Gravity Prospecting For Massive Sulphide Deposits in the Bathurst Mining Camp, New Brunswick, Canada

Thomas, M.D.[1]

1. Geological Survey of Canada, Ottawa, Ontario, Canada

Approximately 100 Zn-Pb-Cu sulphide occurrences have been discovered in the Bathurst mining camp, New Brunswick. They occur at four principal horizons within the Middle Ordovician Tetagouche Group, a volcanic-sedimentary assemblage that probably developed in an ensialic back-arc rift. Recent geological mapping indicates that the four mineralized horizons are representative of just two stratigraphic levels, with thrusting being responsible for repetition. Most of the host lithologies are fine-grained sedimentary rocks, felsic tuffs, or metamorphic equivalents. Many sulphide bodies are located at the contact between tuffaceous and sedimentary rocks. Generally, the bodies take the form of layered stratiform lenses comprising various combinations of pyrite, sphalerite, chalcopyrite and pyrrhotite. Many are underlain by disseminated mineralization, principally pyrite, and/or chloritic iron formation. Many are overlain by or have a laterally equivalent oxide iron formation. Both types of iron formation typically extend laterally beyond the deposits. Sulphide deposits in the Bathurst camp generally have maximum thicknesses on the order of several tens of metres. They commonly have steep structural attitudes, a result of polyphase folding.

Sulphide ore minerals have high densities that range generally from about 4.0 g/cm^3 for sphalerite to 4.62 g/cm^3 for pyrrhotite. Galena attains an exceptionally high value of 7.50 g/cm^3. Associated minerals pyrite, magnetite and hematite have densities of 5.02, 5.18 and 5.26 g/cm^3, respectively. A sample of densities of massive sulphides in the Bathurst camp, determined from measurements on drill core from several sites, indicates that they range from about 3.80 to 4.40 g/cm^3. Those of semi-massive sulphides range from about 3.60 to 3.85 g/cm^3. By comparison, a sample of density measurements made on fine-grained sedimentary and felsic volcanic host rocks indicates densities ranging generally from about 2.70 to 2.85 g/cm^3. Ranges of densities for sedimentary rocks (argillites, siltstones, greywackes), for felsic volcanics and porphyritic rocks and for various tuffs are similar. A density log (Figure 1) for approximately 700 m of core extracted from a hole drilled on the property of the Canoe Landing Lake deposit illustrates some mean densities of lithologies commonly encountered in the Bathurst camp. These and other density data indicate considerable potential for the detection of sulphide deposits in this environment by gravity surveys.

The utility of the gravity method is well demonstrated by measurements made at the Brunswick No. 6 sulphide deposit. This deposit produced about 12 million tonnes of ore and gave rise to one of the largest gravity anomalies associated with a sulphide deposit in the Bathurst camp. The deposit accounted for roughly 4 mGal of the overall amplitude of about 4.5 mGal (Figure 2a; modified from Slichter, 1955). Iron formation accounted for the rest. The large size reflected essentially two characteristics of the body. It was exposed at surface, and it was relatively wide, being about 75 m wide at surface and 100 m wide at a depth of about 100 m. The effect of burying the geological section of the Brunswick No. 6 deposit at the relatively shallow depth of 100 m is dramatic. The composite anomaly has been reduced to roughly one-third of the amplitude for zero depth. Because of this reduction, the signature is smoother and less prominent, and probably would be less likely to be identified as a favourable target for follow-up investigations. Many sulphide deposits in the camp are appreciably narrower, and consequently, if they were buried, unambiguous identification of their gravity signals in terms of a sulphide occurrence would be even more difficult.

The importance of including the gravity method in exploration programs has long been recognized in the Bathurst mining camp, and surveys have been carried out over many sulphide deposits. The associated gravity anomalies are usually of moderate size, in comparison to that over the Brunswick No. 6 body. Some of the larger ones include those over the Armstrong 'A' deposit, 1.8 mGal amplitude, and the Stratmat Main Zone and Devils Elbow deposits, each about 1 mGal in amplitude. Like the Brunswick No. 6 anomaly, these anomalies stand out against the surrounding gravity field, because of a geological setting dominated by low density felsic volcanics and minor fine-grained sediments and schists. Fortunately, from an exploration perspective, higher density mafic igneous rocks are not present in significant quantities near these deposits. Such rocks attain densities around 2.95 g/cm^3. These are much smaller than those of sulphide ores, but contrasted against densities of felsic volcanics and sedimentary rocks they are large enough to produce anomalies comparable in size to those observed over sulphide deposits. The density contrast between mafic rocks and host rocks may be relatively small (~0.15 g/cm^3) compared to that between sulphides and host rocks (~1.2 g/cm^3), but the invariably larger volumes of mafic rocks compensate for the smaller contrast. Thus, identification of signals having economic potential may be impaired by ambiguity. Consequently, besides depth of burial, mafic igneous rocks probably present the biggest

