INDUSTRIAL MINERALS

Geology and exploration, McDame asbestos deposit, Cassiar, B.C.

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ABSTRACT

The McDame chrysotile asbestos deposit located near Cassiar in northern British Columbia is found at depth and on trend to the southeast of the currently mined open-pit Cassiar asbestos deposit. The ultramafic rock hosting the McDame is serpentinized peridotite of the Upper Paleozoic Sylvester Group contained in an ophiolitic sequence preserved within a lower thrust sheet of the Sylvester Allochthon. The Sylvester stratigraphic package is a series of thrust slices composed of argillite, tuff and volcanic flows, diorite and serpentinite. Contacts between units are often fault-controlled.

The McDame asbestos-bearing ultramafite is considered to represent a separate interleaved fault-bounded slice of rock distinct from the Cassiar asbestos deposit.

Asbestos mineralization of the McDame deposit was discovered in 1978. Exploration during 1980 and 1981 focused on extensive underground drilling of the deposit and in 1983 on geological mapping, airborne and ground magnetic surveys. In 1984 a 622.5 m borehole was drilled with a 242 m intersection of McDame ultramafite of which the lower 151 metres contain potentially economic chrysotile asbestos. The McDame deposit averages 90 m thick, trends north-south, dips easterly and plunges southeasterly. The deposit is estimated to contain geological reserves in the order of 62 million tonnes containing asbestos fibre similar in value to the Cassiar deposit.

The McDame is considered a major world-class asbestos deposit. A decision to develop and mine the deposit will require further substantial underground exploration and evaluation. A +1200 m exploration adit driven to the hanging wall of the deposit was undertaken in 1985 in anticipation of bulk sampling and diamond drilling in 1986.

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Al Burgoyne was born in Sherridon, Manitoba and was raised in Vancouver. He obtained a B.Sc. in geology from the University of British Columbia in 1962 and an M.Sc. in geology from the University of New Mexico in 1967. He has been involved in all aspects of mineral exploration and development across Canada and the western U.S.A. for several major Canadian mining companies over the last twenty-three years. He is currently vice-president, exploration, for Brinco Mining Limited based in Vancouver.

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Keywords: Industrial Minerals, Chrysotile asbestos, McDame deposit, Geology, Exploration, Exploration surveys, Drilling.

Introduction

This report details the results of Cassiar Mining Corporation exploration programs conducted largely during 1983 and 1984 on the McDame chrysotile asbestos deposit located near Cassiar in northern British Columbia and at depth and on trend to the southeast of Cassiar's currently mined open-pit Cassiar asbestos deposit.

The town of Cassiar, located in the Cassiar Mountains 160 km southwest of Watson Lake, Yukon, hosts a population of 1 200 (Fig. 1). The Cassiar Mine provides the sole economic base for Cassiar and the infrastructure for the surrounding region.

The Cassiar asbestos deposit and mine is unique and impressive for British Columbia. It is the only operating asbestos mine in the Canadian Cordillera, and as a current producer rates as the second largest continuing mining operation in the history of the province. Cassiar commenced production in 1953 and to December 31, 1984 a total of 23 164 500 tonnes of asbestos ore has been mined from the Cassiar deposit and 2 048 100 tonnes of high-quality/high-value asbestos have been produced.

Exploration History

In 1978 an exploration adit collared at the 1 563 m elevation on McDame Mountain and designed to provide access for in-fill drilling of the Cassiar open-pit asbestos reserves intersected unrelated asbestos-bearing serpentinite below and south of the Cassiar deposit. From 1978 to 1980 this adit was driven for 1 334 m and during 1980 and 1981 12 092 m of underground drilling in 37 holes defined a new buried asbestos deposit now called McDame to contain 30.8 million tonnes of asbestos fibre having a fibre value per tonne similar to the Cassiar deposit. The deposit was open to the south and east; however, the layout of the adit prevented further underground drilling.

Exploration during 1983 included detailed geological mapping, airborne and ground magnetic surveys. A large area - high magnitude aeromagnetic anomaly was found to extend southerly from the McDame deposit indicating that the ultramafite(s) hosting McDame was substantially larger than the drilled deposit, and by correlation the asbestos reserve potential was therefore significantly greater than indicated by the 1980 - 1981 drilling.

In 1984 further detailed ground magnetic and geological surveys were completed and on the basis of geophysical modelling curves a deep drill hole was completed on the east side of

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McDame Mountain. The McDame ultramafite was intersected and potential economic asbestos mineralization was intersected over 151 m. Geological reserves based on the 1984 and previous drilling have increased to 62 million tonnes at a grade and fibre value similar to the Cassiar Mine.

Regional Geology

The McDame asbestos deposit is contained within a separate interleaved fault-bounded slice of serpentinized ultramafite within the upper Paleozoic Sylvester Group on the west limb of a northerly-trending synclinorium. The synclinorium now known as the Sylvester Allochthon comprises an ophiolitic assemblage of +5000 m of chert, volcanic, clastic and ultramafic rocks.

The ultramafic rocks are interpreted to represent fragments of an oceanic lithosphere formed at the axis of an oceanic ridge or rise near the margin of the North American continent or at an island arc at some stage of its history and have moved across the ocean floor by sea-floor spreading and finally lifted above sea level during the obduction processes.

This assemblage of rocks was highly deformed by thrusting in its early history to form a stock of horizontal, fault-bounded tectonolithologic sheets or slivers. These sheets form a highly variable and shifted tectonic "stratigraphy" in which older units are commonly thrust over younger units (Harms, 1985). The Sylvester Allochthon was thrust in a northeast direction over autochthonous strata of the North American continental margin in post-Triassic to pre-mid-Cretaceous times. It now lies as an enormous 200 km long by 20 km wide klippe with the basal Sylvester fault occurring as a continuous and planar structure that lies beneath and outcrops around the allochthon. The general distribution of the allochthon and ultramafic bodies is given in Figure 2.

