Association of Silica Fractal Distribution with Gold Mineralization: a case study from the Takmeh-Dash Region, NW of Iran

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Abstract

The Takmeh-Dash region comprises a wide variety of igneous bodies that have been developed from early to late Neogen. The granitic rocks and related aplite apophyses have been developed along fault-dominated structures which defines a well pronounced mineralized zone. According to isotopic and fluid inclusion studies, most of the quartz-pyrite units are solution-related with some traces of Cu, Pb, Zn and Au in an epithermal regime. In addition, well-developed alteration haloes are recorded around the intrusions and they include a variety of silica phases in which the textural patterns are similar to that of Queensland (Australia). This study introduces a new method for the prognosis of gold mineralization potentiality in an aplitic facies on the basis of self-organized silica textures as well as textural variations in vein type deposits. With the aid of sampling and microscopic investigation, necessary databases have been acquired from the mineralized region before a fractal analysis of silica distributions by power law relationships. It is an innovative approach toward prospecting the self-organized textures of which similarities have a legitimate relation with boiling point mineralization in epithermal environments. As a result, the Takmeh-Dash mineralogical patterns appear to include stepwise textural variations with peculiar zonal appearances due to post-magmatic procedures. For prospected sub-regions, the silica fractal dimensions not only indicate to maturity of quartzitic veins but represent an enough geological potential for the development of colloformed-crustified gold-bearing sequence in a deeper altered formation.

Keywords: Epithermal gold, Fractal distribution, Silica distribution, Textural zoning.

1– Introduction

Takmeh-Dash region is part of the North-West geological zone of Iran and its coordinates are listed in Figure 1. Due to the location and magmatic evolution of the region (Lescuyer, 1978), as one of the leading metal potentials was introduced in Mianeh geologic quadrangle (SN: NJ3812, East Azerbaijan province) (Ale aster, 2001). Intrusions of the region include granitoide facies and late differential phases belong to the felsic magmatism which is typically associated with alkaline magmatic series (Lescuyer, 1978). Young Orogenic movements (Neogene) have impressed the area with a variety of activities along the Anatolian fault system (near North Tabriz Fault).

Moreover, this movement gives rise to extensional - compressional deformations of which structures can be represented by Horst - Graben systems in Mianeh Taphrogenic region (Lescuyer, 1978). Tectono-magmatic activities led to the emergence of alkali granites and subsequent occurrences of aplitic veins through the post magmatic phases for generating a number of hydrothermal mineralization potentials in this region (Ale aster, 2001). In

Figure 2, Takmeh-Dash alterations are separated by image processing techniques for ETM^+ databases (Mehrnia, 2003). According to the electromagnetic spectra, Alteration haloes can be distinguished by false color composite (FCC) applied to: 7, 4, and 3/5 band lengths and subsequent IHS qualitative filters is applied to identify the clay and iron hydroxides occurrences. Next to Aplitic occurrence, a number of silica veins containing pyrites are added while Feldspar alterations are decreased. Propylitic facies are limited and rarely occur in veins and veinlets within brecciated tuffecious formation far from granite outcrops (Mehrnia, 2003).

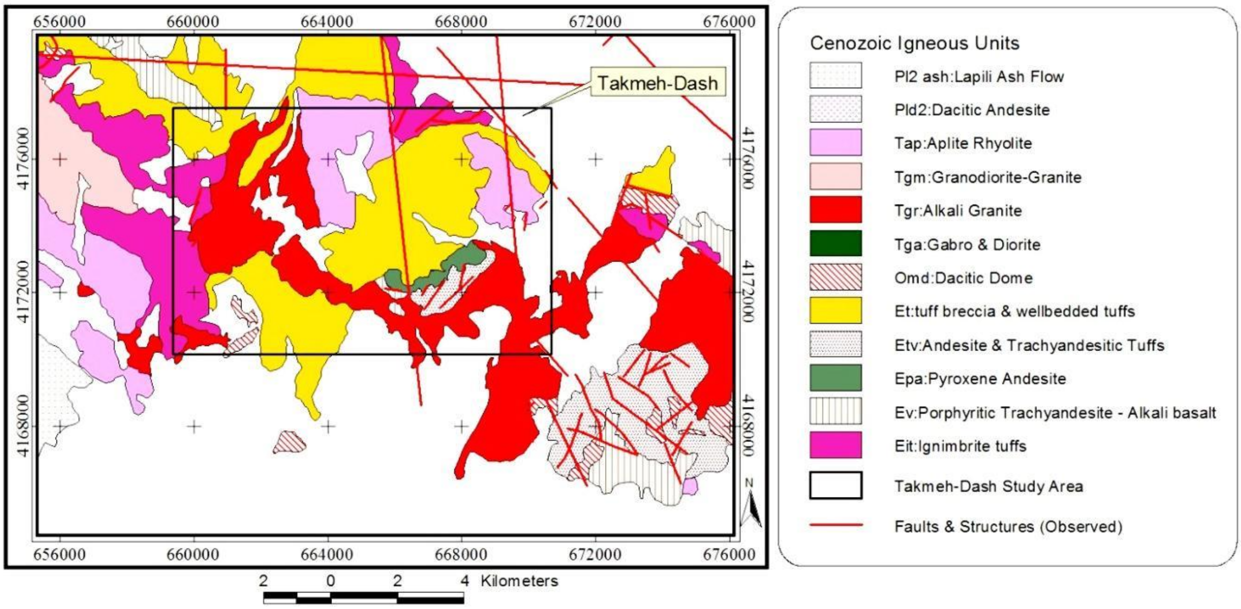

Figure 1) Cenozoic magmatic facies in Takmeh-Dash geologic quadrangle (Geological Survey of Iran, NJ3812, 1998).

Structural movements (stress on Tabriz fault extensions) and significant post-magmatic differentiations have been realized the prospecting indications for mineralization potentials (Ale aster, 2001).

