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Geochemical Exploration of the Tareek Darreh Gold Deposit, North of Torbat-e Jaam, East Iran

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Abstract

The Tareek Darreh gold deposit is located 40km north of Torbat-e Jaam in the Khorassan-Razavi province, NE-Iran. The study area mainly comprises slightly metamorphosed, sedimentary rocks of Jurassic age including alternation of shale, siltstone, and sandstone. These rocks have been intruded by plutonic rocks such as gabbro-norite, diorite, quartz-diorite, and rhyodacite. The ore bodes are exposed by trenching and pitting .In this study, all trenches and pits were systematically sampled and analysed by XRF, XRD, and ICP methods as well as petrological mineralogical studies. The alteration minerals of quartz, chlorite, albite, and sericite are mostly observed on the top or margin of the stocks. Alteration is more intensive at the contacts of the stocks where vein type mineralization has occurred. The veins are mainly composed of silica type and calcite type, arsenopyrite, chalcopyrite, and pyrite main ore minerals. Four promising mineralization zones were selected for further studies. The analytical results for the zones No. 2 and No. 4 confirm high gold, copper, bismuth, tellurium, and silver. In zone No. 2 (50 x 80 m^2) an average of 3.5ppm gold was recorded for one of the trenches, while in zone No. 4 (50 x 250m^2) the average gold content is 1.35ppm. According to our studies, The Tareek Darreh gold deposit is considered to be similar to the "intrusion-related gold systems".

Keywords: *Tareek Darreh Gold Deposit, Geochemical exploration, Intrusion-Related Gold Systems, East Iran.*

1. Introduction

The Tareek Darreh gold deposit is located 40km north of Torbat-e Jaam in the Khorassan Razavi province of Iran (Fig. 1). The whole area is traditionally known for high anomalies of W-(Sn) [1]. In order to investigate the deposit, first the 1:1,000 mining-geological map of the area was prepared, and then several exploration trenches were excavated from which 236 samples were taken for ICP and XRD analyses as well as petrographic and ore microscopic studies.

2. Background to the Research

The first exploration operation in the area was done on the abandoned mining works of Firouzkuh in 1965 [2]. In 1994 Akrami finished his M.Sc. thesis on the petrology and geochemistry of the granitoid intrusive body of Torbat-e Jaam and its contact metamorphic halo [3]. In 2000 the Iran Kanesh consultants accomplished a semi-detailed exploration on the gold deposits of Tareek Darreh and Firouzkuh for the Mines and Metals Office of the Khorassan province [4].

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During 2004-2006 three semi-detailed gold exploration projects were performed in the Tareek Darreh area (Torbat-e Jaam) by the Zarnab Exploration Consultants for the Industries and Mines office of the Khorassan Razavi province [1, 5 and 6].

The previous exploration projects include geological studies on various scales as well as soil and stream sediment geochemical studies. Summarizing the entire previous exploration data lead to the selection of three promising areas for further studies the results of which are presented in this paper.

3. Regional Geology of the Area

The study area is located in the center of the 1:250,000 Torbat-e Jaam geological map [7]. It constitutes the northern part of the 1:100,000 Torbat-e Jaam [8] and Agh-Darband geological maps all of which were prepared by the Geological Survey of Iran (Fig. 2).

The granitoid intrusive body of Torbat-e Jaam with a NW-SE trend covers a large area of the Torbat-e Jaam 1:100,000 geological map. This intrusive body has intruded into an alternation of shale (occasionally with intercalations of coal), siltstone, and sandstone which have been metamorphosed to greenschist facies.

