92 I/12, 13

009567

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

Property File
92I NW 098
Langley Lake

DOLOMITIZATION IN THE MARBLE RANGE LIMESTONES NEAR THE HAT CREEK PROJECT

PRELIMINARY EVALUATION OF POSSIBLE SITES FOR A SOURCE OF MAGNESIUM LIMESTONE

GENERATION PLANNING DEPARTMENT

SYSTEM ENGINEERING DIVISION

Report No. SE 8117

September 1981

Property File
92INW098

DOLOMITIZATION IN THE
MARBLE RANGE LIMESTONES
NEAR THE HAT CREEK PROJECT

PRELIMINARY EVALUATION OF
POSSIBLE SITES FOR A SOURCE OF
MAGNESIUM LIMESTONE

CONTENTS

CONTENTS - (Cont'd)

APPENDICES

ADDENDUM

LIMESTONE AND DOLOMITE SAMPLING NEAR HAT CREEK AND SAMPLES FROM DOMTAR INC., TEXADA ISLAND, B.C.

SECTION 1.0 - INTRODUCTION

This investigation of carbonates (limestone and dolomite) at and near Hat Creek was conducted as a result of a possible requirement for carbonate to scrub gases in a coal-fired pressurized fluidized bed demonstration plant at Hat Creek.

Geological mapping of the Marble Range limestones north of Hat Creek has not been extensive in that only one detailed study has been undertaken.[1] The study area is 60 km north of Hat Creek - rather remote from the site - but the geology of the study area is probably similar to that of the Marble Range closer to Hat Creek. Using the geology of the northern study area as a guide, possible sites for the occurrence of dolomite near Hat Creek have been identified.

SECTION 2.0 - GENERAL GEOLOGY OF THE MARBLE RANGE

2.1 GENERAL GEOLOGY

The Marble Canyon Formation (Fig. 2-1, 2-2), part of the Cache Creek Group, is a northwest trending belt approximately 10 km wide and 90 km long. It is Permian in age and consists mainly of ridge forming, variably bedded limestones, with some poorly exposed chert, pelite, and volcanic rocks. Dolostone beds are rather rare, but nevertheless exist in the western part of the northern study area. In addition, some limestone beds contain small amounts of dolomite.

The Marble Range has undergone considerable deformation which makes interpretation of the stratigraphy very difficult. Similarly the geological environment of deposition is difficult to interpret. A shelf margin may have existed parallel to the present northwest trending attitude of the formation. This shelf could have had an effect on early dolomitization of the limestone near the shelf perimeter, and the restricted shelf tidal flats (Appendix C).

The Marble Canyon Formation consists of six rock units (Appendix A) numbered from one to six. Map-unit 1, which underlies all other units, probably predates the other units (Fig. B-1).

Map-units 2 and 4 are mainly limestone with minor chert, marble, and dolostone in unit 2. Units 2 and 4 could be lithofacies equivalents; unit 2 may have been deposited on the shelf between the deep sea detrital sediment (unit 6) to the west and the thick bedded limestone (unit 4) to the east. The occurrence of dolostone in map-unit 2 may be associated with marginal shelf deposition of the unit, and evaporation of water, with the resulting concentration of brine on top of the shelf (Fig. B-1, C-1, C-2, C-3).

GEOLOGICAL MAP
SHOWING
POTENTIAL LIMESTONE AND DOLOMITE AREAS
NEAR HAT CREEK

Figure 2-1

If the dolostone is a depositional feature, then map-unit 2 is a probable source of dolostone nearer the Hat Creek Project, if the unit extends that far south.

Map-units 3 and 5 are also thought to be lithofacies equivalents. The two units are very similar, consisting mainly of lithic arenite and siltstone, carbonate rocks, chert, and pelite. Unit 3 also has volcanic rocks which are not found in unit 5. For map-units 2 and 4, and map-units 3 and 5 to be lithofacies equivalents, there must be a low angle thrust fault between units 3 and 4 (Appendix B). If this is the case, map units 4 and 5 constitute a thrust sheet that overlies and repeats map units 2 and 3.

Map-unit 6 comprises the western belt, and is Carboniferous (?), Permian (?) and Triassic in age. It consists of chert, pelite, limestone, and volcanic rocks. Unit 6 was probably deposited at the same time as units 2 and 3. Locally, dolomite comprises a few percent of the rock and occurs as rhombohedra that are very fine to finely crystalline in size. The rock is brecciated and traversed by stylolites. The preponderance of interstratified radioloarian chert and pelite in this unit suggest a deeper water environment. If so, the limestones must be submarine slide deposits, but this has not been established.[1] The description given by H. P. Trettin suggests that unit 6 forms the western edge of the map-unit 2 maginal shelf deposits. The existence of dolomite in the unit 6 sediments lends support to the theory that evaporative reflux (Appendix B, C) has occurred in a unit 2 shelf margin setting above and adjacent to map-unit 6.

2.2 METASOMATIC DOLOMITIZATION

In the northern study area, volcanic rocks which underlie the limestone units are thought to predate them. Further south, nearer the Hat Creek Project, basalt and diorite intrusions occur in the limestone strata. These intrusions postdate the limestones; the basaltic unit is Eocene and (?) Oligocene in age and part of the Skull Hill Formation. It consists of dacite, trachyte, basalt, andesite, rhyolite, and associated breccias. The granodiorite and quartz diorite intrusions (further south than the basalts, and nearer the Hat Creek Project) are Cretaceous or Jurassic in age. The intrusive-limestone contacts could be sites of local metasomatic dolomitization (Appendix C-4, Fig. 2-1). The extent of localized dolomitization on intrusive-limestone contacts is unknown, but some samples of limestone from the Houth Meadows Waste Dump Site have been analyzed.[5] Sample locations are not given in the report, but they were taken north of Houth Meadows and more than 1.5 km from any intrusive contact. Both basalt and granodiorite intrusions have occurred in the area, and either could have resulted in dolomitization of the surrounding limestone. The limestone samples that were analyzed showed a maximum of 4 percent $MgCO_3$ by weight, a low value perhaps for the Projects' needs, but indicative of possible metasomatic activity in the area. Other areas, possibly closer to an intrusive-limestone contact, may show higher percentages of $MgCO_3$ (Fig. 4-1).

SECTION 3.0 - SUMMARY OF KNOWN DOLOMITE OCCURRENCES AND ROCK DESCRIPTIONS OF THE GEOLOGICAL UNITS IN WHICH THEY OCCUR

3.1 INTRODUCTION

Several dolomite showings are described by H. P. Trettin in his report on the northern Marble Range. These dolomite showings and their significance are described in the following sections. Reference should be made to the map-unit geology descriptions (Appendix A), the General Geology section in this report (Section 2.1) and the topographic-geology map of the study area for geology and locations of rock sections (Fig. 2-1).

3.2 MOUNT SOUES

The following sections contain some of the more extensive and interesting dolomite showings of the northern study area. Mount Soues is approximately 46 km from the Hat Creek Project site, but relatively inaccessible as far as transportation of limestone to the highway is concerned (approximately 6 km over rough terrain). The dolomite in this area may have formed by the Evaporative Reflux process (Appendix C-1) the Mount Soues site being representative of a shelf margin environment. The following are descriptions of the Mount Soues area geology taken from Trettin, 1979.[1]

Section 1-2 (South slope of Mount Soues). Map-unit 2 is approximately 75 m thick at this section. Rock descriptions are from top of formation to the bottom of formation. The rock is mainly lime wackestone, with some classified as grainstone; fossils are abundant.

1. Well bedded (5 to 30 cm beds) of limestone with stringers and thin beds of chert about 1 to 8 cm thick.

2. The middle part is poorly bedded (30 to 60 cm beds) and lacks chert.

3. Relatively pure limestones; small amounts of detrital quartz, and silt to very fine sand grade in the lowest part at 6 to 7 m above the base of the section.

Euhedral, fine to medium crystalline dolomite is present, but usually comprises less than 5 percent of the carbonate fraction.

The rocks contain numerous veinlets and stylolites and are partly brecciated and recrystallized in the contorted lower 10 m or so of the section, but original limestone textures are still preserved.

Section 2 (West of Mount Soues). 24.4 m of distorted cherty carbonate beds of map-unit 2 outcrop at this section.