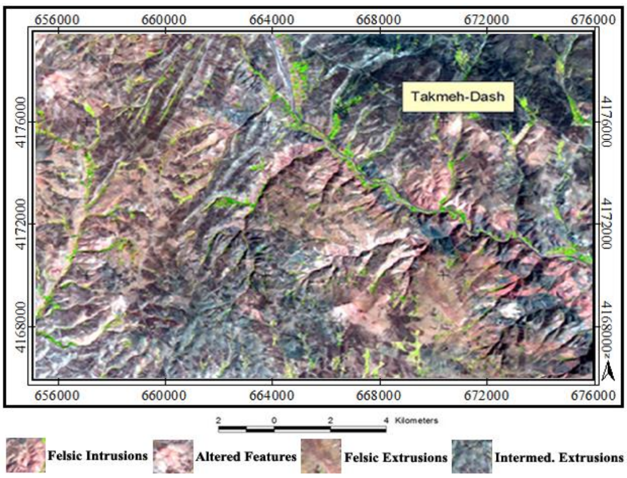

Figure 2) Photo Map of processed Landsat 7 satellite images (ETM^+), Takmeh-Dash. Hydrothermal alteration (white) on the composition of the felsic igneous outcrops (red) are observed.

According to instrumental analysis results, the origin of alkaline magmatic differentiations for both mineralized and altered regions have been determined by fluid inclusions studies and ^{18}O isotopic measurements (Mehrnia, 2003). From mineralogical point of view, gold mineralization process in Takmeh-Dash region is in close relationship with the presence of adularia facies in depth of epithermal system. It is also assumed that the depth of the effective alterations is in coincidence with initial points of the hypogenic enrichments.

For improving the exploration purposes, we need to examine the relationship between silica fractal distributions and textural zoning variations as indirect but effective result of gold mineralization process in the mineralized regions.

Paragenesis of silica minerals and iron hydroxides in the Aplitic veins (specifically around granitoide) is the most important geochemical occurrence in Takmeh-Dash region. Based on the related researches, the location of mineralized veins is the same as the geometrical location of SiO_2 textural variation (which represents the opal conversion to crystalline quartz) (Mehrnia, 2010). Study of the order by which the geochemical trace elements are zoned requires detailed and systemic approaches and the weakness of the adularia facies, observed in the present erosion level, increases the probability of obtaining enriched regions. Therefore, before any exploration activities (by a detailed method) and to reduce any investment risks, SiO_2 textural variation has been studied as a new approach to measure the enrichment of gold (in epithermal deposits), and the basic concepts of fractals and Chaos Theory equations are applied to determine the self-similar peculiarities of texture (Mehrnia , 2010).

Theoretically, the textural features of epithermal deposits along with texture segmentation patterns are considered as a measure to concentrate fundamental and precious metals in mineralized outcrops (Morrison and Guoyi, 2001). Accordingly, study of the various forms of silica including different kinds of chalcedony, opal, agate, amethyst, colloformed, banded sugary and crystalline silica along with measuring grade variations in alteration zones has had an important role in prospecting Queensland gold reserves (Morrison and Guoyi, 2001).

Based on the exploratory records of Takmeh-Dash, this study has compared the textural features of mineralized aplite with textural variations of Queensland deposits. As a result, an appropriate zoning model for Para-genesis of quartz-pyrite minerals was obtained. Therefore, textural zoning in Takmeh-Dash mineralized area has a fairly regular and predictable pattern, which is in accordance with the process of producing gold in epithermal systems. Considering the textural variations in the region, it is possible to solve the equation of exponential distributions of silica (including random changes in the concentration of trapped surface anomalies) and quartz textural variations associated with fluctuations in gold are derived. Reviewing the position of promising regions and study of the alteration trends in the region were included as the objectives of this study to gain new exploratory criteria in Takmeh-Dash region.

2– Textural Zoning of Queensland Deposits

The results obtained from Morrison research (Morrison and Guoyi, 2001) indicate that there is a reproductive association between gold and textural evolution of mineralized Silica veins. As a result, a specific classification is presented to investigate the textural evolution of Queensland deposits (Morison, 2003).

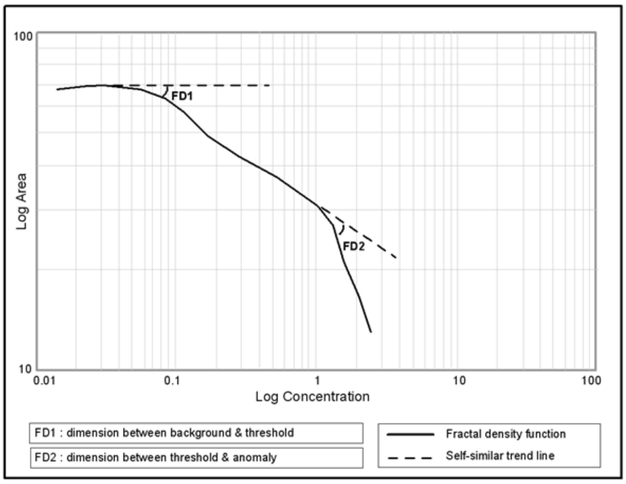

Figure 3) Fractal density function of the area-concentration (A-C) exponential equation (Mandelbrot, 2005). Changes in the fractal dimension are separation between anomaly, thresholds and background communities.

In Table 1, textural zoning of epithermal deposits is listed based on the silica variations and metallic contents. From textural zoning point of view, presence of the Colloform quartzitic texture that is usually accompanied with adularia facies is necessary for primary enrichment of the elements due to gold mineralization processes (Guoyi, 2002). Assumption to regular textural sequences in epithermal systems, abundance of chalcedonic regolith is an important mineralogical indicator for Colloform textural evolutions as the main gold-bearing host unit in depth. In Queensland region, a continuum textural evolution that is passed through the mineralized fluid boiling area give rise to changing the colloidal textures into the whole crystallized quartzes that is known as the sugary features. Passing out the sugary veins, the gold content usually decreases contrary of Pb, Zn and Cu increased content in deeper regions (Guoyi, 2002).

