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TO: M. Naseem Mian
CEntry Constructor and Engineers
FAX: (801) 584-1440

July 18, 1997

FROM: John A. Fleming, Geological Supervisor

RE: Metallurgical Test Sample of Grum Ore

CC: Don Hindy, Dana Haggar, Douglas Kim

Dear Mr. Mian:

The following is in response to your questions regarding the Grum ore sample sent to CEntry for metallurgical test work:

SAMPLE COLLECTION

The 75 kg sample submitted is a composite of three samples collected from the bottom of the Grum pit (sample #'s 1-3) and nine from the surface of the Grum ore transfer pad (sample #'s 4-12). Samples from the pit were collected only along the west wall of the ramp to the 1162 bench between the 1173 and 1180 elevations as most other ore exposures were inaccessible due to water in the pit. Each pit sample represents 20 metres of wall length and was collected by picking up pieces of ore and waste rock about 6 cm in diameter in a 4 to 12 cm range at a frequency of about three pieces per metre of wall length. The ore transfer pad samples were collected from a shallow channel about 30 to 60 cm deep across the pad dug using the edge of a grader blade. The trench was dug across what was recorded as Grum High, Regular and Low Grade ore (3% to >10% Pb+Zn). The samples were collected by picking up rock fragments of similar size and frequency to the pit samples.

SAMPLE PREPARATION

The twelve bagged samples were sent to Northern Analytical in Whitehorse to be crushed to about 1/2 inch size and assayed for lead and zinc. A composite 75 kg sample was prepared by Northern Analytical as requested by Douglas Kim based on the assay results (letter of June 26, 1997 from D. Kim to M. Naseem Mian).

SAMPLE EXPOSURE TO ATMOSPHERE

The pit samples were exposed only from November 1996. Sample #2 was not included in the composite due to its high grade.

The ore transfer pad samples were, according to the September 1996 month end and the May 27, 1997 (sampled surface) survey records, mostly of material stockpiled after the end of September, although some older material from as early as startup may be included. Samples #5 to #7 inclusive skirt the edge of a highly oxidized Vangorda low grade stockpile and may contain a minor quantity of this material. The oxidized material was anticipated, however, and a second, sub-parallel trench was dug south of the main trench prior to sampling and half of samples #5 and #6 were collected from this trench to avoid Vangorda material.

SAMPLE COMPOSITION

The pit samples (#'s 1 and 3) are pyritic massive sulphide (Unit 5) mixed with carbonaceous phyllite while the ore transfer pad samples are mainly carbonaceous and non-carbonaceous quartzite disseminated ore (Units 2 +/- 3). Brief descriptions of Units 2, 3 and 5 from the May 1993 Curragh Inc. (WH9305) internal report on the Grum deposit are attached (p. 11 and 13). The report states that Unit 2 decreases from 53% of millfeed in Stage I through 40% of the entire deposit while Unit 5 increases from 33% in Stage I to 37% for the Stage III pit. Pertinent pages from the February 1978 internal report on the Geology of the deposit by J. Paxton and A.Y. Po are also attached.

DISCUSSION

The sample probably reasonably well represents material supplied to the mill in the last quarter of 1997. How representative this sample is of the remainder of the deposit is uncertain, but it probably has similar ore textures and gangue mineral compositions. The March 1977 report by D.J.T. Carson on the metallurgy of the Grum deposit stated that most of the samples studied were not representative of the orebody and a large number of additional core samples and several additional bulk samples were required to properly assess the deposit. Although sample collection had been started by that time, the results of any analysis do not appear to have been reported.

Sincerely yours,

John A. Fleming

Attachments: 8 pages

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From: John Fleming | Extension 382/313

Number of pages including Cover Page (11)

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MESSAGE:

Memo to follow. Hope this of some use.