Downward the section terminates in overburden, so the thickness of unit 2 at this point is not known. The style of folding, however, suggests that map unit 2 is much thinner here than on Mount Soues. (Possibly because a shelf margin setting existed during deposition). The lower 8 m consists mainly of dolostone and the rest of limestone; both rocks contain stringers and lenses of chert.

The dolostone is microcrystalline, contains some echinoderms, and occurs in thick beds that show some vague laminations.

The limestone beds range in thickness from about 5 to 25 cm.

Specimens from the lower part of the section seem to be wackestones, but specimens from the upper part are packstones. The latter contains small amounts of quartz that is of silt and very fine sand size.

3.3 CLINTON FIRE LOOKOUT

This area has an access road to the fire lookout (in the middle of a number of unit 2 outcrops) and is approximately 60 km (by road) from the Hat Creek Project.

Rock sections 3 and 4 are described below. Map-unit 2 has a minimum thickness of 25 m at section 3 and of 18 m at section 4 which are both located in the vicinity of the Forestry Lookout near Clinton. These figures give the approximate thickness of strata in anticlines. At both sections the unit consists of thin-bedded, variably schistose and recrystallized limestone with stringers and irregular patches of chert. The rock consists of marble, replaced to a varying extent by cryptocrystalline to very finely microcrystalline micrite or microsparite that is elongate and shows twinning and parallel orientation. These features border fractures and stylolites and seem to have formed from solutions that penetrated the rock.

3.4 FIFTY-TWO CREEK ANTICLINE

(Northeastern Part of Northern Marble Range Study Area)

Rock section 5, consisting of rock unit 2, is described below. The unit consists of mainly well bedded limestone with chert lenses, about 197 m thick. The limestone is metamorphosed to marble in the eastern part of the study area, and dolostone is relatively rare. In texture and fossil content the rock of section 5 resembles the rock of other map-unit 2 sections. The unit is thickest in the north-central part of the study area and thins along strike toward the southeast. It also thins markedly toward the southeastern and southwestern flanks of the range. The thickness could have been affected by low angle faulting. However, lime packstone and dolostone, rocks suggestive of a shelf margin setting occur in an area where the unit is relatively thin (section 2) thereby supporting the views that the thicknesses are original.

3.5 WEST SIDE OF NORTHERN STUDY AREA

Sections 6 and 7 on the west side of the northern study area occur in rock unit 4. Unit 4 is composed of massive limestone and rare chert. The rock consists of clear to moderately cloudy, finely microcrystalline calcite; in some cases there is coarser grained, euhedral dolomite.[1]

3.6 NORTH OF TWO-MILE CREEK (Near Mount Soues)

In the only area where it was observed during the present investigation, map-unit 5 consists of lithic arenite, phyllite, and one bed of fractured dolostone.[1]

3.7 WESTERN BELT

Map-unit 6, the western most unit, is thought to be a deep sea deposit. It was deposited adjacent to, and down slope from the shelf margin deposits of units 2 and 3. Units 2, 3 and 6 are believed to have been deposited at the same time. The following is a description of unit 6:

This unit comprises poorly exposed, recessive strata of chert, pelite, limestone and volcanic rocks on the southwestern flank of the Marble Range. At a locality north of lower Two-mile Creek, chert occurs in 1 to 3 cm thick beds that are separated by argillaceous partings. The rock is medicine grey on fresh surfaces and weathers brownish owing to limonite stain derived from weathered pyrite. Thin sections contain numerous shear zones and veinlets. The argillaceous matter has recrystallized to white mica that is oriented in three different planes. Radiolarian skeletons are preserved as inclusion-free ellipsoidal nodules, about 0.06 to 0.3 mm, commonly 0.2 mm long, that are elongate in the plane of the principal schistosity.

The limestones observed are perhaps 5 to 7 m thick. A specimen from lower Two-mile Creek is a lime wackestone, similar to those in map-unit 4 that lies in a cryptocrystalline to finely microcrystalline calcite matrix. Dolomite makes up a few percent of the rock and occurs as rhombohedra, very fine to finely crystalline in size. The rock is brecciated and traversed by stylolites. The preponderance of interstratified radiolarian chert and pelite in this unit suggests a deeper water environment. If so, the limestones may be submarine slide deposits.

SECTION 4.0 - INFERRED SITES OF DOLOMITIZATION

4.1 INTRODUCTION

Using H.P. Trettin's northern study area as a guide, the geology of the southern limestone deposits have been inferred, and possible sites of dolomitization have been identified (Fig. 2-1). The topography of the Marble Range seems to be related to the geology and structure of the range. Map-unit 2, which shows the most promise for limestone dolomitization, is generally resistant to erosion, and forms the steepest mountains and ridges of the Marble Range. Faults in general, and the thrust fault between units 2 and 4 in particular, also show up quite well in the topography. These faults help to define the area of unit 2 outcrop, thus narrowing down the areas of interest for further study. Intrusive contacts with limestone are also sites of possible dolomitization. These intrusive-limestone contacts have been mapped (Fig. 2-1).

4.2 LOCATIONS OF POSSIBLE DOLOMITIZATION IN THE MARBLE RANGE, CLEAR RANGE, TRACHYTE HILLS AND CORNWALL HILLS

The following sections summarize the accessible locations of possible dolomitization in the Marble Range. Reference should be made to Fig. 2-1 for site locations and their accessibility.

Site 1 - Houth Meadows Waste Dump - approximately 5 km from Hat Creek; main access roads are indicated on Fig. 2-1.

Several limestone samples have been analyzed; the highest $MgCO_3$ equivalent recorded is 4 percent. Exact sample locations are not indicated, but the $MgCO_3$ content indicates some dolomitization may have occurred in the area. There are both Cretaceous/(?)Jurassic granodiorite/quartz diorite, and olivine basalt intrusions into the older limestones near Houth Meadows. Intrusive contacts have been mapped (Fig. 4-1).

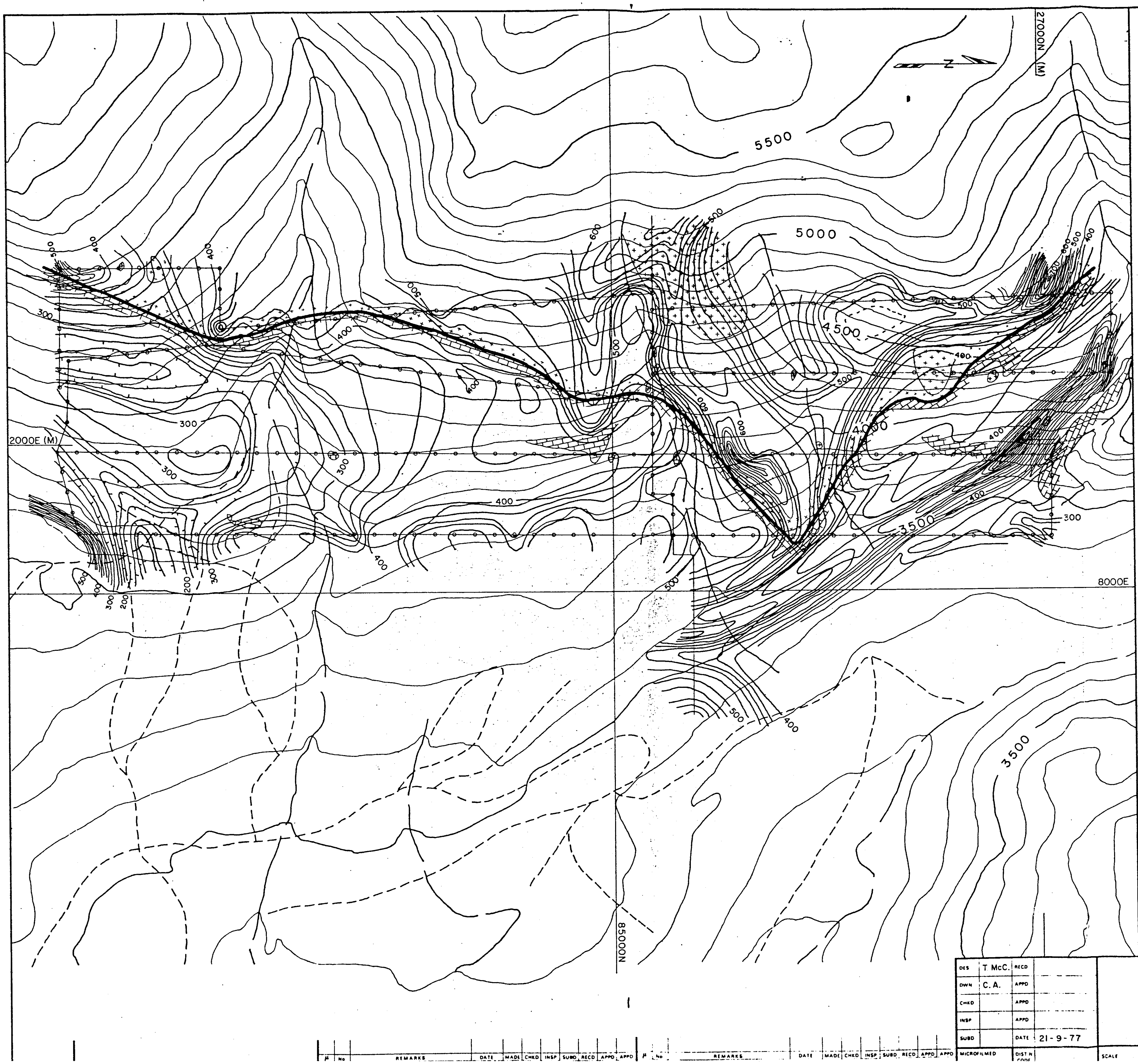
Site 2 - Crown Lake - Pavilion Lake Intrusive Contact - approximately 15 km from Hat Creek; there is an access road through Marble Canyon Provincial Park (Fig. 2-1). There may have been dolomitization of limestone in the area due to a Cretaceous or (?) Jurassic intrusion of granodiorite or quartz diorite into older limestone beds.

