Determination optimal parameters depend on exploration drilling basis on yield model

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Abstract

In designing drilling network, in order to subsurface exploration, the best condition shall be selected that to prevent of budget wasting. Designing of optimal drilling network, contains two main strategies: (i) increase the detection (exploration) probability, (ii) reduce the costs of drilling. These two principles, that two points are opposite of each other. The first stage of drilling network optimization, optimized strike of network that depends on the main direction of ores and shape factor (ratio of length to width) the ore. In the next stage, the yield model (difference of the cost and income function) to be used. An exploration project, in order of income, increases the possibility of ore detection (exploration) and in order of costs, the costs of drilling exploration (as the two principals of optimization model). Exploration probability function, related to some factors such as ore geometry (directional and dimensional parameters), ratio of ore length to drilling network length and angle of borehole. Three geometry types for ore existed: 1D (Vein ore), 2D (band ore) and 3D (porphyry ore). In this present study, ore with three dimensional geometry are researched that be the primary model produced by geophysical investigations. Effective parameters of the drilling cost function are related length of borehole, the type of drilling and angle of borehole. In the final stage, partial derivative of yield model than any of the independent variables (length of drilling network and angle of borehole) solved and put equal zero, and the optimal parameters calculated.

Keywords: *yield model, ore geometry, drilling parameters, Exploration probability function*

Introduction

in the local exploration studying, one of the most important stages is systematic drilling .In a tri-dimension sampling system, all the cells are not available equally and subsequently probability of selecting depth cells are lesser than surface cells; in case that one of the conditions of accurate sampling is to provide a equi-probable sampling space. For this reason, in tri-dimension systems, probability of facing a systematic error especially when accidental variables changes are considerable in comparison with depth, are more than one and two dimensions systems. Therefore, for prospecting deep sample of ore mass, there is no other choice other than excavating hole, borehole or tunnel. Tri-dimension sampling is classified to 3 groups: completely randomized sampling, stratified randomized sampling and stratified systematic sampling. Shape and geometry of drilling network have different shapes and arranging. When the ore geometry is not completely known, one of the best drilling network shapes is square network which has the same length in two dimensions. In this paper, drilling network optimization, which is one of the main points in exploration and depends on ore geometry type, is being studied. In beginning for optimizing the drilling network, direction (strike) of network should be optimized and then by using yield model other characteristics of network are optimized [4].

Optimizing of excavation network direction

At first for optimizing drilling network, we should optimize drilling network direction in relation to the ore direction. Optimized angle between ore direction and drilling network depends on index R which is the ratio of width to length of ore; and by increasing the shape index, angle between ore direction and drilling network in increased about 10-50 degree [3].

$$\begin{aligned} &R < 0.15 \Rightarrow 18° \pm 10° \\ &0.15 < R < 0.5 \Rightarrow 30° \pm 10° \\ &0.5 < R < 1 \Rightarrow 45° \pm 10° \end{aligned} \tag{1}$$

In determination of drilling network direction we should consider that some ores like porphyry ores have natural directions which determining their directions have special problems. In determining network direction which has rotation in relation to the ore, in two dimensions justify ore characteristics. In calculation of network length that pays attention to the optimal exploration probability and drilling angle (Figure 1).

Exploration probability function (profitability)

Profitability function or exploration probability is different according to the ore geometry and depending on factors like length of ore, shape factor (width to length) of ore and ore dip factor and these factors are effective in exploration probability function. Generally, effective factors in exploration probability function depend on ore geometric characteristics and type of striking of borehole to the ore. For this reason, we study surface equation on basis of three parameters (exploration probability, shape index and ratio of ore length to length of network) in four exploration situation [3].

1-ore with clear direction and single exploration

2-ore with clear direction and certain exploration

3-ore with accidental direction and single exploration

4-ore with accidental direction and certain exploration

Accidental directions are used for ores that cannot easily determine ore length and main direction. In these kinds of ores like porphyry copper direction optimization stage is also difficult .amount of certain exploration probability in same conditions is more in single explorations. In cases, that certain exploration probability is wanted, network direction with angle 5-15 degree is increased in relation to the ore direction [1].

Above displayed functions introduce exploration probability distribution base on ore dimensional characteristics in four different modes. Each cases introduced functions' indexes are available in table 1. When ore length and ore shape index is clear, exploration probability function depends only on drilling network length (figure 2).