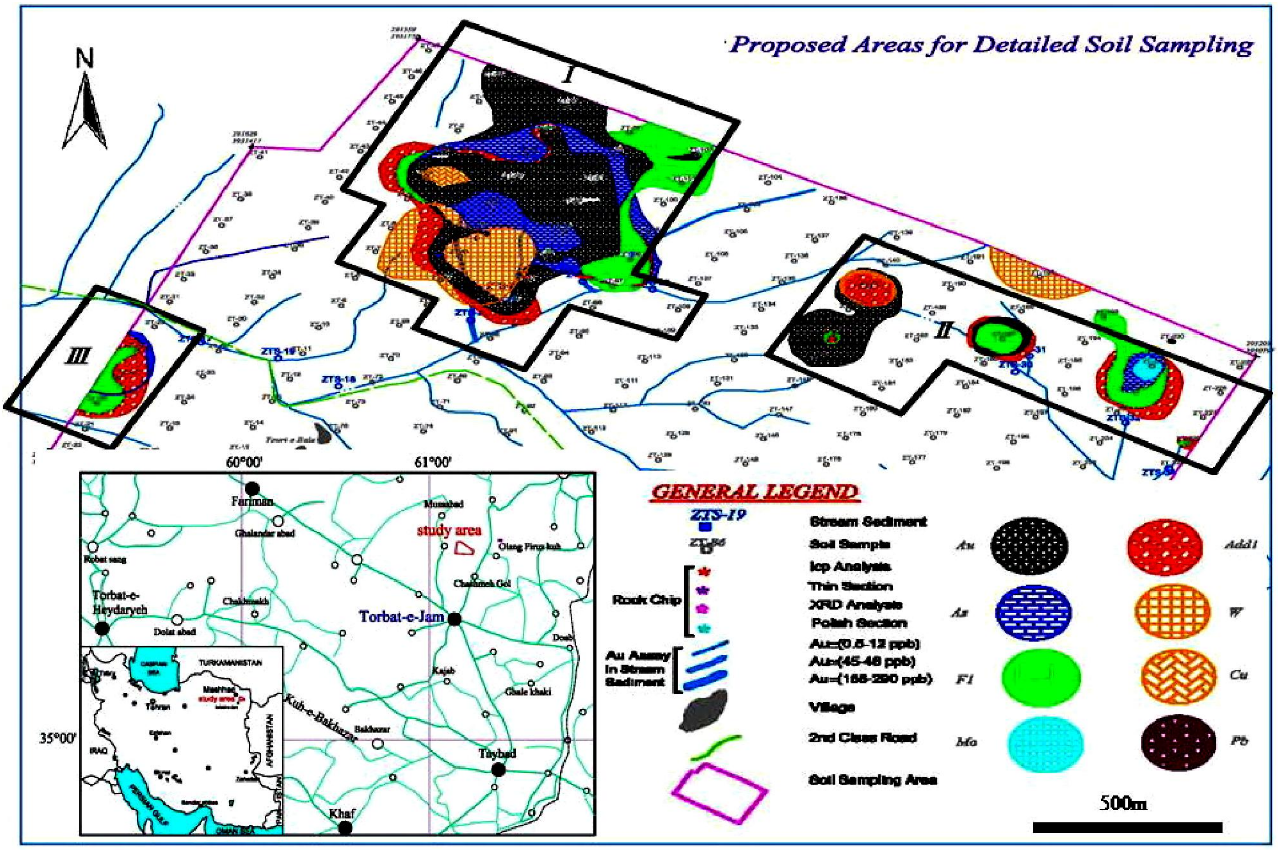

Fig. 1. The promising areas based on the intensity and overlap of the soil geochemical anomalies at the Tareek Darreh deposit (after [5])

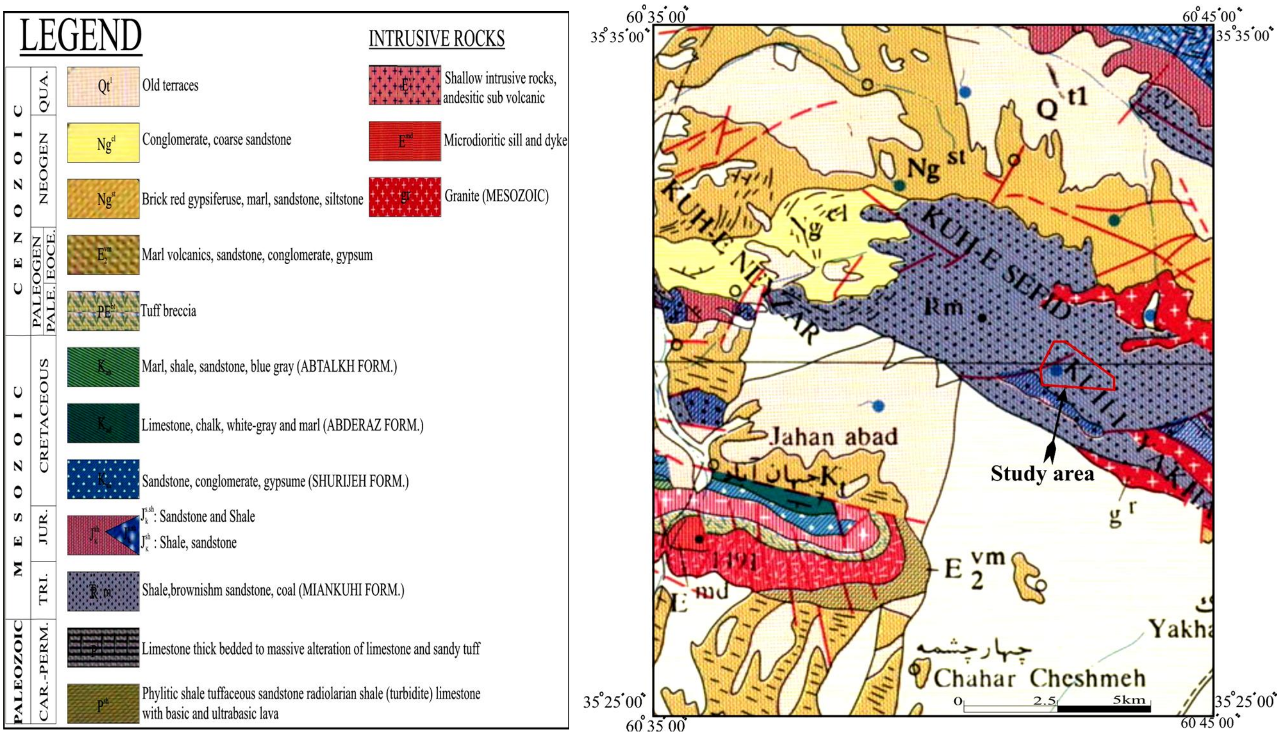

Fig. 2. Location of the study area on the Torbat-e Jaam 1:250,000 geological map.

Since the granitoid intrusive body has been covered unconformably by the Early Bajocian conglomerate at the base of the Kashafrud Formation (JK) and has itself intruded into the Miankuhi Formation, it should be post-Norian and pre-Early Bajocian in age. The intrusive body shows lithologic variations, especially in the northern and eastern sides, from granite (Gr) in the center to granodiorite (Gd), and quartz-diorite and quartz-monzonite (Qd) on the sides. Silica, pegmatite, and aplite veins as well as iron oxide impregnations are often observed in the intrusive body.

4. Deposit Geology

4.1. Lithology

According to the 1:1,000 mining-geological map of the deposit, the study area comprises three main rock units including A) sedimentary rocks, B) metamorphic rocks, and C) plutonic rocks (Figs. 2, 3 and 4). In the following these rock units have been described:

A) Sedimentary rocks

The outcropped sedimentary rocks in the area include an alternation of shale and siltstone (Js). This unit covers a considerable portion in the south, center, west, and north of the area. The unit of red shale and sandstone covers only a small part in the southwest of the area. Alluvial fans (Qt2) and recent alluvia (Qal) comprise the main sediments of the area.

