9237-A61-2E

Summary Report of Outcrop Sampling in the Carcajou Canyon and Blackwater Lake Areas, N.W.T.

Operation Identifier: 9237-A61-2E

Survey Type: Sampling for Geochemical Analysis and Evaluation of Reservoir Potential

Survey Localities: Dodo Canyon (Lat. 64° 56' N, Long. 127° 16' W), Carcajou Canyon Area, N.W.T.; Cap Mountain (Lat. 63° 25' N, Long. 123° 12' W), George Ridge (Lat. 64° 04' N, Long. 123° 28' W), Clark Mountain (Lat. 64° 25' N, Long. 124° 14'W), Blackwater Lake Area, N.W.T.

Operational Dates of Field Work: June 25-29, 2000

Operator Names: Alberta Energy Company Ltd, Renaissance Energy Ltd.

Prime Contractor (Laboratory Studies): Core Laboratories Canada Ltd.

Author: W. Steven Donaldson, B.Sc. Hon., Ph. D.; Consultant for Alberta Energy Company Ltd.

Report Date: September 8, 2000

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Introduction

The Cambrian succession in the subsurface of the Central Northwest Territories has recently attracted renewed attention in the search for new hydrocarbon resources. These strata comprise, from oldest to youngest (Figure 1), a clastic reservoir (Mt. Clark Formation sandstone), which has produced gas within the Colville Hills region in the northern part of the area, an overlying source rock (Mt. Cap Formation shales), whose lowermost strata are age equivalent to the uppermost Mt. Clark sands, an evaporitic unit (Saline River Formation) and a dolostone (Franklin Mountain Formation).

The same rocks also crop out to the southeast of Tulita, adjacent to interests of AEC Oil and Gas in the Blackwater Lake region (E.L 387 and E.L. 392). Here, the Mt. Clark and Mt. Cap formations were sampled in outcrop at 1) Cap Mountain, 2) an unnamed ridge (informally designated George Ridge) and 3) Clark Mountain (Figure 2). A total of 54 samples were collected.

Statistical Summary

Field work commenced on Sunday, June 25th, 2000 and terminated Thursday, June 29th, 2000. Technical personnel involved in field work comprised Dr. Steve Donaldson (Consultant, Alberta Energy Company Ltd.) and Dr. David James (Senior Geologist, Renaissance Energy Ltd.). Non-technical personnel consisted of Fred Andrew (native representative from Tulita) and Ralph Ronza (pilot for Canadian Helicopters Ltd.). All participants in field work are Canadian citizens.

The remote location of all four outcrop sites required helicopter access from Norman Wells. It was determined to be most cost-effective to remain based in Norman Wells and make daily helicopter flights to the outcrop, rather than camp in the field.

No time was lost as a result of either inclement weather or terrain conditions. Weather conditions were sunny to partly cloudy and warm throughout the four day period of field operations. Weather conditions deteriorated as a result of thunderstorm development at the end of final day of field work, during the return helicopter flight to Norman Wells, but this did not affect data collection.

Description of Field Procedures

Grab samples of Mt. Cap Formation outcrop were collected from Dodo Canyon in the Carcajou Canyon region. In the Blackwater Lake region, the Mt. Clark and Mt. Cap formations were sampled, concomitant with Jacob's staff measurement of each of the three outcrop localities to provide a stratigraphic context, as well as a comparison with earlier measurements made by the Geological Survey of Canada (Calgary). These samples were collected for subsequent petrographic and geochemical analysis.

Measured Section Descriptions and Sampling Locations

Stratigraphic sections were not constructed, as mentioned above; however, location information for samples collected from Cap Mountain, George Ridge and Clark Mountain during Alberta Energy Company/ Renaissance Energy Ltd. fieldwork is listed in Table 1. This table also provides stratigraphic location information for all samples collected, including those selected for subsequent petrographic and geochemical analysis.

Appendix 1 contains unmounted photographs taken during a reconnaissance flyby of the eastern side of George Ridge by Canadian Helicopters Ltd. A panoramic mosaic of George Ridge is also included, produced by digitally scanning and joining a number of these photographs.

A compact disk containing 72 JPEG images of the Dodo Canyon, Cap Mountain and Clark Mountain outcrop localities is included in Appendix 1. High-quality hard copies of 20 representative images from this CD of the four outcrop localities, along with brief accompanying descriptions are also included in this Appendix.

Sample Descriptions

12 samples of Mt. Clark Formation were submitted for thin sectioning and petrographic porosity evaluation; brief descriptions of their textural features are outlined below.