Table 1) Shows pattern of textural zoning of Queensland epithermal deposits (quoting Morrison, 2003). Silica textural variations led to presence of the Colloform and adularia (with moss texture) facies in this system and these evolutions are corresponded with gold enrichment process in the hydrothermal fluid boiling area.

The main zone	Chalcedony			Colloform - Crustiform		Crystalline	
Sub-Zone	Carbonate (weathered)	Carbonate - Chalcedony	Massive Chalcedony	Chalcedony-Quartz	Quartz-Chalcedony	The quartz	Quartz - carbonate
Initial texture	Massive, banded	Banded (above)	Massive (dominant)	Colloform-banded	Banded-Crystalline	sugary	Comb
Secondary texture	Replacement	Blade (bottom)	Rare to blade	Recrystallization (moss)	Recrystallization (needle)	Variable	Variable
Associated minerals	Calcite, agate	Amethyst	Chert and iron oxide	Adularia, sulfide and carbonate	Adularia and metal sulfide	Adularia and sulfides	Crystalline calcite
Gold content	Negligible	Low	Moderate	High	Moderate to low	Negligible	
Base metals content	Negligible	Negligible	Negligible	low	High	Variable	

The Gold content along the glassy and amorphous textures (opal and chalcedonic) is less than 250 ppb. However, in most of cases along with the increase in the depth of alteration zones, the probability of increase in gold content is predictable. Therefore, low gold values in the surfaces (with hydrothermal resources) is not a suitable criterion for making decisions about the enrichment of system and this issue requires the evaluation of the pattern of textural zoning in hosted vein. Thus, if the mineralization process has been started by opal and chalcedonic formation, subsequent procedure may be go on with quartz minerals initiation due to colloform and Comb-like textural appearances. There is a probability of increasing in Au-content concern with adularia (low temperature feldspar) and sulfo- arsenide complexes (Morison, 2003).

3– Fractal distribution of silica Compounds in epithermal deposits

Silica formation in epithermal systems seems to be related to acid leaching processes due to chemical interactions between the saturated (SiO_2 – rich) solutions and favorable host units for gold mineralization. In hydrothermal solutions, some variations in temperatures pressures give rise to the conditions for appearing the various types of silica formation near (or along) crossed fault zones as veins and veinlets (Hedenquist *et al*., 1996). According to statistical analysis of geochemical databases, there has not been any significant correlation between the silica distribution and subsequent textural evolution of the mineralized regions. However, by using the initial condition algorithm and based on the concept of chaos theory, a linear regression equation can be rewritten by fractals for obtaining the correlation coefficient of the silica distribution by power law relationships. Due to being the silica mineralization, textural zoning of the vein systems (in epithermal deposits) will be obtained by comfortable fractal statements according to the peculiarities of silica nonlinear distribution (Mandelbrot, 2005). By measuring the SiO_2 content (in altered regions), this research has introduced a new mathematical statement for assessing textural evolutions in epithermal systems. The recent technique is established on the basis of fractal dimension variations (Mehrnia, 2010) as eq1.

The silica power law distribution has three elements including: concentration C (SiO_2), the encircled area proportional to the concentration variation A (SiO_2) and Beta exponential index (β) and after logarithmic transformation in (2), the area- concentration (A-C) equation is presented in Figure 3.

1) $A(SiO_2) \propto C(SiO_2)^{-\beta}$

2) $\text{Log } A(SiO_2) = \beta \text{ Log } C(SiO_2)$

In this figure, the relationship between variations of silica measured in veins with the axis surface proportional to these variations is exponential. On a logarithmic scale, this relationship is expressed as a fractal equation (β slope). Self-similarity in fractal density function indicates the existence of similar self-affine points and by the advent of limit quantities (the point of maximum change in the beta coefficient), it is possible to separate the community groups into the following categories: background, threshold and anomaly (Mandelbrot, 2005).

4– Methodology

The practical way to research began by establishing Takmeh-Dash spatial database (in GIS software) and continued by inserting exploration records including geochemical sampling of the region (Mehrnia, 2003) in order to analyze data and determine the priority of promising regions.