B) Metamorphic rocks

The metamorphic rocks cover a small part of the area and are mainly observed in relation to the contact of the plutonic rocks as well as periphery of the large faults.

C) Intrusive rocks

Plutonic rocks cover one-third of the study area and are composed of basic to intermediate plutons including quartz-monzonite, quartz-diorite, diorite, gabbro, gabbro-diorite, and gabbro-norite. These rock units are of Jurassic age.

4.2. Rock alteration

Alteration is not pervasive in the study area. XRD analyses of the samples from the Tareek Darreh area indicate argillic, quartz-sericitic, and chloritic alterations (Table 1). These alterations are mainly confined to intrusive rocks, the contact of the plutons and the alternation of shale and sandstone as well as margins of the faults as linear alterations. These zones are sometimes accompanied by arsenopyrite-bearing quartz-silica veins mainly situated in the gabbro and gabbro-diorite unit. Several silica veins and rhyodacite dikes are also observed in this unit around which alteration traces are observed locally. The quartz-diorite unit with a more acidic composition is possibly the youngest unit among the intrusive rocks of the area. This unit shows some indications of intensive alteration at its contact, although its primary texture has usually been well preserved (Fig. 5).

The largest extension of the alteration is observed in the plutonic rocks and is often accompanied with brecciation. It seems the fluids have rarely been able to travel beyond the roof or the contact of the intrusive rocks.

Thin and short veins of silica are rather abundant especially in the contacts of the gabbro diorite and gabbro intrusives. These veins are not continuous and are widespread in the altered zones of the intrusives and the sedimentary and metamorphic country rocks. The maximum width of such veins is 40cm, while their length reaches 5-20m. In some cases, arsenopyrite composes up to 90% of such veins.

4.3. Mineralization and geochemistry

The mineralization in the Tareek Darreh deposit bears a general E-W trend and is mainly of vein type which is in a close relationship with the contact of the quartz-diorite intrusive rocks and the shale and siltstone unit. Several arsenopyrite bearing silica-calcite veins have been identified in the crushed zones at the contact of the quartz-diorite. The silica veins are 1cm to several decimeters in size whose arsenopyrite content reaches sometimes up to 90% (Fig. 6). Different copper minerals are observed in diverse host rocks almost in all parts of the alteration zones. The copper mineralization is extensively present together with secondary fractures which show the late stage mineralization for such minerals. Ore microscopic investigations indicate arsenopyrite, pyrite, and chalcopyrite as main ore minerals. Native gold was observed only in one section as inclusions in arsenopyrite (Fig. 7).

The geochemical analyses (by ICP) indicate gold as the main economic metal of the deposit, while copper, bismuth, and tellurium also show high concentrations. Silver, antimony, and molybdenum are among the other anomalous metals (Table 2). After excavating the exploration trenches and sampling, evaluation and assaying were separately accomplished for each trench due to the difference of the length of sampling in each trench. This was done with evaluation of the grade of each sample according to its length. Also the samples of each geological unit and mineralization area were evaluated separately. Table 3 shows the assaying and evaluation calculation for trench 1, as an example of such studies.

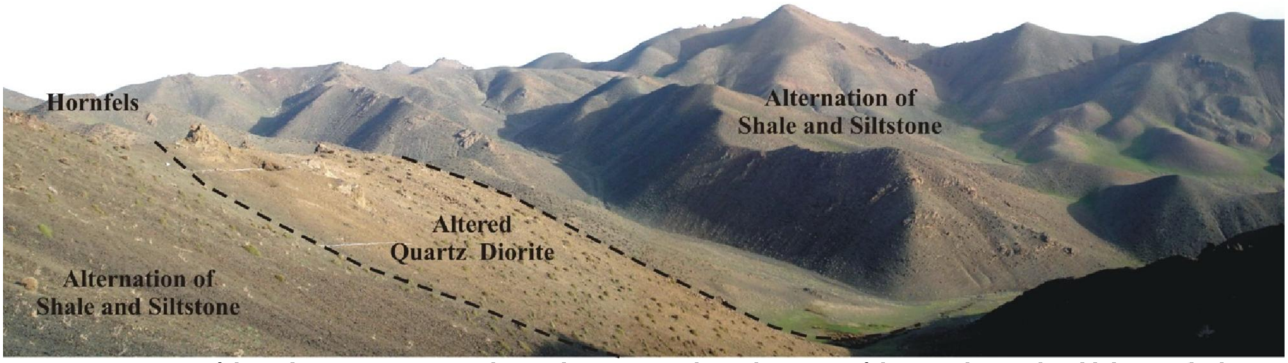

Fig. 3. An overview of the sedimentary, metamorphic, and intrusive rocks in the center of the Tareek Darreh gold deposit (looking to the south).

