W.A. No.

NAME ROK, MAG, BAYMAG, MOUNT BRUSSILOF

SUBJECT REPORTS

82JNW001-07

PROPERTY FILE

003560

M28-1506

[redacted]

CROSS RIVER.
H-10

BAYMAG PROPERTY

1972

SUMMARY REPORT OF GEOLOGY

D.M. Jenkins

February, 1973

INTRODUCTION

G.B. Leech (1965) reported the occurrence of major quantities of magnesite in an area of Lat. 50 47'N. and Long. 115 40'W. This is near the confluence of Assiniboine Creek with Mitchell River in the East Kootenay area of British Columbia (see Figures 1,2 and 3 also Appendix A).

A claim staking rush ensued due to Leech's report. Baykal Minerals Limited eventually acquired control of 344 claims by a combination of claim staking and agreement with the New Jersey Zinc Exploration Co. (Canada) Ltd. (see Figure 4 and Appendix A). A subsequent agreement with Canadian Exploration Limited gave Canadian Exploration responsibility for exploration and development of this mineral prospect.

This report is a general summary of the proceedings and findings of Canadian Exploration's geological staff with regards to their study of the Baymag magnesite deposit. This study has been predominately field oriented with most of the emphasis being placed on obtaining diamond drill core samples of the magnesite. Geological mapping of a portion of the claim area and chip sampling of promising stratigraphic horizons were also carried out. Laboratory-type investigations of this mineral deposit were oriented either towards completing the mineral inventory for the deposit or towards solving a specific geological problem. Ongoing metallurgical investigations by Canadian Exploration's engineering staff are not herein reported in detail.

SUMMARY

Canadian Exploration Limited continued the magnesite exploration program initiated by Baykal Minerals Limited.

The magnesite occurs in the Cathedral Formation of Middle Cambrian age. It was originally deposited as the hydrous carbonate, hydromagnesite, in lagoons surrounded by supralittoral algal flats.

The deposit lies on the west dipping limb of a broad anitcline. The bed strikes north 30 degrees west and dips southwest at 20 to 40 degrees. Major faulting has not been recognized.

"BQ" size diamond drilling was continued on the Rok claims with a total of 7,287 feet cored. Geological reserves based on this drilling and earlier drilling are 10,413 x 10^3 tons with an average grade of 97.15 percent MgO at 96 percent MgO cut-off.

A bulk sample of this deposit was obtained using diamond drilling equipment which had six inch diameter coring capabilities. Six inch core drilling totaled 1,580 feet which yielded approximately 20 tons of sample.

"BQ" size drilling was also carried out on the VANO claims. This work was to test known magnesite outcrops and to fulfil assessment requirements. The footage drilled was 1,800 feet. High grade magnesite was not penetrated.

In preparation for taking ground to lease, a legal survey was carried out between Mitchell River and Assiniboine Creek. Twenty-three claims and fractions were surveyed into four lots.

PALEOGEOGRAPHY

Lower Cambrian sedimentation in southeastern British Columbia and southern Alberta was restricted to the narrow Cordilleran Trough (Figure 5). This was a shallow north west trending marine seaway. It was bounded on both the east and the west by land masses of very low relief.

Gentle downwarping of the eastern land mass began during early Cambrian time and continued intermittently during the Paleozoic. During middle Cambrian time the Lloydminster Embayment came into being as a direct result of this downwarping.

The Lloydminster Embayment was a broad shallow feature. Sedimentation in the eastern half was dominated by clastic sediments derived from the Canadian Shield (Figure 6). A narrow band of similar clastic sediments was deposited adjacent to the western land mass and "Montania" the southern land mass. The central portions of the basin were dominated by a carbonate depositional regime.

The western edge of this carbonate province was a broad intertidal to supertidal algal carbonate platform. The Baymag magnesite occurs in rocks of this facies.

Between the western land mass and the algal carbonates, a shallow shale basin existed. Deposition here was controlled by tidal currents. Maximum water depth was probably never more than a few feet.

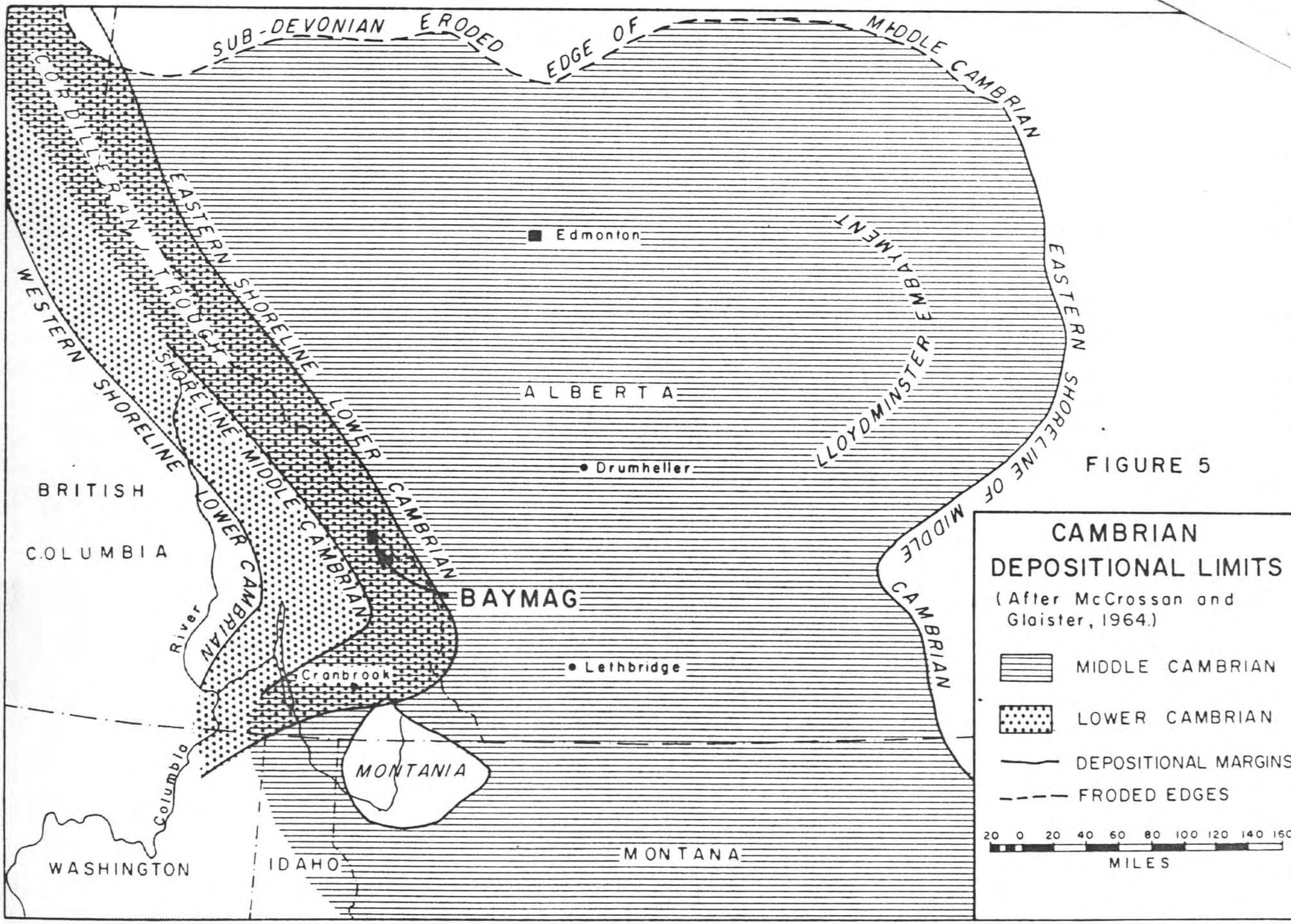
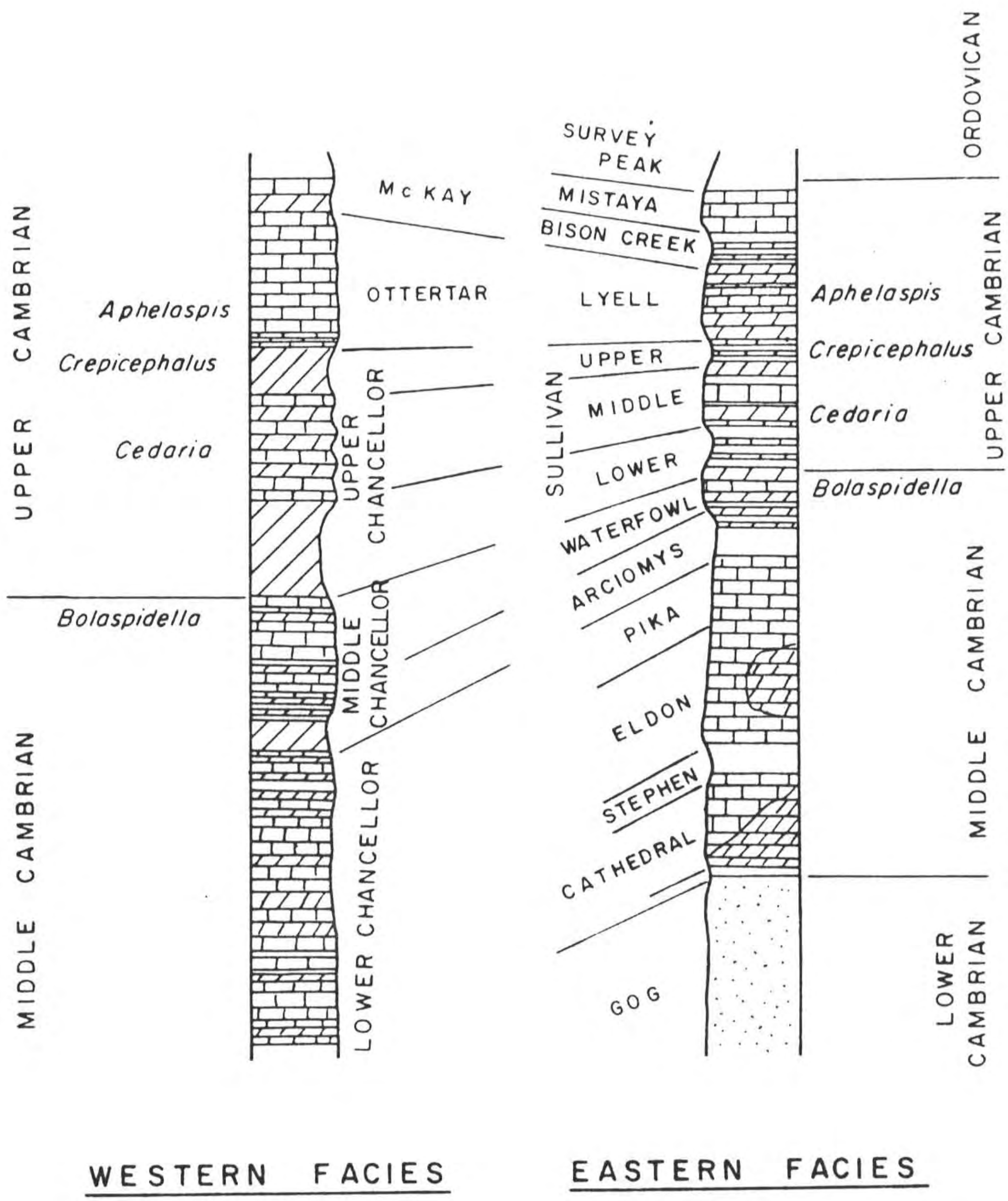

SUB-DEVONIAN ERODED EDGE OF MIDDLE CAMBRIAN
CORDILLERAN TROUGH
EASTERN SHORELINE LOWER CAMBRIAN
WESTERN SHORELINE LOWER CAMBRIAN
SHORELINE MIDDLE CAMBRIAN
LLOYDMINSTER EMBAYMENT
EASTERN SHORELINE OF MIDDLE CAMBRIAN
Edmonton
ALBERTA
Drumheller
BRITISH COLUMBIA
BAYMAG
River
Columbia
Cranbrook
Lethbridge
MONTANIA
WASHINGTON
IDAHO
MONTANA
CAMBRIAN DEPOSITIONAL LIMITS
(After McCrossan and Glaister, 1964.)
MIDDLE CAMBRIAN
LOWER CAMBRIAN
DEPOSITIONAL MARGINS
FRODED EDGES
20 0 20 40 60 80 100 120 140 160
MILES

FIGURE 5



CORRELATION CHART

From Cook (1970)

FIGURE 7

Mount Whyte Formation: Conformably overlying the Gog Group is the Mount Whyte Formation. This formation is well exposed only in the Assiniboine Creek drainage. In the Mitchell River valley, the Mount Whyte is covered by talus.

The sediments comprising this formation are approximately 175 feet thick. The lower most units are light grey weathering calcareous shales. They occur in thin bedded units and typically exhibit only poorly developed fissility. Outcrops with well developed fissility do exist. By gradual increase in the carbonate content, these shales become very fine grained argillacious limstones. Near the top of the section oolites comprise a significant portion of the rock. These oolites have few grain to grain contacts and are best described as floating in a matrix of pelitic carbonate mud. Bedding near the top of this section is intensely deformed in what have been interpreted as structures produced by soft sediment deformation.

Cathedral Formation: Rocks immediately overlying the Mount Whyte Formation are the massive dolomite and magnesite beds of the Cathedral Formation. The nature of the contact between the two formations is obscured first by the soft sediment deformation in the Upper Mount Whyte Formation, secondly by the total recrystalization of most Cathedral carbonates, and thirdly by the strikingly different responses of the two formations to tectonic events. Based on evidence presented by other workers in this Cambrian section, it is assumed that the contact is conformable.

The total thickness of the Cathedral formation at Baymag is not known with any degree of certainty but is estimated to be between 1,200 feet and 1,550 feet.

Megacrystalline dolomite and magnesite comprise in excess of 60 percent of the Cathedral Formation at this locality. The original sediment has been almost totally recrystallized so that the fundamental nature of the sediment has been obscured. The megacrystalline magnesian carbonates occur in two bed-like masses which are separated by 200 to 300 feet of thin bedded dolomites and limestones. Megacrystalline magnesian carbonates occur only along the western boundary of the carbonate facies (Aitken, 1966).

These megacrystalline carbonates are the magnesite hosts and will be discussed in more detail in another section of this report.

Lenses and irregular shaped masses of unrecrystallized dolomite and dolomitic limestone occur infrequently within the magnesite. These are thin to medium bedded, light grey, fine crystalline dolomite or

....

limestone. Invariably close inspection of weathered surfaces reveals the presence of organic structures. These structures are of three types: algal laminates, stromataloidal, and stromatactoidal.

Algal laminates are characterized by thin discontinuous laminae of light coloured, micro-vuggy dolomite in a matrix of fine crystalline dolomitic limestone. These are usually found in close association with stromatolite fossils and rocks displaying stromatactoidal structures. Algal laminates are often draped over the convex upper surfaces of stromatolites.

The stromatactoidal structure occurs in thin beds where closely spaced irregular vuggy bands of fine crystalline dolomite meet the bedding planes at an angle of 30 to 60 degrees. Superficially this resembles planar cross lamination. The structure is obvious only on weathered surfaces and, in most cases, even close inspection fails to reveal the structure on fresh broken surfaces.

These lenses and masses of fine crystalline carbonates are relatively small in all dimensions. The lenses are relatively thin with maximum thicknesses of 5 to 20 feet, with most occurrences in the five to eight feet range. Widths range from a few feet to a few tens of feet for those beds that are totally exposed. In a few cases, the thicker beds which are not completely exposed can be traced in outcrop for 200-300 feet. These may be wedge-shaped interbeds with surrounding carbonate facies.

The lower surfaces of these sedimentary masses are usually planar or nearly planar. Where in contact with megacrystalline carbonates, the upper surfaces are not usually distinct, the transformation between lithotypes being gradational in both chemical and textured aspects. The lateral contacts are similar to the upper contacts in the respect that they are gradational; however, distinct interbeds of megacrystalline carbonates are occasionally observed. Bedding surfaces within the fine crystalline carbonates are frequently marked by a double layer of subhedral to euhedral megacrystalline magnesian carbonate grains.

Between the two megacrystalline magnesian carbonate beds and overlying the upper megacrystalline bed are strata of fine crystalline carbonates. These recessive weathering strata are in each case 200 to 300 feet thick.

These strata are thin to medium bedded fine crystalline dolomites and dolomitic limestones. Many of thes carbonates are argillaceous. Relic fossils or organic structures identical to those reported in

....

the preceding paragraphs are the most common features to be observed in these rocks.

Stromatolite bioherms 20 feet across and 10 feet thick occur in several outcrops. These are the most striking of the fossils, but are volumetrically relatively unimportant when compared with the algal laminates.

Algal laminates in a matrix of very finely crystalline carbonates comprise the bulk of these strata. The percentage of algal laminate varies from bed to bed. Some beds contain as much as 50 percent visible algal laminae while other beds are virtually devoid of visible algal material.

Local accumulations of flat pebble calcirudite occur in several localities. The clasts are of two types, one being algal laminate flakes and the other carbonate mud flakes. The origin of the algal laminate flakes is obviously the erosion of algal laminate beds near the site of calcirudite deposition. The carbonate mud flakes show little in the way of internal lamination or other structures. These flakes are in some cases greater than 25 cm. in diameter and less than 3 cm. thick. Flakes of this type would rapidly break down during transportation. Their shape, therefore, precludes a remote provenance. These flakes could be algal laminate but if this were the case, at least some of the flakes should show distinct algal laminate structure. As these do not, another origin must be considered. Indistinct polygons were observed on bedding planes at a few localities. These polygons could be either syneresis cracks or dessications cracks. The second origin is favoured by this writer. Such dessication features could easily be the origin of the flat non-laminated clasts found in certain flat pebble calcirudites.

The last important lithotype in the Cathedral Formation at Baymag is the oolite. Oolites are found as minor constituents in many of the fine crystalline beds. In a number of places, oolites were observed to be spread over bedding planes in layers one or two ooliths thick. In certain of these instances, soft sediment deformation was observed only because of the bedding plane trace of oolites. Near the northeastern boundary of the Baymay property, beds of oolite become quantitatively important in the zone between the megacrystalline strata. The oolites ranging in size up to about 6 cm. occur in moderately sorted beds several feet thick. The total thickness of oolite beds is not known but is probably less than 25 feet. These distinctive beds are not exposed either along strike or to the dip. Distribution is therefore assumed to be local.

....

Stephen Formation: This is the stratigraphically highest unit that was studied at Baymag. The contact with the underlying Cathedral Formation is gradational. The Cathedral Formation fine crystalline carbonates become thin bedded and argillaceous near the top. Pelitic partings between carbonate laminae become common. Within a few stratigraphic feet of the lowest pelitic parting, there is an abrupt change from dominately carbonate to exclusively pelite deposition. The lower-most shales are maroon to red in colour and are followed stratigraphically by fissile green shales.

No attempt was made to study this formation in detail as it was stratigraphically distant from the important magnesite strata. The distinctive lower shale did serve as a mapping marker horizon during this study.

Western Facies

Chancellor Formation: A single formation belonging to the western facies outcrops in the vicinity of the Baymag property. This is the Chancellor Formation. Only the lower Chancellor outcrops in the area. It contains beds correlative with eastern facies formations previously discussed. Lower Chancellor Formation thickness near Baymag was not determined, but Cook (1970) estimated its thickness to be 3,500 feet in the Mount Stephen-Mount Dennis area. Cook (1970) states "Strata of the Chancellor Formation appear to be at least twice as thick as their correlatives in the eastern facies. Much of this thickening is probably a result of penetrative plastic deformation resulting from horizontal compression". The same is probably true at Baymag.

Chancellor Formation strata are predominately dark grey to black shales. Thin to medium thick beds of black argillaceous dolomite and black dolomitic limestones outcrop at several localities along Mitchell River. At one locality black shales and thin bedded, black, argillaceous stromatactoid dolomites and similar limestones are intimately interbedded through a stratigraphic thickness of several hundred feet. Along strike these lithotypes intergrade one with the other.

....

REGIONAL STRUCTURE

Structural features in the vicinity of the Baymag property can be divided into two suites of structures. Each suite is related to the contrasting deformation styles of the two sedimentary facies in response to horizontal compression. In both facies, most structures trend between north 20 degrees and 30 degrees west.

Massive carbonate rocks of the eastern facies lie in broad, northwest trending, concentric folds. These have wave lengths measured in miles but relatively small amplitudes. Neither thrust faults nor transverse faults of large displacement have been definitely identified in rocks of the eastern facies. A zone of complex structure in Cross River valley, south of the Baymag claim group is believed to be associated with a west dipping thrust fault. This fault has not been traced onto the Baymag property.

Horizontal compression of the western facies pelites against the buttress-like eastern facies carbonates has resulted in a narrow zone of intense deformation. This deformation is confined to western facies rocks adjacent to the facies boundary. These rocks have undergone extreme plastic deformation. Stratigraphic thicknesses have apparently been increased by a factor of two and perhaps even more.

Fold style is demonstrably disharmonic. Attitudes of axial planes range from vertical through recumbent, with most being overturned to the east. Trends of axial traces are variable but average between north 20 degrees and 30 degrees west.

Low angle faults of the thrust-type can be identified in cliff faces along Mitchell and Cross rivers. These faults are west dipping, and they cross bedding planes at low angles. Most are known from a single locality. Continuity of faults between outcrops cannot be demonstrated. It is expected that some of these low angle faults cross the east-west facies boundary in shale tongues. This has not been recognized in the field.

