FINAL GEOLOGICAL REPORT

on

HANNA RIVER AREA

N.W.T.(Canada)

IMPERIAL OIL LIMITED, CANOL PROJECT.

Assignment No. 26.

By: Dr. H.T.U. Smith — Party Chief
Pte. E. Urbach — Assistant
C. G. Moon — Assistant
W. T. Northington — Helper.

Date submitted: August 1943.

Read and accepted by: H.T.U. Smith

Date: 3/16/'44

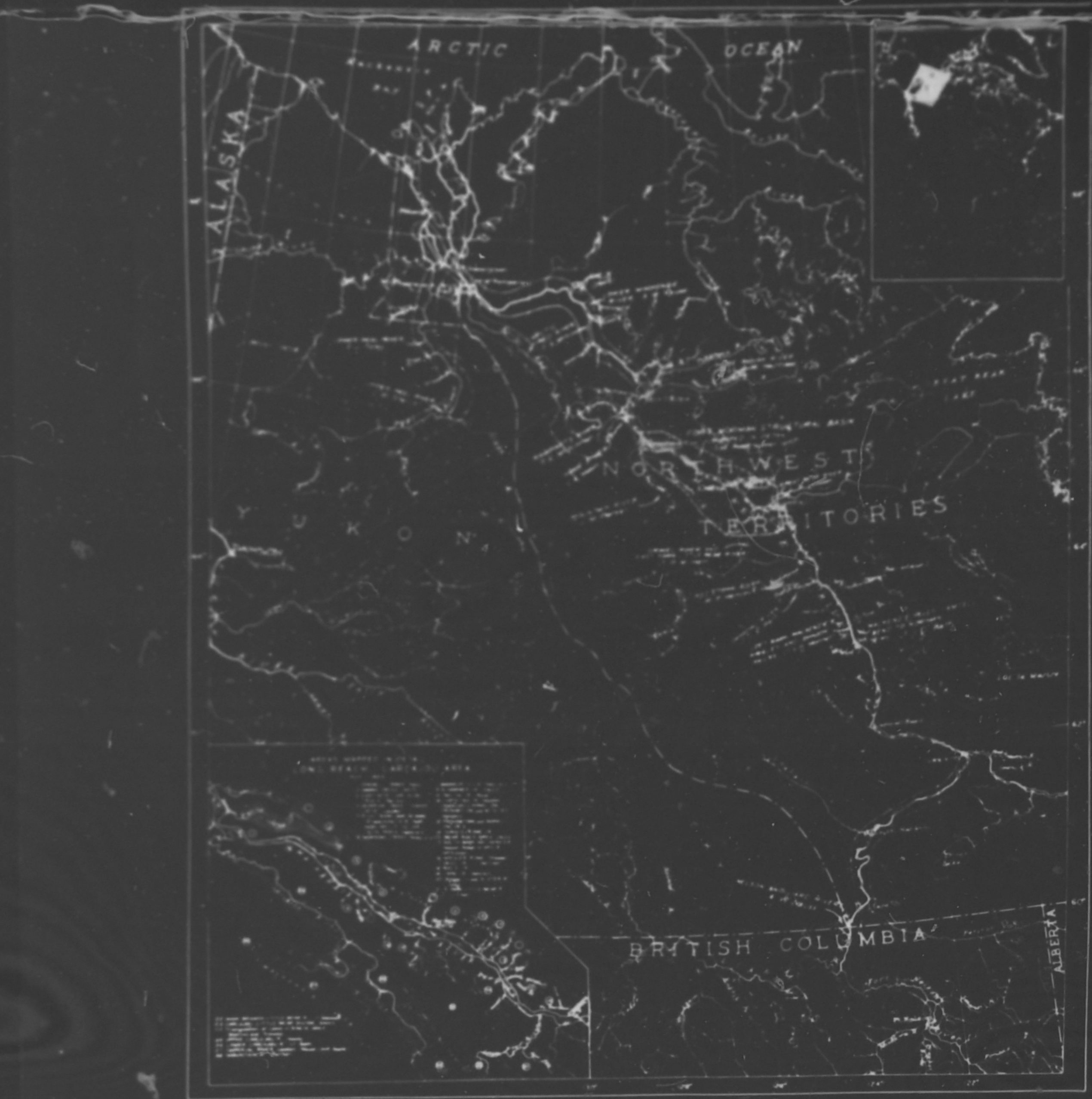
CONFIDENTIAL

TABLE OF CONTENTS

* * * * * * * * *

LIST OF ILLUSTRATIONS

* * * * * * * * * * *



INDEX MAP OF
NORTH WESTERN CANADA SHOWING
HANNA RIVER AREA

I N T R O D U C T I O N

The area considered in this report comprises the drainage basin of the upper and middle stretches of Hanna River, which flows into the Mackenzie River just below San Sault Rapids. The area lies roughly parallel to the Mackenzie Valley, but is separated from it by a series of mountainous ridges - Thomas Mountain, Paige Mountain and Carcajou Ridge.

Field Work

Party "L" landed on Moon Lake on the evening of June 23rd, completed field work on July 29th. and returned to Norman Wells on the evening of July 30th. Several days' time were lost because of rain, and the first three miles of travel downstream from the starting point required four days because of shallow water and rapids.

In the middle of July, the personnel of the party was changed. Mr. Moon was called out on July 15th, and Mr. Worthington arrived to carry on July 17th.

The greater part of the time in the field was spent in the Upper Hanna River area, where outcrops are most numerous. The results of mapping in this area are shown on Plate I. For about ten miles downstream from this area no outcrops were found. Then an area of Cretaceous outcrops extending for some three miles along the stream was traversed, and mapped as shown in Plate II. Beyond this strip, no outcrops were found along Hanna River. Short side trips were made up Carcajou Ridge and East Mountain, however, to observe the character of the formations exposed there.

Field mapping was based entirely on the C.P.A. vertical aerial photos. Plane table traverses were made, however, to check scale to tie in

between two flight strips which failed to overlap, and to fill in gaps. Scale check lines were made on Photo Nos. 259, 267, 448, 455, 584, and 620. The tie-in traverse was run between Photo Nos. 267 and 448. Gaps at and near the mouth of Hanna River (Photos 620 to 615) were filled in, and the mouth of the stream was tied in to P.M. 04. End points of all of the above traverses are marked on the photos of Set No. 2.

