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Willow Creek Mine and Greenhorn Claims
Madison County, Montana

After review of geologic and mine planning evaluation work done by the Exploration Department and the Mines Department from 1979 through March 1984, it is my opinion that these properties are not viable and do not warrant further work. As shown by the attached reports, the Willow Creek property lacks sufficient quantities of high-brightness talc that may be extracted economically, talc and chlorite are intimately mixed to some degree, stripping ratios are unfavorable, tremolite is present in the carbonate zone, and the apparent lack of other valuable minerals categorize this property as one in which Cyprus has no further interest. The attached report on the adjacent Greenhorn claims summarizes an evaluation in which very little talc was encountered, tremolite was again present, and no other valuable minerals were detected.

It is my recommendation that the leases on these properties be terminated.

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Attachment

WILLOW CREEK MINE EVALUATION - 1984

An in-depth study of the Willow Creek Mine has been conducted to determine its viability. This study addresses (1) the criteria of 1981 which led to the decision to not reopen the mine, (2) the viability of the mine based on today's economics and (3) the presence of tremolite within the ore body. This report is based on data derived from a continuous and thorough examination of the Willow Creek Mine which has been carried out by Cyprus Industrial Minerals Company at costs estimated at about \$100,000 since taking control of the mine.

In 1980, when evaluation of geologic and drill hole data began, the ore reserve criteria was 500,000 tons of high brightness (+85 GEB) ore. Reserve calculations made during this initial study indicated that approximately 38,000 tons of +85 GEB talc were present, thus the half-million-ton criteria was not met. No further studies by the Exploration Department were felt necessary at this time. Since the initial study, reserve criteria have changed and smaller deposits are being considered. This change, coupled with a need to document the results of the 1981 work, prompted a re-evaluation of the Willow Creek Mine early in 1984.

The re-evaluation not only considered proven reserves (reserves based on calculations from the initial study), but also considered the stripping ratio (to the 6875 level), and the presence of tremolite.

Prior Work

Prior to the acquisition of the Willow Creek Mine, the former operators, Resource Processors, conducted drilling programs in 1977 (16 drill holes) and 1978 (28 drill holes). Records indicate an investigation of the Willow Creek Mine's chlorite potential was made during 1975. Four analytical reports (dated March 13, April 11, April 21 and May 2, 1975) discussing chlorite potential are attached and conclude that the chlorite is not acceptable for ceramic use (May 2, 1975 report).

History of CIM Exploration Activities

Cyprus Mines Corporation (CIM) entered into a lease/option agreement on the Willow Creek property with Resource Processors, Inc., in May 1979. The mine is situated on four unpatented lode mining claims in Madison County, Montana.

1979 The Exploration and Mine Development Department began evaluation of the property by contracting for and completing an aerial survey of the property. This survey was completed by Intermountain Aerial Surveys, Inc. and a topographic map at a scale of 1" = 200' was generated as a result. In addition, Exploration Research Associates, Inc., of Los Angeles, California, geologically mapped the immediate mine area so that a drilling program could be laid out in an intelligent manner. (See ERA report dated October 8, 1979, attached.)

1980 During 1980, a drilling program was completed by O'Keefe Drilling Company of Butte, Montana. Thirty-four drill holes were completed for a total of 8,830 feet drilled. In addition to drilling, four to six hours of bulldozer work were necessary to prepare and provide access to drill sites. Upon completion of the drilling over 300 samples (which were collected by an on-site geologist) were split and sent to the CIM analytical lab in Los Angeles, California. All samples which were sent for analysis were subjected to three methods of analysis: X-ray diffraction, to determine mineralogy; General Electric brightness, to determine brightness at a specific frequency; and acid soluble content, to determine the amount of either calcium or dolomite that is present. The main pit area was geologically mapped with plane table and alidade at a scale of 1"=50' by Cyprus personnel and a hired consultant in August of 1980.

1980-81 Interpretation of all available data began once drill hole locations were surveyed and coordinates calculated and lab analysis data were received. Interpretation required at least three months to integrate information which was gathered while geologically mapping and drilling the area. The interpretative phase, at a scale of 1" = 50', resulted in the drafting of 50 cross sections and 19 level plans, and upon completion, reserve calculations were made.

The Talc Division initiated an additional drilling program in 1981 with the use of the T-4 drilling rig. The purpose of this program was to hopefully delineate and prove additional reserves of high purity/high GEB talc. Thirty holes were drilled for total footage of 7,290 feet. Data based on lab analyses of samples from five holes supported earlier findings and did not enhance the desirability of this property.

Several samples were assayed for gold and silver content and economical values were not obtained. (See attached assay report from Union Assay Office, Inc., October 31, 1981.)

- 1984 A stripping ratio, based on a preliminary pit design and 1981 reserve calculations, was calculated. The occurrence of fibrous minerals within the Willow Creek orebody was investigated.