Regards

[signature]

FAXED

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LAST SUCCESSFUL PAGE 011

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by rock type. Massive, particularly baritic, sulphides, tend to be high grade, whereas disseminated ores tend to be lower grade (Figure 5). Because of this grade distribution, the tops of the horizons tend to be high grade and the bottoms lower grade (except of course where the horizons are overturned). The sulphide horizons are separated by significant thicknesses of barren phyllite. Interfaces between ore and waste tend to be sharp at the stratigraphic hanging wall contact against barren phyllite but gradational both at the footwall and laterally against sulphide waste.

The Grum deposit was discovered fairly late in the history of the district, largely because it is a completely blind deposit; there is no ore outcrop. The subcrop of the ore structure is buried beneath thick glacial overburden and the remainder of the structure is obscured by phyllite.

Ore Types

Disseminated Carbonaceous Pyritic Quartzite (Unit 2)

Unit 2 is dark grey to black, moderately hard to very hard, well banded, sulphide bearing, carbonaceous, locally micaceous quartzite. Compositional bands usually range from 1mm to 2cm thick. They are dark grey to black, very fine grained, locally micaceous quartzite interbanded with coarser grained, mottled light grey to brassy yellow (to locally red-brown) quartz-sulphide bands. Pyrite is usually the dominant sulphide species with lesser sphalerite and galena. Locally, light reddish-brown sphalerite is dominant. In some places pyrrhotite, rather than pyrite, is dominant, but pyrrhotite is only a minor constituent overall in this deposit. Carbon content is normally within the ¼ to ½% range, and generally occurs in thin coatings concentrated on cleavage surfaces (S_1 and S_2 surfaces). Chalcopyrite occurs locally in traces as small blebs within sulphide bands and fractures.

Total sulphide content varies from 10% to 30% and may locally range up to 60% (the upper boundary into pyritic massive sulphides of Unit 5).

Unit 2 rock types are more abundant than any other ore facies at Grum and constitute 53% of the millfeed in the I.V. Stage 1 Pit and 40% of the I.V. Ultimate Pit millfeed.

Disseminated Non-carbonaceous Pyritic Quartzite (Unit 3 and 4)

Unit 3 is light to medium grey, moderately hard to locally very hard, usually well banded generally well foliated, micaceous, pyritic quartzite. The unit is texturally and mineralogically similar to Unit 2, except that carbon is less abundant and it is, thus, light coloured. Banding is commonly less well developed and sulphide bands in the high grade ore are characteristically redder in colour and contain less pyrite that Unit 2. Unit 3 feed grade is slightly higher in lead and zinc, and gold content is slightly elevated over Unit 2. At Grum, contacts with Unit 2 are commonly gradational over a few feet making a "clean" separation of these ore types at a mining scale difficult.

Unit 3 rock represents 14% of the millfeed from both the I.V Stage 1 and the I.V. Ultimate Pit.

Unit 4 is a low grade, very pyritic variant of Unit 3 with contained lead + zinc less than 4%.

Massive Sulphide (Unit 5 and 7)

The dominant rock type of the massive sulphides is massive pyritic sulphide (Unit 5) which grades into massive sulphides with up to 10-30% barite (Unit 7). Massive sulphides consist of banded to homogeneous, usually weakly foliated, fine grained massive pyrite +/- barite with lesser sphalerite and galena. Total sulphide +/- sulphate content is by definition at least 60%, almost always greater than 80% and commonly near 100%. Gangue consists of quartz, carbonates (calcite, dolomite, ankerite, siderite)and some muscovite and chlorite. Accessory minerals include pyrrhotite, magnetite, chalcopyrite, very minor arsenopyrite and marcasite.

