Nguyen Quoc Long - Pham Thi Lan
Nguyen Viet Nghia - Khuong The Hung
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Geo-spatial Technologies and Earth Resources (GTER 2017)

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Application of three-dimensional geological model in reserve estimation of the Khe Cham I coal mine, Cam Pha, Quang Ninh

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ABSTRACT: Khe Cham I coal deposit is situated in the Mong Duong district, Cam Pha city, Quang Ninh province with an area of 5.6-kilometer square in the northern part of Cam Pha city. Using a 3-D model, which is possible to evaluate the distribution of sedimentary rocks, both through space and time. This study has to aim a better understanding of the Khe Cham I coal basin through 3-D geological analysis and re-estimation of coal-reserve which has done using continuous (top & base) surface modeling for the target coal seam. The continuous trends of coal seam are conceded for the volume calculation of coal seam which is not considered previously for volume calculation like of Khe Cham I basin in Quang Ninh. The coal deposit is bounded with the Duong Huy valley and Bac Huy fault to the north, Cao Son coal mine to the south, Mong Duong coal mine to the east, and Khe Cham III coal mine to the west. As the V14-5, V14-4, V14-2, and V13-2 seams have been fully exploited from 2013 of years, the drilling and working faces of the Khe Cham I coal mine are focusing on the center of the V13-1 and V12 seams. Therefore, this paper is focused only on the V12 and V13-1 coal seams. Researched results show that re-estimated coal resources have a good agreement which has been found with the traditional estimates.

KEY WORDS: Quang Ninh, coal, 3-D geological modeling, surface contour, Khe Cham I coal mine

1. INTRODUCTION

Reserve volume is the comprehensive evaluation of coal exploration and development. Consequently, the rationality of reserves calculation affects the decision of coal exploration and exploitation. The reserves calculation method based on the tridimensional geological model can be used to deal with the issues that the reserve parameters are difficult to correctly acquire when estimating complex coal's reserves regarding traditional volume method. Coal evaluation utilizing reserves value and reserves abundance value which has been calculated before, with other related parameter provides the geological basis for coal development and adjustment (Fallara et al., 2006; Wang et al., 2007, 2009a, b, 2012).

With the rapid evolution of the computer, three-dimensional modeling technology of geological model has been the prime methods of coal and mineral deposit industry making mining description. Three-dimensional geology modeling of the mining geology can reflect the characters of distribution and regularities of variation in geological model space attribute. That provides geology basis for mineral deposit development (Kaufmann and Martin, 2008; Förster and Merriam, 2013).

This paper aimed to estimate the amount of coal in Khe Cham I mine and to establish three-dimensional geological modeling for Khe Cham I mine using geophysical data and borehole data. Fig 1 shows coal field opened of the study area in the Cam Pha city, Quang Ninh Province.

Fig 1. Coal fields opened in Khe Cham I mine, Cam Pha, Quang Ninh (photo of Khuong, 2017)

2. GEOLOGIC CHARACTERISTICS

Research area is located in Mong Duong district, Cam Pha city, Quang Ninh province. The tectonic location is at the Hon Gai – Cam Pha coal belt, which is an anticline with fault complication. In Khe Cham I mine, faults are caused stratigraphic displacement and created the cataclastic zone. The mine has just discovered the F-L and FN and K-K faults. Further, many small faults are developed along major faults; they are caused difficult mining exploitation in Khe Cham I. Upper part of the Hon Gai formation is distributed over all the study area, it also contains all coal beds of the Khe Cham I mine including seams of V12 and V13-1.

3. METHODOLOGY

Geophysical data and borehole data were employed in Rockwork to estimate the geological structure and coal reserves and to establish the 3-dimensional model for Khe Cham I mine. The structural and attribute models were first obtained and were used in Rockwork to calculate the reserves and the value compared to the value of the reserves using the traditional method. Following methods are used to employee objectives.

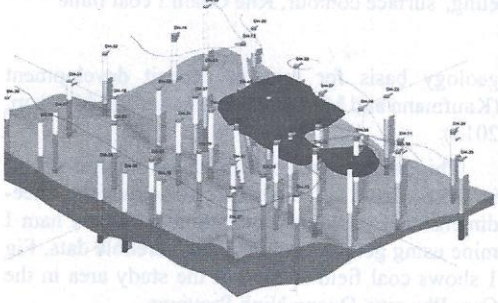

Fig 2. 3-D geological model is created by Rockwork software (according to Rockworks 15 manual)

4. RESERVES ESTIMATION

The method of reserves estimation is a volumetric method in Rockwork. Based on the 3D geological model having a high degree of accuracy, reserves of each grid cell were calculated, followed by calculation of the accumulated grid cell. In the current project, the 'net volume' calculation is considered. Mathematically, the volume under a function f(x, y) is defined by a double integral

$$Volume\,(V) = \int_{X_{min}}^{X_{max}} \int_{Y_{min}}^{Y_{max}} f(x,y)dxdy \qquad (1)$$

In Surfer, this is computed by first integrating over X (the columns) to get the areas under the individual rows, and then integrating over Y (the rows) to get the final volume (Press et al., 1988).