On September 5th, an airplane trip over the field area made it possible to extend the mapping across the area north of Moon Lake, and to check the mapping of structural features and the tie-in with the mapping of adjoining areas.

Use of Aerial Photos

Photos for the area covered by field work were studied in Edmonton for some time before field work was started. This provided opportunity to check the results of purely office interpretation, and to appraise the possibilities of the latter. It was found that the major structural features could be located quite satisfactorily by office methods alone. Minor structures, however, such as those which might be most significant for oil production, escaped detection, and for the most part correlations could not be made with any degree of satisfaction. Had the office study been made after field study of some area in the same general region, rather than before, more definite results could have been obtained, and various minor surface markings shown on photos would have been of much greater significance. Even so, it is clear that the scope of office interpretation is decidedly limited. This is due mainly to the following factors; (1) small scale and lack of critical sharpness of definition on the photos available; (2) marked lateral variations in the lithology of formations; (3) capricious variations in

the surface expression of the same formation even where lithology is essentially unchanged, due at least partly to glacial action, and (4) gaps in the outcrop pattern due to masking or camouflaging by glacial erosion and deposition.

In the field, aerial photos were used as guide maps and location maps. It was found that stereoscopic examination on the ground was absolutely necessary to use the photos to best advantage. The use of even a pocket stereoscope away from camp was found to be impractical, however, and stereo-vision with the unaided eyes was found to be most convenient.

In traversing muskeg areas, Brunton-pedometer traverses were found most satisfactory for checking locations between definite landmarks. Compass bearing was checked every 50 to 100 yards, and the pedometer, graduated to quarters of a mile was read to twentieths of a mile by interpolation. In this way, it was nearly always possible to arrive within sight of a predetermined point even where the visibility in between was practically nil.

On the completion of field work, final stereoscopic study of the photos provided the basis for integrating field observations, refining the geologic mapping, extending structures and formation boundaries, and making general correlations with adjoining areas. Visual observation from the air, both before and after field study, aided greatly in photo interpretation.

The geologic maps, Plate I and II, were assembled from the aerial photos by center-to-center plotting, without correction for parallactic distortion except by free-hand sketching. Where relief is strong, distortion is noticeable, and detail does not quite match from one photo to the next.

Spot heights used in plotting profiles for the geologic cross sections were obtained from stereometric measurements on photos.

Acknowledgments

Fossil identifications were made by Mr. Stelck. The maps were prepared with the help of Mr. Frame and Mr. Gibson.

Chapter II.

TOPOGRAPHY

The Upper Hanna River area is a basin topographically and structurally, and forms a well-defined topographic unit. It is bounded on the south by the Thomas and Richard Mountains, on the southwest by Paige Mountain, on the northwest by Brokenoff Mountain, and on the north and northeast by outward facing escarpments of varying height and prominence. From the top of Paige Mountain or Brokenoff Mountain the general outline of the basin is readily observable.

In form, the basin is asymmetric, with the longer slope on the northeast and the shorter slope on the southwest. The Hanna River traverses the axis or trough of the basin, and is bordered on both sides by broad strips of featureless muskeg.

Hanna River in this area is a narrow, winding stream with alternating shallows and deeper stretches. It is navigable by canoe only with difficulty, for considerably more time must be spent in dragging the canoe through shallows than in floating. Greenhorn Creek, fed by Moon Lake, is the principal tributary. It is even more difficult for canoes, and a portage is necessary.

Paige Mountain is a large, narrow, asymmetric ridge about 1600 feet above the Mackenzie Valley, and about 1200 feet above Hanna River. Talus slopes form the north side and dip slopes are prominent on the south side, where, however, talus slopes are present also.

Brokenoff Mountain is a massive, curved limestone mass which dies out to the northeast and is separated from a longer, larger range to the northwest by a deep notch. It rises about 1400 feet above Hanna River.

The Thomas and Richard Mountains are [illegible] ridges with gentle dip slopes on the north and steep escarpments on the south.

The Middle Hanna River Basin is a less distinct topographic unit, and merges into the Lower Hanna River Basin. It lies between Carcajou Ridge on the south and a massive limestone escarpment on the northeast. The Hanna River is easily navigable by canoe in this stretch, with difficulties only where log jams occure.

[illegible] R A P H Y

The rocks exposed in the upper Hanna River Basin range from Silurian Mt. Ronning to Devonian Upper Fort Creek. Cretaceous beds outcrop along one stretch of the Middle Hanna River. These rocks are described below in order of age.

SILURIAN

Mt. Ronning Formation

Massive beds of light grey cherty crystalline limestone and/or dolomite are exposed on Brokenoff Mountain, Paige Mountain, and on the eastern flanks of the Thomas Mountains. The rock weathers to a characteristic buff, in places of rusty hue. Where exposed in steep cliffs, this formation characteristically gives rise to spectacular talus slopes and rock streams. On vertical aerial photos, the truncated beds of the formation present a characteristic rounded to jagged rugose appearance. The thickness of the formation is estimated to be well upwards of 1000 feet. The base of the formation is not exposed.

Fossils were found in the above rocks at only one horizon, exposed on the top of Brokenoff Mountain, (Fossil Locality No. 1). *Zaphrentis* and two species of *Favosites* were identified from the levtion made at this place. The rocks are correlated with the Mt. Ronning formation on the basis of general lithologic similarity and stratigraphic position.

The Mt. Ronning beds are non-petroliferous. The rock appears to have low porosity, and it is doubtful whether it would make a reservoir rock unless extensively fractured.

Gypsum Beds

Thick beds of gypsum and gypsiferous material are exposed at both ends of Paige Mountain, and on the eastern slopes of Thomas Mountain.

The rock exposed generally displays only a rude zoning and little distinct bedding. A contorted appearance is common. Funnel-shaped sink-holes, ranging in diameter from ten feet to upwards of a hundred feet, are characteristic. Owing both to lack of bedding and to surficial deformation by solution and collapse, satisfactory dip and strike readings are difficult to obtain. Neither the upper nor the lower contact is well exposed, and the outcrops are generally discontinuous. No place suitable for studying a detailed section was found.

The thickness of the gypsum is estimated to be about 500 to 700 feet at the eastern end of Paige Mountain, and possibly upwards of 800 feet at the western end of the mountain. At the latter place, however, exposures are unsatisfactory, and it is possible also that some distortion of thickness by deformation may have occurred.