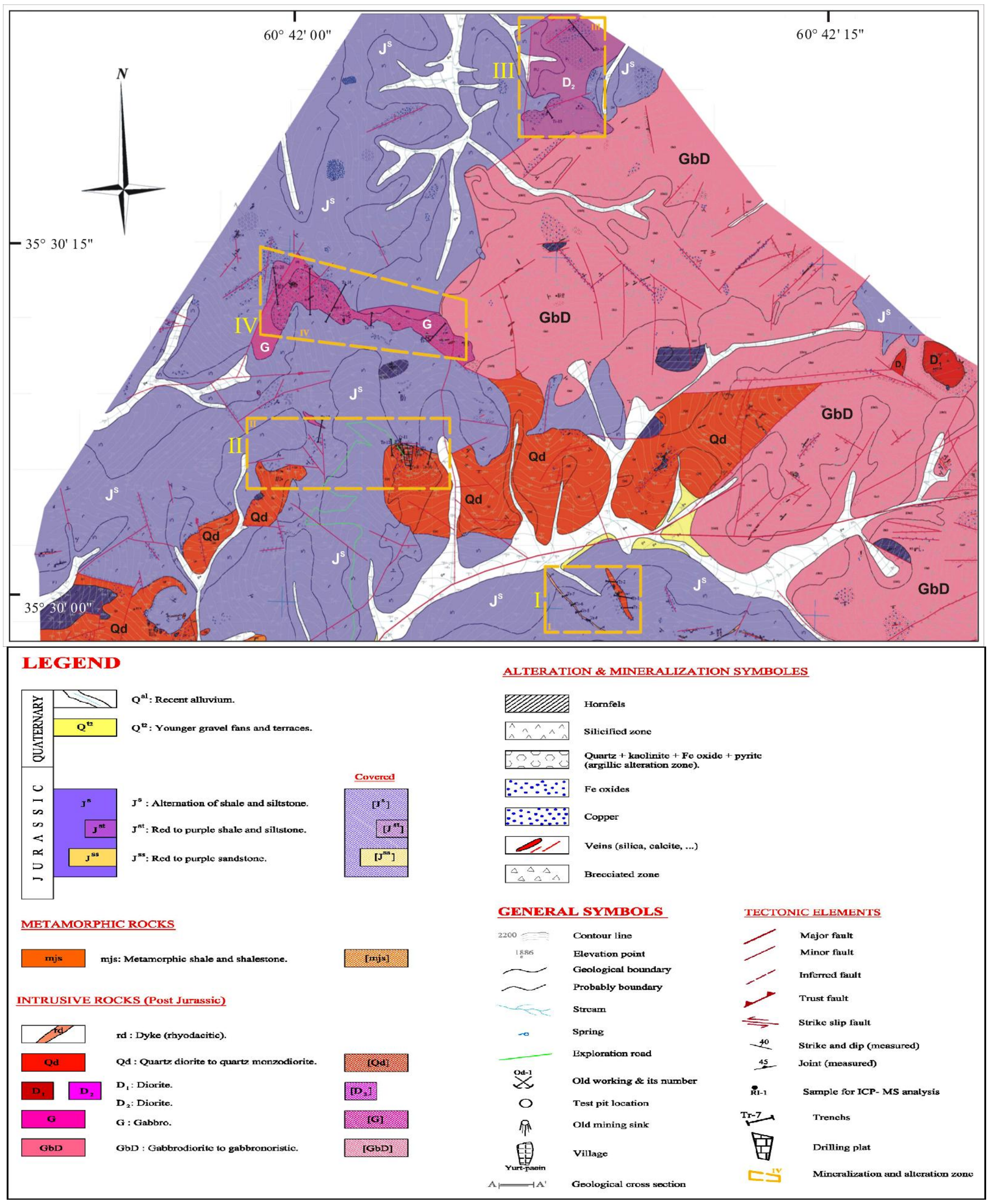

Fig. 4. The (reduced) 1:1,000 mining-geological map of the Tareek Darreh gold deposit showing the four mineralization zones and the trenches excavated in the area.

Fig. 5. Right: Argillic and sericitic alteration in the gabbro diorite contact; Left: Fe- oxide impregnation (goethite) together with argillic alteration.

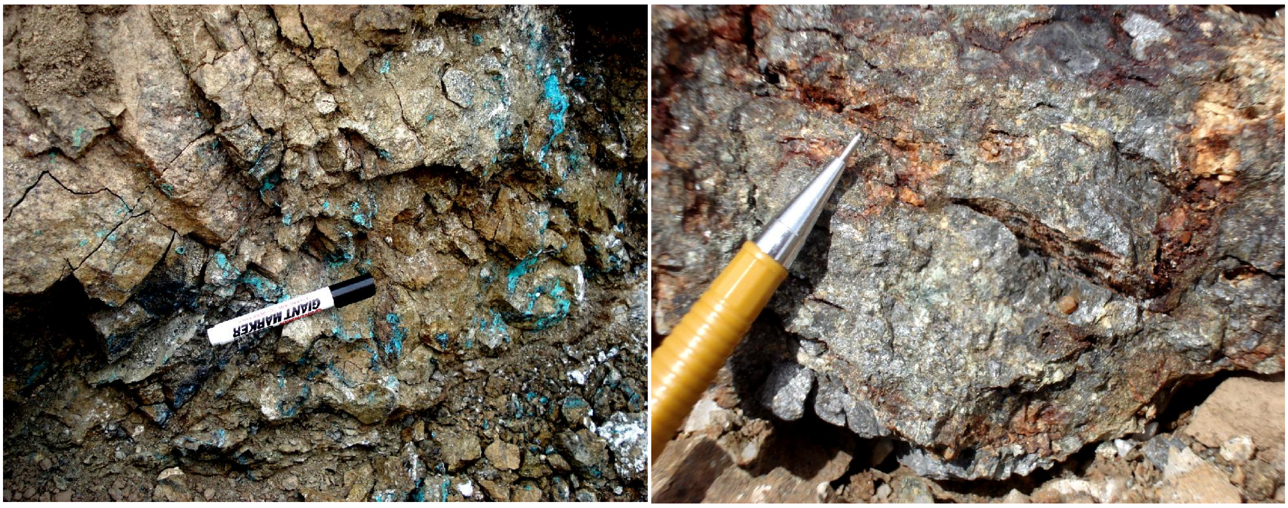

Fig. 6. Right) A close up of arsenopyrite mineralization together with quartz and Fe-oxides in fractures; Left) Malachite mineralization in the fractured quartz diorite unit.