....

DETAILS OF THE DEPOSIT

Onerous topography precludes mine development at Baymag except in two areas; along the Cross River upstream from its confluence with the Mitchell River and between Mitchell River and Assiniboine Creek.

Along the Cross River suitable grade magnesite has not been found. Therefore, this area is no longer considered promising for mine development.

Between Assiniboine Creek and the Mitchell River, two megacrystalline carbonate beds outcrop. The lower of these two megacrystalline beds has the greatest potential for economically viable development at Baymag. Hence, virtually all study and consideration has been applied to this unit. The following discussion deals specifically with the lower megacrystalline unit; however, the mineralogical information which follows is generally true for the upper megacrystalline bed also.

Geometry

The actual geometry of the lower megacrystalline unit has not been defined due to lack of exposure and incomplete penetration of the unit by diamond drilling. Interpretation of exposures in the Assiniboine Creek drainage indicates a wedge shaped geometry with the thin edge of the wedge to the east of the drill pattern. Calculations based on the thickness of magnesite penetrated by diamond drill hole C-22 and dips taken on limestone beds within the drill pattern indicate a maximum magnesite thickness in excess of 400 feet. Magnesite is not exposed west of the drill pattern. Exposures along Mitchell River, one quarter mile west of the drill pattern, are thin bedded shales and carbonates of the Chancellor Formation. Exact stratigraphic equivalence of the Mitchell River exposures and the magnesite can not be demonstrated. Therefore, the geometry of the western edge of the magnesite is undefined.

Along the strike of the lower megacrystalline carbonate bed, the only exposures of the unit are on Mount Brussilof approximately three-quarters of a mile to the south. Here at the same stratigraphic interval, several lenses of magnesite occur in a thicker section of megacrystalline dolomite. These lenses have maximum exposed thicknesses of 20 to 70 feet. Due to the cliff forming nature of the rock, it is not practical to "walk out" exposures of magnesite. However, interpretation of observations made at intervals along strike indicates that the thicker lenses have a north-south lateral extent of 1,000 to 3,000 feet.

....

The above observations compare well with observations made by Aitken (1966). He states "Megacrystalline dolomite is invariably white. It occurs in lensoid masses 3 to 70 feet thick, and rarely more than ten times broader than thick, and consists of crystals ranging up to 5 centimeters and more on the edge."

Deductions based on the above observations would give the Baymag deposit a lens like cross-section with a maximum thickness of approximately 400 feet and lateral extent of one to two miles on the north-south axis and less than one mile on the east-west axis.

Mineralogy

The following paragraphs describe minerals which have been identified at Baymag and their occurrences. Table II is a summary of this data.

Magnesite: Quantitatively, magnesite is the most important mineral in the Baymag deposit. Within each lens, it occurs in discrete masses of irregular shape separated by pyrite rich bands. The shape and grain size of these masses is dependent upon physical conditions at the time of recrystalization.

Grain size varies from mass to mass. It is, in fact, the most easily discernable megascopic difference between two adjacent magnesite masses. Range in grain size is from approximately 1 mm. to 3 cm. Close inspection and staining frequently disclose differences in intergranular dolomite content between masses. Presumably other minerals will also show strong quantitative variations across these boundaries.

Magnesite in all of the masses exhibits granoblastic texture composed of sub-equigranular but unequidimensional crystals. Grain size of magnesite crystals within any one mass shows a narrow to moderately wide distribution about the median for that mass. Median grain sizes range from approximately 1 mm. to 2.5 cm. A statistical analysis of grain size distribution has not been undertaken; however, the most commonly reported grain size lies in the range 0.5 cm. to 1.0 cm.

Microprobe analyses of Baymag magnesite crystals have proven this magnesite to have a narrow compositional range. This compositional variation has a mean of 97.63 percent MgO and a standard deviation

....

STRUCTURE OF THE DEPOSIT

Geological structure underlying the area which has been drilled has not been closely defined. The massive magnesite outcrop gives no indication of bedding attitude. Outcrops of associated beds from which attitudes can be taken, occur only in a small area at the south end of the magnesite outcrop (Figure 8 and Appendix A). Complete penetration of the magnesite by drilling has been affected only near the southern edge of the drill pattern.

The magnesite appears to strike approximately north 30 degrees west and dips to the southwest at 20 to 40 degrees.

Major joints occur at intervals of several feet. The best developed is a set of extension joints with a strike of north 60 degrees east and vertical dip. A second set of joints is nearly as well developed. These have an average strike of north 30 degrees west. Their dip is vertical. These are thought to be release joints which are parallel to major fold areas of the region. A third set of joints does exist but is relatively unimportant when compared with the previously listed sets. These are sheeting joints oriented at approximately north 40 degrees west with 35 degree dip to the southwest.

....

GENETIC HYPOTHESIS

Megacrystalline magnesian carbonates occurring in the Middle Cambrian deposits of the Lloydminster Embayment do not preserve sedimentary structures or other sedimentary features yielding evidence concerning their genesis. It is therefore necessary to use associated sediments and sedimentary structures to determine the environment of deposition. This information coupled with deductions from mineralogical data and data concerning the geometry of the deposit should allow an adequate definition of the deposits genesis.

Sediments stratigraphically enclosing the megacrystalline carbonates are in almost all cases dolomitic limestones with fossil algae or stromatolites. Sedimentary structures within these rocks are small ripple marks, dessication cracks, and embricated flat pebble conglomerate. Both sedimentary lithotypes and sedimentary structures are shoal water to supratidal assemblages.

These rocks are believed to have been deposited on a carbonate bank. The top of this bank being exposed at low tide, and large portions of it being submerged only during spring tides.

Dolomitization of these beds is irregular. Certain beds are totally dolomitized while others are only mottled with dolomite. The dolomite in these beds is consistently fine grained and contacts with unreplaced rocks are generally gradational.

The megacrystalline carbonates are spatially distributed along the western edge of the bank facies. This fact coupled with the sharp contacts between algal limestones and megacrystalline carbonates and the fine crystalline texture of algal carbonates indicate the megacrystalline carbonates originated in a unique sedimentary environment.

The textural differences between these carbonates indicates that the primary carbonate minerals deposited in the two types of beds were different. The coarse textures developed in the megacrystalline lithotypes points to a metastable primary carbonate.

The work of Alderman (1959) and Alderman and van der Borch (1960, 1961, 1963) in Australia has resulted in an understanding of magnesian carbonate sedimentation. They found mixtures of magnesite with dolomite and aragonite with hydromagnesite ($Mg_4\ (OH)_2(CO_3)_3\ 3H_2O$) being deposited in the shallow hypersaline lagoons of South Australia. Physical parameters of the environment are temperature which range up to 30 degrees C,

....

and higher, pH greater than 9 and salinities up to and exceeding 14 percent. Mixtures of hydromagnesite and aragonite are deposited from water which is unique in that it has been altered to an unusually high carbonate-bicarbonate content by perculation through porous carbonate sediments.

The genesis of the Baymag magnesite deposit is intimately related to the initiation of carbonate shoals during late Early Cambrian time. These shoals were produced by winnowing of fine clastics from coarse carbonate debris at depths above wave base and in areas distal from clastic sediment input sites (Figure 11). These carbonate shoals formed barriers which were subsequently occupied by algae. The algae tended to stabilize the barriers.

With the barrier thus established, basinal deposition in the vicinity of the barrier was divided into three regimes:

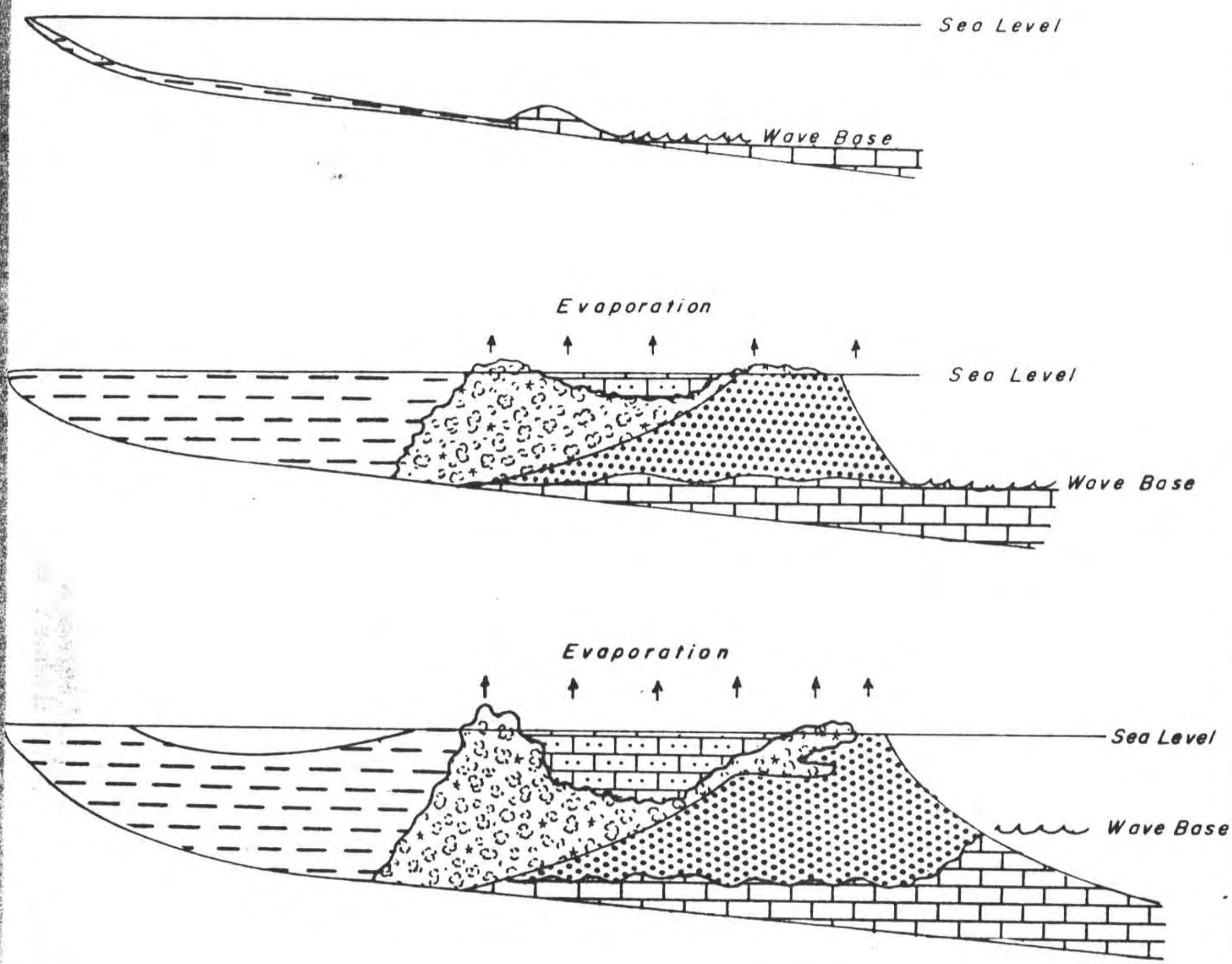
1. An eastern regime dominated by coarse-grained carbonates including oolites;
2. a western regime characterized by fine-grained clastic detritus;
3. a central area of tidal and supratidal carbonate flats dominated by algal derived carbonate and hydrous chemical precipitates concentrated in hypersaline lagoons.

Figure 12 demonstrates the author's conception of the spatial distribution of facies.

The Sediment

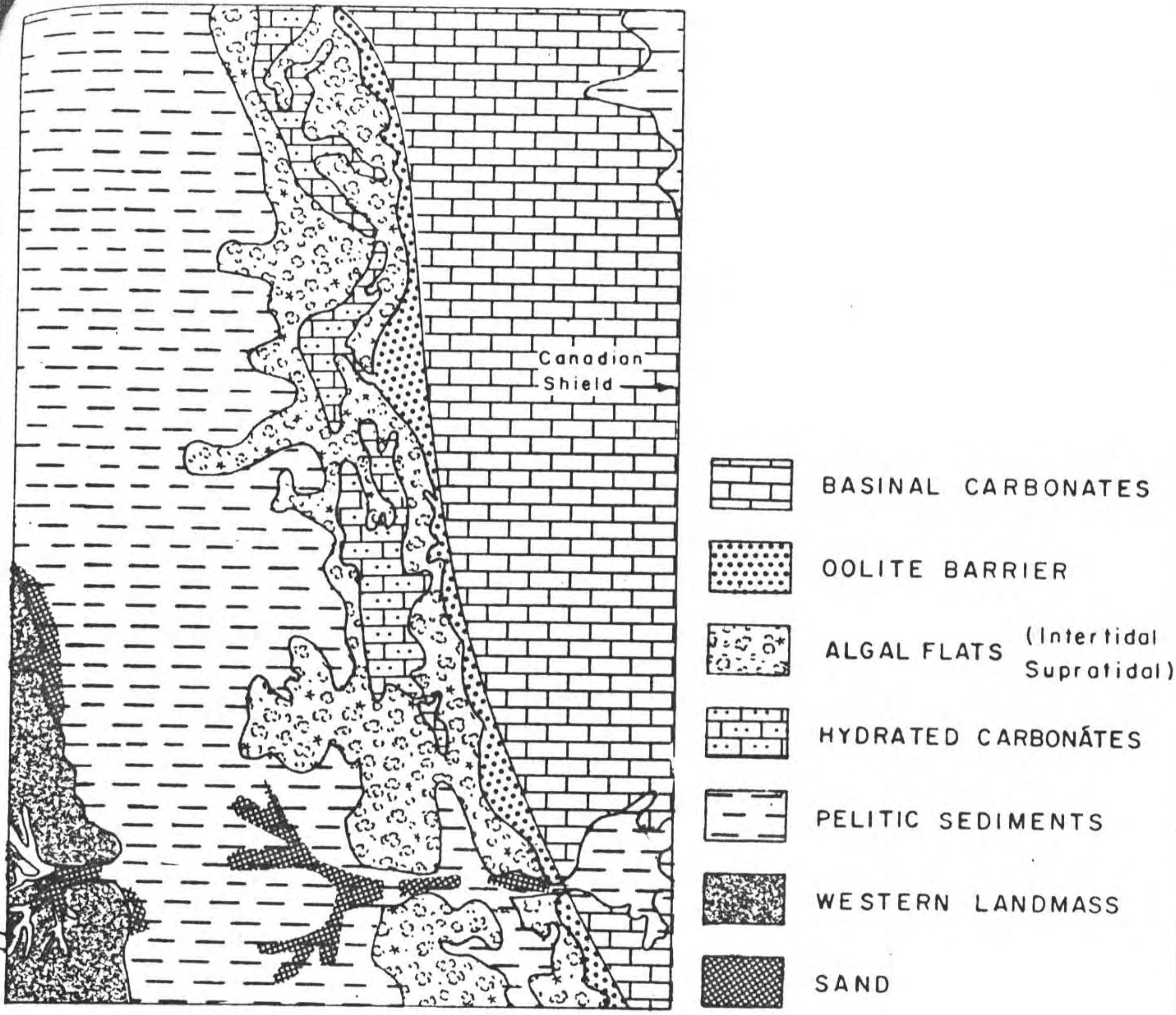
Hydrated carbonates within the lagoons would be magnesium carbonate rich. Contamination, in terms of lowering the magnesium carbonate content, would be by calcium carbonate contribution from the lagoon edges and occasional incursions of water with higher calcium content. In either case, alteration during diagenesis by magnesium rich pore fluids would push the bulk composition of the deposit towards the magnesium end point. Grade of the individual magnesite lenses would be dependent upon the balance between calcium input into the system and the ability of the pore fluid to exchange magnesium for calcium in the sediments.

....



Sections Illustrating Generation of Carbonate Barrier with Hypersaline Lagoons

FIGURE 11.



Diagrammatic Reconstruction of Sedimentary Facies in Plan View

FIGURE 12.

Primary Features

Sedimentary loading and burial with concommitant increase in temperature and pressure would initiate recrystallization and alteration. Loss of molecular water during recrystallization would alter hydromagnesite to magnesite and dolomite. The final product of recrystallization would be a magnesite plus dolomite solid solution in equilibrium with pore fluids and temperature. The higher the temperature the greater the quantity of dolomite that can be accommodated in the solid solution (Harker and Tuttle, 1955).

Under conditions of elevated temperature molecular water in the hydromagnesite would promote development of coarse crystalline textures. Hence coarse crystalline magnesite-dolomite would be the final product.

Textural evidence indicates that silica, alumina, and iron combined with the magnesia rich pore fluid during recrystallization. This resulted in the formation of talc, phlogopite, muscovite, and leuchtenbergite as constituent minerals.

Secondary Features

Folding followed by unloading due to erosion and concomitant lowering of temperature resulted in new equilibrium assemblages of carbonate minerals. As the temperature of the rocks was lowered during uncovering the magnesite-dolomite solid solution was no longer in equilibrium and exsolution of dolomite took place. Exsolution features are well illustrated in the report by White (1972). Silica and alumina rich fluids entered new fractures in the massive rock and quartz along with sericite was deposited in these fractures.

Weathering

Continuation of erosion eventually culminating in exposure of the deposit was accompanied by many changes within the deposit. Oxidizing ground water altered pyrite to limonite in surficial areas. Oxidation of the pyrite resulted in ground water with a low pH. This water produced solution features which later became the sites of dolomite and quartz deposition. At the time of exposure in outcrop, limonite and clay were transported from the surface along open fractures to moderate depths. These minerals were carried as much as 200 feet below the surface. Palygorskite and huntite were locally deposited from surficial water descending along these fractures.

REFERENCES

Aitken, J.D. (1966) Middle Cambrian to Middle Ordivician Cyclic Sedimentation, Southern Rocky Mountains of Alberta; Bull. Can. Petrol. Geol., v. 14, pages 405-441.

Alderman, A.R. (1959) Aspects of Carbonate Sedimentation; Jour. Geol. Soc. Australia, v. 6, pages 1-10.

Alderman. A.R. and Von Der Borch, C.C. (1960) Occurrence of Hydromagnesite in Sediments of South Australia; Nature, v. 188, page 931

Alderman, A.R. and Von Der Borch, C.C. (1961) Occurrence of Magnesite-Dolomite Sediments in South Australia; Nature, v. 192, page 861

Alderman, A.R. and Von Der Borch, C.C. (1963) A Dolomite Reaction Series; Nature, v. 198, pages 465-466

Cook, D.G. (1970) A Cambrian Facies Change and its effect on Structure, Mount Stephen - Mount Dennis Area, Alberta - British Columbia; Geol. Association Can., Special Paper Number 6, pages 27-39.

Harker, R.I. and Tuttle, O.F. (1955) Studies in the System $CaO-MgO-CO_2$, Part 2, Limits of Solid Solution Along the Binary Join $CaCO_3-MgCO_3$; Am. Jour. Science, v. 253, pages 274-282.

Leech, G.B. (1965) Kananaskis Lakes, W. ½ Area; in Report of Activities May to October, 1965; Geol. Serv. Can., Paper 66-1.

Luteijn, A. (1972) Baymag - Visit to Property and Reserves, September 1972; Placer Development Limited inhouse report.

McCrossan, R.G. and Glaister, R.P. (eds.) (1964) Geological History of Western Canada; Alberta Soc. Petrol. Geol., Calgary Alberta, 231 pages

White, G. P.E. (1972) Mineralogy of the Baymag Mines Ltd. Magnesite Prospect, South Kootenay Area, B.C.; Unpubl. report for Acres Western Limited

As. R. 6565

(M10)

6565

82J/13E

ASSESSMENT REPORT, YELO CLAIMS

CROSS RIVER - MITCHELL RIVER

AREA OF BRITISH COLUMBIA

Alice Payne Leech, P. Geol.

