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"THE SSW PROBE: a new high-tech tool to raise ore grades by reducing dilution within metal mines."

Abstract

It is possible to selectively mine an orebody by combining the use of the SSW probe with any bulk mining methods as well as narrow vein exploitations. In other words, thanks to the use of the SSW probe, mining operators will be able to reduce and control dilution that is generally associated to every mining operation. Already, quick and substantial savings have been obtained.

Falconbridge mines have demonstrated in Sudbury and Raglan operations, that the SSW probe can log nickel, copper and iron sulphides in blast holes. They have raised the grade and reduced dilution by outlining the limits of the ore zones before selectively loading explosives in the blast holes. By lowering the probe in a blast hole, a profile of the ore content is instantly measured and recorded. Logging cored diamond drill holes at the mine have demonstrated that the ore content (nickel, copper, cobalt, PGM) as assayed is proportional to the intensity of the probe's electromagnetic response (EM), probably because the nickel / pyrrhotite ratio is uniform within a given orebody. The probe also measures the intrinsic conductivity of the sulphides and the percentage of magnetite. All probe readings are displayed and automatically stored at a 10-cm interval within the same reading unit. A 30-meter blast hole takes less than 2 minutes to survey. The whole instrument is light (12 kg) and very simple to use. One operator can carry the SSW system and survey either down or up-holes. The probe works from –40°C to +50°C.

Plotting the measurements of the SSW probe in blast holes (2-3-4-6-10 inches in diameter) before blasting allows to determine the exact shape of the orebody within the waste rock and uneconomic low-grade ore. Thus, only the portion of the holes that contains ore is blasted. The dilution is then much reduced and, by leaving the waste and low-grade ore in place, the mine saves on transportation, blasting, crushing, backfilling, milling, etc. Thousands of dollars are thus saved. Some savings may also be achieved during the development of stopes by guiding development drifts and by replacing diamond drilling by percussion drilling. In some circumstances, when the probe shows that some of the rich ore was not drilled-off, additional blast holes will allow to recover pockets of rich ore that otherwise would have been abandoned in the walls of a stope.

Introduction

This paper describes the characteristics of the SSW dilution control probe , then presents examples of survey profiles measured with the probe, either in DDH or in blast holes.

A common dilemma: productivity versus dilution. Is there a solution?

Low dilution but high cost

In the past, mining methods such as shrinkage or cut-and-fill, either allowed miners to see the ore or the samplers to sample the face and mark the ore limits. Dilution was minimized but mining costs were high.

Low cost but high dilution

More recently, many mines adopted more productive and less costly mining methods such as vertical crater retreat (VCR) and sub-level long holes. These methods have reduced the cost of mining a ton of ore. Diamond Drill Holes (DDH) spaced between 15 and 50-meter intervals are used to define the shape of the orebody from which an infill drilling pattern is laid out. Blast holes are then drilled, loaded with explosives and blasted. Exploitation costs are reduced but generally dilution is higher: rich ore may be left in the walls of stopes and waste blasted with the ore because of an imperfect definition of the ore limits.

Low cost and low dilution

Today, in many metal mines, it is possible to survey blast hole walls with the SSW probe, so as to outline the ore limits before selectively loading explosives. By doing so, one can extract most of the ore and leave waste in place.

Two societies are using daily the SSW in their mining operations: Falconbridge in five mines in Sudbury and Raglan, and Mineração Serra da Fortaleza Ltd mine of Rio Tinto in Brazil. Several other mines are about to adopt our instrument.

A description of the SSW

A complete probe is shown on figure 1. It consists of a reading module, fixed on a winch mounted on a tripod. The winch can accept cables from 20 to 80 meters in length. The whole instrument has been conceived so as to be carried and operated by one person.

Figure 1a

A man backpacking the SSW.

Figure 1b

The SSW ready to be used.

Figure 1c

The SSW being used.

Figure 1d

The SSW ready to be shipped.

