MINISTRY OF EDUCATION AND TRAINING
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ASSESSING RESOURCE POTENTIAL AND ORIENTING THE SEARCH AND EXPLORATION OF COAL BELOW THE -300M LEVEL IN THE HON GAI - CAM PHA AREA, QUANG NINH

MAJOR: GEOLOGICAL ENGINEERING

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SUMMARY OF DOCTORAL THESIS IN GEOLOGICAL ENGINEERING

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PREAMBLE

1. The urgency of the subject: The Hon Gai - Cam Pha area is a part of the Quang Ninh Coal Basin that has been studied for nearly 200 years (1840 ÷ 2023) of exploiting, searching, exploring and evaluating coal reserves with 263 reports on the results of research, search, preliminary exploration and detailed coal exploration, although the volume of reports as stated is very large, however, up to now, the Hon Gai - Cam Pha coal-bearing area has only been meticulously studied up to -150m and preliminary to -300m. To be effective in investment work and avoid extensive research, it is necessary to synthesize and use available research methods to to interpolate from existing data as a basis for determining an appropriate exploration network for the deep underground is extremely necessary. From the issues mentioned above, in order to help the management and strategic planning of the coal industry achieve high and effective results and avoid waste, research and evaluation to clarify the resource potential below -300m to the bottom of the coal layer, thereby delineating potential areas and choosing an appropriate exploration network is very urgent. Originating from practical requirements, topics: "**Assessing resource potential and orienting the search and exploration of coal below the -300m level in the Hon Gai - Cam Pha area, Quang Ninh"** was selected by the PhD student as a doctoral thesis in the field Geological engineering is intended to contribute to meeting the requirements demanded by reality.

2. Project objectives: Accurate research on geological structure, identify and clarify geological factors affecting the morphology - structure of coal seams, distribution characteristics of coal seams in Hon Gai - Cam Pha area; from which, assess coal resources and orient the investigation, assessment and exploration of coal below the -300m level to serve planning coal exploration and mining in the period 2020 ÷ 2030 and vision after 2030.

3. Objects and scope of the research: Coal seams and geological formations containing coal in the Hon Gai - Cam Pha area.

4. Research content

- Synthesize and systematize geological, geophysical, and mining documents to clarify geological structure characteristics, distribution rules of coal seams and their relationship with geological formations substance in each main coal-containing structure.

- Research to clarify the characteristics and distribution rules of coal-bearing sediments, and accurately determine the coal-bearing structure in the Hon Gai - Cam Pha area, contributing to solving the task of linking and identifying coal seams between mines and structural blocks of Hon Gai - Cam Pha coal area.

- Prepare coal seam exposure maps at -300m elevation levels; main cross-sections to the bottom of the coal bed in the Hon Gai - Cam Pha area to clarify the distribution rules of coal seams.

- Apply modeling methods and quantitative forecasting methods to evaluate coal resources below the -300m level to the bottom of the coal bearing layer. Zoning the area with coal prospects below -300m as a basis for orienting a suitable search and exploration network for relatively homogeneous blocks in the Hon Gai - Cam Pha area

5. Research Methods: To solve research tasks, PhD student uses a combination of the following methods: Traditional geological methods, combined with a systems approach; Modeling methods (geological cross-section, combined with mathematical models) with the help of information technology software; Analyze, synthesize and systematize the results of coal exploration and mining in the mine to gain a more comprehensive and in-depth understanding of the geological structure and morphological and structural characteristics of coal seams in the Hon Gai - Cam Pha mine area; Assess the complexity of the structural morphology of coal seams (Mine Group) combined with the use of structural functions (variogram) with the help of SURPAC software to evaluate the characteristics of coal seam thickness variations and establish coal mine exploration network; Methods of assessing coal reserves and resources

6. New points of the thesis

6.1. The F.A fault zone tends to be inserted to the North and exists quite continuously from Ha Tu to Quang Loi. The change in the fault's insertion direction leads to a large change in coal reserves/resources of Hon Gai - Cam Pha area.

6.2. The Hon Gai - Cam Pha area has been divided into 5 relatively homogeneous structural blocks, in which each block is characterized by elements of tectonic structure, number of coal seams, coal content, and depth of industrially valuable coal seams. This is the basis for assessing the coal resource potential below -300m in the Hon Gai - Cam Pha area.

6.3. The Hon Gai - Cam Pha area below the -300m level has a total coal reserve/resource potential that is quite large and has an uneven distribution in terms of number of seams, coal density and concentration of coal reserves/resources. in the blocks Nga Hai - Khe Tam - Khe Cham; Binh Minh - Ha Lam - South Suoi Lai; North Suoi Lai - Ha Rang - West Nga Hai; Mong Duong - North Coc Sau; South F.A fault.

6.4. Morphological and structural characteristics and changing characteristics of the main industrial geological parameters of coal seams below -300m have a level of variation belonging to the complex to very complex group corresponding to exploration mine group III and one part of group IV, this is an important basis to orient the search and exploration of coal below the -300m level.