Reserve Calculations

A professionally accepted method was used to calculate the reserves. This method is a statistical approach, and it tends to be generous. This method was acceptable for a first look at the ore body.

First the carbonate zone was planimetered and total volume calculated. The following method was used:

Example No. 1

Level	Area Ft. ²
A	100
B	200

$$\frac{(\text{Avg. Area of 2 levels}) (\text{Bench Height})}{27 \text{ Ft.}^3/\text{Yd.}} \times 2.25 \text{ Tons/Yd.} = \text{Tons}$$

- 1) $\frac{100 \text{ Ft.}^2 + 200 \text{ Ft.}^2}{2} = 150 \text{ Ft.}^2$ (average area of two levels)
- 2) $\frac{(150 \text{ Ft.}^2) (25 \text{ Ft.})}{27 \text{ Ft.}^3/\text{Yd.}} \times 2.25 \text{ Tons/Yd.} = 312.5 \text{ Tons}$ carbonate for this bench

The quantity (percentage) of talc present within the entire carbonate zone was then calculated. Following is the step-by-step procedure which was used to make these calculations:

- 1) The total footage of the carbonate zone (dolomite-talc-chlorite-calcite) was determined for each hole and then within this zone the total talc bearing interval was determined.
- 2) Within the talc interval, the average grade of the talc was determined.
- 3) The average grade of talc within the talc interval was multiplied times the total footage of the talc interval to obtain a "weighted footage talc" of contained talc.
- 4) The total footage of carbonate was determined for all drill holes, and this number was divided into the "weighted footage talc" (total

for all drill holes) of talc to obtain a percentage of talc within the carbonate zone.

Example No. 2

(1) Drill Hole	(2) Total Footage Carbonate	(3) Total Footage Talc Zone	(4) Avg. % of Talc Within Ore Zone	(5) Weighted Footage Talc [(3) x (4)]
1	100	50	65	32.5
2	50	25	75	18.8
Total	150	75	-	51.3

$51.3 \div 150 = 34.2\%$ contained talc within the carbonate zone.

The quantity of talc of a given GEB value was determined as follows:

- 1) The total footage of talc of a given GEB range (>85, 80-85, 75-79 and <75) for all drill holes was determined.
- 2) The total footage of a given GEB range of talc was then compared to the total footage of the talc zone (Column (3), Example No. 2), and the percentage of this grade of talc within the interval was obtained. This procedure was repeated for each grade of talc. This represents the percentage of a given grade of talc that is present within the talc zone of the ore body.

Example No. 3

Drill Hole	Total Footage +85 GEB	Total Footage 80-85 GEB	Total Footage 75-79 GEB	Total Footage <75 GEB
1	2	4	3	5
2	5	3	3	4
Total	7	7	6	9

$7 \div 75$ (Column 3, Example No. 2) = 9.3% +85 GEB within the ore zone

$(9.3\%) \times (\text{total tons of talc}) = \text{tons of +85 GEB talc}$

Reserve calculations showed that substantial quantities of high brightness talc (Table No. 1) did not exist on this property. The total mineralized zone (dolomite-talc-chlorite-talcose rock types) was calculated to be approximately 2.5 million tons, of which 772,500 tons (30.9%) was talc. Of the 772,500 tons of talc, only 37,982 tons (5.0%) was +85 GEB, and, based on these results, it was recommended by the Exploration and Mine Development Department that the property be dropped.

Stripping Ratio

In order to fully understand the viability of the Willow Creek Mine with respect to today's (1984) economics, the stripping ratio was calculated. An industry-accepted method was employed to calculate the volume of material to be removed to recover the proven talc reserves. A preliminary open pit mine was designed with an overall pit slope of 45°, and included removal of material from level 6875 (toe of pit) to level 7450, a depth of 575 ft. below present pit bottom. Upon completion of the pit layout, each level was planimetered and tonnage was calculated. (See Example No. 1.)

An additional 15% of the total calculated tonnage was added to allow for safety benches, benches and haulage roads. This resulted in 21,895,580 tons of material (waste plus ore) to be removed.

Anticipating 75% recovery (based on CIM past experiences), the following stripping ratios would result:

Ore Categories	(Tons) Contained Talc	(%) Recovery	Tons of Recoverable Talc	Tons of Waste	Waste/ Ore
All Contained Talc	775,136	.75	581,352	21,314,228	37:1
+75 GEB	229,441	.75	172,081	21,723,499	126:1
+80 GEB	158,128	.75	118,596	21,776,984	184:1
+85 GEB	37,982	.75	28,487	21,867,093	768:1

Note: See attached map showing pit design.

Economic parameters used in 1981 as well as those used in 1984 show that stripping ratios of these magnitudes are out of the question for CIM to reopen and operate this mine.