The ultramafic bodies vary considerably in size and degree of serpentinization (Leaming, 1982) and are black to dark green, weathering light green. They are highly sheared and slickensided along major fault zones, but massive and competent where they have escaped deformation. Most are pyroxene-bearing peridotites and therefore originally were harzburgite and wehrlite.

In the mid- to late-Cretaceous, quartz monzonite of the Cassiar batholith intruded the western part of the allochthon and was responsible for formation of the Sylvester Synclinorium and later block faulting.

Local Geology

The geology in the vicinity of the McDame deposit and Cassiar Mine is illustrated in Figure 3. The rocks for this discussion are divided into two packages, pre-Sylvester and Sylvester.

The pre-Sylvester rocks include Lower Paleozoic autochthonous shelf-platform dolomites, limestones and argillites of the Cambro-Ordovician Kechika Group, Ordovician Sandpile Group and the Devonian McDame Group.

All of these rocks trend north-northwest and dip variably to the east. As one approaches the main basal Sylvester Thrust fault the rocks become progressively more deformed. Regionally the basal Sylvester thrust fault lies over the McDame Group carbonates; however, locally the thrust fault crosscuts stratigraphy downward through the McDame Group into the Sandpile Group.

Although regionally the Sylvester fault is depicted as a planar continuous structure, locally on McDame Mountain it appears to be close *en echelon* thrust faults.

The Sylvester Group rocks are upper Paleozoic in age and compositionally are 50% clastic and 50% volcanic. The argillites are medium to dark grey in colour and commonly siliceous or cherty. Locally thin beds of limestone are contained within siliceous argillite. Other varieties of argillite include those intermixed with thin tuff layers.

Volcanic units altered through saussuritization to greenstone were originally basalts and andesites. Both tuffs and flows are recognized.

Diorite units are present and appear similar in colour to the greenstone but are generally coarser grained and appear as stratiform sills.

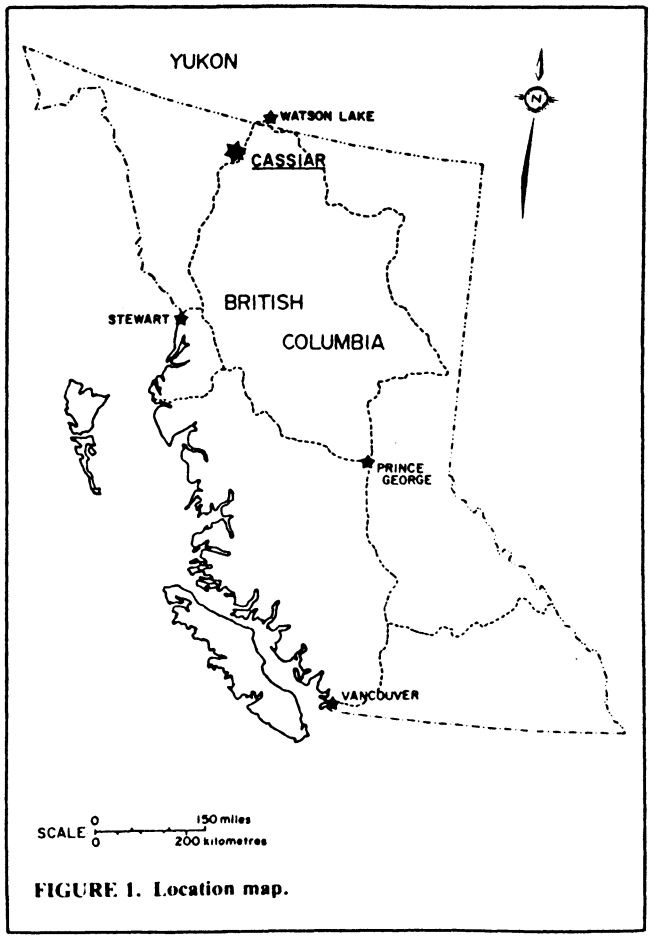

FIGURE 1. Location map.

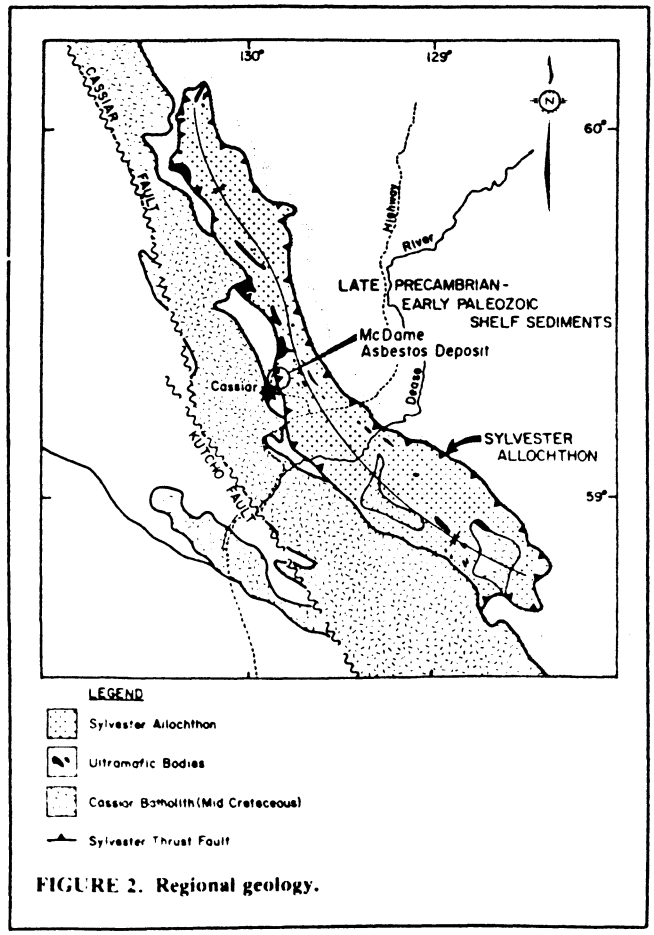

FIGURE 2. Regional geology.

