GEOLOGY OF THE ANZAC MAGNESITE DEPOSIT (93J/16W, 93O/1W)

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KEYWORDS: Industrial minerals, magnesite, Anzac, Gog Group, Misinchinka Group, Cambrian, refractories.

INTRODUCTION

Examination of the Anzac magnesite deposit is part of an ongoing study of sediment-hosted magnesite deposits in British Columbia. Other work is documented by Hancock and Simandl (1992), Simandl and Hancock (1991, 1992) and Simandl *et al.* (1992a). Magnesite is used in the production of refractory materials, magnesium chemicals and magnesium metal, and has significant potential in environmental applications (Simandl *et al.*, 1992b). Ministry work included mapping of lithologic sections across known magnesite-bearing units together with geochemical sampling, x-ray and petrographic analysis. This paper is a summary of field observations and preliminary laboratory results from work on the Anzac magnesite showings.

LOCATION

The Anzac magnesite deposit is on the western slopes of Mount Emmet, 122 kilometres north-northeast of Prince George and 43 kilometres due east of McLeod Lake (Figure 3-2-1), in the Misinchinka Ranges of the Rocky Mountains.

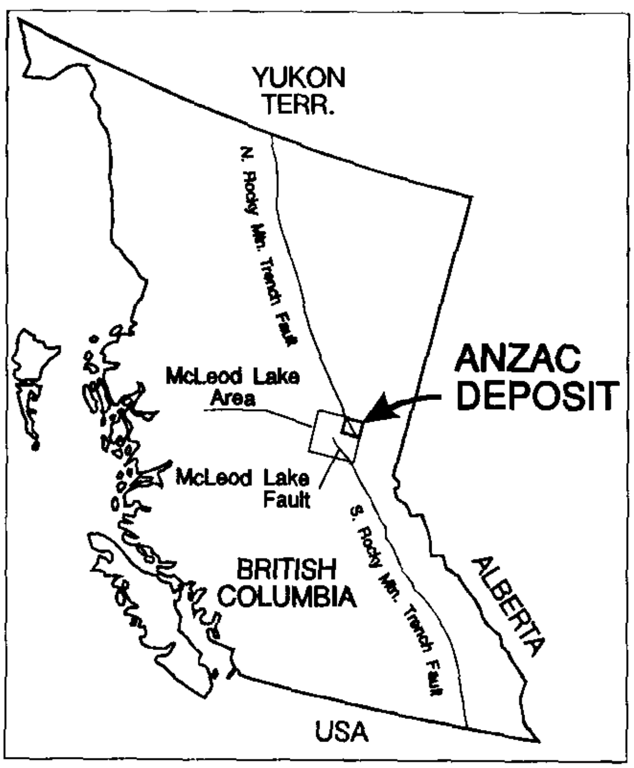


Figure 3-2-1. Location of the Anzac deposit and major regional structures.

There is no road access to the site; the property can be reached by secondary roads from Highway 97 which pass through the Anzac siding of the B. C. Electric Railway and flying the last 22 kilometres, or by air directly from Prince George.

HISTORY

The magnesite occurrences were first reported by Muller and Tipper (1969) of the Geological Survey of Canada. They were staked and reconnaissance mapped by MineQuest Exploration Associates Ltd. for Norsk Hydro in 1986. Additional mapping, sampling and drilling of three holes for a total of 287 metres were completed in 1989. Core was stored on site but the boxes have since been upset by animals. The work identified six large showings: from north to south, Hela, Odin, Emmet, Knob, Knoll and Fria. Further mapping and sampling by MineQuest Exploration Associates Ltd. and section mapping with sampling by the Geological Survey Branch were done in 1991.

REGIONAL GEOLOGY

The region is transected by a major structural break defined by the Northern Rocky Mountain Trench and the McLeod Lake fault (Figure 3-2-1). This divides the area into Precambrian and Paleozoic sediments to the east with lower Paleozoic sediments and suspect terranes to the west. The McLeod Lake fault may have transferred dextral strike-slip movement along the northern part of the Southern Rocky Mountain Trench to the Northern Rocky Mountain Trench (Price and Carmichael, 1986). East of these major structures, thrusts and folds are typically east vergent although some folds verge west (McMechan, 1987). Northeast-trending extensional faults crosscut the northwest-trending faults. These structures are associated with Late Cretaceous to Early Tertiary east-vergent shortening (McMechan, 1987).