December, 1977

ASSESSMENT REPORT, YELO CLAIMS,

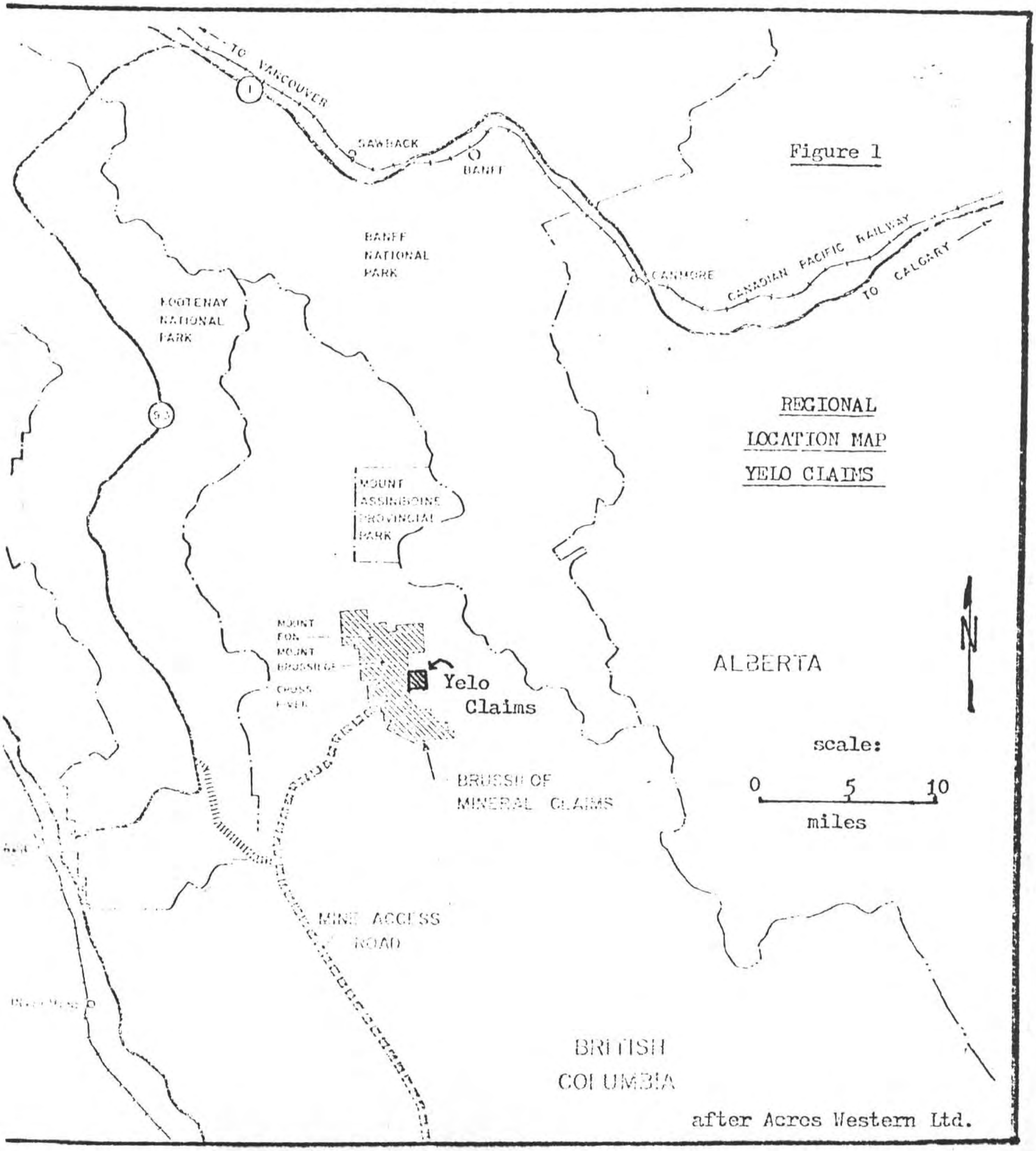
Cross River - Mitchell River Area of British Columbia.

INTRODUCTION

The occurrence of magnesite within the Middle Cambrian Cathedral formation in the Cross River - Mitchell River area (NTS maps 82J/13E and 82J/12E) has been well documented. The most useful references are 1) G.B. Leech's initial report following his discovey of the deposit in 1965 (Geological Survey of Canada Paper 66 - 1, 1966, pp. 65-66), 2) the feasibility study prepared by Acres Western Ltd. (Brussilof Magnesite Project Feasibility Study, Feb. 1971) for Baymag Mines Ltd., and 3) E.W. Grove's recent report for the B.C. Department of Mines (Summary Report on the Mt. Brussilof Magnesite Deposit, 1975).

Baymag Mines claims have been carefully located to cover most of the magnesite outcrops on the west flanks of Mt. Brussilof and Mt. Eon (Figure 1); portions of the area originally held by Baymag Mines Ltd. were allowed to lapse, and the Yelo Claims were staked adjacent and to the east of the Baymag group. Access to the Yelo claims was by helicopter, although it is possible to drive at least as far as the junction of the Cross and Mitchell rivers (Figure 2).

During reconnaissance of the area, preliminary samples were taken at several accessible outcrops of white crystalline carbonate rocks at localities along the Cross and Mitchell rivers. Sample locations are shown on Figure 2 and chemical analyses are included in Table 1 as a matter of interest.


TO VANCOUVER
1
SAWBACK
BANFF
Figure 1
BANFF
NATIONAL
PARK
CANMORE
CANADIAN PACIFIC RAILWAY
TO CALGARY
KOOTENAY
NATIONAL
PARK
93
REGIONAL
LOCATION MAP
YELO CLAIMS
MOUNT
ASSINIBOINE
PROVINCIAL
PARK
MOUNT
FON
MOUNT
BRUSSILOF
Yelo
Claims
ALBERTA
CROSS
RIVER
scale:
0 5 10
miles
BRUSSILOF
MINERAL CLAIMS
MINE ACCESS
ROAD
BRITISH
COLUMBIA
after Acros Western Ltd.

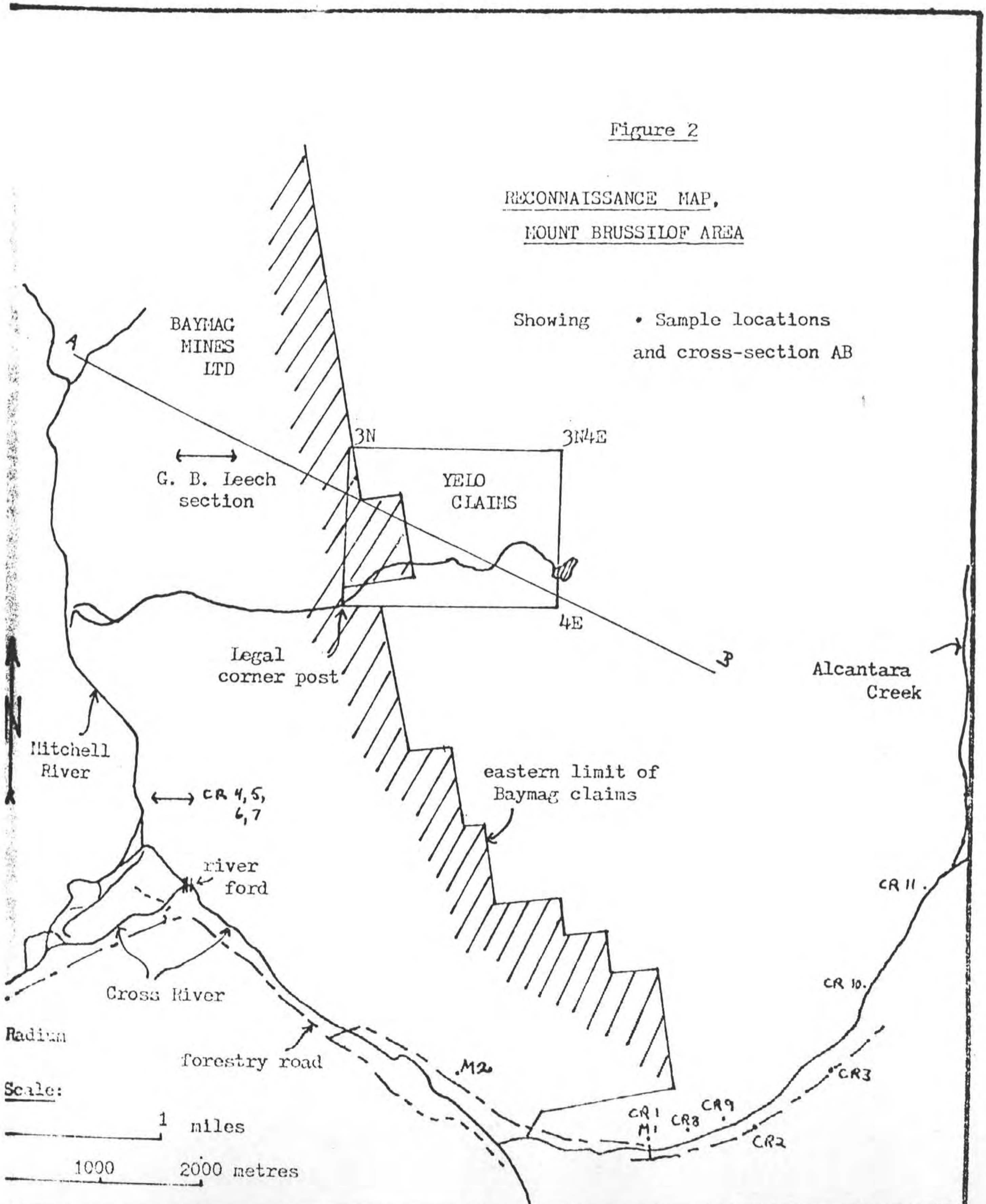


Figure 2
RECONNAISSANCE MAP,
MOUNT BRUSSILOF AREA
Showing • Sample locations
and cross-section AB
BAYMAG
MINES
LTD
A
3N
3N4E
G. B. Leech
section
YELO
CLAIMS
4E
B
Legal
corner post
Alcantara
Creek
Mitchell
River
eastern limit of
Baymag claims
CR 4, 5,
6, 7
river
ford
CR 11
CR 10
Cross River
Radium
forestry road
M2
CR3
CR 1
M1
CR8
CR9
CR2
Scale:
1 miles
1000 2000 metres
N

GEOLOGICAL INVESTIGATION, YELO CLAIMS

The thick, cliff-forming Middle Cambrian Cathedral formation outcrops throughout the Yelo claim. The 800' to 1800' thick formation consists of massive, silicious to argillaceous, fine to medium grained light to dark grey dolomite. Lenticular pods of pyritized coarse grained white or pinkish white dolomite also occur frequently, and these are easily confused with magnesite. Areas of brecciation occur throughout the formation, especially near recrystallization zones and possible fault zones.

Overlying the Cathedral formation, outcropping outside the boundaries of the Yelo claims, is the 90' to 350' thick Mt. Stephen formation, which consists of silicious shales, slates and the thinly bedded limestone which forms the highest peaks surrounding the valley of the Yelo claims. These outcrop pattern of these rocks is sketched on the accompanying map (Figure 3) because of their use in interpretation of structural features. The Mt. White formation, underlying the Cathedral and Mt. Stephen formations is not present in the area.

Sample locations and available geological data is shown on Figure 3, which was compiled from an enlarged air photo base of BC 7829 No. 143, included in the pocket. Figure 3 may be used as an overlay of the enclosed air photo enlargement.

Strikes and dips were taken where possible, but the carbonate rocks were generally massive and measurements were impossible except in the few locations shown. Detailed descriptions of the rocks are included in the sample description list in the Appendix, which may be used in conjunction with the maps; a typical section (Figure 4) may be seen looking north or east from the vicinity of the camp.

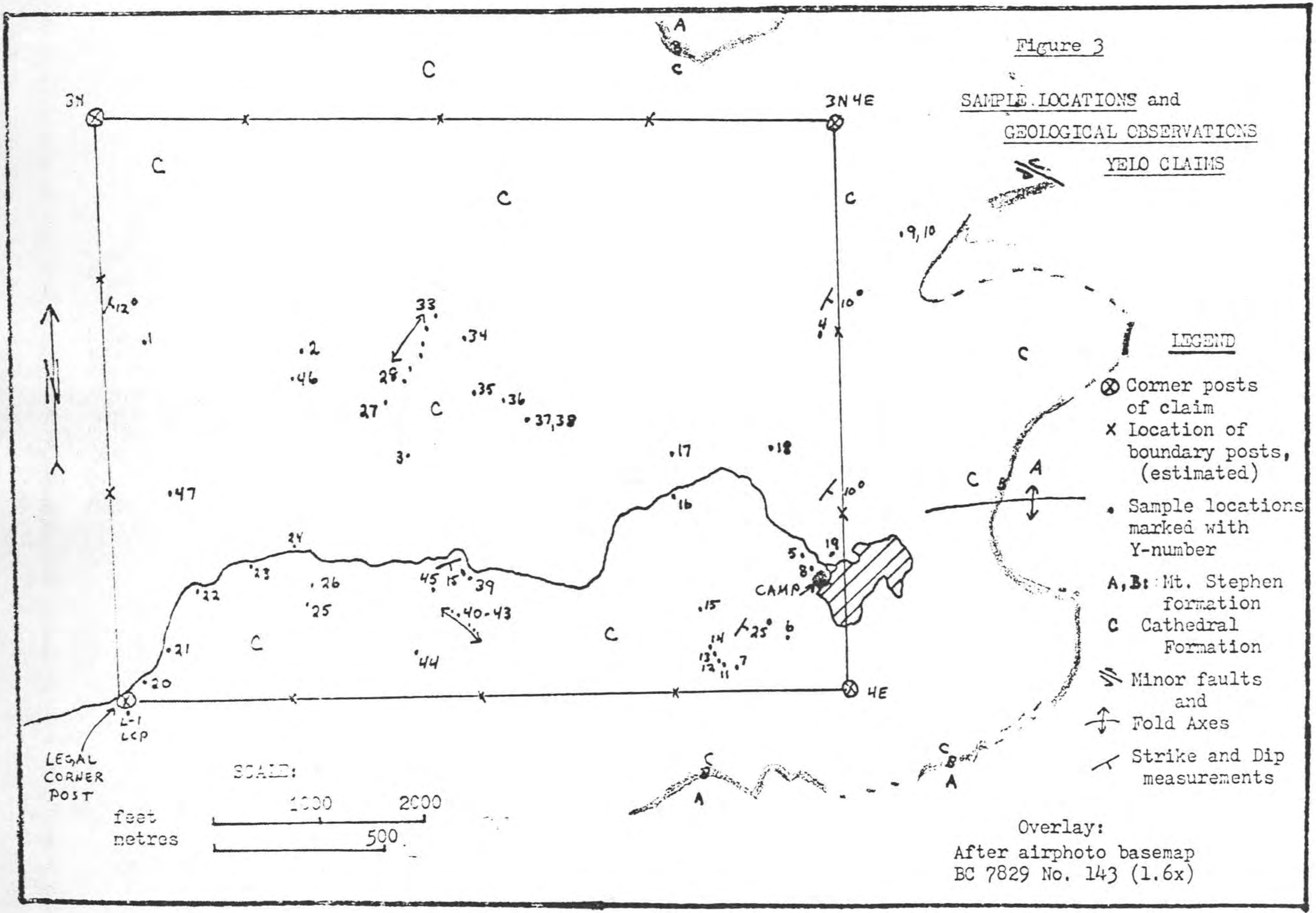


Figure 3
SAMPLE LOCATIONS and
GEOLOGICAL OBSERVATIONS
YELO CLAIMS
3N
3N 4E
4E
LEGAL CORNER POST
L-1 LCP
CAMP
LEGEND
⊗ Corner posts of claim
X Location of boundary posts, (estimated)
• Sample locations marked with Y-number
A, B: Mt. Stephen formation
C Cathedral Formation
Minor faults and Fold Axes
Strike and Dip measurements
SCALE:
1000 2000
feet
metres
500
Overlay:
After airphoto basemap
BC 7829 No. 143 (1.6x)

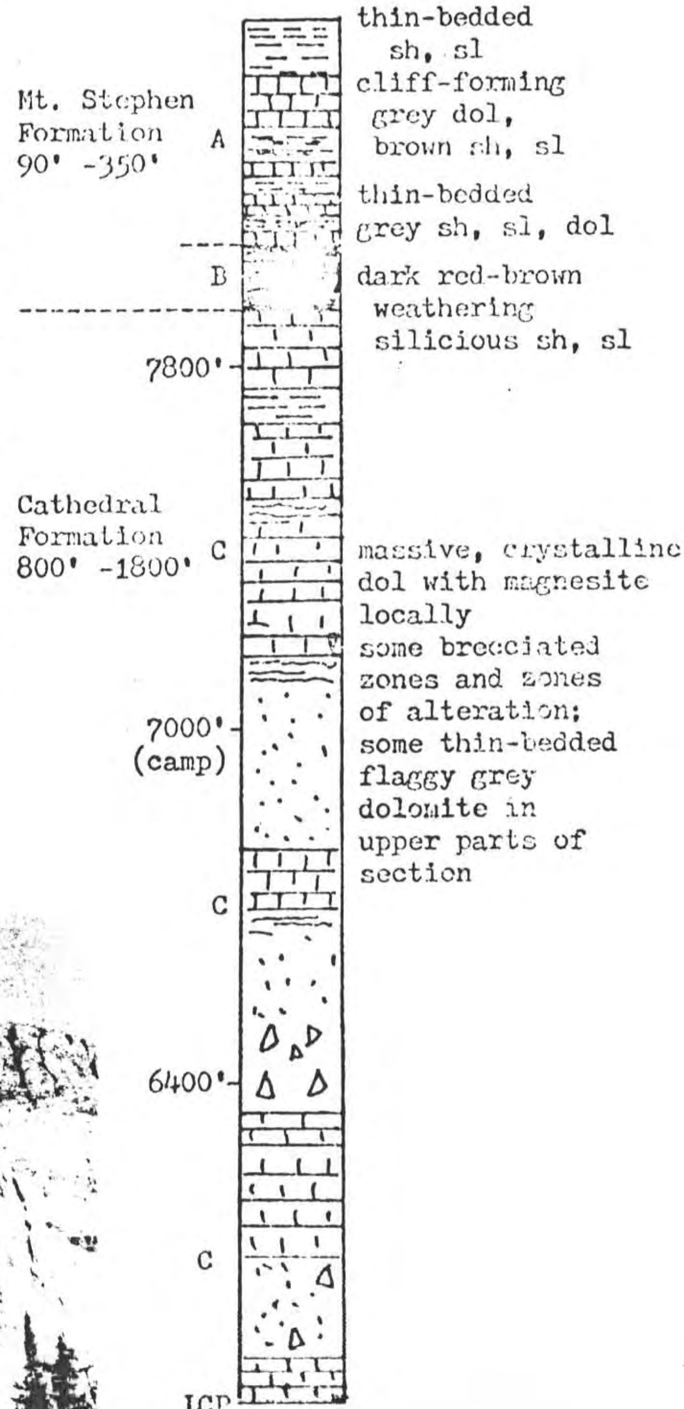
Figure 4

MIDDLE CAMBRIAN SECTION

YELO CLAIMS

Looking North from 4E to 3N4E

Looking East from Camp



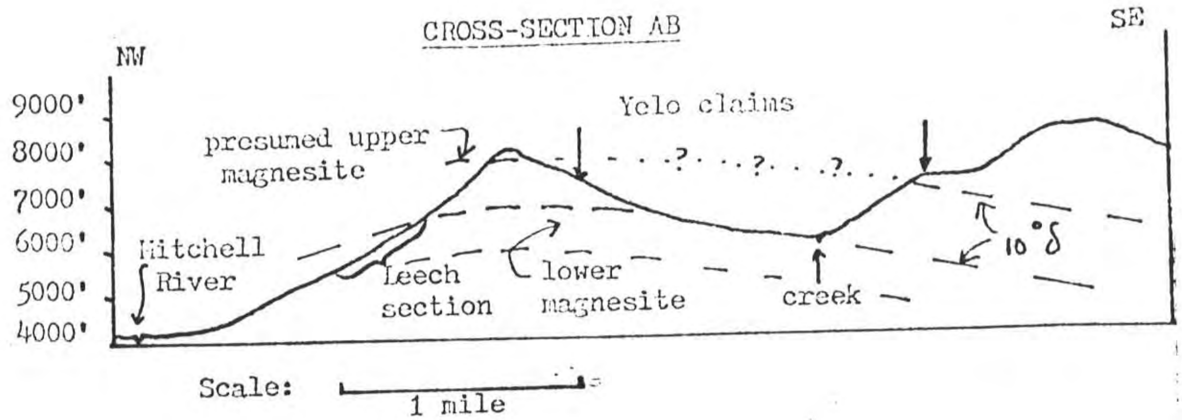
Samples were taken routinely at outcrops examined; where a profile was desired, rocks were sampled at 25' intervals (Y-11 to Y-15, Y-27 to Y-33). Sampling activities were limited by steepness or scree, but the walls of the valley were sampled, and outcrops in the creek bed. The valley floor was covered with rock debris and fans of scree extended well up the mountain sides. These (and the avalanche chutes) are easily distinguishable on the accompanying air photo enlargement.

Three areas of interest - areas of white crystalline carbonate rock within the ordinary grey dolomite of the Cathedral formation - were discovered and sampled on the Yelo claims. To the south of the creek in the southwestern portion of the claims, the outcrops were of fine to coarse grained, sugary, white, light grey or pink rocks, with many brecciated zones and some mottled grey banding. In another area north of the creek in the centre of the Yelo claim block, the outcrop of coarse pink, white and grey crystalline carbonate was heavily weathered and crumbly with buff weathered sand. The outcrop area extended up the slope, but the hoodoo-like bluffs steepened and could not be samples and scaled further to the north. A third area of interest was located at the southeast corner of the claim block, on the west face of the hill below the camp.

Using the field observations, a cross-section across the regional strike of the beds was constructed, and is shown below as postulated. Data is scanty; the section was drawn using the shallow 10° dips observed throughout the area, and assuming 40° as the average strike. The section (see Figure 2 and Figure 5) extends through the magnesite deposit zone described by Leech and across

Mt. Brussilof, intersecting the Yelo claims and extending towards Alcantara Creek:

Figure 5



The magnesite deposit on Mt. Eon, on which drilling and bulk sampling were carried out (see Acres report), has a strike of 30° and an average dip of 40°SW, and it occurs at about 5000' elevation. One of Leech's sections on the west side of Mt. Brussilof was taken on the crest of a gentle anticline, with the rocks dipping about 20° westerly, and once more the magnesite occurs at evevations from 5500' to 6550'. Within the Yelo claim, on the other limb of the anticline, dips are southeasterly and gentle, and beds may be traced laterally along the valley walls and across the creek bed, in spite of some faulting and gentle folding, as shown in the photos of Figure 4.