Contained within the Sylv[illegible] Group rocks are ultramafic bodies of variable size, shape and form that have been totally serpentinized. They are strongly magnetic due to a high magnetite content and are the cause of most major magnetic anomalies in the area. The ultramafites locally contain dykes of strongly altered diorite known as rodingite.

Within the serpentinites magnetite and talc occur in veinlets and stringers although some magnetite is found as disseminations; chrysotile asbestos fibre as crosscutting veinlets and fractures, pyrite as anhedral blebs associated with disseminated magnetite. The olivine and pyroxenes have been converted to serpentine and the pyroxene pseudomorph bastite, can locally be recognized. On outcrop brucite is found erratically.

The pattern of asbestos veins is controlled by the joint system (Gabrielse, 1955) and the veins have probably formed by fracture filling. Offsetting of one veinlet by another is common. Economically cross-fibre veins are most important; here fibres are oriented at large angles to the vein walls.

Structure

In the Sylvester Group the dominant deformation structures are thrust faults subparallel to bedding. Other structures include steep faults, fractures and joints. The layering has a general easterly dip but in detail deformation is extensive, beds pinch and swell and are irregular in thickness. The thrust-type deformation is useful in explaining the complex stratigraphy and structure of the Sylvester Group.

Four major thrust sheets can be distinguished as we go structurally upward through the Sylvester Group from west to east on McDame Mountain as illustrated in plan on Figure 3 and in cross section on Figure 4. These major thrust sheets are in turn composed of one or more lesser sheets. The relative ages of the thrust sheets are not known although it is suspected that in many cases older sheets overlie younger sheets. Further mapping and conodont age dating may resolve the relative and absolute ages of the sheets. Within each thrust sheet a normal sequence of

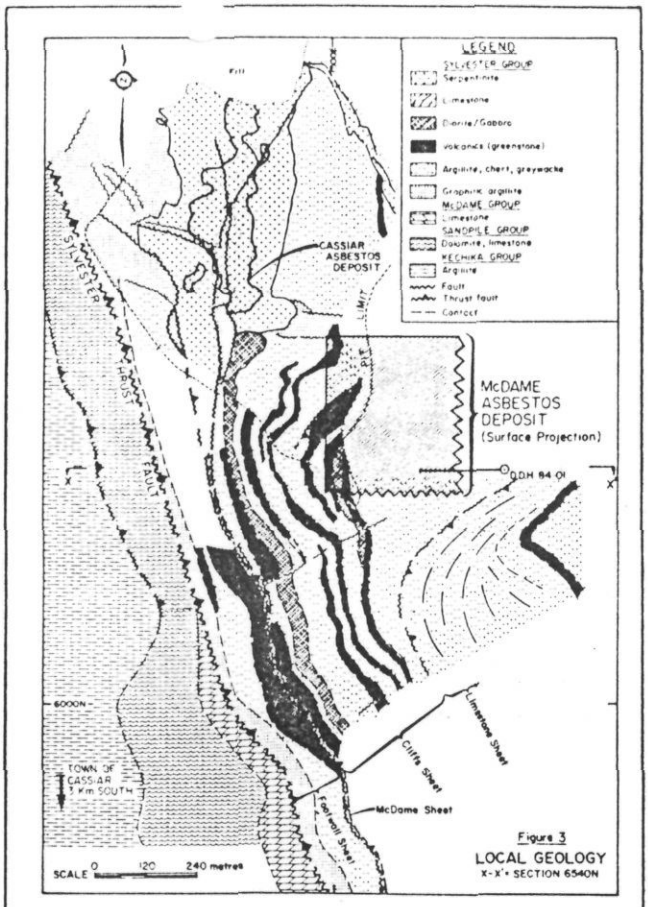

FIGURE 3. Local geology x-x' = section 6540N.

