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MINERALOGICAL INVESTIGATION OF NICKEL-COPPER ORE FROM THE McWATTERS MINE, LANGMUIR TOWNSHIP, ONTARIO

by

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MINERAL SCIENCES DIVISION

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SUMMARY OF RESULTS

The nickel in most of the samples occurs chiefly as millerite; one sample, however, contains abundant nickel-rich pentlandite. Minor amounts of nickel are also present as violarite and nickeliferous pyrite and pyrrhotite. The pentlandite is coarse grained, whereas much of the millerite is quite fine grained, requiring fine grinding for liberation. Chalcopyrite, the other mineral of economic importance, is also quite fine grained.

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INTRODUCTION

On October 21, 1970, Mr. R. Drake, on behalf of the consulting firm of Watts, Griffis and McOuat Limited, Toronto, requested a mineralogical examination of samples of nickel-copper ore on which he was conducting beneficiation tests using the facilities of the Mineral Processing Division. The samples were reported to be from the McWatters mine in Langmuir Township, Porcupine Mining Division in northern Ontario, currently controlled by Tontine Mining Limited.

Fourteen samples of split diamond-drill core were received, which Mr. Drake had combined into six composite samples with the following approximate nickel contents: (1) 0.4% Ni; (2) 0.6% Ni; (3) 0.8% Ni; (4) 1.1% Ni; (5) 3.9% Ni; (6) 4.7% Ni. Copper analyses were not provided. The author picked several core fragments at random from each of the sample bags, and Mr. Drake subsequently provided crushed head samples produced from each of the six composite samples.

METHOD OF INVESTIGATION

Polished sections were prepared from the selected drill-core fragments and from the crushed head samples. Heavy-liquid separations were made on the -65 +325 mesh portions of the head samples to aid in the identification of the minerals, and polished sections were made from some of the resulting concentrates. The polished sections were examined under an ore microscope to identify the minerals and to study their intergrowths. X-ray powder diffraction analysis was used to assist in the identification of some of the minerals, and X-ray diffractometry was used on one sample to determine the principal gangue minerals.

Mineral compositions were obtained by electron-microprobe analyses of the polished sections.

GENERAL DESCRIPTION OF SAMPLES

Most of the samples consist of a dark green matrix of gangue minerals throughout which are disseminated the oxide and sulphide minerals; sample No. 6 contains a particularly high proportion of sulphides. The gangue minerals consist largely of serpentine, chlorite, talc, magnesite, and dolomite, with lesser amounts of amphibole, olivine, and sphene. The principal oxide minerals are magnetite and chrome spinel, together with a small amount of ilmenite. The principal sulphides are pyrite and millerite, although pentlandite was found in samples 5 and 6. Minor amounts of violarite and pyrrhotite were detected in a few of the samples.

The elements of primary economic interest -- nickel and copper -- are restricted almost entirely to the sulphide minerals. The oxides and gangue minerals in many of the samples were analysed for nickel by the electron probe, but no appreciable nickel was detected in these phases.

DETAILED DESCRIPTIONS OF ORE MINERALS

Sulphides

Pyrite appears to be the chief sulphide mineral. It occurs as fine to coarse disseminations in the gangue minerals, and is frequently associated with the other sulphides. A typical intergrowth of pyrite and millerite is shown in Figure 1, and pyrite and pentlandite in Figure 2; Figure 3 shows an unusual fine-grained intergrowth of pyrite and chalcopyrite.

The great majority of the pyrite does not contain detectable nickel, but appreciable amounts of this element (up to 3% Ni), were found in several of the pyrite grains. This nickeliferous pyrite generally has a different appearance than the rest, usually containing abundant fine-grained inclusions of oxides and other sulphides. From an examination of pyrite from all the samples, it appears that only a small percentage of the total nickel in the ore is accounted for by the presence of the nickeliferous pyrite.

Millerite is the second most abundant sulphide, and accounts for most of the nickel. It occurs both as disseminations in gangue (Figures 4 and 5) and as intergrowths with pyrite (Figure 1) and magnetite (Figure 6). Much of the disseminated millerite is quite fine grained, and frequently occurs as narrow splinters and sharp shards (Figures 4 and 5). In contrast, the millerite intergrown with the pyrite and magnetite is irregular in form.