The Anzac magnesite deposit is located in the northeast corner of the McLeod Lake map sheet mapped by Muller and Tipper (1969), Struik (in press, 1989, 1990) and Struik and Fuller (1988). Equivalent stratigraphy occurs to the northwest (Struik, 1992; Struik and Northcote, 1991; McMechan, 1987). Three major stratigraphic units are present in the Anzac area: the Misinchinka, Gog and Kechika groups (Figure 3-2-2).

The Precambrian Misinchinka Group consists of fine to coarse-grained, marine clastic rocks separated into four subdivisions by Struik (in press). The lower two subdivisions consist of grey slate, fine quartzite, grit, diamictite, phyllite and minor carbonate rocks of Hadrynian age. The upper two subdivisions consist of white quartzite, grey slate and black slate of Hadrynian to Early Cambrian age. There is a gradational change from the Misinchinka Group into the Gog Group. The Lower Cambrian Gog Group is separated into two divisions (Struik, in press). The lower division consists of quartzite, dolomite, sandy dolomite and slate. The upper member consists of limestone, dolomite, shale and siltstone. Poorly preserved *Archaeocyathid* fossils are present sporadically in carbonate rocks of the Gog Group (McMechan, 1987; Muller and Tipper, 1969; Struik, 1989). Magnesite occurs within the Gog Group. Struik (1989) measured several sections across the transition from the Misinchinka Group through the Gog Group, east of the Anzac deposit. These sections provide detailed descriptions of the groups in the Anzac area. The Kechika Group consists of Upper Cambrian to Lower Ordovician slate, phyllite and platy limestone together with some undifferentiated Cambrian to Devonian carbonates with minor clastics (Struik, in press; Muller and Tipper, 1969).

Magnesite-bearing rocks occur within a down-faulted block of both the Gog and Misinchinka groups (Figure 3-2-2). The block is bounded by west-dipping normal faults with the centre slightly down dropped. Rocks within the graben are folded into an open east-verging antiform. The Gog Group outcrops over most of the fault block and the upper Misinchinka Group forms the core of the antiform. The upper member of the Gog Group forms the northeastern and southwestern limbs of the antiform. The lower member of the Gog Group is mostly quartzite and the upper member is mostly carbonate. The Misinchinka Group consists of black and dark green slate and phyllite. To the east and west of the block are rocks of the Misinchinka Group. Axial planar cleavage is well developed in fine-grained clastic rocks and absent in quartzites and carbonates.