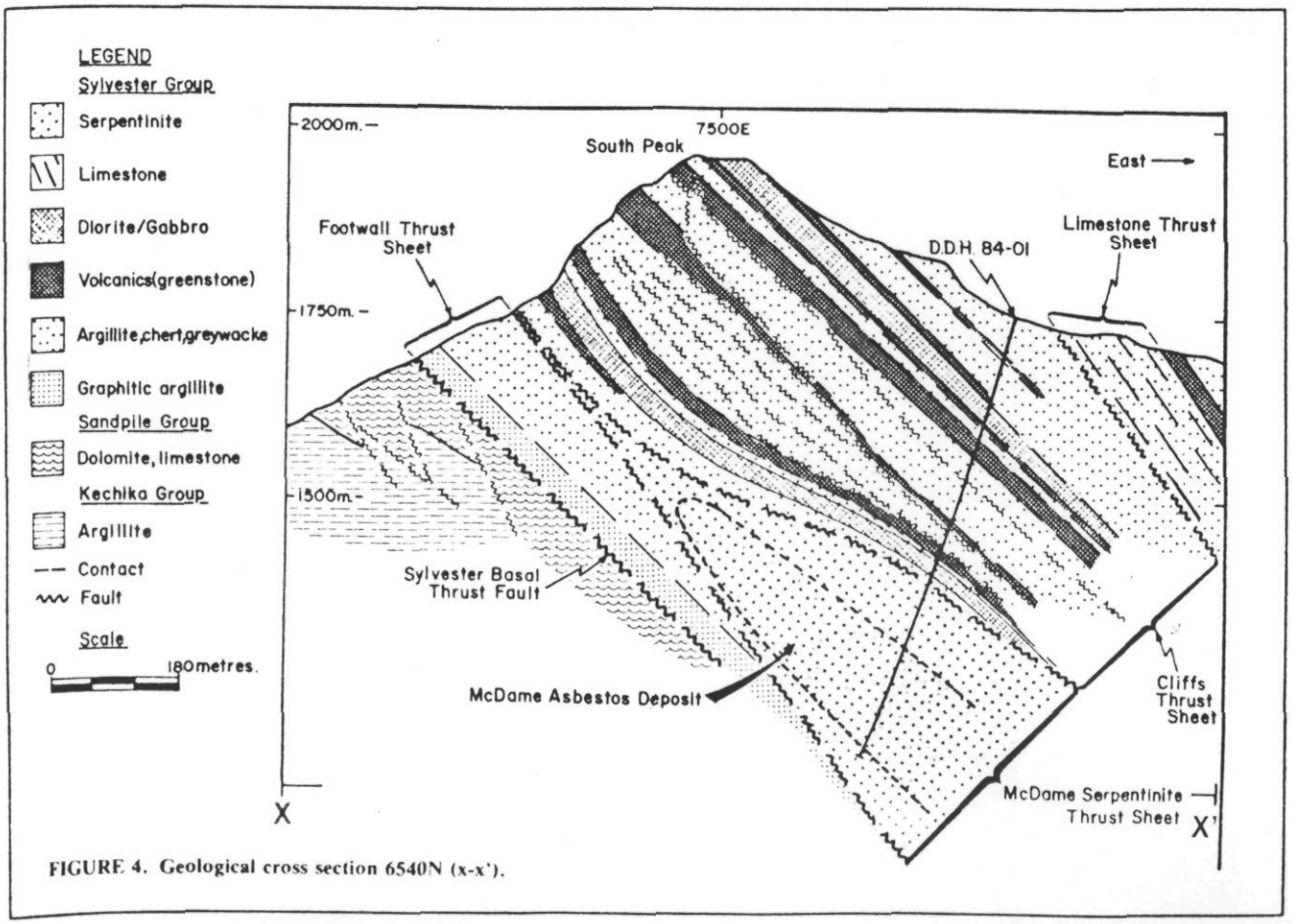

FIGURE 4. Geological cross section 6540N (x-x').

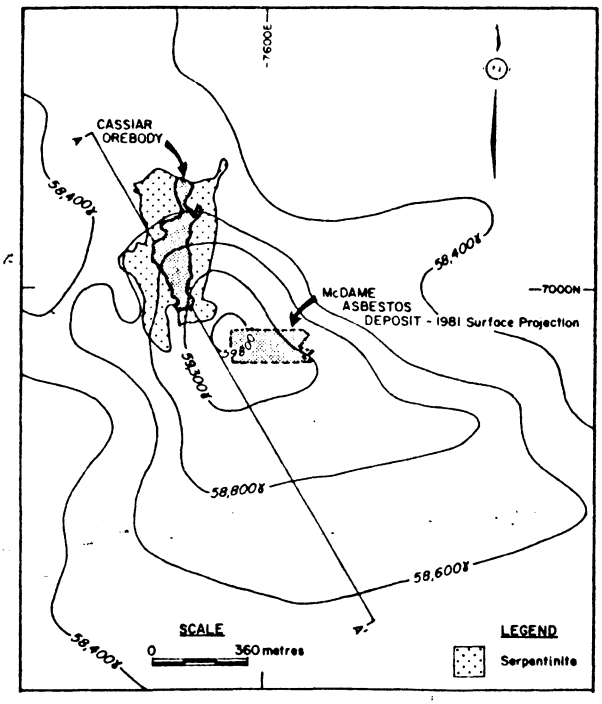

FIGURE 5. Aeromagnetic anomaly McDame and Cassiar deposits.

strata is present that becomes relatively younger as one progresses from the footwall to the hanging wall.

The Footwall Sheet lies over the basal Sylvester thrust fault and below the McDame Serpentinite sheet. The basal part of the sheet over the Sylvester thrust fault is highly deformed and sheared and is marked by carbonaceous or graphitic argillite.

The McDame Serpentinite Sheet which hosts the McDame asbestos deposit is exposed on its updip western edge or tail where a sheared and altered 2 m to 3 m wide discontinuous zone can be traced along trend for several hundred metres. This thin edge is altered to talcy and tremolite schist and schistose serpentinite. The McDame ultramafite dips easterly under McDame Mountain where it attains a thickness of 300 m and is bounded on its hanging wall and footwall by thrust faults. The McDame ultramafite is a separate thrust sheet or slice of rock distinct from several other *en echelon* thrust sheets to the north that contain the Cassiar ultramafite and respective asbestos deposit. The McDame asbestos deposit does not subcrop and is covered by rock averaging 400 metres.

The Cliffs Sheet overlies the McDame serpentinite sheet and is wedge-shaped in plan and section. From limited drilling we suspect that this sheet is deformed by multiple thrusting and contains several smaller thrust slices. The sheet is truncated on its footwall and hanging wall by the McDame Serpentinite and Limestone Sheets, respectively.

Normal faulting is prominent in an easterly and northeasterly direction. It is speculated that the orientation of jointing and fracturing is a function of the tectonic deformation that each respective thrust sheet has undergone during thrusting and emplacement and later deformation caused by intrusion of the Cassiar Batholith.

