Geology, Geochemistry and Mineralogy of the Tareek Darreh Gold Deposit, Northeast Irán

Geología, Geoquímica y Mineralogía del Depósito de Oro Tareek Darreh, Noreste de Irán

Kourosh Shabani[1], Nima Nezafati[1*], Morteza Momenzadeh[2] & Iraj Rassa[3]

[1]Economic Geology Department, Science and Research Branch, Tehran, Islamic Azad University, ko_shabani@yahoo.com, nnezafati@gmail.com
[2]Zarneh Research Group, Tehran, mortezamomenzadeh@gmail.com
[3]Economic Geology Department, Shahid Beheshti University, Tehran, Iran, iraj.rassa@gmail.com
[*]Corresponding Author

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Abstract

The Tareek Darreh gold deposit is 40 km north of Torbat-e Jaam in the Khorasan-Razavi province, northeast-Irán. The study area is mainly comprised of slightly metamorphosed, sedimentary rocks of Jurassic age including shale, siltstone, and sandstone. These rocks have been intruded by plutonic rocks such as gabbronorite, diorite, quartz-diorite and rhyodacite.

The ore bodies were exposed after trenching and pitting. In this study, all trenches and pits were sampled and analysed by XRF, XRD, ICP, and ICP-MS as well as petrological studies.

The alteration minerals of quartz, chlorite, albite, and sericite are mostly observed on the top or margin of the stocks. Alteration is more intense at the contacts of the stocks where vein type mineralization has occurred. These veins are mainly composed of quartz and calcite with arsenopyrite, chalcopyrite, and pyrite as the main ore minerals. Four promising mineralization zones were selected. The analytical results for the zones 2 and 4 confirm high Au, Cu, Bi, Te, and Ag-contents. In the zone 2 (50 x 80 m^2) an average of 3.5 ppm Au was recorded for one of the trenches, while in zone 4 (50 x 250 m^2) the average gold content is 1.35 ppm. 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, alteration, Jurassic, Northeast Iran

Resumen

El depósito de oro de Tareek Darreh está localizado a 40 km al norte de Torbat-e Jaam en la provincia Khorasan-Razavi, NE- de Irán. El área de estudio está constituida principalmente por rocas sedimentarias de edad Jurásica con metamorfismo leve y una alternación de shales, lodolitas y de areniscas. Estas rocas han sido intruidas por rocas plutónicas como gabronoritas, dioritas, cuarzo-dioritas y riodacitas. Los cuerpos mineralizados solamente afloraron después de hacer canales de exploración y apiques. En este estudio, todos los fosos y apiques fueron muestreados sistemáticamente y analizados con fluorescencia y difracción de rayos X (XRF y XRD), ICP, ICP-MS, y petrográficamente. Los minerales de alteración como cuarzo, clorita, albita y sericita se observan sobre todo en la parte superior y lateral del stock. La alteración es más intensiva en los contactos del stock donde ha ocurrido la mineralización en forma de vetas. Las vetas están compuestas principalmente por cuarzo y calcita con arsenopirita, calcopirita y pirita como mena principal. Cuatro zonas prometedoras de la mineralización fueron seleccionadas para otros estudios. Los resultados analíticos para las zonas 2 y 4 confirman altos contenidos de oro, cobre, bismuto, telurio y plata. En la zona 2 (50 x 80 m^2) un promedio de oro de 3.5 ppm fue registrado en uno de los apiques, mientras que en la zona 4 (50 x 250 m^2) el contenido medio de oro es 1.35 ppm. Según nuestros estudios, el depósito del oro de Tareek Darreh puede pertenecer a los sistemas de oro relacionados con intrusiones (Intrusion-Related Gold Systems).

Palabras clave: Depósito de oro, Tareek Darreh, exploración geoquímica, oro relacionado con intrusiones, alteración, Irán nororiental

Introduction

The Tareek Darreh gold deposit is 40 km north of Torbat-e Jaam in the Khorasan Razavi province, northeast Irán (Fig. 1). The whole area is traditionally known for having high anomalies of W-(Sn) (Zarnab Exploration Consultants, 2004, 2005). According to the geological subdivisions of Irán (Stöcklin, 1968, 1977 and Nabavi, 1976), the study area is at the border of Central Iran and the Kopet Dagh lithotectonic domains. The ancient mining relics in the area led to several exploration projects that showed the potential of gold mineralizations in the area.

Background

The first exploration operation in the area was done on the abandoned mining works of Firouzkuh in 1965 by Taghi Zadeh (Geological Survey of Irán). In 1994 M. 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. 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 Khorasan province. 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 Khorasan Razavi Province. These projects included geochemical soil investigations (Fig. 1) from which three promising areas were proposed for further studies that were investigated during the current study.

Methods

For this study all the previous investigations were reviewed and summarized. The previous exploration projects include geological studies in various scales as well as geochemical soil and stream sediment studies. Summarizing the whole preceding exploration data led to choosing three (promising) areas for further studies which results are presented in this paper.