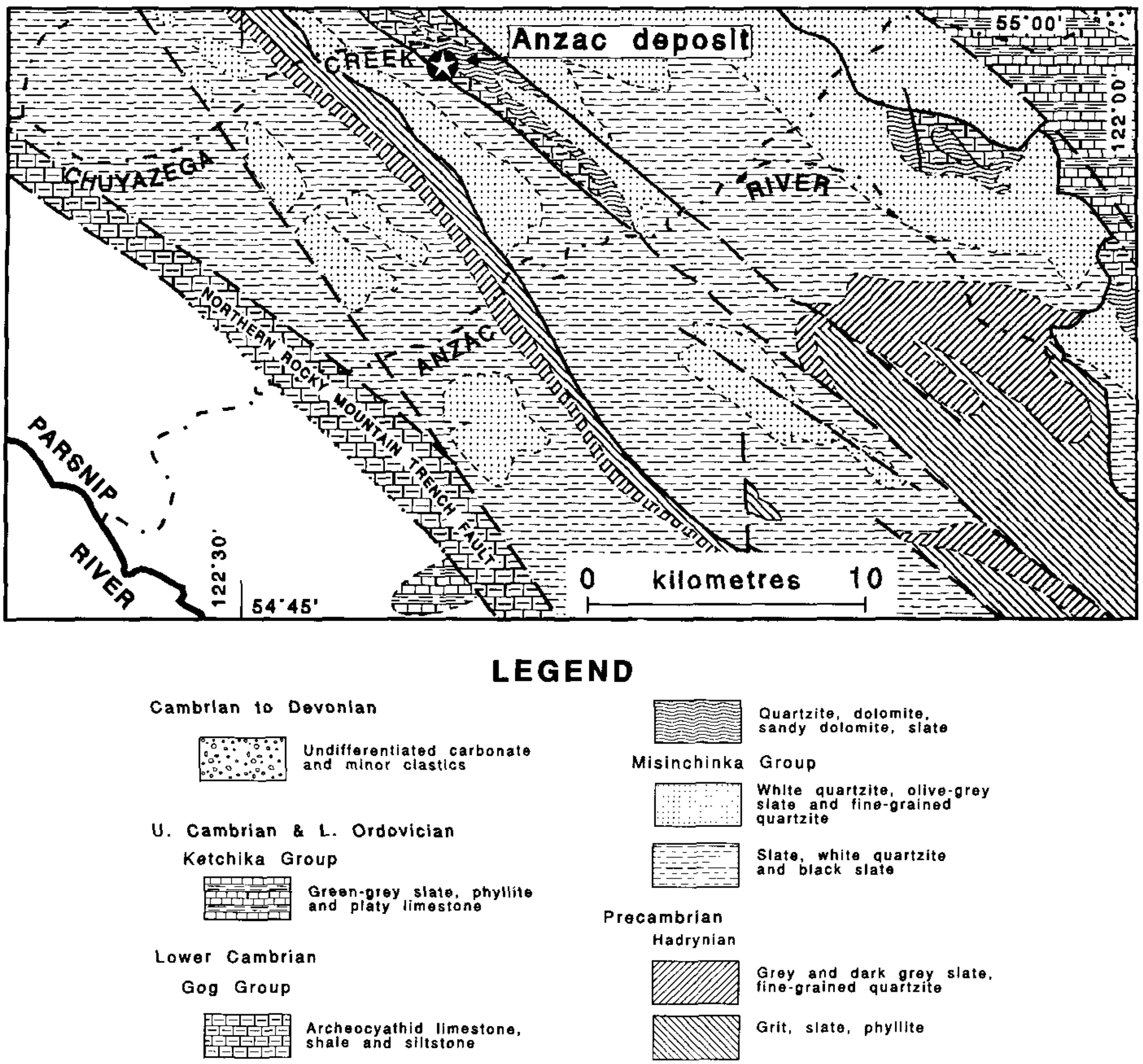


Figure 3-2-2. Regional geology of the Anzac deposit (modified from Struik, in press).

THE ANZAC DEPOSIT

The Anzac deposit consists of six showings (Figure 3-2-3). The Fria, Knoll and Knob showings are isolated outcrops of massive, sparry magnesite. Sections were prepared across the Hela, Emmet and Odin showings (Figures 3-2-4, 5 and 6). Due to possible structural thickening or fold repetition these are lithologic sections only. From the sections, eleven lithofacies were identified which are grouped into three units. These are, in descending order, units of carbonate, argillite and quartzite. The argillite and quartzite are probably part of the lower member of the Gog Group. The carbonates are most probably correlative with an *Archaeocyathid* carbonate unit of the upper Gog Group (Struik, in press) and host the magnesite deposits. Grab samples were taken from the sections and isolated outcrops for whole-rock geochemical analysis. Chemical analyses are listed in Table 3-2-1. Lithologic correlation between sections is poor, possibly as a result of interfingering of lithofacies or structural complications.

Magnesite at the Anzac deposit is massive, sparry and has few preserved sedimentary features. Rocks containing more than 80 per cent bladed crystals, with more than 36.5 per cent MgO, are referred to as magnesite (Table 3-2-1) and approach stoichiometric magnesite composition. The value of 36.5 per cent MgO is equivalent to 70 per cent MgO in calcined product. This is considered as the minimum grade for economic development in the current magnesia products market. A scatter plot of CaO *versus* MgO shows a tight cluster over 36.5 per cent MgO (Figure 3-2-7).

Zones of magnesite range from 3 to 11 metres wide. Contacts with hostrock are gradational across up to 50 centimetres. Individual crystals are bladed, range in size from 5 to 20 millimetres and are usually randomly oriented, but they also form fans or rosettes. Magnesite is either white to buff or medium to light grey in colour on fresh surfaces. The buff to white, sparry magnesite is similar to that seen in southeast British Columbia, however, the medium grey magnesite has not previously been recorded in the province. Thin section analysis of grey, "high-grade" magnesite rock shows that small amounts of dolomite are present in the matrix as well as abundant, micron-scale inclusions within the magnesite crystals. X-ray analysis also shows the presence of talc and chlorite. Chlorite is absent in white magnesite. The grey colour is due to matrix dolomite and accessory minerals. Common impurities are dolomite, pyrite, limonite and hematite. Dolomite occurs as either scattered remnant matrix or masses of white, rhombic crystals. Pyrite occurs in or near small fractures, either as disseminated crystals or thin coatings, and is usually partially oxidized. Occasionally, limonite and hematite occur as fist-sized, amorphous masses.