Site 3 - Anderson Creek Intrusive Contact - approximately 7 km from Hat Creek (Fig. 2-1). There may be partial access. There may have been dolomitization of limestone in the area due to a Cretaceous or (?) Jurassic intrusion of granodiorite or quartz diorite into older limestone beds.

Site 4 - Medicine Creek Intrusive Contact - on Medicine Creek Waste dump Site; approximately 5 km from Hat Creek. There is good access in the area (Fig. 2-1). There may have been dolomitization in the area due to Kamloops Group basalt, andesite or rhyolite intrusions into older limestone beds. The "intrusions" are Eocene and/or Miocene in age. Shallow water dolomitization may also have occurred near greenstone rocks in the area.

Sites 5 and 6 - Marble Range Limestone - approximately 22 km from Hat Creek (Fig. 2-1). These two sites may have shelf margin dolomitized limestone of map-unit 2. Fig. 2-1 illustrates known dolomite occurrences. The geology in this area could be similar to that on Mount Soues. Site 5 is close to Permian and/or earlier (?) sedimentary rocks which predate limestone beds. The detrital sedimentary outcrops could indicate shallow seas during the deposition of limestones near site 5.

Sites 7 - Marble Range Limestone - approximately 50 km from Hat Creek; near the Pavilion Mountain Microwave Tower; there is an access road (Fig. 2-1). This site could possibly be a shelf margin setting, the lithofacies equivalent of Mount Soues map-unit 2. In addition, a large



SCALE (IN METERS)
0 100 200 300

SCALE (IN FEET)
0 200 400 600 800 1000

LEGEND

ROAD

CREEK

TOPOGRAPHIC CONTOUR - ELEVATION IN FEET

(M) METRIC COORDINATE

—500— MAGNETIC CONTOUR (IN GAMMAS)

NOTE: ADD 57,000 GAMMAS TO CONVERT TO TOTAL FIELD MAGNETIC CONTOUR

GRANODIORITE

LIMESTONE

Figure 4-1

DES	T McC.	RECD	
DWN	C. A.	APPD	
CHKD		APPD	
INSP		APPD	
SUBD		DATE	21-9-77
MICROFILMED		DIST N CODE	

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

GEOLOGY & MAGNETIC SURVEY OF WEST HOUTH MEADOWS

#	No	REMARKS	DATE	MADE	CHKD	INSP	SUBD	RECD	APPD	APPD

SCALE

DWG No R

outcrop of detrital sedimentary rocks which predates the limestone of the Marble Range, lies adjacent to Pavilion Mountain. These detrital sedimentary rocks could be part of the shelf margin on which the limestones were deposited, and on which dolomitization may have occurred. Basaltic intrusive rocks of the Skull Hill Formation (Eocene and (?) Oligocene) lie within the proposed outcrop area of map-unit 2, so the possibility of metasomatic dolomitization of limestone also exists in the area.

Sites 5, 6 and 7 were chosen for their accessibility, and because they are topographically similar to the Mount Soues Formation, map-unit 2.

Site 8 - Marble Range Limestone Along Pavilion Creek - approximately 35 km to Hat Creek; access may be good (Fig. 2-1). The limestone of this area is probably part of map-unit 4. The limestone borders on a basaltic intrusion of the Skull Hill Formation, so metasomatic activity, and dolomitization, may have taken place on the limestone-intrusive contact.

SECTION 5.0 - CONCLUSION

The sites listed in this report may contain dolomitic deposits and magnesium limestones on the basis of their geological setting. More work is required to adequately evaluate their potential.

SECTION 7.0 - SUBSEQUENT WORK

A number of sites in the Hat Creek area were visited and samples were collected subsequent to writing this report. In addition samples were collected from the Steel Brothers quarry in Marble Canyon and from the Domtar quarry on Texada Island. These samples are described and analyses of them are summarized in the Addendum at the end of this report.

REFERENCES

1. Trettin, H.P. 1979. Permian Rocks of the Cache Creek Group in the Marble Range, Clinton Area, British Columbia; Geological Survey of Canada, paper 79-17.

2. Blatt/Middleton/Murray. Origin of Sedimentary Rocks, Prentice-Hall, Inc., Englewood Cliffs, New Jersey © 1980.

3. S. Duffell, K.G. McTaggart; Map/Carte 1010-A; 1952.

4. R.B. Campbell, H.W. Tipper; Map/Carte 1278A; Geology of Bonaparte Lake map-area (92-P) 1971.

5. British Columbia Hydro and Power Authority Generation Planning Department, System Engineering Division; Hat Creek Project Detailed Environmental Studies, Minerals and Petroleum, May 1978.

APPENDIX A

STRATIGRAPHY

APPENDIX A

STRATIGRAPHY

The following are rock descriptions of the Marble Canyon Limestone Formation of the Cache Creek Group taken from H. P. Trettins' work.[1]

CENTRAL BELT

(a) Map-unit 1

Volcanic rocks, chert and limestone underlie the Marble Canyon Formation on the south slope of Mount Soues evidently with stratigraphic contact, although it is possible that the contact is a low-angle fault.

The lowest 6 m of the exposed section consist of medium grey chert, partly massive and partly pinching and swelling, in beds that are 4 to 10 cm thick. A representative specimen, examined in thin section, shows two sets of veinlets, filled with calcite and quartz, that intersect at low angles.

The chert is overlain by approximately 7 m of limestone with 0.5 to 2.5 cm thick chert stringers. One specimen examined in thin section is a lime wackestone composed of peloids, about 1.5 mm in diameter, in a cryptocrystalline calcite matrix. Another is a lime mudstone, composed of about 3 to 8 μm long microsparite crystals.

The contact with the overlying volcanic rocks (unit 1v) is sharp but wavy, the undulations - probably small-scale folds - have half-wave lengths of approximately 30 to 45 cm and amplitudes of about 15 cm. The volcanic unit is approximately 139 m thick and consists mainly of basalt with minor amounts of intercalated chert and a small limestone lens. The rocks are dark greenish grey and weather brownish grey. They are massive with closely spaced fractures. A single pillow structure, about 30 cm long, was observed 53 m above the base of the section. The microscopic texture of the basalt is intersertal, intergranular, or microporphyritic. The rocks consist mostly of intensely sericitized feldspar - largely or entirely albite - and fresh clinopyroxene with lesser amounts of chlorite and opaque minerals, probably mainly ilmenite and magnetite. Pumpellyite may be present in small amounts but has not been identified with certainty. Shear zones and numerous veinlets in the volcanic rocks contain chlorite and lesser amounts of carbonate, quartz, and epidote. The vein material is so abundant that most rocks are unsuitable for chemical analysis. However, one specimen, the least altered, was submitted for chemical analysis. The rock was classified as "tholeiitic basalt, K-rich series" by means of a computer analysis of the chemical data based on the classification of Irvine and Baragar (1971). It is uncertain whether the relatively large potassium content of the rock is an original feature or the result of submarine weathering or other types of alteration.