7. Scientific significance and practical value

7.1. Contribute to clarifying the coal-bearing geological structure of the Hon Gai - Cam Pha area; in particular, the morphological and structural changes of coal seams in each relatively homogeneous geological block; provides a scientific basis for selecting and applying a coal exploration network below the - 300m level suitable for each relatively homogeneous structural block of Hon Gai - Cam Pha area.

7.2. Practical significance: Clarify resource potential and reserves to have orientations for exploration and mining to serve the development of strategies and planning for the coal industry in particular and energy strategy in general. Save costs and improve efficiency in mining the part above the -300m level and exploring and determining coal reserves/resources below the -300m level.

8. Thesis defense arguments

Argument 1: The Hon Gai - Cam Pha area has quite large coal potential below -300m; concentrated in Nga Hai - Khe Tam - Khe Cham block, followed by the Binh Minh - Ha Lam - Nam Suoi Lai block; North Suoi Lai - Ha Rang - West Nga Hai block; Mong Duong - North Coc Sau block, at least the South F.A block and mainly distributed at levels from - 300m ÷ - 600m.

Argument 2: Most of the coal seams below the -300m level within the relatively homogeneous blocks of the study area belong to exploration mine group III (80%), with some blocks belonging to mine group IV. The most reasonable network for arranging exploration works is to use a linear

network, with reserves up to level 122; Distance between probe lines: 125m ÷ 250m, distance between works on the route: 75m ÷ 125m for mine group III and distance between lines: 75m ÷ 125m, distance between works on the route: 50m ÷ 75m for type IV mines.

9. Document basis: Geological research documents in the Quang Ninh coal basin area; published research projects on Quang Ninh coal basin geology, reports on investigation and assessment results, progress in coal exploration, current status of exploration and mining that have been and are being conducted, research projects, articles, theses, dissertations, textbooks, and scientific reports published domestically and internationally related to the research object of the thesis. Documents collected by PhD student, or directly compiled during their time working at Vietnam National Coal And Mineral Industries Holding Corporation Limited; especially new documents collected and synthesized during the process of studying as a PhD candidate at Hanoi University of Mining and Geology.

The data was collected, synthesized and processed using Surpac, Surfer, Mapinfo software... Specifically:

+ Number of drill holes collected: 6,015 drill holes/1,839,810 meters of drilling.

+ Number of deep holes: 30 drill holes/30,334 meters of drilling.

+ Number of samples processed: 24,201 samples.

10. Dissertation implementation place: The thesis was completed at Department of Prospecting and Exploration Geology, Faculty of Geological Sciences and Engineering, Hanoi University of Mining and Geology under the scientific guidance of Dr. Nguyen Tien Dung, Dr. Tran Van Mien.

The PhD student would like to respectfully express his deep gratitude for the guidance and dedicated help of the scientific instructors; The attention and facilitation of Hanoi University of Mining and Geology and the following units: TKV, VITE. Thanks to the scientists, geologists, and colleagues who allowed the PhD student to consult, use, and inherit previous research materials to complete this thesis.

Chapter 1

OVERVIEW OF RESEARCH AREA

1.1. Geological position of Hon Gai - Cam Pha area in the Quang Ninh coal basin structure: According to the tectonic zoning diagram of North Vietnam, the Hon Gai - Cam Pha area occupies a position in the middle part of the Coastal zone. The north is in contact with the An Chau zone, a part of the Pha Lai - Mao Khe - Ke Bao reservoir extending into an extended arc, the arc faces south, the arc length is about 200km and the width is from 3-4km to 13-14km.

1.2. Geological and mineral characteristics of Hon Gai - Cam Pha area

a. Stratigraphic features: Participating in the geological structure of the Hon Gai - Cam Pha area are sedimentary and metamorphic formations dating back to the Paleozoic age (Tan Mai Formation; Bac Son Formation; Bai Chay Formation); Mesozoic (Hon Gai Formation) to Cenozoic (Neogene Formation), Hon Gai Formation (T_3n- r*hg*) are distributed almost throughout the mine, thickness of about 1,800m, divided into three sub-formations: The lower subformation (T_3n- r*hg1*) is mainly coarse-grained sediments that do not contain coal. The middle subsystem (T_3n- r*hg2*) has a petrographic composition including layers of cobblestone, sandstone, siltstone, claystone, coal clay and coal seams. The upper sub-formation (T_3n- r*hg3*) is located on top of the Hon Gai formation (T_3n- r*hg*), consisting of coarse-grained sediments that do not contain coal.

b. Construction features: The Hon Gai - Cam Pha area is controlled by two large Bac Huy faults in the North and Nam Fault in the South bordering Road 18[a]. In the strip there are many block faults and secondary faults. Along with the fault systems are folds in which the large-scale fold system has an axis extending in the sub-parallel direction (in the same direction of extension of the coal strip) on which develop secondary folds and other folds of later phases, folds entail large faults that complicate the main folds.

c. Characteristics of coal seams: Coal-bearing strata are from 500 to 2,500m thick, containing from 5 to 59 coal seams with each seam thickness from 0.60 to 33m, including 3 to 20 industrial coal seams, with an average thickness of 1.5 m. ÷ 4m, most coal seams have a relatively complex structure.