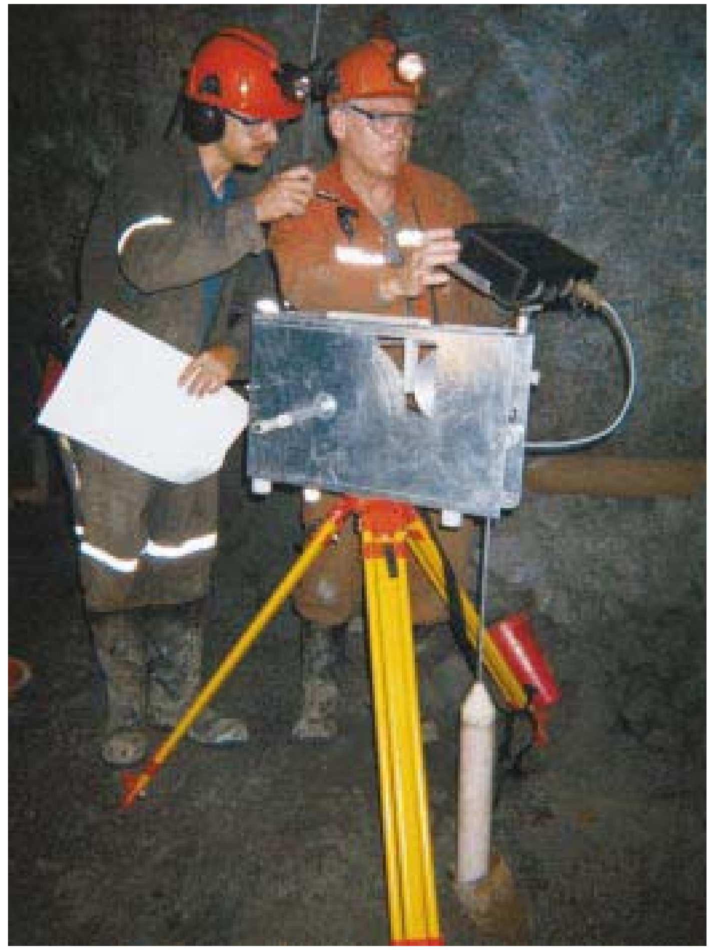

Figure 2: Steve Falconer and Chris Morley logging blast holes with the SSW probe at the Craig mine.

On Figure 2, an early prototype is being tested by Falconbridge's personnel at the Craig mine in Sudbury. The survey can be run while standing up.

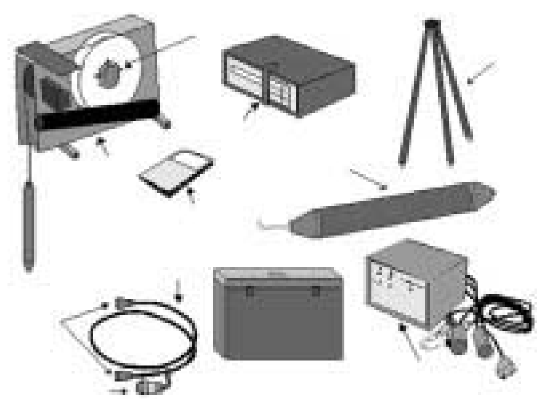

Figure 3: The components of a SSW dilution control probe.

Figure 3 shows the components of the SSW dilution probe. The receiver will operate with probes of any diameter suitable for the blast holes of a given mine. A lead weight can be added to lower the probe in water filled holes. The probe with all the components weighs less than 12 kilograms and can withstand extreme conditions, from -40 °C to +50 °C, even in a very wet environment. The module, powered by a rechargeable battery, displays the readings and the position of the probe on a back-lighted screen and, as the probe is lowered, the data are automatically stored in an internal memory.