Cap Mountain

Cap 1 (0 ft.)

Very coarse-grained, well-sorted quartz sandstone. Quartz grains subangular, resulting from overgrowth development. Concavo-convex grain contacts observed, grading to sutured in some areas. Greenish, low birefringent clays also observed, partly occluding pore space and postdating quartz overgrowths. Porosity is estimated at 5-6%, and appears secondary; some grain edges appear slightly corroded.

Cap 2 (10 ft.)

Coarse- to very coarse-grained, well-sorted quartz sandstone. Quartz grains presently subangular, as a result of overgrowth development. Greenish, low birefringent clay lines detrital grain edges and partly occludes pore space. Rare heavy minerals also present. Porosity is estimated at 3-4%.

Cap-3 (30 ft.)

Coarse-grained, well-sorted quartz-rich sandstone. Quartz grains predominantly monocrystalline, with concavo-convex contacts and are subangular as a result of secondary quartz overgrowths. Oxidized ?carbonate cement is present, comprising masses of subhedral granular crystals. Greenish clay is also observed, partly occluding pore space and postdating oxidized ?carbonate cement. Pore space is estimated at 1-2%.

Cap 4 (50 ft.)

Medium- to coarse-grained quartz-rich sandstone. Quartz grains predominantly monocrystalline, with concavo-convex contacts and are subangular as a result of quartz overgrowths. Original detrital grain outlines are not visible. Rare monocrystalline and polycrystalline quartz granules up to 2 m in size are also observed. Trace of oxidized ?carbonates (similar to Cap 3-30 above) also visible. Greenish clay also partly occludes pore space. Pore space between detrital grains appears secondary, resulting from pulling apart of adjacent quartz grains with 'fitted' textures.

Cap 5 (75 ft.)

Coarse-grained, well sorted quartz-rich sandstone. Mono- and polycrystalline quartz grains present, with concavo-convex contacts. Grains now subangular, as a result of overgrowth development. Rare quartz granules up to 3 mm in size also observed. Texture of sample suggests decompression; formerly fitted grains are now separated by a gap. Greenish pore-lining and pore-filling clay observed; clay is also visible between adjacent quartz overgrowths. Rare aggregations of pyrite are also observed, postdating the pore-filling clay. The sample porosity is estimated at 2-3%.

Cap 6 (95 ft.)

Medium to coarse-grained, well-sorted quartz-rich sandstone. Quartz grains presently subrounded; original detrital grain outlines not visible. Greenish clay lines pores between quartz grains and partly fills pore spaces, postdating overgrowths. Clay dissolution may enhance porosity. Trace of heavy minerals present. Porosity of this sample is estimated at 2-3%.

CU-7 (270 ft.)

Medium-grained, well-sorted quartz-rich sandstone. Quartz monocrystalline, originally well-rounded, now subangular; some original grain boundaries still recognizable. Concavo-convex contacts between detrital grains. Greenish clay observed between quartz grains. Trace of heavy minerals also observed. Sample porosity is estimated at 1%.

George Ridge

G-1-50

Poorly sorted quartz-rich sandstone displaying concavo-convex contacts between grains. Grain size distribution bimodal, clustering around coarse sand and very fine sand sizes. Quartz grains are monocrystalline; some display undulose extinction. Grains are subangular as a result of overgrowth development; original detrital grain boundaries are no longer visible. Clays present between grains; trace of heavy minerals observed. Porosity of this sample is 2-3%.

G-2-120

Poorly sorted sandstone dominated by monocrystalline quartz; rare polycrystalline grains observed. Grains bimodally distributed between coarse sand and silt sizes. Grains exhibit concavo-convex contacts and are subangular as a result of overgrowth development; original grain boundaries are no longer evident. Rare, greenish pore-filling clay is observed between detrital grains. This sample's porosity is estimated to be 1-2%.

Clark Mountain

MC-2-25

Moderately sorted quartz-rich sandstone. Grains show a bimodal distribution between medium to coarse sand- and silt-size; grain size alternations appear to be the result of bedding. Original detrital grains very well-rounded, but are now subangular as a result of overgrowth development, which almost completely fill pore space. Trace of

heavy minerals observed, as well as small amounts of greenish authigenic clay. Sample porosity is approximately 1%.

MC-3-210

Well-sorted medium-grained sandstone dominated by monocrystalline quartz. Grains now subangular because of overgrowth development. Two types of heavy minerals are present, one of which (?tourmaline) shows development of secondary overgrowth. Authigenic clays observed between detrital grains; trace of carbonate cement also present. Sample porosity is 1-2%.