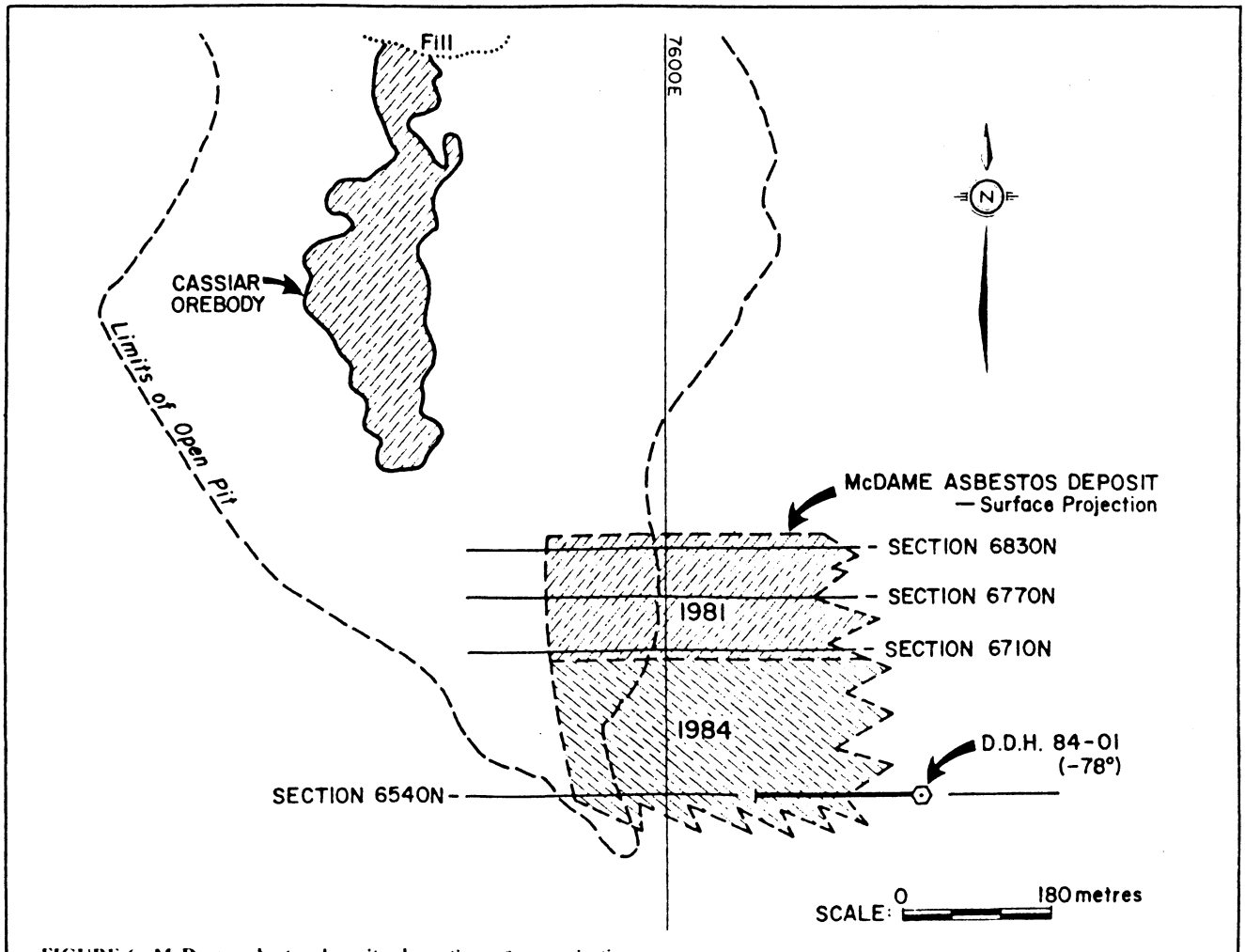

FIGURE 6. McDame asbestos deposit schematic surface projection.

Exploration Surveys

In June 1983 an airborne magnetic survey was completed in the Cassiar area by Apex Airborne Surveys Ltd. of Vancouver, British Columbia in an effort to better define the distribution and extent of known ultramafites and to discover new ultramafites. Line spacings over the McDame deposit area were 200 m apart. The terrain [illegible]ery rugged and precipitous ranging in elevation from 1200 m to 2100 m. The survey defined a bullet-shaped aeromagnetic anomaly over the McDame and Cassiar deposits with a threshold of 58 500 gammas and reaching a peak of 59 900 gammas straddles an area of some 1.8 km in length by 1.0 km wide (Fig. 5). Subsequent detailed ground magnetic surveys defined and confirmed the aeromagnetic

