Using Fractal Distribution of Geomicrobiological Anomalies For Prospecting Gold Mineralization Potentials in North West of Iran

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Abstract

At the recent years, using bacteria for prospecting gold deposits in USA and Australia, is known as new approach to success investment and hope full mine activities. Based on scientific evidences, geomicrobiological anomalies have some individual aggregations of resistant bacteria nearby gold bearing regoliths. As a rule, the favorite regoliths may update their biological content during sporification or enzyme constraining processes which cause to better reactions against toxic environments. According to Australian Regoliths, long surviving and zonal variation of cereus colonies is directly depended to toxicity ranges of precious metals may be distributed by hydrothermal solutions during geochemical alterations. As a rule, increasing of precious metals give rise to increasing of toxins with unusual absence of pedophiles except to unique bacillus subtypes which protect themselves through longtime resistance mechanism. In this research, Aghvaran gold bearing prospect in east Azerbaijan province have been selected for microbiological studies after sampling and quantitative analyses of toxic elements may control the population of bacteria are living in regoliths above hydrothermal systems. The results; indicate to fractal distribution of Cereus bacteria show zonal aggregations around gold indices of supergene haloes. Furthermore, formation of the quartz pyrite veins is known as most important facies contain more than 500^{ppb} of Au in correlation with geomicrobiological anomalies.

1. Introduction

Bacillus cereus is a gram-positive, anaerobic rod-shaped bacterium able to form spores. It is a pedophile resistant micro-organism found in soil and regoliths [1]. Spores from cereuses can germinate and colonize at low temperatures under atmospheric pressures [2]. To finding relationships between rate of sporification and gold mineralization processes, the major effort is focused on determining the causes of the resistivity and the mechanisms of colonization. It has well established that gold play a major role in pedosphere toxic effects. Also, most of precious metals (e.g. gold, mercury, etc) in their soluble form are toxic for micro-organisms. Some bacteria like B. cereus form spores when the environment changes to unfavorable conditions. Therefore cereus bacteria are peculiar to surrounding underground mineralization which is covered by toxic regoliths. According to Australian Prospects [3] gold bearing formations have made cereuses empowered to form countable spores based on microscopic evidences.

Figure1 shows two micrographs obtain from nontoxic and toxic horizons around silicified veins in Australian regoliths. In this figure, increasing of toxic elements cause to decreasing of pedophile bacteria except to cereuses can form individual spores in toxic soils. As a rule, gold can be released, transported and precipitated in the regoliths. Different phases are known as carbonates, organic maters and iron oxides for gold mineralization [4]. Regarding to colonization processes and counting cereus spores in the soil samples, a new method could be

implicated for economical explorations. Indeed geomicrobiological halos are simpler for detecting and cheaper to analyses than geochemical anomalies may point to some deposits are covered by alluvials with thick layers.

2. Fractal Distribution of B. Cereus

The concept of fractals was developed by Mandelbrot (1982) for solution the complexity problems in nonlinear systems [5].

Mathematically, recursive functions are main statements for assessing dynamic behaviors of complex systems at the edge of chaos [5]. According to geo-environmental studies, the natural patterns with their invariant properties may indicate to iterations on simple logistic maps [5]. For instance, lithosphere magnetization and most of geophysical nonlinearities could be explained by cantor set in their evolutionary stages. In microbiology, generation of soil bacteria is a dependent parameter to chemistry of pedosphere may contain toxic elements related to different horizons. [2].

Current researches around bacillus species are shown that the behavior of the most of pedophiles like cereuses could be functioned by number–size equation as below:

$$N(\rho) = \alpha \left(\rho\right)^{-\beta} \tag{Eq.1}$$

where, $N(\rho)$ is the number of bacteria encircled by the colonies under the size variations greater than ρ as the spatial cutoff values in micrographs. α is a constant and β is the exponent which has several values for different sizes of colonies.

Concerning to number values $N(\rho)$ versus size of bacteria (ρ), the variables may be fitted by straight lines on the logarithmic scales. Indeed, the measured gradients of breaking points between two straight lines are known as fractal dimension. Therefore the various dimensions can be selected and used for separating anomalies from threshold and background populations on the basis of self-affine properties. In other word, a set of real dimensions which manifest the nonlinearities of micro-organism are needed as the filter values for discriminating random and deterministic processes during bacterial formations. Each of filters represents the regions where the iteration statement (e.q.1) shows the similar scales. The above mentioned filters are used to decompose bacterial distributions due to anomalous generations in toxic environments. For example, B. cereus colonies and the relevant spores could be appeared with different zonation depend on distances from mineralized regoliths in which a number of elements including gold and other precious metals may be increased and caused to toxic effects of environments. It means, applying the filters in geomicrobiological anomalies is a useful method for estimating the ranges of pedosphere toxicities as the main factor which controls the micro organisms' population according to their resistivity or constraint measurements versus solubility of toxic materials at different horizons.

For reject or promising targets regarding to their gold potentials, priorities of geomicrobiological pathfinders will be added to suitability maps. In this prognostic map we can focus on individual distributions of resistant bacteria such as cereus colonies and related spores for taking advantages of the models which help us during mineral explorations.

Although using bacteria for obtaining fractal patterns may or may not be related to gold mineralization, it is take for this research granted due to studying of available cases which are characterized to well develop toxins in regoliths as the main evidences for prospecting gold bearing ore bodies in depth of mineralized indices.

3. Geomicrobiological Studies in Eastern Azerbaijan

Evidences from geological studies in Eastern Azerbaijan have been emphasized on Neogene volcanites as essential host units which have played the major roles during gold mineralization processes associate with hydrothermal solutions [6].