1.3. Existing problems that need to be researched and resolved in coal

prospecting and exploration in the Hon Gai - Cam Pha area

- *In term of stratigraphy:* Currently, the division and connection of the middle Hon Gai sub-formation still has many hypothetical and contradictory locations regarding coal-bearing thickness that need to be further researched on the basis of in-depth research on structure, petrology, geophysics...

- *In term of construction:* Fault destruction activities are very complex, documents compiled in exploration reports are not consistent, currently the connection between two adjacent mines (according to exploration reports) still has many shortcomings, even large-scale block faults such as Bac Huy fault, F.A fault, Southernmost fault,... F.A fault does not have enough data to prove the direction of the plug.

- *In term of the issue of same name:* Research on coal quality, paleogeological characteristics, petrology, rock facies, paleogeography... below the -300m level has not been fully researched to classify the work of identifying coal seams, but is mainly based on relying on the visual basis of geometry to relate them can easily cause confusion.

- *In term of the assessment of resources and reserves:* Have gone through many additional exploration reports, synthesize documents, and calculate the conversion of reserves and resources of many mines, there has been no report updating, inventorying, and summarizing reserves and resources of the entire coal basin in general and the Hon Gai - Cam Pha area in particular. Published data vary according to the synthesis and forecast of each author and each unit, and some reports have not been appraised and approved by State management agencies. This causes inconsistent understanding for managers and planners at all levels. The quantity of resources and coal reserves is unreliable and inconsistent, leading to large deviations in exploration planning and exploitation planning, especially mobilizing reserves and resources in the mines' annual plans. For that reason, it is urgent that the assessment of resources and reserves be paid attention to in order to provide data to ensure the reliability of each task for the planning of coal exploration and mining in the coming years.

- *In term of determining the appropriate exploration network when exploring deep:* Research on the characteristics and geological conditions of the Hon Gai - Cam Pha area above the -300m level has basically been clarified, however, the part below -300m is still quite preliminary and

needs to be continued investment in research, however, implementing in-depth research requires huge costs, so the need to research to determine a suitable exploration network is an urgent requirement and is also a major problem that has not been implemented in previous research stages.

Chapter 2

THEORETICAL BASIS AND RESEARCH METHODOLOGY

2.1. Theoretical basis

2.1.1. Overview of mineral coal and fields of use

Coal is a solid, combustible, sedimentary mineral that is a modified product of the coalification process of plant and microbial residues. The physical composition of coal includes organic substances, minerals and moisture.

Mineral coal is currently used mainly as fuel (fuel); In addition, mineral coal is also used in the chemical industry to create products such as pharmaceuticals, plastics, artificial fibers and a few are used to create fine art products...

2.1.2. Types of origin of mineral coal:

Types of origin of mineral coal: There are two types of coal: primary coal and secondary coal.

Periods of coal formation

On the world: In the history of geological development of the earth's crust, coal materials from the Neo - Proterozoic period have been discovered. Coal formations are present in Silurian (S) and Devonian (D) sediments, but are of no industrial significance. The history of geological development has 5 main periods of coal formation: Carbon (C), accumulating over 25%; Late Permian (P3), Triassic - Jurassic (T3-J2), which accumulated over 20%; Jura - Cretaceous (J3 - K) and Paleogene - Neogen (E - N), the latter two periods accumulated coal over 54% of the total potential of coal resources in the world.

In Vietnam: The history of geological development in Vietnam has 3 periods of formation of coal mines: Late Permian, Late Triassic and Paleogene - Neogen

2.2. Research Approach and Methods

2.2.1. Approach

a. Access the system

In mineral resource assessment research, systematic integration between actual data sources and research methods is needed. The mineral formation space in a certain research area is an open system of natural geological processes; in which all components of the geological - mineral system are closely related to each other, every fluctuation of each component in the system has an impact on other components. There, a process always occurs that changes over both space and time. Therefore, according to a systematic approach, the research and assessment of coal mineral resources will be conducted more synchronously, systematically and comprehensively. The essence of the method lies in the characteristics of geological bodies or mineral coal accumulations and the ability to obtain through research and collection of test results of mineral documents and coal seams in a given geological formation.

To model geological structures, it is necessary to research from the synthesis of experimental data, the best solution is a systematic approach. According to this principle, geological formations in coal seams and coal seams are considered as a system including a set of constituent elements, depending on the scale and task to be solved. Research models must have common characteristics in a specific system, which are:

- A specific coal region, coal strip or coal mine, set of coal seams, coal seams that need to be modeled.

- The relative distribution between structures controls them.