MC-4-100

Very fine-grained quartz-rich sandstone dominated by monocrystalline quartz. Grains subangular due to overgrowth development, with concavo-convex contacts. Trace of heavy minerals (?tourmaline) with overgrowths observed; authigenic clays present between detrital quartz grains. The porosity of this sample is 1-2%.

Petrographic Summary

Samples of the Mt. Clark Formation from Cap Mountain typically comprise medium to very coarse-grained quartz arenites, with a trace of detrital clay and pyrite. Mt. Clark Formation porosity is highest at this, the most southerly of the three outcrops, which unfortunately is situated the farthest from Alberta Energy Company interests. The lowermost 32 m of Mt. Clark Formation section consists of friable sandstone containing up to 5-6 % porosity; above this, sediments comprise quartzite with 1-3% porosity.

The porosity within the lowermost part of the section appears secondary. Clays may have acted as a barrier preventing complete quartz cementation and interpenetrating quartz grains may have separated during subsequent uplift and erosion following maximum burial. Bitumen is not observed in any samples.

In contrast, the rocks at George Ridge are bimodal quartz arenites (quartzites); grain sizes typically cluster around coarse sand and silt grain sizes. Pervasive quartz overgrowth development has occluded most primary pore space; present porosity is estimated at 1-3%. No bitumen is present in any of the examined samples.

At Clark Mountain, the Mt. Clark Formation comprises quartz arenite (quartzite) with interpenetrating quartz grains and pervasive quartz overgrowth development. The porosity of the samples examined ranges from 1-2%. These samples also lack bitumen.

Geochemical Analysis

Samples of Mt. Cap Formation limestones and shales from Clark Mountain (Blackwater Lake area) and Dodo Canyon (Carcajou Canyon area) outcrop were sent to Core Laboratories Canada Ltd. for organic carbon (TOC) and Rock-Eval pyrolysis analysis to evaluate their potential as source rock in these areas. Analysis results are listed in Table 2. Data for four samples from Dodo Creek range from 0.05 to 0.15 wt. % TOC; corresponding Tmax values range from 484 to 503 °C. Data for eight samples from Clark Mountain range from 0.03 to 0.63 wt. % TOC and 464 to 506 °C, respectively (Table 2). All Tmax values should be considered overestimates, as a result of the very low TOC content of these samples. The very low TOC values appear to negate the source

rock potential of the Mt. Cap Formation in both the Blackwater Lake and Dodo Canyon regions.