Drill holes below the Emmet showing, 80 metres south of section A-A′, cut several magnesite sections separated by dolomite, over lengths of 1 to 21 metres, with MgO concentrations between 31 and 43 per cent (Gourlay, 1989). Correlations between drill intersections and surface exposures are speculative. Broad zones can be distinguished but segment by segment correlations are impossible. This suggests that the magnesite may occur as discrete lenses or braided zones.

Dolomite is the most common rock type in the sections. It is typically massive, dark to medium grey, weathers light

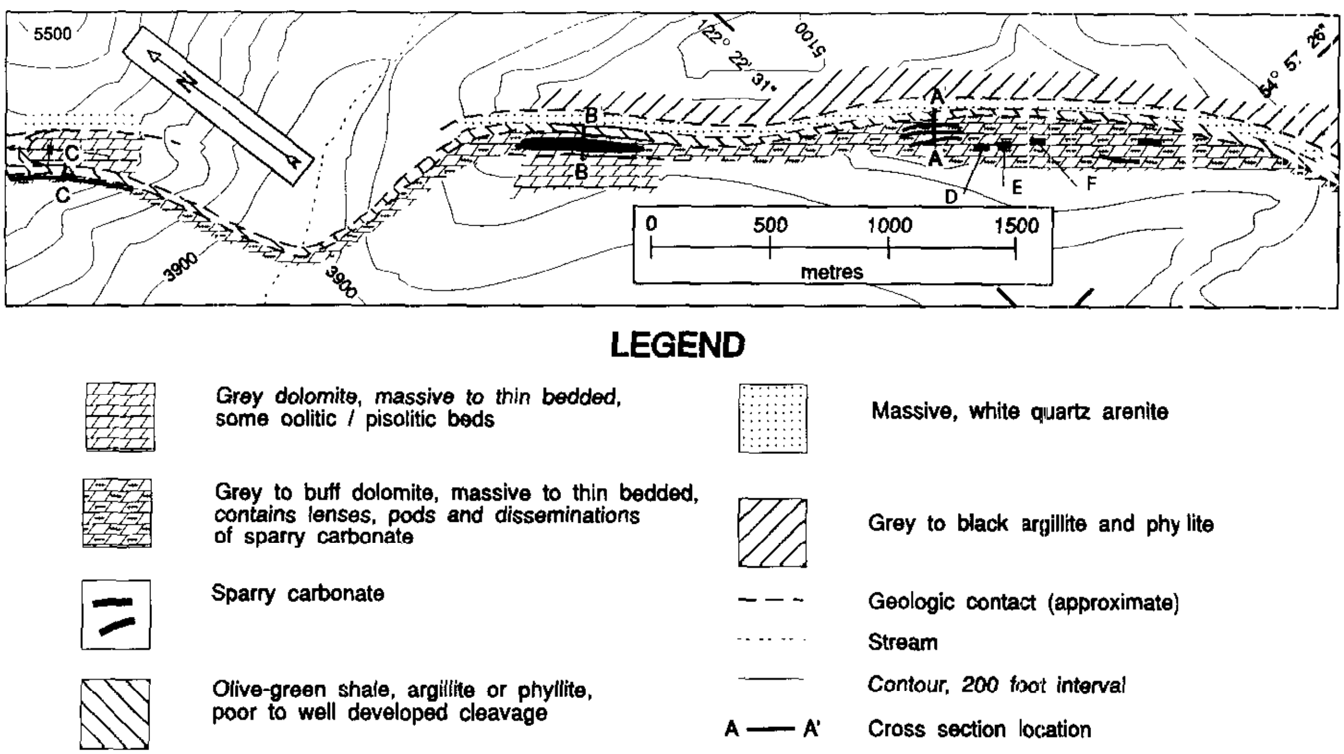


Figure 3-2-3. Geology of the Anzac deposit (modified from Gourlay, 1989, 1991). AA′ = Emmet showing; BB′ = Odin showing; CC′ = Hela showing; D = Knob showing; E = Knoll showing; F = Fria showing.