Ductile flow along the margins of the massive sulphides has caused grain size reduction microtextures which have not been annealed by continued heating. These textures result in fine grained ore with complex intergrowths which account for the galena in sphalerite and galena + sphalerite in pyrite middlings that characterize some Grum ore metallurgically (Carson, 1977). Ductile flow has also led to the widespread occurrence of sulphide clast in sulphide matrix breccias in the massive sulphides. Typically, less pyritic or more quartz-bearing lithologies occur as fragments in a more lead-zinc sulphide rich matrix. The clasts commonly show some matching margins along which the clasts can be fit back together indicating these are flow breccias, rather than primary slump or explosion breccias. Ductile flow causes abrupt local thickness change, particularly of massive sulphides in the lower second phase fold hinge. In extreme cases of ductile flow massive sulphides have been observed to intrude phyllites (Paxton and Po, 1977)

Near fault zones, or near the bedrock surface massive sulphides, are slightly oxidized and porous or vuggy. In extreme cases the sulphides become disaggregated sulphide sand. As noted below, some allowance has been made for potential metallurgical impact of this material within 6m of the bedrock surface.

Massive sulphide ore types are the highest grade ore type at Grum and represent 33% of the millfeed from the I.V. Stage 1 Pit and 37% of the millfeed from the I.V. Stage 3 Pit.

(b) Sulphide Units

The sulphide layers are basically made up of two main sulphide units, namely: massive sulphides and quartz sulphides. Both units form distinct but contiguous bands. Generally more Pb and Zn are concentrated in the massive sulphide, although in some cases the opposite may be true.

Massive Sulphide: This unit is a fine grained, dense mass with sulphide contents over 50%. Almost no foliation can be identified. Compositional banding is common. This compositional banding (sphalerite-galena-pyrite) is believed to be an F_1 structure similar to that found in the phyllites (Plate 17).

Variations in the massive sulphide units were noted, based on mineralogy and texture. These are listed below, together with the codes used during core logging:-

M - General term for massive sulphide, particularly dense, hard and compact mass having 75% or more sulphides. (Plate 18).

MV - Porous, vuggy and firable sulphide (Plate 19), with some associated barite in the groundmass.

MB - Hard, dense and brittle mass showing compositional banding (Plate 17).

MX - Brecciated massive sulphides (Plate 20).

MI - Fine grained and massive with rounded fragments of quartz/calcite. This is believed to have undergone plastic deformation (Plate 21).

Mb - With 25% to 75% fine grained barite crystals in the groundmass. 'This massive sulphide type generally grades above 10% combined lead-zinc (Plate 22).

MQ - Hard and brittle with 25% to 50% quartz in the groundmass.

Quartz-Sulphide: This unit consists of narrow 2 - 5 mm bands and lenses of quartz, sulphides, and associated phyllitic material, as well as disseminations of sulphides in a siliceous groundmass. Both F_1 and F_2 foliations are noticeable in this unit. The sulphides are usually disposed along the F_1 but it is not rare to find sulphide grains along the F_2 planes (Plate 2).

Sulphide content ranges from 5% to as high as 50%.

Sedimentary features are preserved within this unit, i.e. grain size sorting which also indicate reworking of earlier deposits (Plate 23), flame structures and load cast features (Plate 24).

Variations in this unit are listed below, together with core logging symbols:-

P	-	General term for quartz-sulphide
PB	-	Mineralogically massive sulphide interlaminated with quartz, sericite or graphite. The sulphide generally follow the F_1 foliation (Plate 25)
PG	-	Quartz sulphide with interstratified graphitic material
PP	-	Granulose quartz and sulphides. The rock has a beaded texture due to "boudins" of quartz (Plate 26)

David Carson of Noranda Exploration, in his report on the Metallurgy of the Grum Orebody (1977), estimated the percentages of each type of sulphide present as follows:-

M + MB	-	15%
Mb	-	10%
MQ	-	20%
MV	-	7%
MI	-	2%
MX	-	< 1%
P (low grade)	-	25%
(medium grade)	-	20%

2. Mineralogy: Pyrite, sphalerite and galena, in that order of abundance, are the common base metal sulphides present. Minor minerals are chalcopyrite, arsenopyrite, tennantite, pyrrhotite, magnetite and marcasite. Native gold was also reported, by David Carson, in 2 out of 88 sample sites he studied.