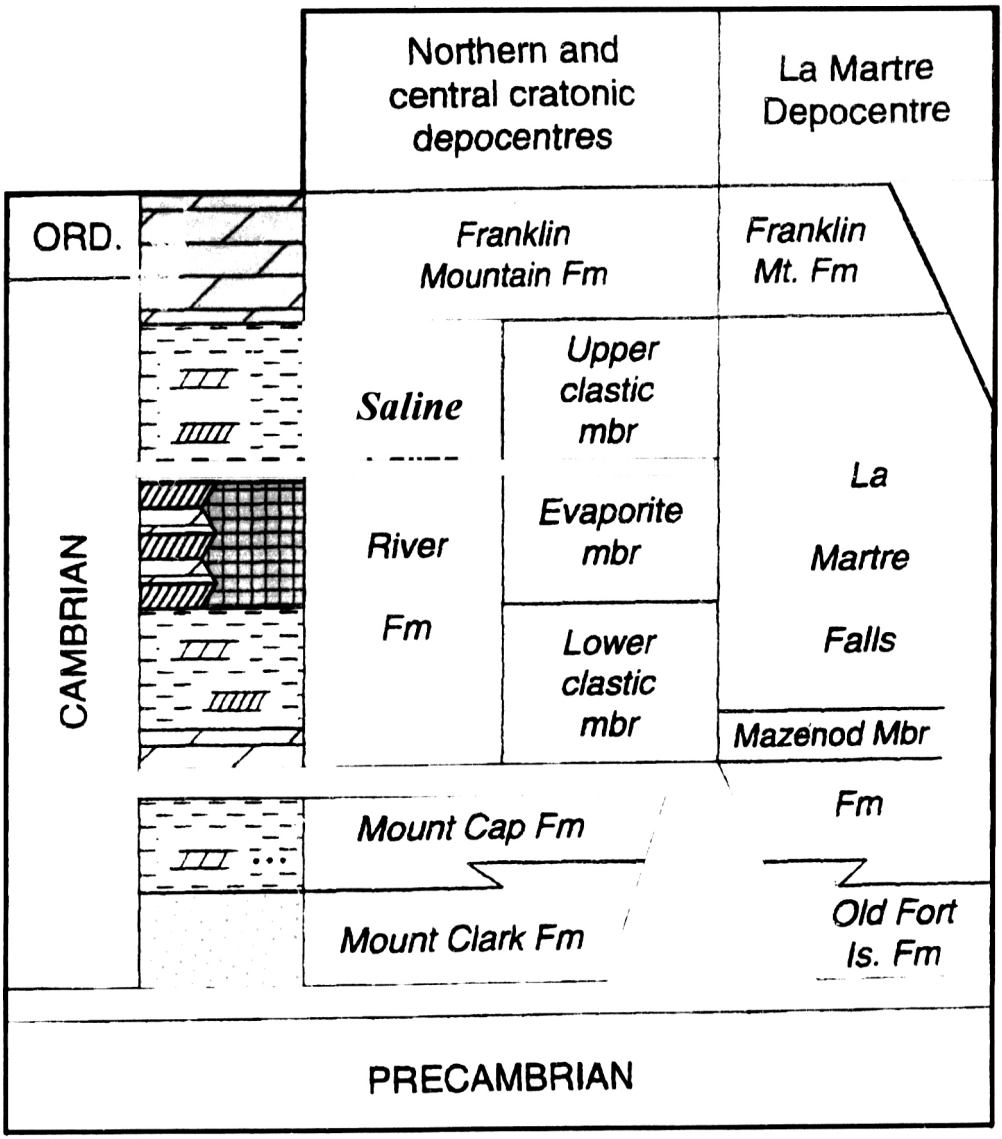
Summary

The Cambrian Mt. Clark Formation comprises a basal Cambrian sandstone unconformably resting upon the Proterozoic and is overlain by shales of the Mt. Cap Formation. Although the Mt. Clark Formation is a hydrocarbon reservoir to the north within the Colville Hills, it lacks hydrocarbons within the Blackwater Lake area. Deeper burial of this formation has resulted in the development of pervasive quartz overgrowths and the loss of original porosity. In addition, the overlying Mt. Cap shales do not contain significant amounts of organic carbon in this area (maximum of 0.63%).

The conclusions of this study are that sandstones of the Mt. Clark Formation are not a potential target in this southern area of the Central Territories, since their reservoir qualities are very poor. As well, the overlying Mt. Cap Formation shales lack sufficient organic matter to be a viable hydrocarbon source.

References

Dixon, J. (1997). Cambrian stratigraphy of the Northern Interior Plains, Northwest Territories. Geological Survey of Canada, Open File 3510, 27p.



(After Dixon, 1997) **Figure 1**

Table 2 ORGANIC CARBON AND ROCK-EVAL PYROLYSIS DATA

Dodo 1 WP 38, 2 Dodo Creek #37, & Mt. Clark #2

DGSI Project: 00/4772

SAMPLE IDENTIFICATION DGSI ID	Depth (Feet)	TOC Wt%	S1 mg/g	S2 mg/g	S3 mg/g	Tmax degC	S1/ TOC	HI	OI	S2/ S3	PI
1	Dodo 1 WP 38 1	0.08	0.01	0.06	0.30	495	13	75	375	0.20	0.14
2	Dodo 2 WP 38 2	0.10	0.02	0.05	0.26	502	20	50	260	0.19	0.29
3	Dodo 3 WP 38 3	0.05	0.01	0.05	0.28	484	20	100	560	0.18	0.17
4	2 Dodo Creek CPS #37	0.15	0.02	0.06	0.39	503	13	40	260	0.15	0.25
5	Mt Clark Section 2 5	0.07	0.01	0.03	0.09	497	14	43	129	0.33	0.25
6	Mt Clark Section 2 100	0.03	0.00	0.04	0.20	480	0	133	667	0.20	0.00
7	Mt Clark Section 2 210	0.08	0.00	0.02	0.23	484	0	25	288	0.09	0.00
8	Mt Clark Section 2 305	0.03	0.00	0.03	0.21	475	0	100	700	0.14	0.00
9	Mt Clark Section 2 330	0.04	0.00	0.07	0.24	464	0	175	600	0.29	0.00
10	Mt Clark Section 2 400	0.23	0.00	0.02	0.38	478	0	9	165	0.05	0.00
11	Mt Clark Section 2 495	0.63	0.01	0.01	0.46	506	2	2	73	0.02	0.50
12	Mt Clark Section 2 610	0.11	0.00	0.02	0.35	484	0	18	318	0.06	0.00