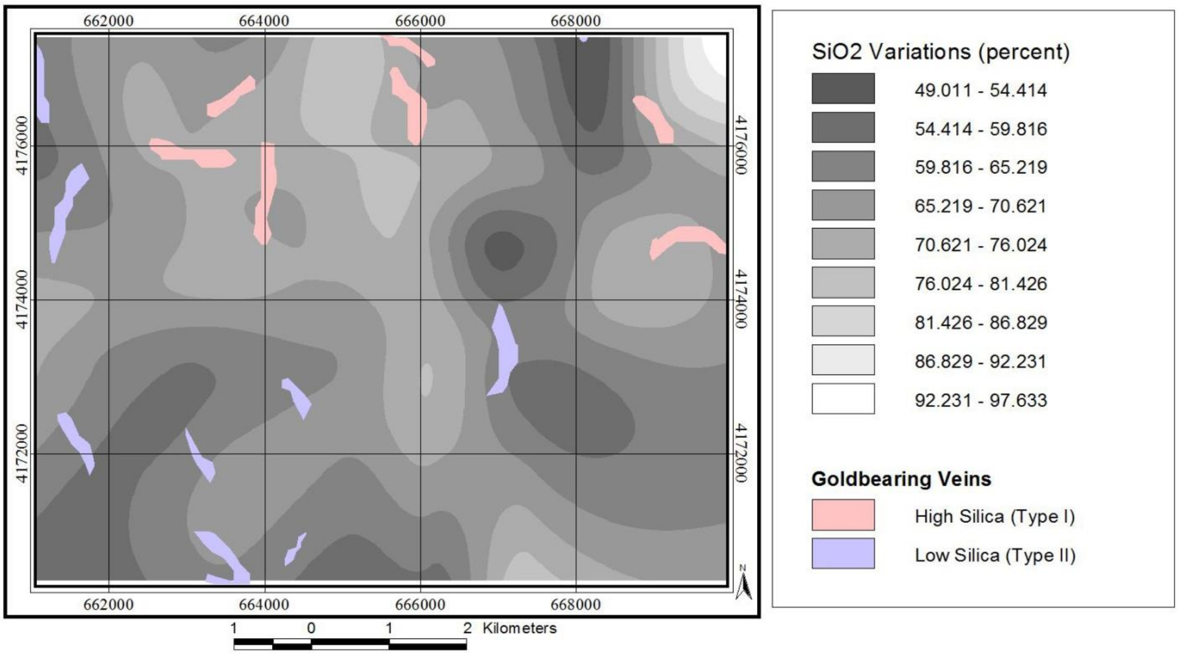

Figure 4) Results of silica interpolation regardless of fractal considerations (GIS Spatial Analyst). Anomaly of silica (minimum and maximum values) are relative consistent with locus veins.

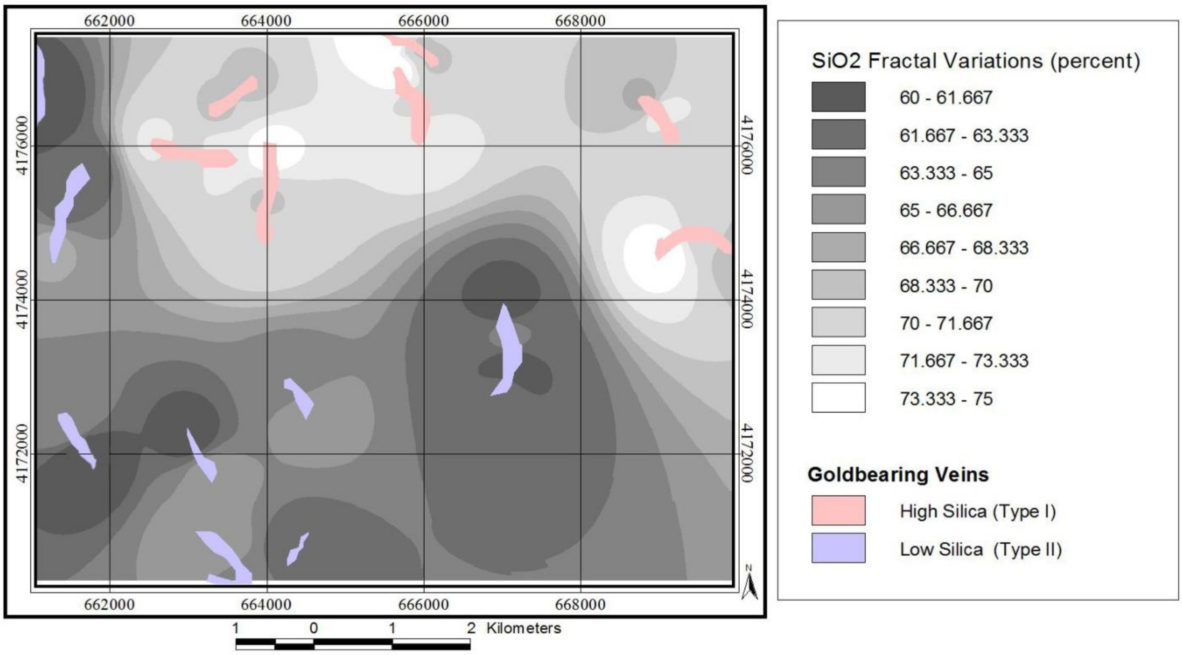

Figure 5) Results of silica interpolation with respect to fractal considerations (GIS Spatial Analyst) Anomaly of silica (minimum and maximum values) is fully consistent with the locus veins.

Table 2) Results of quantitative measurement of base and precious metals with silica phase variations and the host rock alteration on samples obtained from Takmeh-Dash.

Samples characteristic					Analysis of metal elements (ICP)				Hosted veins characteristic					
			Coordinates (UTM)		Au	Cu	Pb	As	Alteration			Silica textural variation		
Veins type	Subgroup	Sample Code	Easting	Northing	ppb‡	ppm†			Silicification	Iron Oxide	Carbonate	Glass	Chalcedony - Opal	Crystalline Quartz
Pyrite-bearing (Type I)	Hematite-bearing	007-90	665949.944	4176223.55	78	19	14	nd	x	x				
		008-90	665938.896	4176510.8	92	nd	7	nd	x	x			x	x
		011-90	665684.79	4176985.87	51	nd	7	2	x	x	x	x	x	
		015-90	666126.713	4177107.4	88	52	10	8	x	x			x	
		017-90	665960.992	4177273.12	85,	nd	nd	nd	x	x				x
	No hematite	027-90	665563.261	4177405.7	295	11	nd	nd	x			x		x
		033-90	664005.482	4174809.4	129	29	7	11	x					x
		034-90	664005.482	4175273.42	162	nd	7	11	x				x	x
No pyrite (Type II)	Hematite-bearing	041-90	663033.251	4172224.15	20	nd	nd	nd	x	x			x	
		043-91	661696.434	4171914.8	20	nd	nd	nd	x	x		x		
		047-90	661442.328	4172445.11	32	14	nd	nd	x	x	x	x	x	
		049-90	661276.607	4174698.92	8	23	14	nd	x	x		x		
		051-90	661398.135	4175196.08	13	nd	3	nd	x	x	x	x	x	
		052-90	661630.145	4175693.25	10	nd	3	6	x	x		x		
		056-90	661099.837	4176510.8	10	20	5	3	x	x	x	x		

During the quantitative measurement of mineralized samples, 15 samples were selected to be sent to AMDEL laboratory in order to have instrumental analysis using inductively coupled plasma mass spectrometry (ICP-Mass). According to Table 2, there was a significant correlation between SiO_2 variations and the basic or precious metals content throughout the veins with felsic aplitic occurrences.