Light greenish grey, thinly laminated chert was observed 121.9 m above the base of the section. X-ray diffraction and thin section analysis indicate that it contains small amounts of white mica, and plagioclase in addition to the predominant quartz. A limestone lens, about 1 m long and 30 cm thick, and apparently oriented obliquely to bedding, occurs at a stratigraphic height of 118 m.

The nature of the upper contact of map-unit 1 with the overlying map-unit 2 is uncertain because the lower part of that unit is strongly contorted. This may indicate differential movements on a normal contact, or a low-angle fault.

Map-unit 1 has not yielded any fossils. The lower part of map-unit 2 probably is early Wordian in age. Thus, if the contact is normal, map-unit 1 probably is early Wordian and/or late Leonardian in age.

Map-units 2-5

Four different map-units are distinguished in the remaining part of the central belt - two well exposed carbonate units (map-units 2 and 4), and two poorly exposed noncarbonate units (map-units 3 and 5). These units succeed each other in several folds (in the order indicated by their numbers), but it is uncertain whether the present order is original or the result of an episode of low-angle faulting prior to the folding. Map-units 2 and 4 clearly are part of the Marble Canyon Formation, but the original position of map-unit 3 is problematic. A discussion of the lithology, thickness, and depositional environment of these units will be followed by a discussion of their age and possible stratigraphic relationships.

Lithology, thickness and depositional environment

Map-unit 2 (cherty limestone unit). Map-unit 2 consists of generally well bedded carbonate strata, mainly limestone but locally dolostone or marble, with abundant lenses and stringers of chert. A brief description of the measured sections is followed by a summary of the lithology and thickness of the unit and of its mode of origin.

At section 1-2, on the south slope of Mount Soues, map-unit 2 is about 75 m thick. The overlying map-unit 3 is not preserved, but the present land surface probably is close to the top of the unit. In consists mainly of well-bedded limestone with stringers and thin beds of chert, about 1 to 8 cm thick, but the middle part is poorly bedded and lacks chert. In the well-bedded parts of the section, bed thickness ranges from about 5 to 30 cm, and in the poorly bedded part from about 30 to 60 cm.

The limestones are relatively pure. Small amounts of detrital quartz, of silt to very fine sand grade, were noted only in specimens from the lowermost part, about 6 to 7 m above the base of the section. Dolomite, generally euhedral and finely to medium crystalline, usually does not make up more than about 5 percent of the carbonate fraction. The rocks contain numerous veinlets and stylolites and are partly brecciated and recrystallized in the contorted lower 10 m or so of the section, but original limestone textures are nevertheless preserved. Nineteen of twenty thin sections are classified as lime wackestone and only one is regarded as a probable grainstone. The framework of the wackestones, in so far as it is identifiable, consists mainly of fragments of echinoderms, foraminifers - both fusulinaceans and smaller forms - and dasycladacean algae with abundant peloids and some oncoids. Radiating tufts of micritized bryozoans, probably in growth position, were observed about 19.5 m above the base of the member. The grainstone, occuring as talus at stratigraphic height of 62 m, consists of spar-cemented fusulinaceans and echinoderm fragments.

At section 2, west of Mount Soues, map-unit 2 is represented by about 24.4 m of distorted cherty carbonate beds. The top of the unit probably coincides with the top of the uppermost resistant limestone bed, but the upper contact, with the recessive map-unit 3, is concealed. Downward, the section terminates in overburden and it is not known whether its base coincides with the base of map-unit 2 as map-unit 1 is not exposed nearby. The style of folding, however, suggests that map-unit 2 is much thinner here than on Mount Soues.

The lower 8 m consist mainly of dolostone and the rest of limestone, both rocks containing stringers and lenses of chert. The dolostone is microcrystalline, contains some echinoderms, and occurs in thick beds that show some vague laminations. The limestone beds range in thickness from about 5 to 25 cm. Petrographic classification is difficult because of recrystallization and veining. Specimens from the lower part of the section are wackestones, but specimens from the upper part are packstones. The latter contain echinoderms, fusilinaceans, intraclasts (some are pelletal), and small amounts of quartz of silt and very fine sand grade.

Sections 3 and 4. Map-unit 2 has a minimum thickness of 25 m at section 3 and of 18 m at section 4, both are located in the vicinity of the Forestry Lookout near Clinton. These figures give the approximate thickness of strata in anticlines; the contacts with underlying and overlying strata are not exposed. At both sections the unit consists of thin-bedded, variably schistose and recrystallized limestone with stringers and irregular patches of chert.

Four thin sections from section 4 consist of marble, replaced to varying extent by cryptocrystalline to very finely microcrystalline micrite or microsparite that is elongate and shows twinning and parallel orientation. The micrite-microsparite borders fractures and stylolites and seems to have formed from solutions that penetrated the rock.

At section 5, located at the Fifty-two Creek Anticline, map-unit 2 consists of well-bedded limestone with chert lenses, as in most other areas. Photogrammetric measurement indicated a thickness of about 197 m. About 4 km to the east, the limestone is locally completely replaced by chert.

Limestone is the most common carbonate rock, but it is metamorphosed to marble in the eastern part of the study area, and dolostone is relatively rare. The limestone is generally well bedded with bed thickness ranging from about 5 to 30 cm, but beds up to 60 cm thick also occur. Most limestone specimens analyzed in thin section were wackestones; packstones and grainstones were less common. Bioclastic fragments in these rocks were derived mainly from echinoderms and foraminifers and to a lesser extent from dasycladacean algae and bryozoans; oncoids and peloids also are present.

Texture and biota of the lime wackestones suggest deposition in a protected, but well-aerated subtidal shelf environment, favourable to a variety of organisms. The packstone at section 2 could have formed in a slope environment, but this is not certain.

The chert stringers and lenses, which are the most characteristic features of this unit, probably are of replacement origin because they are irregular in shape and seem to lack radiolarians. Locally the carbonate rocks are entirely replaced by chert.

Measured thicknesses range from 18+ to 197 m. Although none of the sections are complete, they probably indicate at least the order of thickness in given areas, and the overall pattern of variation in thickness. The unit is thickest in the north-central part of the study area and thins along strike toward the southeastern and southwestern flanks of the range. The thickness could have been affected by low-angle faulting. However, the occurrence of lime packstone and dolostone, rocks suggestive of a shelf margin setting, in an area where the unit is relatively thin (section 2), supports the view that the thicknesses are original.

Map-unit 3. This is a poorly exposed, recessive unit, which in the vicinity of section 2 is composed of lithic arenite, siltstone, chert, volcanic flow rocks, and limestone. Its apparent thickness in that area is about 90 m, but the true thickness could be much larger or smaller because the concealed internal structure almost certainly is complex.

Lithic arenite and siltstone are intermittently exposed through a 38 m thick interval in the middle of the unit and are composed of angular to subrounded fragments of chert, cherty limestone, and limestone. A specimen of medium grained arenite is poorly sorted, whereas a specimen of fine grained, silty arenite is well sorted. The fragments are tightly packed, commonly with pressure-solution contacts. They obviously were derived from Cache Creek strata, but exposure of primary structures was too poor to determine mode of derivation - whether by subaerial or submarine erosion - and depositional environment.

A characteristic specimen of volcanic rock is medium grey, brownish grey weathering, porphyritic and has amygdules of calcite and chlorite. The phenocrysts, ranging to about 5 mm long and comprising a few percent of the rock, consist of albite that is mostly replaced by sericite and chloritized glass. The groundmass is composed of unidentifiable plagioclase microlites, clinopyroxene and iron ore.

The chert, which is very poorly exposed, is dark grey and argillaceous.

<u>Map-unit 4</u> (massive limestone unit). This unit, composed of limestone, is distinguished from map-unit 2 by its massive character, lesser chert content and greater maximum thickness.

