

**PRIORITY DECISION FOR RATIONAL EXPLOITATION AND
UTILIZATION OF JILIN NON-METALLIC MINERALS AND
MINES**

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ABSTRACT

Prior order models of rational exploitation and utilization for Jilin non-metallic minerals and mines in Jilin Province are established by AHP, and the priorities of rational exploitation is determined and a thorough analysis is made in modelling. This paper has been included in the inner publication "Research on Scientific and Technical Exploitation of Jilin Non-Metallic Minerals", which has won the third prize in Jilin Province. It provides the scientific basis for making decision of the leading group.

Key words Non-metallic mineral, AHP, Systems Analysis.

INTRODUCTION

There are 70 varieties of non-metallic minerals to be found out in Jilin Province, and in which there are 38 varieties of minerals to be prove up deposit and to be exploited to some extent. Yet the condition for the 38 varieties of minerals to have,

its many-sided situation and many kinds of factors to restrict its development have much more differences, so the tactics of exploitation should not be accepted of advancing side by side and attending to each and every aspect of a matter. And we should put limited economic resources on the minerals of the most latent potentialities and the most exploiting prospects, that will be a selection of superior minerals which ought to lay stress on exploitation by some chosen standards and principles, so as to lead to a direction for the research of concrete tactics and strategy of exploitation follow-up parts. Thus we select 14 varieties of minerals to have a comprehensive superiority according to 5-sided standards and principles, including 7 varieties of new rising minerals. The selection of 14 varieties of minerals is a rough outline, only shows a basis direction of exploitation and utilization from macro angles, however, each mineral comprises many mines, each of which has different conditions of market, technique, resource, finance and mining, and different production capacities and social and economic situations as well as geographic places. The concrete differences of these cases will result in different practical effects of exploitation. To be sure, for the mineral resources of Jilin Province to be exploited and utilized with the largest scale can yet be regarded as an ideal goal, but the exploiting ranges, speed and scale can not but be limited by financial ability, material and manpower within Jilin Province and in the localities, and have to be restricted by the market demand in some term. So on the basis of giving full play to the superiorities of mineral resources, and through the synthetical analysis of complex factors, decision analyses are done of the priority of superior minerals development. The decision analysis is the process comprehensive considering varieties of complex factors and conditions and the combination of qualitative and quantitative information with experiences and judgements of specialists to carry out systems analysis. Here, we adopt The Analytic Hierarchy Process by Prof. T. L. Saaty in U. S. to model the prior order of rational exploitation. That is the optimum selection of minerals and mines exploiting and the prior arrangement of 22 mines to 14 varieties of minerals.

MODELING AND DECIDING

1. Determination of the factors for priority models of rational exploitation of minerals and mines.

Compared and chosen the known factors influencing the rational exploitation of non

—metallic mines, we divide these factors into 6 restricted aspects and 29 restricted factors according to their characters and varieties, and each factor is divided into some concrete indexes by qualitative description and quantitative explanation. We take C as the restricted aspect and F as the restricted factor in order to calculate clearly and without error later.

1.1 Mineral resource conditions C_1

C_1 is a materials base and an original power for exploitation. Under the situation of the modern socialized and the large-scaled commodity production, however, its position in economic development is the lowest level of market—technology—resource, which should be clearly understood while appraising it. C_1 is shown by three restricted factors, and the recoverable reserves refers to a real possibility of exploitation, the prospective reserves means a potential possibility of exploitation, and the grade index is a rule to the mineral's quality as well as a standard of the mineral's economic value. Every factor is reflected with different indexes or subfactors as following:

F_1 : The recoverable reserve (ten thousand tons), which is divided into six quantity indexes. $F_1^1: <100$; $F_1^2: <100 \sim 500$; $F_1^3: <500 \sim 1000$; $F_1^4: 1000 \sim 3000$; $F_1^5: 300 \sim 5000$; $F_1^6: >5000$.

F_2 : The prospective reserve (ten thousand tons). $F_2^1: 0$; $F_2^2: 0 \sim 100$; $F_2^3: 100 \sim 1000$; $F_2^4: 1000 \sim 5000$; $F_2^5: >5000$.

1.2 Mining conditions

C_2 is the outer natural environment for exploitation, which has direct relation with whether minerals can be exploited and is worthy of exploitation or not; and with a basic investment on constructing mines and equipments as well as the cost and price of ores. C_2 includes (The concrete meanings of these indexes will be no longer written out in the following for saving spaces): F_4 : Mining ways; F_5 : Stripping-to-ore ratio; F_6 : Hydrogeologic conditions; F_7 : Distances between mines and railway stations (km).