The millerite, theoretically NiS, contains appreciable chemically combined iron, compositions with up to 1.8% Fe having been found by electron probe.

Pentlandite was found in appreciable amounts only in Samples 5 and 6, where it represents one of the chief sulphides and accounts for a major part of the nickel. It is generally quite coarse grained, and is closely associated with pyrite (Figure 2). The pentlandite has a much higher nickel-iron ratio than normal, and electron-probe analyses give a nickel content of 42.3% which is in contrast to the usual nickel content of about 34%.

Chalcopyrite is present in all the samples, although it is quantitatively inferior to pyrite and millerite. It is generally very fine grained, generally less than 200 mesh in size. It occurs chiefly as disseminated grains in gangue, and as veinlets and inclusions in the other sulphides. Some samples were seen to contain numerous inclusions of a micaceous gangue mineral, probably chlorite (Figure 7). The fine-grained myrmekitic intergrowth of chalcopyrite and pyrite shown in Figure 3, was observed only in Sample No. 6.

Violarite is present only in very minor amounts and is not considered to be of much significance. It was found only in two of the samples where it occurs as veinlets in, and in association with, pyrite (Figure 8) and millerite.

Pyrrhotite was found only in trace amounts, as tiny inclusions in some of the pyrite. Electron-probe analyses indicated nickel contents varying between 0.4 and 0.8% Ni.

Oxide Minerals

The two principal oxide minerals are magnetite and a chrome spinel. The chrome spinel is always associated with magnetite in the form of coarse euhedral crystals consisting of a core of chrome spinel and an outer margin of magnetite (Figure 9). The chrome spinel is a mixed spinel of composition $(Fe, Cr)_3O_4$, with iron and chromium in about equal proportions. The magnetite rim, on the other hand, is nearly pure magnetite with only a minor chromium content. No nickel was detected in either of the two phases. Magnetite also occurs in all the samples as fine-grained disseminations throughout the gangue and, to a lesser extent, as inclusions in or as intergrowths with, the sulphides. This fine-grained magnetite does not appear to contain appreciable amounts of either chromium or nickel.

Ilmenite was observed in minor amounts as tiny disseminated grains in several of the samples.

Silicate Minerals

The principal silicate minerals are serpentine, chlorite, and talc. These minerals are virtually indistinguishable from each other by optical means because they have similar refractive indices and because their colours, which vary through shades of yellow, green, and grey, do not appear to be characteristic. It has, therefore, not been possible to make estimates of the relative abundances of these three minerals. The results of flotation tests indicate that some of the samples have a high talc content, comprising nearly half the sample by weight (R. Drake, personal communication). X-ray diffraction analyses of the "talc concentrates" showed, however, that they contained substantial amounts of chlorite, as well as talc, so that the actual amount of talc present in the ore is probably less than that indicated by the flotation results.

Amphibole is generally less abundant than the three gangue minerals noted above, although it is fairly abundant in Samples 5 and 6, appearing to comprise most of the gangue in Sample No. 5. Judging by its optical properties, the amphibole appears to be of the actinolite variety.

Other silicate minerals, occurring in small amounts include sphene, garnet, and clay minerals.

The silicate minerals were examined for nickel by the electron probe, but no appreciable amount of nickel could be detected in any of the silicates. Several "talc concentrates", provided by Mr. Drake and reported to contain up to 0.5% Ni, were analysed by electron probe, but no nickel could be detected in the gangue minerals. On the other hand, tiny grains of millerite were found in the sample, which indicates that the nickel content of the "talc concentrates" is due, in a large part at least, to entrapped sulphide minerals.

Carbonate Minerals

Carbonate minerals occur in appreciable amounts in Samples 1 to 4, inclusive, but are less abundant in Samples 5 and 6. The carbonate minerals include dolomite and magnesite, but the relative amounts of these minerals cannot be estimated because of their similar optical properties. The carbonate minerals were also analysed for nickel but none was found.