- Geological factors related to and controlling the formation process (formation) of coal seams, coal seam sets...

b. Inheritance approach

The goal of this approach is to exploit domestic and foreign information sources on issues related to research subjects such as: geological structure characteristics, origin and formation conditions, results of investigation, assessment, coal exploration and mining in the Hon Gai - Cam Pha area. Therefore, the author will inherit knowledge and experience from scientists in the country and around the world through collecting documents from scientific reports, articles, reference books, or conferences, scientific seminars and scientific cooperation exchanges related to the research content of the thesis.

c. Practical approach

This is an important approach in geological research in general, and coal mineral exploration geology in particular;. Because, the practical approach allows to be aware of the factors (geological structure of the mine, methods of investigation and evaluation, exploration, methods of calculating reserve resources that have been conducted; assessing the effects of this factor affects the reliability of exploration and calculation of coal reserves in the Hon Gai - Cam Pha area in particular, and the Quang Ninh coal basin in general.

d. Focused and focused approach

Based on an overview of the Hon Gai - Cam Pha area, the PhD student conducted detailed research at a number of typical mines. This is a focused, key approach to solving the goals and contents of the thesis.

e. Modern approach

The thesis has applied achievements of modern science and technology such as applying modeling and information technology methods; from there, it helps quantitative assessment and ensures reliability in assessing potential and orienting the search and exploration of coal below the -300m level in the Hon Gai - Cam Pha area.

2.2.2. Research methodology

a. Synthesize and process documents

Document synthesis and processing is used to access the tasks that need to be solved in the thesis and are always updated, processed, and supplemented during the time of studying and writing the thesis.

b. Survey and field research methods

Survey and field research methods are carried out to collect additional information on petrographic characteristics, stratigraphy, structure, tectonics, measurement of microstructural elements, mineral discovery, tissue, describe and locate newly discovered seam outcrops, current exploitation status in recent years or seam outcrops that differ from previous investigation and exploration results.

c. Modeling method

Modeling is the scientific field of simulation, reducing realistic parameters but still describing the properties of each component in the model.

**** Mine geometry method***

Suude the method of modeling the cross-section along the route that has different azimuths, especially the characteristic cross-sections, the cylindrical isometric diagram for the number of main seams to evaluate the morphological characteristics - the structure of the coal seam.

**** One-dimensional statistical model***

The method of using statistical mathematics to model the properties of research objects is divided into one-dimensional statistical mathematics, two-dimensional statistical mathematics and multidimensional statistical mathematics. In the thesis, the PhD student used a one-dimensional statistical model to evaluate the statistical distribution characteristics of coal seam industrial geological parameters to solve the following two basic issues: Modeling to characterize the statistical distribution of coal seam geological parameters and exploiting the model to determine the statistical characteristics of coal seam industrial geological parameters. In the thesis, the PhD student uses modeling of research objects using specific models: cylindrical contour maps of coal seams and a number of geological mathematical models to process geological documents of coal seams and geophysical documents to serve research and assessment of coal potential below -300m in Hon Gai - Cam Pha area.

d. Geostatistical method: Geostatistics is a new, modern method that is becoming very popular, especially in countries: France, USA, Canada, UK.... Geostatistics is not only widely applied in exploration, mining, geophysics, hydrogeology, engineering geology, geochemistry, and petroleum, but also in many other fields: agriculture and forestry, biology, hydrometeorology, fisheries, mechanics, environment, landscape ecology, sociology... Geostatistics is also applied to interpolate attribute data, digital elevation models, spatial change data... in geographic information system (GIS) technology and remote sensing.

e. Matching method: From the areas and locations that have data, compare them with regulations, compare with mining documents and exploration areas, from which to evaluate the similarity of factors and geological characteristics of the reservoirs. coal above -300 level with below -300m level.

f. Methods for assessing and forecasting coal resources in Hon Gai - Cam Pha area

*** Assessment of identified coal resources**

The basis for calculating determined resources (reserves and estimated resources) according to this method is the horizontally projected isometric map for the secang method and the vertically projected isometric cylindrical map for the cosecang method, on which the divided into blocks to calculate reserves/resources for each reservoir.

*** Forecasting resource assessment method**

To quantitatively forecast coal resources below -300m in the Hon Gai - Cam Pha area, the PhD student used a straight calculation method based on the coal containment coefficient, essentially using the coal containment parameter determined according to the hole documents. Search drilling and deep exploration were conducted on each relatively homogeneous block divided to the bottom of the coal layer.

g. The method is combined by expert based on practical experience

The content of the method is to draw on the practical experience of PhD student and geologists who have researched for many years, combining the opinions of experts in the field of coal geology, prospecting, and exploration, to propose a combination of methods for searching and exploring coal deep (below -300m) in the Hon Gai - Cam Pha area, ensuring economically efficient exploitation and use of natural resources, contributing to promoting sustainable and environmentally friendly socio-economic development.

h. Application software

In the thesis, the PhD student used MapInfo Professional, AutoCAD, Microsoft Excel, Microsoft Word software; Surfer; Surpac to support calculating statistical parameters, building models, and calculating coal resource reserves.