A Silica geochemical variation was used as an appropriate criterion for locating pyritic quartz veins. Obtaining the distribution function of silica phases requires interpolating the quantities and creating a spatial correlation between the anomalies. Therefore, according to Figure 4 by using Spatial Analyst (SA) tools, the silica contours were plotted by geo-statistical methods (Inverse Distance Weighting, IDW). During this process, random range discrete anomalies were substituted with a network of continuous variables and as a result, the nonlinear distribution of silica has been studied by A-C logarithmic function (Equation 2). After separating corresponding components, self-similarity properties of anomaly communities were verified by SA software tools and the results are presented in Figure 5. In Figure 4 and Figure 5, in addition to silica dispersion model, gold values variation can be seen as a topological index corresponding with geometric location of geochemical gradients. In comparison, the spatial correlation between silica and distribution model of mineralized veins has been increased after applying fractal techniques. This shows that chaotic behaviors govern the geochemical distribution processes relevant to constructive elements of silicate network during post-magmatic phases. Simultaneous with the interpolation of geochemical parameters, textural evolution of samples were analyzed by studying 15 thin sections and 15 polished sections and the results are presented in Table 2. The microphotographs indicate the association of semi-crystalline to glassy textural variations with the veins that are probably mineralized by gold-bearing solutions. Coarse grain quartz has been extended in favorite samples and cause to more Au content due to quartz-pyrites mineralization process. Crystalline quartz has space-filling or alternative textures of which textural maturities could be added in depth of alterations.

5– Takmeh-Dash Textural Variations

Due to the lack of variations in host rock and the same alteration facies in Takmeh-Dash region, textural variations have been plotted on Figure 6 and studied by considering two types of silica paragenetic mineralization as below:

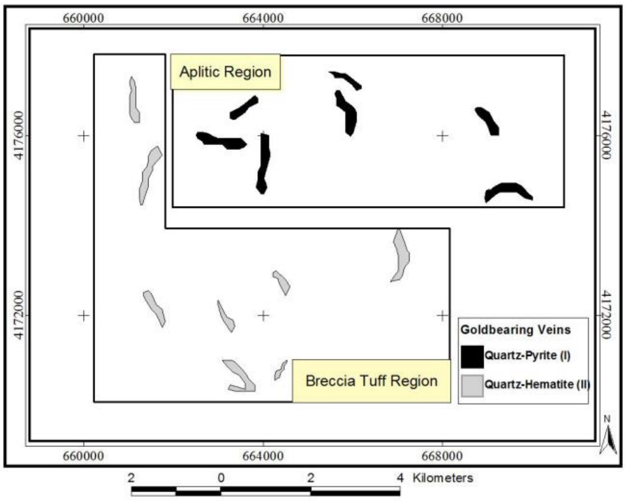

Figure 6) Position of Quartz-Pyrite and Quartz-Hematite veins in Takmeh-Dash exploration quadrangle. Type I veins hosted by aplitic facies and Type II veins hosted by Breccia Tuff facies. Type I veins have higher gold grade than Type II veins and their outcrops located in the north and east north of Takmeh-Dash region.

Type I: This type contains veins that are typically located immediately adjacent to aplitic facies and are found in fine crystal background with a mixture of silica and feldspar minerals. Hematite and pyrite are the main ore minerals in these veins. Figures 7 and 8 show the polished and thin sectioned micrographs obtain from *Type I* veins. The mineralized unit that is associated with aplitic granites consists of dispersed but fine grain quartz (Neogene) with the whole chalcedonic appearances (Fig. 7b).

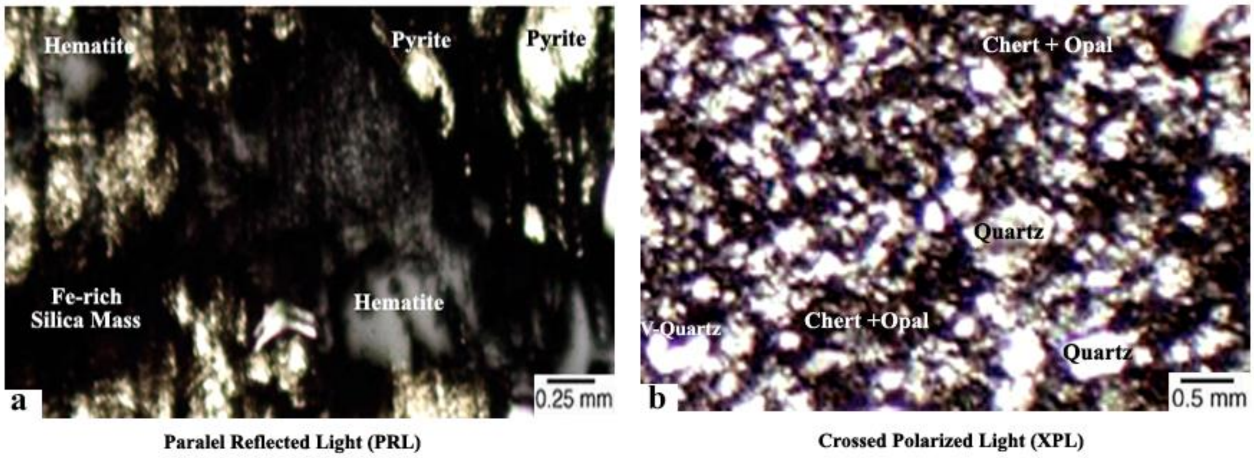

Figure 7) Microscopic sections of pyritic quartzitic vein (Type I, high grade) in the Takmeh-Dash area (sample 008-90, Table 2). a: Polished sections, pyrite and hematite mineralization in silica-rich iron with gold grade 92 ppb, a: Thin section, fine-grained quartz in silica minerals background consists of opal and chert.