The thickness of the unit generally is difficult to determine because of the obscurity of bedding and the locally complex structure. Measured thicknesses range from 37+ to 253+ m and demonstrate marked thinning on the southwestern flank of the range, as also is shown by map-unit 2. If the unit is bounded at the base by a low-angle fault, as suggested below, then the thinning could be the result of truncation by this fault.

Eight specimens from sections 6 and 7, examined in thin section, are classified as lime wackestone. The identifiable skeletal grains were derived from echinoderms, fusulinaceans and other foraminifers, and dasycladacean algae. Oncoids are common at both sections, and peloids also are present. The oncoids range in diameter from approximately 0.3 to 3.74 mm and are spheroidal, ellipsoidal, or irregular in shape. Most are simple, but some are compound. They are characterized by concentric dark layers, about 8 to 180 µm thick, composed of cryptocrystalline calcite with a relatively large concentration of submicroscopic carbonaceous matter, separated by slightly coarser (finely microcrystalline) and purer layers. Most oncoids have several dark layers, but some have only one. The cores usually consist of clear to moderately cloudy, finely microcrystalline calcite, in some cases with coarser grained, euhedral dolomite. Oncoids are generally interpreted as the product of blue-green algae.

The unit appears to have been deposited in a subtidal shelf environment, comparable to the depositional environment of map-unit 2. The texture of the rocks (wackestones) as well as the delicate dasycladacean algae indicate a tranquil setting.

Map-unit 5. North of Two-mile Creek, the only area where it was observed during the present investigation, map-unit 5 consists of lithic arenite, phyllite, and one bed of fractured dolostone. It seems to overlie map-unit 4, but the contact is concealed and could be a fault. The arenite is represented mostly by rubble and its primary structures are not apparent. It ranges in grain size from medium to very coarse and pebbly. The arenites consist mostly of chert with some limestone fragments in pebbly rocks. The chert is variably argillaceous, commonly contains radiolarians, and appears to be mostly of primary origin. The clasts generally are poorly sorted and evidently have been abraided in situ by tectonic processes. They are fairly closely packed, but surrounded by a matrix of white mica that has recrystallized in a plane of schistosity that coincides with the plane of flattening of the fragments. These arenites, like those of map-unit 3, were derived from the Cache Creek Group, but their mode of origin and depositional environment are uncertain.

An outcrop of chert and pelite, and another outcrop of carbonate rocks, mapped on the northeastern flank of the First Ridge Anticline in 1958 (Trettin, 1961, Fig. 1B) are also included in map-unit 5.

Map-unit 6

This unit comprises poorly exposed, recessive strata of chert, pelite, limestone and volcanic rocks on the southwestern flank of the Marble Range.

At a locality north of lower Twomile Creek, chert occurs in 1 to 3 cm thick beds that are separated by argillaceous partings. The rock is medium grey on fresh surfaces and weathers brownish owing to limonite stain derived from weathered pyrite. A thin section of this rock is traversed by numerous shear zones and veinlets. The argillaceous matter has recrystallized to white mica that is oriented in three different planes. Radiolarian skeletons are preserved as inclusion-free ellipsoidal nodules, about 0.06 to 0.3, commonly 0.2 mm long, that are elongate in the plane of the principal schistosity.

The limestones observed are perhaps 5 to 7 m thick. A specimen from lower Twomile Creek is a lime wackestone composed of oncoids and coated grains, similar to those in map-unit 4, in a cryto-crystalline to finely microcrystalline calcite matrix. Dolomite makes up a few percent of the rock and occurs as rhombohedra, very finely to finely crystalline in size. The rock is brecciated and traversed by stylolites.

A specimen of flow breccia from this general area consists of intensely sericitized, unidentifiable plagioclase microlites in a matrix of altered glass. Calcite veinlets and replacements are common.

The preponderance of interstratified radiolarian chert and pelite in this unit suggests a deeper water environment. If so, the limestones must be submarine slide deposits, but this has not been established.

The only fossil collected from map-unit 6 is a Neoschwagerina sp. (from east of the mouth of Barney Creek) that probably is late Leonardian or earlier Guadalupian (early Wordian) in age. The unit may include deep water facies equivalents of the Marble Canyon Formation, but the precise relationship between the shelf limestones and deep water sediments could not be established because of the poor exposure of the noncarbonate rocks, tight folding, and scarcity of fossils.

APPENDIX B

SUMMARY OF STRUCTURE AND STRATIGRAPHY

APPENDIX B

SUMMARY OF STRUCTURE AND STRATIGRAPHY

The following sketches indicate the sequence of events through geologic time which may have led to the present Marble Range limestone Formation.

The sequence of Deposition and Orogeny was as follows:

1. Deposition

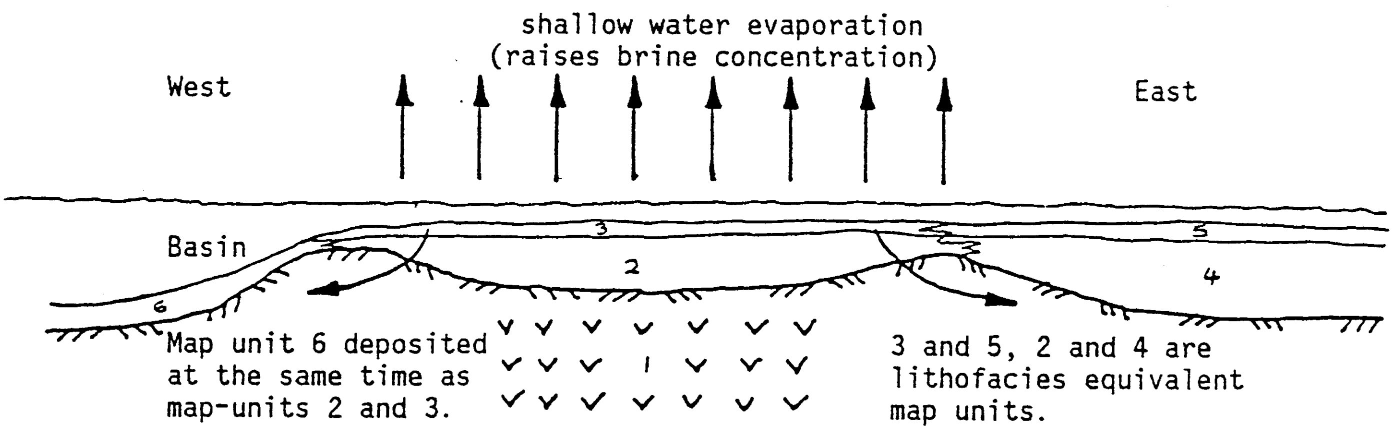


Fig. B-1

2(a) Orogeny

The thrust sheet of units 4 and 5 is thought to[1] have been emplaced by compression forces, not by gravitational glide.

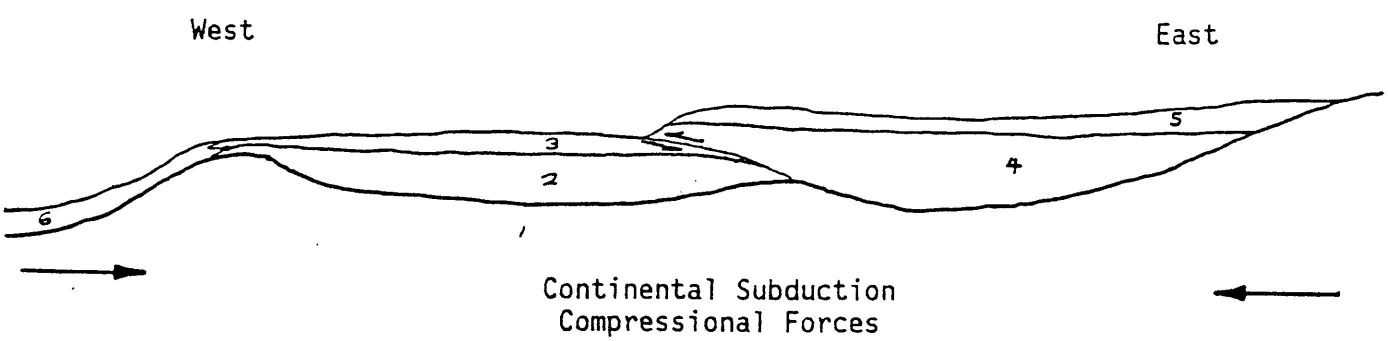
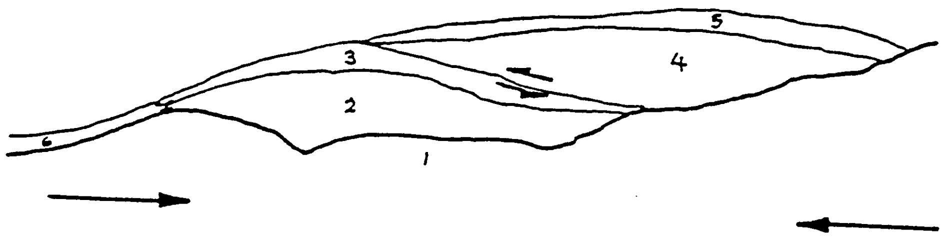