1.3 Mining and dressing means C_3

A level of the production forces of mines is reflected by C_3 . F_8 : Mining means; F_9 : Difficulty degrees in mining; F_{10} : Difficulty degree in hand dressing.

1.4 Present situations and developing potentialities of mines

A present situation of mines indicates its current production and management status, and a developing potentiality mirrors the maximum possibility of a mine in the future and is obtained from the comprehensive analysis of the conditions of a mine enterprise.

F_{11} : Deep-processing product output (tons/a year); F_{16} : Developing potentiality of oneself

1.5 Market and forecast C_5

C_5 shows a sale situation of mineral products in the domestic-overseas markets and the forecast of the need in the future. There are four markets by a processing degrees.

F_{17} : Domestic market of raw ore; F_{18} : Overseas market of raw ore; F_{19} : Domestic market of primary and deep-processing products; F_{20} : Overseas market of primary and deep-processing products.

1.6 Economic and social benefits C_6

C_6 is a synthetical reflection on the inner conditions, the outer environments of a mine and the state of managing a mine enterprise, which is illustrated by the absolute values and the relative ones.

F_{21} : Output value of raw ore (ten thousand yuan /a year); F_{22} : Profit and tax rate of raw ore; F_{23} : Output value of primary and deep-processing products; F_{24} : Profit and tax rate of primary and deep-processing products; F_{25} : Social benefit of primary and deep-processing products.

1.7 Capital C_6

In the early period of exploiting non-metallic mines, the source and the amount of capital make great influence on the development, thus, it is also an evaluation standard of the exploited value whether a mine enterprise is able to raise funds, to receive investments from the local and central government and the foreign investors or not.

2. Determination of programmes.

Here is minerals and mines of optimum seeking. We have selected fourteen varieties of superior minerals, from which twenty-two mines with bright future are chosen out and are taken for the objects of prior order in order to make priority decision by further analysis and calculation. $M_1 \sim M_{22}$ are only used to indicate these 22 mines below.

3. Establishment of the graded herarchy structure (see Fig.)

Besed on the above analysis, the graded hierarchy structure of priorities of rational exploitation of Jilin non-metallic minerals and mines is determined.

4. Construction of judgement matrixes

Thus, all the initial judgement matrixes are worked out by several major experts studing in "The Research on Technical and Scientific Exploitation of Jilin Non-Metallic Minerals" by means of back against back. On this basis, we make some necessary modifications. To reduce the amount of work and to improve the precision of caluclation, we make dealing with all the judgement matrixes in quantity before computering, merging some factors with similar quantitative and qualitative information. Therefore, there is no lose in the whole data and information, that is, the merged factors are comprehesively considered by ratio scales. The calculation results have proved that it is meaningful.

5. Priority decision

Finally, we abtain the prior order decision on rational exploitation of Jilin superior non-metellis mirerals and mines

5.1 Importance analysis on the restricted aspect's influence to rational exploitation.

The model of Table 1 shows the ratio scales of various aspects under the general goal A governing and the weight of various aspects for the general goal A.

Table 1 Judgement matrix of A—X

A	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆	W _i
C ₁	1	1/4	1/3	1/6	1/4	1/5	0.0371
C ₂	4	1	2	1/5	1/3	1/4	0.0904
C ₃	3	1/2	1	1/4	1/2	1/3	0.0765
C ₄	6	5	4	1	4	3	0.4200
C ₅	5	4	3	1/3	1/2	1	0.1848

$\lambda_{max} = 6.4752$, C. I = 0.0950 R. I = 1.24 C. R = 0.076

By the amount of the weights in Table 1, we notice that the total of the marketing of ore products W₅ and economic & social benefits W₆ and capital sources is 0.796, the sum of those weights makes up 80% of all the weights. Therefore, to expand needs of markes, to enhance managements of mines and to increase technical competence levels and to create a better capital environments, should be given more attention to