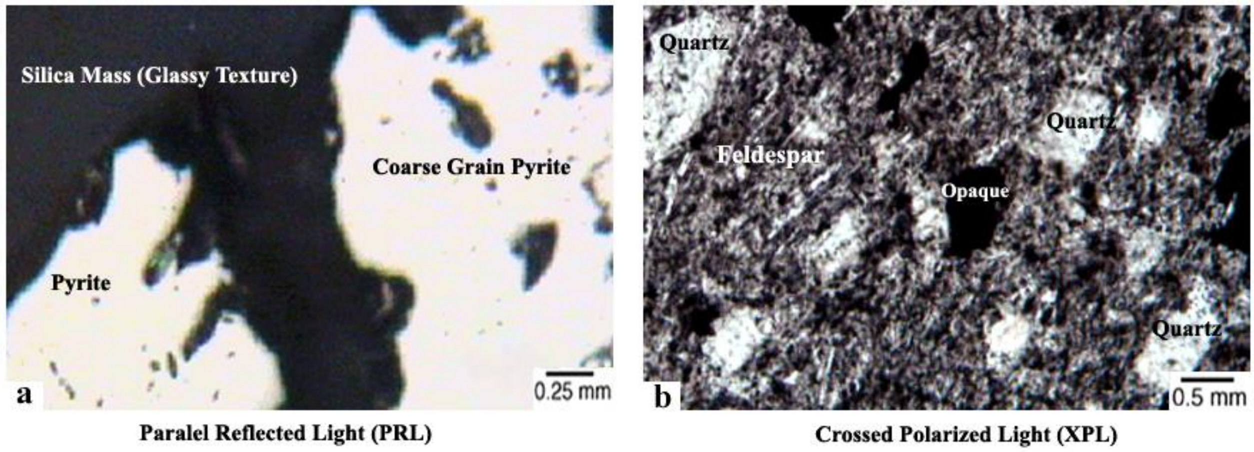

Figure 8) Microscopic sections of Pyrite-bearing vein (Type I, high grade) in the Takmeh-Dash area (sample 027-90, Table 2). a: Polished section, coarse grain pyrite in silica mass background with gold grade 295ppb, a: thin section, quartz and feldspar in glassy background.

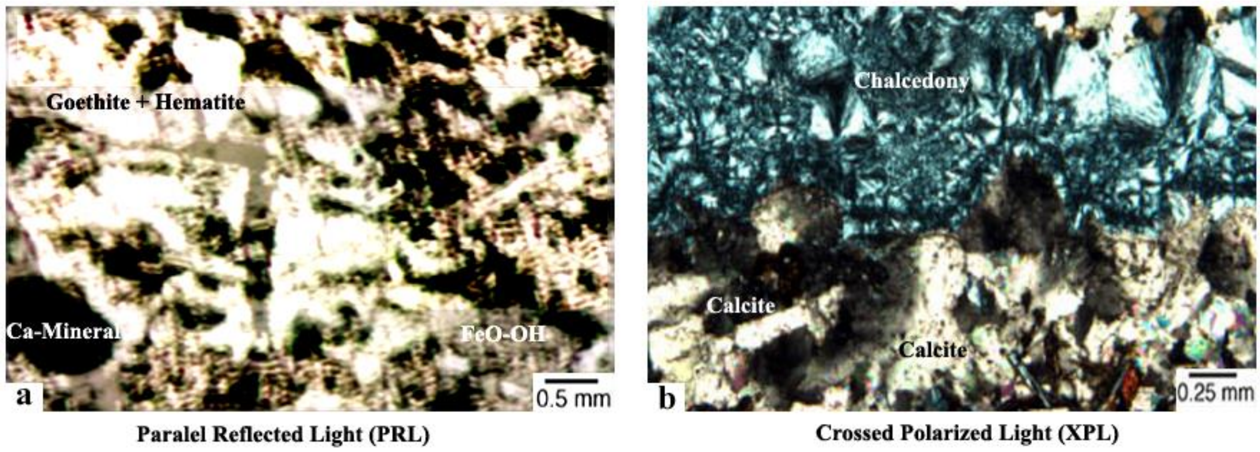

Figure 9) Microscopic sections of hematite-quartz veins (Type II) in the Takmeh-Dash area (sample 047-90, Table 2). a: Polished section, genesis of secondary Ca-minerals in amorphous clay minerals (Goethite), Hematite and iron hydroxide background without the presence of pyrite, with gold grade of 32ppb, b: thin section, the crystallization of calcite and Chalcedony in silica background.

Gold traces in pyrite and hematite veins (Fig. 7a) are less than 100 mg per ton. However, by increasing the crystalline silica content (Fig. 8b) and subsequent abundance of pyrite (lack of hematite, Fig. 8a); gold traces may be increased to 220 mg per ton. As mentioned, the appearance of *Type I* has been affected by the location of aplitic outcrops and therefore has limited geographical expansion with iron oxide and silica alteration haloes (Ale aster, 2001 and Mehrnia, 2003).

Type II: This type contains veins that are typically located far from aplitic facies and are found in glassy to fine crystal backgrounds with a mixture of silica and carbonate minerals. Hematite and iron hydroxides (goethite - limonite) are the most important minerals of this vein. Figure 9 shows an example of polished and thin sections of *Type II* veins. The host rock of the mineralized unit is a type of volcano-sedimentary formation which is attributed to the activities of late Neogene and is composed mainly of amorphous glassy texture (Fig. 9b). Gold content in hematite and iron hydroxides (Fig. 9a) is less than 50 mg per ton and is dependent from silica textural evolution. Since most of *Type II* veins are found far from aplitic outcrops (out of epithermal center), they have an extended spatial distribution and therefore have irregular altered haloes contain silica and carbonate minerals (Ale aster, 2001 and Mehrnia, 2003).

Based on the above considerations, gold values fluctuation in the veins nearby aplitic occurrences is a function of silica textural zoning pattern and the method applied in this research is useful to identify probable underground high grade regions around surficial veins. However, in Type II veins, gold fluctuation is too minimal and silica textural variations are weak. Thus, gold content in areas far from aplitic occurrences is independent from silica textural zoning that is provable by fractal calculations.