In order to investigate the deposit, first the 1:1,000 mining-geological map of the area was prepared. During the 1:1,000 mapping 43 samples were taken from the area from which 14 were analyzed using ICP-MS, 21 were petrographically investigated, and 4 altered samples were analyzed by means of XRD and XRF. Afterwards, the location of exploration trenches was determined and accordingly 200 chains of trenches (with a total length of 716 m, Fig. 3) were dug from which 236 samples were taken for ICP- and XRD-analyses as well as petrographical and ore microscopic studies.

The ICP-MS analyses were performed at the Amdel-Laboratories in Australia, while XRD and XRF-analyses were done by Zarazma-Tehran. The petrographical and mineralogical studies were performed at the Zarnab Exploration Consultants and the Islamic Azad University, Science and Research Branch.

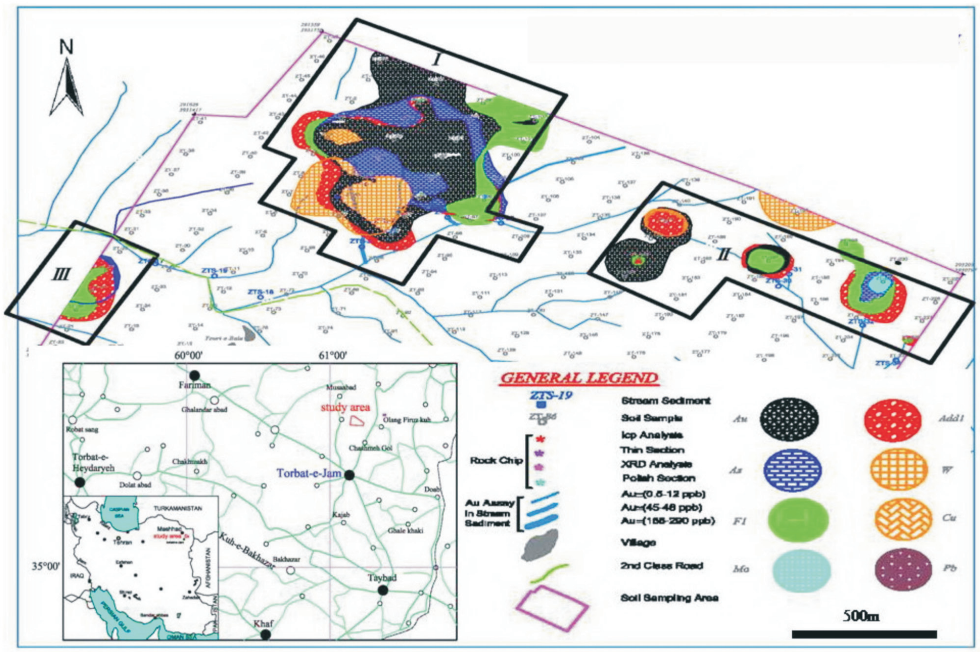

Figure 1: The promising areas based on the intensity and overlap of the soil geochemical anomalies at the Tareek Darreh deposit (After Zarnab Exploration Consultants 2005)

Regional geology of the area

The study area is located in the center of the 1:250,000 Torbat-e Jaam geological map. It comprises the northern part of the 1:100,000 Torbat-e Jaam and Agh-Darband geological maps, which were prepared by the Geological Survey of Irán (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. Since the granitoid intrusive body has unconformably been covered 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 (Based on the 1:100,000 geological map). 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 its borders. Silica, pegmatite and aplite veins as well as Fe-oxide impregnations are often observed in the intrusive body.

Deposit geology

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 3 and 4), as follows:

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.

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 at the 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 (based on the 1:100,000 geological map). Alluvial fans (Qt2) and recent alluvial deposits (Qal) comprise the main sediments of the area.

