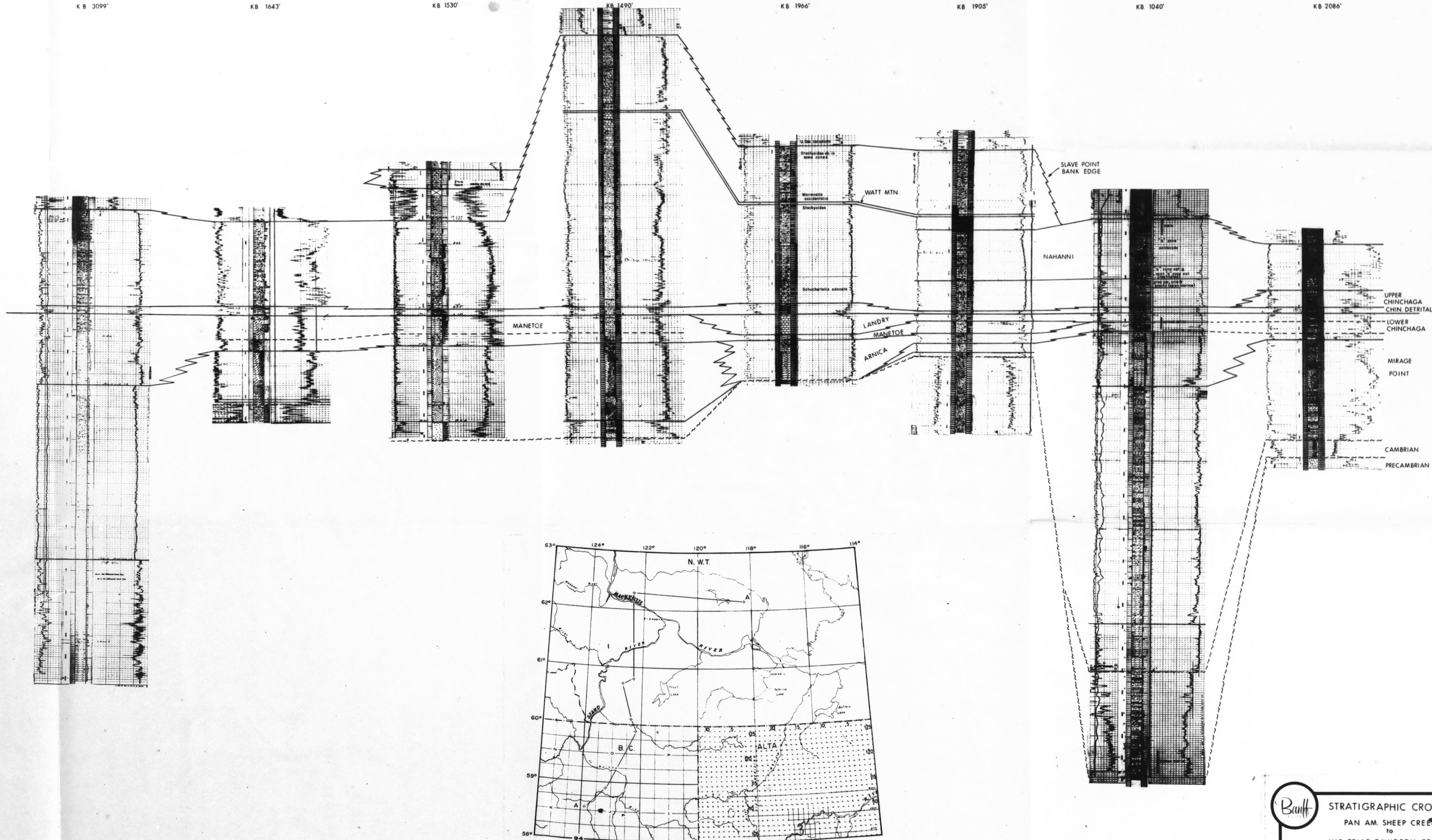
IOE TRIAD EBBUTT D-50

62° 19' 01" N. 122° 24' 05"
KB 1040'

IMP. TRIAD DAVIDSON CREEK P-2

62° 11' 45" N. 118° 15' 05" W.
KB 2086'

A'