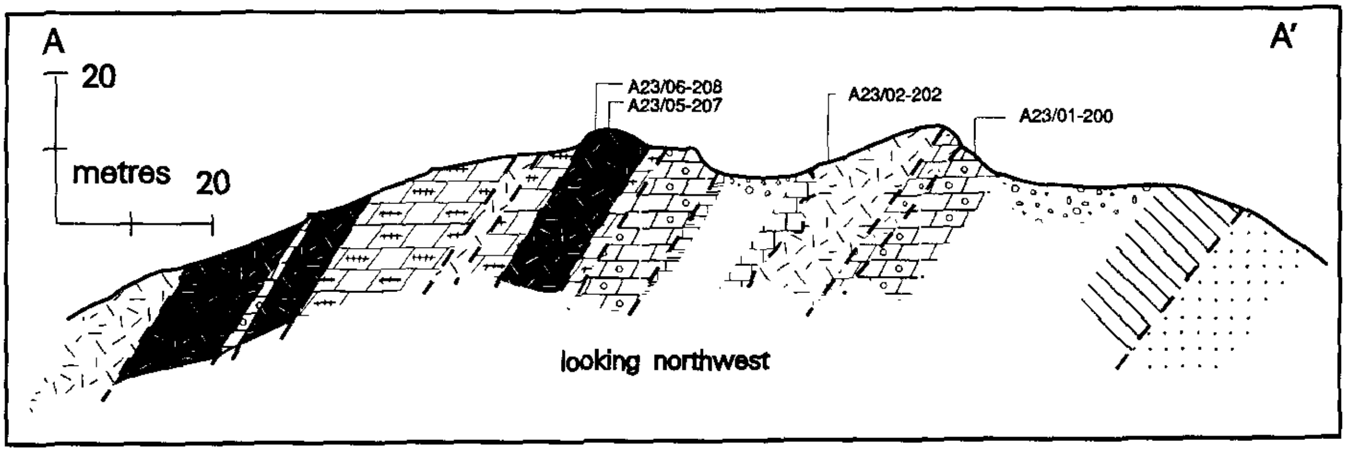


Figure 3-2-4. Lithologic section of the Emmet showing with sample locations.

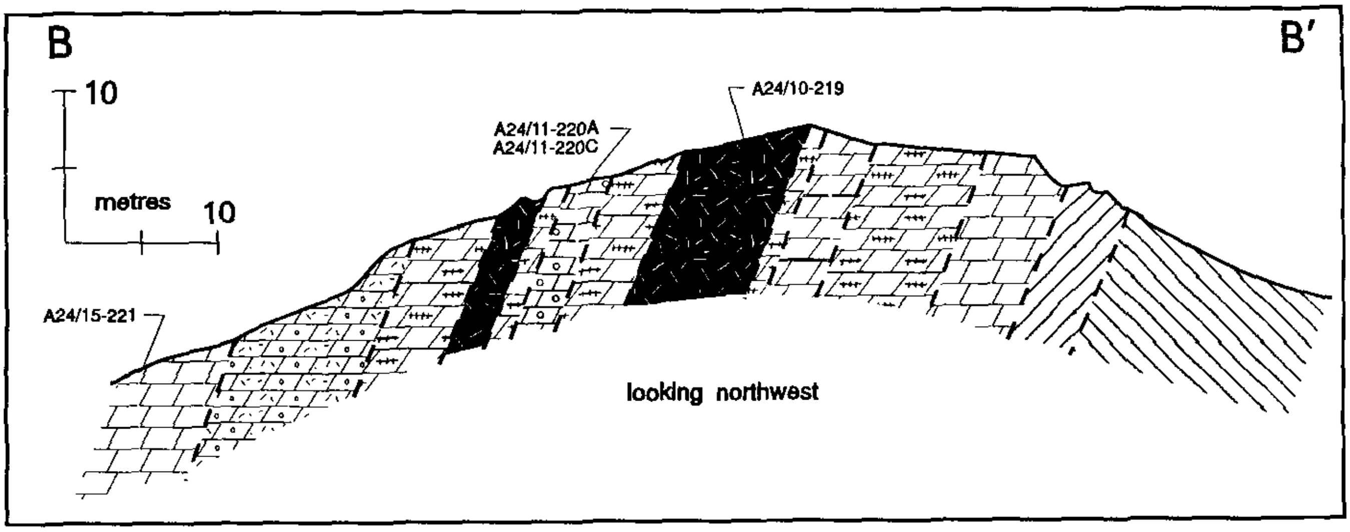


Figure 3-2-5. Lithologic section of the Odin showing with sample locations.