Thus, it was possible that the Yelo claims could contain extensions of the upper and lower magnesite zones mentioned in the Acres report; the top of the thousand foot lower section sampled by Leech might be present in the centre of the Yelo claims, while the upper magnesite zone outcropped at the eastern end of the claims.

ANALYTICAL RESULTS OF SAMPLING PROGRAM

Samples which looked promising in the field proved dolomitic in the laboratory. The sample locations are shown in Figures 2 and 3 and described (from the Yelo claim only) in the Appendix. For the sake of interest, the CR series of samples are included in this report with their analyses, although they were taken outside the Yelo claim block as part of a reconnaissance survey. Samples BM-1 and BM-2 were taken from the Baymag sampling dump, to be used as standard samples for analysis. M-2 was also taken for a standard.

Flame tests and acid tests (using acids of various strength for different time periods) developed for field use were not at all conclusive. In an effort to avoid chemical analysis of the samples, a specific gravity determination was used for the samples Y-5 to Y-47. The specific gravity determinations were based on a S.G. of 2.86 for dolomite and 3.0 to 3.1 for magnesite; diiodomethane (S.G. 3.0) was diluted with acetone until the gravity was exactly 2.9, and samples of dolomite crystals, Baymag magnesite, and M-2 were used as standards.

The results of the analyses for the samples are in the Appendix to this report. Y-7 was the only sample with a high MgO content; all the other samples proved disappointing. It was hoped that the chemical analyses would disprove the gravity results, and instead the negative results of preliminary tests were correct.

CONCLUSIONS

1. No magnesite of the required purity was found on the surveyed areas of the Yelo claim block.
2. It is possible that magnesite exists on the Yelo claim, beneath the valley floor. Because no magnesite was found in the scree, it is highly unlikely that there are any "upper magnesite" beds within the claim block.
3. There was no indication of continuity within the rocks of the Cathedral formation on the Yelo claims. Even if magnesite was present, it would have to exhibit greater consistency than the ordinary dolomites.

Respectfully submitted,

Alice Payne Leech

Alice Payne Leech, P. Geol.

December 30, 1977

R.M.HARDY & ASSOCIATES LTD. TECHNICAL REPORT

CONSULTING ENGINEERING AND PROFESSIONAL SERVICES

ANALYTICAL CHEMISTRY DIVISION

FILE EC 0074
DATE August 30, 1976.
CLIENT P.O.
C.C.

TO: Mrs. Alice Leech,
11618 - 75 Avenue,
EDMONTON, Alberta.
T6G 0J2

PROJECT: Analysis of Magnesite Samples

SUBJECT:

Sample Number	Magnesium Oxide (MgO) %	Calcium Oxide (CaO) %	Silicon Dioxide (SiO_2) %	Aluminium Oxide (Al_2O_3) %	Ferric Oxide (Fe_2O_3) %
A-1 *A-1*	26.7	37.2	< 0.0002	< 0.002	0.41
CR-1 *CR-1*	27.6	37.5	< 0.0002	< 0.002	0.81
CR-2 *CR-2*	29.7	35.4	< 0.0002	< 0.002	0.26
CR-3 *CR-3*	37.0	18.3	< 0.0002	< 0.002	0.18
3E-1 *3E-1*	28.3	35.3	< 0.0002	< 0.002	0.64
3E-2 *3E-2*	29.7	32.3	< 0.0002	< 0.002	1.15
L-1 *L-1*	27.8	39.7	< 0.0002	< 0.002	1.06
LCP *LCP*	32.6	29.7	< 0.0002	< 0.002	0.27
Y-1 *Y-1*	32.3	31.9	< 0.0002	< 0.002	0.22
Y-2 *Y-2*	35.3	41.3	< 0.0002	< 0.002	0.60
Y-3 *Y-3*	44.0	18.9	< 0.0002	< 0.002	0.99
Y-4 *Y-4*	28.6	33.4	0.41	0.86	0.61

Yelo Claims (handwritten bracket beside samples 3E-1 to Y-4)

Report Certified,

R. M. HARDY & ASSOCIATES LTD.,

Per: *[signature]*

R. Cowdrey, B.Sc.,
Laboratory Supervisor.

RC:ssj

91 STREET, P.O. BOX 746 T5J 2L4 EDMONTON, ALBERTA (403) 436-2152 TWX 610 831-1316
CALGARY DAWSON CREEK EDMONTON GRAND PRAIRIE LETHBRIDGE PRINCE GEORGE RED DEER WINNIPEG

R.M.H. DY & ASSOCIATES LTD. CHNICAL REPORT

CONSULTING ENGINEERING AND PROFESSIONAL SERVICES

ANALYTICAL CHEMISTRY DIVISION

FILE	EC 0076
DATE	September 3, 1976.
CLIENT P.O.	
C.C.	

: Mrs. Alice Leech,
11618 - 75 Avenue,
EDMONTON, Alberta.
T6G 0J2

OJECT: Analysis of Magnesite Samples

JBJECT:

ample umber	Magnesium Oxide (MgO) %	Calcium Oxide (CaO) %	Silicon Dioxide (SiO_2) %	Aluminum Oxide (Al_2O_3) %	Ferric Oxide (Fe_2O_3) %
R-4	53.5	10.7	< 0.01	0.20	0.41
R-5	41.0	29.6	< 0.01	0.05	0.17
R-6	90.7	6.4	0.82	0.62	0.23
R-7	36.5	29.7	< 0.01	0.05	0.16
R-8	29.7	37.7	"	< 0.002	0.46
R-9	33.2	35.8	"	"	0.73
R-10	30.1	33.1	"	0.05	0.02
R-11	31.0	34.3	"	"	0.25
BM? M-1 (< 170)	55.7	2.0	"	< 0.002	0.27
M-1 (> 170)	54.3	2.0	"	"	0.25
BM M-2	52.7	2.0	"	"	0.25

Report Certified,

R. M. HARDY & ASSOCIATES LTD.,

Per: [signature]

R. Cowdrey, B.Sc.,
Laboratory Supervisor.

RC:ssj

STREET, P.O. BOX 746, T5J 2L4 EDMONTON, ALBERTA (403) 436-2152 TWX 610 831 1316
CALGARY DAWSON CREEK EDSON GRAND PRAIRIE LETHBRIDGE PRINCE GEORGE RED DEER WINNIPEG

OF THE CHIEF ANALYST AND ASSAYER

THE GOVERNMENT OF THE PROVINCE OF BRITISH COLUMBIA

DEPARTMENT OF MINES AND PETROLEUM RESOURCES
VICTORIA

PLE RECEIVED FROM P. GROVE

RESS 2396 Barbara Place, Victoria, B. C.

ABORATORY No.	SUBMITTER'S MARK	LABORATORY RE...
34835	CR-1	MgO - 21.7% CaO - 31.1% Fe_2O_3 - 0.52% ± 0.02% CO_2 - 45.98%
34836	CR-2	MgO - 24.5% CaO - 27.7% Fe_2O_3 - 0.26% ± 0.02% CO_2 - 47.38%
34837	CR-3	MgO - 31.4% CaO - 19.2% Fe_2O_3 - 0.29% ± 0.03% CO_2 - 48.06%
34838	M-1	MgO - 39.9% CaO - 8.63% Fe_2O_3 - 0.35% ± 0.03% CO_2 - 49.61%
34839	M-2	MgO - 43.1% CaO - 4.55% Fe_2O_3 - 0.51% ± 0.04% CO_2 - 50.53%

September 8, 1976

BONDAR-CLEGG & COMPANY LTD. geochemists • assayers • analytical chemists

1500 PEMBERTON AVENUE, NORTH VANCOUVER, B.C. V7P 2S2
PHONE: 985-0681

OF Magnesite Analysis

REPORT No. IT26 - 143

DATE: October 26, 1976

TO Pat Grove
2396 Barbara Place
Victoria, B.C.

Sample: Y 7

Loss on Ignition = 50.2 %

Analysis of Ignited Material

SiO_2 = 2.50%

Fe_2O_3 = 1.18%

Al_2O_3 = 0.60%

CaO = 7.50%

MgO = 87.5 %

BONDAR-CLEGG & COMPANY LTD.

R. Sawyer
Chief Chemist

RS/sja

BONDAR-CLEGG & COMPANY LTD.
geochemists • assayers • analytical chemists
1500 PEMBERTON AVENUE, NORTH VANCOUVER, B.C. V7P 2S2
PHONE: 985-0681

RT OF Magnesium Determinations — REPORT No. IT27 - 57

CT: — DATE: April 29, 1977

RTED TO Mr. J.W. Ondrack
c/o International Brick & Tile
10910 Mayfield Avenue
Edmonton, Alberta T5P 4B6

Sample No.	% MgO	Sample No.	% MgO
Y11	42.0	Y31	60.2
Y12	42.2	Y32	68.0
Y13	43.5	Y33	64.3
Y14	42.5	Y34	45.0
Y20	62.5	Y35	45.5
Y21	42.0	Y36	50.2
Y24	41.2	Y37	47.3
Y28	58.0	Y38	46.0
Y29	68.4	Y41	47.4
Y30	63.6	Y42	47.7
		Y43	47.5

BONDAR - CLEGG & COMPANY LTD.

R. Sawyer
Chief Chemist

RS/yd

AS.R. 2048

(M10)

2048

82J/13E

PRELIMINARY GEOLOGICAL REPORT

ON THE

MAG 1 TO 36 MINERAL CLAIMS

LAT. 50° 50') - LONG. 115° 40'

MOUNT BRUSSILOF

RADIUM, BRITISH COLUMBIA

PROFESSIONAL ENGINEER
PROVINCE OF
O. BAYKAL
BRITISH COLUMBIA

Expiry Date: November 28, 1969

BY:

AUGUST, 1969

ORHAN BAYKAL, P. ENG., P. GEOL.

The area east of the Mitchell River fault appears to be gently folded and relatively undisturbed except for a small subsidiary cross-fault that extends eastward, dips to the north and displaces the magnesite beds. The prevailing strike of the beds in this area is about N 46° E with a gentle dip of 6° to 10° to the northwest. These beds form the west flank of a gently folded anticline the axis of which is almost at the eastern border line of the map-area.

ECONOMIC GEOLOGY:

According to the present interpretation of the geological and structural setting of the map-area, it appears that two major magnesite beds are present within the Cathedral formation.

The upper bed, called "A" bed in Figure 3, at sample Location 1, is about 250 - 280 feet thick and appears to be a massive homogeneous deposit of magnesite. This bed can be followed across the Mt. Brussilof's western face to the mountain found between Aurora Creek and Mitchell River. However in this area, this bed or zone, looses its homogeneous setting, becomes feathery and the magnesite beds of different thickness are thus separated by dolomite beds which are barren of magnesite.

The lower bed, called "B" bed, at sample Locality 2, is about 200 to 250 feet thick. The same as the upper bed, it appears to be a massive homogeneous deposit of magnesite. This bed could also be followed across the western face of Mt. Brussilof and into the same mountain found between Aurora Creek and Mitchell River. However, unlike bed "A", this zone appears to retain its massive and homogenous setting. In sample localities 3-4 and 5, the magnesite occurs again in massif form throughout a vertical distance of 250 feet. Consequently, it can be stated that the lower bed "B" is more continous and appears to retain its massif and homogeneous form across the western face of Mt. Brussilof to sample localities 3-4 and 5. The stratigraphic separation in between the two beds appears to be in the order of 450 to 500 feet.

The magnesite, is white to greyish and usually coarsely crystalline. At about sample locality 2, it becomes medium to finely crystalline, but becomes coarsely crystalline again at locality 3-4 and 5. On weathered surface, iron staining and disintegration take place. The disintegration causes the magnesite to crumble into separated coarse crystals giving the appearance of a magnesite "sand".

Sampling has been conducted on the magnesite beds by the Geological Survey of Canada, P. Sparks, R.W. Oddy, and the writer. The analyses of all the different samples have yielded the same type of results indicating a Magnesite, $MgCO_3$ content varying between 87% to 99%, possibly averaging 97% $MgCO_3$ (Appendix "A", "B" & "C" and Plate 2).

The Geological Survey analyses indicate for bed "A" at location 1, an $MgCO_3$ content of 98% to 99%. The sample collected by the writer yielded an MgO value of 46.33% and a CO_2 value of 51.29%, equivalent to an $MgCO_3$ content of 98.12%. Likewise, in sample localities 3-4 and 5, the $MgCO_3$ content was analyzed as being between 98.06% and 98.48% against a G.S.C. sampling by Leech of 99%. In the same area sample collected by R.W. Oddy gave an $MgCO_3$ content between 97.43% and 97.54% (Plate 3 & 4).

On examing assay of sample at location 1, it appears that the magnesite bed "A" has a higher Fe_2O_3 (Appendix A) content (0.94%) than the lower bed "B" (0.77% to 0.80%).

As far as the genesis of the magnesite deposit is concerned it appears that the deposit is of sedimentary origin. It was formed probably by the deposition of $MgCO_3$ from concentrated solution in a saline environment. The original solution could have been in form of magnesium sulphate reacting with sodium carbonate to yield insoluble hydrated magnesite which has been accumulated as a relatively pure $MgCO_3$ precipitate.

As far as the possible reserves are concerned it can be stated, at this stage, that about 10,000,000 tons of $MgCO_3$ can be recovered from this property by an open-pit mining method. The above figure will have to be confirmed by subsequent work. However, enough data has been collected to recommend a preliminary feasibility study which will include detailed geological mapping and systematic sampling. This operation will be followed, if warranted, by further diamond drilling and sampling, in order to outline an economic ore body.

SUMMARY:

The geological study that has been conducted on this property has indicated that two major beds of relatively pure magnesite occur within the Cathedral formation of middle-Cambrian age. The upper "A" bed is thought to be about 250 to 280 feet thick and the lower "B" about 200 to 250 feet thick. This lower "B" magnesite bed is considered to have a more homogeneous continuity than the upper "A" bed.

A possible reserve of about 10,000,000 tons of $MgCO_3$ can be expected to be recovered by open-pit mining method. This reserve would have to be ascertained through further detailed geological work and sampling on this property.

The investigation conducted to date fully justifies the next phase of the exploration which entails detailed geological study and systematic sampling of the magnesite deposit.

ORHAN BAYKAL, P. Eng., P. Geol.

MICAL & GEOLOGICAL LABORATORIES LTD.

4605 - 12th Street N.E. Calgary 67, Alberta

July 25, 1969

Appendix-A

Mr. O. Baykal
Baykal Minerals Ltd.
109, 718 - 8th Avenue S.W.
CALGARY 2
Alberta

Laboratory Number: C69-4910
Five Ore Samples for Analyses

Dear Sir:

As requested in your letter of July 9th, we give you the following:

ONTENT % WEIGHT	SAMPLE #1	SAMPLE #2	SAMPLE #3	SAMPLE #4	SAMPLE #5
gnesium Oxide (MgO)	46.83	47.02	46.48	46.66	47.01
lcium Oxide (CaO)	0.53	0.49	0.53	0.55	0.43
on Oxide (Fe_2O_3)	0.94	0.77	0.80	0.80	0.80
uminum Oxide (Al_2O_3)	0.10	0.10	0.10	0.10	0.10
lica Dioxide (SiO_2)	0.14	0.09	0.10	Nil	Nil
rbon Dioxide (CO_2)	51.29	51.52	51.58	51.82	51.44
id Insoluble (Most ely $BaSO_4$)	0.17	0.02	0.28	0.06	0.18
tal	100.00	100.01	99.87	99.99	99.96
	± 0.1%	± 0.1%	± 0.1%	± 0.1%	± 0.1%

Averaging the magnesium oxide on the five samples, we arrive at a magnesium carbonate that is 97.87% pure.

To the writer's knowledge this is the purest bulk sample of magnesite that has been analyzed. It is well worth investigating as the magnesium market is on an upswing and the large producers in the U.S.A. cannot meet the growing demands. Magnesium besides being 40% lighter than aluminum is worth 40% more.

Yours truly,

W. Morrison

W. Morrison

Appendix B

ANALYSIS OF SAMPLE

SUBMITTED BY F.R. SPARKS, P. ENG.

Those samples were collected from approximately the same areas as Localities 1 - 2 and 4, indicated in this report and shown in Figure 3.

CaO	1.35%	to	2.40%	
SiO_2	2.10%	to	2.10%	
Fe_2O_3	0.75%	to	0.75%	
$BaSO_4$	Nil		Nil	
Al_2O_3	0.2%	to	0.20%	
			5.45%	Traces
% $MgCO_3$			94.55%	Pure

Therefore % MgO (Magnesia) approx. 43.0%

GSC P66-1

42. KANANASKIS LAKES, W 1/2, AREA

G.B. Leech

Field work was completed during a partial field season devoted chiefly to the vicinity of the Rocky Mountain Trench. Further instances[1] of the stratigraphic control of thrust faults exerted by Devonian strata were recognized north of Whiteswan Lake and at various places in the Stanford Range from Canal Flats northward. On the other hand certain breccia zones, e.g. in the upper Lussier Valley, that had been interpreted as faults proved to be solution breccias in the Devonian sequence and to lack significant movement.

Magnesite in apparently major quantities occurs on the west flank of Mount Brussilof near the forks of Cross and Mitchell Rivers. The host rock is the Cathedral Formation of Middle Cambrian age. The magnesite occurs within masses of coarsely crystalline carbonate that weather lighter coloured than the surrounding carbonate formation. Magnesite outcrops commonly weather crumbly and yield a coarse "sand" of disaggregated crystals.

Grab samples were collected at roughly one hundred foot vertical intervals on traverses down the lower west flank of Mount Brussilof, across the strike of the formation, 1 3/4 miles and 2 1/4 miles respectively north of the junction of Cross and Mitchell Rivers. The samples were analyzed by J.L. Jambor at the Geological Survey with an X-ray diffractometer, using counting ratios compared to a curve based on various known mixtures of magnesite, dolomite, and calcite. The analyses, though reported to two significant figures, are within ±5 per cent limits.

Analyses of grab samples from the southern traverse, listed in order of elevation of sampling site are:

Approximate elevation	Per cent Magnesite
6,350	0
6,100	0
5,900	99
5,850	0
5,775	0
5,775	0
5,650	98
5,550	99
5,350	99
5,250	0
5,100	99
4,950	87
4,900	1-2
4,750	75
4,700	0

(No outcrop below)

The differences in elevation between samples are greater than the stratigraphic distances, because the beds dip gently in the same direction as the slope of the mountain. The section between elevations 5,650 and 5,350 consists of continuous outcrop of apparently homogeneous magnesite-rich rock.

Analyses of grab samples from the northern traverse, in order of elevation of sampling site are:

Approximate elevation	Per cent Magnesite
6,550	95
6,500	84
6,400	98
6,300	99
6,200	40
6,100	0
6,000	50
5,850	99
5,800	79
5,700	80
5,600	95
5,500	94

(No outcrop below)

The top of this northern series of grab samples is on a spur knob a mile southeasterly from the forks of Mitchell River and Assiniboine Creek.

Magnesite occurs also in the Cathedral Formation at the south end of the ridge between Mitchell River and Assiniboine Creek. X-ray analyses of specimens of medium to coarsely crystalline carbonate from this ridge are as follows:

Approximate elevation	Per cent Magnesite
5,900	98
5,900	60
5,800	0
5,800	95
5,700	0
5,550	0
5,550	98
5,450	1
5,100	Trace
4,950	99
4,700	99

Two out of five pieces of coarsely crystalline carbonate rock selected from talus from the upper part of the Cathedral Formation, above 5,900', contain 95 per cent of magnesite.

[1] Leech, G.B.: Kananaskis Lakes (W 1/2) (82J W1/2) map-area; in Jenness, S.E. (comp.), Report of Activities: Field, 1964; Geol. Surv. Can., Paper 65-1, p. 77 (1965).

82J/13E (M10)

Summary Report on the Mt. Brussilof Magnesite Deposit

Location

The Mount Brussilof magnesite deposit is located about 20 air miles northeast of Radium Hot Springs, at the junction of Mitchell River and Assiniboine Creek (NTS map 82J/13E, 50° 48', 115° 39').

The claims lie about 8 miles west of the B. C. - Alberta border, about 4 miles south of Mount Assiniboine Provincial Park, and about 5 miles east of the eastern boundary of Kootenay National Park (Fig. 1).

Access

Best access to the mineral claim area is by helicopter. The route from Canal Flats along Settlers Road which involves at least three river fords and is impossible at high water is about 60 miles long. The area can also be reached from Radium via highway 93 and a bush road, a distance of about 30 miles. The claims and the immediate area are shown in Figure 2.

History

The occurrence of magnesite in major quantities was established by G. B. Leech in 1965 during routine field work (Leech, 1966). Thirty-six mineral claims (Mag 1-36) were staked and recorded by Mr. P. Roy Swainson of Calgary, and examined by Baykal Minerals Ltd of Calgary during 1969. The work included geological mapping and sampling. Baymag Mines Co. Ltd. was formed in 1971 to handle the 300 (±) claim property. In January 1972 the prospect was optioned to Canex Placer Ltd. who undertook an extensive program of exploration and development involving detailed geological mapping, diamond drilling and bulk sampling, metallurgical testing and research, production feasibility studies, and market analysis.

Canex Placer Ltd. dropped its option September 17, 1974 and the property has reverted to the vendors who are apparently attempting to reach marketing agreements with U. S. and European interests.