STRATIGRAPHIC CROSS SECTION
PAN AM. SHEEP CREEK
to
IMP. TRIAD DAVIDSON CREEK

INTERPRETED BY: S.D.F.	CONTOUR INTERVAL:
DATE: OCTOBER, 1970	SCALE: VERT. 1" = 200' HOR. NIL
REVISED:	FILE NO.:

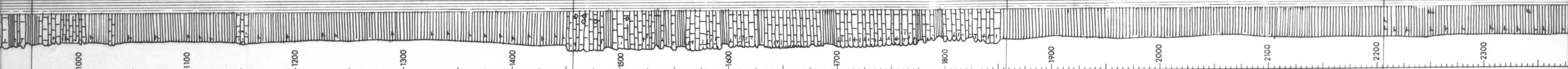
INDEX MAP

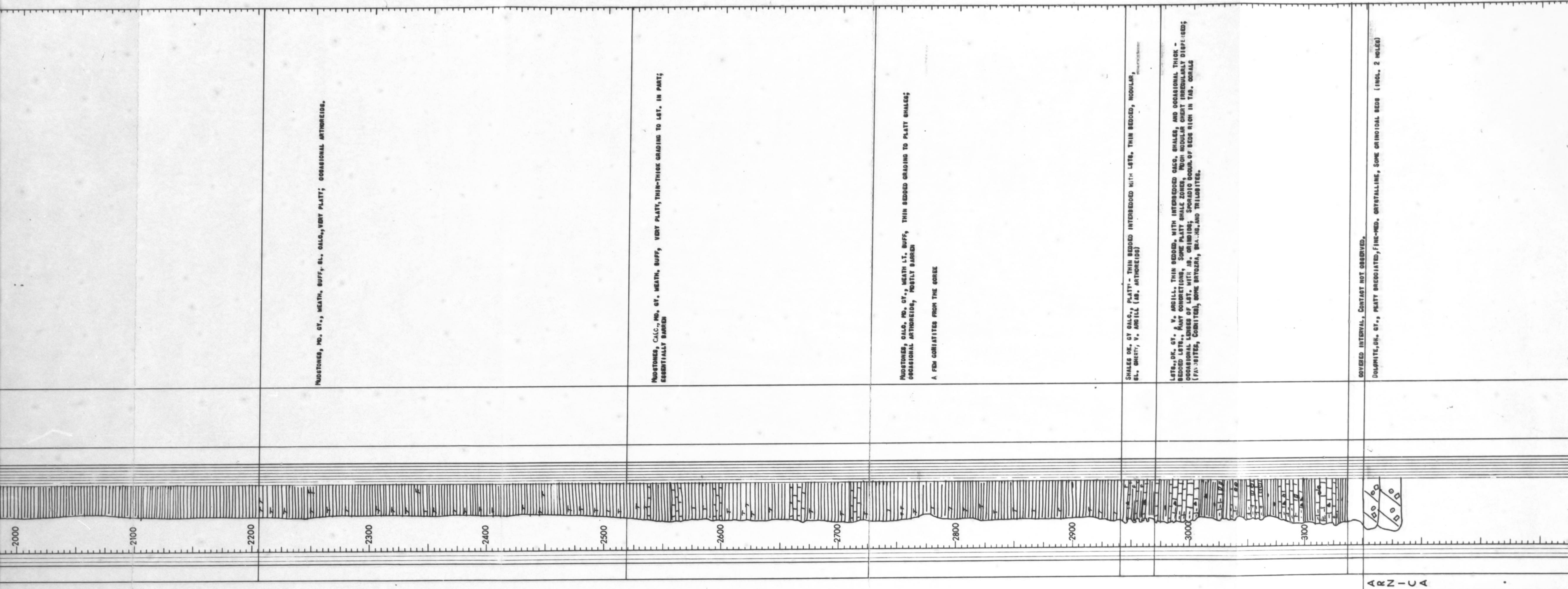
SHALES, MD. CY., WEATH. LT. BUFF, GILC., FISSILE, PAPER THIN AND PLATT;
RARE INTERBEDS OF V. SHALY LIT. TOWARDS THE TOP.

LIMESTONE, OR. CY. SHALY, GRADING TO LIMY SHALE; THIN-MED. BEDDED-V. REGULAR BEDDED; A FEW
INTERBEDS OF PLATT SHALES; GENERALLY BARREN.