Pyrite is ubiquitous in both massive and quartz sulphide units. It often shows a high degree of crystallinity with clear and clean crystal faces, but it also occurs as rounded grains and with inclusions of sphalerite. In a polished section of massive sulphide, plates 27A to 27F, several of these textural variations are shown. Bands of anhedral grains change abruptly to bands of closely packed euhedral pyrite with interstitial sphalerite and galena. Abrupt changes in grain size also occur. These variations are attributed to changing conditions prevailing during sedimentary deposition and subsequent differing rates of crystal growth of the original pyrite nuclei. This process is further illustrated by plates 28A to 28D where small pyrite crystals are grouped into semicircular aggregates sometimes with nuclei of sphalerite. Although most of the pyrite grains show crystalline form, these authors believe that these are preserved atoll textures indicative of colloidal deposition. From this original colloidal state, the pyrite grew by accretion and began assuming the cubic crystal form trapping some sphalerite in the process. Where such grains occurred close together, the atolls began fusing to form circular aggregates of cubic pyrite.

Sphalerite and galena commonly occur together as contiguous grains, or as an inclusion of one in the other. These two minerals do not show the same degree of crystallinity as pyrite, perhaps due to their relative mobility. All specimens studied under the microscope show anhedral grains sometimes with simple locking (clean rectilinear or curving interface) and sometimes with mottled relationships (emulsion texture). Many large grains of sphalerite have inclusions of galena and occasionally chalcopyrite. Barite prisms were also observed completely surrounded by sphalerite and partly by galena (Plate 22).

The minor minerals occur in varying modes either interstitially between bigger crystals (chalcopyrite, tennantite and gold), exsolved from major mineral phases (chalcopyrite from sphalerite; pyrrhotite from pyrite), replacing pre-existing minerals (pyrrhotite after pyrite or marcasite; marcasite after pyrite), microveinlets (tennantite), and as independent and isolated grains (magnetite, arsenopyrite). Cases of complex intergrowths (?) between galena and arsenopyrite were also observed (Plate 29). It is not clear whether this relationship is a case of simultaneous nucleation or replacement. But, based on crystallinity, it appears in this slide that arsenopyrite is building up slowly at the expense of galena.