Geology

Magnesite occurs within the Middle Cambrian Cathedral Formation along the west flank of Mount Brussilof at the junction of Cross and Mitchell rivers. The Cathedral Formation is a 1,200 foot thick, cliff-forming unit comprising mainly sandy to argillaceous' fine grained, light to dark grey dolomite.

The magnesite occurs as massive irregular lenticular bodies 200 to 300 feet thick within the dolomite. Two major magnesite zones (A & B zones) have been outlined within the Cathedral Formation in this area. A-zone has been traced across the upper, steep slope of Mount Brussilof and the upper slope of the ridge between Mitchell River and Assiniboine Creek. B-zone extends along the lower slope of Mount Brussilof and the ridge (Fig 3).

The magnesite is white to greyish in color, and varies from fine grained and compact to very coarsely crystalline and friable. In places weathering has produced extensive surficial accumulations of magnesite sand.

The area of most immediate interest is the lower slope between Assiniboine Creek and Mitchell River where a large area of B-zone is exposed and has been explored in some detail by Canex Placer Ltd. (Fig. 4).

Exploration

The bulk of the exploration activity on the B-zone (Mag claims) took place during 1972 when 7,531 feet of BQ core drilling and 1,530 feet of 6 inch core drilling was carried out by Canex. The 6 inch core weighing about 27 tons was used in subsequent metallurgical studies.

Mineral Reserves

The work carried out by Canex has partially outlined a complexly shaped, cigar-like zone of magnesite aggregating from 15-20 million tons of better than 93% MgO. The deposit has not been delimited, that is, more drilling would increase the present geological reserve significantly

Results of the 1972 Canex assay program published by Baymag Mines Co. Ltd. (1972) is as follows.

Cut-off	Tons	MgO	Fe_2O_3	CaO	SiO_2	Al_2O_3
90%	21,265,000	95.70	0.92	2.19	0.47	2.25
95%	14,748,000	96.68	0.63	1.90	0.39	0.21
96%	10,413,000	97.15	0.53	1.74	0.35	0.18
97%	5,857,000	97.69	0.47	1.53	0.28	0.14
98%	1,807,000	98.28	0.44	1.38	0.23	0.12

Mining

An open pit operation is the only method deemed feasible but is of course subject to the ususal variables that afflict any such operation. The 'Gaps', Nevada magnesite deposit has been studied by Canex because of its comparability. Grade control and grain size control must be considered in the mining operation.

Metallurgy

Canex encountered a number of serious technical difficulties during the metallurgical testing and preparation of a product of the desired density and purity. The market requirement for a higher class of refractory than has been in normal use has come about because of the change over of the steel-making industry from the open-hearth to the basic oxygen furnace process.

As a result of this changing demand the $CaO:SiO_2$ ratio, the Fe_2O_3 content, and even the initial grain size of the magnesite have become controlling parameters. A major problem also encountered by Canex was in the dead-burning of the Baymag magnesite to produce a final product with a specific gravity as close to 3.56 g/cm^3 as possible. The initial technique involved a final double (two stage) burning after briquetting. Canex's most recent advance has been to develope a more economical one-stage burn. The basic flow chart essentially involves:

(1) Grinding - (2) pyrite floatation and separation - (3) briquetting - (4) burning

The metallurgical studies have led to a near solution for the material from the Baymag magnesite but more testing is required.

Marketing

A major problem encountered by Canex was marketing. Magnesite sales etc are apparently exploited by a European cartel with Greece the leading exporter. Also the continually changing economic parameters, including rising energy and labor costs resulted in hazy forecasting.

Conclusions

The geological mineral reserves of the Baymag magnesite deposit are considered (by Canex) of an adequate size and grade to support a world-scale plant. There appears to be no need for further geological inventory but more metallurgical testing, plant location, transportation, production study, market analysis and energy considerations are necessary. These last items include a wide spectrum of problems which have been considered in detail by Canex Placer in their most recent feasibility studies.

E. W. Grove,

Senior Geologist

Baymag: High Purity MgO from Natural Magnesite

PROPERTY FILE

CIM Bull May 1986 p 43-47

BAYMAG - High purity MgO from natural magnesite

Hagen B. Schultes, Ph.D.
Vice President, Production
Baymag Plant

200, 1144 - 29th Avenue, N.E.
Calgary, Alberta
T2E 7P1

BAYMAG - High purity MgO from natural magnesite

Refratechnik, a leading German refractory company, acquired a majority shareholding in Baymag in 1979. This acquisition included the mining rights for a magnesite deposit of exceptionally high purity in the Canadian Rocky Mountains.

The deposit, situated in the Kootenay region, is of Cambrian age and has proven ore reserves of 50 million m.t. of magnesite. The Baymag magnesite deposit is one of the purest in the world. The deposit was opened up and mining commenced in early 1982. The production of various caustic calcined magnesia products in a rotary kiln operation in Exshaw, Alberta was started in mid 1982. The product application ranges from pulp and paper production over chemical industry to animal feed supplements. Since the end of 1983, Baymag has produced high quality refractory grade fused magnesium oxide for specialty applications in the steel industry.

Introduction

Despite the fact that magnesium is the eighth most plentiful element in the earth and forms about 2.06% of the earth's crust, common knowledge about magnesium and especially magnesium oxide as an industrial mineral is not very distinct. The main reason might be that with the exception of magnesium metal as the element, a negligible amount of MgO qualitites are sold as final products to end users, but rather are needed for the production of final products such as steel, cement, paper etc. Therefore some general words should be said about the different sources of MgO, the different products, world production and consumption, before Baymag specifics are addressed. Magnesium metal will not be discussed in this paper.

Sources of Magnesia

While the element Mg is found in 60 or even more different minerals, only magnesium carbonate or Magnesite ($MgCO_3$) and to a far lesser degree, Brucite, the natural form of magnesium hydroxide ($Mg(OH)_2$), are commercially used to produce MgO. Aside from the extraction of MgO from these natural sources, the synthetic production of magnesia from seawater and brines plays an especially important role for higher grade products.

Magnesite, is mined in about 30 - 35 countries from more than 65 deposits. It occurs mainly in two different forms: as coarse crystalline and crypto-crystalline magnesite. Knowing that theoretically 2.4 g of MgO can be extracted out of each liter of seawater and that all oceans together contain 51 x 10^{15} m.t. of water, the reserves seem infinite. It is difficult to compare production of MgO from natural ores with a seawater magnesia operation, because the comparison is between a mining operation and a chemical plant. The process of obtaining MgO from seawater is definitely more complex than the rather simple calcination of $MgCO_3$ to MgO. As shown in Table 1 below, it is necessary to first produce a material you do not want, calcined limestone or dolomite, to obtain magnesium hydroxide sludge - after an ion exchange reaction - which is finally calcined to MgO.

TABLE 1: **MAGNESIA PRODUCTION PROCESSES**

NATURAL MAGNESITE PROCESS

$$MgCO_3 \xrightarrow{T} MgO + CO_2\uparrow$$

SEAWATER PROCESS

a1. $CaCO_3 \xrightarrow{T} CaO + CO_2\uparrow$

a2. $CaO + H_2O \longrightarrow Ca(OH)_2$

b. $Ca(OH)_2 + MgCl_2 \longrightarrow CaCl_2 + Mg(OH)_2$

c. $Mg(OH)_2 \xrightarrow{T} MgO + H_2O\uparrow$

The purity of the final product depends very much on the complexity of the chemical system and mainly on the purity of the limestone or dolomite. A very important contaminant, boron oxide, should be mentioned. Boron oxide which is characteristic of seawater magnesia, is damaging to the refractoriness of a dead burnt MgO product.

WORLD MARKET

Some general figures about the magnesia world market should be given, before switching specifically to Baymag. As Table 2 illustrates, the production capacity of caustic calcined and dead burnt magnesia adds up to about 7 million mtpy, excluding figures for the USSR which vary between about 2 and 4 million mtpy, pointing out as well that dead burnt MgO is by far the leading product between the two.

TABLE 2: **WORLD PRODUCTION CAPACITY**

WORLD PRODUCTION CAPACITY

MAGNESIA

NATURAL MAGNESITE*	
CAUSTIC CALCINED MAGNESIA	= 1.0×10^6 MT
DEAD BURNT MAGNESIA	= 3.5×10^6 MT

SEAWATER/BRINE MAGNESIA	
CAUSTIC CALCINED AND DEAD BURNT MAGNESIA	= 2.5×10^6 MT

*USSR NOT AVAILABLE

While dead burnt MgO only serves as a raw material for the production of basic refractories -the consumption for steel making refractories is by far the leading application- caustic calcined magnesia's applications are of a far higher variety. Table 3 gives a rough idea of only the more important applications. This diversified structure is the main reason for a higher stability of this tonnage-wise smaller portion of the magnesia market.

TABLE 3: **APPLICATIONS**

APPLICATIONS

CAUSTIC CALCINED MAGNESIA

1. ACID NEUTRALIZATION
2. ANIMAL FEED SUPPLEMENT
3. CELLULOSE ACETATE
4. EPSOM SALT
5. FERTILZER
6. FLUE GAS DESULPHURIZATION
7. MgO BASED CEMENTS
8. PHARMACEUTICAL INDUSTRY
9. PULP & PAPER INDUSTRY
10. RUBBER/RAYON INDUSTRY
11. SUGAR REFINEMENT
12. URANIUM REFINEMENT
13. WATER TREATMENT

BAYMAG - The Company

Baymag, a 100% German owned company has been commercially producing caustic calcined magnesia since June 1982. Baymag Mines Co. Limited was founded in 1971 in Calgary as a amalgamation of Baykal Minerals Ltd. and Brussilof Resources Ltd. Exploratory work and claim staking in the Mt. Brussilof area near Radium Hot Springs, B.C., goes back to the mid 1960's after the magnesite deposit was originally discovered by G.B. Leech of the Geological Survey of Canada in 1966. The first extensive feasibility study about exploitation of the deposit for production of up to 200,000 mtpy of dead burnt MgO was carried out by Acres in 1970/71 and was based on a large diamond drilling program. The results of the study were very encouraging.

In 1973/74 additional core drilling by Canex Placer Ltd. as well as preliminary technical Research and Development for the production of MgO products were carried out at Veitscher Magnesitwerke, Austria.

The contacts between Refratechnik, Baymag's parent company and Baymag go back to the year 1975. Refratechnik, a major German producer of refractory products, showed interest in the Baymag deposit, due to the lack of deposits in Germany, and the possibility of securing a raw material source. Between these initial contacts and 1979, several research programs were carried out to develop modern technology for calcining and dead burning Baymag magnesite.

In 1979 Baymag was finally acquired by its German owners and a large feasibility study was carried out by Techman/Kilborn which was finished in 1981. The positive outcome of the study finally led to large scale industrial testing of calcining Baymag magnesite in a rotary kiln at Canada Cement LaFarge, Exshaw, Alberta in the spring of 1981. The exciting results of these tests, as well as an agreement between Canada Cement LaFarge and Baymag about the leasing of part of the Exshaw facilities (including 2 rotary kilns), formed the basis for Baymag's successful beginning in the caustic calcined magnesia market. In mid 1982 reconstruction of the existing facilities turned them from a cement to a magnesia production plant.

The Deposit

As mentioned before, the Baymag/Mount Brussilof Magnesite Deposit was originally discovered in 1966 by G.B. Leech of the Geological Survey of Canada (GSC) during summer field mapping in the vicinity of the Rocky Mountain Trench at the British Columbia/Alberta border. Leech indicated that magnesite occurs within the Cathedral Formation of Middle Cambrian Age along the west flank of Mount Brussilof near the confluence of the Cross and Mitchell Rivers. The deposit lies on a west-dipping limb of a broad anticline. The beds strike north 30° west and dip southwest at $20-40^{\circ}$. No major faulting has been found. The exact geographical position is 115° 39' west and 50° 49' north. Magnesite was also noted to occur at the south end of the ridge between the Mitchell River and Assiniboine Creek, within the same formation. Grab samples were collected and analyzed by the GSC and found to contain up to 97% MgO.

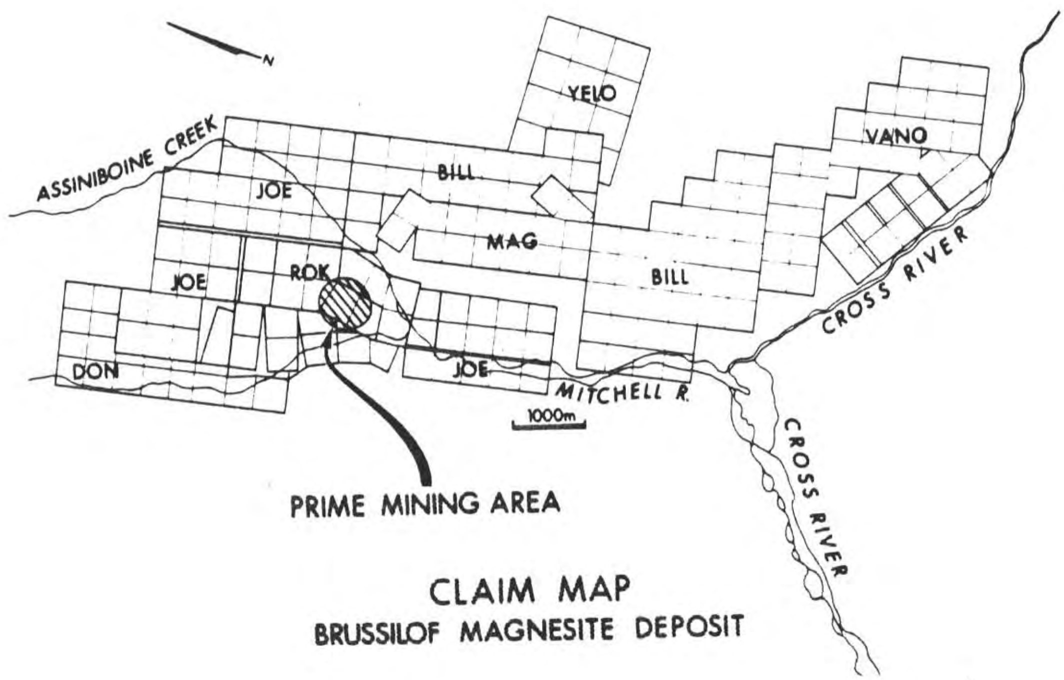


FIGURE 1: **CLAIM MAP**

Shortly after, a claim staking rush started by several different companies, leading finally to the configuration shown in Figure 1 with 233 claims in total. This block extends from approximately 8 miles north of the prime mining area to approximately 10 miles south of the Cross River/Mitchell River confluence. Exploration carried out within the claims indicated that the magnesite ore is present throughout the block.

Exploratory core drilling to date consists of 59 holes varying in length from 32.3 m to 143.3 and totalling to 5,255 metres (17,239 feet), see Figure 2. The drill hole spacing over the deposit is variable with most of the reserves indicated being extrapolated beyond the drilled area. A total of 1,160 samples of core were assayed for MgO, CaO, Fe_2O_3, Al_2O_3, and SiO_2 in predominantly 10 foot (64% of samples) and 20 foot (23% samples) lengths.

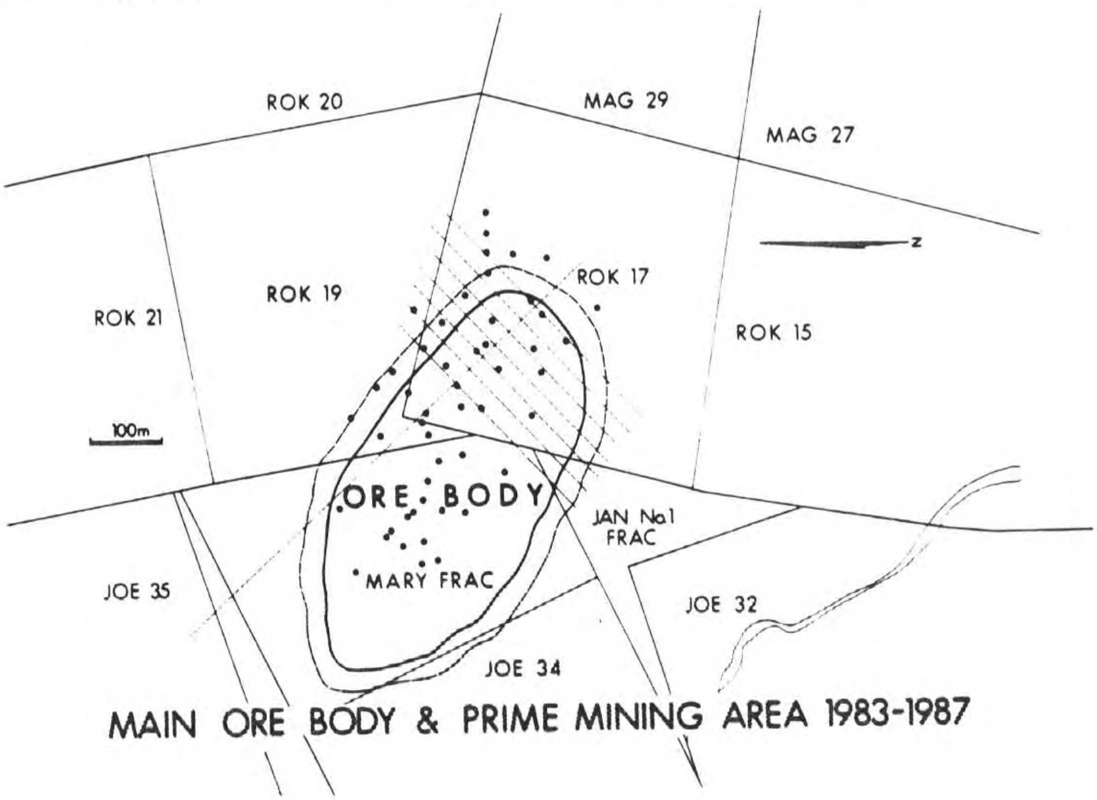


FIGURE 2: **MAIN ORE BODY & PRIME MINING AREA 1983 - 1987**

The proven and probable geological reserves in the vicinity of the prime mining area were calculated by Techman Engineering Ltd. to total approximately 9.5 million tonnes of High Grade ore of +95% MgO and 13.6 million tonnes of ore containing 93-95% MgO. An additional 17.6 million tonnes of ore, with an average grade of 92.44%, have been identified as possible reserves with the deposit.

The precise geometry of the Mount Eon magnesite deposit cannot be defined due to inadequate exposure and incomplete penetration by diamond drilling. The deposit, as has been drilled thus far, is approximately 790 m in length (along a NW-SE axis), and about 500 m wide (along a NE-SW axis). The maximum thickness of the ore body is at least 120 metres.

The main lithologies present on the Baymag property include magnesite, dolomite with minor limestone, quartzite, shale and argillite. Magnesite which occurs mainly as white, very coarsely grained, massive, crystalline rock is quite resistant and weathers to light buff-coloured projections with overhanging cliffs. Dolomite and dolomitic limestone lenses occur within the magnesite. As well, thin irregular stringers of finely crystalline pyrite occur in fracture fillings.

Some controversy exists as to whether the origin of the magnesite is sedimentary or replacement. Although the deposit is rather massive and bedding is rarely seen, there are some sharp contacts with the surrounding dolomite. These contacts could be evidence that the deposit had a sedimentary origin. Conversely, the presence of many veins and veinlets, indicative of hydrothermal emplacement, and the presence of some gradational contacts with the dolomite, suggest the magnesite might have resulted from replacement phenomena. While magnesite is the most predominant mineral, with dolomite, pyrite and calcite present to a lesser extent, other minerals including leuchtenbergite, sericite and illite are present in minor quantities and constitute most of the alumina and silica content in the deposit, as shown in Table 4.

TABLE 4: **TRACE MINERALS IN THE BAYMAG DEPOSIT**

Anberite $Ca(Mg,Fe)[CO_3]_2$
Pentlandite $(Fe,Ni)_9S_8$
Boulangerite $Pb_5Sb_4S_{11}$
Muscovite $KAl_2[(OH,F)_2/AlSi_3O_{10}]$
Leuchtenbergite $(Mg,Fe^{2+},Al)_6[(OH)_8/Al_{>0.5}Si_{<3.5}O_{10}]$
Phlogopite $KMg_3[(OH,F)_2/AlSi_3O_{10}]$
Talc $Mg_3[(OH)_2/Si_4O_{10}]$
Palygorskite $(Mg,Al)_2[(OH)/Si_4O_{10}] \cdot 2H_2O + 2H_2O$

Ore quality and quantity as shown in Figure 3 were evaluated using a geostatistical computer program (Kriging method) and were based on the results from exploratory drilling. These results showed that the Baymag deposit is the largest and most pure coarse crystalline magnesite deposit of the western world and that it is possible to consistently ensure an ore quality, for the production of magnesia qualities with +97% MgO contents, by using strictly controlled selective mining with no special ore treatment or any beneficiation.