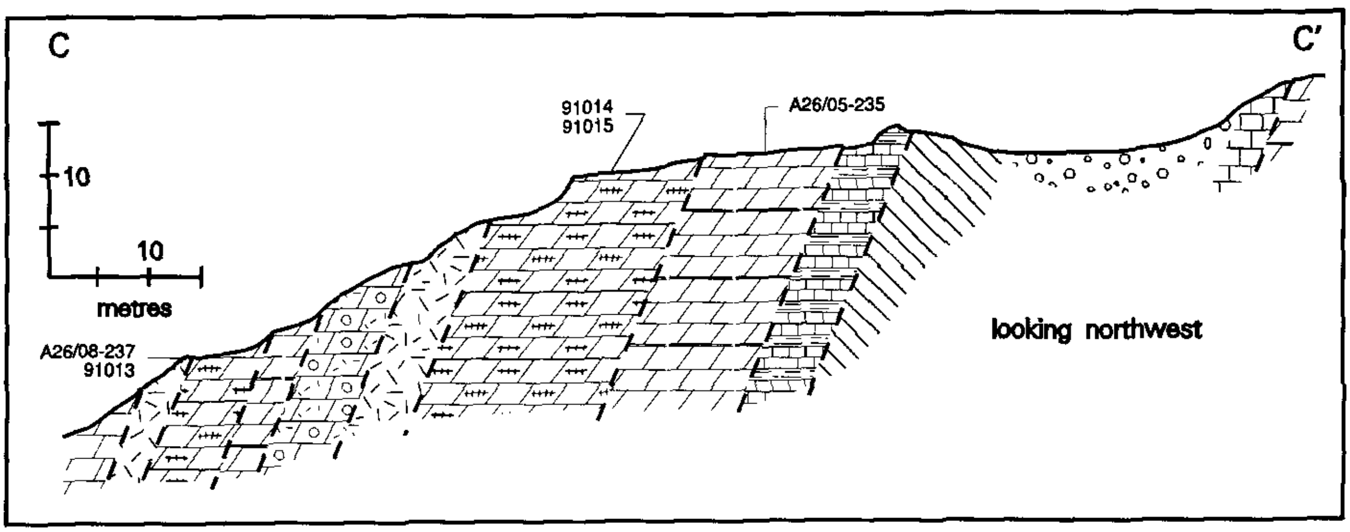


Figure 3-2-6. Lithologic section of the Hela showing with sample locations.