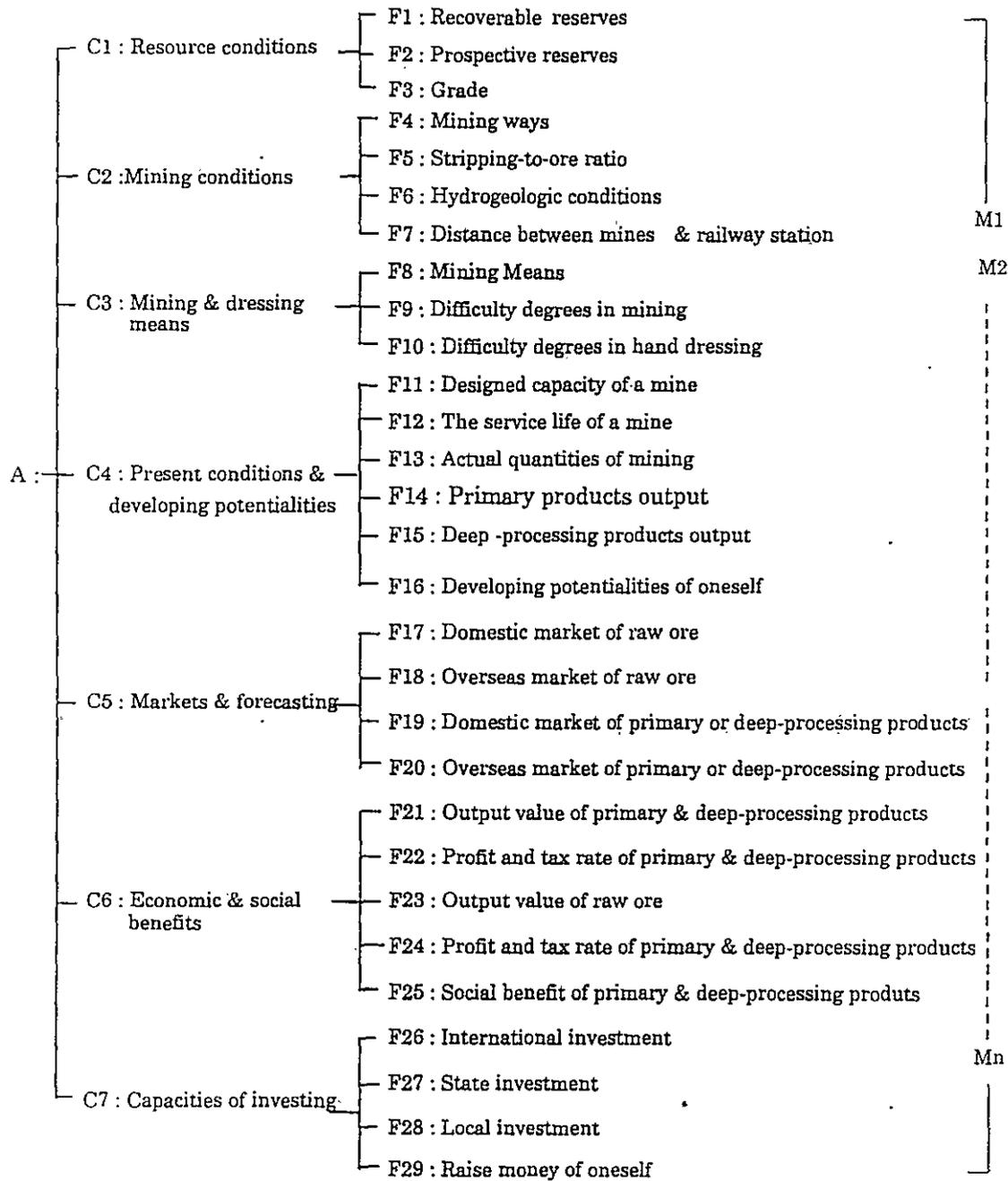


Fig. The graded hierarchy for rational exploitation of Jilin non-metallic menerals & mines.

develop non-metallic mines.

5.2 Importance analysis on the restricted factors influence to rational exploitation
The model of Table 2 reflects the relative weights of various factors F_i under various aspects C_i governing and the weights of various factors for the general goal A.

In the restricted factors of the same group, from the weights in Table 2, we notice that Grade $W_2: 0.80$; Transport distance $W_4: 0.75$; Developing potentialities of oneself $W_7: 0.6370$; Domestic and overseas market of raw ore $W_8: 0.75$; Profit and tax rates of raw ore and primary & deep-processing products $W_{11}: 0.6483$; Overseas investment $W_{13}: 0.75$. Above those hold more weights, one should specially take those factors into account while making a concrete consideration for various restricted aspects.