Chapter 3

ASSESSMENT OF CALCULAR RESOURCES HON GAI - CAM PHA AREA

3.1. Some new research results on geology and minerals in the Hon Gai - Cam Pha area.

3.1.1. In term of coal-bearing strata and the depth of existence of coal seams: The assessment that coal-bearing sediments in the Hon Gai - Cam Pha area have a thickness of up to -2,800m is unconvincing, and the existence of coal seams, especially coal seams with industrial value, is only in level -1,000m or more. In the Hon Gai - Cam Pha area, for the northern region, a clear trend can be seen in the coal seams in the east (Nui Beo - Ha Lam - Binh Minh) and west (Mong Duong - Bac Coc Sau) all only exist at a maximum level of -600m ÷ 700m, in the central area (Ha Rang - Khe Cham) the coal seams exist at a deeper level than expected up to -1,000m. And the southern area (Lo Tri - Deo Nai - Coc Sau) is located on the uplift wing of the F.A fault, so coal seams only exist at -600m.

3.1.2. In term of construction: One of the largest and most important tectonics in the study area is the F.A fault, this fault divides the Hon Gai - Cam Pha area into 2 blocks with geological characteristics that are quite clearly different, according to documents. Previous research shows that this fault has a strike-slip angle to the south and with a combined amplitude of no more than 700m. However, the basis for determining that the F.A fault is pointed to the north, not to the south, is based on on some of the following signs:

- Signs of fracture appear in deep drill holes in the northern part of the fault

- Landslides on the banks of the mining pits in the North wing.

- Sudden loss of seams and narrowing of the coal seam area of Cao Son coal mine.

3.1.3. Joint name and seam connection work: The PhD student conducted a link and identified a number of coal seams in the study area. Research results show that different coal seams in some coal mines can be linked and have the same name, specifically as follows: Seams 5, 6, 7, 8, Binh Minh area correspond to seam 14; 13; 11; 10 Ha Lam areas and seams 13; 12; 10; 9 South Suoi Lai area. Characteristics of these seams are their large thickness (from 3 to 7m), continuous maintenance and widespread distribution throughout the study area.

3.2. Division of relatively homogeneous geological blocks in the Hon Gai - Cam Pha area

3.2.1. The basis for dividing the structural blocks

In previous periods, the research and evaluation of geological objects, especially coal seams in the Quang Ninh coal basin in general and the Hon Gai - Cam Pha area in particular, was often limited according to geographical boundaries, exploration routes without considering tectonic factors (folds, faults...) or in other words, mineral deposits, this causes great difficulty in planning future exploitation and production plans. This is because it is impossible to apply the same mining technology to an area that has different geological characteristics.

From practical experience, it has been shown that in the mineral body/coal seam there are always some relatively uniform structures, the changes of research parameters often have different characteristics and degrees of variation in each its area.

Based on the results obtained during the process of searching, exploring and exploiting coal in the Hon Gai - Cam Pha area; inheriting the research results of many previous geologists. The division of relatively homogeneous geological blocks is based on the following bases:

- Differences in complexity of geological structures.

- Characteristics of variations in seam morphology and structure, degree of continuity and discontinuity of coal seams within each block.

- Characteristics of changes in reservoir industrial geological parameters.

- Number of coal seams and coal content of each block.

- Existing depth of coal seams, especially industrial coal seams.

- The blocks are limited by large-scale faults.

3.2.2. Overview of relatively homogeneous step division diagrams conducted on coal tanks

Inheriting the results of previous research, with the purpose of researching and finding the most reasonable combination of methods that allows clarifying the relatively homogeneous hierarchies that create the heterogeneous system of the coal basin as the basis basis for forming exploration methods as well as principles and methods for economic-geological assessment of Quang Ninh coal mines, 1994. Associate Professor, Dr. Nguyen Phuong completed and successfully defended his thesis to win the degree of PTS in Geographical and Geological Sciences with the title “Dividing the system of heterogeneous hierarchies in the

Quang Ninh coal basin to properly resolve issues in exploration methods and economic assessment of coal resources in the coal basin". Research results Associate Professor, Dr. Nguyen Phuong divided the coal basin into 44 homogeneous blocks.

3.2.3. Dividing the Hon Gai - Cam Pha area into relatively homogeneous geological blocks according to geological factors

3.2.3.1. Fault factor

The study area is limited by large faults as mentioned in Chapter 1, however, new exploration and mining results allow to determine the existence of many large faults, which divide the study area into blocks with many different geological characteristics.

3.2.3.2. Coal content coefficient

Evaluating parameters such as coal storage coefficient, number of coal seams and especially the variation in total thickness of coal seams between areas divided by tectonic factors as mentioned above, we get the results are as follows:

Table 3.1. Table summarizing the coal content coefficient of the blocks

No.	Construction block	Coal content coefficient (%)	Note
1	Binh Minh - Ha Lam - South Suoi Lai	1.9%	
2	North of Suoi Lai - Ha Rang	2.6%	
3	Nga Hai - Khe Tam - Khe Cham	2.3%	
4	Mong Duong - North Coc Sau	2.1%	
5	South F.A Fault	2.0%	

3.2.3.3. Number of coal seams and degree of seam variation

There are differences in deformation between blocks. The block with the largest deformation coefficient is the Southern F.A fault block (113%), the block with the least variability coefficient is Binh Minh - Ha Lam - Nam. Suoi Lai (79%), details in table 3.2