CONCLUSIONS

The principal nickel minerals are millerite and pentlandite. Millerite greatly predominates in Samples 1 to 4, inclusive, whereas pentlandite appears to predominate in Samples 5 and 6. Although some of the millerite is quite coarse, much of it occurs as fine shards, splinters, and lamellae disseminated in the gangue minerals, therefore fine grinding will be required for a high degree of liberation. The pentlandite, on the other hand, is relatively coarse and should be liberated more readily. The minor amount of nickel in the form of violarite, nickeliferous pyrite, and nickeliferous pyrrhotite does not appear to be quantitatively very significant. The nickel content of the silicates and other gangue minerals is below the limit of detection.

The presence of talc can be expected to cause difficulties, in the beneficiation of the ore by flotation, because this mineral is normally very difficult to suppress.

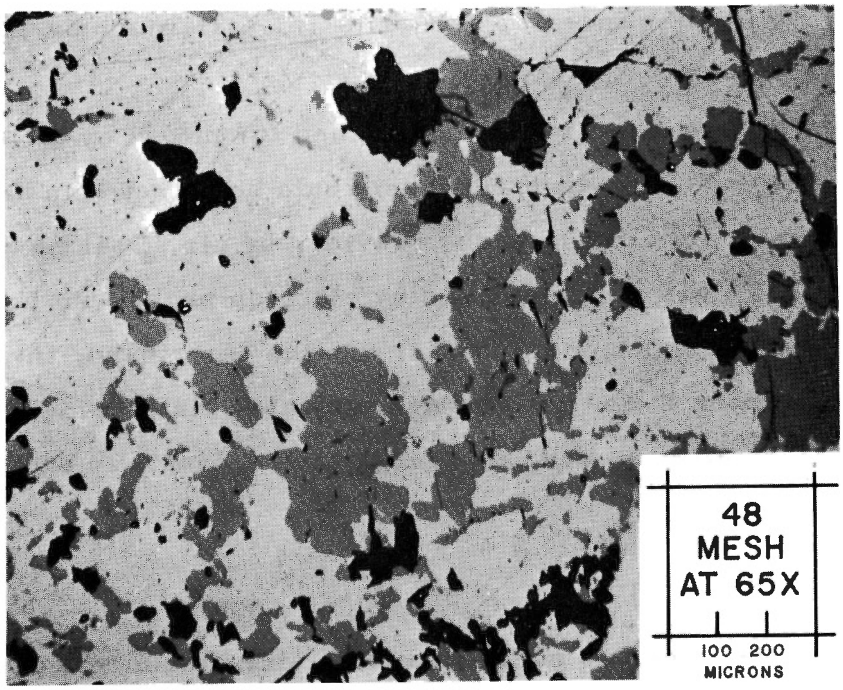

Figure 1. Sample No. 6, crossed nicols. Intergrowth of pyrite (light grey) and millerite (medium grey). Gangue minerals are black.

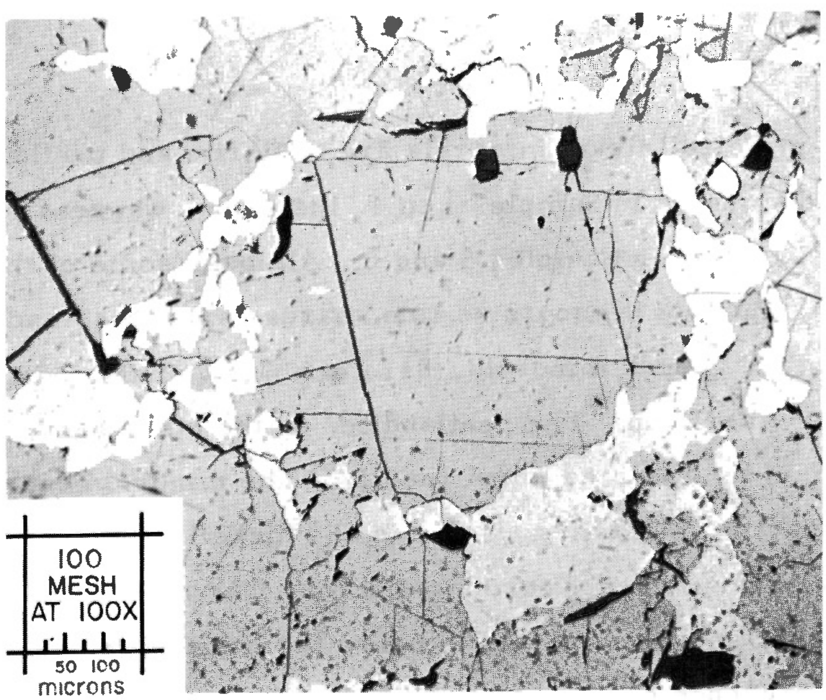

Figure 2. Sample No. 6. Intergrowth of pyrite (white) and pentlandite (light grey). Contrast has been enhanced by deposition of a thin carbon film.

