

Diamond Core Drilling for Narrow Vein Graphite Exploration - As Practiced at Bogala Mines, Sri Lanka (A Case Study)

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Abstract

The vein type graphite deposits which are rich in carbon found in Sri Lanka occur in metamorphic rocks as narrow steeply dipping veins. In Sri Lanka, generally these graphite deposits are explored by diamond core drilling technique. This technique has revolutionized the mining industry and directly resulted in the discovery of many minable ore bodies that would otherwise have gone untapped. Generally in this technique, possible ore bodies (veins) are explored by drilling a series of exploratory drill holes according to a pattern of drill holes designed by a competent geologist. After receiving core samples and related data sheets, core logging activity is carried out by the geologist for each and every bore hole. It is usually one of the last stages of exploration, and with data taken from core logging can be used to interpret 3-dimensional view with the support of software like Surpac. Finally it would be possible to determine whether the prospect is economically viable or not for mining. This paper looks at the suitability of diamond core drilling technique practiced in exploring narrow graphite veins in Bogala Graphite Mines of Sri Lanka and will discuss in detail pros and cons of the applying method.

Keywords: Deposits, Dipping, Ore body, Recovery, Rock

1. Introduction

Graphite has appeared in the international trade since 16th century after which time the mining industry was present mainly in Germany and Siberia. Subsequently, more and more countries began producing graphite and the occurrences of graphite in Sri Lanka had first been reported in 1675 by the then Dutch governor Rycloff Van Goens. However, this became known to Sri Lanka as a mining industry as well as an important export commodity during the British colonial period. Graphite is one of the main minerals mines and exported by

Sri Lanka over the last 175 years and it has been an important export commodity similar to tea, rubber and coconut. Sri Lanka is also considered as the only country to mine vein graphite commercially [1].

Natural graphite found in Sri Lanka is unique and it is mined in lump form and has a purity of more than 90% carbon. This graphite very often occurs as veins within fissures, fractures and hard rocks [2]. These veins can be several millimetres to several centimeters thick, but sometimes in certain areas the thickness increases to match meter scales. Such good quality graphite displays a metallic sheen an

fibrous or needle like morphological characteristics [3].

Bogala Graphite Mines consist of three main steeply dipping veins, namely Na, Mee and Kumbuk extended along the north-west and north -east to south-west directions respectively. The in-situ carbon content of this vein graphite in Bogala varies from 90% to 99%. In Bogala Graphite Mine, all three veins are accessed by vertical shafts. Alfred shaft continues down to 124m depth, and 5th pit, another vertical shaft access to greater depths, from 124m level to 476m level. (Figure 1)

To explore vein extensions at deeper levels, diamond core drilling is practiced in Bogala mines for last couple of decades. The ultimate results taken by drilling are taken into consideration for mine development and block-out available graphite reserve which decides the mine life in long term basis.

2. Methodology

The diamond drilling has revolutionized the mining industry and directly resulted in the discovery of many minable ore bodies that would otherwise have gone unmined. Before the introduction of mainstream diamond drilling, mining was still primarily dependent on finding outcrops of rock, with little information available about ore concentrations below the surface.

2.1 Drill Structure

Diamond core drilling is so called because it uses a 'diamond bit'. This drill bit is composed of group of small, industrial grade diamonds set into a metallic, soft matrix. As the ground is drilled, this matrix will wear away and expose more diamonds.

This is then attached to a drill rod, which is around 10 feet in length, and then more sections of pipe can be attached to the top of this so a greater depth can be drilled. The depth that is

