

Mineralogical Examination of 82
Samples from the Vangorda Deposit of
Curragh Resources

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Project No. L.R. 3458A

NOTE:

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LAKEFIELD RESEARCH
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S U M M A R Y

Seventy-one polished sections and eleven pol-thin sections were prepared and examined from characteristic ore samples from the Vangorda deposit. Descriptions of the ore minerals, their relationships and liberation characteristics are given. The samples are subdivided into 6 general ore categories based on their pyrite, base metal mineral and barite content.

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INTRODUCTION A suite of 82 samples, selected from 16 holes in the 1987 Vangorda drilling program, was received for ore microscopic examination. The samples were selected to represent the full range of ore types encountered and a selection of alteration regimes for each type. Accompanying the samples was a code sheet identifying the field classification marked on each sample (see reference sheet attached). Of the 82 samples, twelve were requested for polished-thin section examination, the others in polished section only.

Mineralogical descriptions were to be given of the following items in order to allow selective compositing of ore types based both on lithostratigraphic coding and grain size or liberation.

- 1) Estimates of major sulphide mineral proportions (area %)
- 2) Frequency and nature of occurrence of minor minerals (including arsenopyrite, native gold, silver sulphosalts, etc.)
- 3) Frequency and nature of occurrence of potential gangue diluents (graphite, talc, sericite, chlorite, barite, etc).
- 4) Estimates of value mineral (base metal sulphides, BMS) grain size in microns (range and rough area - weighted mean).
- 5) Locking characteristics for value minerals (nature of grain boundaries, presence of inclusions or locking within gangue, association of ga/py, sph/py, ga/sph likely to generate locked particles after grinding).
- 6) Locking of value minerals with non-sulphide gangue (especially graphite, talc, micas, barite, carbonates in thin section)
- 7) Surface characteristics of value mineral grains, especially with samples annotated "weathered", "sandy" or "oxidized" (are alteration envelopes visible? how deep?)
- 8) Characterization of sphalerite grains as high, low or medium iron (from colour? in thin section?)

PROCEDURES Of the 12 pol-thin sections requested one (sample 87V-06 at 123.8) was too sulphide-rich for thin section preparation. Seventy-one polished sections and eleven pol-thin sections were prepared and examined. Photomicrographs were taken of representative sulphide textures in the sample suite. X-ray powder diffraction analysis was used to confirm or check the identification of gangue minerals, especially barite, in several samples.

The attached tables give estimated proportions (% area) of minerals in all the sections, estimated liberation of base metal sulphides present in concentrations of more than 1% by area at a nominal grind of 200 mesh, association of BMS locking characteristics with other sulphides, oxides and gangue, and proportions of gangue minerals in the polished thin sections. Field classifications were used as a guide to the subdivision of ore types but for metallurgical purposes the sample suite was broken down into the following broad categories:

<u>Ore Type</u>	<u>Characteristics</u>
A	Low Pyrite ($\leq 20\%$); High BMS ($> 10\%$)
C	Low Pyrite ($\leq 25\%$); Low BMS ($< 10\%$)
E ₁	High Pyrite ($> 25\%$); Low BMS ($< 10\%$)
E ₂	High Pyrite ($> 20\%$); High BMS ($\geq 10\%$)
GE	High Pyrite ($> 20\%$); High BMS ($> 10\%$); Barite
G	Low Pyrite ($\leq 20\%$); High BMS ($> 10\%$); Barite

Figure 25, a plot of % Pyrite vs % BMS (Sphalerite + Galena + Chalcopyrite) illustrates the distribution of the 82 samples among the various categories.

RESULTS Tables 1 and 2 summarize the results of mineralogical examination in terms of mineral proportions and estimated liberation at a nominal grain size of 200 mesh. Distributions of all samples are plotted in Figures 26 to 30, (% Pyrite vs % Sphalerite + % Galena + % Chalcopyrite) showing samples with high arsenopyrite ($> 2\%$), presence of gold/electrum and tetrahedrite, high chalcopyrite ($> 2\%$), high magnetite ($\geq 10\%$) and high pyrrhotite + marcasite ($\geq 10\%$).