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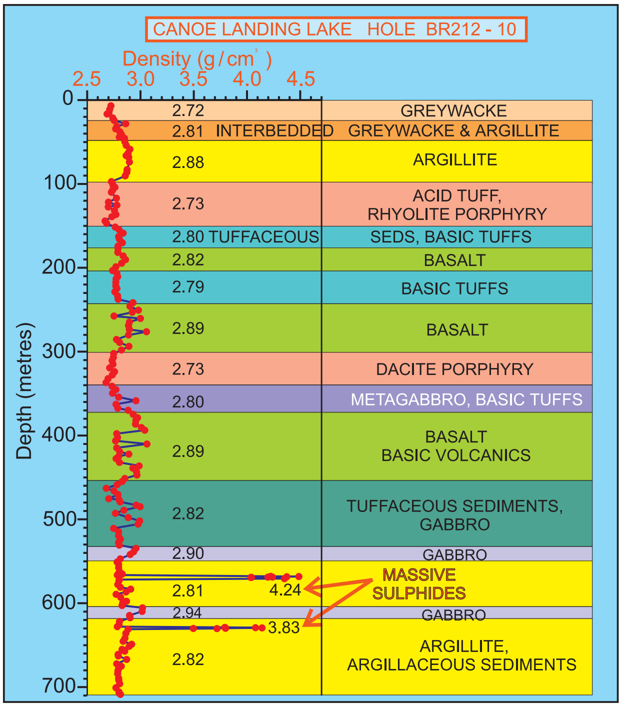

Figure 1: *Density log based on measurements made on core from hole BR212-10 drilled on the property of the Canoe Landing Lake deposit. Mean densities of units in g/cm^3 are indicated.*

obstacle to gravity exploration in the camp. Assemblages of felsic volcanics and sedimentary rocks cover most of the camp, but mafic volcanic and/or gabbroic rocks are found locally, and dominate in some areas.

The difficulties posed by mafic igneous rocks are exemplified by the gravity response observed over the Brunswick No. 12 deposit. This is the largest deposit in the mining camp, past production and reserves totalling almost 150 million tonnes, yet the occurrence of thick basalt units on the west flank of the deposit (Figure 2b) has transformed a potentially symmetrical high over the deposit into a step-shaped anomaly. Instead of being marked by a 3.5 mGal amplitude high, the presence of the deposit is suggested by a much weaker local peak attaining about 0.8 mGal above background values immediately west of the body. While such a peak would doubtless be flagged for further consideration in an exploration program, the full impact of the deposit on the gravity field is not readily discernible. A similar situation prevails at the Half Mile Lake deposit, although there, dense argillite in contact with lower density andesite is the apparent source of asymmetry in the gravity anomaly.

Some of the smaller gravity anomalies in the camp are related to small ore bodies close to the surface. That over the Armstrong 'B' deposit attains an amplitude of 0.3 mGal. The anomaly associated with the 200 000-tonne Captain North Extension deposit, buried by up to 15 m of overburden, has an amplitude of about 0.3 mGal. The Key Anacon No. 2 Zone deposit, at a depth of around 50 m and just over 1 million tonnes, produces an anomaly of about 0.25 mGal amplitude. It is important to remember, given the decrease in amplitude with increasing depth of burial, that not all small anomalies necessarily indicate small deposits. Anomalies as small as a few tenths of a mGal merit the close