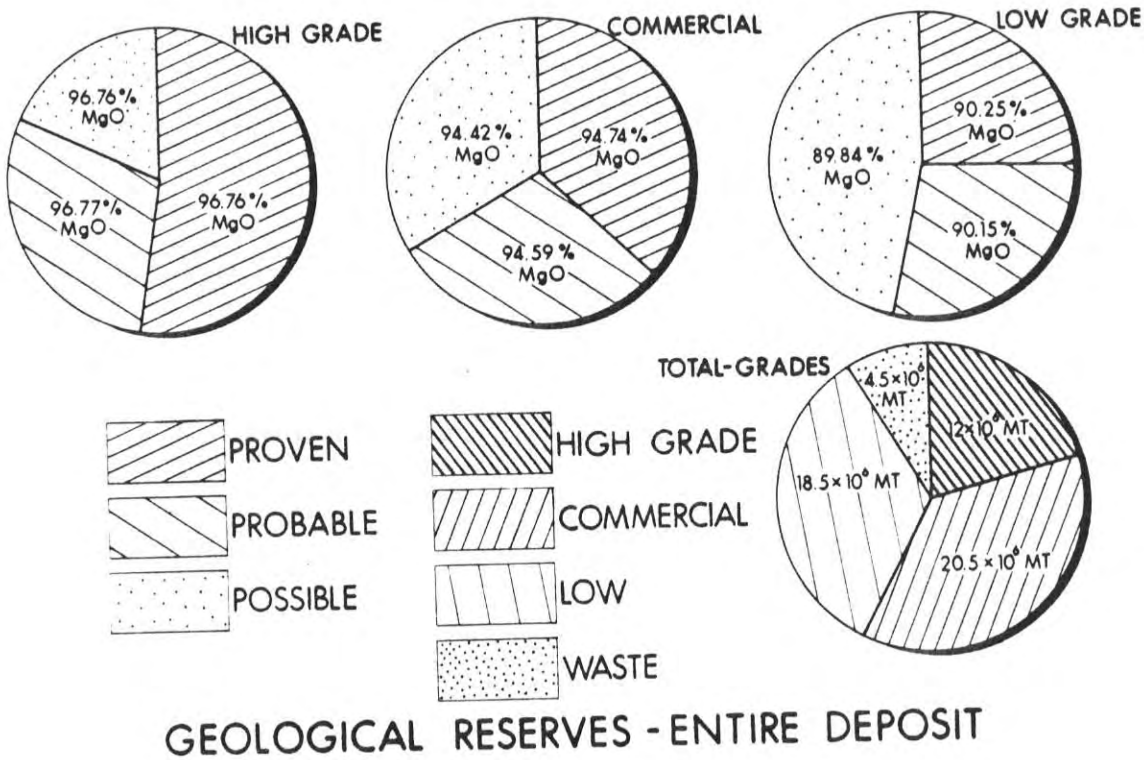


FIGURE 3: **GEOLOGICAL RESERVES - ENTIRE DEPOSIT**

The Mine and Ore Transportation

The Baymag mine is an open pit operation which is run year round and produces at the time being between 100 - 130,000 mtpy of high quality magnesite ore. In 1981 Baymag entered into a contractual agreement with John Wolfe Construction Co. Ltd. to operate the mine and also be responsible for the necessary ore supply to the production plant at Exshaw.

In the preproduction period in 1981/1982, the following work had to be carried out to be ready for starting up:

- 5.4 km access road construction including construction of three bridges,
- 42 km road upgrading - existing Forestry Road system - Cross River bridge to junction of Settlers Road and Highway 93,

- 65 ha logging and clearing - mine site, mine road, material handling area and dumps,
- 1,000 m mine road construction,
- 176,000 m^3 pit waste stripping and initial bench development, and
- installation of a primary crusher and screening system, stockpile, load out facilities and truck scale.

The commercial scale mining started in the second quarter of 1982 and increased dramatically since then from about 35,000 m.t. in 1982 to more than 85,000 m.t. in 1984 with an expected tonnage of 110,000 m.t. in 1985. The mining operation consists of the following functions:

- stripping and stockpiling of top soil and overburden,
- drilling and blasting the ore and waste,
- hauling, crushing and screening the ore,
- loading and hauling the ore for processing.

Figures 4 and 5 show the development of the mining operation up to 1987. It is obvious that the waste to ore ratio becomes more favourable at the higher production rate, mainly as a function of still being in mine development as can be seen in Figure 4. This figure shows that even for the next years, the "to be mined" area will be opened up further, meaning that year by year, there will still be an excessive amount of overburden and cap rock to be removed. But even now, the waste to ore ratio has rarely exceeded 1:1. Comparing this to other magnesite mines, figures of about 10:1 are considered to be normal, going as high as over 100:1 at some grecian deposits of crypto-crystalline magnesite.

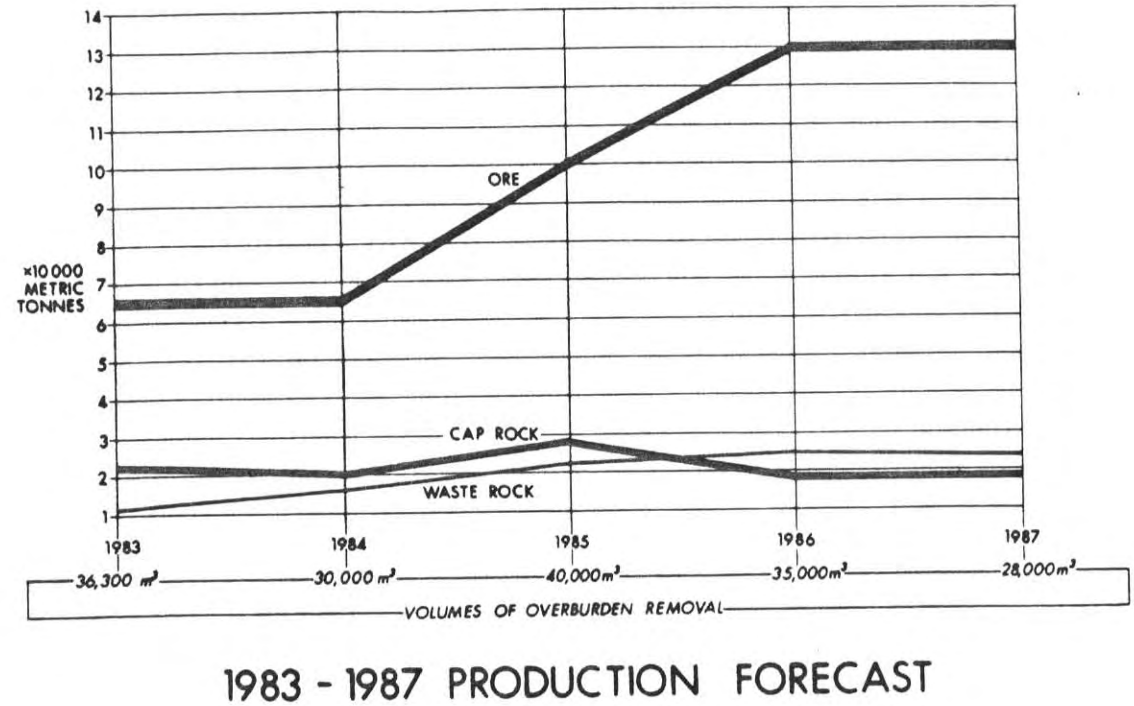


FIGURE 4: **1983 - 1987 PRODUCTION FORECAST**

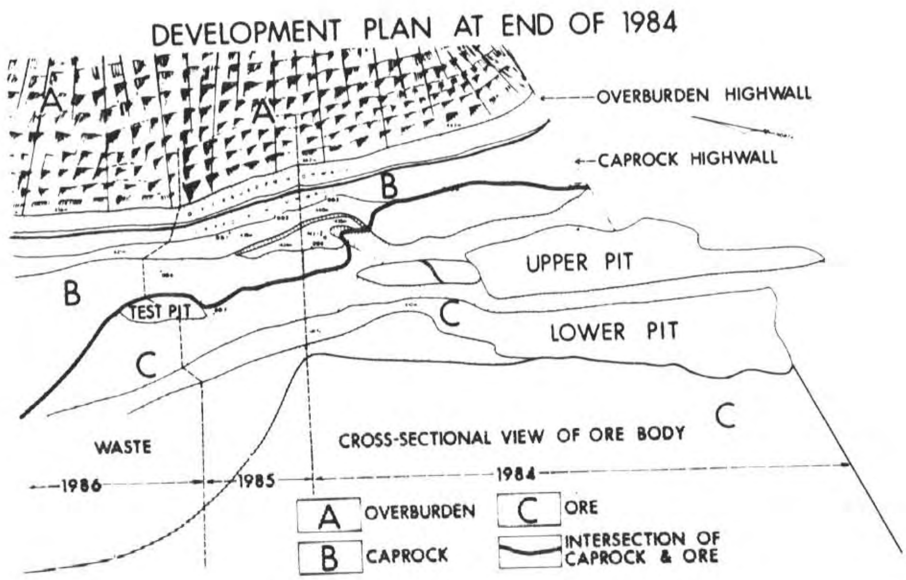


FIGURE 5: **DEVELOPMENT PLAN AT END OF 1984**

Figure 6 shows the very simple layout of the mine site facilities. Before rock blasting, a selection of drill cuttings from blastholes is analyzed in Baymag's quality control lab in Exshaw to build the base for a selective mining. After blasting the high grade ore is loaded into 20 m.t. end dump mine trucks using a backhoe, hauled down to the primary crusher area and either dumped directly into the jaw crusher, which reduces the size to -6", or onto the raw ore stockpile. After primary crushing the ore goes to a triple deck screener where the so called fines (-1/2" fraction) are removed. This is an additional quality assurance measure, because it was found that most contamination from clay filled cracks, dirt, and roadways ends up in this fraction. The -6" +1/2" primary crushed ore is again stockpiled to be loaded onto 38 m.t. payload trucktrailer units, and hauled to the production facilities at Exshaw.

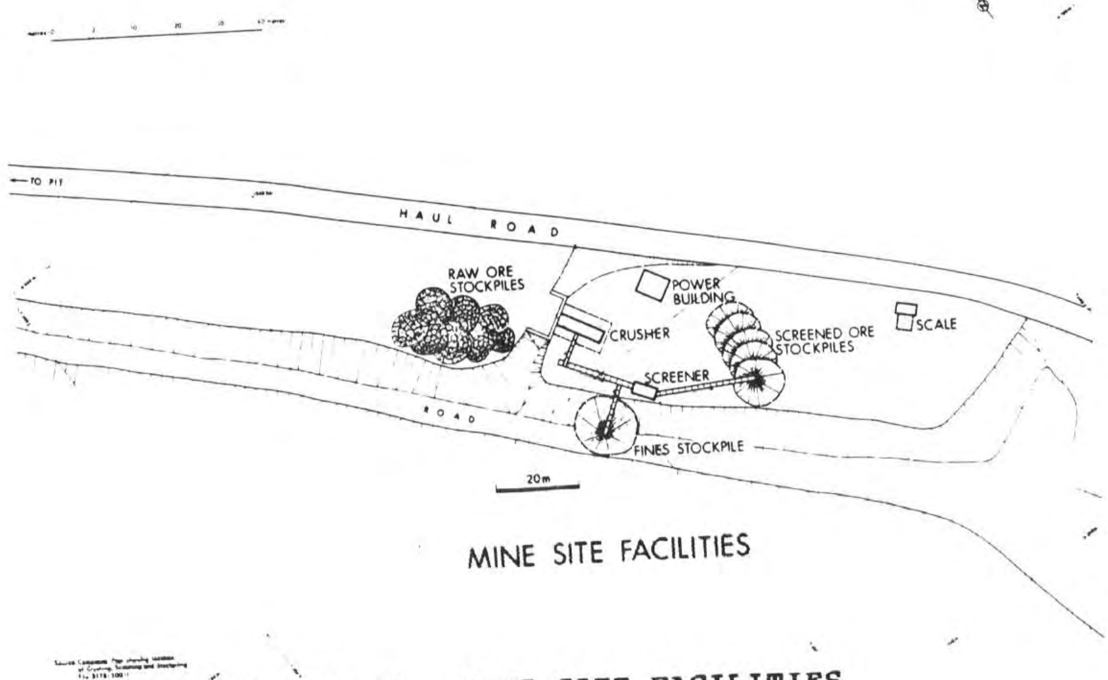


FIGURE 6: **MINE SITE FACILITIES**

The route is highlighted in Figure 7. It is about 200 km in length and leads over about 40 km of forestry road from the mine to Highway 93 junction and from there another 160 km over Highway 93 and TransCanada Highway No. 1. While the mine site obviously lies outside of the National Park boundaries, a fair bit of the 200 km long haul crosses the Kootenay and Banff National Parks and Baymag needed special permission to haul over the Settler's Road portion crossing part of the Kootenay National Park.

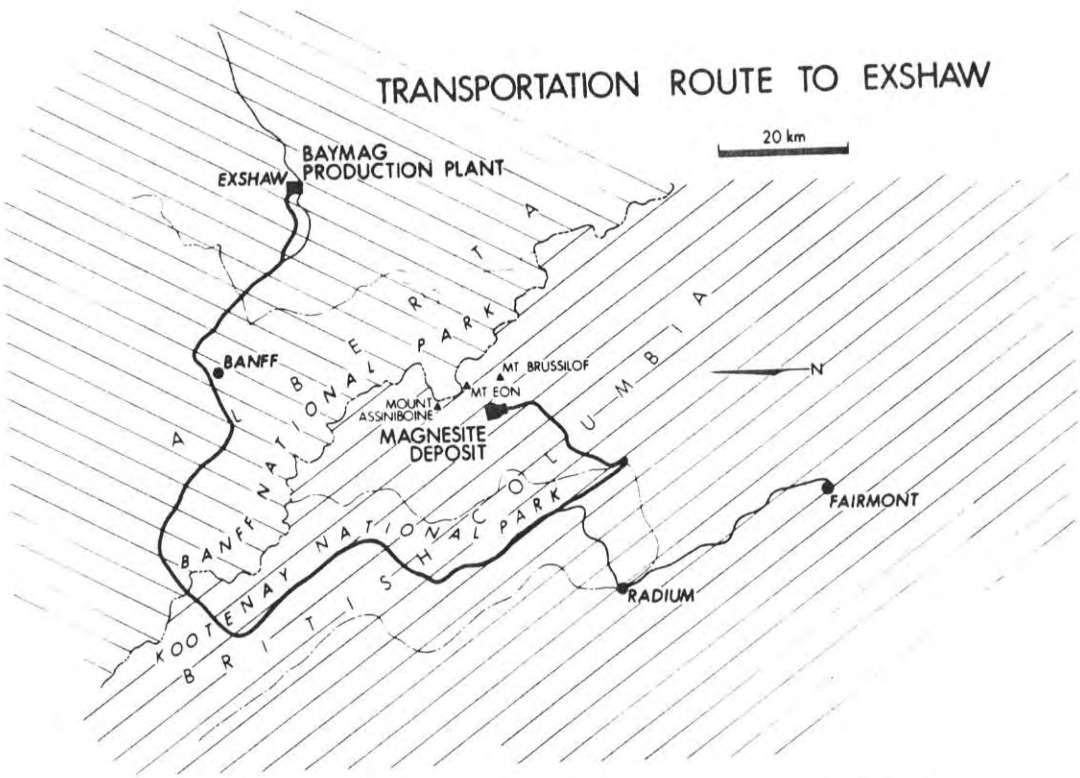


FIGURE 7: **TRANSPORTATION ROUTE TO EXSHAW**

Hauling as well as mining is done year round with two exceptions:

- hauling stops from 2 - 6 weeks during spring breakup season,
- hauling is restricted during the peak tourist season in July/August.

The Plant

The Baymag ore processing plant is situated in Exshaw, Alberta, on the grounds of the Canada Cement LaFarge Plant. As stated earlier, Baymag is leasing a part of CCL's facilities, mainly consisting of two rotary kilns as well as the kiln building and necessary auxiliary equipment.

Before commencing production, Baymag had to add certain equipment to transform its part of the cement plant into an independently functioning MgO calcining facility: the ore storage pads, secondary ore crushing/storage, kiln feeding, product screens, air separator, controlled grinding circuit, general bulk handling equipment, storage and load-out facilities as well as offices and a quality control laboratory.

Nevertheless, the kiln remains the most important piece of equipment in this production flow sheet. It is the facility which adds sufficient heat to the magnesite ore to set the CO_2 free and leave the MgO behind. This reaction theoretically starts at about 650° C and requires about 770 Kcal/kg for completion. Depending on the type of caustic calcined MgO which shall be produced, the calcining temperature in the kiln burning zone needs to be between 850 and about 1,350° C and the heat consumption is about double to three times the theoretical due to kiln shell and mainly off-gas heat losses.

Second in importance after the kiln, are the sizing facilities. Chemical reactivity, one characteristic specification of the product, is not only influenced by the kiln burn but equally influenced by the final fine grinding of the product.

One interesting phenomenon about Baymag magnesite should not be forgotten: the decrepitation at calcination. The grain destruction at elevated temperatures is not easily explained but severely effects the burning technology. The destruction works to Baymag's advantage because the most common contaminants - calcite and dolomite - do not show this behaviour and therefore beneficiation by selective screening can be used. This phenomenon is not unique for Baymag magnesite, but it is restricted to coarse crystalline magnesite and has not yet been determined at crypto-crystalline magnesite.

To put it in the simplest terms, a description for caustic calcined magnesia could be: MgO with clearly defined chemical reactivity, chemistry and sizing. Contrary to dead burnt magnesia, caustic calcined is "alive" and may change with age, depending mainly upon general storage conditions. This sensitivity makes it necessary to carry out a very detailed on-line quality control. Baymag's production is permanently quality controlled on up to eleven (11) subsequent positions before the product ends up in storage. Once it is finally shipped, a separate quality certificate is issued for each single shipment and a retain sample is thereafter kept for minimum one half year.

The production capacity runs at the moment at about 60,000 mtpy, but ongoing technical improvements will have increased it to 75,000 mtpy in early 1986.

<u>The Products/Markets</u>

Returning to the market for caustic calcined magnesias as it is shown in Table 3, Baymag's two mainstays are MgO for the pulp and paper industry and animal feed market. In addition to these two, Baymag is active in most of the mentioned market areas, offering a line of products in sizes from 95% minus 200 mesh, to special fractions for feed grade applications; MgO contents range from minimum 94% up to over 97% and specially designed reactivities for various chemical applications are available.

The Future

While the future of Baymag, in all studies completed so far, has always been connected to the production of mainly dead burnt MgO with caustic calcined magnesia as a byproduct, in 1982 it made most sense to begin a pure calcination operation. There were two very good reasons for this decision: an overly saturated world market for dead burnt MgO and the availability of existing facilities for calcining versus the need for a very high investment for dead burning.

After nearly three years in production and being one of the three leading caustic calcined magnesia producers in North America, the obvious question arises: Where does Baymag go from here? While Baymag will always be committed to the existing market for its calcined products and hopes to double sales in this area within the next five years, it cannot deny its parent company's "refractory heritage".

One year ago Baymag jumped into cold water again, left well known territory and started to develop and market a brand new product: fused magnesia, specially developed and designed for refractory applications.

A pilot plant at Exshaw was started up at the end of 1983 for trial production and soon it became necessary to upgrade it to produce commercial quantities because of the very strong market response. Fused magnesia becomes a unique refractory raw material due to its special treatment during production. It crystallizes out of molten magnesia at temperatures above 2,800°C once brought to these temperatures by an electric arc. This treatment makes the resulting product superior to chemically comparable dead burnt magnesias and with advanced steel making technology there is a need for top quality MgO refractory raw materials. Baymag is in the process of carefully studying the possible expansion of its fusing capacity in 1986.

Summary

Baymag, founded in 1971, controls the purest coarse crystalline magnesite deposit in the western world. After intensive exploratory work in the deposit which was discovered in 1966, and the final takeover in 1979 by the German owners, Baymag has started producing caustic calcined magnesia in 1982. Since then, the company has become one of the three leading suppliers of high quality caustic MgO in North America. Plans for building up a second production line for fused MgO are in progress.

REFERENCES

1. Sivertson, L. Magnesite A Commodity Study, Department of Mines and Petroleum Resources, Mineral Development Division, 1975.

2. Palfreyman, M. Refractory - Grade Magnesia in Canada, Department of Energy, Mines and Resources, Mines Branch, TB 163, 1972.

3. Petrascheck, W.E. Beziehungen zwischen kryptokristallinem und spatigem Magnesit, Radex-Rundschau, Heft 5, 1972.

4. Weiss, V. Die Aufbereitung von Magnesit, Handbuch der Keramik, Verlag Schmid GmbH, 1968.

5. Flick, W. et al. Magnesium-Verbindungen, anorganische, Ullmanns Encyklopadie der technischen Chemie, 4., neubearbeitete und erweiterte Auflage Band 16, Verlag Chemie GmbH, Weinheim, 1978.

6. The Economics of Magnesite, Dolomite and Magnesium Compounds, Roskill Information Services Ltd., Third Edition, 1983.

7. Hotz, G. and H. Schultes, Das Baymag - Projekt Ein Rohstoffsicherungsvorhaben der Refratechnik, TIZ Fachberichte, Vol. 108, No. 3, 1984.

8. Cook, D.G. A Cambrian Facies Change and Its Effect on Structure, Mount Stephen, Mount Dennis area, Alberta-British Columbia; The Geological Association of Canada; special paper no. 6, 1970.

9. Jenkins, D.M. Baymag Property 1972 Summary Report on Geology; private report for Canadian Explorations Co. (Canada) Ltd., February 1973.

10. Stary, E. Geological Report on the Brussilof Project British Columbia; private report prepared for Baykal Minerals Ltd., December 1970.

11. White, G.P.E. Mineralogy of the Baymag Mines Ltd. Magnesite Prospect, South Kootenay Area, B.C.; unpublished report for Acres Western Limited, 1972.