Evaluation Costs

It is estimated that since 1979 CIM has invested over \$100,000 in order to evaluate this property. (See attached memo to Ralph Godell, March 30, 1984.)

TABLE NO. 1

1981 RESERVE CALCULATIONS
 PLANIMETERED VOLUMES (MINERALIZED ZONE)

N-S Cross Sections: 2,492,200 Tons
 E-W Cross Sections: 2,518,507 Tons
 Level Plans: 2,514,889 Tons
 Average: 2,508,532 Tons
 Percent Error:
 N-S vs. E-W 1.0%
 E-W vs. Level Plans .1%
 N-S vs. Level Plans .9%

Tonnage Breakdown:

<u>Commodity</u>	<u>Percent of Structure</u>	<u>Tonnage</u>
Talc	30.9%	775,136
Chlorite	30.6%	767,611
Dolomite/Talcose	38.5%	965,785

Tonnage by GEB (Based on Footage)

85+	=	37,982 Tons
80-84	=	120,146 Tons
75-80	=	71,313 Tons
Below 75	=	545,695 Tons

Tremolite Occurrence

Analytical data based on analysis of chip samples from the Willow Creek Mine have confirmed the presence of tremolite throughout the down dip extension of the ore body.

A detailed study of the tremolite occurrence was made in 1984 in order to determine if the tremolite was zoned and whether selective mining methods could be employed to mine the talc and not touch the tremolite. The tremolite was present in 16 holes (see Table No. 2). Each hole was looked at to determine where the tremolite occurred within it with relationship to the hanging wall, footwall, carbonate zone, and the horizontal distribution within the area. A phone call was made by R. L. Weeks to Patricia Colville (Supervisor, Minerals Characterization, Cyprus Research Lab) to confirm the laboratory data, and after additional work, Mrs. Colville verified that the specific mineral tremolite was present and is the fibrous variety. The occurrence of the mineral tremolite at the Willow Creek Mine has been noted by R. B. Berg of the Montana Bureau of Mines and Geology (Montana Bureau of Mines and Geology Memoir 45, 1979, p. 46.)

Based on the analysis of the above data, it can be concluded that the tremolite is not zoned and that selective mining methods could not be successfully employed to avoid mining tremolite. As indicated on the planview map, tremolite occurs along 80 percent of the strike length of the ore body. A detailed look at each hole containing tremolite revealed the distribution of tremolite to be random. Tremolite was found to occur within the carbonate zone, the hanging wall gneiss, footwall gneiss, at both the contact of the hanging wall gneiss and carbonate zone and the footwall gneiss and carbonate zone. Quantity of tremolite in these occurrences ranged from a trace to 20 percent.

TABLE NO. 2

TREMOLITE OCCURRENCES IN DRILL HOLES AT WILLOW CREEK MINE

WC-3-80 (1-2%):	In F.W. and H.W. None present within carbonate zone.
WC-10-80 (trace only):	Occurs within chlorite zone, at contact of chlorite zone and talc/carbonate zone and within zone of best talc.
WC-11-80 (trace only):	Occurs within chlorite zone throughout hole. Occurs at lower contact where going from talc back to chlorite within talc zone.
WC-12-80 (less than 2%):	Within carbonate zone.
WC-13-80 (trace):	Within zone of best talc.

CP-5-80 (trace-10%): Within carbonate zone and at contact of carbonate zone and F.W. falling within both zones.

WC-5-80 (trace-1%): Within talc-chlorite zone, present within zone of best GEBs (83.6).

WC-401 (10%): Within F.W. at contact of carbonate and F.W.

WC-403 (5%): Within talc-chlorite zone.

WC-407 (1-10%): Within chlorite-talc zone, and dolomite-calcite-talc zone (not associated with F.W. or H.W.).

WC-408 (1-10%): Within H.W. and within dolomite-calcite zone.

WC-409 (trace): Within dolomite-talc zone.

WC-410 (trace-20%): Within H.W., within dolomite-talc, talc-dolomite zone.

WC-411 (trace-2%): Within talc-dolomite zone.

WC-413 (1%): Within talc-chlorite-dolomite zone.

WC-416 (1-10%): Within dolomite-calcite-talc-chlorite zone.

Graphite and Pyrite

The presence of both graphite and pyrite was noted in the talc zone in drill holes completed during 1980. The presence of both of these minerals has the effect of lowering the brightness of the talc.

Conclusions

Based on economic criteria in use by Cyprus Industrial Minerals in 1981, reserve studies indicated mining was not economic. A new look at the economics in light of CIM talc requirements in 1984 which greatly reduced the reserve criteria (a minimum of 20,000 tons of ore with a GEB of +86 and no greater than a 20:1 waste/ore ratio) showed that mining would not be economic due to high stripping ratios. Above all, the presence of the tremolite throughout the carbonate zone negates this property for consideration for mining.

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