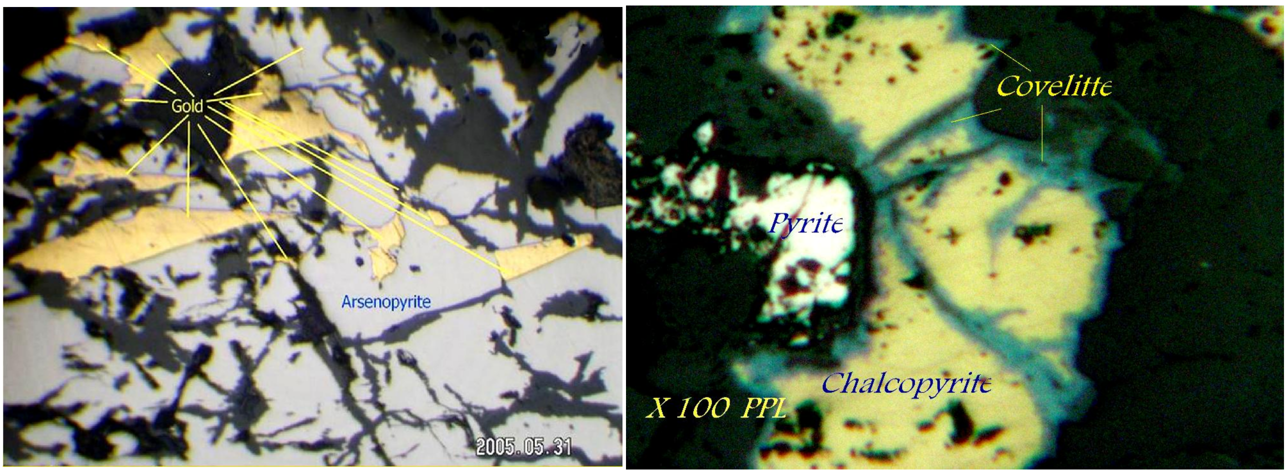

Fig. 7. Pictures of some ore minerals of the deposit; Right) Pyrite, chalcopyrite, and secondary covellite, Left) Gold in arsenopyrite.

Table 1. XRD results of the Tareek Darreh samples for recognition of different types of alteration.

Row	Samples	Major Phases										Minor Phases										Trace Phases	
		Qz.	Sco.	Ano.	Hor.	Mos-Ill.	Chl.	Orth.	Ca.	Mon.	Al.	Orth.	Mon.	Mos.	Mos-Ill.	Al.	Ca.	Goe.	Hor.	Chl.	Qz.	Hor.	Mos-Ill.
1	T4RD-10	*						*		*	*			*				*					
2	TT18D-7									*	*								*	*	*		
3	TT16D-9	*									*				*				*	*			
4	TT18D-7									*	*								*	*	*		
5	TT16D-9	*									*								*	*			
6	TT19D-14	*								*	*							*	*				
7	TT15D-7	*													*	*		*		*			
8	TT14D-5	*								*	*									*		*	
9	TT18D-14	*					*			*	*								*				
10	TT13D-12	*									*				*					*		*	
11	TT9D-7	*				*	*				*								*				
12	TT14D-11	*								*	*									*			
13	TT11D-11	*				*					*	*	*									*	
14	TT13D-13	*					*				*				*								
15	TT5D-4	*									*		*		*					*			
16	TT11D-12	*						*		*	*				*							*	
17	T4SD-6	*					*		*		*											*	*
18	TT1D-15	*					*				*		*		*								
19	TT19D-13										*		*				*		*		*		
20	TT20D-12	*		*			*			*					*			*	*				
21	T4RD-2	*					*				*												
22	T4SD-14	*			*		*				*												*
23	TCHD-5	*	*				*			*						*			*				

Qz.= Quartz, Sco.= Scorodite, Ano.= Anorthite, Hor.= Hornblende, Mos.-Ill.= Muscovite-Illite, Chl.= Chlorite, Orth.= Orthoclase, Ca.= Calcite, Mon.= Montmorillonite, Al.= Albite, Mos.= Muscovite ; Goe.= Goethite.

Table 2. ICP results for samples taken from the Tarrek Darreh deposit (analyzed at Zarazma Laboratory, Tehran); values in ppb for Au and in ppm for the other elements.

Rock type	Alteration	Au	As	S	K	Na	Ag	Bi	Te	Cu	Sb	Mo
Siltstone & shale	Si, FeO	9	68400	6650	4940	2530	3.46	1540	209	58.8	26.2	32.1
Diorite	Si, FeO	22	97.4	6190	9450	24400	0.37	0.8	0	87.2	2.1	4.2
Quartz diorite	Si	36	204	280	21500	16700	0.28	1	0	2000	1.5	0.9
Rhyodacite	Si, FeO	12	700	2440	53700	8210	0.42	1.1	0	890	2.9	2.5
Siltstone & shale	Cal	55	200	1890	22200	3990	1.48	7.5	0	562	4.1	5.1
Siltstone & shale	Si, FeO	6	586	80	8590	3840	0	1.6	0	43.6	2.1	2.7
Quartz vain	Si, Epi, Arg	52300	41.40%	970	9270	20900	0.59	0.3	0	79.3	2.4	4.2
Diorite	Si, FeO	267	1750	9010	12800	7790	0.42	9.3	1.7	1290	3.6	4.5
Diorite	Si, FeO	28	247	0	12900	25000	0.25	2.6	0.4	269	1.1	1.3
Quartz diorite	Si	14600	44600	111000	676	111	8.63	442	78.3	25000	78.1	35.7
Quartz diorite	FeO	613	2710	220	18600	19700	1.06	34.4	2.3	1860	3.8	2
Quartz vain	Si, FeO	4560	26500	17500	2980	1030	1.16	185	26.4	2830	26.2	9
Metamorphosed siltstone	Si, FeO	14	1830	21500	31500	1780	0.57	12.2	0	348	5.4	1.7
Quartz diorite	Cal, Si, FeO	2	242	920	947	2960	0.06	0.9	0	37.5	8.2	6.1

4.4. Statistical parameters

According to the analysis results of the 236 ore and rock samples, gold is the most promising element, while silver, arsenic, copper, bismuth, and tellurium show considerable concentrations whose highest contents are 15.7ppm, 70600ppm, 1540ppm, 25600 ppm, and 216ppm, respectively. The elements whose variation coefficient is more than 100 can be considered as promising or potential bearing elements.