Fig. B-2

2(b)
West

East

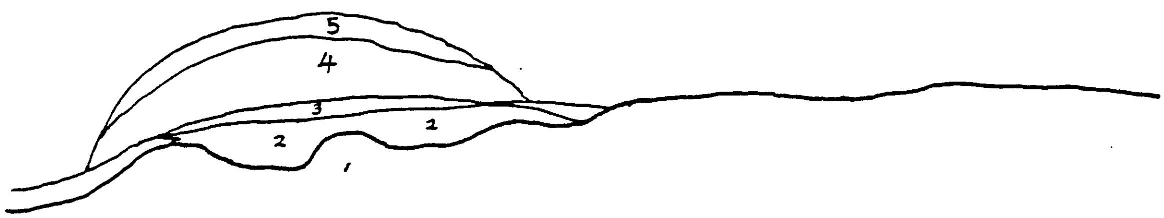


Overthrusting

Fig. B-3

2(c)
West

East



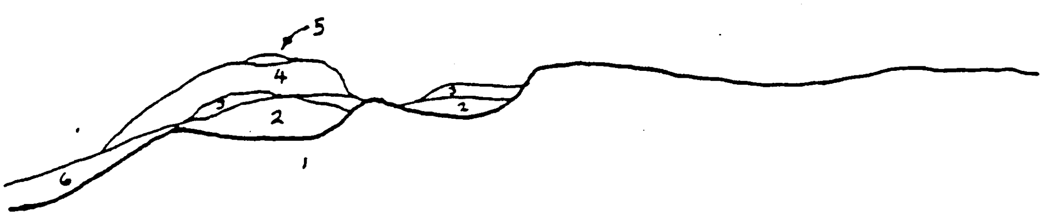
Further Overthrusting

Fig. B-4

3. <u>Erosion</u>

West

East



Present Day

Fig. B-5

APPENDIX C

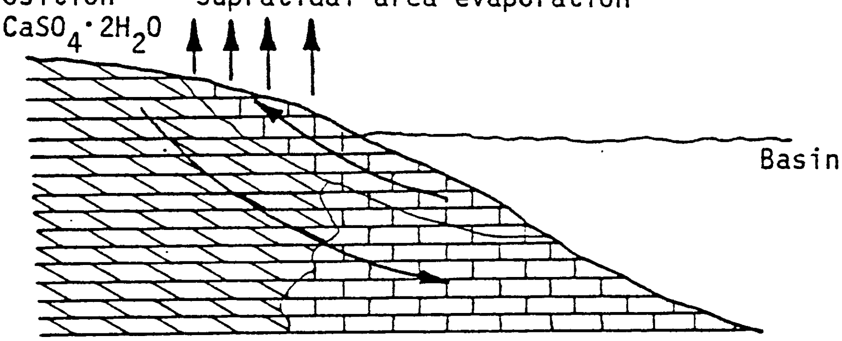
DOLOMITIZATION PROCESSES

APPENDIX C

DOLOMITIZATION PROCESSES

Dolomitization processes can be divided into several types:[2]

C-1 Evaporation Reflux Model



Evaporation raises the Mg/Ca ratio and the more dense hypersaline brine sinks into the limestone where dolomitization takes place.

Fig. C-1

Brine is drawn up into the limestone by capillary pressure and evaporation at the surface. Due to the higher Mg/Ca ratio, the Mg ions replace the Ca ions in the limestones through which they circulate.

Gypsum is often found associated with the dolomite, but may not always be present. The gypsum that was originally deposited may have been washed away by meteoric water.

C-2 The same sort of process with slight variation occurs in shallow water brine basins which are essentially isolated from the sea (so that brine only flows in to replenish the water that has evaporated).

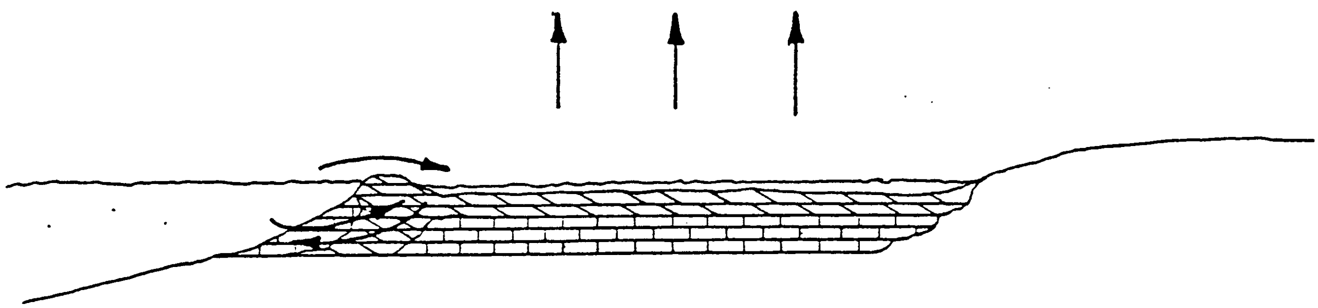


Fig. C-2

Evaporation raises the Mg/Ca ratio when gypsum is deposited (lowering the concentration of Ca in the brine) so that dolomite (instead of calcite) will precipitate from solution.

C-3 Dorag Model

Dolomitization of limestone may occur in a zone of mixing between fresh and salt water (brackish environment).

Fig. C-3 gives a summary of depositional dolomite in standard limestone facies belts.

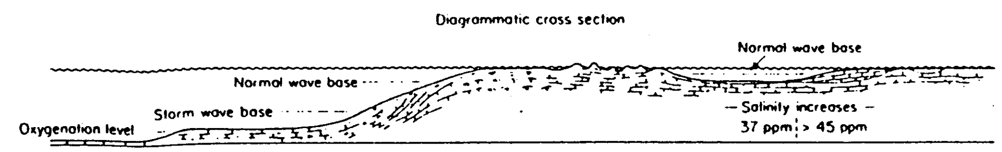
C-4 Metasomatic Dolomitization

Hot fluids associated with the intrusive rock circulate through adjacent limestone beds, depositing new mineralization and altering the limestone beds. The type of mineralization and alteration depends upon the termperature, pressure and composition of the circulating fluid. If the fluid is rich in Mg, dolomite alteration may be abundant.

SECTION 6.0 - RECOMMENDATIONS

A number of areas have been identified that have some potential for dolomite or dolomitic limestone. These sites should be investigated by briefly examining each site and sampling where appropriate. Between 1 to 2 weeks of fieldwork would be required. Preference in this investigation should be given to sites closer to Hat Creek.