SHALES-LT. MED. CY., BUFF WEATH., FISSILE AND PLATT, OFTEN PAPER THIN; BARREN OF FOSSILS
EXCEPT FOR OCCASIONAL ARTHROPODS

MUDSTONES, MD. CY., WEATH. BUFF, SL. CALC., VERY PLATT; OCCASIONAL ARTHROPODS.



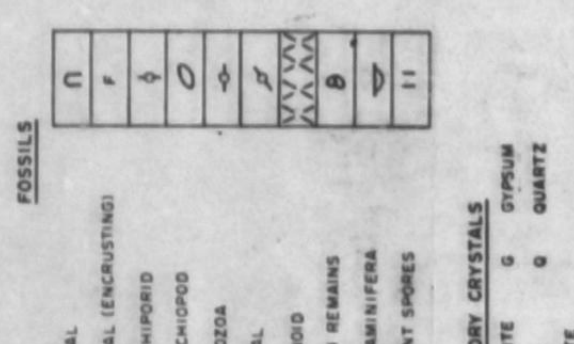
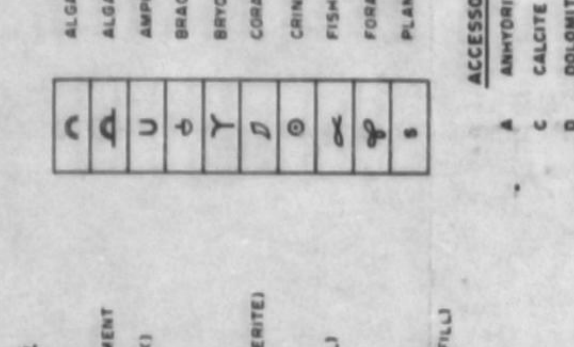
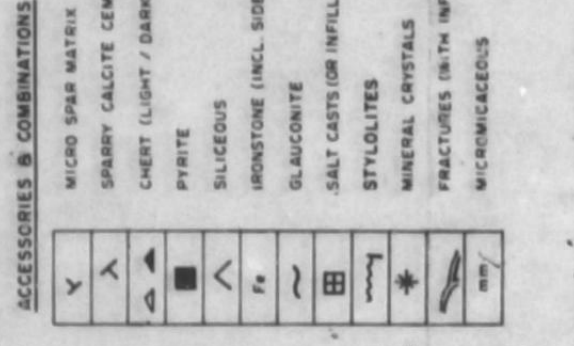
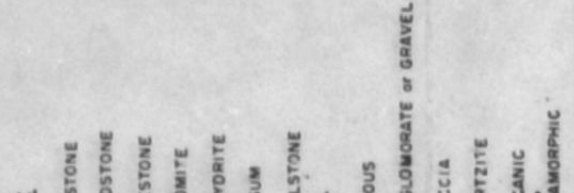
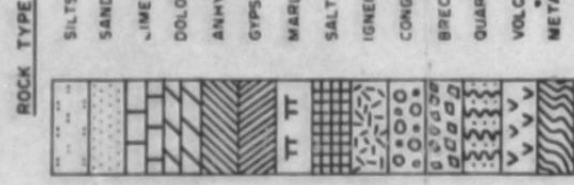
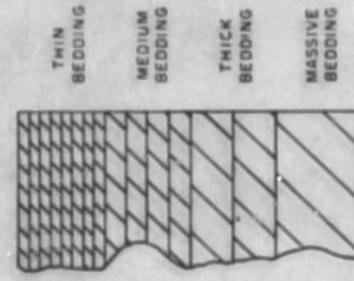