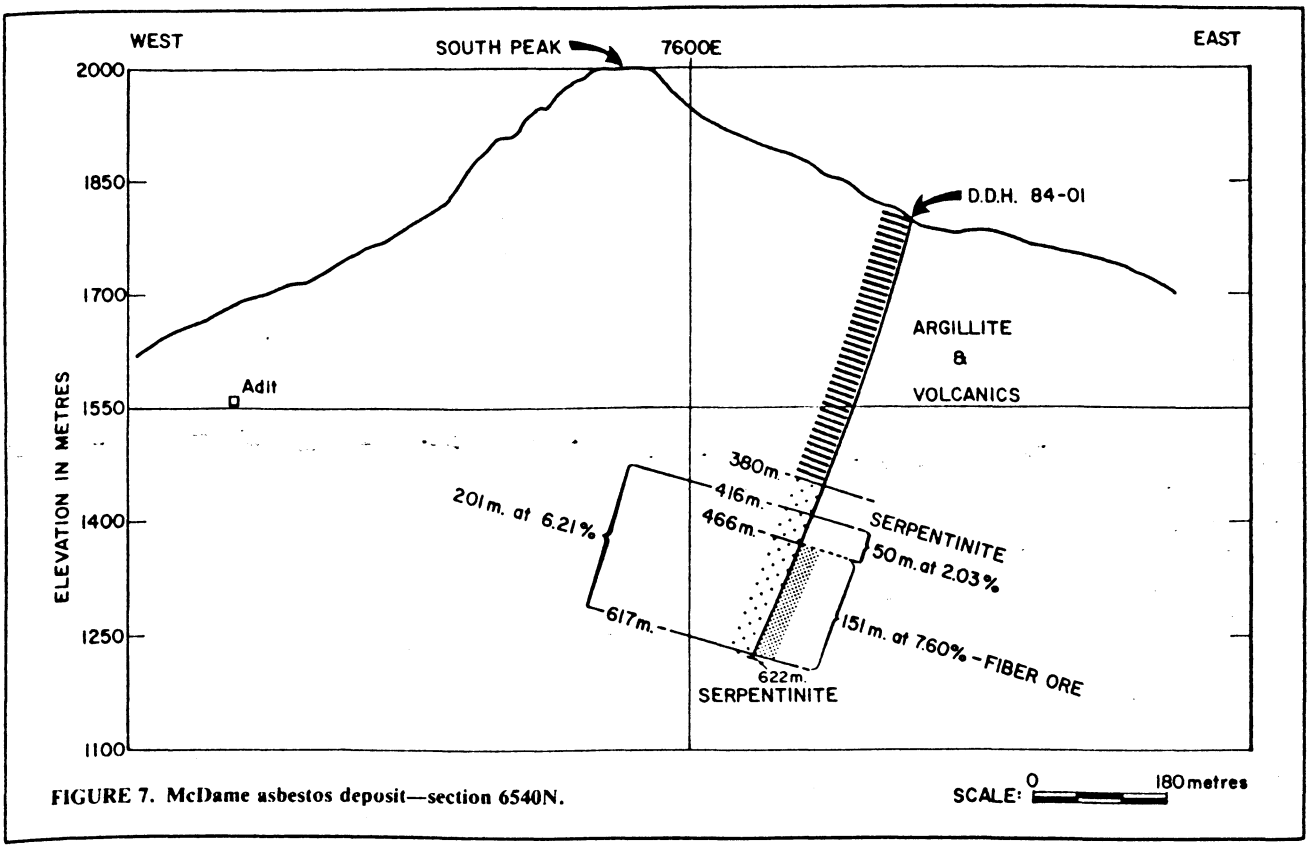

FIGURE 7. McDame asbestos deposit—section 6540N.

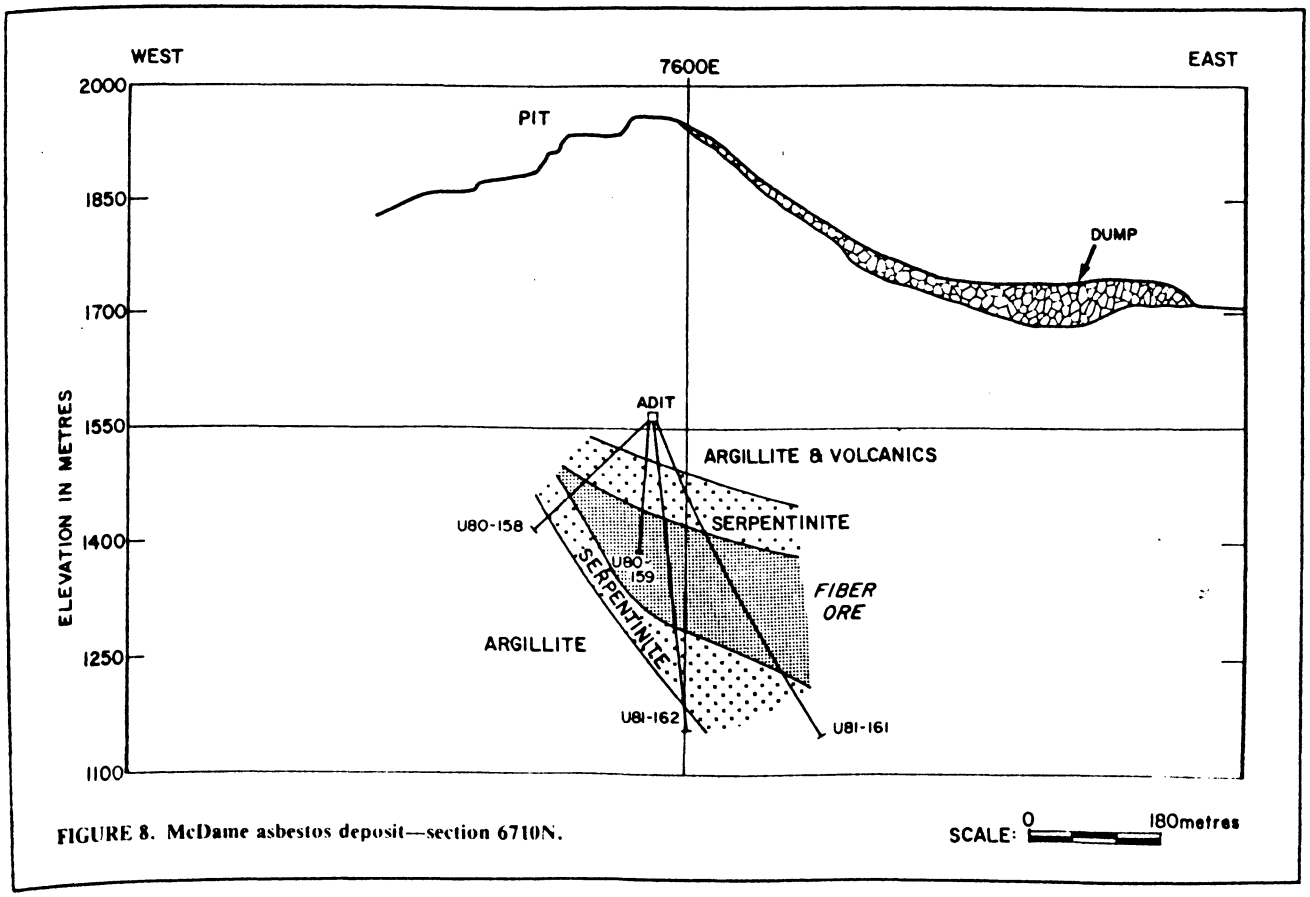

FIGURE 8. McDame asbestos deposit—section 6710N.