On aerial photos, the outcrop belt of gypsum beds is characterized mainly by the presence and form of the sink-holes, which, however, occur also in other formations. Where this rock is well exposed, a white color is characteristic also, but again is not necessarily diagnostic.

The gypsum beds are assigned to Silurian age on the general basis of the prevalence of that type of rock in the Silurian.

The gypsum beds are non-petroliferous. The cavernous character of the rock at the surface suggests that the formation might make a reservoir rock, but it is doubtful whether opening would persist to any great depth in so weak and yielding a rock.

DEVONIAN

Although Devonian formations ranging from Bear Rock to Upper Fort Creek are present in the area, localities suitable for measuring continuous sections are few. Most satisfactory of all is the east side of Brokenoff Mountain, where a section from the basal Bear Rock to the

9.

top of the Beavertail was measured with the plane table. Even in this section, however, there are two long covered intervals in the Bear Rock. Above the Beavertail, no continuous section could be measured, and although small, scattered outcrops are numerous, contacts are poorly exposed and places suitable for reliable dip readings are poorly distributed from the stratigraphic viewpoint. The thicknesses given in Plate III are therefore only rough estimates.

Bear Rock Formation

Beds correlated with the Bear Rock formation overlie Mt. Ronning limestone on the east side of Brokenoff Mountain and rest on gypsum beds at the west end of Paige Mountain. At the east end of Paige Mountain and on the east slopes of Thomas Mountain, no recognizable Bear Rock beds are exposed, and the Beavertail - Ramparts beds appear to rest directly on the gypsum. It is possible, however, that Bear Rock is present, but weak and thin.

The Bear Rock formation attains a maximum thickness of some 1200 feet on the east side of Brokenoff Mountain. The section is shown graphically on Plate III. The basal member of this section corresponds to the typical Bear Rock breccia of such other localities as Schooner Creek. It rests on the Mt. Ronning unconformably. (Fig. 1)

The rock is a massive, highly porous, cavernous "limestone" of jumbled, brecciated appearance. Travertine-like material is present, and the appearance suggests secondary solution and redeposition. Locally this member weathers into pinnacle forms. This basal member was found only at the Brokenoff Mountain locality.

Three hundred feet above the basal member, and separated by a covered interval, is a 53-foot zone of medium to thick bedded grey limestone. Some beds show a banded appearance, but without parting.

Four hundred and seventy feet above the medial limestone zone, and separated from it by a second covered zone, is a massive upper limestone member. This is the only part of the section found elsewhere in the area. The rock is hard and brittle, and presents a shattered appearance where deformed. Bedding is poorly-defined, and a more or less obscure brecciated structure is found in places. Banding occurs at some horizons. Small stylolites were observed in a few places. The rock weathers into a mass of angular blocks. The weathered rock is rusty brown on steep slopes, but grey in gentler slopes where weathering has proceeded farther. The rusty color is distinctive where present, not being found in the overlying Beavertail - Ramparts.

On aerial photos only the basal breccia of the Bear Rock shows any distinctiveness of appearance, and it by reason of its jagged weathering forms.

Owing to the seemingly abnormal thickness of the section described above, the possibilities of duplication of beds by faulting was considered carefully, but no indications of such could be found. In fact the effects of thrust faulting would be to reduce the apparent thickness, and it is thrust faulting which is believed to be associated with the Brokenoff Mountain structure. (Plate V, Section A-A') Normal faulting could increase the apparent thickness of the formation appreciably only if of low-angle dip, which is considered improbable in this area. Lithology of the beds involved is not sufficiently distinctive to provide evidence either for or against duplication. The improbability of duplication, however, is inferred from structural relations.

The reasons for the great variation in thickness of the Bear Rock cannot be wholly ascertained from any one limited area. It is postulated, however, that the formation was deposited on a surface of

considerable relief, possibly concurrently with deformation. The apparent absence of the formation in some places could then be explained by non-deposition. The fact that maximum thickness is found where gypsum is absent below, and that minimum thickness occurs where a considerable thickness of underlying gypsum is present, suggest the possibilities of deposition in valleys or lowlands eroded through the gypsum. The relations of the Bear Rock to underlying formations, however, may well be governed in part by angular unconformity also.

Some workers have considered the gypsum beds to be a part of the Bear Rock. I am not familiar with the reasons for reaching this conclusion, and cannot refute it from specific evidence from the area which I mapped. Until convincing arguments for said interpretation are forthcoming, however, I believe that the relations which I observed are more satisfactorily explained by an erosional (and probably angular) unconformity between two separate groups of beds.

No fossils were found in any part of the Bear Rock formation. It is provisionally assigned to the Devonian only by reason of its unconformable relations with known Silurian. Correlations with Bear Rock beds of other localities are based on lithologic similarity and stratigraphic position.

A petroliferous odor was noted at some place on nearly every exposure of the formation studied. The cavernous basal member, where present, would make an effective reservoir rock if porosity persists with depth.

Beavertail - Ramparts Formations

These two formations were mapped as one unit, and so far as the area studied is concerned, any division between them is of purely academic interest. The most completely exposed section found in the area

was on the east side of Brokenoff Mountain, where the dip ranges from about 70° to nearly vertical (Fig.2). This section is shown graphically on Plate IV. Most prominent are three limestone members, one at the base, one at the top, and one near the top. These members are medium-bedded to massive, and in many places form well defined topographic ridges. As a group, they form excellent horizon markers. Between the resistant limestone members are thinner-bedded limestones and shaly limestones. A more or less rubbly weathered surface is characteristic of all except the basal limestone. In contrast to the underlying Bear Rock, the Beaver-tail - Ramparts formation is well bedded.

The following fossils were collected at the localities indicated (See map, Plate I):

Locality No. 2

Cladopora
Productella
Schuchertella
Alveolites
Acervularia
Cystiphyllum
Favosites

Locality No. 3. (Near top of formation)

Cystiphyllum
Productella
Martinia
Cladopora
Favosites
Pleurotomaria
Atrypa spinosa

Locality No. 4

Cladopora
Atrypa spinosa
Cystiphyllum

At nearly every exposure of the Beavertail Ramparts a petroliferous odor could be detected at some place. From surface indications, however, a high porosity would not be expected, and it is doubted whether this formation would make a very promising reservoir rock in this area unless much fractured.