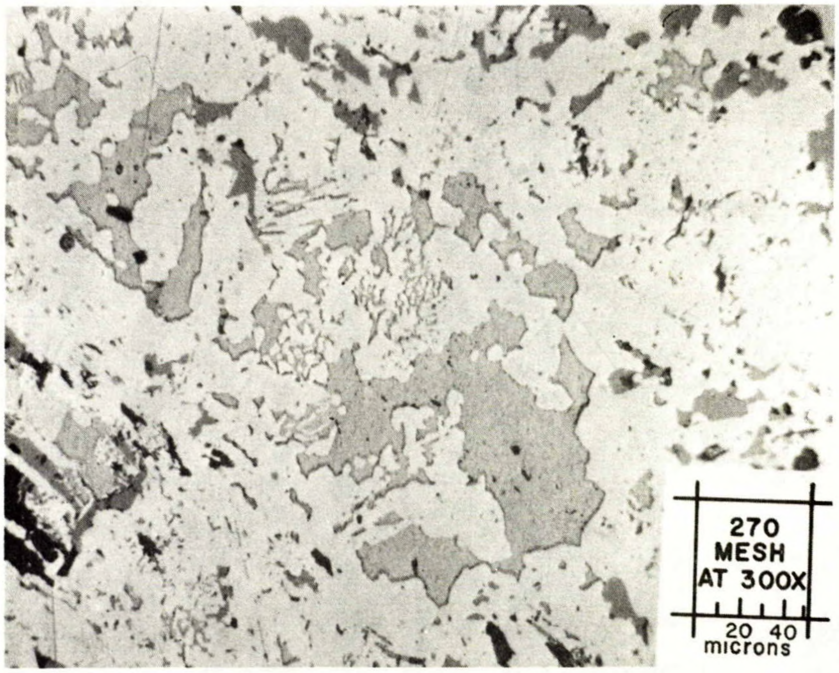

Figure 3. Sample No. 6. Fine-grained intergrowth of pyrite (light grey) and chalcopyrite (medium grey).

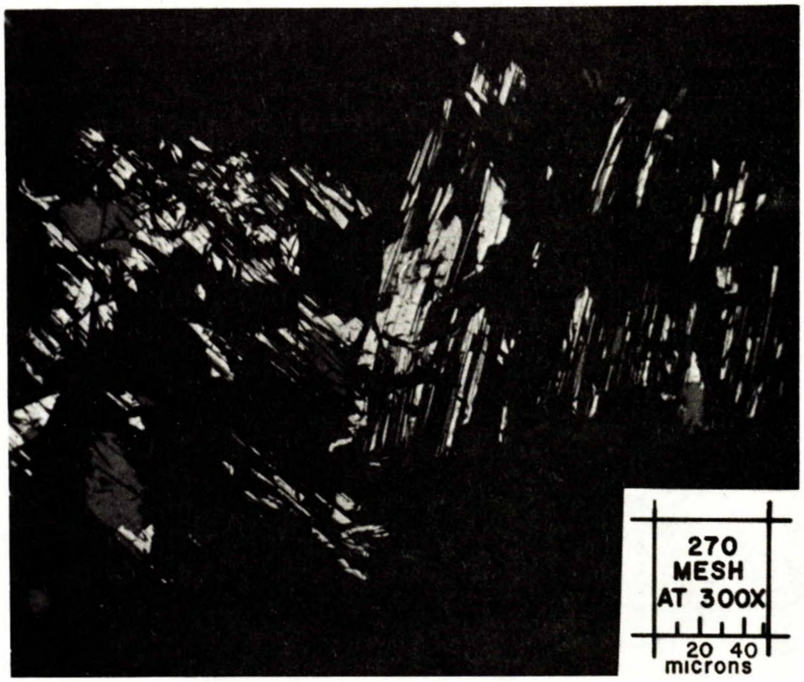

Figure 4. Sample No. 1. Fine-grained splinters of millerite (white) in gangue (black). Several grains of magnetite (grey) are also present.

