Notice of Retraction

After careful and considered review of the content of this paper by a duly constituted expert committee, this paper has been found to be in violation of IEEE’s Publication Principles.

We hereby retract the content of this paper. Reasonable effort should be made to remove all past references to this paper.

The presenting author of this paper has the option to appeal this decision by contacting TPII@ieee.org.
Study on the Gob-effect Mines and Its Risk Classification Method

Abstract—Gob consequentially exists in those mines where open-stope method is adopted, and its area will be growing with the constantly mining. Due to lack of scientific understanding and management, the accidents of gob roof caving in large occurred sometimes, causing heavy casualties and property losses. In recent years, the typical accidents have occurred more and more frequently, and the severity and danger has initially appeared. Therefore, at the point of safe production and disaster prevention, it is necessary to make risk classification to these mines. This article puts forward the concept of gob-effect mines and the method of risk classification from the view of disaster prevention and hazard control, which helps to make risk assessment to this type of mines and develop effective preventive measures according to the classification.

Keywords—gob-effect; mine; risk classification

I. CONCEPT AND CONNOTATION OF GOB-EFFECT MINE

A. Concept of gob-effect mine

Gob-effect mines refer to those that left over sizeable mined-out space with the danger of caving in large scale. Exactly speaking, gob is the result of using open-stope method in these mines, what’s more, these is no any settlement to mined-out area. Or it is diseconomy to employ filling mining method because of low ore value. On the other hand, caving mining method is not applicable under some conditions. In a word, gob-effect mines are those where there is great hidden danger and threat for safety production under influence of mined-out space with the characteristic of large scale, forming long time and having reached the limit equilibrium state.

B. Connotation of gob-effect mine

Generally speaking, gob damage belongs to mine geological disaster. There is both similitude and difference from environmental geological disasters caused by land subsidence. Mined-out area in this kind of mines has unique characteristic. That is, large scale, long existing time with no support or shoring unreasonable, and falling in lager in similar mines. “Gob-effect mines” has technical connotation for adopting feasible mining method, has economic connotation for not using filling mining method because of low ore value, and has time meaning for its mined-out space long standing. Therefore “Gob-effect mines” is a complex concept with economic and technology meaning, space meaning and time meaning.

II. CLASSIFICATION OF GOB-EFFECT MINE

A. Type of gob-effect mine

1) Idea of Classification

To classify “gob-effect mines” is complex system engineering as it is affected by several factors such as natural geology, mining technology, production and management, ecological environment, and social stability. Only to seize the essential attribute playing leading role and make twice or more consecutive division according to different basis, can gradually reveal the attribute and significant features of complex system, and propose scientific and valuable classification schemes.

2) Basis for Classification

It is a complex system to make classification to “gob-effect mines” due to several influencing factors stated above. It is impossible to consider all factors in the study but to seize those essential attribute and significant features in leading role. According to analysis, the main factors to assess “gob-effect mines” include mined-out space scale, area ratio and its formation time.

3) Classification of damage degree

In "Geological Hazards Prevention Act" Article IV, geological disaster is divided into four grades according to extent of casualties and economic losses. Super-huge type refers to 30 death tolls or more than 10 million RMB direct economic losses; huge type, 10-30 death tolls or 5-10 million RMB direct economic losses; medium type, 3-10 death tolls or less than 5 million RMB direct economic losses; and mini type, 3 death tolls below or less than 1 million RMB direct economic losses.
economic losses. This classification mainly aims at severity after accidents.

In order to fully reflect the thinking of prevention-first, according to the scale, area ratio and formation time of mined-out space, “gob-effect mines” is divided into serious hazard mine, medium hazard mine, general hazard mine and potential hazard mine. In this classification, harm degree basically keeps coincidence with rules stated in “Geological Hazards Prevention Act”, however, casualties and property losses may be discrepant.

B. Three-dimensional classification scheme

1) Classification model

According to the classification basis mentioned above, the article proposed three-dimensional classification model of “gob-effect mines" consisting of 36 cubes [1]. X-axis stands for scale of mined-out space, Y-axis for area ratio, Z-axis for formation time and the cube means type of “gob-effect mines" [“Fig. 1”].

![Figure 1. Three-dimensional classification model of “gob-effect mines"](image)

2) Classification index and coding instruction

a) Scale of mined-out space (S)

A grade, S ≥ 10^5 square meters, large-scale, serious hazard; B grade, 5×10^4 ≤ S <10^5 square meters, medium-scale, medium hazard; C grade, 2×10^4 ≤ S <5×10^4 square meters, secondary medium-scale, slight hazard; D grade, S < 2×10^4 square meters, small-scale, potential hazard.

b) Area ratio of mined-out space (η)

A grade, η ≥ 30%, large area ratio, serious hazard; B grade, 10% ≤ η <30%, medium area ratio, medium hazard; C grade, η <10%, small area ratio, general hazard.

c) Formation time of mined-out space (t)

A grade, t ≥ 10 years, long formation time, serious hazard; B grade, 5 ≤ t <10 years, second long formation time, medium hazard; C grade t ≤5 years, short formation time, general hazard.

The matrix is used here based on the above classification scheme, as is shown in table I [2].