In this regard, gold with a variation coefficient of 350 has the highest chance after which sulfur, tungsten, bismuth, cobalt, and tellurium can be considered (with variation coefficients from maximum 412 to minimum 287) (Table 4).The coefficient of correlation for gold is considerable with tellurium, arsenic, bismuth, antimony, and copper, respectively (Table 5). Gold also shows a meaningful coefficient of correlation with cerium.

Table 3. Assay results and evaluation of gold, copper, and arsenic for the Tarrek Darreh samples taken from trench 1.

Sample No.	Litho.Type	indication	Samp.Length (m)	Au	As	Cu	Bi	Te	W	Ag	Samp.Total Length(m)	Au average
TTI-1	Js		3	0.002	80	45.2	0.4	0	4	0.43		
TTI-2	Js		2	0.002	116	55.6	0.5	0	4.4	0.39	72	0.002
TTI-3	Js		2.2	0.002	253	91.8	0.3	0	5.2	0.16		
TTI-4	Qd	Fe	1.5	0.011	162	414	1	0	8	0.36		
TTI-5	Qd	Fe	2	0.005	215	1320	1.1	0.3	9.3	0.49		
TTI-6	Qd	Fe,Cu	2	0.022	701	3500	1.8	1.9	7.3	1.25		
TTI-7	Qd	Fe,Cu	1.5	0.018	582	816	1.3	0.4	4	0.47	12	0.02913
TTI-8	Qd	Fe,Cu	1.5	0.024	924	2570	1.9	0.6	3.4	1.14		
TTI-9	Qd	Cu	1.5	0.026	422	9190	1.9	0.6	4.9	1.16		
TTI-10	Qd	Fe,Cu	1	0.143	3460	4240	20.3	4.4	3.2	0.95		
TTI-11	Qd	Cu,Si	1	0.034	1360	4560	3.8	1.1	6.6	0.88		
TTI-12	Js+Qz Vein	Si	0.8	0.447	4480	2890	55.4	12.6	3.3	2.32	0.8	0.447
TTI-13			3	0.008	101	1010	0.4	0	3.9	0.33	55	0.00891
TTI-14		Cu	2.5	0.01	110	2540	0.8	0	3.4	0.57		

Js = Siltestone & shale Qd = Quartz diorite Qz vein = Quartz vein Fe = Fe oxide, (Cu= Cupper mineralization Si= Silicification)

Table 4. Statistical parameters of samples taken from the Tarrek Darreh deposit (Au in ppb rest in ppm).

Elements	Au	Ag	As	Cu	Mo	Sb	Zn	Sn	W	Bi	Te	Mn	Ni	Pb	Sr	Ba	Fe
N	183	183	183	183	183	183	183	183	183	183	183	183	183	183	183	183	183
Mean	1488.1	1.2	3966.4	2516.1	3.9	5.6	83.3	5.0	7.9	47.1	12.0	944.6	25.5	17.5	330.6	471.6	84315.3
Median	40	0.5	443	654	2	2	76.7	3.3	4.1	1.8	0.4	967	20	11.3	331	468	77600
Std. Deviation	5213.9	2.0	11043.4	4471.2	6.8	12.9	44.9	5.9	26.6	154.4	34.5	434.2	21.2	19.6	137.7	231.3	36040.0
Minimum	0	0	21.9	28.9	0.6	0.5	15.2	0.3	0.8	0	0	30	0	0	0.2	4.1	36800
Maximum	52300	15.7	70600	25600	57.6	103	327	59.5	348	1540	216	4210	201	127	625	2580	325000
C.V.%	350	174	278	178	173	231	54	119	336	328	287	46	83	112	42	49	43

Elements	Al	La	Ca	P	Mg	K	Na	S	Co	Cs	U	Hg	Th	Y	Ce	Tl	Rb
N	183	183	183	183	183	183	183	183	183	183	183	183	183	183	183	183	183
Mean	83432.1	78.2	31081.3	1230.6	21360.1	14454.4	16352.9	2392.3	120.8	9.1	3.0	0.1	7.9	20.3	129.9	0.8	74.4
Median	87600	41	26600	1070	22400	13700	16600	210	27.1	7.2	2.5	0.07	7.93	17.3	75.2	0.8	62.6
Std. Deviation	19330.5	142.0	23802.1	490.8	7805.2	6633.0	6113.4	9845.9	373.6	7.1	1.9	0.2	3.1	15.6	203.0	0.4	47.2
Minimum	3710	0	437	109	121	676	111	0	1.6	1.2	0.49	0	0.61	0.76	6.1	0	3.6
Maximum	117000	1150	221000	2700	36800	53700	33400	111000	3020	39.8	11.7	1.9	19.8	177	1580	2.1	268
C.V.%	23	182	77	40	37	46	37	412	309	78	64	190	39	77	156	49	63