FIGURE C-3 IDEALIZED SEQUENCE OF STANDARD FACIES BELTS.*



	Basin-starved or filled: Little benthonic carbonate produced. Sedimentation depends on influx of detrital silicates and plankton.	*Open shelf:* Water depth 10 to 100s m. Normal marine salinity. Minor sediment transport by currents.	*Basin margin:* Toe of the slope. Sediment derived from plankton.	*Foreslope:* Slope may be 30°. Sediment moved by gravity, waves, currents.
Facies	(a) Fine clastics (b) Carbonates (c) Evaporites	Open marine neritic (a) Carbonates (b) Shale		(a) Bedded fine grained sediments with slumps (b) Foreset debris and lime sands (c) Lime mud masses
Lithology	Dark shale or silt, thin limestones (starved basin); evaporite fill with salt	Very fossiliferous limestone interbedded with marls; well-segregated beds	Fine-grained limestone; cherty in some cases	Variable, depending on water energy upslope; sedimentary breccias and lime sands
Color	Dark brown, black, red	Gray, green, red, brown	Dark to light	Dark to light
Grain type and depositional texture	Lime mudstones; fine calcisiltites	Bioclastic and whole fossil wackestones; some calcisiltites	Mostly lime mudstone with some calcisiltites	Lime silt and bioclastic wackestone-packstone; lithoclasts of varying sizes
Bedding and sedimentary structures	Very even mm lamination; rhythmic bedding; ripple cross lamination	Thoroughly burrowed; thin to medium, wavy to nodular beds; bedding surfaces show diastems	Lamination may be minor; many massive beds; lenses of graded sediment; lithoclasts and exotic blocks, rhythmic beds	Slump in soft sediments; foreset bedding; slope bioherms; exotic blocks
Terrigenous clastics admixed or interbedded	Quartz silt and shale; fine-grained siltstone; cherty	Quartz silt, siltstone, and shale; well-segregated beds	Some shales, silt, and fine-grained siltstone	Some shales, silt, and fine-grained siltstone
Biota	Exclusively nektonic-pelagic fauna preserved in local abundance on bedding planes	Very diverse shelly fauna preserving both infauna and epifauna	Bioclastic detritus derived principally from upslope	Colonies of whole fossil organisms and bioclastic debris

	Organic-build up	*Platform edge sands:* Water depth 10–0 m Tidal bars, tidal deltas. Few organisms due to shifting substrate.	*Open platform:* Shallow marine < 10 m Normal marine limited fauna	*Restricted shelf tidal flats:* Fine sediment in ponds, coarse in tidal channels and beaches wind deposited detrital silicates and swamps	*Evaporative:* Supratidal sabkha-salinas, saltflats. Arid climate, land derived detrital silicates
Facies	(a) Boundstone mass (b) Crust on accumulation of organic debris and lime mud; bindstone (c) Bafflestone	(a) Shoal lime sands (b) Islands with dune sands	(a) Lime sand bodies (b) Wackestone-mudstone areas, bioherms (c) Areas of clastics	(a) Bioclastic wackestone in lagoons and bays (b) Litho-bioclastic sands in tidal channels (c) Lime mud-tide flats (d) Fine clastic units	(a) Nodular anhydrite and dolomite on salt flats (b) Laminated evaporite in ponds
Lithology	Massive limestone-dolomite	Calcarenitic-oolitic lime sand or dolomite	Variable carbonates and clastics	Generally dolomite and dolomitic limestone	Irregularly laminated dolomite and anhydrite, may grade to red beds
Color	Light	Light	Dark to light	Light	Red, yellow, brown
Grain type and depositional texture	Boundstones and pockets of grainstone; packstone	Grainstones well sorted, rounded	Great variety of textures; grainstone to mudstone	Clotted, pelleted mudstone and grainstone; laminated mudstone; coarse lithoclastic wackestone in channels	
Bedding and sedimentary structures	Massive organic structure or open framework with roofed cavities; Lamination contrary to gravity	Medium-to-large scale cross-bedding; festoons common	Burrowing traces very prominent	Birdseye, stromatolites, mm lamination, graded bedding, dolomite crusts on flats. Cross-bedded sand in channels	Anhydrite after gypsum, nodular, rosettes, chickenwire and blades; irregular lamination; carbonate caliche
Terrigenous clastics admixed or interbedded	None	Only some quartz sand admixed	Carbonates and detrital silicates in well segregated beds	Detrital silicates and carbonates in well segregated beds	Windblown, land derived admixtures; clastics may be important units
Biota	Major frame building colonies with ramose forms in pockets; in situ communites dwelling in certain niches	Worn and abraded coquinas of forms living at or on slope; few indigenous organisms	Open marine fauna lacking (e.g., echinoderms, cephalopods, brachiopods); mollusca, sponges, forams, algae abundant; patch reefs present	Very limited fauna, mainly gastropods, algae, certain foraminifera (e.g., miliolids) and ostracods	Almost no indigenous fauna, except for stromatolitic algae

*From J. L. Wilson, 1970, 1974, 1975.

C-5 Abundance of Dolomite Through Geological Time

The calcite/dolomite ratio decreases (in overall rock abundancies) from near infinity in Quaternary rocks to 80:1 in Cretaceous rocks to 3:1 in Early Paleozoic rocks to 1:3 in Precambrian rocks. This may in part reflect the increased opportunity with time for a carbonate rock to become dolomitized. It could, however, reflect a greater prevalence of the depositional and diagenetic environments conducive to the formation of dolomite in the Paleozoic and Late Precambrian as contrasted to later times.[2]

The ratio of calcite/dolomite in Permian rocks (the age of Marble Range Limestones) would then be about 80:1.

ADDENDUM

LIMESTONE AND DOLOMITE SAMPLING NEAR HAT CREEK
AND SAMPLES FROM DOMTAR INC.,
TEXADA ISLAND, B.C.

ADDENDUM

LIMESTONE AND DOLOMITE SAMPLING NEAR HAT CREEK AND SAMPLES FROM DOMTAR INC., TEXADA ISLAND, B.C.

The sample sites were selected based on Report No. SE 8117, "Dolomitization in the Marble Range Limestones near the Hat Creek Project". The sites near Hat Creek are illustrated in Fig. Addendum-1 and the analyses from these sites and from Texada Island are summarized in Table Addendum-1. The samples from Texada Island were supplied by Domtar Inc. of Blubber Bay, B.C. and included a limestone and a magnesian limestone.

Sample Site LST 1: The site is near the eastern contact of the Mount Martley stock at an elevation of 1340 m. The sample is mostly white limestone, although some of it is grey. The sample was taken from angular float. The limestone is medium-grained (grain size is approximately 2.5 mm).

Sample Site LST 2: The site is 190 m at 129° from Sample Site LST 1. The sample is light grey to black, medium-grained limestone (grain size is approximately 1.3 mm), similar to LST 1, but it has better banding.

Sample Site LST 3: The site is in outcrop, above the reclamation test site, north of Houth Meadows. The limestone is fine-grained and dark grey.

Sample Site LST 4: The sample site is near the east end of a large limestone outcrop area, north of Anderson Creek, at an elevation of 1770 m. The site is near the southeastern contact of the Mount Martley stock. The limestone is black and fine-grained.


SYMBOLS
BOUNDARY OF AREA OF DETAILED MAPPING
SMALL OUTCROP
GEOLOGICAL BOUNDARY
BEDDING, TOPS KNOWN (INCLINED, OVERTURNED)
BEDDING, TOPS KNOWN, ESTIMATED DIP (MODERATE)
BEDDING, TOPS KNOWN (DIP DETERMINED BY PHOTOGRAMMETRY)
BEDDING, TOPS UNKNOWN (INCLINED, VERTICAL)
BEDDING, TOPS UNKNOWN, ESTIMATED DIP (MODERATE, VERY STEEP)
SLATY CLEAVAGE (INCLINED)
FAULT (THRUST) (NORMAL OR STRIKE-SLIP)
ANTICLINE
ANTICLINE (OVERTURNED)
SYNCLINE
SYNCLINE (OVERTURNED)
STRATIGRAPHIC SECTION (SHORT, LONGER, PHOTOGRAMMETRIC SECTION)
FOSSIL LOCALITY
POTENTIAL SITE FOR DOLOSTONE OR DOLOMITIC LIMESTONE
SAMPLE LOCATION
LST 1
LST 16
LST 15
LST 10
LST 11
LST 12
LST 13
LST 14
LST 19
STEEL BROS
LST 8
LST 1
LST 2
LST 3
LST 5
LST 4
LST 6
LST 7
FRASER
PLATEAU
LEGEND
QUATERNARY
UNCONSOLIDATED SEDIMENTS
TERTIARY
TRIASSIC OR PERMIAN
PERMIAN OR CARBONIFEROUS
CACHE CREEK GROUP
GREENSTONE, CHERT, ARGILLITE, GREENSCHIST, QUARTZITE AND LIMESTONE
WESTERN BELT
CARBONIFEROUS(?), PERMIAN AND(?) TRIASSIC
CACHE CREEK GROUP
6cb: LIMESTONE
PERMIAN
CENTRAL BELT
MARBLE CANYON FORMATION
LIMESTONE (CONTAINS UNITS 1-6 WHICH HAVE NOT BEEN MAPPED IN DETAIL; WHERE THE GEOLOGY OF THE LIMESTONES HAS BEEN MAPPED IN DETAIL, THE DETAILED UNITS ARE INDICATED
UPPER PERMIAN (GUADALUPIAN)
MARBLE CANYON FORMATION
MASSIVE LIMESTONE (PROBABLY FACIES EQUIVALENT OF MAP UNIT 2, SUPERIMPOSED ON 3 BY THRUST FAULT)
LITHIC ARENITE AND SILTSTONE, VOLCANIC ROCKS, CARBONATE ROCKS, CHERT, PELITE; 3cb: CARBONATE ROCKS
WELL-BEDDED LIMESTONE WITH STRINGERS OF CHERT, MINOR MARBLE, DOLOSTONE
UPPER AND/OR LOWER PERMIAN (GUADALUPIAN AND/OR LEONARDIAN)
CACHE CREEK GROUP
BASALT, CHERT, PELITE, CARBONATE ROCKS; 1cb: CARBONATE ROCKS; 1ch: CHERT, PELITE; 1v: VOLCANIC ROCKS; MINOR LIMESTONE, CHERT.
INFERRED GEOLOGY
MARBLE CANYON FORMATION
PALEOZOIC AND(?) MESOZOIC
SCALE
B.C. HYDRO
GEOLOGICAL MAP
SHOWING
POTENTIAL LIMESTONE AND DOLOMITE
NEAR HAT CREEK
FIGURE ADDENDUM