<table>
<thead>
<tr>
<th>Grade</th>
<th>Risk grading</th>
<th>Classification of hazard extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Serious</td>
<td>AAA</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>BAA</td>
</tr>
<tr>
<td></td>
<td>General</td>
<td>CAA</td>
</tr>
<tr>
<td></td>
<td>Potential</td>
<td>DAA</td>
</tr>
<tr>
<td>II</td>
<td>Serious</td>
<td>BBB</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>CBB</td>
</tr>
<tr>
<td></td>
<td>General</td>
<td>BBC</td>
</tr>
<tr>
<td></td>
<td>Potential</td>
<td>DBC</td>
</tr>
<tr>
<td>III</td>
<td>Serious</td>
<td>CCA</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>CCA</td>
</tr>
<tr>
<td></td>
<td>General</td>
<td>CCA</td>
</tr>
<tr>
<td></td>
<td>Potential</td>
<td>CCA</td>
</tr>
</tbody>
</table>

Damage extent and risk classification to gob-effect mine doesn’t only aim at one or several gobs but the whole mine. The classification theory expresses more practical significance to assess this series of mines. And also, it is much convenient to use to assess single gob. In practical application, damage extent and risk classification can be made to gob-effected mines according to the theory above, and then security measures are put forward. Next step is to make probing to individual large gob and give suggestions.

Three-dimensional classification code indicates: the first place means scale of gobs, the second means area ratio, and the third stands for formation time. For example, the code AAA means that the scale of mined-out space exceed 100 thousand square meters, area ratio over 30%, and formation time more than 10 years. The mine belongs to serious hazard type and risk grading I, remaining with high risk. Therefore analysis and evaluation must be done. Another example, the code DAA expresses that the scale of gob is less than 20 thousand square meters, yet area ratio exceeds 30% and the new mine-out space is growing. Also it belongs to serious hazard type and risk grading I. Here the assessment to mining method should be in view besides the solution to gobs.

C. Two-dimensional classification scheme

While making risk assessment to practical mines some problems arise. Sometimes it is unable to make sure actual situation of mined-out space due to certain reasons. Here two-dimensional classification scheme is adopted to make assessment. The scheme expunges the index “scale of gob” compared to three-dimensional classification scheme but the index of area ratio and formation time is divided in more detail. This method is often used to assess those mines with gob scale over 100 thousand square meters.

The main indexes in two-dimensional classification scheme only include area ratio of mined-out space (η) and Formation time (t).

1) Area ratio of mined-out space (η)

A grade, η≥30%, large area ratio, serious hazard; B grade, 20% ≤ η < 30%, relatively large area ratio, large
hazard; C grade, 10% \leq \eta < 20\%, medium area ratio, medium hazard; D grade, \eta \leq 10\%, small area ratio, general hazard.

2) Formation time of mined-out space (t)
   A grade, t > 10 years, long formation time, serious hazard; B grade, 5 \leq t \leq 10 years, relatively long formation time, large hazard; C grade 3 \leq t \leq 5 years, medium long formation time, medium hazard; D grade, t \leq 3 years, short formation time, general hazard.

The Classification scheme above can be expressed in matrix form as table II below:

<table>
<thead>
<tr>
<th>Risk grading</th>
<th>Classification of hazard extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade I</td>
<td>Serious (AA) Medium (BA) General (CA) Potential (DA)</td>
</tr>
<tr>
<td>Grade II</td>
<td>Serious (AB) Medium (BB) General (CB) Potential (DB)</td>
</tr>
<tr>
<td>Grade III</td>
<td>Serious (AC) Medium (BC) General (CC) Potential (DC)</td>
</tr>
<tr>
<td>Grade IV</td>
<td>Serious (AD) Medium (BD) General (CD) Potential (DD)</td>
</tr>
</tbody>
</table>

In actual classification to mines, the main research and assessment focus on those types that are circled by heavy line in table II above. Then processing measures are made according to the results. The code here has the same meaning as referred in Three-dimensional classification scheme. Such as the code AA, it means the scale of gob exceeds 100 thousand square meters but its current situation is not very clear. In accordance with the provisions, the mine with area ratio of mined-out space above 30\% and formation time over 10 years belongs to serious hazard type and risk grading I, with high fatalness. It is necessary to make processing to mined-out space according to the analysis results.

III. SIGNIFICANCE OF RISK CLASSIFICATION

Open-stope mining method accounts for about 60\% in domestic nonferrous metal underground mines, and an average of 50\% in foreign countries. In gypsum mines the proportion is 70\% and there are almost no any treatments to mined-out space. Large area of the gob roof collapse, surface cracking and subsidence, mine earthquakes and other malignant mine accidents have occurred recently and pose a great threat to the safety production and personnel security. Especially with the mining depth increasing, deep pressure activities become more intense. The expansion of mining areas causing roof fall makes probability of rock burst and mining earthquakes increase. Therefore to assess and classify this series of mines is thorny issue and need to solve urgently.

Practice has proved that risk assessment to single or group gobs helps mines promote safe production and management and make treatments to mine-out section. Yet there is no uniform approach to assess the whole gob-effect mines. The paper summarizes common characteristics of gobs and proposes the concept of “gob-effect mines” and its classification method, which help safety department promote sort management ability. Also it is convenient for mining enterprises recognize the risk grade of their mines and potential hazard during producing and put forward corresponding measures to avoid severe accidents happen. In all, it makes very important significance on ensuring the safety of people's lives and property.

IV. CONCLUSIONS

The article proposes the concept of “gob-effect mines” and states the basis and idea of classification and risk grading to them. Aiming at different situation of mined-out area three-dimensional classification schemes and two-dimensional classification schemes are put forward. The former is used under the condition of clear situation of gobs, and the latter for unclear situation of gobs. For some certain mine, through the surveys to formation history of gob and the mining method currently used, combining the classification mentioned in article, it is convenient and easy to make classification of hazard and risk grading. However, some parameters in assessment may need to be improved more scientific. Strongly suggest the safety authorities carry out systematic research to develop practical and feasible parameters and make it in the form of regulations to implement.

REFERENCES