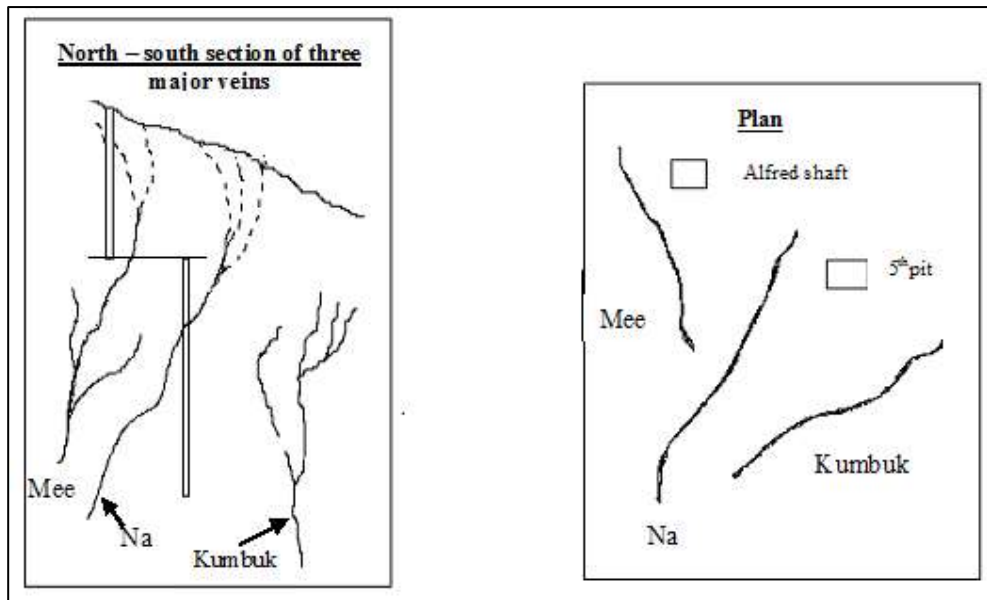


Figure 1 - North-South section and plan view of the Bogala Graphite Mines (not to scale)

drilled to is estimated by the number of rods attached to the top of the drill rod.

Inside the first drill rod, a core barrel that is attached to a cable via a latching mechanism. The core barrel is lifted to the collar using the cable, so that the solid core can be removed.

There are two primary types of diamond drilling-rotary drilling and wire line drilling. Rotary drilling is used primarily for bore hole drilling, whereas wire line drilling is used for solid core sampling.

There are five standard drill rod sizes [4]. They are as follows:

- AQ (48mm)
- BQ (60mm)
- NQ (75.8mm)
- HQ (96mm)
- PQ (122.6mm)

The drill rod size used depends on the desired core diameter and the desired depth of drilling, and the wider the diameter of the tube, the more power that is required to drive the drilling. At Bogala, currently BQ series bits are used for drilling.

2.2 Core Extraction

To extract core, the drill rod rotates the diamond bit, spinning it into the ground. As the drill bit bores through the rock, solid rock is taken into the circular opening at the end of the bit, into the core tube, and can then be recovered at the surface as it piles up. Once the core is recovered at the surface it is broken along natural fractures and stored in core trays to await analysis. A standard core tray can hold around 10 feet of core.

3. Core drilling method practiced in Bogala Mines

Bogala Graphite Mines has been using a pneumatically driven diamond core drilling machine (Figure 2) for last couple of decades to prospect graphite mineralization zones in underground [5]. The objective of diamond core drilling is to obtain cores for analysis. Diamond drill powered with high pressure air (pneumatic power) is used in the mine. The core barrel is at the lower end of a line of drill rods, and at the end of the rods, there is a drill bit. Drill bit is a small cylindrical barrel with diamond pieces mounted on one end and a screw thread on the other end. The rock core cut by the drill bit is allocated in the core barrel which is usually five or ten feet long. Once the core barrel is filled, it can be pulled out and the core sample can be collected from the core barrel (Figure 3).



Figure 2 - B.B.U. 2 Air powered two columned (J.K.S BOYLES) drilling machine



Figure 3 - Core samples kept in core box for analysis

For core drilling and logging, below steps are practiced in Bogala [6].