Table 1

Site	Latitude	Longitude	Sample	Height	Comments
Dodo Canyon WP 37= Dodo 3	64 56 197	127 16 073	1		**Measured Sunday, June 26th.** Mt. Cap Formation exposure approximately 1 5 km downstream of Echo Canyon Precambrian-Cambrian contact exposed; bioturbated glauconitic silty limestones overlie nodular red mudstones
WP 38			1		Taken above uppermost red bed in Mt. Cap Fm. limestones, fossils?
			2		
			3		Taken 15 ft. below sample 2
Cap Mountain >1554 5 m (5100 ft) at top of mountain Lower outcrop 32 m (105 ft) of measured section WP= Cap 1	63 24 597	123 12 466			**Measured Monday, June 26th.** Mt. Clark Formation measured from base of exposed Cambrian section
			Cap 1	0 m (0 ft.)	Granular gritty sand. Taken from base of exposed Mt. Clark section, Precambrian contact not exposed 1 sample for thin section, two piece 1 kg sample for AFTA
			Cap 2	3 1 m (10 ft.)	Same lithology as previous but harder
			Cap 3	9 2 m (30 ft.)	Very coarse-grained friable sand
			Cap 4	15 2 m (50 ft.)	Same lithology as previous
				18 3 m (60 ft.)	1m thick silty bed
			Cap 5	22 9 m (75 ft.)	Fine sand with occasional pebbles
			Cap 6	29 m (95 ft.)	
				32 m (105 ft.)	Top of first lower continuous outcrop, forms a grassy bench
Cap Mountain Second upper outcrops 146 3 m (480 ft) of measured section WP= Cap 4 Elevation 1455 5 m (4755ft)	63 24 484	123 12 394	Cap Upper 1	0 m (0 ft.)	Mt. Clark Formation measured from covered interval overlying lower friable sand
			CU 2	10 7 m (35 ft.)	
			CU 3	24 4 m (80 ft.)	Entire section comprised dm to m-scale sandstone beds full of *Skolithos* , not observed in underlying section
			CU 4	33 5 m (110 ft.)	
			CU 5	42 7 m (140 ft.)	
			CU 6	59 4 m (195 ft.)	
			CU 7	82 3 m (270 ft.)	
			CU 8	97 3 m (320 ft.)	*Skolithos* decreases in abundance at or before this level
			CU 9	134 1 m (440 ft.)	1 kg sample taken for AFTA analysis
George Mountain WP= G1 Elevation at top 1085 1 m (3560 ft) Measured 35 4 m (116 ft.) on lower section	64 03 465	123 27 796			**Measured Tuesday, June 27th.**
			G-1-0	0 m (0 ft.)	Indurated sandstone
			G-1-30	9 1 m (30 ft.)	Indurated sandstone
			G-1-50	15 2 m (50 ft.)	Indurated fine sandstone with *Skolithos*

Site	Latitude	Longitude	Sample	Height	Comments
George Mountain (cont'd)					
				16.8-32 m (55-105 ft.)	Interval covered, comprises loose blocks
			G-1-115	32-35.1 m (105-115 ft.)	Outcrop, 1 sample for thin section, 1 kg sample for AFTA
George Mountain			G-2-0	0 m (0 ft.)	
WP=G2	64 04 183	123 28 541			
Measured 56.4 m (185 ft.) of Mount Clark sandstone			G-2-20	6.1 m (20 ft.)	
			G-2-70	21.3 m (70 ft.)	
			G-2-120	36.6 m (120 ft.)	
				39.6 m (130 ft.)	*Skolithos* present
			G-2-185	56.4 m (185 ft.)	
Clark Mountain					Measured in stream gully on NW flank of Clark Mountain anticline
Section 1					Friable sand present in stream bed
(Waypoint Clark-1)	64 25 861	124 13 724			
Elev. 946.4 m (3105 ft.)			MC-1	0 m (0 ft.)	
32 m (105 ft.) of Mount Clark sandstone			MC-2	7.6 m (25 ft.)	
				13.1 m (43 ft.)	
			MC-3	19.8 m (65 ft.)	
			MC-4	32 m (105 ft.)	Quartzite cliff near top of contact, possible fault running through gully?
					Mt. Clark sand at lower level on S side. Resistant ridge on S side not traceable to N side
Clark Mountain					Top of Mt. Clark Fm.; stratigraphically higher, but measured further down same gully as section 1
Section 2	Location				
Continuation of above but now in the Mount Cap	As above		MC-2-0	0 m (0 ft.)	Sample from top of Mt. Clark Fm.
187.5 m (615 ft.) of Mount Cap shales and silts			MC-2-5	1.5 m (5 ft.)	Mt. Cap Fm.
			MC-2-100	30.5 m (100 ft.)	
			MC-2-210	64 m (210 ft.)	
			MC-2-305	93 m (305 ft.)	
			MC-2-330	100.6 m (330 ft.)	Platy shale
			MC-2-400	121.9 m (400 ft.)	Platy shale
			MC-2-495	150.9 m (495 ft.)	Calcareous black shale
				182.9 m (600 ft.)	Colour change to orange brown above sharp contact
			MC-2-610	185.9 m (610 ft.)	Hard platy orange shales
				187.5 m (615 ft.)	End of section, contact with overlying drift