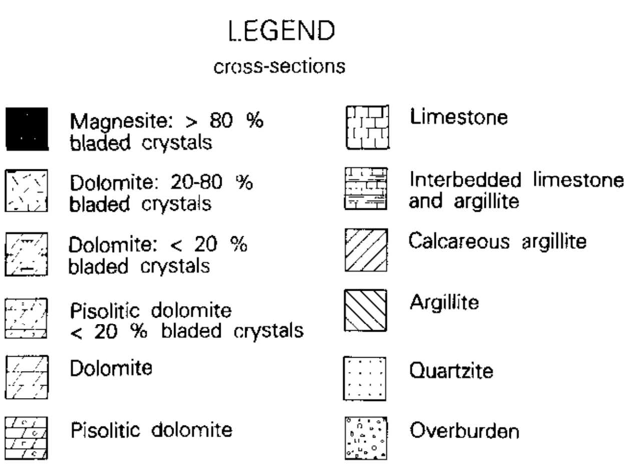
TABLE 3-2-1
WHOLE-ROCK GEOCHEMISTRY FROM THE ANZAC DEPOSIT

SAMPLE	SHOWING	ROCKTYPE	MgO	CaO	Al_2O_3	Fe_2O_3	SiO_2	TiO_2	MnO	Na_2O	K_2O	P_2O_5	LOI	TOTAL	CaO/MgO
A23/5-207	Emmet	magnesite	43.99	0.72	0.11	0.98	2.23	0.01	0.02	0.01	0.01	0.86	50.01	9[illegible].95	0.016
91001	near Emmet	magnesite	39.70	6.74	0.22	1.30	1.62	0.01	0.03	0.05	0.06	0.10	50.00	9[illegible].24	0.169
A23/8-210	Knob	magnesite	43.05	1.89	0.09	0.61	0.74	0.01	0.01	0.02	0.01	0.87	53.25	100.55	0.044
91003	near Knob	magnesite	41.02	5.52	0.11	1.10	0.36	0.01	0.03	0.05	0.07	0.08	50.80	9[illegible].14	0.135
91004	Knoll	magnesite	42.76	3.15	0.21	1.01	0.64	0.01	0.03	0.05	0.06	0.08	51.10	9[illegible].11	0.074
91005	near Fria	magnesite	40.68	5.48	0.22	0.90	1.22	0.01	0.03	0.05	0.06	0.10	50.40	9[illegible].13	0.135
91006	near Fria	magnesite	42.92	3.20	0.20	0.97	0.56	0.02	0.02	0.05	0.07	0.09	51.10	9[illegible].19	0.074
91007	near Fria	magnesite	43.56	1.86	0.26	0.96	1.28	0.01	0.02	0.05	0.09	0.08	51.00	9[illegible].15	0.043
91008	near Fria	magnesite	38.55	4.17	0.49	1.76	5.53	0.02	0.04	0.06	0.05	0.14	48.50	9[illegible].30	0.108
91011	near Fria	magnesite	43.81	1.04	0.24	0.98	1.93	0.01	0.02	0.06	0.08	0.09	50.80	9[illegible].06	0.024
91012	near Fria	magnesite	44.81	1.23	0.14	0.87	0.46	0.01	0.02	0.05	0.05	0.10	51.40	9[illegible].06	0.027
A24/10-219	Odin	magnesite	43.79	3.14	0.21	1.16	0.44	0.01	0.02	0.01	0.01	1.04	50.36	100.19	0.072
91009	near Odin	magnesite	39.35	6.36	0.36	1.48	1.36	0.02	0.04	0.05	0.10	0.13	50.00	9[illegible].23	0.162
91010	near Odin	magnesite	41.47	3.52	0.37	1.55	1.17	0.01	0.04	0.05	0.05	0.14	50.50	9[illegible].11	0.085
A23/1-200	Emmet	dolomite	22.03	31.12	0.11	0.89	0.36	0.01	0.11	0.04	0.03	0.53	46.75	10[illegible].98	1.413
A23/2-202	Emmet	dolomite	25.32	27.12	0.56	0.71	0.94	0.02	0.06	0.03	0.01	0.55	46.00	10[illegible].32	1.071
A23/6-208	Emmet	dolomite	14.32	31.54	0.16	13.29	0.15	0.01	0.03	0.01	0.01	0.57	41.27	10[illegible].36	2.203
A24/11-220A	Odin	dolomite	21.84	31.18	0.01	0.84	0.39	0.01	0.06	0.02	0.01	0.49	46.78	10[illegible].63	1.428
A24/1-220C	Odin	dolomite	26.16	25.76	0.02	0.81	0.01	0.01	0.05	0.01	0.01	0.62	47.92	10[illegible].38	0.985
A24/15-221	Odin	dolomite	22.25	31.01	0.14	0.75	0.24	0.01	0.06	0.03	0.02	0.52	46.83	10[illegible].86	1.394
91002	near Knob	dolomite	30.10	18.80	0.19	0.88	0.59	0.01	0.03	0.05	0.11	0.13	48.50	99.40	0.625
A26/5-235	Hela	dolomite	21.15	30.73	1.00	0.88	1.58	0.04	0.08	0.04	0.29	0.49	45.82	10[illegible].10	1.453
A26/8-237	Hela	dolomite	34.23	16.70	0.08	0.76	0.39	0.01	0.02	0.01	0.01	0.82	48.95	10[illegible].98	0.438
91013	Hela / *237	dolomite	32.26	16.11	0.13	1.25	0.67	0.01	0.04	0.05	0.05	0.08	48.80	99.38	0.499
91901	dup 91013	dolomite	33.81	13.81	0.27	1.20	1.21	0.01	0.02	0.01	0.04	0.04	48.40	98.82	0.408
91014	Hela / #235	dolomite	20.33	29.85	0.13	0.96	3.22	0.01	0.03	0.05	0.05	0.08	45.10	99.74	1.458
91015	Hela / #235	dolomite	19.47	29.33	0.27	0.74	5.57	0.02	0.04	0.05	0.05	0.08	44.10	99.67	1.506
91016	Hela / #237	dolomite	19.65	32.47	0.06	0.68	0.96	0.04	0.04	0.05	0.05	0.06	45.70	99.72	1.652
91017	near Hela	dolomite	19.10	32.44	0.13	0.74	0.86	0.01	0.03	0.05	0.05	0.06	46.00	99.40	1.698
A23/7-209	near Emmet	limestone	1.05	48.30	0.30	0.01	13.00	0.01	0.03	0.01	0.12	0.01	37.89	100.73	46.000

Samples prefixed "A" are the authors and samples prefixed "91" are from Gourlay (1991,) Minequest.

grey to buff and is recrystallized. Grain size ranges from 0.1 to 0.5 millimetre and is usually around 0.25 millimetre. Sedimentary features are only visible on fresh surfaces; stylolites are common though poorly developed. The lithologic descriptions below are all variants of this massive dolomite.