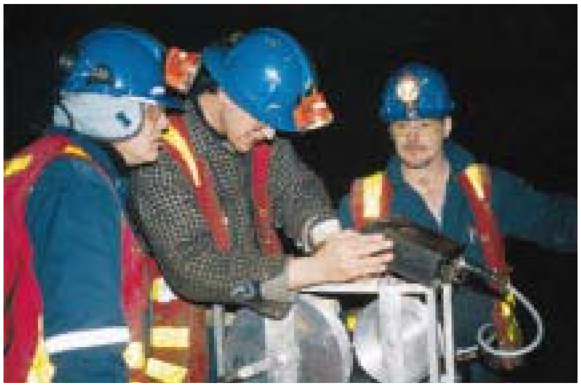

Fig. 4: Ron Lemery, Ken Germain and Mario Fluet at Raglan Mine are setting the new SSW system to verify ore contacts in their blast holes.

The SSW can detect and quantify as little as 0,1% or as much as 100% of conductive sulphides such as pyrrhotite, chalcopyrite, and pendlandite, and some but not all pyrites or galenas, even in the presence of magnetite. It can also detect and quantify just as great a range of magnetite, but precision for magnetite is somewhat imperfect when strong conductors are present.

Methodology used to introduce the SSW probe in a mine

Logging diamond drill holes in several nickel mines has demonstrated that the ore content (nickel, copper, cobalt, PGM), as assayed in the core, is proportional to the intensity of the probe's electromagnetic response that we call HFR. This relationship holds probably because the nickel/pyrrhotite ratio is relatively uniform within a given orebody. To illustrate this correlation on figure 5, one can observe that in this DDH from Craig Mine, the assays in red correlate with the grade in blue calculated from the response of the SSW.

At the Craig Mine, Falconbridge calibrated the response of a variety of probes in a large diameter blast hole by:

- drilling a BQ diamond drill hole in a stope and assaying its core
- running the small probe and correlating its response to the assays
- redrilling the same DDH to a large diameter with a percussion drill

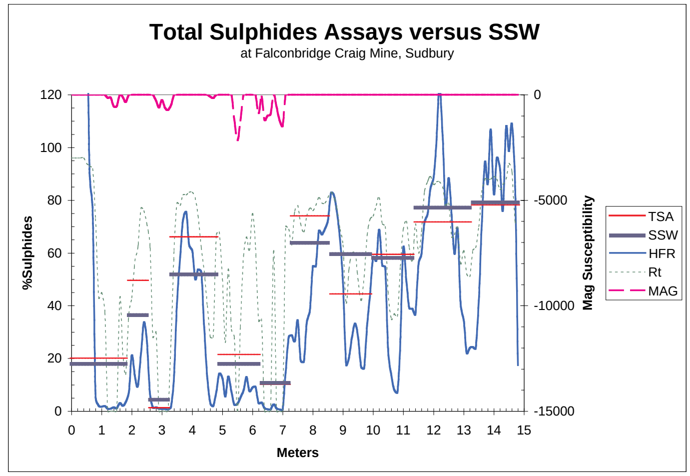

Figure 5.

- calibrating the different diameter probes of the SSW in that blast hole.

Please note that any of the GDD probes will underestimate the sulphides if the diameter of the hole is made larger than the calibration hole. We suggest to calibrate the probe for any given diameter of holes. The estimated sulphide content will be more reliable if the probe is as large as practical for the hole surveyed.

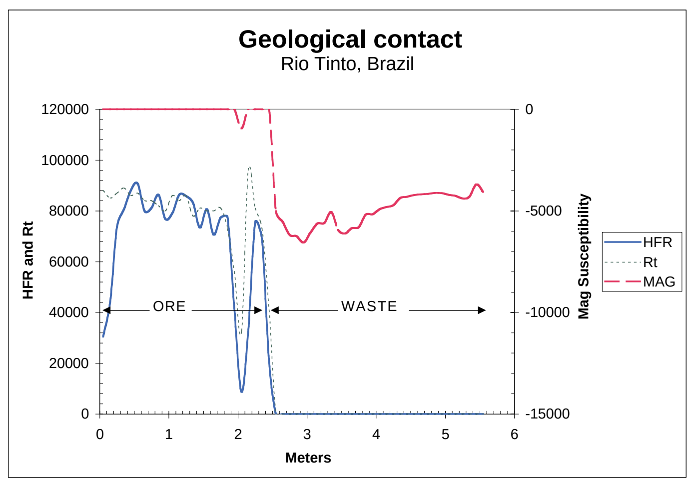

Figure 6.