5. Conclusions

The Tareek Darreh area (Fig. 1) is composed of an alternation of shale and sandstone of Jurassic age into which some intrusives have intruded. Diverse and numerous alterations have occurred at the contact of the intrusives and the country rocks. The alteration is more intense at the contact of the quartz-diorite and gabbro-diorite and their country rocks. The E-W trend of these stocks has caused alterations with the same trend at their contact. The intrusives have been attributed to Jurassic age. The alterations are characterized by occurrence of quartz, chlorite, calcite, and sericite and show impregnations of iron- and arsenic-bearing minerals. The presence of arsenopyrite-, chalcopyrite-, and pyrite-bearing silica veins, together with gold in relation to these alterations indicate the significance of this phase of intrusion and its fertility for mineralization. The main mineralization in these veins and altered zones is for gold, arsenic, copper, bismuth, tellurium, and molybdenum. This paragenesis suggests a high temperature for mineralization. The paragenesis of mineralization, the form and shape of mineralization, presence of high temperature elements, and setting of the mineralization at the contact of the quartz-diorite and gabbro-diorite is comparable with the Intrusion-related gold system model [9, 10, 11, 12, 13 and 14; Table 6).

Table 5. Correlation of the elements using Spearman method for the samples taken from the study area (Using ICP results for 44 elements at Zarazma-Amdel).

Au1	1.00	0.04	0.23	-0.28	-0.17	0.59	-0.41	-0.11	0.24	-0.40	0.02	0.43	0.43	0.48	0.76	0.76	0.61	0.61	0.43	0.70	0.29	0.46	0.35	0.77	0.50	0.39	0.39
Te	0.77	-0.14	0.35	-0.25	-0.38	0.61	-0.48	-0.11	0.10	-0.44	-0.18	0.59	0.36	0.64	0.84	0.89	0.59	0.67	0.61	0.69	0.38	0.51	0.33	1.00	0.40	0.45	0.19
As	0.76	-0.10	0.27	-0.28	-0.33	0.71	-0.59	-0.11	0.14	-0.53	-0.16	0.61	0.43	0.58	1.00	0.82	0.66	0.68	0.57	0.77	0.30	0.54	0.43	0.84	0.43	0.46	0.30
Bi	0.76	-0.23	0.36	-0.32	-0.42	0.59	-0.55	-0.07	-0.02	-0.51	-0.20	0.61	0.34	0.69	0.82	1.00	0.54	0.66	0.68	0.76	0.27	0.50	0.37	0.89	0.34	0.38	0.23
Sb	0.70	-0.08	0.39	-0.36	-0.41	0.59	-0.61	-0.22	0.05	-0.52	-0.13	0.61	0.41	0.56	0.77	0.76	0.54	0.52	0.63	1.00	0.17	0.46	0.35	0.69	0.40	0.28	0.24
Cu	0.61	-0.07	0.24	-0.21	-0.13	0.63	-0.37	0.04	0.17	-0.39	-0.05	0.54	0.25	0.63	0.68	0.66	0.55	1.00	0.57	0.52	0.51	0.64	0.44	0.67	0.30	0.53	0.31
Co	0.61	0.31	0.28	-0.29	-0.18	0.52	-0.32	-0.28	0.40	-0.40	0.03	0.33	0.32	0.38	0.66	0.54	1.00	0.55	0.31	0.54	0.44	0.25	0.10	0.59	0.55	0.22	0.24
Fe	0.59	0.14	0.15	-0.24	0.02	1.00	-0.49	-0.15	0.32	-0.66	0.12	0.51	0.32	0.54	0.71	0.59	0.52	0.63	0.52	0.59	0.42	0.49	0.35	0.61	0.41	0.42	0.29
Ce	0.50	0.44	0.24	0.00	0.05	0.41	-0.09	-0.05	0.47	-0.26	0.28	0.07	0.40	0.09	0.43	0.34	0.55	0.30	0.17	0.40	0.42	0.23	0.13	0.40	1.00	0.25	0.44
Ag	0.48	-0.27	0.34	-0.30	-0.28	0.54	-0.50	-0.08	-0.05	-0.42	-0.20	0.54	0.25	1.00	0.58	0.69	0.38	0.63	0.69	0.56	0.40	0.52	0.41	0.64	0.09	0.35	0.04
Sn	0.46	-0.18	0.30	-0.14	-0.13	0.49	-0.38	0.32	0.00	-0.51	-0.22	0.37	0.17	0.52	0.54	0.50	0.25	0.64	0.43	0.46	0.43	1.00	0.54	0.51	0.23	0.52	0.32
Hg	0.43	-0.05	0.18	-0.03	-0.13	0.32	-0.08	-0.04	0.11	-0.18	-0.07	0.19	1.00	0.25	0.43	0.34	0.32	0.25	0.19	0.41	0.09	0.17	0.51	0.36	0.40	0.34	0.22
Mo	0.43	-0.34	0.36	-0.39	-0.43	0.52	-0.61	-0.20	-0.21	-0.47	-0.18	0.66	0.19	0.69	0.57	0.68	0.31	0.57	1.00	0.63	0.27	0.43	0.30	0.61	0.17	0.25	-0.03
S	0.43	-0.32	0.33	-0.39	-0.44	0.51	-0.50	-0.19	-0.15	-0.35	-0.18	1.00	0.19	0.54	0.61	0.61	0.33	0.54	0.66	0.61	0.26	0.37	0.25	0.59	0.07	0.22	0.08
Tl	0.39	-0.13	0.15	0.08	0.07	0.42	-0.11	0.48	0.20	-0.35	-0.06	0.22	0.34	0.35	0.46	0.38	0.22	0.53	0.25	0.28	0.36	0.52	0.50	0.45	0.25	1.00	0.61
Rb	0.39	0.08	0.19	0.05	0.29	0.29	0.08	0.48	0.31	-0.27	0.27	0.08	0.22	0.04	0.30	0.23	0.24	0.31	-0.03	0.24	0.29	0.32	0.19	0.19	0.44	0.61	1.00
W	0.35	-0.32	0.16	-0.05	-0.12	0.35	-0.30	0.33	-0.14	-0.27	-0.31	0.25	0.51	0.41	0.43	0.37	0.10	0.44	0.30	0.35	0.17	0.54	1.00	0.33	0.13	0.50	0.19
Zn	0.29	0.27	0.39	-0.09	0.15	0.42	-0.12	0.04	0.37	-0.26	0.18	0.26	0.09	0.40	0.30	0.27	0.44	0.51	0.27	0.17	1.00	0.43	0.17	0.38	0.42	0.36	0.29
Mg	0.24	0.76	-0.14	0.09	0.42	0.32	0.17	-0.13	1.00	0.09	0.48	-0.15	0.11	-0.05	0.14	-0.02	0.40	0.17	-0.21	0.05	0.37	0.00	-0.14	0.10	0.47	0.20	0.31
Pb	0.23	-0.15	1.00	-0.08	-0.31	0.15	-0.22	0.14	-0.14	-0.32	-0.27	0.33	0.18	0.34	0.27	0.36	0.28	0.24	0.36	0.39	0.39	0.30	0.16	0.35	0.24	0.15	0.19
Mn	0.04	1.00	-0.15	0.15	0.37	0.14	0.20	-0.21	0.76	0.11	0.46	-0.32	-0.05	-0.27	-0.10	-0.23	0.31	-0.07	-0.34	-0.08	0.27	-0.18	-0.32	-0.14	0.44	-0.13	0.08
P	0.02	0.46	-0.27	0.03	0.61	0.12	0.27	-0.23	0.48	0.25	1.00	-0.18	-0.07	-0.20	-0.16	-0.20	0.03	-0.05	-0.18	-0.13	0.18	-0.22	-0.31	-0.18	0.28	-0.06	0.27
K	-0.11	-0.21	0.14	0.43	0.15	-0.15	0.27	1.00	-0.13	-0.05	-0.23	-0.19	-0.04	-0.08	-0.11	-0.07	-0.28	0.04	-0.20	-0.22	0.04	0.32	0.33	-0.11	-0.05	0.48	0.48
Ti	-0.17	0.37	-0.31	0.19	1.00	0.02	0.40	0.15	0.42	0.18	0.61	-0.44	-0.13	-0.28	-0.33	-0.42	-0.18	-0.13	-0.43	-0.41	0.15	-0.13	-0.12	-0.38	0.05	0.07	0.29
Ba	-0.28	0.15	-0.08	1.00	0.19	-0.24	0.47	0.43	0.09	0.30	0.03	-0.39	-0.03	-0.30	-0.28	-0.32	-0.29	-0.21	-0.39	-0.36	-0.09	-0.14	-0.05	-0.25	0.00	0.08	0.05
Na	-0.40	0.11	-0.32	0.30	0.18	-0.66	0.57	-0.05	0.09	1.00	0.25	-0.35	-0.18	-0.42	-0.53	-0.51	-0.40	-0.39	-0.47	-0.52	-0.26	-0.51	-0.27	-0.44	-0.26	-0.35	-0.27
Al	-0.41	0.20	-0.22	0.47	0.40	-0.49	1.00	0.27	0.17	0.57	0.27	-0.50	-0.08	-0.50	-0.59	-0.55	-0.32	-0.37	-0.61	-0.61	-0.12	-0.38	-0.30	-0.48	-0.09	-0.11	0.08