Table 3.2. Table summarizing the variability of the blocks

No.	Construction block	Variation coefficient (%)	Note
1	Binh Minh - Ha Lam - South Suoi Lai	79%	
2	North of Suoi Lai - Ha Rang	87%	
3	Nga Hai - Khe Tam - Khe Cham	101%	
4	Mong Duong - North Coc Sau	96%	
5	South F.A Fault	113%	

The coefficient of circumference variation between blocks is different. The block with the largest coefficient of variation in circumference is the block South of the F.A fault (1.84), the block with the least variation coefficient is Mong Duong - Bac Coc Sau (1.80%), details in table 3.3

Table 3.3. Table summarizing the coefficient of variation of seam circumference of the blocks

No.	Construction block	Coefficient of variation of reservoir circumference	Note
1	Binh Minh - Ha Lam - South Suoi Lai	1.81	
2	North of Suoi Lai - Ha Rang	1.83	
3	Nga Hai - Khe Tam - Khe Cham	1.83	
4	Mong Duong - North Coc Sau	1.80	
5	South F.A Fault	1.84	

From the results of synthesis, analysis, and comparison as mentioned above, it is the basis for the PhD student to divide the research areas into 5 relatively homogeneous blocks and use the names of the mine areas to name the corresponding blocks. The division into 5 relatively homogeneous geological blocks as above will allow assessment of reserves, resources and orientation of coal prospecting and exploration below the -300m level in accordance with the geological structure.

Figure 3.1. The block map is relatively uniform in the Hon Gai - Cam Pha area

3.3. Assessment of coal resources in the study area

In previous reports, the determination of reserves/resources was mainly divided by mines, in this study we will determine reserves/resources according to geological blocks as divided above, with the characteristics of the Hon Gai - Cam Pha research area have been studied for a long time. Although the levels are different, basically from the exposed seam to the -300m level has been studied in great detail, so in the thesis, the PhD student determines reserves/resources for the part above -300m level and below -300m level according to the principles below.

a. Above -300m level

From seam exposure to -300m, we will use statistical methods and documents from reports approved by competent state management agencies:

Table 3.4. Summary table of reserves/resources according to geological blocks from outcrop to -300m level

No.	Construction blocks /Mine name	Reserves and resources (thousands of tons)				
		Total	Sure (111+121)	Trust (122+222)	Estimated (333)	Forecast (334a)
	Total	**1,560,200**	**291,897**	**965,420**	**285,986**	**16,897**
1	Binh Minh - Ha Lam - South Suoi Lai	477,828	75,769	256,184	144,268	1,606
2	North Suoi Lai - Ha Rang - West Nga Hai	56,868		40,076	11,613	5,179
3	Nga Hai - Khe Tam - Khe Cham	709,346	199,783	439,167	67,564	2,833
4	Mong Duong - North Coc Sau	154,687	13,826	92,763	41,309	6,789
5	South FA Fault	161,470	2,519	137,230	21,232	490

b. Below -300m level

To evaluate the forecast resources below - 300m, the PhD student conducted research and evaluation on 5 relatively homogeneous geological blocks as mentioned above, the results were determined as follows:

Table 3.5. Total forecast resources are below -300m
Hon Gai - Cam Pha area

No.	Resource assessment block	Coal resources by high level (thousand tons)					
		- 300 ÷ -450m	- 450÷ -600m	-600 ÷ -750m	-750÷ -900m	- 900÷ - 1000	Total
1	Binh Minh - Ha Lam - South Suoi Lai	210,080	207,493	173,931	-	-	**591,504**
2	North Suoi Lai - Ha Rang - West Nga Hai	72,529	116,316	81,809	58,864	16,638	**346,157**

No.	Resource assessment block	Coal resources by high level (thousand tons)					
		- 300 ÷ -450m	**- 450÷ -600m**	**-600 ÷ -750m**	**-750÷ -900m**	**- 900÷ - 1000**	**Total**
3	Nga Hai - Khe Tam - Khe Cham	284,359	205,497	157,119	85,812	43,092	**775,879**
4	Mong Duong - North Coc Sau	114,188	105,492	65,521	33,448	2,231	**320,880**
5	South of the FA fault	136,756	138,160	-	-	-	**274,915**
	Total	**817,912**	**772,958**	**478,381**	**178,121**	**61,961**	**2,309,336**

Because from the level below -300m, the level of search and exploration research is limited and only in some mine areas; separating reserves and resource levels in areas that have been searched and explored below the -300m level faces many difficulties, so in the PhD thesis, it was agreed to classify the coal resource level as 334a for the coal resources forecast below -300m level, the previously assessed reserves and resources are considered part of the forecast level 334a resources.