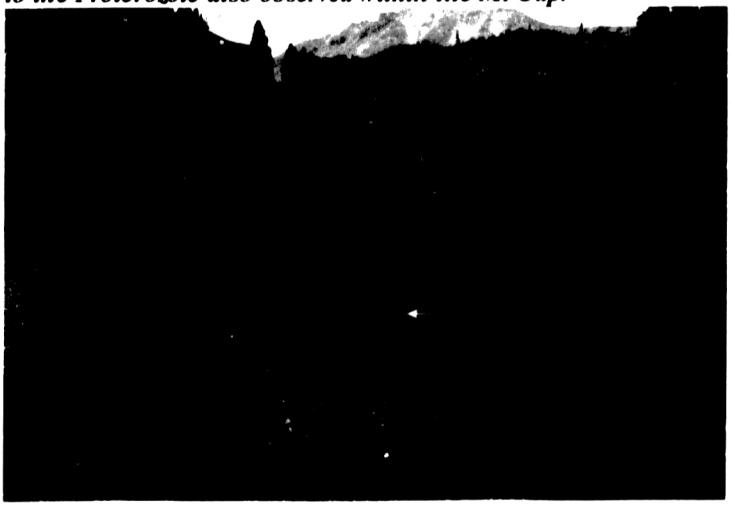
Site	Latitude	Longitude	Sample	Height	Comments
Clark Mountain					**Measured Wednesday, June 28.**
Section 3					Lower Mt. Clark measured in ravine to the N of the previous section
Top of Section (WP 40)	64 25 119	124 14 324			Section measured upwards from waterfall
Bottom of section = Clark 4	64 25 595	124 14 882		0 m (0 ft.)	*Skolithos* present
74.7 m (245 ft.) of Mount Clark sandstones measured			MC-3-20	6.1 m (20 ft.)	
(lower)			MC-3-40	12.2 m (40 ft.)	
30.5 m (100 ft.) of uppermost Clark at contact with Cap			MC-3-70	21.3 m (70 ft.)	
			MC-3-115	35.1 m (115 ft.)	
			MC-3-180	54.9 m (180 ft.)	Section continues upwards for approx. 65 ft. to top of cliff
			MC-3-210	64 m (210 ft.)	
			MC-3-245	74.7 m (245 ft.)	Top of cliff above waterfall
			MC-3--40	12.2 m (40 ft.) minus	Sample from 40 ft. below waterfall
Clark Mountain			MC-4-0	0 m (0 ft.)	
Section 4			MC-4-25	7.6 m (25 ft.)	
			MC-4-70	21.3 m (70 ft.)	
			MC-4-100	30.5 m (100 ft.)	
			MC-4-110	33.5 m (110 ft.)	Approximate base of Mt. Cap Fr., comprising silty shales