In resume, we calibrated the probe using the assays of cores from BQ diamond drill holes, and confirmed our ability to distinguish high, medium and low grade ores. The logs of DDH cores confirmed also that geological contacts and even lithology could be identified from the geophysical responses. The geophysical profiles and the localisation of the readings are almost perfectly repeatable, and the surveys were easily performed in production up holes and down holes. An illustration of a perfectly clear contact between ore and waste determined from the SSW probe is shown on Fig. 6.

Examples of savings using the SSW in blast holes

Once the SSW is calibrated in DDH and when mine staff can identify ore and waste, the probe can be used in blast holes.

By running the probe in blast holes, a profile of the ore content is instantly measured and recorded from the response of the nickel, copper and iron sulphides. Knowing the position of the ore before blasting, one can selectively load the holes with explosives to avoid blasting tons of waste, and thus increase grades and lower production costs. The following examples come from Mineração Serra da Fortaleza Ltd mine of Rio Tinto in Brazil.

On the left of Fig. 7 and 8, the original outline of the ore is shown, while on the right, appears the outline corrected after running the SSW. In figure 7, three of the five blast holes believed to be drilled in ore were actually in waste. By not blasting them, the mine will avoid dilution caused by 450 tons of waste.

On figure 8, the five centre holes were drilled in ore. Of the two side tests, the right hole showed that the ore-waste contact was exactly where expected. The left side hole indicated that the ore was two meters wider than expected and this short test of the SSW has allowed to ship an extra 360 tons of good ore to the mill.

Plotting the measurements of the SSW probe in blast holes before blasting allows to outline the exact shape of the orebody within the waste and uneconomic low-grade ore. Thus, only the portion of the holes that contains ore are blasted. The dilution is much reduced, and, by leaving the waste in place, the mine saves on transportation, crushing, milling, etc. By reducing dilution and by recovering pockets of ore that would have been left in the walls of a stope, the mill will produce more concentrate with the same equipment and thus, extend the life of the mine.

AVOID BLASTING WASTE WITH THE SSW PROBE

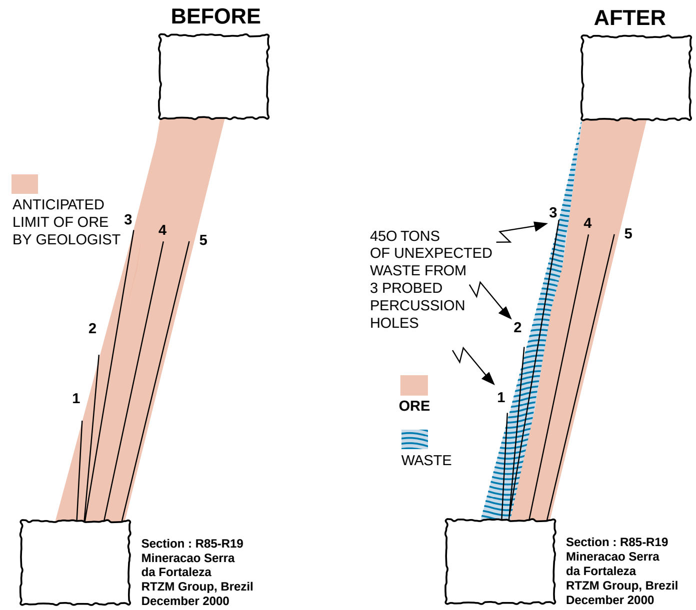

Figure 7.