Descriptions of the textural relationships of ore minerals are given on the following pages and are illustrated in Figures 1 to 24.

Tables 3 to 8 give estimates of mineral proportions and liberation characteristics for each sample within the 6 major ore categories.

CONCLUSIONS The sample suite consists of major pyrite, sphalerite, galena, pyrrhotite/marcasite and magnetite with minor amounts of chalcopyrite, arsenopyrite, tetrahedrite, native gold and electrum. Host rocks to the mineralization consist of quartzites, carbonaceous quartzites and barite-bearing quartzites with variable amounts of carbonate.

The ores have been classified into 6 categories depending on the concentration of pyrite, of BMS (sphalerite + galena + chalcopyrite) and presence or absence of barite. Variations exist among the 6 categories in terms of liberation characteristics. At a grain size of 200 mesh, estimates of free and composite grains of sphalerite are about 45% and 55% respectively. The majority (~ 40%) of composite grains are with pyrite and gangue. Similar estimates for chalcopyrite and galena indicate ~ 30% free grains at 200 mesh and ~ 50% associated with pyrite and gangue.

An estimate of the iron content of sphalerite was obtained by measuring its unit cell edge by x-ray powder diffraction. The FeS content of 23% (\cong 14.6% Fe) should be checked by electron probe analysis to give a more reliable figure for metallurgical balance purposes.

Trace amounts only of tetrahedrite and native gold or electrum are present in a few sections. The native gold/electrum usually occurs with galena or chalcopyrite within massive pyrite.

"Weathered" or "oxidized" samples show no effects of sulphide oxidation. The porous textures appear to have formed by dissolution of barite with no oxidation of the adjoining sulphides.

Figures 26 to 30, illustrating the distribution of higher than average contents of pyrrhotite + marcasite, magnetite, chalcopyrite, arsenopyrite, native gold/electrum and tetrahedrite, show that there is wide distribution of these various minerals among all of the ore types.

PYRITE

The major sulphide (between 25% and 30% overall) occurs in three distinctive textures a) as massive anhedral masses with small intergranular patches of gangue or base metal sulphides (Figure 1), b) as semi-massive subhedral to anhedral grains with intergranular BMS and gangue (Figure 2), and c) as scattered disseminated grains, often coarse and highly corroded especially when surrounded by BMS (Figure 3). Occasional euhedral grains with sharp boundaries (see Figure 1) are present, other grains show fracturing and replacement by BMS (Figure 4).

A fourth texture which is present in only a few sections is illustrated in Figures 5 and 6. Secondary pyrite shows penetration along fractures and grain boundaries in magnetite or pyrrhotite. This texture is likely due to late stage sulphidization.

Sphalerite is the major base metal sulphide and averages between 8% and 10% of the total sulphides in the suite. It is usually honey-brown in colour (Figure 7) with an FeS content of about 23% (\cong 14.6% Fe). This was determined by measuring its unit cell by x-ray powder diffraction (Debye-Scherrer camera) and using the plot from Skinner et al's paper* of unit cell versus wt% FeS. This single measurement should be confirmed by other means, especially by electron probe analysis, if a more reliable Fe content is required for metallurgical balance purposes.

It forms mutual boundary relationships with galena, especially in the common "network" textures observed in type G and GE ores. Figure 8 illustrates the pervasive nature of sphalerite/galena throughout granular barite in sample 87V-17 at 27.0. The corrosive nature of the galena/sphalerite is also illustrated in the irregular pyrite rims in the photomicrographs.

In addition to its intimate, fine grained association with galena (Figure 8) and pyrite (Figure 2), sphalerite may also be intimately intergrown with gangue (Figure 9). Overall, its association at the 200 mesh size (Table 2) shows about 40-45% liberated grains, ~ 20% associated as composite grains with each of pyrite and gangue, and 10% with galena.