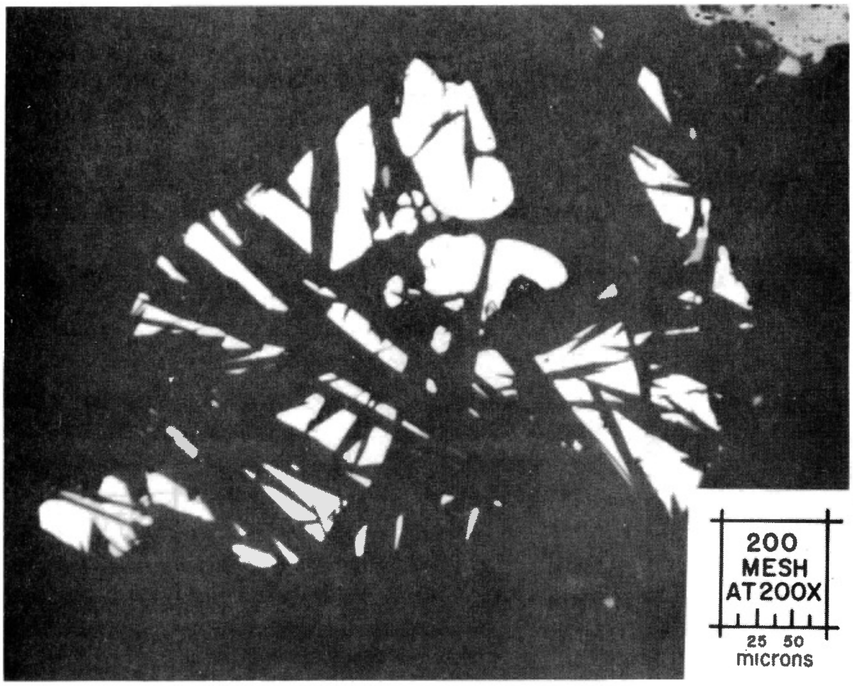

Figure 5. Sample No. 4. Shards and splinters of millerite (white) in gangue (black).

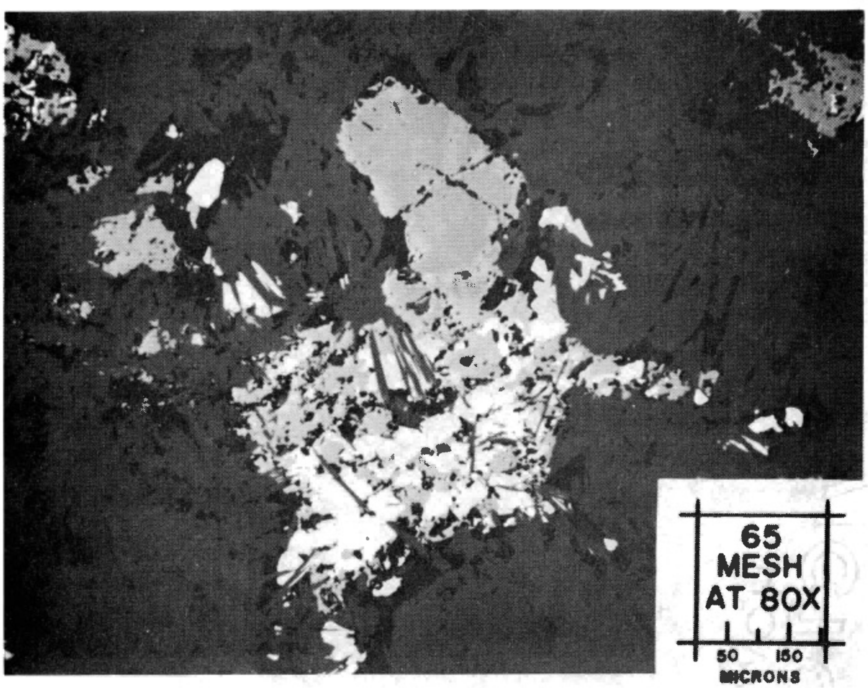

Figure 6. Sample No. 4. Intergrowth of millerite (white) and magnetite (light grey) in gangue (dark grey). Polishing pits are black.