12. Aitken, J.D. Middle Cambrian to Middle Ordivician Cyclic Sedimentation, Southern Rocky Mountains of Alberta; Bull. Can. Petrol. Geol. 1966.

Baymag — high-purity magnesium oxide from natural magnesite

HAGEN B. SCHULTES
Vice-President
Baymag Plant
Calgary, Alberta

ABSTRACT

Refratechnik, a leading German refractory company, acquired a majority shareholding in Baymag in 1979. This acquisition included the mining rights for a magnesite deposit of exceptionally high purity in the Canadian Rocky Mountains.

The deposit, situated in the Kootenay region of southeastern British Columbia, is of Cambrian age and has ore reserves of 50 million m.t. of magnesite. The Baymag magnesite deposit is one of the purest in the world. The deposit was opened up and mining commenced in early 1982. Production of various caustic calcined magnesia products in a rotary kiln operation in Exshaw, Alberta, was started in mid-1982. The product application ranges from pulp and paper production, to the chemical industry, and to animal feed supplements. Since the end of 1983, Baymag has produced high-quality refractory grade fused magnesium oxide for specialty applications in the steel industry.

Introduction

Although magnesium is the eighth most abundant element in the earth and forms about 2.06% of the earth's crust, common knowledge about magnesium and especially magnesium oxide (MgO) as an industrial mineral is not widespread. The reason might be that, with the exception of magnesium metal as the element, magnesia products are not generally sold as final products to end-users, but rather are needed for the production of final products such as steel, cement, paper, etc. Therefore, some general comments are given about the different sources of MgO, the different products, world production and consumption, before Baymag specifics are addressed. Magnesium metal will not be discussed in this paper.

Hagen Schultes

Dr. Schultes attended the University of Goettingen, West Germany, where he received a diploma in mineralogy in 1976 and a Ph.D. in natural science in 1977.

He worked for Refratechnik GmbH in Goettingen from 1977 to 1982 where he held the position of manager of product development, and geoscience and raw materials. In 1983 Dr. Schultes became manager of research and development at the Baymag plant and is currently vice-president of the Baymag plant in Calgary, Alberta, where he is responsible for all aspects of mining, production, quality control, project management, and research and development.

Keywords: Industrial minerals, Magnesium oxide, Magnesite, Caustic calcined magnesia, Baymag, Ore processing, Development, Transportation.

Sources of Magnesia

While the element Mg is found in more than sixty minerals, only magnesite ($MgCO_3$) and to a much lesser degree, brucite, the natural form of magnesium hydroxide [$Mg(OH)_2$], are commercially used to produce MgO. In addition to the extraction of MgO from these natural sources, the synthetic production of magnesia from seawater and brines plays an especially important role for higher grade products.

Magnesite is mined in about 30 to 35 countries from more than 65 deposits. It occurs mainly in two forms; coarse crystalline and crypto-crystalline magnesite. It is difficult to compare MgO production from natural magnesite ores with a seawater magnesia operation, because the comparison is basically between a mining operation and a chemical plant. The process of obtaining MgO from seawater is decidedly more complex than the rather simple calcination of $MgCO_3$ to MgO. As shown in Table 1, it is necessary to start with a different mineral material limestone or dolomite, to obtain magnesium hydroxide sludge — after an ion exchange reaction — which is finally calcined to MgO.

The purity of the final product depends very much on the complexity of the chemical system and mainly on the purity of the limestone or dolomite. Boron oxide, which is a significant contaminant characteristic of seawater magnesia, is damaging to the refractoriness of a dead burnt MgO product.

World Market

As Table 2 illustrates, the world production capacity of caustic calcined and dead burnt magnesia adds up to about 7 million

TABLE 1. Magnesia production processes

Natural Magnesite process

$MgCO_3 \xrightarrow{T} MgO + CO_2\uparrow$

Seawater Process

a1. $CaCO_3 \xrightarrow{T} CaO + CO_2\uparrow$

a2. $CaO + H_2O \longrightarrow Ca(OH)_2$

b. $Ca(OH)_2 + MgCl_2 \longrightarrow CaCl_2 + Mg(OH)_2$

c. $Mg(OH)_2 \xrightarrow{T} MgO + H_2O\uparrow$

Paper reviewed and approved for publication by the Industrial Minerals Division of CIM.

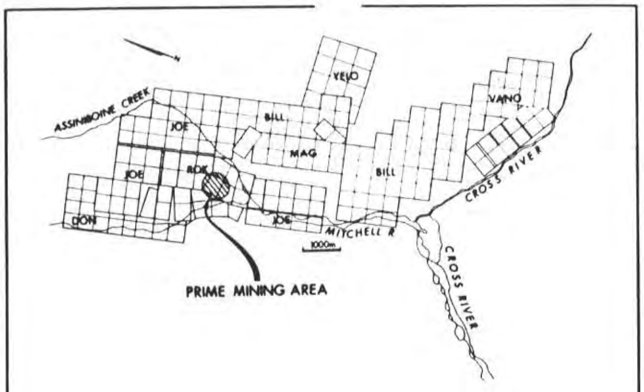


FIGURE 1. Claim map.

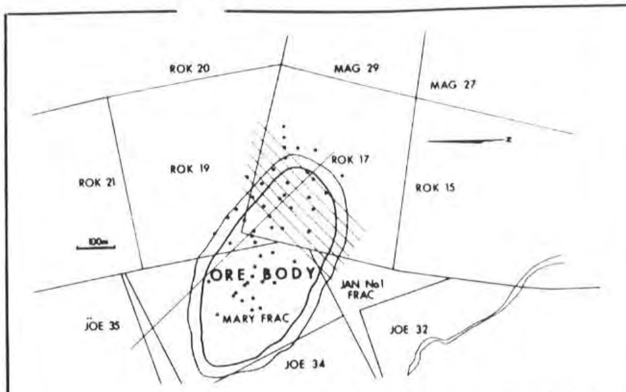


FIGURE 2. Main orebody and prime mining area, 1983-1987.

metric tonnes per year (mtpy) (excluding figures for the U.S.S.R. which vary between about 2 and 4 million mtpy), pointing out that dead burnt MgO is by far the leading product of the two.

While dead burnt MgO serves only as a raw material for the production of basic refractories (the consumption for steel-making refractories being the leading application), caustic calcined magnesia's applications are of a much higher variety. Table 3 gives an idea of the more important applications. This diversity is the main reason for a higher stability of this smaller portion of the magnesia market.

Baymag — The Company

Baymag, a 100% German-owned company, has been commercially producing caustic calcined magnesia since June 1982. Baymag Mines Co. Limited was founded in 1971 in Calgary as an amalgamation of Baykal Minerals Ltd. and Brussilof Resources Ltd. Exploratory work and claim staking in the Mount Brussilof area near Radium Hot Springs, British Columbia goes back to the mid-1960s after the magnesite deposit was originally discovered by G.B. Leech of the Geological Survey of Canada in 1966. The first extensive feasibility study toward exploitation of the deposit, for production of up to 200 000 mtpy of dead burnt MgO, was carried out by Acres during the period 1970-71 and was based on a large diamond drilling program. The results of the study were very encouraging.

In 1973 to 1974 additional core drilling was carried out by Canex Placer Ltd., as well as preliminary technical research and development for the production of MgO products at Veitscher Magnesitwerke, Austria.

The contacts between Refratechnik, Baymag's parent company and Baymag go back to the year 1975. Refratechnik, a major German producer of refractory products, showed interest in the Baymag deposit due to the lack of deposits in Germany, and the possibility of securing a raw material source. Between these initial contacts and 1979, several research programs were carried out to develop modern technology for calcining and dead-burning Baymag magnesite.

In 1979 Baymag was finally acquired by its German owners and a major feasibility study was carried out by Techman and Kilborn. The positive outcome of the study, finished in 1981, led to large-scale industrial calcining testing of the Baymag magnesite in a rotary kiln at the Canada Cement Lafarge plant, Exshaw, Alberta, in the spring of 1981. The results of these tests, as well as an agreement between Canada Cement Lafarge and Baymag on the leasing of part of the Exshaw plant facilities (including two rotary kilns), formed the basis for Baymag's successful beginning in the caustic calcined magnesia market. In mid-1982, reconstruction of those facilities turned them from a cement to a magnesia production plant.

The Deposit

As mentioned earlier, the Baymag Mount Brussilof magnesite deposit was originally discovered in 1966 by G.B. Leech of the Geological Survey of Canada (GSC) during field mapping in the Kootenay region of southeastern British Columbia near the Alberta border. Leech indicated that magnesite occurs within the Cathedral Formation of Middle Cambrian Age along the west flank of Mount Brussilof, near the confluence of the Cross and Mitchell Rivers. The deposit lies on a west-dipping limb of a broad anticline. The beds strike north 30 degrees west and dip southwest at 20 - 40 degrees. No major faulting has been found. The exact geographical position is 115 degrees 39′ west and 50 degrees 49′ north. Magnesite was also noted to occur at the south end of the ridge between the Mitchell River and Assiniboine Creek, within the same formation. Grab samples collected and analyzed by the GSC were found to contain up to 97% MgO in the calcined product.

Shortly after, a claim staking rush occurred, involving several different companies and leading to the configuration shown in Figure 1, with 233 claims in total. This block extends from approximately eight miles north of the prime mining area to approximately ten miles south of the Cross River/Mitchell River confluence. Exploration carried out within the claims indicated that the magnesite ore is present throughout the block.

Exploratory core drilling to date consists of 59 holes varying in length from 32.3 m to 143.3 m and totalling to 5 255 m (17 239 ft) (Fig. 2). The drill hole spacing over the deposit is variable, with most of the indicated reserves being extrapolated beyond the drilled area. A total of 1 160 samples of core in predominantly 10-ft intervals (64% of samples) and 20-ft intervals (23% of samples), were assayed for MgO, CaO, Fe_2O_3, Al_2O_3 and SiO_2.

The proven (estimation variance 0 - 4%) and probable (estimation variance 4 - 8%) geological reserves in the vicinity of the prime mining area were calculated by Techman Engineering Ltd. to total approximately 9.5 million tonnes of high-grade ore of +95% MgO and 13.6 million tonnes of ore containing 93 - 95% MgO. An additional 17.6 million tonnes of possible (estimation variance greater than 8%) reserves with an average grade of 92.44%, have been identified within the deposit.

The precise geometry of the Mount Brussilof magnesite deposit cannot be defined due to inadequate exposure and incomplete penetration by diamond drilling. The deposit as drilled thus far is approximately 790 m in length (along a NW-SE axis) and 500 m wide (along a NE-SW axis). The maximum thickness of the orebody is at least 120 m.

The main lithologies present on the Baymag property include magnesite, dolomite with minor limestone, quartzite, shale and argillite. Magnesite occurs mainly as white, very coarsely-grained, massive, crystalline rock; it is quite resistant and weathers to light buff-coloured projections with overhanging cliffs. Dolomite and dolomitic limestone lenses occur within the magnesite. As well, thin irregular stringers of finely crystalline pyrite occur in fracture fillings.

TABLE 2. World production ...pacity of magnesia

Natural Magnesite*		
Caustic calcined magnesia	=	1.0×10^6 MT
Dead burnt magnesia	=	3.5×10^6 MT
Seawater/Brine Magnesia		
Caustic calcined and Dead burnt magnesia	=	2.5×10^6 MT

* U.S.S.R. figures not available.

TABLE 3. Applications of caustic calcined magnesia

1. Acid neutralization
2. Animal feed supplement
3. Cellulose acetate
4. Epsom salt
5. Fertilizer
6. Flue gas desulphurization
7. MgO-based cements
8. Pharmaceutical industry
9. Pulp and paper industry
10. Rubber/rayon industry
11. Sugar refinement
12. Uranium refinement
13. Water treatment

TABLE 4. Trace minerals in the Baymag deposit

Anberite Ca (Mg, Fe) $[CO_3]_2$
Pentlandite (Fe, Ni) $_9S_8$
Boulangerite $Pb_5Sb_4S_{11}$
Muscovite KAl_2 $[(OH, F)_2/AlSi_3O_{10}]$
Leuchtenbergite (Mg, Fe^{2+}, $Al)_6$ $[(OH)_8/Al_{>0.5}Si_{<3.5}O_{10}]$
Phlogopite KMg_3 $[(OH, F)_2/AlSi_3O_{10}]$
Talc Mg_3 $[(OH)_2/Si_4O_{10}]$
Palygorskite (Mg, $Al)_2$ $[(OH)/Si_4O_{10}] \cdot 2H_2O + 2H_2O$

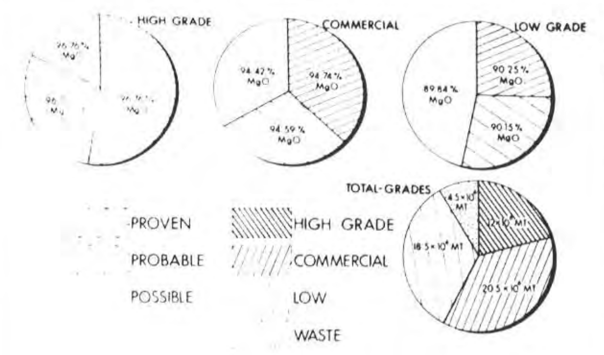


FIGURE 3. Geological reserves of the entire deposit.

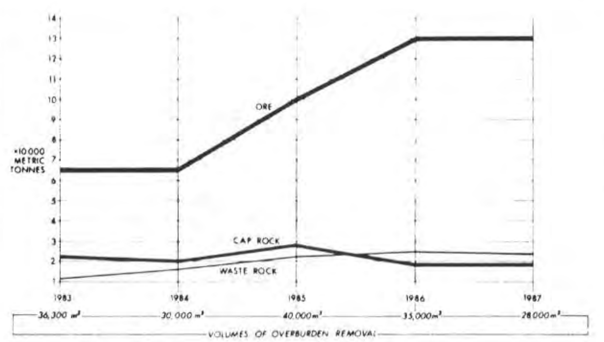


FIGURE 4. 1983-1987 production forecast.

Some controversy exists as to whether the origin of the magnesite is sedimentary or replacement. Although the deposit is rather massive and bedding is rarely seen, there are some sharp contacts with the surrounding dolomite. These contacts could be evidence that the deposit had a sedimentary origin. Conversely, the presence of many veins and veinlets, indicative of hydrothermal emplacement, and the presence of some gradational contacts with the dolomite, suggest that the magnesite might have resulted from replacement phenomenon. While magnesite is the most predominant mineral, with dolomite, pyrite and calcite present to a lesser extent, other minerals including leuchtenbergite, sericite and illite are present in minor quantities and constitute most of the alumina and silica content in the deposit, as shown in Table 4.

Ore quality and quantity as shown in Figure 3 were evaluated using a geostatistical computer program (Kriging method) and were based on the results from exploratory drilling. These results showed that the Baymag deposit is the largest and purest coarse crystalline magnesite deposit currently known in the western world, and that is would be possible to ensure a consistent ore quality for the production of magnesia with +97% MgO content by using strictly controlled selective mining, with no special ore treatment or beneficiation.

The Mine and Ore Transportation

The Baymag mine is an open-pit operation which is run year 'round and currently produces between 100 000 and 130 000 mtpy of high-quality magnesite ore. In 1981 Baymag entered into a contractual agreement with John Wolfe Construction Co. Ltd. to operate the mine and also be responsible for ore supply to the production plant at Exshaw.

During the pre-production period 1981-82, the following work had to be carried out:

— 5.4 km access road construction, including construction of three bridges;
— 42 km road upgrading of existing Forestry Road system — Cross River bridge to junction of Settlers Road and Highway 93;
— 65 ha logging and clearing — mine site, mine road, material handling area and dumps;
— 1,000 m mine road construction;
— 176 000 m^3 pit waste stripping and initial bench development; and
— installation of a primary crusher and screening system, stockpile, load-out facilities and truck scale.

Commercial-scale mining started in the second quarter of 1982 and has increased dramatically since then from about 35 000 m.t. in 1982 to more than 85 000 m.t. in 1984, with an expected tonnage of 110 000 m.t. in 1985. The mining operation consists of the following functions:

— stripping and stockpiling of top soil and overburden,
— drilling and blasting the ore and waste,
— hauling, crushing and screening the ore, and
— loading and hauling the ore for processing.

Figures 4 and 5 show the development of the mining operation up to 1987. As seen in Figure 4, it is obvious that the waste-to-ore ratio becomes more favourable at the higher production rate, mainly as a function of the mine still being in development. For the next few years, the "to-be-mined" area will be opened up further, meaning that year by year, there will still be an excessive amount of overburden and cap rock to be removed. Even at present, however, the waste-to-ore ratio has rarely exceeded 1:1. Comparing this to other magnesite mines, figures of about 10:1 are considered to be normal, going as high as over 100:1 at some Grecian deposits of cryptocrystalline magnesite.

Figure 6 shows the very simple layout of the mine site facilities. Before rock blasting, a selection of drill cuttings from blastholes is analyzed in Baymag's quality control lab in Exshaw to build the base for a selective mining. After blasting, the high-grade ore is loaded by backhoe into 20 m.t. end-dump mine trucks, hauled to the primary crusher area and dumped

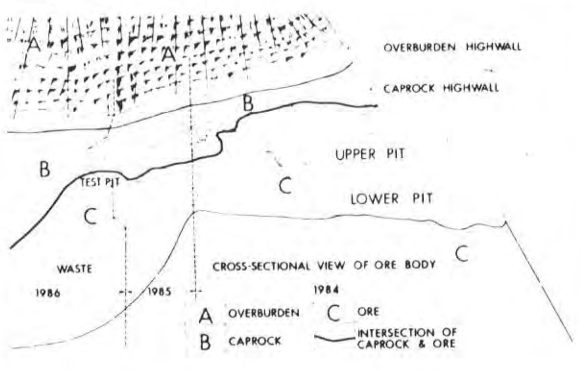


FIGURE 5. Development plan at end of 1984.

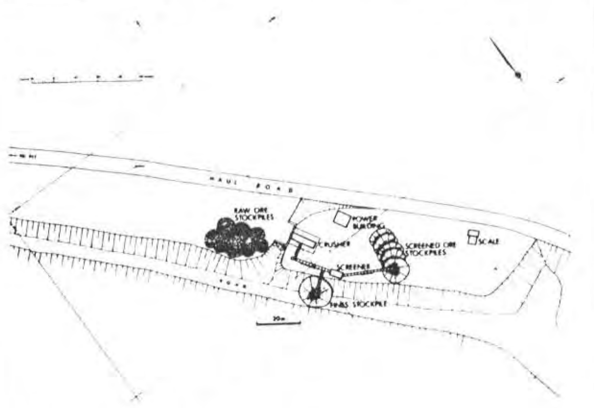


FIGURE 6. Mine site facilities.

either directly into the jaw crusher, which reduces the size to 6 in., or onto the raw ore stockpile. After primary crushing, the ore goes to a triple deck screener where the so-called "fines" (-1/2 in. fraction) are removed. This is an additional quality assurance measure, because it was found that most contamination from clay-filled cracks, dirt, and roadways ends up in this fraction. The 6 in. +1/2 in. primary crushed ore is again stockpiled, to be loaded onto 38 m.t. payload trucktrailer units and hauled to the production facilities at Exshaw.

The route is highlighted in Figure 7. It is about 200 km in length and leads over about 40 km of forestry road from the mine to Highway 93 junction and from there another 160 km over Highway 93 and TransCanada Highway No. 1. While the mine site lies outside of the National Park boundaries, a fair bit of the 200 km long haul crosses the Kootenay and Banff National Parks and Baymag needed special permission to haul over the Settler's Road portion crossing part of the Kootenay National Park.

Hauling as well as mining is done year 'round with two exceptions: hauling stops from two to six weeks during spring breakup season; and hauling is restricted during the peak tourist season in July-August.

The Plant

The Baymag ore processing plant is situated in Exshaw, Alberta, on the grounds of the Canada Cement Lafarge plant. As stated earlier, Baymag is leasing a part of CCL's facilities, mainly consisting of two rotary kilns as well as the kiln building and necessary auxiliary equipment.

Before commencing production, Baymag had to add certain equipment to transform its part of the cement plant into an independently functioning MgO calcining facility: the ore storage pads, secondary ore crushing/storage, kiln feeding, product screens, air separator, controlled grinding circuit, general bulk handling equipment, storage and load-out facilities, as well as offices and a quality control laboratory.

The kiln is the principal piece of equipment in this production flowsheet. It is the facility which applies sufficient heat to the magnesite ore to set the CO_2 free and leave the MgO behind. This reaction theoretically starts at about 650°C and requires about 770 Kcal/kg for completion. Depending on the type of caustic calcined MgO to be produced, the calcining temperature in the kiln burning zone needs to be between 850°C and about 1 350°C. Heat consumption is about two to three times the theoretical, due to kiln shell and mainly off-gas heat losses.

Second in importance after the kiln are the sizing facilities. Chemical reactivity, a primary specification of the product, is influenced not only by the kiln burn but equally by the final fine grinding of the product.

One interesting phenomenon about Baymag magnesite is the decrepitation that occurs with calcination. The grain destruction at elevated temperatures is not easily explained, but is a major factor in the burning technology. The destruction works to Baymag's advantage, because the most common contaminants — calcite and dolomite — do not show this behaviour; therefore, beneficiation by selective screening can be used. This phenomenon is not unique to Baymag magnesite, but it is restricted to coarse crystalline magnesite and has not been observed in the crypto-crystalline type.