Lower Fort Creek Shale

This formation is a soft, poorly-exposed, slate-grey shale. Rust colored chips are common on the weathered surface. All exposures studied were masked by weathered float, and in no place could bedding be observed or dip and strike measured. No bituminous material was found in this formation, but the possibility of its presence locally is not excluded. Near the base a calcareous zone is present, at least locally. The thickness of the formation is estimated to be roughly 340 feet, but may range considerably from this figure. No fossils were found. The largest exposures are along Greenhorn Creek.

This formation would be of no importance for petroleum production except as a cap rock.

Kee Scarp Limestone

A persistent limestone member forms a low but prominent bluff around the north side of the Upper Hanna River Basin, and is exposed also along Greenhorn Creek, Rusty Creek, and Chasm Creek, and in the area between the latter and Brokenoff Mountain. Lithology varies somewhat from one exposure to another, being massive in some places and well bedded in others. Most distinctive and widely distributed, however, is a clastic highly coralline limestone, which, in some places, may be termed a Cladopora conglomerate.

At a majority of the localities visited, typical bituminous

Upper Fort Creek shale was found either immediately on top of the limestone, or a very short distance above it on the upward side stratigraphically. The base was everywhere covered, but in may places exposures of Lower Fort Creek shale were found fairly close on the downward side stratigraphically. The recognition and mapping of the formation was based partly on its relation to the associated shales, partly on its coralline character, and partly on lithology.

The following fossils were found in the formation at the localities indicated:

Locality No. 5

Cystiphyllum
Atrypa spinosa
Cladopora

Locality No. 6

Atrypa reticularis (?)
Martinia (ambocoelus)
Stringocephalus burtini

Locality No. 7

Heliophyllum
Cladopora roemeri
Atrypa spinosa
Cystiphyllum
Alveolites
Atrypa devoniana
Zaphrentis

The significance of the above fossils is not entirely clear. The presence of Stringocephalus burtini at Locality No. 6 apparently suggests affiliation with the Beavertail-Ramparts, and it is possible that it is a part of that formation which outcrops at the locality. Exposures in surrounding territory are not adequate to eliminate this possibility, but the lithology is unlike that of typical Beavertail-Ramparts, and does resemble that of one part of the Kee Scarp. Until the range of the fossils in question is more definitely known, a post-

Beavertail-Ramparts age is accepted by the writer.

Correlation of the limestone described above with the Kee Scarp of the type locality is provisional only, and is based on stratigraphic position and general lithologic resemblances. It is entirely possible that the two limestone bodies are discontinuous, either at the same horizon or at different horizons within the Fort Creek formation.

The Kee Scarp (?) limestone, like the other Devonian limestones, gives off a petroliferous odor at some zone on nearly every outcrop. The coralline conglomerate beds are highly porous, and should constitute ideal reservoir rocks.

Upper Fort Creek

Two distinct types of rocks are mapped as Upper Fort Creek; a lower hard, black bituminous shale, and an upper soft, blue-grey shale with beds and lenses of sandstone.

The lower, bituminous shale and siltstone is black, but weathers grey. Yellowish incrustations of sulphur are common. At many places, the rock apparently has been burned by forest fires, and has a clinkery appearance, with a light grey to bright red color. This zone is well exposed at many localities, and even where exposures are poor, the surface float is persistent and distinctive.

The upper, non-bituminous shale is soft and poorly exposed, and the contact between the two shales was nowhere found to be exposed. The shale and its included fine-grained sandstone beds may be seen at various places along the lower stretches of Rusty Creek and Chasm Creek, and along the Hanna River, downstream from the latter. The general appearance is somewhat similar to that of the Norman sandstone and shale.

The thickness of the bituminous zone is estimated to be about

270 feet, and of the non-bituminous zone about 200 feet or more. The top of the latter is covered by muskeg.

The highly bituminous character of the lower shale zone suggests that it might be a source rock for oil, and the readiness with which it fractures suggests further that it might also act as a reservoir rock to a limited degree. The upper shale would be of importance only as a cap rock.

CRETACEOUS

Numerous outcrops of Cretaceous beds occur along Middle Hanna River for a stretch of some three miles, in the area north of Carcajou Ridge, (Plate II). Soft, blue-grey shale with numerous ironstone lenses and concretions predominates, but sandstone and pebbly sandstone, in part cross-bedded, occur toward the southern end of the outcrop belt. Neither the top nor the bottom of the section is exposed, and the thickness is undetermined.

The following fossils were identified: Beudanticeras sp. at locality No. 8, and Gastroplites (?) at Locality No. 9.

QUATERNARY

Glacial sands, clays, and silts are poorly exposed at numerous points along the middle and lower Hanna River. At most places, the surface is sloughed over so that the true nature of the material cannot be seen. At many places glacial deposits give rise to mudflows which constrict the stream channel and start log jams. Except along the immediate river valley, glacial deposits seem to be thin, and glacial erosion apparently was more effective than glacial deposition.

Chapter IV

S T R U C T U R A L G E O L O G Y

The Upper Hanna River area represents a broad, shallow structural basin flanked on three sides by sharp, mountainous uplifts, and interrupted near the center by a minor "wrinkle", the Greenhorn Anticline. It is possible that other minor anticlines exist under cover. The Middle Hanna River area is a broad synclinal basin, bordered on the south by the Carcajou Ridge uplift, and on the north by the Gibson Peak Range. These structures are described individually below, and are shown on the detailed map, Plate I, the general regional map (not included with this report), and the cross-section sheet, Plate V.

Upper Hanna River Basin

This asymmetric structural basin is rimmed on the north and north-east by ledges and escarpments of Beavertail-Ramparts and Kee-Scarp limestone. At the west it is cut off by the Brokenoff Mountain structure, and on the southwest it bends up sharply into the Paige Mountain structure. On the south it merges into the Thomas and Richard Mountain structures (not described in this report). Dips range from 5 to 14 degrees around the edges, but decrease to a few degrees toward the center. The Greenhorn Anticline represents a local reversal of the dips, and is described separately below.