* Effect of FeS on the Unit Cell Edge of Sphalerite: A. Revision. B.J. Skinner, P.B. Barton Jr., G. Kullerud. Econ. Geol. Vol 54. P. 1040 1959.

A few sections only display fine exsolution chalcopyrite in sphalerite (Figure 10). For the most part, the sphalerite is not "diseased" and should produce a low copper-bearing zinc concentrate.

Galena, the next most abundant BMS, averages between 4% and 5% for the total sample suite. It displays textures similar to those of sphalerite including intergranular patches within pyrite and gangue and replacement blebs in pyrrhotite (Figure 6) and magnetite (Figure 11). Figure 12 illustrates typical streaky development of galena along grain boundaries in gangue and Figure 13 is a galena/sphalerite rich sample enclosing rounded and corroded grains of pyrite and gangue.

By comparison to sphalerite, galena is generally finer grained and hence less liberated (< 30%) at the nominal 200 mesh size. Overall it is associated mainly with gangue (25-30%), pyrite and sphalerite (~20%). It forms more replacement textures after pyrite than sphalerite (see Figure 9) and rarely contains fibrous gangue as illustrated in Figure 14. This texture was seen in only a few sections and is not representative of the gangue/galena relationship.

Chalcopyrite forms just over ~ 1% of the total sulphides. It occurs mainly with galena, often as intergranular streaks and patches in pyrite or gangue (see Figures 12, 15 and 16). Similar to galena, it is ~30% liberated at 200 mesh and would form composite grains mainly (< 30%) with pyrite and gangue. Less than 10% is closely associated with sphalerite, rarely as fine exsolution blebs as illustrated in Figure 10.

Pyrrhotite/Marcasite. Fresh pyrrhotite occurs in similar relationships to the other base metal sulphides (Figures 6, 16 and 17). Marcasitization of the pyrrhotite ranges from 0% to 100% and starts off as streaky layers formed along basal planes of the pyrrhotite (Figure 17). An example of complete marcasitization is shown in Figure 15 where the intergranular pyrrhotite has been completely altered. Fresh pyrrhotite, accompanied by sphalerite and galena has penetrated fractured pyrite in Figure 4.

Arsenopyrite occurs in 36 of the 82 samples examined. It generally occurs in amounts of less than 1/2% but one sample 87V-07 at 45.3 contains more than 10%. It is generally subhedral to euhedral (Figures 15 and 18) and is often enclosed by or attached to pyrite. The very coarse grains illustrated in Figure 18 (sample 87V-05 at 94.4) are less common than the smaller blocky grains in Figure 15 (sample 87V-25 at 244.9).

Magnetite forms almost 4% of all opaque minerals in the suite. It is invariably blocky, usually coarse grained and often replaced by sphalerite, galena, marcasite or secondary pyrite (Figures 5, 11, 17 and 19). It is interstitial to blocky pyrite and is often fractured and penetrated by gangue (Figures 17 and 19).

Tetrahedrite occurs in trace amounts only in 8 sections. It occurs with chalcopyrite and galena in textures indicative of mutual boundary relationships. The grain size of the tetrahedrite is generally small as illustrated in Figure 20. The sample with the highest content of tetrahedrite (< 1%) is 87V-09 at 134.5.