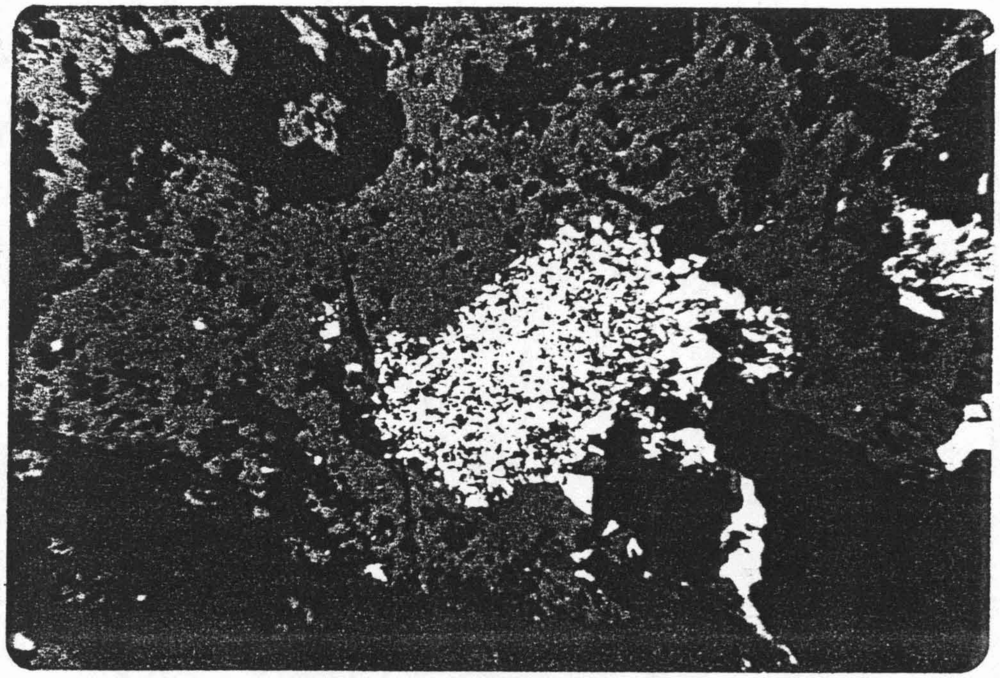

Plate 29: Intergrowth of arsenopyrite and galena.

3. Paragenesis

The paragenetic relationships of the sulphide assemblage is difficult to determine with full certainty. Based on the degree of crystallinity, cubic pyrite was the earliest to form and followed by the rest almost simultaneously with growth from independent nuclei. The colloidal pyrite may have begun precipitating together with the rest of the sulphides, but the process of crystallization of pyrite outlasted those of the other sulphides.

4. Metallurgical Response

Bulk metallurgical testing of the Grum deposit was done in various testing centres in Canada, as well as in Japan. The latest test was done at Mattagami Lake Mines Limited and completed in January 1977. In earlier tests done up until November 1976, the metallurgical response was very poor and the ore samples were subjected to fine grinding to get optimum recoveries. However, even with such treatment, the tailings still contained high lead and zinc while the lead concentrate showed unsatisfactory liberation of zinc.

In November 1976, David Carson of Noranda Exploration started a detailed mineragraphic investigation of the Grum deposit. He identified two characteristics of the ore that caused the poor ore dressing response of earlier tests. These were: (1) Strong oxidation which probably affected less than 5% of the orebody, and (2) A middling producing texture, consisting of fine inclusions of galena in sphalerite, galena-sphalerite in pyrite, and in some degree galena-sphalerite with gangue minerals.

In his report, Carson concluded that:

1. The main metallurgical problem, oxidation and galena-sphalerite intergrowth texture producing excessive amounts of middlings, probably occurs to a serious degree in less than 5% of the orebody.

2. Most Grum ores that were tested metallurgically up until November 1976 were not representative of the orebody. The test samples possessed both problems to an extreme extent.

3. It should be possible to obtain acceptable metallurgical results for more than 90% of the Grum deposit.

4. Grain size, though fine, is much coarser than other ores known to be metallurgically difficult, such as those of the Bathhurst area.

In the Mineral Inventory Report of March 1977, grain sizes were reported to be (average range): Pyrite 0.3 - 0.6 mm, galena 0.08 - 0.2 mm, sphalerite 0.05 - 0.04 mm and pyrrhotite 0.01 - 0.02 mm.

5. Stratigraphy

It is difficult to accurately ascertain the stratigraphic succession in the Grum deposit. Close inspection of the geological sections reveal numerous contradictions and ambiguities due mainly to the complex deformation of the area. Ignoring minor differences, it is nevertheless possible to make a stratigraphic model based on the more consistent patterns found (Fig. 4).

In sections of dense drilling (72W, 74W, 76W), the following general sequence occurs: quartz sericite phyllite - graphitic phyllite - bleached sericite phyllite - massive sulphide with interlayered bleached sericite phyllite - quartz sulphide - quartz sericite phyllite. The other rock units were not included because they lack the same consistent pattern found during drilling.

The sulphide zone is made up of two main layers whose continuity is drill proven and some peripheral layers not fully delineated. Whether these layers represent rhythmic sulphide depositions or repetition of one horizon due to complex folding is not clear (see Unresolved Problems, Page 43). In each of the two main layers, the massive sulphide tends to form a unit on one side (believed to be the stratigraphic top) and quartz sulphide on the other. However, there are cases where the massive sulphide grades into and is partly surrounded by quartz sulphide.