Greenhorn Anticline

The Greenhorn Anticline is best exposed along Greenhorn Creek, and in the muskeg area extending about two miles southeast of this creek. Kee Scarp limestone is exposed around the edges, the Lower Fort Creek shale in the core. Dips in the north flanks range from 20 to 25 degrees, and on the south flank from 14 to 70 degrees. The latter figure however, appears to be exceptional and purely local. The anticline plunges in

both directions, and apparently there is one local reversal in plunge toward the east, causing a constriction in the outcrop pattern. The eastern end of the anticline is lost in the muskeg, and the problematical mapping there is based only on rather vague markings observed on aerial photos.

On Rusty Creek, the anticline is represented only by a reversal of dip in the Upper Fort Creek shale. At some indeterminate point between the two creeks the Kee Scarp limestone plunges underground. West of Rusty Creek, the anticline passes into a fault, which continues to Brokenoff Mountain. Its relations to the thrust fault bordering that mountain, however, are uncertain.

Brokenoff Mountain Structure

Brokenoff Mountain represents a faulted, asymmetric anticline. (Plate V, Section A-A'). The core of the anticline is of Mt. Kenning limestone. The structure plunges and dies out to the northeast, but continues for a long distance to the west, though with a sharp bend in its trend. The anticline is sliced obliquely by the precipitous south side of the mountain, and the axis of the structure is cut off. It seems a perfect example of a traditional criterion for the Basin-Range type of structure - internal structure truncated by external form. Actually, however, these structural effects are best explained by thrust faulting. The evidence for this is found in (1) a locally overturned dip in the Kee Scarp limestone on the southeast side, (2) subparallelism of the fault and anticlinal axis, and (3) the relations to broader structural trends.

Paige Mountain Structure

Paige Mountain also is interpreted as an asymmetric anticline (Plate V, Section C'-C"), thrust faulted on the north side. At the

northwest end, the mountain abuts abruptly against a synclinal nose, and appears to be faulted against the latter, although the exact relations are not clear. The bounding fault cuts across anticline and syncline alike, and has sliced off the north limb of the anticline so as to leave virtually no reversed dip in the Mt. Ronning limestone. To the southeast, the Paige Mountain thrust passes into the Thomas Mountain thrust, and thus represents a scissors type of faulting with the upthrown side on the south in the Paige Mountain sector, and on the north in the Thomas Mountain section. The best exposure of the fault is at the west end of Thomas Mountain, where steeply dipping Beavertail-Ramparts is faulted against Mt. Ronning. Near the end of the Mt. Ronning outcrop belt at the southeast end of Paige Mountain, the fault is represented geologically by north-dipping gypsum against south-dipping Mt. Ronning, and topographically by a distinct linear depression.

Middle Hanna River Syncline

The southeastern end of this syncline abuts the Paige Mountain uplift, and there the in-dipping ledges of Beavertail-Ramparts and Bear Rock form strong continuous ridges. The north flank of the structure is cut off by the Paige Mountain fault, and the south flank bends sharply to form an anticline which, however is cut off immediately to the south by a fault of unknown displacement. The anticlinal axis aligns with the axis of Carcajou Ridge, and is believed to be continuous with that structure.

To the northwest, the syncline loses its surface expression, plunging under the muskeg flats of the Middle Hanna River Basin. The northerly dips in the Cretaceous outcrop belt, however, indicate that the axis cannot lie south of Hanna River, and the pattern of low, rounded topographic swells north of the point where the river makes

its abrupt ends to the south suggests the presence of the proposed synclinal axis.

Minor Structure in Cretaceous Gutierrez Area

One local reversal in the apparent dip of shale (believed to be fairly close to true dip) occurs in the area mapped on Plate II. It is doubtful whether this is more than a very minor "wrinkle".

Chapter V

OIL POSSIBILITIES

The Devonian limestones in the Upper Hanna River Basin are nearly everywhere moderately to strongly petroliferous, and the lower zone of the Upper Fort Creek shale is strongly bituminous. These facts indicate that source rocks must be present and that oil has been generated.

Reservoir rocks might be provided either by the clastic coralline beds of the Kee Scarp limestone, or by the Bear Rock formation. The former, however, are comparatively thin, and the latter are yet to be tested for production.

The prospects for suitable structural traps, however, are less favorable. The Greenhorn Anticline is the most obvious possibility. If production on Beavertail-Ramparts or in still older rocks could be expected. However, it is estimated that the depth to the Beavertail on the crest of the structure is only a few hundred feet, and it is possible that the Beavertail-Ramparts is underlain directly by gypsum rather than by Bear Rock. It is probable that the structure is too shallow for the retention of any oil which may have accumulated.

It is possible that other structures similar to the Greenhorn Anticline may lie under the muskeg cover south of Hanna River. Such structures, if they exist, could be detected only by geophysical methods.

Probably a more promising area for structural traps is the Middle Hanna River Basin, where possible producing horizons are deeply enough buried to prevent escape of any trapped oil. Except for the one minor reversal of dip along the Cretaceous outcrop belt, which is of doubtful significance, any such structures are wholly lacking in surface expression and could be located only by geophysical testing. The area along

the northwestward projection of the Paige Mountain fault is one in which irregular warping might reasonably be expected, and structural traps might occur.

No specific information on possible stratigraphic traps is yet available, but it is possible that such traps might be provided by the wedging of the Bear Rock breccia against the Silurian gypsum, if my interpretation of the relations between these formations is correct.

Chapter VI

CONCLUSIONS AND RECOMMENDATIONS

Petroliferous beds and potential reservoir rocks occur in the Upper Hanna River Basin, but the one possible structural trap is believed to be too shallow to have retained any oil. In the Middle Hanna River Basin, the same rocks occur under much thicker cover, but any favorable structures which might exist are concealed by muskeg.

When and if circumstances warrant further consideration of areas at this distance from Norman Wells and from the Mackenzie River, it is recommended that geophysical exploration be carried on in the Middle Hanna River Basin, starting in the area between Brokenoff Mountain and the eastern end of Carcajou Ridge, and then proceeding to the north and west.

PHOTOGRAPHIC ILLUSTRATIONS

Fig. 1. Contact of Mt. Ronning limestone and Bear Rock formation on east side of Brokenoff Mt. (See text of report.)

Fig. 2. Steeply inclined beds of Bear Rock and Beaver-tail-Ramparts formations on east side of Brokenoff Mt. (See text of report.)

Fig. 3. Typical sink hole in tilted and contorted beds of Silurian gypsum at east end of Paige Mt.