Range of profitability function change between 0-1 and depends on ore geometry that relates to ore dimensional and directional situations. In a vertical drilling we can only study profitable function's dimensional effect on network distance but in condition that has inclined drilling, ore dip effect and drilling angle should be studied. Profitable functions in two mode of vertical and inclined drilling are shown base on drilling angle and ore dip (figure 3) [5].

$$\text{For Vertical Drilling} \Rightarrow P = R(x) = G_1(\frac{L}{S}, R) \xrightarrow{R, L \text{ are definite}} P = R(S) = G(S)$$

$$\text{For Inclined Drilling} \Rightarrow P(\beta \cap S) \xrightarrow{\beta, S \text{ are independent}} P(\beta \cap S) = P(\beta) \times P(S) \tag{2}$$

$$\Rightarrow P = R(x) = G_1(\frac{L}{S}, R).Sin(\alpha + \beta) \xrightarrow{R, L, \beta \text{ are definite}} P = R(S, \beta) = P(\beta) \times P(S) = G(S).Sin(\alpha + \beta)$$

Cost function

Cost function does not depend on ore geometric parameters and only depend on drilling parameters and drilling types. Almost diamond like drilling is three times more than percussion drilling. Cost of inclined drilling has opposite (inverse) relation to angle sinus of drilling [2].

$$C(S, \beta) = \frac{acS^{-n}}{Sin\beta} \tag{3}$$

Cost function moreover network length, depends on drilling angle(c=price of every 100 meters according to dollar) and drilling types which cost function extent is more than 0-1 and drilling angle factor is represented in opposite(inverse) of its sinus. Base on different ores we can calculate (n) and (a) indexes in the equation (3) (table 2).

Introducing yield model

One of the sampling network optimization methods is to use yield model function for an exploration project. Yield model consist of exploration probability function and cost function that each of them have constant indexes. This modeling has full proportion in every stage of exploration process. Here we use objective function optimization for this case, we should calculate cost and profit functions and by using constant indexes (k & m) and profit function difference (R(x)) and cost (C(x)) we can get the optimization distances (length of network). .therefore the first stage for yield function modeling is to determine profit function (exploration probability) [3].

$$F(x) = K \times R(x) - M \times C(x) \tag{4}$$

In yield model in one hand profit function is limited between 0-1 and on the other hand cost function can change between 0-1. To remove this inhomogeneity, we should define index or function in a way that cost function in that index be in the range of 0-1. There are different ways in which we can put the numbers between 0-1: constant index k in equation is 1.05. for index M, dividing data to maximum of cost function (base on minimum of network length) is one of the other ways to put cost function in the range of 0-1. Numerator M is for opposite effect of sinus complement of ore dip angle. Here amount of cost in defined according to the minimum network length which is used as an index.

$$M = \frac{1}{Sin(90 - \alpha) * C_{Max}} = \frac{1}{Cos(\alpha) * C(S_{Min})} \tag{5}$$

For studying yield model we can rewrite the relations as follows and get the optimal network distance, optimal drilling angle and optimal probability.

$$F(S, \beta) = K * R(S, \beta) - M * C(S, \beta) = 1.05 * G(S).Sin(\alpha + \beta) - \frac{1}{Cos(\alpha) * C(S_{Min})} * \frac{acS^{-n}}{Sin\beta} \tag{6}$$

Now we can get the yield model partial derivation according to each of the independent variants (drilling network length and drilling angle) and put it equal to zero. Result will be something from two synchronous and dependent equations. This equation should be solved to get each of the independent variants according to the process; two independent variants (drilling network length and drilling angle) should be put in the yield model to get the optimal exploration probability. By using tri-dimension modeling, exploration probability in relation to the drilling network length and drilling angle is calculated according to optimal exploration probability, the drilling angle and network length amounts are optimized (figure 4).

Conclusion

The first stage for optimizing drilling network we should optimize drilling network direction that related to shape factor. Profitability function (exploration probability of ore) is different according to the ore geometry and shape factor and studied in four different situations. Profitability function is defined by drilling angle, dip of ore and ratio of ore length dimension to the network. Yield model is calculated by deducing profitability function from cost function and optimizing length of network and angle of drilling parameters.

References

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Table1. Relation of ore exploration type and relation of exploration probability