Chapter 4

ORIENTATION OF SEARCH AND EXPLORATION WORK BELOW -300M IN HON GAI - CAM PHA AREA

4.1. Orientation for the search (investigation and assessment) of below-grade coal -300m

From the issues mentioned above, it can be seen that the Hon Gai - Cam Pha area needs to continue investing in search work to clarify coal prospects below -300m, specifically:

- For the south of Hon Gai, according to gravity geophysical documents, exploration and mining documents, from the boundary of Ha Rang mine; Binh Minh to the south (the flooded area of Cuoc Be Bay) needs to be invested in to evaluate and clarify coal prospects here.

- For the remaining blocks, although exploration and mining have been done, to fully understand the prospect of coal reaching the bottom of the coal layers, it is necessary to arrange deep boreholes to control to the bottom of the coal-bearing sediment layer.

4.2. Orientation of coal exploration work below -300m level

4.2.1. Mine group and exploration network

Research to identify groups of exploration mines is important in assessing the industrial value of coal mines, greatly influencing the choice of exploration network density. The grouping of exploration mines must be based on the study of the mine's geological structure, size, coal seam morphology and structure, and the degree of variation in thickness, ash level, seam slope angle, etc. To determine the group of coal exploration mines above and below the -300m level, we mainly rely on documents collected during the process of coal exploration and mining at mines in the Hon Gai - Cam Pha area to accurately determine the main parameters reflecting the characteristics of the mine's geological structure, morphology - structure and the degree of change in industrial geological parameters of the coal seam in the Hon Gai - Cam Pha area.

Table 4.1. Summary of criteria to establish exploration mine groups for coal mines

No.	Parameter name	Group I	Group II	Group III	Group IV
1	Thickness variation coefficient (Vm,%)	< 40	40 - 75	75 - 100	>100
2	Coefficient of variation of ash VA (%)	< 40	40 - 75	75 - 100	>100
3	Circumferential variation coefficient (μ)	1.0 - 1.4	1.4 - 1.8	>1.8	>1.8
4	Variation index (Pbv)	0 - 25	25 - 100	>100	>100
5	Target rate of destruction zone (PP, %)	0 - 4	4 - 8	>8	>8
6	Coefficient of reservoir discontinuity (Kd,%)	<10	10 - 20	20 -40	>40
7	Internal structure of reservoir and rock clamp ratio (Kk,%)	<10	10 - 50	>50	>50
8	Slope angle variation coefficient (Kα)	≥ 1	< 1 - 0.625	< 0.625	< 0.625

4.2.2. Identify mine groups for the Hon Gai - Cam Pha area

Through the results of calculating the parameters of coal seam morphology and structure characteristics for geological blocks of the Hon Gai - Cam Pha area, the PhD student would like to summarize through statistical table 4.2 as follows:

Table 4.2. Summary of criteria to establish a group of exploration mines for the Hon Gai - Cam Pha area

No.	Parameter name	Binh Minh - Ha Lam - South Suoi Lai block	North Suoi Lai - Ha Rang - West Nga Hai block	Nga Hai - Khe Tam - Khe Cham Block	Mong Duong - North Coc Sau block	South F.A Fault block
1	Thickness variation coefficient (Vm%)	85	87	78	79	108
2	Coefficient of variation of ash VA (%)	54	35	44	44	55
3	Circumferential variation coefficient (μ)	1.81	1.83	1.83	1.8	1.84
4	Variation index (Pbv)	79	87	101	96	116
5	Target rate of failure zone (PP %)	20	14	21	31	13
6	Coefficient of reservoir discontinuity (Kd%)	20	20	11	16	20
7	Internal structure of reservoir and rock clamp ratio (Kk%)	19	14	10	16	27
8	Slope angle variation coefficient (Kα)	0.38	0.37	0.44	0.59	0.52
	Classification of mine groups	**III**	**III**	**III**	**III**	**IV**

4.2.3. Proposed exploration network below -300m level in Hon Gai - Cam Pha area

Comparing the degree of morphological change in the structure of coal seams of relatively homogeneous geological blocks in the Hon Gai - Cam Pha area, according to the depth above and below the -300m level, the results show that in the same geological block, the morphology and structure of the coal seams are quite similar, which can lead us to draw

the conclusion that within the same geological block, the mine group above and below the -300m level is similar.

Based on the identified group of exploration mines established in table 4.2. Applicable according to Decision No. 25/2007/QD-BTNMT dated December 31, 2007 of the Ministry of Natural Resources and Environment promulgating Regulations on exploration and decentralization of coal reserves and resources. From there, orient the network of exploration works below the -300m level for the Hon Gai - Cam Pha area, specifically shown in Table 4.3.