Pisolitic dolomite contains variable amounts of pisolites and oolites, ranging from 5 to 20 millimetres in diameter. Where well preserved, the concentric nature of the grains is readily apparent and core grains are visible. The texture ranges from scattered oolites or pisolites to rock approaching grainstone. Two further variants include massive dolomite and pisolitic dolomite with bladed crystals. The crystal abundance is less than 20 per cent. Chemically the rock composition is that of the massive dolomite. Bladed crystals vary from 5 to 25 millimetres in length, are light grey to white and are found as scattered grains or bipolar growths along stylolites or fractures. Massive dolomite and pisolitic dolomite with bladed crystals are commonly found adjacent to massive, sparry magnesite or massive dolomite with abundant bladed crystals. The latter consists of a framework of 20 to 80 per cent bladed crystals in massive dolomite. This rock is similar in colour and texture to massive, sparry magnesite when the bladed crystal content reaches the upper limit. Chemically, the MgO content is less than 36.5 per cent, often less than 30 per cent. Dolomite with bladed crystals approaching 80 per cent of the rock mass plots as magnesium-rich rock on Figure 3-2-7. X-ray and thin-section analysis shows that the high magnesium content is due to the abundance of magnesite crystals rather than high-magnesium dolomite. The magnesite is interstitial to and replaces dolomite. Other dolomite samples, either with few or no bladed crystals, plot near the stoichiometric dolomite composition. Contacts between massive, sparry magnesite, magnesite crystal rich dolomite and the crystal-poor (<20%) dolomites are distinct though gradational over



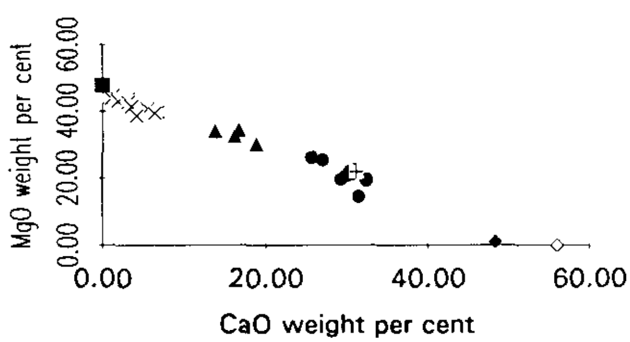


Figure 3-2-7. CaO/MgO plot for the Anzac deposit. Data are in Table 3-2-1. Square = stoichiometric magnesite; × = magnesite; Triangle = high-magnesium carbonate; Filled circle = dolomite; Cross = stoichiometric dolomite; Filled diamond = limestone; Diamond = stoichiometric calcite.

0.5 metre. The contacts are generally bedding parallel and subplanar although in some locations are highly irregular.

Limestone is rarely exposed at the Anzac deposit (Figure 3-2-6). Where found, it is medium to light grey and fine grained with a platy parting along bedding spaced at 10 to 20 millimetres. At the Hela showing there is a colour variation to beige at the downslope side of the outcrop. At or near the base of the carbonate unit are either interbedded limestone and argillite or calcareous argillite. The interbedded limestone and argillite consists of rust-coloured, fine-grained, recessive weathering limestone and green, thinly cleaved argillite. The calcareous argillite consists of interbedded brown and green, thinly cleaved argillite. The brown argillite is dolomitic and the green argillite is calcareous. Bedding is less than 5 millimetres thick.

Slaty argillite and quartzite underly the carbonate member. Argillite is olive green, thinly bedded and well cleaved. It is recessive weathering and only the parts adjacent to the more competent carbonate or quartzite units are exposed. Quartzite is resistant and forms low bluffs. It is white weathering and light grey on fresh surfaces. Grains are well rounded and fairly uniform in size, ranging from 0.1 to 0.25 millimetre in diameter. Where visible, planar bedding is 10 to 15 millimetres thick but the rock appears generally massive.

CONCLUSIONS

Magnesite at the Anzac showings is hosted by carbonate of the upper division of the Lower Cambrian Gog Group. The geological setting of the deposit is similar to that of the Lower Cambrian strata at Mount Brussilof and the Marysville area and the Helikian strata in the Brisco area. The MgO content of the high-grade material is also similar to the southeastern British Columbia deposits. The silica content is similar to the Brisco deposits and less than that of the Marysville deposit. Mapping shows that a magnesite-bearing unit extends over a length of several kilometres but continuity between individual showings is not established. Further exploration along strike to the north and south is justified. Equivalent carbonate units of the Gog Group elsewhere in the area may host similar magnesite mineralization. Our work also suggests that favourable conditions within the Cambrian carbonates may extend northward from the Anzac River area to the Selwyn Basin.

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NOTES