kind of direction	kind of exploration	$G_i(L/S,R)$
clear direction	single exploration	$\dfrac{((a+e.\ln R+i(\ln R)^2)+(c+k.\ln R)\ln(\frac{L}{S})+g(\ln(\frac{L}{S}))^2)}{((1+d.\ln R+h(\ln R)^2)+(b+j.\ln R).\ln(\frac{L}{S})+f(\ln(\frac{L}{S}))^2)}$
	certain exploration	$e^{\left[(a+\frac{h\ln R}{R}+\frac{i}{R})+b.\ln(\frac{L}{S})+\frac{c}{(\frac{L}{S})^{0.5}}+\frac{d.S}{L}+\frac{e}{(\frac{L}{S})^{1.5}}+\frac{f}{(\frac{L}{S})^{2}}+ge^{-(\frac{L}{S})}\right]}$
accidental direction	single exploration	$z=(a+cy+eR^2+hR^3)+(\frac{b}{L}+\frac{f.R}{L}+\frac{iR^2}{L}).S+(\frac{d}{L^2}+\frac{jR}{L^2}).S^2+\frac{g}{L^3}.S^3$
	certain exploration	$\dfrac{((a+e.R+i.R^2)+(c+k.R).\ln(\frac{L}{S})+g(\ln(\frac{L}{S}))^2)}{((1+d.R+h.R^2)+(b+j.R).\ln(\frac{L}{S})+f(\ln(\frac{L}{S}))^2)}$

Table 2. Displaying n and a in cost equation for index c

Kind of ore	a	n
generally	30589	1.55
Porphyry copper	53008	1.29
Copper and zinc of Mississippi	27510	1.54
Gold of carlin	61723	1.68