In simplest terms, a description for caustic calcined magnesia could be: MgO with well defined chemical reactivity, chemistry and sizing. Contrary to dead burnt magnesia, caustic calcined is "alive", and may change with age depending mainly upon storage conditions. This sensitivity makes it necessary to carry out a very detailed on-line quality control procedure. Baymag's production is permanently quality-controlled at up to eleven points before the product ends up in storage. Once it is finally shipped, a separate quality certificate is issued for each single shipment and a retained sample is kept for a minimum of six months.

The production capacity currently runs at about 60 000 mtpy. Ongoing technical improvements will increase it to 75 000 mtpy early this year.

The Products/Markets

Baymag's two main markets are the pulp and paper industry and the animal feed market (Table 3). In addition, Baymag is active in most of the mentioned market areas, offering a line of products in sizes from 95% minus 200 mesh, to special fractions for feed grade applications; MgO contents range from minimum 94% up to over 97%, and specially designed reactivities for various chemical applications are available.

The Future

In all studies completed so far, the future of Baymag has been connected to the production of mainly dead burnt MgO, with caustic calcined magnesia as a byproduct. Even so, in 1982 it made most sense to begin a pure calcination operation. There were two very good reasons for this decision: an overly saturated world market for dead burnt MgO, and the availability of existing facilities for calcining versus the need for a very high investment for dead burning.

After nearly three years in production and being one of the three leading caustic calcined magnesia producers in North America, the obvious question arises: Where does Baymag go from here? While Baymag will always be committed to the existing market for its calcined products and hopes to double sales in this area within the next five years, it cannot deny its parent company's "refractory heritage".

One year ago Baymag began to develop and market a brand new product, *fused magnesia*, especially developed and designed for refractory applications. A pilot plant at Exshaw was started up at the end of 1983 for trial production and soon it became necessary to upgrade it to produce commercial quantities because of the very strong market response. Fused magnesia becomes a unique refractory raw material due to its special method of production. It crystallizes out of molten magnesia at temperatures above 2 800°C, brought to these levels by an electric arc. This treatment makes the resulting product chemically superior to comparable dead burnt magnesias. With advanced steelmaking technology there is a need for top-quality MgO refractory raw materials. Baymag is in the process of carefully studying the possible expansion of its fusing capacity in 1986.

Summary

Baymag, founded in 1971, controls the purest coarse crystalline magnesite deposit in the western world. After intensive exploratory work on the deposit, which was discovered in 1966, and the final takeover in 1979 by the German owners, Baymag started producing caustic calcined magnesia in 1982. Since then, the company has become one of the three leading suppliers of high-quality caustic MgO in North America. Plans for building up a second production line for fused MgO are in progress.

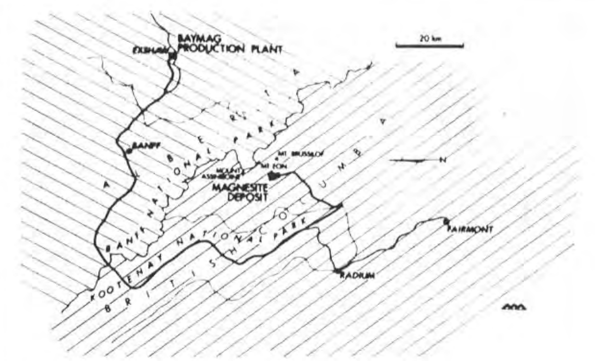


FIGURE 7. Transportation route to Exshaw.

BIBLIOGRAPHY

1. SIVERTSON, L., Magnesite — A Commodity Study, Dept. of Mines and Pet. Resources, Mineral Development Division, 1975.
2. PALFREYMAN, M., Refractory-Grade Magnesia in Canada, Dept. of Energy, Mines and Resources, Mines Branch, TB 163, 1972.
3. PETRASCHECK, W.E., Beziehungen zwischen kryptokristallinem und spatigem Magnesit, Radex-Rundschau, Heft 5, 1972.
4. WEISS, V., Die Aufbereitung von Magnesit, Handbuch der Keramik, Verlag Schmid GmbH, 1968.
5. FLICK, W., *et al.* Magnesium-Verbindungen, anorganische, Ullmanns Encyklopadie der technischen Chemie, 4, neubearbeitete und erweiterte Auflage Band 16, Verlag Chemie GmbH, Weinheim, 1978.
6. The Economics of Magnesite, Dolomite and Magnesium Compounds, Roskill Information Services Ltd., Third Edition, 1983.
7. HOTZ, G., and SCHULTES, H., Das Baymag — Projekt Ein Rohstoffsicherungsvorhaben der Refratechnik, *TIZ Fachberichte, Vol. 108, No. 3, 1984.*
8. COOK, D.G., A Cambrian Facies Change and Its Effect on Structure, Mount Stephen, Mount Dennis area, Alberta-British Columbia; Geol. Assoc. of Canada; Special Paper No. 6, 1970.
9. JENKINS, D.M., Baymag Property 1972 Summary Report on Geology; Private Report for Canadian Explorations Co. (Canada) Ltd., Feb. 1973.
10. STARY, E., Geological Report on the Brussilof Project British Columbia; Private Report Prepared for Baykal Minerals Ltd., December 1970.
11. WHITE, G.P.E., Mineralogy of the Baymag Mines Ltd. Magnesite Prospect, South Kootenay Area, B.C.; Unpublished Report for Acres Western Limited, 1972.
12. AITKEN, J.D., Middle Cambrian to Middle Ordovician Cyclic Sedimentation, Southern Rocky Mountains of Alberta; *Bull. Can. Petrol. Geol., 1966.*

5th IFAC Symposium on Automation

IFAC Symposium on Automation in Mining, Mineral and Metal Processing is arranged for the fifth time this year in Tokyo, sponsored by the IFAC Technical Committee on Application. Organized by the Society of Instrument and Control Engineers, Japan, the symposium will be held on **August 24-29, 1986**.

The objectives of these symposia are to review the latest progress in the field and to offer an opportunity to discuss new areas of control as well as exchange experience at the international level.

Although the over-all program is arranged to cover almost all aspects of automation in mining, mineral and metal processing, International Program Committee has given a certain preference to contributions which present new automation applications and theories that have practical potentials. In addition to many advanced applications diffused in the organizing country, the symposium program is supported by visits to local industries. The technical program consists of the following: plenary sessions, technical sessions, round-table discussions, and exhibitions.

The official language of the symposium is English. Also, various tours to factories relevant to mining, mineral and metal processing have been planned.

For information, contact:
The Secretariat of IFAC—5th MMM 1986
c/o International Congress Service, Inc.
Kasho Bldg., 2F, 2-14-9
Nihombashi Chuo-ku
Tokyo 103, Japan

CIM

Eighth Rapid Excavation and Tunneling Conference

A call for papers has been issued for the Eighth Rapid Excavation and Tunneling Conference (RETC), **June 14-18, 1987**, New Orleans, Louisiana.

The conference is designed to provide a forum for the exchange of new developments in the technology of underground rapid machine excavation and tunneling on a worldwide scale.

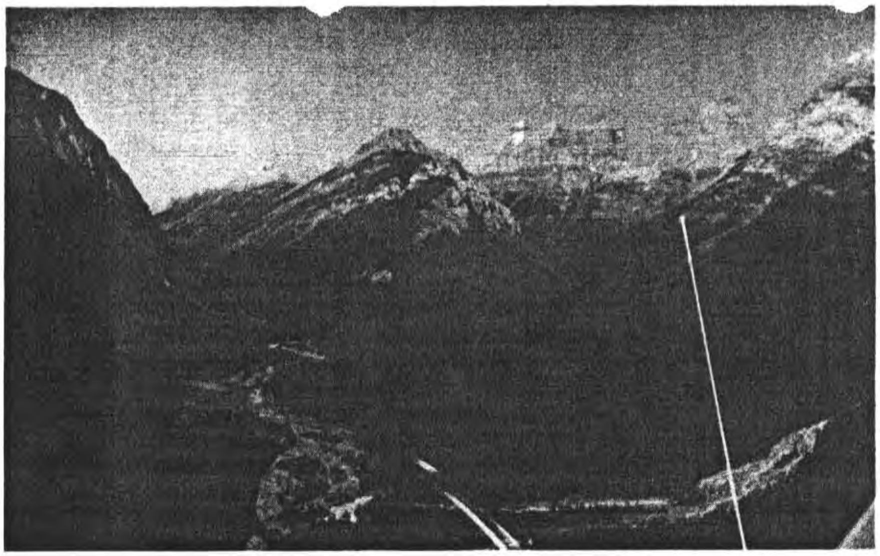
The RETC is jointly sponsored by the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) and the American Society of Civil Engineers (ASCE). The Society of Mining Engineers of AIME is coordinating the technical program.

On behalf of the Program Committee, a call for papers is issued covering the following topics:

Tunnel Boring Machine Histories and Developments; Soft Ground and Roadheader Case Histories; Large Diameter Tunnels and Underground Chambers Case Histories; Shafts and Inclines Case Histories; Geotechnical Data for Underground Projects; and Lining and Permanent Support Methods. Additional topics include: Improvements in Conventional Tunneling Methods; Underground Safety; Ground Water Control in Shafts and Underground Openings; Conventional and Mechanical Shaft Sinking; Shaft and Tunnel Lining Techniques; New Technology in Underground Excavation; Design, Construction, and Support of Large Underground Openings; Difficult Ground Conditions and Unforeseen Occurrences; Underground Contracting Methods and Disputes, Recent International Experiences, and Computer Applications.

Abstracts of 100 words or less should be submitted by July 1, 1986, to Darline D. Daley, Assistant Conference Manager, RETC, Caller No. D, Littleton, CO 80127, U.S.A.

CIM



Baymag magnesite project: looking northeast toward Eon Mountain; main magnesite outcrop is indicated

Magnesite has long-term potential in Canada

Among the projects of Mineral Resources International Limited is a 51% interest in Baymag Mines Co Ltd, which has a major magnesite property in British Columbia. (MRI holds more than 50% of Nanisivik Mines Ltd: WM Oct'77 p20). Refractory grades of dead-burn magnesite are used in the steel, cement, and other industries as a furnace or hearth lining.

The Baymag property is some twenty miles east of Radium Hot Springs, BC. It was explored by Canex Placer, under option, during 1972-4. The main deposit outcrops along a strike length of 6000 feet just above the valley floor along the lower flank of Eon Mountain.

Drilling outlined a wedge-shaped deposit open to the north, with a maximum thickness of 450ft. There is little overburden, and the deposit is suitable for open-pit mining. Indicated ore was reported (rounded-off in million-tons): low grade (90-95% MgO) 6.5; medium grade (95-97% MgO) 7.1; high grade (97%+) 7.7. Greater potential is expected.

The world market for dead-burn magnesite is several million tons a year, and in 1974-5 Baymag investigated, with others, the feasibility of a 200,000 ton/year dead-burn magnesite project, for which capital costs would have been of the order of $75-million. Because of the slow-down in world industrial growth and in the steel industry, Baymag suspended negotiations for bringing the project into production.

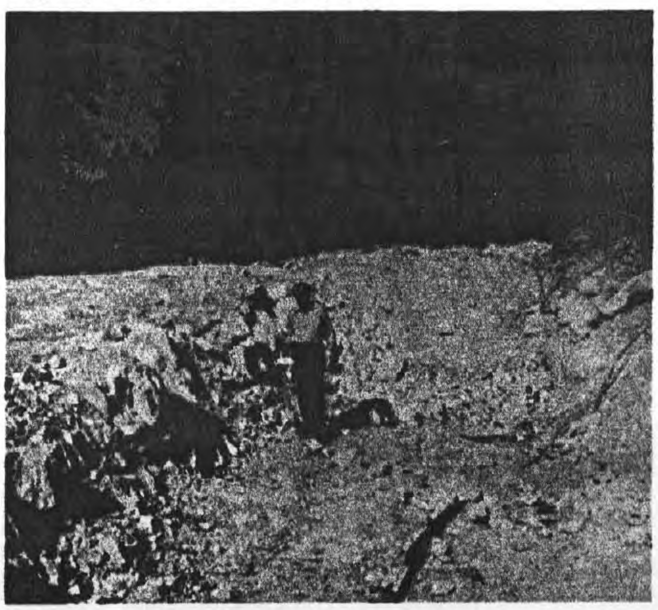
A study in 1976 showed a growing demand for non-refractory caustic burn magnesite, and further studies indicated that it may be feasible to bring into production a 30,000 tonne/year caustic burn magnesite operation. This could be followed by a 60,000 tonne/year dead-burn magnesite plant, to be integrated into the project as warranted by markets. The company is pursuing this possibility with other principals.

A longer-term marketing possibility is the supply of material to a magnesium plant. Magnesite (pure) contains 28.84% (wt) magnesium, and there is a potential for greater use of lightweight magnesium alloys in the automotive industry. Volkswagen have used considerable amounts of magnesium in their cars for some years, and demands for better fuel consumption could lead the large US car makers to use more light alloys.

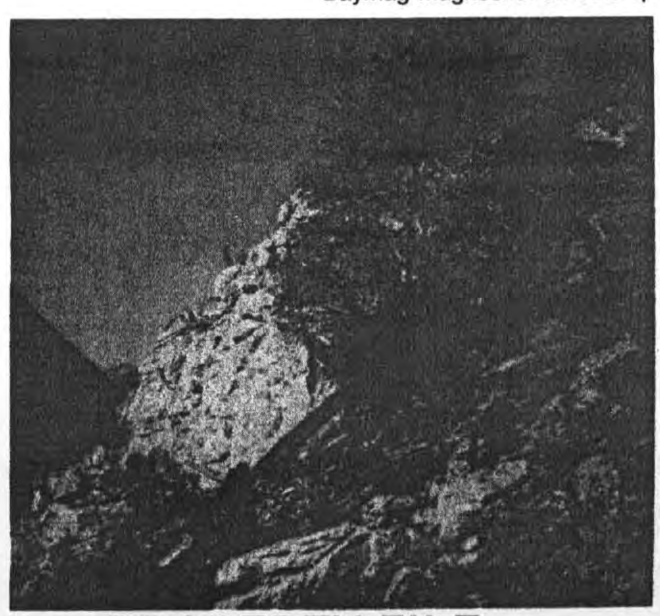
Baymag have suggested a possible plant, in the future, located in Alberta or British Columbia, where there are reliable supplies of coal or coke, electrical power, and chlorine from the petrochemical industry. These materials could be used to produce anhydrous magnesium chloride as feedstock for the electrolytic production of magnesium metal.

Recent work: During the summer of 1977, Baymag worked on a road and bridge for access on the property. A 220-ton sample has been taken for various tests and evaluations.

Baymag magnesite: bulk sample pit



Baymag magnesite: an outcrop



Province of British Columbia — Ministry of Energy, Mines and Petroleum Resources

MINFILE

IDENTIFICATION

MINFILE NO. 082JNW001 NATIONAL MINERAL INVENTORY NO. ______

NAMES
BAYMAK
ROK
Mt EON

CLAIMS ______

OWNER ______

OPERATOR ______

STATUS ☐ SHOWing ☐ PROSpect ☐ DEveloped PRospect ☒ U PRODucer ☐ O U PAst PRoducer

LOCATION

NTS 082J013E MINING DIVISION GOLD

LATITUDE 50° 47' 20" LONGITUDE 115° 40' 40" ELEVATION 1500 metres

UTM ZONE ______ NORTHING ______ EASTING ______

LOCATION CERTAINTY ☒ WITHIN 500m ☐ 2 WITHIN 1 km ☐ 3 WITHIN 5 km

COMMENT ON IDENTITY ______

MINERAL OCCURRENCE

COMMODITIES Mg Mt (listed according to economic importance)

RESERVES TYPE --- TONNES 27,027,027. GRADES MgO 94.66% CaO 2.07% SiO_2 0.63% Fe_2O_3 1.36%
OR BEST ASSAY DATA Al_2O_3 0.32% HF Insolubles 0.23%
COMMENTS ______

PRODUCTION YEARS ______ TONNES MINED ______
METALS RECOVERED ______

MINERALOGY ECONOMIC MINERALS MGNS
COMMENTS ______
GANGUE MINERALS PYRT
COMMENTS ______
ALTERATION MINERALS ______
COMMENTS ______
ALTERATION TYPE ______
AGE OF MINERALIZATION ______ ISOTOPIC AGE ______
DATING METHOD ______ MATERIAL DATED ______

DEPOSIT TYPE
☐ 01 VEIN ☒ 09 STRATIFORM
☐ 02 STOCKWORK ☐ 10 CONCORDANT
☐ 03 PORPHYRY ☐ 11 PLACER
☐ 04 PIPE ☐ 12 PRECIPITATE
☐ 05 IGNEOUS ☐ 13 DISSEMINATED
☐ 06 SKARN ☐ 14 MASSIVE
☐ 07 PEGMATITE ☐ 15 UNKNOWN
☐ 08 STRATABOUND ☐ 16 UNCLASSIFIED

GENETIC TYPE
☒ 1 REPLACEMENT ☐ 6 EPIGENETIC
☐ 2 MAGMATIC ☐ 7 HYDROTHERMAL
☐ 3 VOLCANOGENIC ☐ 8 RESIDUAL
☒ 4 SEDIMENTARY ☐ 9 UNKNOWN (UNCLASSIFIED)
☐ 5 SYNGENETIC

SHAPE OF DEPOSIT ☐ 1 REGULAR ☐ 2 TABULAR ☐ 3 CYLINDRICAL ☐ 4 Bladed ☐ 5 IRREGULAR

MODIFIER ☒ 1 FOLDED ☐ 2 FAULTED ☐ 3 FRACTURED ☐ 4 SHEARED ☐ 5 OTHER ______

DIMENSION ______

ATTITUDE N30°W 20→40°SW ☒ STRIKE/DIP ☐ 2 TREND/PLUNGE

COMMENT ON STRUCTURE ______

PROPERTY FILE

HOST ROCKS

A. DOMINANT ROCK TYPE ☒ SEDIMENTARY [2] PLUTONIC [3] VOLCANIC [4] METASEDIMENTARY [5] METAPLUTONIC [6] METAVOLCANIC [7] METAMORPHIC

B. SUPERGROUP ______ GROUP ______

FORMATION CATHEDRAL MEMBER ______

AGE 374 ISOTOPIC AGE ______

DATING METHOD ______ MATERIAL DATED ______

ROCK TYPE DLMT MGNS

LITHOLOGY dolomites and magnesite.

C. IGNEOUS/METAMORPHIC/OTHER ______

AGE ______ ISOTOPIC AGE ______

DATING METHOD ______ MATERIAL DATED ______

ROCK TYPE ______

LITHOLOGY ______

COMMENT ON HOST ROCK ______

GEOLOGICAL SETTING

TECTONIC BELT ☐ INsular ☒ OMIneca ☐ Coast Crystalline ☐ EAstern ☐ InterMontane

TERRANE NORTH AMERICAN

PHYSIOGRAPHIC AREA Rocky Mountains.

METAMORPHISM: TYPE [1] CONTACT [2] REGIONAL

RELATIONSHIP [1] PRE-MINERALIZATION [2] SYN-MINERALIZATION [3] POST-MINERALIZATION

GRADE ☐ HornFels ☐ BlueSchist ☐ AMphibolite ☐ EClogite ☐ SubBituminous ☐ ZeoLite ☐ GreenSchist ☐ GranuLite ☐ Lignite ☐ Low Vol. bituminous ☐ Med. Vol. bituminous ☐ HI Vol. bituminous ☐ Semi Anthracite ☐ ANthracite

COMMENT ON GEOLOGICAL SETTING

CAPSULE GEOLOGY Magnesite occurs within the Middle Cambrian Cathedral Formation along the west flank of Mount Brussilof and immediately north of the junction of Assiniboine Creek and Mitchell Rivers. The Cathedral Formation is a ~~[illegible]~~ 366m thick, cliff forming unit composed mainly of sandy to argillaceous, fine grained, light to dark grey dolomite.

The magnesite occurs as massive, irregular lenticular bodies 60 to 100 meters thick within the dolomite. Two major magnesite zones have been identified in this area separated by up to 100 meters of Cathedral Formation dolomite. The magnesite is white to greyish in color and varies from fine grained and compact to very coarsely crystalline and friable. Dolomite and dolomitic limestone lenses occur within the magnesite and thin, irregular stringers of finely crystalline pyrite occur as fracture fillings.

Studies indicate the Baymag deposit is the largest and purest crystalline magnesite deposit currently known in the western world. It has about 9.5 mtonnes of +95% MgO, 13.6 mtonnes of 93 to 95% MgO and an additional 17.6 mtonnes of possible reserves with average grades of 92.44% MgO.

BIBLIOGRAPHY (place 'best' or most recent source first)

*BCDM PROP FILE 82JNW001
W. Miner, Nov 1977 - 24
*CIM Bull May 1986-43
GSC P66-1 pg 65
BCDM GEM 1970-503, 1972-603, 1973-551
BCDM EXPL 1975-201, 1976-205, 1977-252
BCDM MMAR 1966-270, 1967-310, 1968-323
*BCDM ASS RPT 2048, 6565
~~GSC MEM 207~~
BCDM Bull 35

CODED BY BG. initials FIELD CHECKED: YES ☐ NO ☒ DATE CODED 86 yr 6 mo 30 day

REVISED BY ______ initials FIELD CHECKED: YES ☐ NO ☐ DATE CODED ______ yr ______ mo ______ day