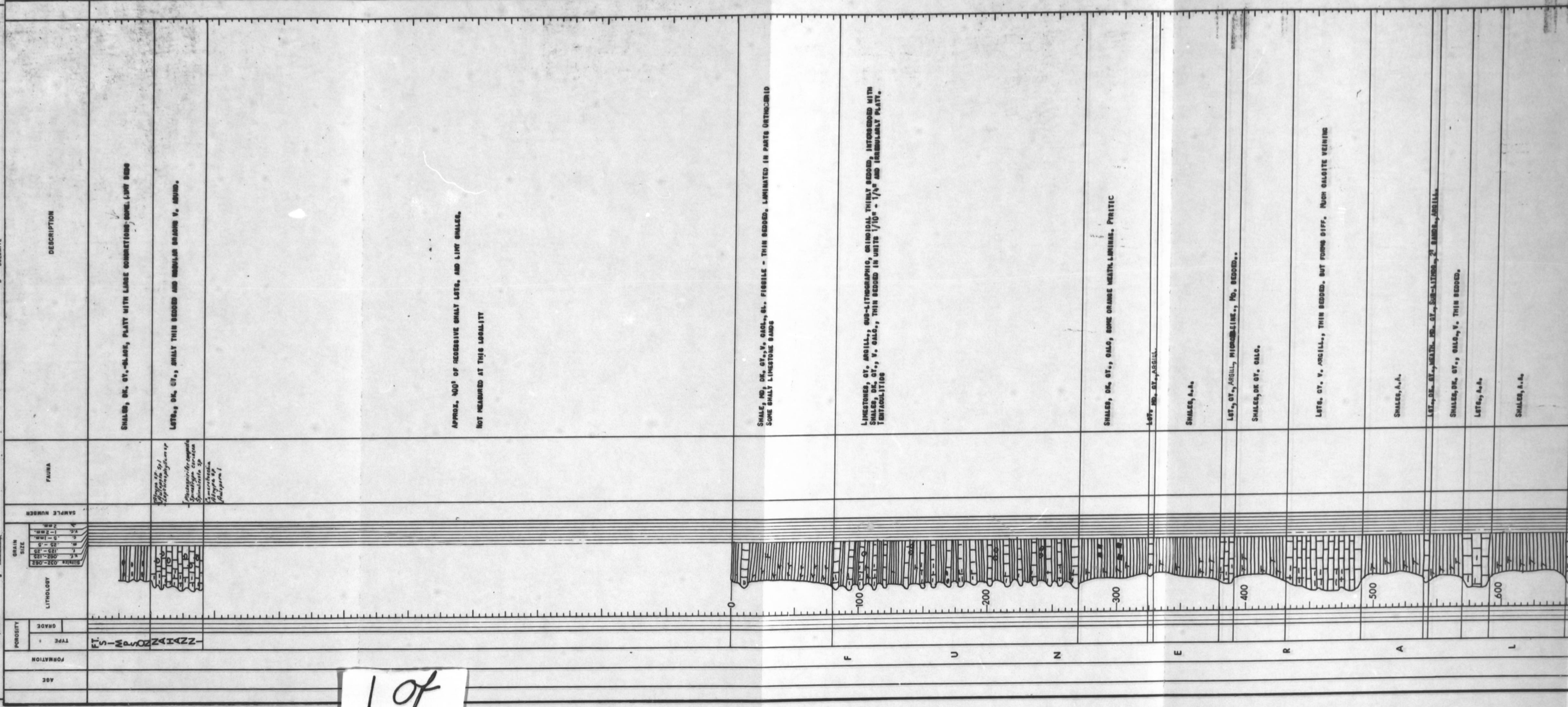
STRATIGRAPHIC SECTION NO. J.N.3&4

Composite Section

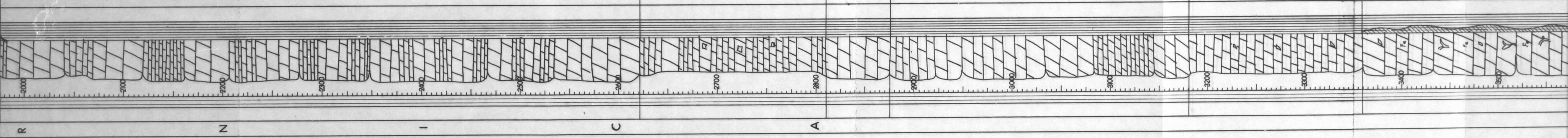
LOCATION CATHEDRAL MOUNTAIN, N.W.T.
COORDINATES: LAT. N. 61° 43' LONG. W. 125° 40'
MAP AREA VIRGINIA FALLS
FIELD PARTY LIARD BASIN YEAR 1968
FORMATIONS FT. SIMPSON - DELORME
THICKNESS MEASURED 4275' MEASURED BY J.P.A. Noble



POREXITY TYPE
V Void
PP Pigment
F Fracture
E Earth
M Interstratification



1 of



DOLomite, CRYSTalline, THIN BEDDED UNITS (6" THICK) ALTERNATING WITH THIN-NO. BEDDED UNITS, LAMINATED IN PART., MUCH SED. COL., AB. VUGS.