GAIN EXTRA ORE WITH THE SSW PROBE

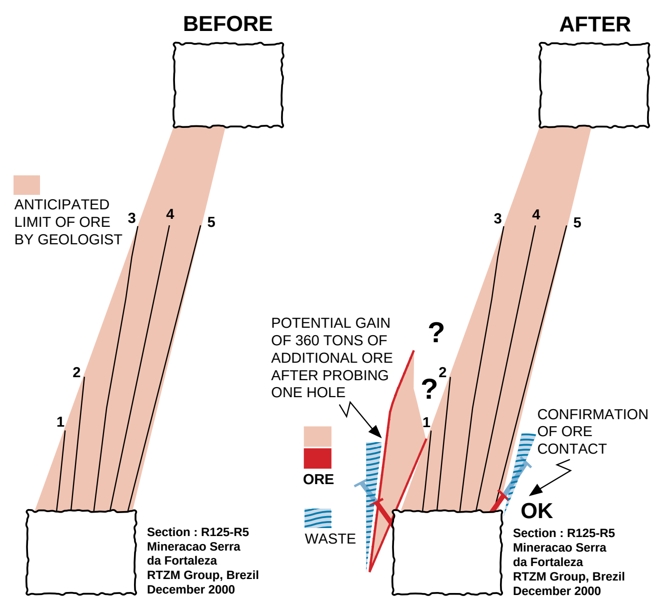

Figure 8.

Practical benefits of using the SSW

By using the SSW on a daily basis, one can:

- Improve the limits of the orebody for modelling and planning purposes in oblique fan drill holes.
- Get a better outline of ore contacts in production drill holes before blasting stopes.
- Estimate the average nickel grade in stopes before mining for blending purposes.
- Get better recovery of ore in the mine.
- Occasionally, avoid contaminants associated with the waste that could affect the recovery in the mill.
- Guide development drifts toward ore and save time.

- Replace short DDH by blast holes in the walls of stopes to facilitate the recovery of pockets of ore that otherwise would have been abandoned in the walls of a stope. One does not have to wait for assays to take a decision.

Future developments

GDD is going to introduce a new reading unit that will be able to store over 100,000 readings. Among other things, the new reading unit will have the ability to be linked to computer to display the data in real time within a software like Datamine. Falconbridge Sudbury is working with GDD to introduce as soon as possible this new system.

After drilling a long hole, in a few minutes, a miner in a stope could log that hole before moving his drill. He would thus immediately confirm if he has reached the ore waste contact from the response of the SSW probe. If not, he would deepen the hole before moving the drill. This way, all the ore would be drilled off. As it is well known, it is difficult and expensive to deepen a long hole after the drill has been moved.

For those who that may be interested, GDD is working to develop other techniques that will quantify and detect other substances, among them, gold.

Conclusion

Between sub-levels, the use of the SSW dilution control probe in blast holes, before blasting, will improve the definition of the orebody limits. The tests done at the mines confirmed that the GDD SSW dilution control probe can define ore contacts. It discriminates ore types and geological contacts. Nickel grades can be estimated after calibration adjustments. Within days of the acquisition of this equipment, the mines have saved several times the purchasing cost of the equipment.

The use of the SSW dilution control probe in blast holes has proven to be very successful for Falconbridge operations. Its application has allowed the use of low cost mining methods like VCR (vertical crater retreat) without the higher dilution normally associated. Improved profitability has been obtained by outlining the limits of the ore before selectively loading explosives in the blast holes. Several Falconbridge operations in Canada now use this new technology on a daily basis.

It is likely that even the use of the current SSW probe could contribute to reduce dilution in other types of mines, as for instance: copper, zinc, gold, silver, iron, etc. The three parameters measured by this probe suggests that one can often define at least ore contacts from the SSW measurements. Instrumentation GDD Inc. is looking for mining operations to test the new SSW probe. All samples of ore sent to us will be tested at no charge to evaluate if the new SSW probe could be successful in your mine. After several tests, our probe has been adapted to Falconbridge nickel mines ores and we could most certainly adapt it to other types of mines.