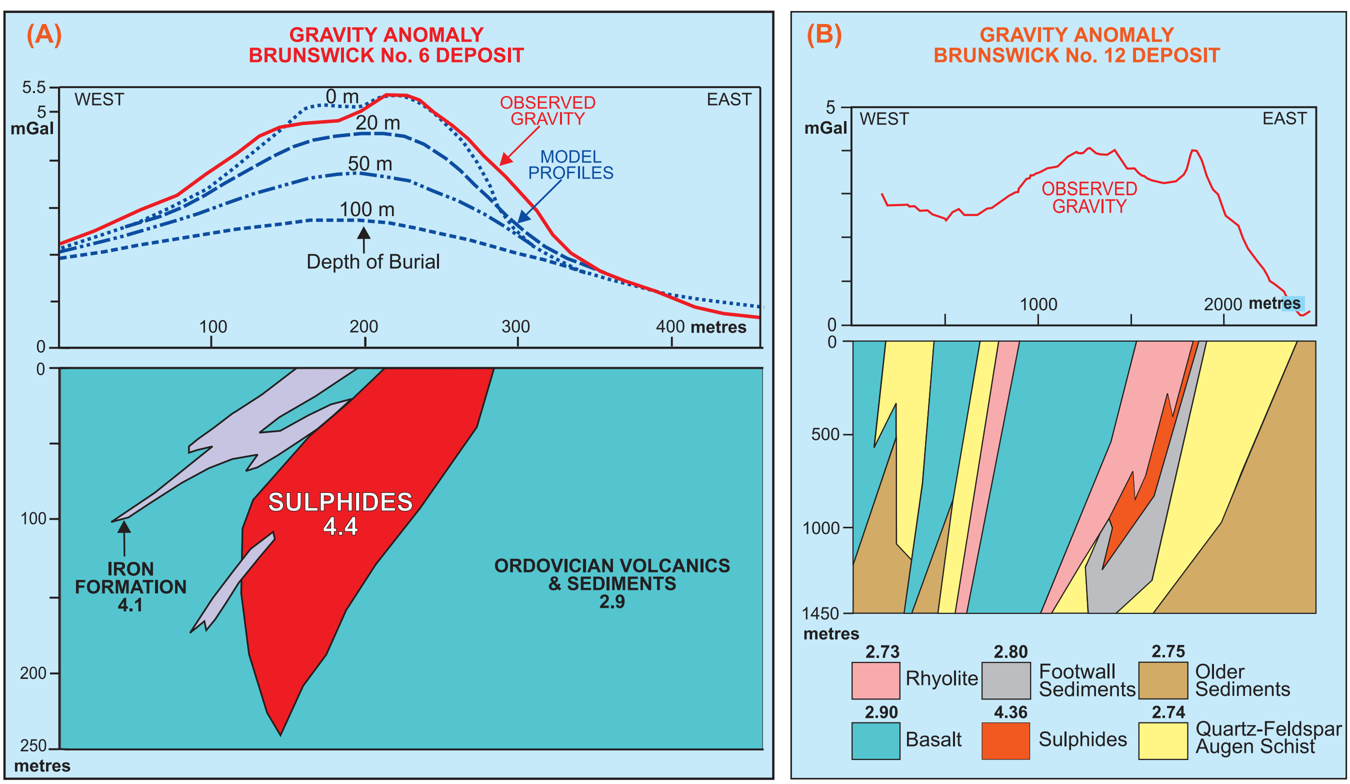

Figure 2: *Gravity profiles across (**a**) the Brunswick No. 6, and (**b**) the Brunswick No. 12 sulphide deposits. The section for the No. 12 deposit was kindly provided by Graham Ascough, Noranda Exploration Ltd. Values of densities in g/cm3 are indicated.*

attention of the explorationist. The importance of such anomalies has been demonstrated by the 0.5 mGal anomaly associated with the 300–700 m deep Neves-Corvo sulphide deposits in Portugal, which played a key role in their discovery. These deposits are estimated to exceed 250 million tonnes.

Although mafic igneous rocks can be problematical to gravity exploration in the Bathurst mining camp, provided the problem is recognized and researched, the contribution of the method to an exploration strategy would appear to outweigh any such disadvantage. An important, and essential, role for gravity surveys in the Bathurst camp is in the evaluation of specific geochemical, electromagnetic and magnetic anomalies. A recent high resolution airborne geophysical survey has outlined numerous electromagnetic and magnetic anomalies that warrant further investigation by the gravity method.

REFERENCE

Slichter, L.B., 1955, Geophysics applied to prospecting for ores, Economic Geology Fiftieth Anniversary Volume, 1905–1955, Part II, 885-969.