Tons of coal the seam= V*C (2)

where, V - Volume of coal seam,

C - Conversion factor.

5. RESULT

5.1. Three-dimensional analysis of coal basin

The Khe Cham I basin is progressively shallower to the east and deeper to the west, north and south away from the depocenter near the mining boundaries. The western area of the basin is down with 380 meters as indicated by fault movement of the basement between LK2358 and LKBS86 boreholes. The deepest part of the pool and also the thickest sedimentary succession is accumulated near the LKBS86 and LKBS71 drill holes about 200 meters. The coal seams have gentle easterly, southerly, or northerly dip towards the depocenter depending upon the position in the basin. The subgroup of the roof of the V12 and V13-1 seams are not well established in south and north. Most of the seams are covered by upper part of the Hon Gai formation (Le Hung et al., 1996).

The V12 seam is distributed along two sides of the T.XVI line, in which the thickness is quite continuous, widely distributed throughout the mine area. The structural seam is not too complicated, relatively stable. The V13-1 seam lies on the V12 seam and distance to the V12 seam of about 27m wide, distributed throughout the mine area. On the sections show that the southern part of the F.L fault, there is a split and combined the V13 seam, while the northern part of the F.L fault, V.13-1, and V13-2 seams always exist in parallel. The seams are relatively stable in thickness.

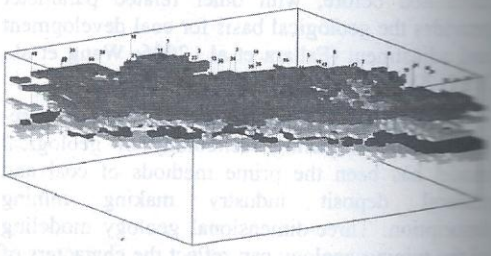

Fig 3. Created 3-D model for coal beds of the Khe Cham I mine

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5.2. Comparison of the estimates

In present estimation and calculation, with inverse distance to a power algorithm, data are weighted during interpolation such that the influence of one-point relative to another decline with distance from the grid node. So, any effects of distance between two data points are reduced. However, the amount calculated is less than the previous study which conducted handcrafted method to calculate the seam volume. The coal seam bonded with boundary fault and subgroup which is applied to the surface by blanking these two surfaces, using .bln extension file in the Surfer program. Therefore, the two surfaces reduced in volume, which goes another way to a perfect estimate. The polygon method is considering accurate compared to arithmetically averaged borehole data due to variation in borehole distribution data. The reserve estimated with continues gridding of upper and lower surface has counted a thickness which varies with a grid to grid in more than 90000 rectangular grids in 5.6 km^2 area of the basin.

5.3. Three-dimensional characteristics of the coal sequences

As the V14-5, V14-4, V14-2, and V13-2 seams have been fully exploited from 2013 of years, the drilling and working faces of the Khe Cham I coal mine are focusing on the center of V13-1 and V12 seams. Therefore, this paper is focused only on the V12 and V13-1 coal seams. The seams have topography with variable depth of occurrence range <300 m to >100 m below ground level, e. g., 260 m at LKBS66, LKBS73 and 140 m at the borehole LKBS72. In the south-eastern Khe Cham I basin, the V12, and V13-1 seams are thicker. The highest thickness is near about 7.39m of the V12 seam and 8.40m of the V13-1 seam are in the adjacent area of LK2719.

The three-dimensional figure can give the clear idea of the shape of whole seams by two side view. The undulation is counted, and coal seams are deeper in south eastern part. The color code shows the elevation in a different part of the seams in 3-D (Fig 3).

5.4. Coal Reserve

Coal seam V12 and V13-1 have the amount of reserve and the plan to mine out this time and have stable thickness. For the estimation of the volume of coal in seam V12 and V13-1 continuous surfaces were produced: one of is at the top of seam and other is at the bottom. Total volume calculated below as an average of volume by equations two above. Cut and fill volume and area also show in the paper as there is no place found where the lower surface up crosses the upper surface.

Table 1. The volumes are calculated by (2)

Number	Seam	Volumes (m^3)	Weight (ton/m^3)	Mineral resources (m.ton)
1	V12	14 498 554	1.38	20 008
2	V13-1	35 812 194	1.40	50 137

6. CONCLUSION

The Khe Cham I coal basin analysis in 3D shows how geological surface maps and another three-dimensional figure can be used to understand better how the geological structure and thickness of coal beds and other strata vary on a small scale. Besides, applying this information across areas which have mined out will increase the understanding and accuracy of the model.

The re-estimation of the coal reserve has been done using the three-dimensional method. The results are conducted 20,008mt for the V12 seam, and 50,137mt for V13-1 seam, a good agreement has been found with the previous estimates with one calculated in during the exploration study estimated 20,035mt of the V12 and 49,918mt of the V13-1 seams (Pham Tuan Anh et al., 2008). Therefore, the 3-D analysis of the coal-basin reveals better visualization of the coal reserve. This outcome of the current project would shed some lights towards a better understanding of the Khe Cham I coal mine.

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