6– The Role of Silica Fractal Distribution in Genesis of Takmeh-Dash Mineralization

Figure 10 shows silica nonlinear distribution according to A-C model (Eq. 2) and is calculated separately for type-I and type-II veins. As shown, separating anomaly communities from thresholds and background values is on the basis of variations in fractal dimensions and is proportional to coefficients of the mentioned equation in logarithmic scale (Mehrnia, 2006).

In Table 3, the increase in the fractal dimension is consistent with the appearance of Type I veins and give rise to increasing in gold content due to beginning the iterative (self-similar) peculiarities of SiO_2 minerals (Fig. 8). In comparison, textural zoning of pyrite-bearing vein systems (type I) have a better condition than veins containing iron oxide (or hydroxide) minerals (type II). It means that continuing the exploration phases can be considerable within the veins close to aplitic occurrences. Accordingly, silica geochemical distribution conform to fractal dimension variations as an exponential component which fits into chaotic developments and turning points of silica density function within the Takmeh-Dash aplitic area that is regularly corresponded to the geometric location of self-affined quantities.

In Table 3, a developed pattern of self-similarities and increasing of the iterative components indicate to initializing and continuity of effective textural variations in a generative epithermal system. Since stability of above mentioned system depends on establishing the physicochemical balances between the post magmatic solutions and immigration environments, the textural variations in SiO_2 minerals is not only considered as a relevant process to evolution of gold-bearing complexes but is applicable for forecasting the mineralization locations by fractal statements.

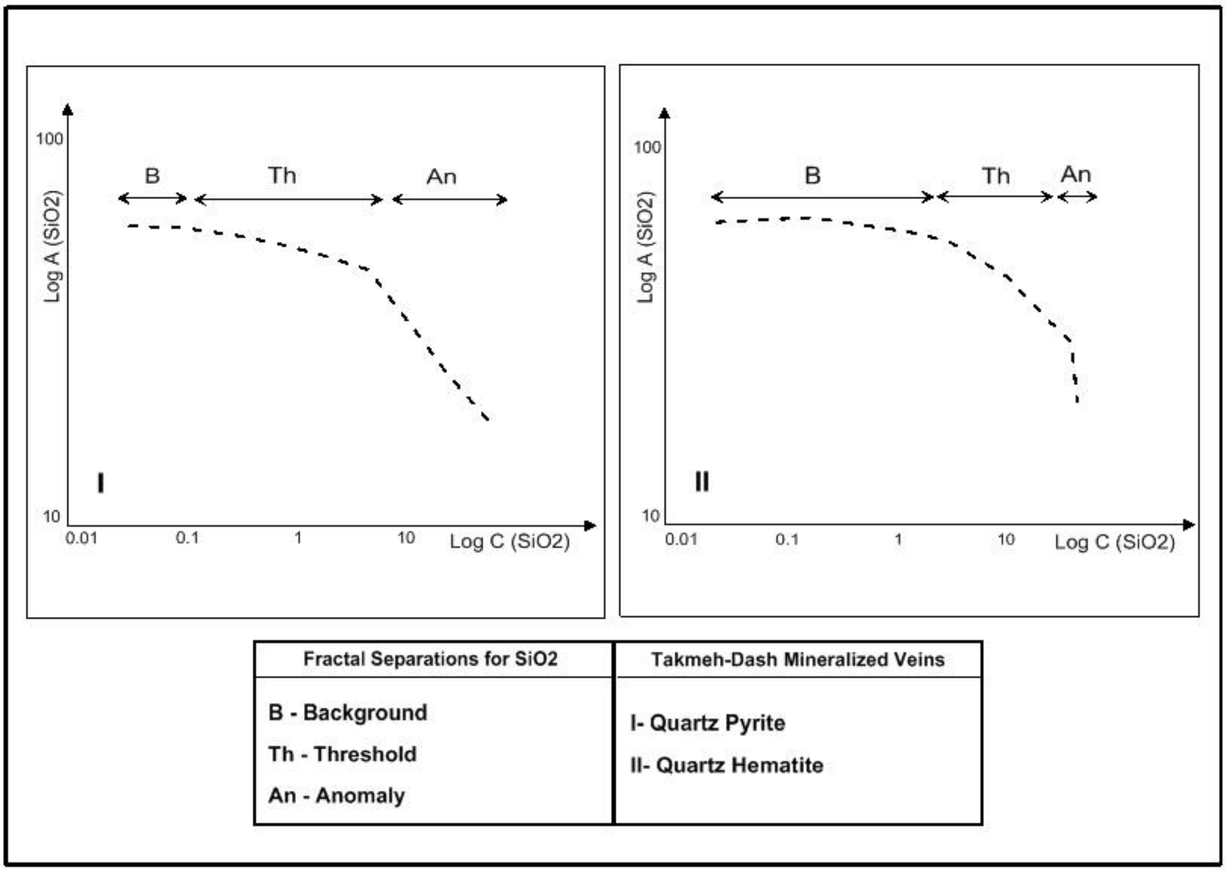

Fig. 10 - Separation of fractal communities in the Type I and Type II veins (based on area- concentration (A-C) equation) - 1: Divided communities in the first type of veins with limited background, developed threshold and moderately developed anomaly. 2: Breakdown of community in the second type of veins with developed background and threshold and limited anomaly.

Table 3) Relationship between silica fractal distribution and minerals textural variations in samples obtained from Takmeh-Dash. A developed pattern of corresponding pairs (similar) during the silica fractal distribution are in direct with variations of gold content and confirms the textural zoning in Type I veins. Type II veins lacking the corresponding quantities and have less priority from fractal point of view.