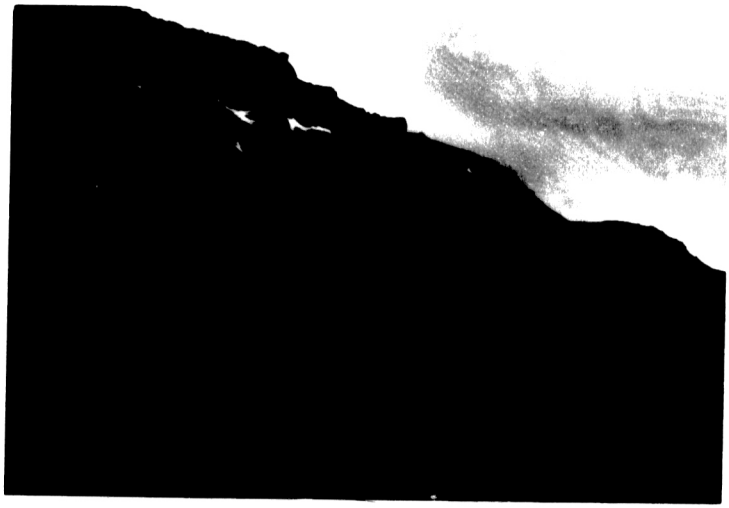
General view of Mt Cap Formation carbonates, Dodo Canyon, Carcajou Region.

Red nodular Proterozoic shale erosionally overlain by Mt Cap Formation carbonates, Dodo Canyon, Carcajou Region. (Person for scale).

Close-up view of Mt Cap Formation unconformably overlying red Proterozoic shale, Dodo Canyon, Carcajou Region. (Person for scale).

General view of Mt Cap Formation unconformably overlying red nodular Proterozoic shale, Dodo Canyon, Carcajou Region. Contact is placed at arrow; reddish coloration continues upward into basal Mt Cap beds. Occasional reddish nodular beds similar to the Proterozoic also observed within the Mt Cap.



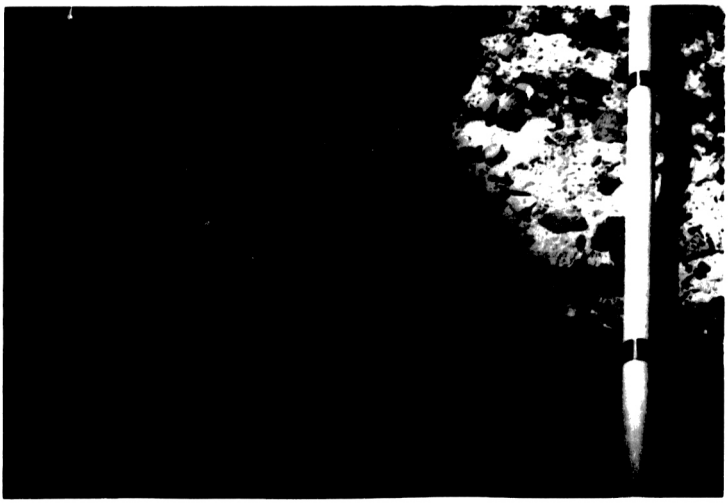


General view of Mt Clark Formation quartzite at comprising upper outcrop Cap Mountain.

General view of Mt Clark Formation lower sandstone at Cap Mountain. Contact with underlying red Proterozoic shales (approximately at position of arrow) is covered.

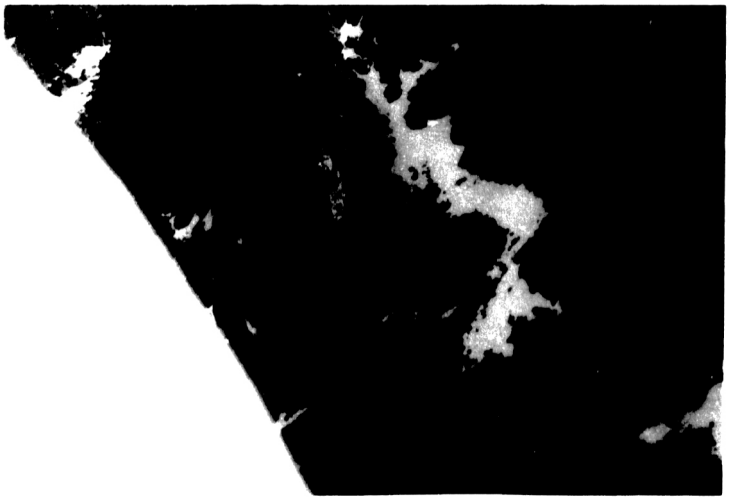
General view of Mt Clark Formation quartzite comprising upper outcrop at Cap Mountain

Friable sand observed at base of Mt Clark Formation lower outcrop at Cap Mountain.