Table 2 Weights of C—F and A—F

C—F F_i	C_1	C_2	C_3	C_4	C_5	C_6	A—F WI
	0.0371	0.0904	0.0765	0.4200	0.1912	0.1848	
F_1	0.20						0.0074
F_2	0.80						0.0296
F_3		0.25					0.0226
F_4		0.75					0.0678
F_5			0.1047				0.0080
F_6			0.2583				0.0197
F_7			0.6370				0.0487
F_8				0.75			0.3150
F_9				0.25			0.1050
F_{10}					0.1220		0.0233
F_{11}					0.6483		0.1240
F_{12}					0.2297		0.0439
F_{13}						0.75	0.1386
F_{14}						0.25	0.0464

C. I. = 0.0018 R. I. = 0.1553 C. R. = 0.0118

The model of Table 2 also mirrors the combined weights for various factors to realize the general goal A after synthetically investigating every restricted aspect (the general weights of A to F_i). Among them, $W_8: 0.3150$; $W_{13}: 0.1386$; $W_{11}: 0.1240$; $W_9: 0.1050$; $W_4: 0.0678$; $W_7: 0.0487$; which show, in the concrete factors of influencing rational exploitation of Jilin non-metallic minerals, whether or not

widen overseas and domestic markets F_8 ; whether or not introduce overseas investment F_{13} ; how much profit and tax rates of raw ore and primary & deep-processing products, should be focused. Secondly, Overseas and domestic markets of primary and deep-processing products F_9 ; Transport distances F_4 ; Developing potentialities of oneself F_7 ; which have some influences, too. Those six factors make up 78% of the whole weight of all fourteen factors. To work hard on these links will greatly promote exploiting for non-metallic minerals and mines of Jilin Province.

After making the synthetically analysis on every restricted factors to the realization of the general goal, we can relate every programme with the general goal through the restricted factors and aspects and finish the final decision.

Table 3 Final Weights of Wollastonite Mines

A-F		Mi F—M	Mine Code				C. R.
			M_1	M_2	M_3	M_4	
F_1		0.0074	0.3750	0.1250	0.3750	0.1250	0.0000
F_2		0.0296	0.2857	0.2857	0.1429	0.2857	0.0000
F_3		0.0226	0.1768	0.4336	0.1984	0.1984	0.0077
F_4		0.0678	0.3333	0.1667	0.3333	0.1667	0.0000
F_5		0.0080	0.4000	0.2000	0.2000	0.2000	0.000
F_6		0.0197	0.5714	0.1429	0.1429	0.1429	0.000
F_7		0.0487	0.0487	0.1182	0.1182	0.2762	0.0572
F_8		0.3150	0.2495	0.0955	0.0955	0.05596	0.0161
F_9		0.1050	0.6667	0.1111	0.1111	0.1111	0.000
F_{10}		0.0233	0.1194	0.2009	0.4598	0.2198	0.0170
F_{11}		0.1240	0.7283	0.0909	0.0909	0.909	0.0000
F_{12}		0.439	0.6667	0.1111	0.1111	0.1111	0.0000
F_{13}		0.1386	0.5168	0.3329	0.0751	0.0751	0.0122
F_{14}		0.0462	0.4195	0.2966	0.0742	0.2097	0.0499
Wi of A—M			0.4379	0.1631	0.1267	0.2723	0.0122

5.3 Priority Decision of wollastonite mines

The prior order model is illustrated in Tble 3 of four mines of wollastonite ($M_1 \sim M_4$), and its concrete meaning is as follows:

The model shows how much each mine depends on the different factors. For instance, for the primary and deep-processing capacity of production F_6 , M_1 , its weight is 0.5714, has a distinct advantage, but for other mines, the effect of F_6 is same basically. Finally, we work out the priority decision of rational exploitation for wollastonite mines from this model. The general weights from A to $M_1 \sim M_4$ are:

$$W_1:0.4379; W_4:0.2723; W_2:0.1631; W_3:0.1267$$

Obviously, the optimum decision of exploitation for wollastonite mines is M_1 (Dadingshan wollastonite mine of Lishu County).

Above, take wollastonite mines as an example to show the concrete analysis and decision of AHP. Other minerals is the same and is omitted here as having limited space.

CONCLUSION

Through AHP, we work out the priority decision of rational exploitation for 14 varieties superior minerals and 22 mines which have developing prospects. In the near future, these mines should be given priority to arrange development of Dadingshan Wollastonite Mine; Changbai Mountain Diatomite Mine; Changbai Mountain Pumice Mine; Liufangzi Betonite Mine; Yaolin Talcum Mine and Jinchang Dolomite Mine. Of cause, we can get more information than these from above models. For example, we may obtain the second and the third group of exploiting objects, and decide the rational proportion of exploitation and so on.

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