- Required space in underground is created at selected location. The machine needs 9 feet height, 11 feet length and 5 feet width for its smooth operation
- Two vertical legs of the drilling machine are positioned parallel to the bearing and fixed to the bottom and upper walls of the tunnel using the screws
- Two vertical legs of the drilling machine are positioned parallel to the bearing and fixed to the bottom and upper walls of the tunnel using the screws
- The machine is fixed at the correct height of the legs
- Positioning the drill hole direction and carve out the exact drilling spot on the drilling wall manually
- When drilling, core samples of every 5 feet lap are taken and store in core box
- Data taken by examining the core samples are incorporated on to a data sheet and core logging sheet

is prepared (Figure 4) Based on the same data, if needed cross section of the bore holes can be drawn (Figure 5)

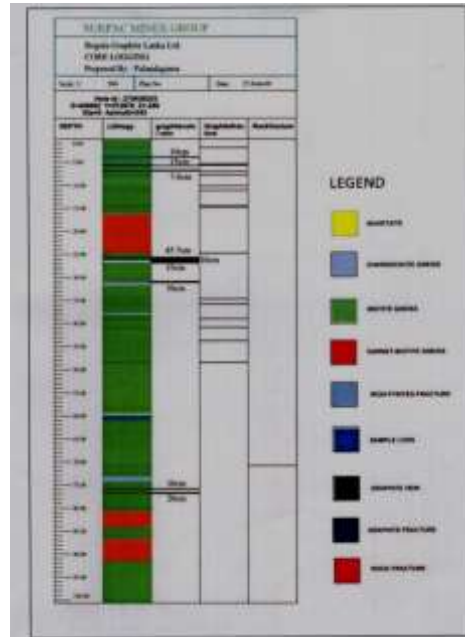


Figure 4 - Core logging sheet

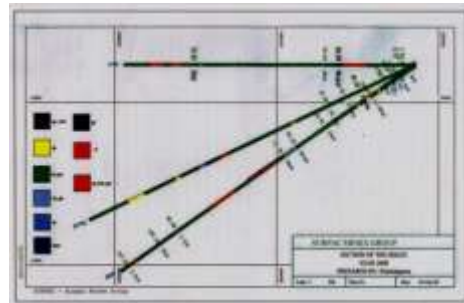


Figure 5 - Cross section of bore holes

4. Discussion

Considering the mineralization of graphite and other factors related to the ore body, host rock and it's behaviour, choosing an exploration technique is not complicated for Bogala mines. The best exploration technique for a narrow vein ore body would be diamond core drilling technique.

Therefore the diamond core drilling technique can be undoubtedly recommended for exploring graphite vein system in Bogala Mines, as it has key advantages over any other exploratory drilling techniques as mentioned below.

1. Quantitative analysis of prospective reserve- Vein widths can be measured using many information taken analysing core samples so that available ore reserve can be calculated
2. Qualitative analysis of graphite in veins- Carbon % can be easily determined using graphite core samples
3. Economic viability of mining can be determined beforehand for prospective veins found with core drilling
4. Details of rock types and structures, joint patterns and fracture or weak zones can be found with core samples so that designing of excavation upto the prospective veins can be done considering such information
5. 3-D modelling of the prospective veins can be done easily with core recovery data
6. Intersected veins can be viewed with the support of micro camera inserting into the hole and get precise data and compare with core logging data
7. Very less man power (Even one person can be assigned) is required to operate the machine

Few disadvantages of diamond core drilling can be categorized as follows

based on experience of the practising this method for years in Bogala mines.

1. It is very difficult to do core drilling through highly fractured zones as drill bit always tends to get over heating and struck while insufficient drilling water at the drill cutting face due to leakages through fractures which hampers flushing of drill hole.
2. Graphite core sample gets easily flushed away if the intersected graphite is soft in nature. In such situation, it is very difficult to determine the thickness of the vein intersected as non-availability of core recovery.
3. If vein widths vary considerably in a short distance (-both vertically and laterally), predictable ore reserve using core logging data may be not precise.

5. Conclusions

Based on site experience as described above, it is considered that diamond drilling is an effective means for exploration drilling / delineating of the graphite fissure or veins. Furthermore, this technique can be recommended to apply explore possible graphite veins and any Sri Lankan new graphite mines in case graphite narrow veins as well as other geological features found are more or less compatible with graphite mineralization in Bogala.

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