Veins type	Sample	Percent silica	Variation of silica fractal dimension			Textual evaluations			Gold (ppb)
			General	Slight	Self-similarity Phenomenon	Quartz	Feldspar	Calcite	
Pyrite-bearing (Type I)	007-90	73/43	1/082	1/09	Creation of corresponding couples - straight	Chalcedony - Tiny crystals	The alteration was observed	fine crystal - scattered	78
	008-90	71/11		1/08					92
	011-90	74/00		1/09					51
	015-90	70/28		1/06					88
	017-90	70/15		1/10					85
	027-90	75/25		1/09					295
	033-90	71/00		1/11					129
	034-90	70/00		1/04					162
No pyrite (Type II)	041-90	61/80	1/027	1/01	Discounting the corresponding quantities	Amorphous silica	There was no	Fine to coarse crystals - scattered	20
	043-91	60/75		1/02					20
	047-90	65/00		1/01					32
	049-90	67/45		1/03					8
	051-90	63/90		1/01					13
	052-90	62/15		1/07					10
	056-90	60/40		1/04					10

In our case study, the mineralized sub-regions of type I veins have spatial associations with a deep and epithermal alteration haloes. In these sub-regions may be enough potential for reach in the gold content to economic cutoff values (500 ppb) and more with aim full prospects on aplitic granitic formations of Takmeh-Dash region.

In contrast, type I veins; we are faced with number of disordered alterations due to more instabilities in the geochemical haloes of type II veins. Also more weakening and irregularities of the alterations can be seen by stepwise distances from epithermal center (almost by getting away from aplitic formations). Substantial increases in carbonated minerals (representing propylitic facies) and replacement of pyrite by iron oxides are two effective processes which cause to decreasing in gold content and regular distribution of pathfinder elements in anomalous regions (Table 3). From fractal point of view, a weakened textural evolution (see type II) usually gives rise to deficient iterations with low or missing mineralization potentials (Fig. 10-2). In these cases, a silica density function may be obtained by lesser dimensional variations. Also a lack of self-affined points (as a criterion for self-similarity of phenomena in Table 3) has caused irregularity intensification in textural zoning pattern of vein. Irregular patterns usually reduce the possibility of silica crystallization and subsequently cause an embedded sulfide mineralization with lack of metallic paragenesis.

By distances from aplitic formations (as gold bearing host units), decrease in silica content in addition to changes in thermo-dynamical conditions are the main factors affecting infertility of type II veins. Thus, it seems that the textural evolution of type II veins and related fluctuations in gold content is independent from fractal dimensions (Mehrnia, 2010).

6– Conclusions

In this research, a new method is presented by using the properties of silica fractal distribution to illustrate the gold correlation with the fractal dimension of silica which results in exploration of priority determination in mineralized areas within the Takmeh-Dash aplitic outcrops. Since the textural zoning criteria of Takmeh-Dash region were selected according to the model derived from Queensland deposits textural evolution, data interpolation process has been done after sampling from promising areas and measuring silica geochemical variations to determine the silica (SiO_2) variation density function by using geostatistical methods and by accessing continuous variables ranges (Grid Data, Fig. 6). Moreover, the situation of mineralized outcrops was examined due to rewriting the distribution components (On A-C logarithmic equation). In this equation, the fractal dimension variation has been used as an exponential indicator of the corresponding quantities the correlation between corresponding quantities and SiO_2 textural variations mechanism has been proven (Table 3). Thus, the results of the study, with emphasis on gold exploration priority in type I veins, are as follows:

1- Small alteration haloes within the pyritic quartzitic vein systems (Type I) contain silicification of primary minerals in addition to iron oxides and dispersed quartz crystallization in a background enriched by glassy textures. Textural zoning pattern has corresponding quantities with significant self-similar characteristics. By increasing the silica crystalline, gold values may be increased. As a result, nonlinear distribution of SiO_2 minerals can be used by fractals for obtaining dimensional variations related to gold fluctuations. Considering the multiplicity of pyrite mineralization beside the fractal properties of textural distributions, detailed exploration phases along and within type I veins is recommended.

2- Irregular dispersed alterations in quartz–carbonate facies (Type II vein) include secondary calcite recrystallization and genesis of secondary dolomites in amorphous silica and iron hydroxide background. Weathering effects have increased within these vein zones and silicate minerals (such as feldspars) residues are disappeared due to the appearance of clay compounds (argillization process). Reduction of gold fluctuations has been associated with the lack of corresponding quantities (in Table 3) and infertility of secondary veins can be justified by their long distances from the center of magmatic evolution. Therefore, further exploration activities of type II veins are not recommended.

3- Comparing type I and II veins indicates that the silica textural zoning pattern in Takmeh-Dash region has a dual behavior. Therefore, near the aplitic units the genesis of epithermal system is provided and its textural evolution is similar to silica mineral behavior of Queensland deposits. Meanwhile, far from aplitic units and along with decreasing the silica content in samples, textural evolution has been undermined and any textural variation would be independent of gold fluctuations. The result of this comparison recommends carrying out mining excavations (trenches, pits and boreholes) in vicinity of the aplitic units and preventing further exploration activities in independent veins of Takmeh-Dash aplitic formations.

4- Detailed explorations should be carried out by geochemical sampling from deeper trenches and the pits. For the condition being a silica textural evolution with regular relationships between crystallization processes and increases in gold content, it is recommended to continue the next exploration phases by borehole techniques in promising areas. It should be noted that from theoretical point of view, gold values in metal-sulphide Paragenesis and the hosted silica units in hypogenic environments is 3 times more than the content obtained from chalcedonic veins on erosion surfaces (regolith area).

5- Systematic geochemical sampling which provide reliable databases for achieving the enriched and hypogenic deposits is needed. In the meantime, study on textural zoning evolution, increases the chance of achieving mineralized regions that is assumed to be extended in depth of quartz-pyrite facies. Therefore, there is a possibility of deduction in geochemical zoning of gold-bearing deposits by using current research technique for prospecting epithermal mineralization potentials with a lower cost approach than traditional methods.

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