Fig. 4. View eastward from east end of Paige Mtn., across Twin Lakes, showing beds dipping inward around the rim of the Upper Hanna River basin. The Discovery Range, Morrow Mts., and Cleaver Mt. stand against the skyline. The dashed line is the fault between Mt. Ronning limestone (dipping to the right), and gypsum (dipping to the left.)

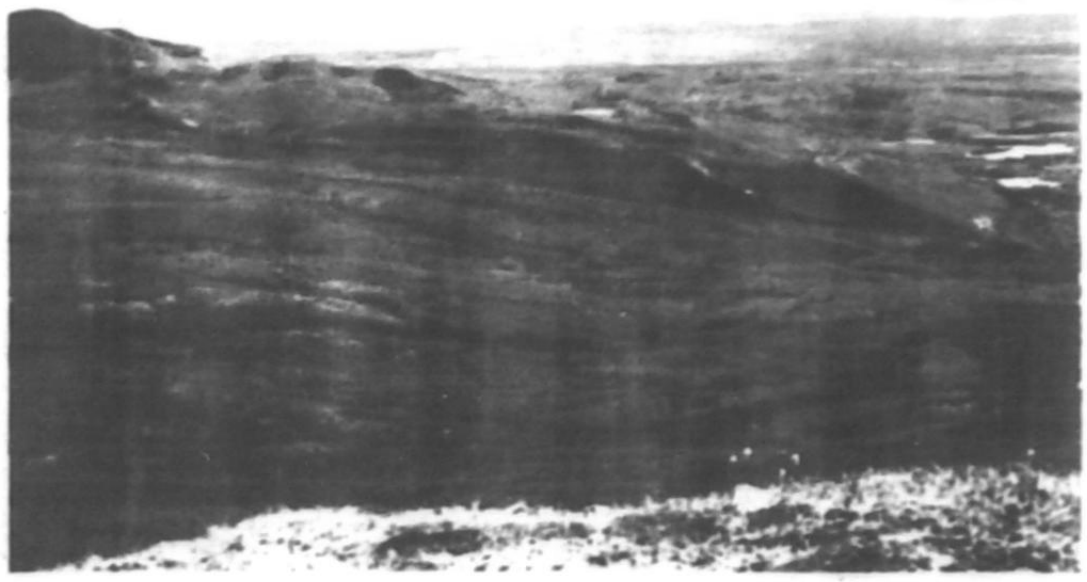


Fig.5 View across west end of Paige Mtn., from crest of Brokenoff Mtn. The Mackenzie River is in the background.

Fig.6 View west along south scarp of Brokenoff Mtn., showing precipitous nature of the inferred fault-line scarp, and of the massive rock streams at its foot.

APPENDIX

January 11, 1944.

MEMORANDUM:

TO: Dr. T. A. Link.

RE: Fossil Identification.

Attached is a tentative identification of fossils collected by Dr. H. T. U. Smith on Assignment No. 25 - Hanna (East Mtn.) River and adjoining areas.