Table 4.3. Orientation of coal exploration works network below -300m level in Hon Gai-Cam Pha area, Quang Ninh

Group of exploration mines	Reliable reserves (Level 122)		Estimated resources (Level 333)	
	Exploration route distance (m)	Distance of works on the route (m)	Exploration route distance (m)	Distance of works on the route (m)
Complex (III)				
Binh Minh - Ha Lam - South Suoi Lai block	125 ÷ 250	75 ÷ 125	250 ÷ 500	125 ÷ 250
North Suoi Lai - Ha Rang - West Nga Hai block	125 ÷ 250	75 ÷ 125	250 ÷ 500	125 ÷ 250
Nga Hai - Khe Tam - Khe Cham Block	125 ÷ 250	75 ÷ 125	250 ÷ 500	125 ÷ 250
Mong Duong - North Coc Sau block	125 ÷ 250	75 ÷ 125	250 ÷ 500	125 ÷ 250
Very complex (IV)				
South F.A Fault block	75 ÷ 125	50 ÷ 75	125 ÷ 250	75 ÷ 125

4.2.4. Determine the exploration network using the geological mathematical modeling method (Variogram)

With the goal of testing and evaluating the exploration network, the PhD student chose a structural function method (model) to evaluate the influence distance between the thickness parameters of the works used

and isotropic or anisotropic properties of coal seam thickness parameters. Selecting and evaluating geological blocks, in each block, select 02 coal seams with large reserves and many controlled drilling exploration works to build a structural function model. Variogram model was surveyed using Surpac software.

Table 4.4. Comparison table of the results of determining the exploration network by mine group and structural function survey (Variogram)

Group of exploration mines / Geological block	According to the exploration mine group: reliable level reserves (level 122)		According to the results of the Variogram function survey	
	Distance between routes (m)	Distance of works on the route in the direction of the seam (m)	Distance between routes (m)	Distance of works on the route in the direction of the seam (m)
Complex (III)/Binh Minh - Ha Lam - South Suoi Lai block	125 ÷ 250	75 ÷ 125	120 ÷ 240	125 ÷ 150
Complex (III)/North Suoi Lai - Ha Rang Block	125 ÷ 250	75 ÷ 125	140 ÷ 280	115 ÷ 140
Complex (III)/Nga Hai - Khe Tam - Khe Cham Block	125 ÷ 250	75 ÷ 125	120 ÷ 240	145 ÷ 170
Complex (III)/Mong Duong - North Coc Sau Block	125 ÷ 250	75 ÷ 125	350 ÷ 270	125 ÷ 150
Very Complex (IV)/South FA Division	75 ÷ 125	50 ÷ 75	100 ÷ 150	60 ÷ 85

From the above comparison table, it can be seen that the exploration network determined according to the results of structural function survey (Variogram) is relatively consistent with that determined by mine group and according to current regulations. However, because the network amplitude determined by the Variogram structural function is relatively large and basically covers the entire network according to regulations, the PhD student proposed a network for blocks of Hon Gai - Cam Pha area according to the current regulations.

CONCLUSIONS AND RECOMMENDATIONS

1. CONCLUSIONS

1. The Hon Gai - Cam Pha area is divided into 05 relatively homogeneous geological blocks; Each block has structural characteristics, coal content, quantity, thickness and especially the depth of coal seams below - 300m.

2. Seams 5, 6, 7, 8, Binh Minh area correspond to seam 14; 13; 11; 10 Ha Lam areas and seams 13; 12; 10; 9 South Suoi Lai area. Characteristics of these seams are their large thickness (from 3 to 7m), continuous maintenance and widespread distribution throughout the study area.

3. The F.A fault is oriented to the North, different from previous observations that it is located to the South. This change has a great impact on the assessment of coal resource potential at levels below -300m in the study area.

4. The resource potential and coal reserves in the Hon Gai - Cam Pha area below -300m are quite large, forecast at about 2.3 billion tons; concentrated in the Nga Hai - Khe Tam - Khe Cham block, followed by the Binh Minh - Ha Lam - South Suoi Lai block, the North Suoi Lai - Ha Rang block, the Mong Duong - North Coc Sau block and finally the South FA block. Except for the Nga Hai - Khe Tam - Khe Cham block, which tends to concentrate large reserves and resources from outcrop to -150m, the remaining blocks tend to concentrate coal at -300m ÷ - 600m and have special characteristics. The common point is that it gradually decreases to -1000m; below -1,000m, coal seams almost no longer exist.

5. In the Hon Gai - Cam Pha area, most of the coal seams below the -300m level within the relatively homogeneous blocks of the study area belong to exploration mine group III (80%), with some blocks belonging to mine group IV. The most reasonable network for arranging exploration works is to use a linear network, with reserves up to level 122; Distance between probe lines: 125m ÷ 250m, distance between works on the route: 75m ÷ 125m for mine group III and distance between lines: 75m ÷ 125m, distance between works on the route: 50m ÷ 75m for type IV mines.

2. RECOMMENDATIONS

1. The Hon Gai - Cam Pha area has coal resource potential below -300m which is quite large, but concentrated in some blocks and at certain depths; therefore, it is necessary to pay attention to this characteristic to choose a reasonable area and depth during investigation, evaluation and exploration for mine development.

2. First of all, it is necessary to focus on assessing the prospects of the flooded area of Cuoc Be Bay (east of Ha Rang mine area, Binh Minh). Investigation, assessment and exploration work below the -300m level, in addition to quality research and reserve calculation, should focus on research on mining conditions (DCTV - DCT and mine gas). During the construction process of the Exploration Project, it is necessary to carry out the construction sequentially according to the steps corresponding to the preliminary exploration stage to the previous detailed exploration.

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