Native Gold/Electrum

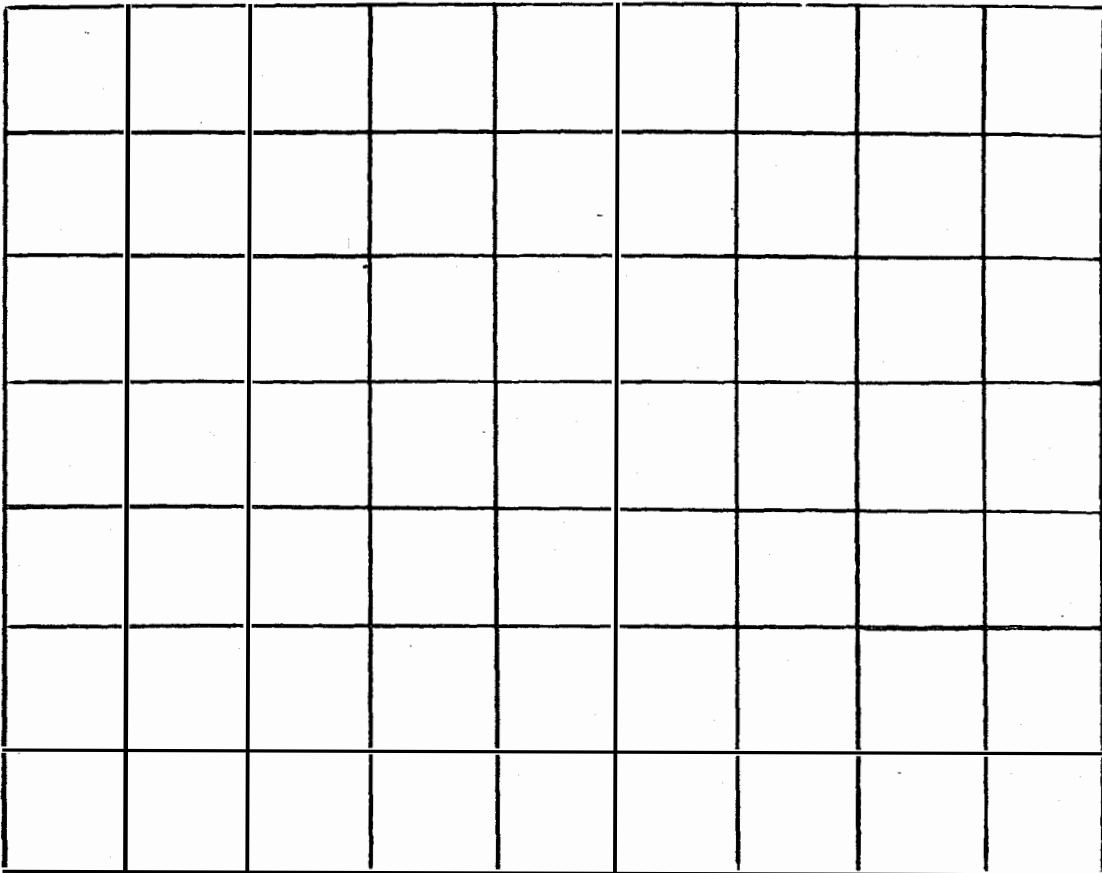
Seven sections contain a total of 10 particles of native gold or electrum. The largest of these, measuring about $17 \times 17 \mu\text{m}$, is illustrated in Figure 22. On average, the grains measure about $6 \times 4 \mu\text{m}$. Only two grains are dark enough to be considered native gold, the others likely have a higher content of silver which gives them a pale yellow colour. The typical occurrence of electrum/native gold is illustrated in Figure 21 where it occurs with chalcopyrite \pm galena along narrow grain boundaries in massive or semi-massive pyrite.

Gangue Minerals. Of the 11 samples examined in pol-thin section, six were classified in the field as type 4A4, sulphide-bearing, ribbon banded, graphitic quartzites. In pol-thin section, however, the black streaky schist plane material does not consist of crystalline graphite and should properly be called carbonaceous. The sheared quartzite consists mainly of granular quartz with warped layers of muscovite and occasional granular carbonate. Figure 23 illustrates a deformation zone or kink band of muscovite with heavily strained and granulated quartz.

Sections cut from the G-type or baritic samples all have barite as the major gangue component. It is usually coarse grained and blocky and is accompanied by carbonate and quartz. Ten other samples of G-type were checked positively for barite content by x-ray powder diffraction. From pol-thin section examination and x-ray diffraction analysis, no talc was identified in the samples. Traces only of chlorite were noted in one sample (87V-09 at 211.2).