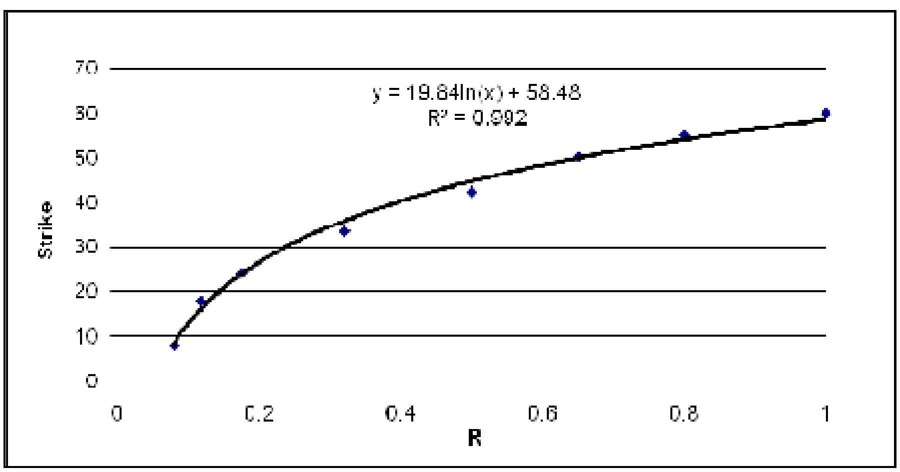

Figure1. Relation of R and angle between ore direction and drilling network

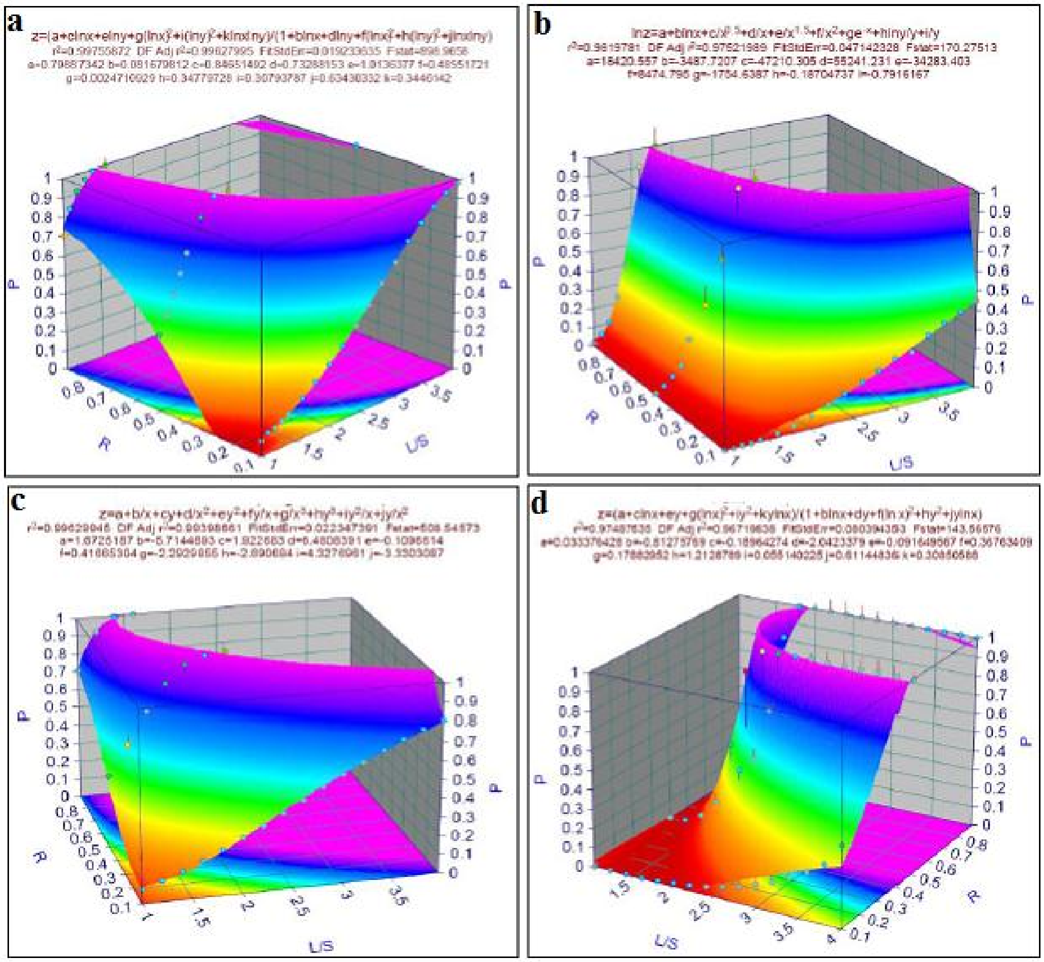

Figure 2. Display of exploration probability to R (shape index) and ratio of ore length dimension to the network

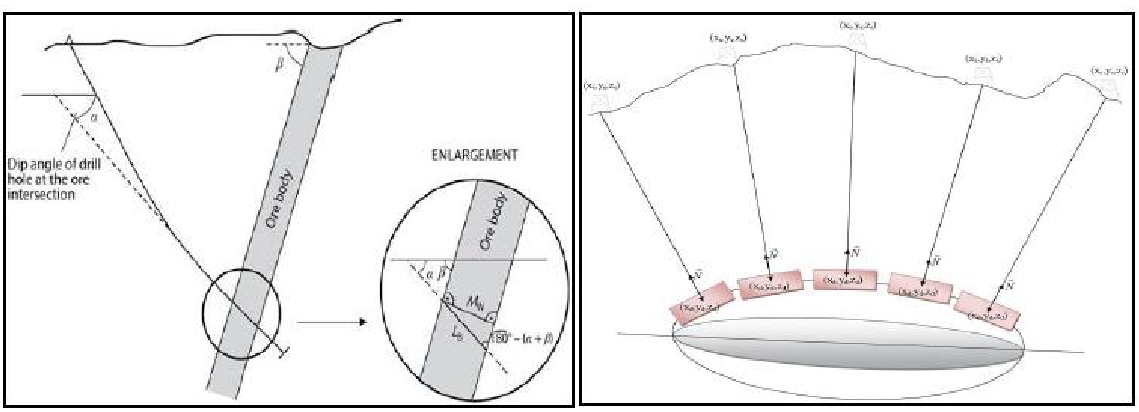

Figure 3. Display of intersection between angle borehole and inclined seam (2-D and 3-D)

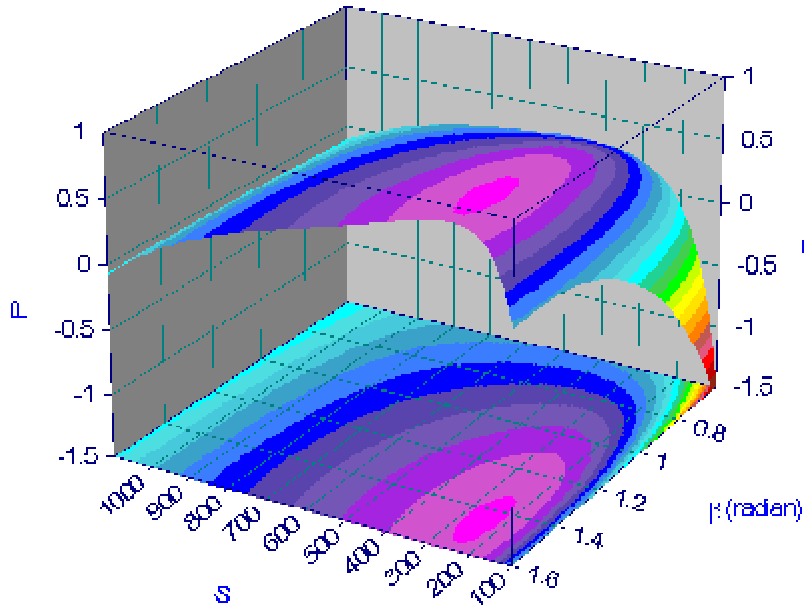

Figure 4. Tri-dimensional display of yield model and optimize zone