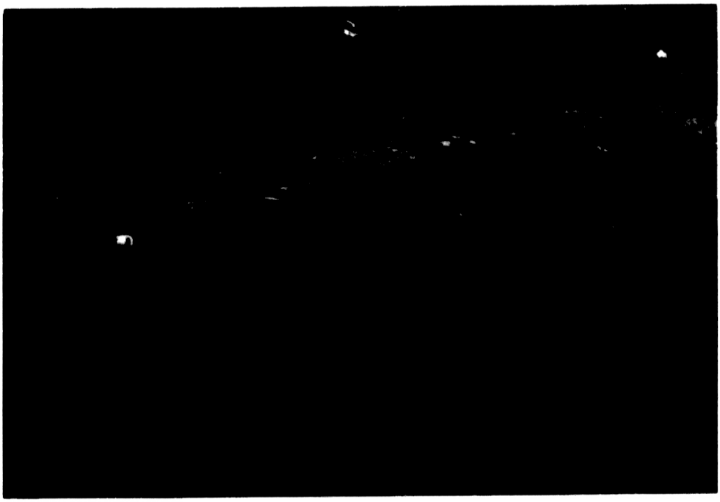
Mt Clark Formation quartzite upper outcrop at Cap Mountain. (Person for scale).

General view of Mt Clark Formation quartzite upper outcrop at Cap Mountain.



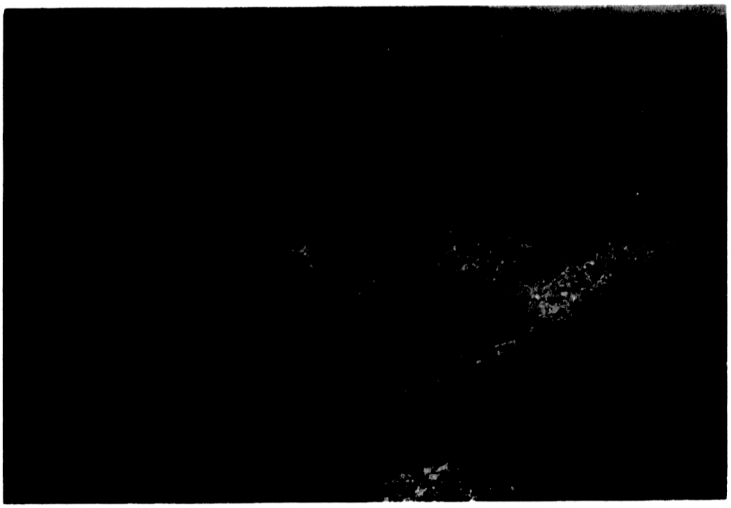
General view of Mt Clark Formation quartzite upper outcrop at Cap Mountain.

General view of Mt Clark Formation sandstone lower outcrop at Cap Mountain.



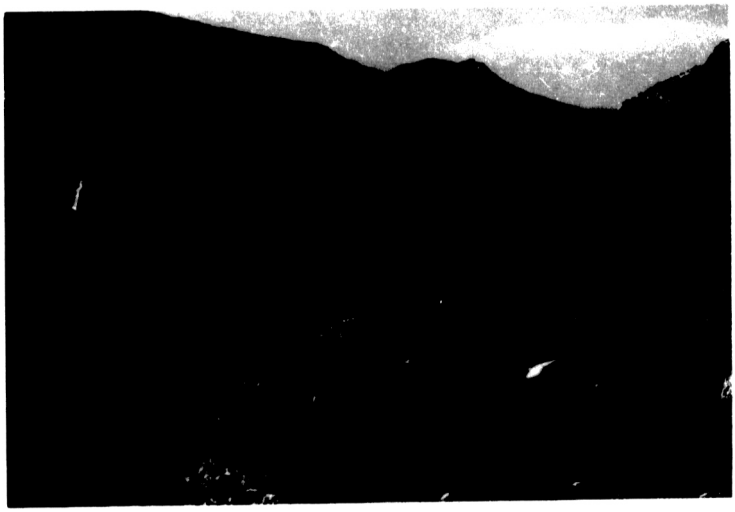
General view of Mt Clark Formation sandstone lower outcrop at Cap Mountain.

General view NNE along top of George Ridge. Arrow demonstrates orientation of dip slope.



General view of Mt Cap Formation in ravine at Clark Mountain Section 2

General view of Mt Cap Formation in ravine at Clark Mountain Section 2



General view of Mt Cap Formation in ravine at Clark Mountain Section 2.

General view of ravine at Clark Mountain, where Mt Clark Formation Section 3 was measured.

Close-up of Mt Clark Formation sandstone at Clark Mountain Section 3.

General view of Mt Clark Formation sandstone at Clark Mountain Section 3.