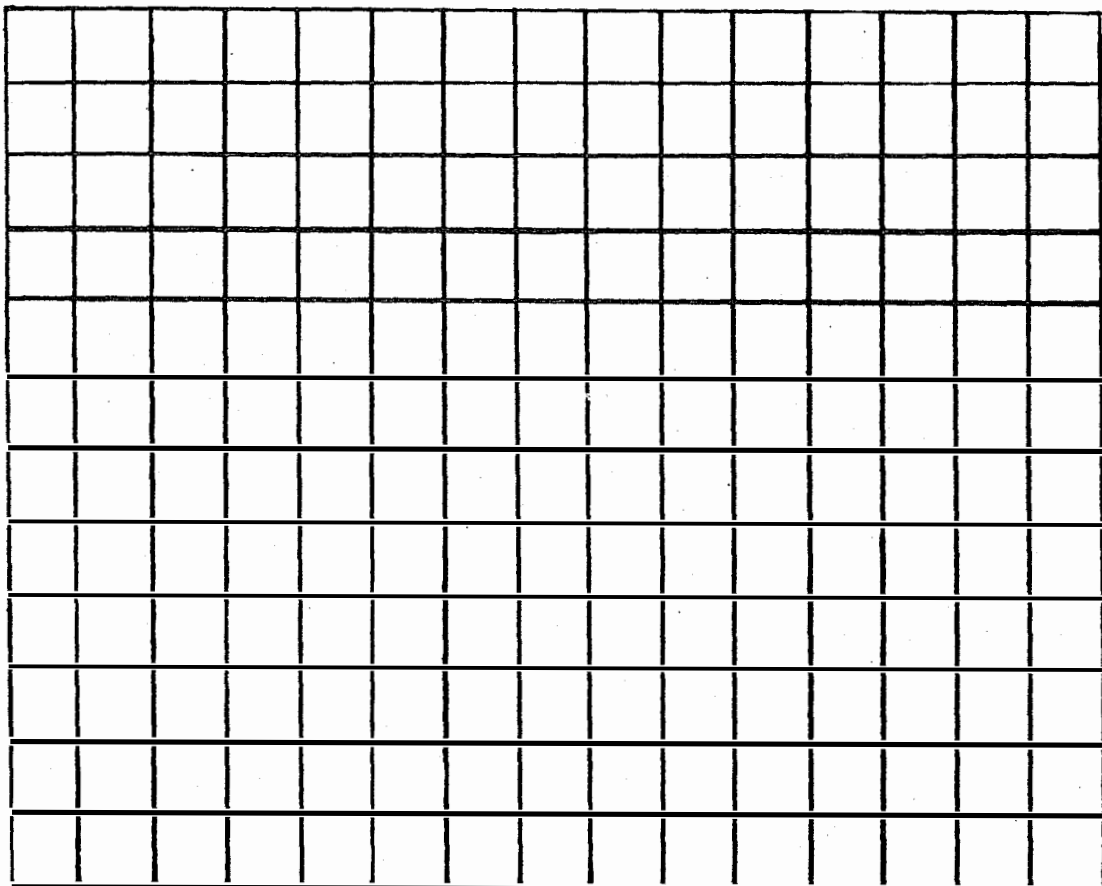
"Weathered" or "Oxidized" samples. Twelve samples were annotated as 'weathered', 'oxidized' or 'sandy'. In each case the polished section appearance was similar, with porous areas throughout the gangue as illustrated in Figure 24. It is apparent that one of the gangue constituents has been weathered, leaving solution pores throughout the ores. Examination of one of the partly weathered grains by x-ray diffraction revealed that it consists of barite.

No evidence of surface weathering of any of the ore minerals occurs in any of these samples so that metallurgical treatment should not be affected by secondary coatings such as covellite.



200 MESH

TEMPLATE FOR PHOTOMICROGRAPHS AT X200 MAGNIFICATION



325 MESH