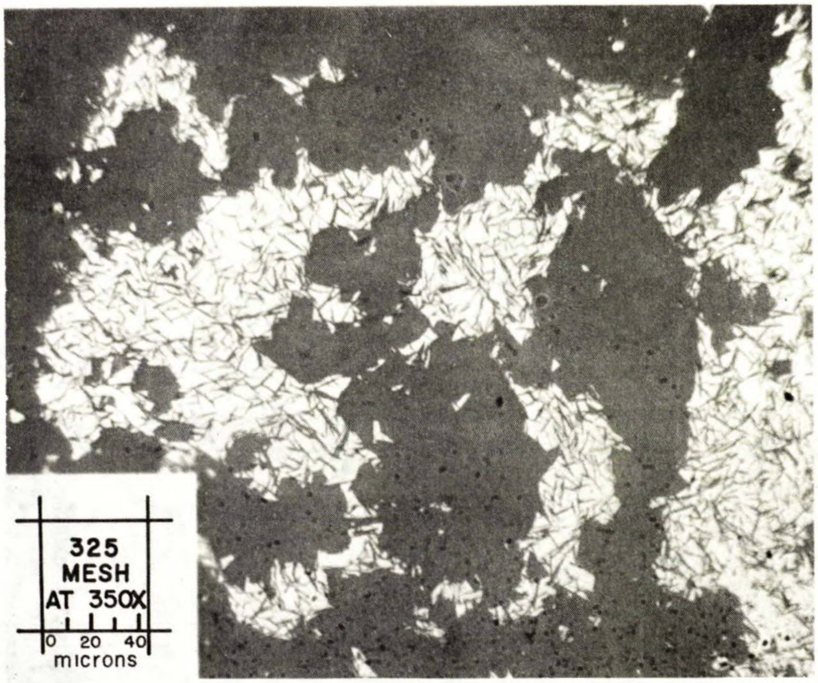

Figure 7. Sample No. 2. Chalcopyrite (white) with numerous inclusions of a micaceous gangue mineral (grey).

Figure 8. Sample No. 4. Violarite (light grey, pitted) associated with pyrite (smooth, white) in gangue.

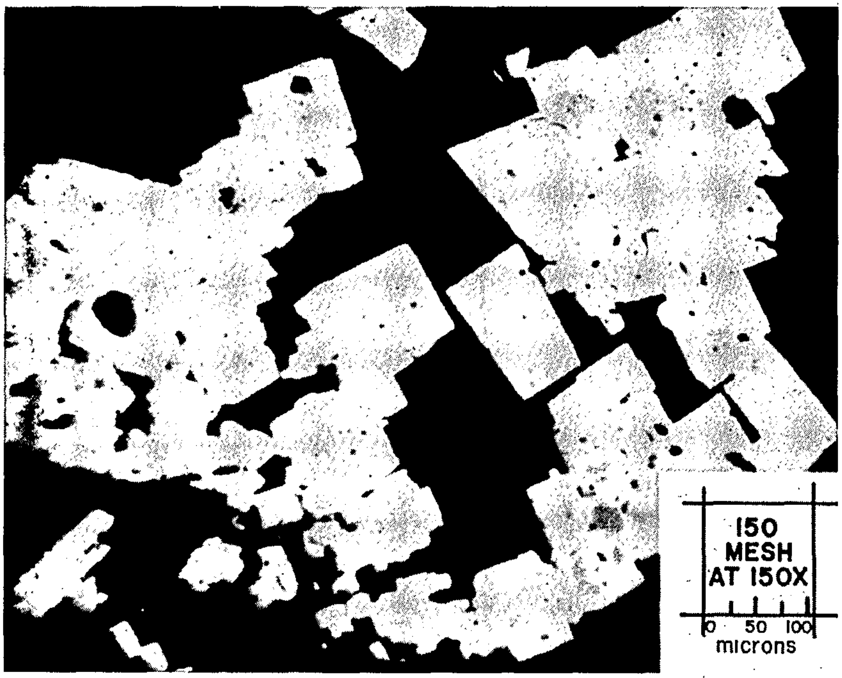

Figure 9. Euhedral crystals consisting of a core of chrome spinel (medium grey) rimmed by magnetite (light grey).