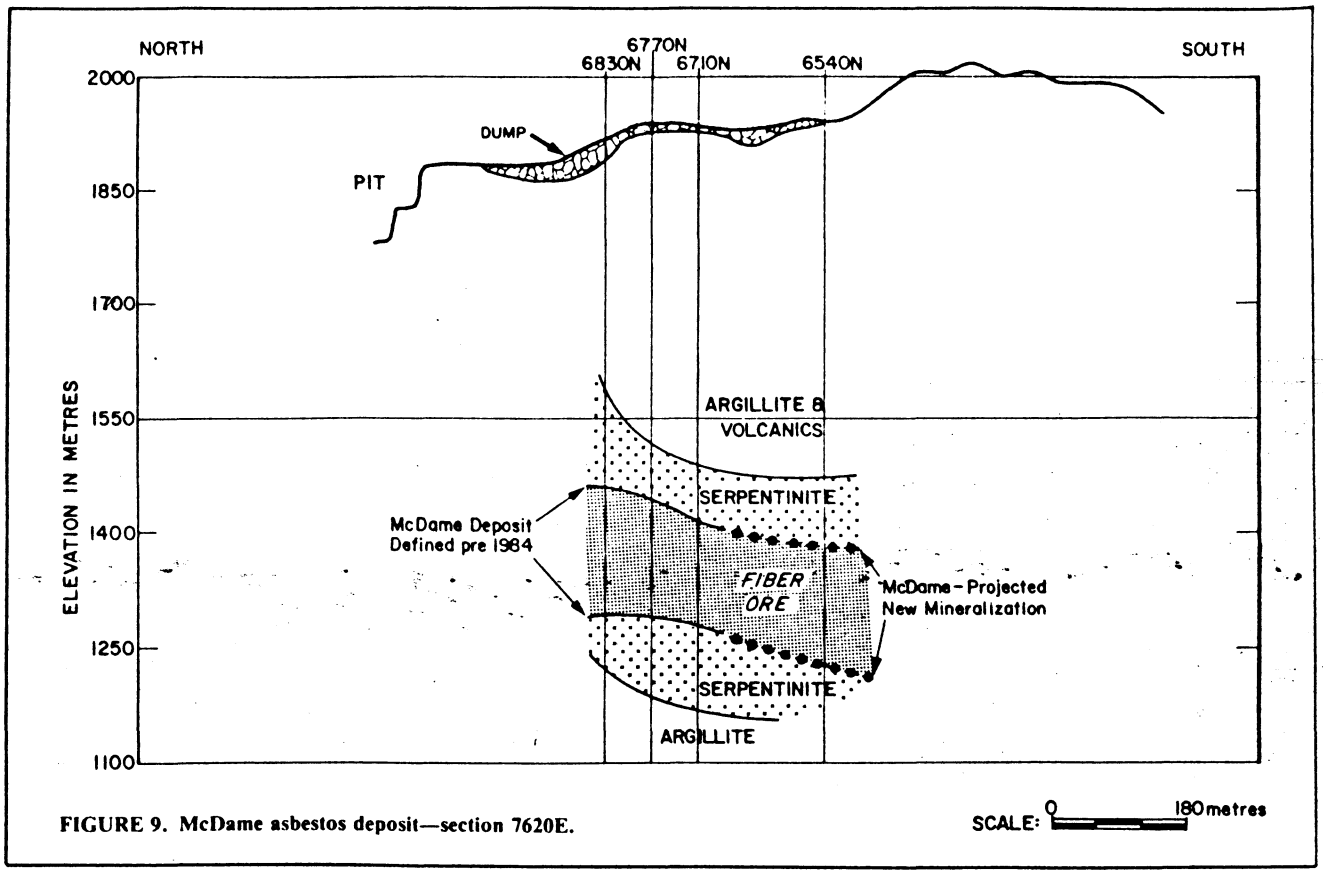

FIGURE 9. McDame asbestos deposit—section 7620E.

anomaly. The magnetic anomalies generated by airborne and ground surveys encompass an area much larger than previously indicated by known distribution of ultramafites. It was immediately suspected that the largest part of magnetic anomaly located to the south of the Cassiar Mine was due to a very large buried ultramafic mass composed of single or multiple thrust sheets which in part or in whole was due to the McDame ultramafite.

Magnetic modelling curves constructed in order to give an approximation of the shape, form, and depth of the causative sources, gave multiple sources from 180 m to 380 m depth from surface which represented one or more sheet-like or tabular bodies dipping to the east.

Drill testing of the large magnetic anomaly was recommended with the objective of testing the causative source and asbestos potential. Two or more possible deposit scenarios were obvious; i) a near surface deposit including a possible up-faulted part of the McDame asbestos deposit; and ii) an extension, at depth, of the McDame asbestos deposit. It was subsequently decided to test both scenarios with a drill hole to a minimum depth of 450 m and if an ultramafic body was penetrated to continue the drill hole, if possible, to its footwall contact. In July 1984 a drill site (D.D.H. 84-01) was set-up on the east side of McDame Mountain in a glacial cirque some 200 m southeast of the previously drilled-off McDame deposit (Fig. 6).

D.W. Coates Diamond Drilling Limited of Vancouver, British Columbia utilizing a Longyear 44-type drill completed a 622.5 m drill hole. The drill hole intersected argillite, volcanics and diorite of the Cliff Thrust Sheet before intersecting the McDame Serpentinite Thrust Sheet at 377 m and in which it continued to the bottom of the hole (Fig. 7). Asbestos-bearing serpentinite grading 7.6% fibre at a 3% cutoff was intersected over 151 m from 466.5 m to 617.4 m.