TABLE - ADDENDUM-1

LIMESTONE-DOLOMITE ASSAYS
(%)

Sample	I.D.	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	Total	Dolomite[*1]
LST	1	1.23	0.75	0.17	0.02	4.57	50.47	0.02	0.07	0.02	43.49	100.81	20.91
LST	2	1.11	0.55	0.13	0.02	2.19	53.17	0.02	0.02	0.02	43.05	100.28	10.02
LST	3	1.15	0.59	0.14	0.02	2.06	53.29	0.02	0.02	0.02	43.19	100.50	9.42
LST	4	1.14	0.52	0.17	0.02	2.07	53.27	0.02	0.02	0.02	43.22	100.48	9.47
LST	5	0.64	0.57	0.24	0.02	2.13	53.35	0.02	0.02	0.02	43.48	100.49	9.74
LST	6	5.83	0.50	0.18	0.02	17.47	33.83	0.02	0.02	0.06	43.03	100.96	79.93
LST	7	67.00	0.30	0.60	0.02	1.42	17.22	0.02	0.02	0.11	14.24	100.95	6.50
LST	8	11.50	0.66	0.21	0.02	2.86	47.81	0.02	0.02	0.02	38.69	101.83	13.08
LST	9	4.94	0.53	0.14	0.02	3.24	50.94	0.02	0.02	0.02	41.25	101.13	14.82
LST	10	0.46	0.50	0.11	0.02	2.45	53.90	0.02	0.02	0.02	43.49	101.08	11.21
LST	11	2.78	0.85	0.17	0.02	4.69	49.76	0.02	0.20	0.20	42.29	100.81	21.46
LST	12	1.71	0.52	0.11	0.02	4.47	51.16	0.02	0.02	0.02	43.26	101.36	20.45
LST	13	1.63	0.56	0.13	0.02	17.09	36.56	0.02	0.02	0.02	45.58	101.63	78.19
LST	14	1.57	0.56	0.12	0.02	6.04	49.57	0.02	0.02	0.02	43.53	101.49	27.63
LST	15	0.57	0.61	0.16	0.02	2.09	54.23	0.02	0.02	0.02	43.49	101.24	9.56
LST	16	0.73	0.70	0.26	0.05	20.44	33.22	0.02	0.02	0.03	46.13	101.60	93.51
Tex	Ca	0.63	0.58	0.17	0.02	2.15	54.52	0.02	0.02	0.02	43.47	101.60	9.84
Tex	Mg	1.70	0.76	0.39	0.03	10.22	44.32	0.02	0.02	0.02	43.99	101.50	46.76
Steele Bros[*2]		0.4	-	0.3[*3]	-	0.2	54.60	-	-	-	44.20	99.70	0.92

[*1] Stochiometric calcite has 56.03 percent CaO and 43.97 percent CO_2, whereas dolomite has 30.41 percent CaO, 21.86 percent MgO and 47.73 percent CO_2. Ideally, the percentage dolomite may be obtained by multiplying the MgO content by 4.575.

[*2] Typical sample from Steele Brothers quarry, assayed in 1978.

[*3] Combined Fe_2O_3 and Al_2O_3.

Sample Site LST 5: The sample site is near the west end of a large limestone outcrop area north of Anderson Creek at an elevation of 1650 m. The site is near the southereastern contact of the Mount Martley stock. The limestone is grey and fine-grained.

Sample Site LST 6: The sample site is from a rock quarry, at the south end of the upper Hat Creek valley, near the entrance to the Reynolds Ranch. The elevation is 1090 m. The sample is a fine-grained, dark grey to buff brown, somewhat siliceous dolomite (approximately 80 percent dolomite, 14 percent limestone, 6 percent quartz).

Sample Site LST 7: The sample site is 35 m west of the rock quarry, at the south end of the upper Hat Creek valley, near the entrance to the Reynolds Ranch. The elevation is 1090 m. The sample is a dark grey to white, siliceous, reef flank breccia. The sample contains 67.00 percent SiO_2, 17.22 percent CaO and it is low (1.42 percent) in MgO.

Sample Site LST 8: The sample site is in the limestone area, east of the No. 1 Deposit, near Hat Creek and between PLT 12 and PLT 9. The limestone is siliceous, light grey and fine-grained.

Sample Site LST 9: The sample site is west of the south end of Pavilion Lake, at 1330 m elevation. The site is 300 m at 310° from a quartz diorite outcrop of the Mount Martley stock. The sample consists of white, coarse-grained, siliceous marble.

Sample Site LST 10: The sample site is on a ridge crest, near the head of Maiden Creek and at an elevation of 1375 m. The sample is fine-grained, grey limestone. Bedding is sub-parallel to the ridge.

Sample Site LST 11: The sample site is near the south end of the same ridge as sample Site LST 10. The site is directly accessible by truck. The sample is a fine-grained, slightly siliceous and magnesian limestone. Bedding is sub-parallel to the ridge.

Sample Site LST 12: The sample site is on the north end of a ridge, east of Robertson Creek and at an elevation of 1425 m. The sample is mostly grey, slightly magnesian limestone with minor white limestone and white calcite veins. Bedding is subparallel to the ridge.

Sample Site LST 13: The sample site is on the south end of a ridge, east of Robertson Creek and at an elevation of 1440 m. The sample is white to grey dolomite (approximately 78 percent dolomite, 1.5 percent quartz and 20.5 percent limestone). Bedding is striking 168° and dips 56° NE. The dominant fractures trend 062°, dipping 90°, and 070°, dipping 45° NW. The zone is at least 10.3 m wide. The strike length may be limited to the south, but outcrops in this direction are sparse. At an outcrop farther south along the same ridge, the beds strike 136° and dip 54° SW.

Sample Site LST 14: The sample site is on a small ridge, east of the ridge where samples 12 and 13 were taken, and at an elevation of 1290 m. The sample is medium grey, fine-grained magnesian limestone.

Sample Site LST 15: The sample site is south of the road and 0.2 km west of the B.C. Hydro microwave tower at the top of Pavilion Mountain. The outcrop consists of well-bedded, locally shaley, grey limestone. The bedding strikes 142° and dips 87° SW.

Sample Site LST 16: The sample site is on the south side of the road and 4.55 km west of the B.C. Hydro microwave tower at the top of Pavilion Mountain. The outcrop (roadcut) consists of a 15 m zone of light grey dolomite (approximately 93 percent dolomite, 2 percent quartz, 5 percent limestone). The dolomite is in a limestone breccia sequence. Bedding stikes 157° and dips 76° SW.

The Tex Ca sample consists of dark grey, fine-grained limestone.

The Tex Mg sample consits of dark grey, fine-grained, slightly siliceous, magnesian limestone (approximately 47 percent dolomite, 2 percent quartz and 51 percent limestone).

The Steele Brothers limestone sample consists fine-grained, white limestone.