According to Lescuyer (1978, 2003) and Mc Aleaster (2002), Aghvaran district with several gold bearing indices is located in 250k sheets of Mianeh region. Approximated surfaces of indices cover 12 km² of geological occurrences which majorly consists of Paleogene volcano-sedimentaries and Neogene intrusives could be differentiated from Cenozoic magmatism by Alpine orogenic phases as shown in figure 2. From structural points of view, Most of alterations have been occurred in crossed fault systems. Also, some known mineralized indices such as Aghvaran prospects are located in sheared zones as the multi strained regions may be covered by recent alluvials or residue thick layers of the soils. [6]. It means that, probable ore deposits in Mianeh region may be extended in depth of crushed zones of which postmagmatic processes could be controlled by major fractures in vein system .

There are various types of hydrothermal facies including argillic and propylitic halos which surround the silica aggregations as the vein form alterations on the top of Aghvaran regoliths [7]. For understanding the behaviors of micro-organisms relevant to gold mineralization processes, amounts of cereus bacteria in soil samples have been measured as a new area of researches in Aghvaran indices.

3-1. Sampling and Microbial Content of Aghvaran Regoliths

At the first step, the surveyed area was profiled into 4 major trends for obtaining 20 soil samples in respect to sampling distances from siliceous occurrences as mineralized locations. After sampling, ICP-MS analysis and microbiological studies have been done in order to finding toxin resources relevant to bacterial cycles whose aggregations (colonies or spores) are able to resist against toxic environments. Table1 is shown both results obtained from instrumental and microscopic analyses of 8 favorite samples as below:

- In nontoxic regoliths are represented by the samples: BS02, BS03 and BS13, average of gold values is lesser than 50^{ppb} as the background toxicity of Aghvaran regoliths. Anyway these samples could be characterized by simple joining of rod-shaped bacteria as the pairs or couples without have colonies, spores or other resistant particles at 20-25^m distances from mineralized locations.

- In semi-toxic regoliths are represented by the samples: BS10 and BS11, absence of major pedophiles is a natural responding to increasing of gold values ($50^{ppb} \le Au \le 300^{ppb}$) at $10-15^{m}$ distances from mineralized locations. Extended colonies of B. cereus are the most important aggregations with no trace of spores under semi-toxic conditions.

- In toxic regoliths are represented by the samples: BS15 and BS17, both cereus colonies and disseminated spores are observed in 3-5^m distances from mineralized locations. At least two

types of individual mechanism such as enzyme constraints and fungi secretes are involved to long surviving of cereuses under toxic conditions $(300^{ppb} \le Au \le 500^{ppb})$.

- In hyper-toxic regoliths are represented by the sample: BS20, gold is increased to more than 500^{ppb} as known cutoff values in epithermal systems .was picked up from eroded levels contain clay minerals may have different sources of altered units in lesser than 2^m distances from mineralized locations. Comparing the amounts of cereus spores in toxic and hyper toxic locations indicate that the counted spores under studying of BS20 micrograph is up to 10 times higher than spore counts under BS17.

3-2. Applying Equation to Bacterial Halos

According to Reith (2003), cereus colonies may display scale independent properties in association with their zonal distributions under spatio-temporal variations. Fractal algorithms like number–size equation (e.q.1) can support the evidences for reliable iterations which appear during colonization of bacteria [7]. Although spore counts is a casual approach to the local mineralizations of Australian regoliths [4], the current research introduced to power law functions for finding nonlinear relationships between bacterial zonation and geochemical halos which may lead to better results than spore counts. Also table1 shows iterative sequences are peculiar to cereus zonation in Aghvaran regoliths. In this table the self-similar properties of residual colonies could be changed to self-affined properties of resistant spores as a result of bacterial reactions against toxicity ranges of gold bearing formations in respect to sampling distances from major ore bodies. Therefore nonlinear processes of cereus distributions take advantages of individual zonation which is relevant to probable gold mineralization in depth of Aghvaran regoliths.

4. Conclusions

In this research, Microbial processes are known as essentials to control distribution of gold traces under supergene environmental conditions which lead to manifestation of toxic regoliths as the main locations for geomicrobiological studies. Instrumental results show that relatively high number of cereus spores are in spatial relevant to gold containing soils in Aghvaran indices which are known as main volcanogenic prospects in eastern Azerbaijan. Preliminary studies of residual colonies in addition to spore counts under micrographs, are suggested the possibility of B. cereus serving as biological indicator for underlying gold deposits. This research has used fractal equations for legitimate assessing of cereus distributions nearby quartz pyrite veins. Therefore nonlinear dimensions of self similar colonies may reveal the chaotic behaviors of resistant bacteria as new bio-pathfinders which point the ways to covered mineralizations better than geochemical halos.

5. References

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The 1 st International Applied Geological Congress, Department of Geology, Islamic Azad University - Mashad Branch, Iran, 26-28 April 2010

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Table 1-Geomicrobiological Results According to Sampling and Fractal Analyses in Aghvaran Regoliths

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Figure 1- Diversity of Pedophile Bacteria in Nontoxic (A) and Toxic (B) Micrographs (400x – XPL)
(A) There Are Several Types of Coccies and Bacillus Microorganisms Live in Soils
(B) Cereus Bacteria are Living in Toxic Regoliths as Colonies & Resistant Spores

The 1 st International Applied Geological Congress, Department of Geology, Islamic Azad University - Mashad Branch, Iran, 26-28 April 2010



Figure 2- Geological Map of Aghvaran Gold bearing Indices Relevant to Alteration Halo, NW of Iran