Reserves

The schematic surface projection of the McDame deposit is given in Figure 6. Reserves have been calculated for a deposit having approximate dimensions of 320 m north-south trend length, 540 m of east-west dip length and a thickness of 15 m to 150 m. Typical sections perpendicular to dip and parallel to trend are given in Figures 8 and 9, respectively. The deposit dips and thickens to the east and plunges gently south.

Reserves have been calculated using a modified weighting three-dimensional block model method utilizing the 1980 - 1981 and current drill hole information.

The geological reserves of fibre-bearing serpentinite at a 3% fibre cutoff total 62 065 000 tonnes at an average fibre grade of 6.5%. The geological categories with their respective reserves are given below:

Geological Category	Tonnes
Probable	15 385 800
Possible (A)	14 004 000
Possible (B)	32 676 000
Total	62 065 000

The usage of the above reserve categories are those defined by the Association of Professional Engineers of Ontario publication given under References.

The Possible (A) reserves represent a higher confidence level and include tonnage on the drill cross section of hole DDH 84-01.

Possible (B) reserves largely represent the assumed downdip extension of the deposit. Reserve calculations based on the 1984 drilling and reinterpretation of earlier drilling results indicate that the reserve increase from 1981 occurs exclusively in the geological possible category.

Reserves are open on trend to the south and downdip to the east. Preliminary interpretations of the size and distribution of the McDame ultramafite based on its aeromagnetic expression suggest that substantial asbestos reserve potential exists for the McDame asbestos deposit.

Future Exploration

A decision to develop and mine the McDame asbestos deposit will require further substantial underground exploration and evaluation. A +1200 m exploration adit driven to the hanging wall of the deposit followed by extensive underground drilling

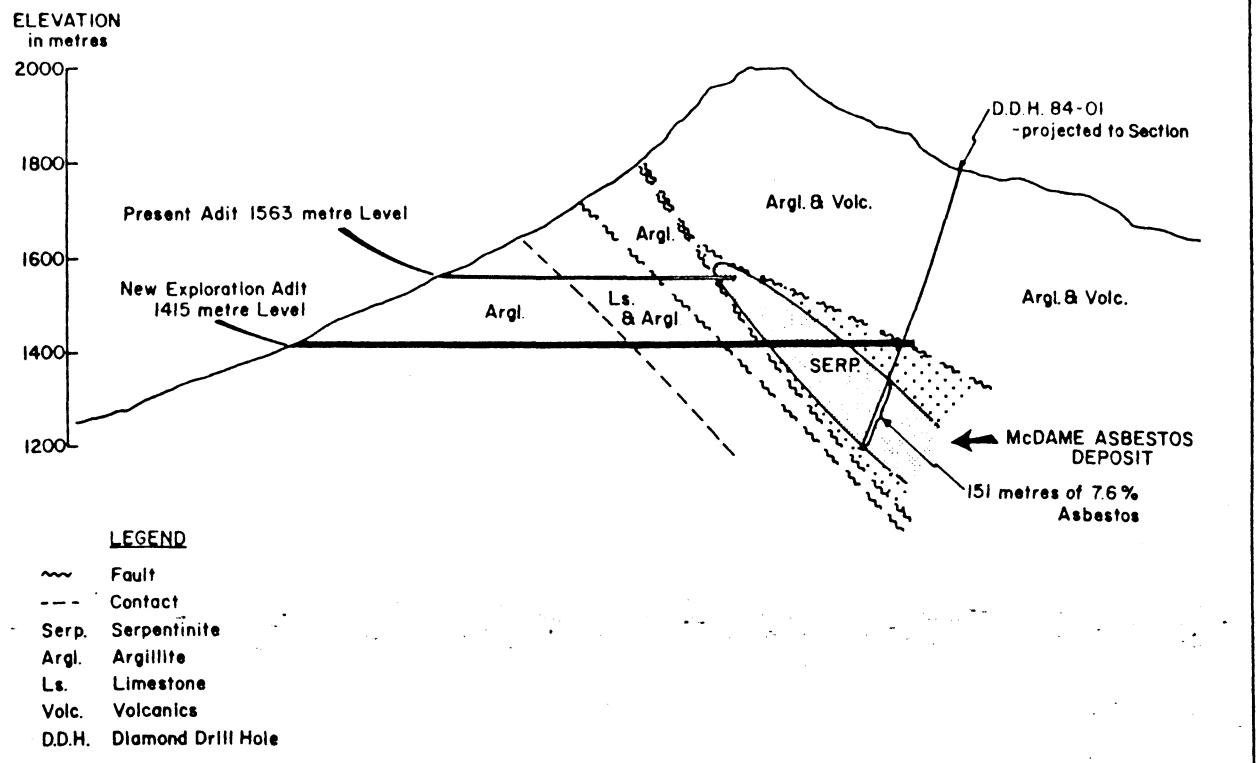

FIGURE 10. Proposed exploration adit, McDame asbestos deposit.

and bulk sampling is being undertaken in 1985 - 1986. A production decision, utilizing block caving mining methods, will be contingent on continuing favourable exploration results, mine operating costs, financing, and markets. A schematic section illustrating underground access to the deposit to complete further exploration is given in Figure 10. If McDame is brought to production the life of the mine at Cassiar can be projected well into the twenty-first century.

Acknowledgments

The author wishes to thank the management of Cassiar Mining Corporation for permitting release of this information relating to the McDame deposit. Several individuals at Cassiar have provided substantial background information and have completed major studies dealing with many aspects of the deposit that are presented in this paper. I would also like to thank Mrs. B. Clegg for typing this paper and H. Holm for drafting the numerous figures.

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