DOLomite, LT. GR., CRySTalline, MOSTLY THIN BEDDED, OFTEN MASSIVE, BUT SOME THICK BEDDED UNITS OFTEN COARSELY LAMINATED, MINOR BRECCIA.

DOLomite, LT. GR., CRySTalline, MASSIVE

DOLomite, LT. GR., CRySTalline, MANY SMALL WHITE BLENDS OF SED. COL., BEDDING VARIABLE, THIN BEDDED-MASSIVE

DOLomite, LT. GR., CRySTalline, NO. BEDDED, CORALS COMMON, FAVORITIDS, CORNITES, AND OTHER TABULATE CORALS.

DOLomite, NO. GR., FINE ALLINE, MOSTLY MASSIVE, MUCH SED. COL. WEIRING, HEMITID, FRACTURES, SOME TABULATE CORALS

ORONOLITES IN CORAL.

DOLomite, LT. GY., CRYSTOLLINE, MANY SMALL WHITE BLUES OF SED. SOL., BEDDING VARIABLE, THIN BEDDED-MASSIVE

DOLomite, LT. MO. GY., CRYSTOLLINE, MO. BEDDED, CORALS COMMON, FAVORITIDS, SCIMITERS, AND OTHER TABULATE CORALS.

DOLomite, MO. DK. GY., FINE X-LINE, MOSTLY MASSIVE, MUCH SED. SOL. VEINING, HERMATIDID, FRACTURES, SOME TABULATE CORALS

ORCHOLITES IN CORE.

ANGULAR DISCONTINUITY WITH IRREGULAR RELIEF (SEE PHOTO) MUCH RED STAINING.

DOL., SL. ARGILL., MO. SED., TRACE OF GRINOLIDS AND BRACHIO.

COVERED INTERVAL

LOT., ARGILL., WITH A FEW THIN SHALY BEDS, GRINOLIDS COMMON, BRACHIO MORE COMMON UPWARDS.

LOT., MO. GY., ARGILL., THIN-MO. BEDDED, SCATTERED BRACHIO AND GRINOLIDS

LOT., MO. GY., ARGILL., THIN-MO. BEDDED, RICHLY FOSSILIFEROUS

LOT., MO. DK. GY., ARGILL., THIN BEDDED, SOME SHALY LENTILS, BARREN EXCEPT FOR A FEW ISOLATED ATRYPAS AND GRINOLIDS.

LOT., ARGILL., RICHLY FOSSILIFEROUS

LOT., ARGILL., INTERBEDDED WITH CALC. MUD STONES ESSENTIALLY BARREN.

LOT. ARGILL., THIN-MO. BEDDED (8"-1" BEDS), PROLIFIC FAUNA, ESP. ATRYPA AND CYPRIDULA

LATS., MO. GY., ARGILL., THIN BEDDED, 1ST. OCCUR OF ATRYPAS AT 140', CYPRIDULA AT 155'.

LATS., MO. GY., V. ARGILL. GRADING TO LIMY SHALES, THIN-MO. BEDDED, BRITTLE FRACTURE, SPORADICALLY FOSSILIF., OCCASIONAL GRINOLIDS AND PELECYPODS

SLATES, MO. GY., WEATH. LT. GY. BUFF, V. GLASSY AND FLATT.

D
E
L
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R
M
E

CSG

MEASURED BY A. W. NORRIS

PERIOD	AGE	FORMATION	POR TYPE	LITHOLOGY	GRAIN SIZE	GRAIN TYPE %	ACCESS TYPE %	CLAS. TICS	FRAME - WORK	STROM COR	SAMPLE NUMBER	FAUNA	DEPTH OF WATER	DESCRIPTION	
					Silstone 092-062	0.02-0.05 mm	SKELTAL	INTERCLASTS	PELLETS	TYPE %	AMOUNT %	ARGILLACEOUS	SILT	SAND	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	0.02-0.05 mm	
					0.02-0.05 mm	0									