KH/cm

C. R. Stelck

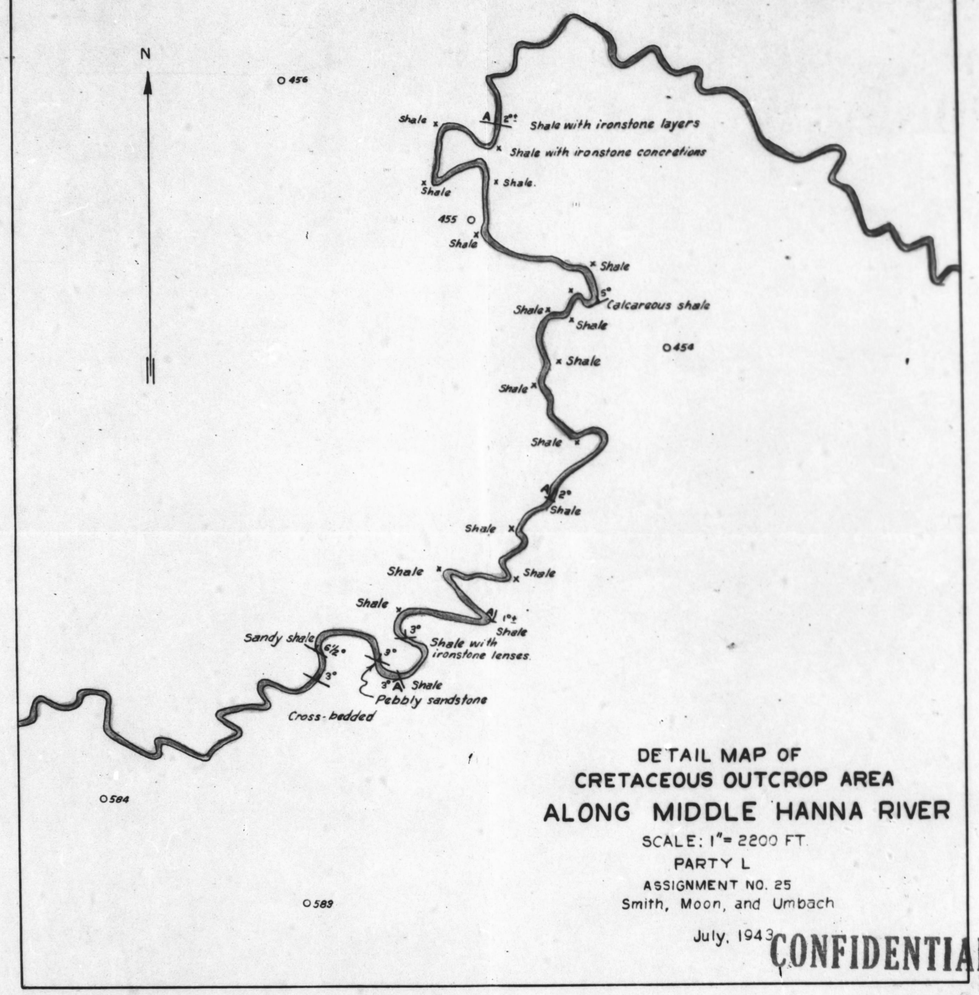
FOSSIL IDENTIFICATION - HANNA RIVER

Dr. H.T.U. Smith

Suite No.	Location	Fossil	Accession No.	Age
—	From Crest Brokenoff Mtn.	Favosites	41101	Silurian
"	"	Zaphrentis	41102	"
584-F	Hanna River	Gastroplites ?	41103	Cretaceous
—	East end of section below H Brokenoff Mountain	Cystiphyllum	41104	Ramparts
"	"	Favosites	41105	"
"	"	Acervularia	41106	"
"	"	Pachyphyllum	41107	"
264-I	Hanna Riv r	Sandstone	41108	----
—	East end of Section Bed H Brokenoff Mountain	Alveolites	41109	Ramparts
—	Hanna River	Beudanticeras	41110	Cretaceous
Photo 261	Hanna River	Rice pudding	41111	---
"	Hanna River	Stringocephalus	41112	?
"	Hanna River	Gypidula	41113	?
"	Hanna River	Atrypa	41114	?
Photo 442	Location "A" Hanna River	Atrypa spinosa	41115	----
"	"	Cladopora	41116	?
"	"	Cystiphyllum	41117	?
Photo 261	Hanna River	Atrypa spinosa	41118	----
"	"	Cladopora	41119	?
"	"	Cyathophyllum	41120	?
—	Just east Camp 7 Hanna River	Cyathophyllum	41121	Ramparts
"	"	Crinoid stem	41122	"
"	"	Cladopora	41123	"
"	"	Atrypa spinosa	41124	"
"	"	Atrypa	41125	"
"	"	Martinia	41126	"
"	"	Productella	41127	"
"	"	Favosites	41128	"
—	East section between Hand K Brokenoff Mountain	Cladopora	41129	---
"	"	Schuchertella	41130	?
"	"	Productella	41131	?

38

PLATE II



DETAIL MAP OF
CRETACEOUS OUTCROP AREA
ALONG MIDDLE HANNA RIVER

SCALE: 1" = 2200 FT.

PARTY L

ASSIGNMENT NO. 25

Smith, Moon, and Umbach

July, 1943

CONFIDENTIAL

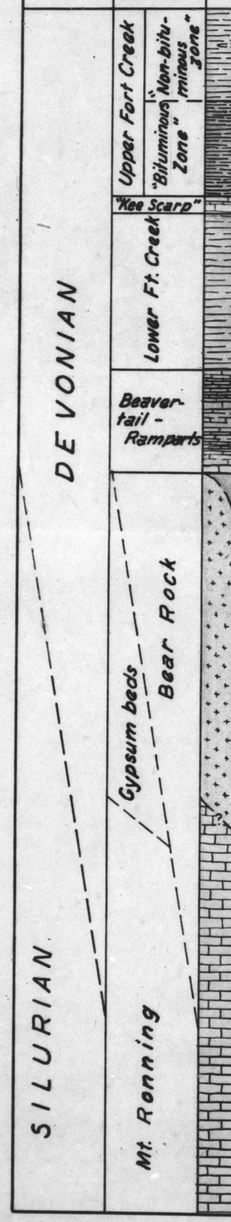
F-2.167

38

PLATE III

GENERALIZED COLUMNAR SECTION OF UPPER HANNA RIVER
ASSIGNMENT 25

PARTY L
Smith, Moon, Umbach
July, 1943
SCALE: 1" = 200 FT.



Age	Formation	Thickness	Description
DEVONIAN	Upper Fort Creek "Non-bituminous zone"	200'±	Soft, blue-grey shale with beds and lenses of fine-grained, grey sandstone. Base and top covered, exposures poor throughout.
	"Bituminous Zone"	270'±	Hard, black, bituminous shale and siltstone, weathering grey.
	"Kee Scarp"	40'-75'	Medium-bedded to massive grey limestone, coralline limestone, and coralline conglomerate. Weathers grey to brown. Stromatoporoids Bucklini
	Lower Ft. Creek	340'±	Soft, poorly exposed, slate-grey shale, with rust-colored chips on weathered surface.
	Beaver-tail - Ramparts	220'	Massive limestone members with intervening thin to medium limestone beds and shaly limestone. Rubbly weathering characteristic. Contains corals, gastropods, and brachiopods.
SILURIAN	Bear Rock Gypsum beds Mt. Ronning	0'? - 240'±	Hard, massive, non-fossiliferous limestone, obscurely bedded except for some banded zones. Brecciated structure in places. Weathers medium grey to rusty brown.
		0'-470'	Covered interval.
		0'-53'	Local, medium to thick-bedded limestone member.
		0'-300'	Covered interval.
		0'-150'	Massive, brecciated, porous to cavernous limestone of jumbled appearance. No distinct bedding. Weathers into pinnacle forms locally.
		1000'+	Massive, crystalline, cherty limestone and-or dolomite beds. Non-fossiliferous except for one horizon Overlain by possibly as much as 800 ft. of gypsum.

CONFIDENTIAL

F 2.168

B

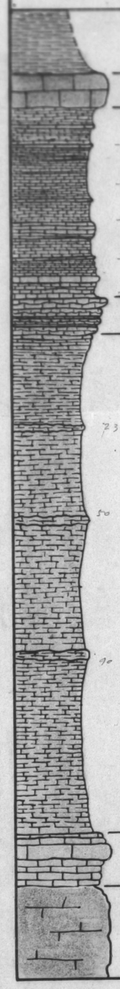
PLATE IV

DETAILED COLUMNAR SECTION OF BEAVERTAIL - RAMPARTS FORMATION ON EAST SIDE OF BROKENOFF MOUNTAIN

ASSIGNMENT 25

PARTY L

SCALE: 1"= 25 FT.

LITHOLOGY	THICKNESS	DESCRIPTION	FOSSILS
		Soft, poorly exposed Lower Fort Creek shale.	
	9'	Hard, massive limestone.	890
	51'	Soft, shaly limestone with beds of slightly harder, thin to medium bedded limestone.	60 985
	11'	Hard, medium-bedded to massive limestone; weathers rubbly.	Alveolites 71 956
	134'	Soft, poorly exposed, shaly limestone and-or limy shale, with zones of slightly harder rubbly limestone.	Acervularia, Cystiphyllum, Favosites. Cladopora, Productella, Schuchertella. 205 1090
	15'	Medium-bedded to massive, hard gray limestone.	220 1105
		Massive Bear Rock limestone.	