Table 6. Comparison of the Tareek Darreh deposit and the intrusion-related gold systems.

Characteristic	Intrusion-related gold systems [10]	The Tareek Darreh Deposit
Geologic setting	Magmatic provinces known for W-Sn deposits	A zone known for W-Au mineralization
Tectonic setting	Convergent plate boundaries	Location in the collision of the Kopet Dagh and Central Iran plates
Age	Middle Cretaceous and after	Post Jurassic
Country rock	Meta-sedimentary rocks	Slightly metamorphosed shale and siltstone
Characteristic of the intrusives	Reduced meta-aluminous felsic to intermediate intrusions	Quartz-diorite
Fluids	Carbonaceous fluids	Silicic and carbonaceous fluids
Alterations	Locally restricted, commonly weak hydrothermal alteration	Weak hydrothermal alteration
Metal assemblage	Gold with elevated Bi, W, As, Mo, Te, and/or Sb,	Gold with elevated W, Cu, Te, As, Fe, Bi, Sb
Sulfide Content	A low sulfide mineral content, mostly <5 vol%,	Mostly <5 vol%,

The correlation of the gold mineralization with tellurium, arsenic, bismuth, and antimony is another indication of high temperature of mineralization. Despite the presence of vast mineralization over the study area, most of the mineralization is of minor economic importance due to the small size. Mineralization is considerable only in the following four zones which have been proposed for further investigations (Fig. 4).

Zone No. 1 is located in the south of the study area. Seven trenches were dug in this zone from which 36 samples were taken for ICP analysis. The highest content of gold was recorded in one of the samples from this trench with 0.8m length (0.447 ppm). The other samples did not show high contents of gold (maximum several tens of ppb).

Zone No. 2 covers the center of the study area. Five trenches were dug in this part. This zone bears the highest volume of alteration and gold and copper mineralization. Almost all samples that have been taken from the quartz diorite unit show high contents of gold. The average content of gold is 3.66ppm for a 14.8m sampling length.

Zone No. 3 is located in the north of the study area in which the average content of gold for a 12.8m length is 1.18ppm.

Zone No. 4 is located in the northwest of the study area in which five trenches were dug. It is almost totally altered and some silica-arsenopyrite veins with 50cm width are observed. The highest contents of gold for two sampling lengths of 5.1m and 12.9m were 1.4ppm and 1.28ppm respectively.

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