CONFIDENTIAL

F 2.169

PLATE V

GEOLOGIC CROSS SECTIONS
UPPER HANNA RIVER AREA

ASSIGNMENT 25

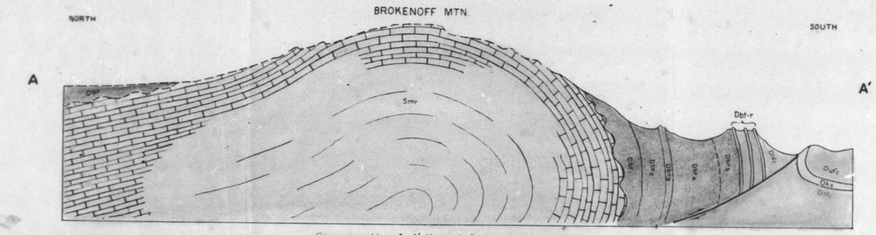
PARTY L

Smith, Moon, Umbach

July, 1943

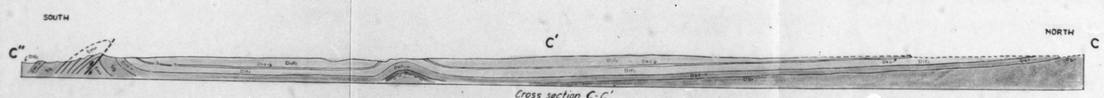
LEGEND

Non-bituminous zone, sandy	$Dufc_2$
Bituminous zone	$Dufc_1$
Kee Scarp (reef limestone)	Dks
Lower Fort Creek shale	Dlfc
Beavertail - Ramparts	Dbt - r
Bear Rock	Sbr
Gypsum beds	Sg
Mt. Ronning (?)	Smr
Dip and strike, Field observation	



Cross section A-A' through Brokenoff Mtn.
Scale (both vertical and horizontal): 1" = 500 ft.

Cross section B-B'
Scale (both vertical and horizontal): 1" = 2300 ft.



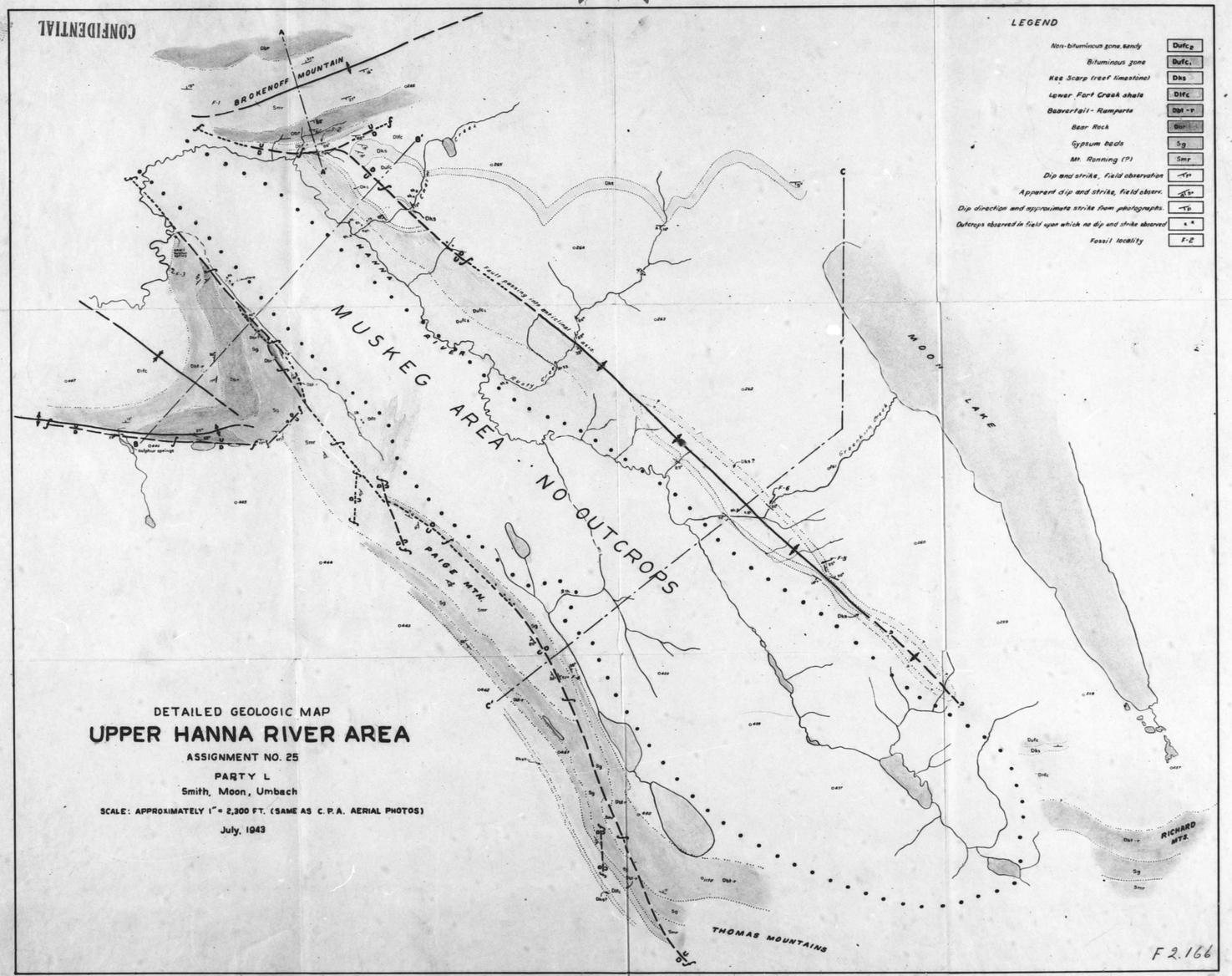
Cross section C-C'
Scale (both vertical and horizontal): 1" = 2300 ft.

CONFIDENTIAL

F 2.170

35

CONFIDENTIAL



DETAILED GEOLOGIC MAP

UPPER HANNA RIVER AREA

ASSIGNMENT NO. 25

PARTY L

Smith, Moon, Umbach

SCALE: APPROXIMATELY 1" = 2,300 FT. (SAME AS C.P.A. AERIAL PHOTOS)

July, 1943

F 2.166

(251) F 2.166