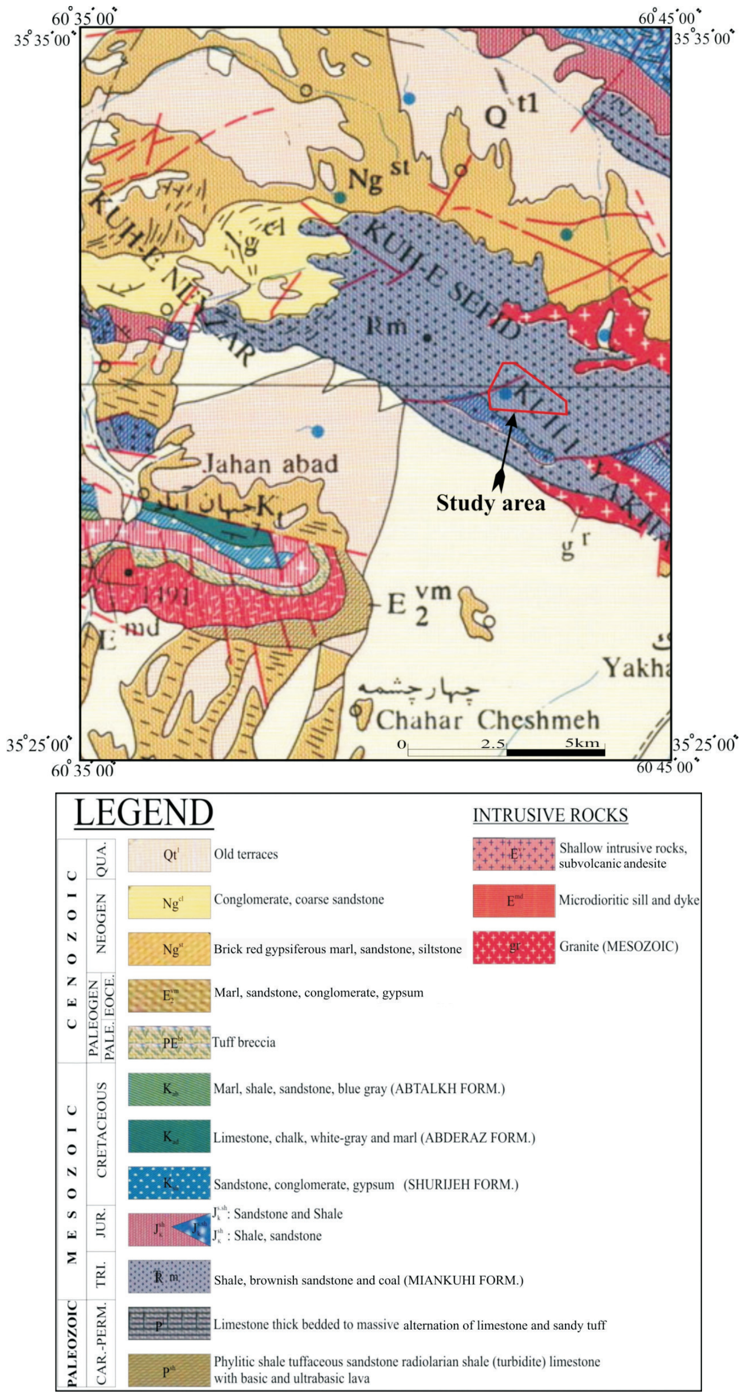

Figure 2: Location of the study area on the Torbat-e Jaam 1:250,000 geological map (After Eftekhar Nezhad *et al.,* 1993).

Alteration

Alteration is not pervasive in the study area. The samples taken from the Tareek - Darreh area analised by XRD are mostly indicative of clay (montmorillonite and illite), quartz-sericitic, Fe-oxide, and chloritic alterations (Tab. 1 and Fig. 5). These alterations are mainly confined to intrusive rocks, the contact of the plutons, and the alternation of shale and sandstone as well at the margins of the faults as linear alterations. These zones are sometimes accompanied with arsenopyrite bearing quartz-silica veins. These veins are 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 is possibly the youngest unit among the intrusive rocks of the area. This unit shows some indications of alteration (especially clay and Fe-oxide alterations) 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 that the fluids have rarely been able to exceed 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 width of such veins is maximum 40 cm, while their length reaches 5-20 m. In some cases, arsenopyrite composes up to 90% of such veins.

Mineralization and geochemistry

The mineralization in the Tareek - Darreh deposit bears a general E-W trend and is mainly of the vein-type in association with the contact of the quartz-diorite intrusive rocks and the unit of shale and siltstone. Several arsenopyrite bearing silica-calcite veins have been identified in the crushed zones at the contact of the quartz-diorite. The silica veins are 1 cm to several decimeters in size with arsenopyrite contents which reach sometimes up to 90% (Fig. 7). Different copper minerals are observed in diverse host rocks almost in all parts of the alteration zones.

The copper mineralization is ubiquitous in association with secondary fractures which show late-stage mineralization for such minerals. Ore microscopy investigations indicate arsenopyrite, pyrite, and chalcopyrite as main ore minerals (Fig. 7). Native gold was observed only in one section as inclusions in arsenopyrite (Fig. 6).

The geochemical analyses (by ICP-MS) show that gold is the main economic metal of the deposit, while copper, bismuth, and tellurium occur also in high concentrations. Silver, antimony, and molybdenum are among the other anomalous metals (Tab. 2). After digging the exploration trenches and the relative sampling, due to the difference of the length of sampling in each trench, evaluation and assaying were separately accomplished for each trench. This was done with evaluation of 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 for such studies.

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 15.7 ppm, 70600 ppm, 1540 ppm, 25600 ppm, and 216 ppm, respectively.

The elements whose variation coefficient is more than 100 can be considered as promising or potential bearing elements. In this regard, gold with variation coefficient of 350 has the highest chance after which sulfur, tungsten, bismuth, cobalt, and tellurium can be considered (with variation coefficient from maximum 412 to minimum 287) (Tab. 4).

The coefficient of correlation for gold is considerable with tellurium, arsenic, bismuth, antimony, and copper, respectively (Tab. 5). Gold also shows a meaningful coefficient of correlation with cerium.

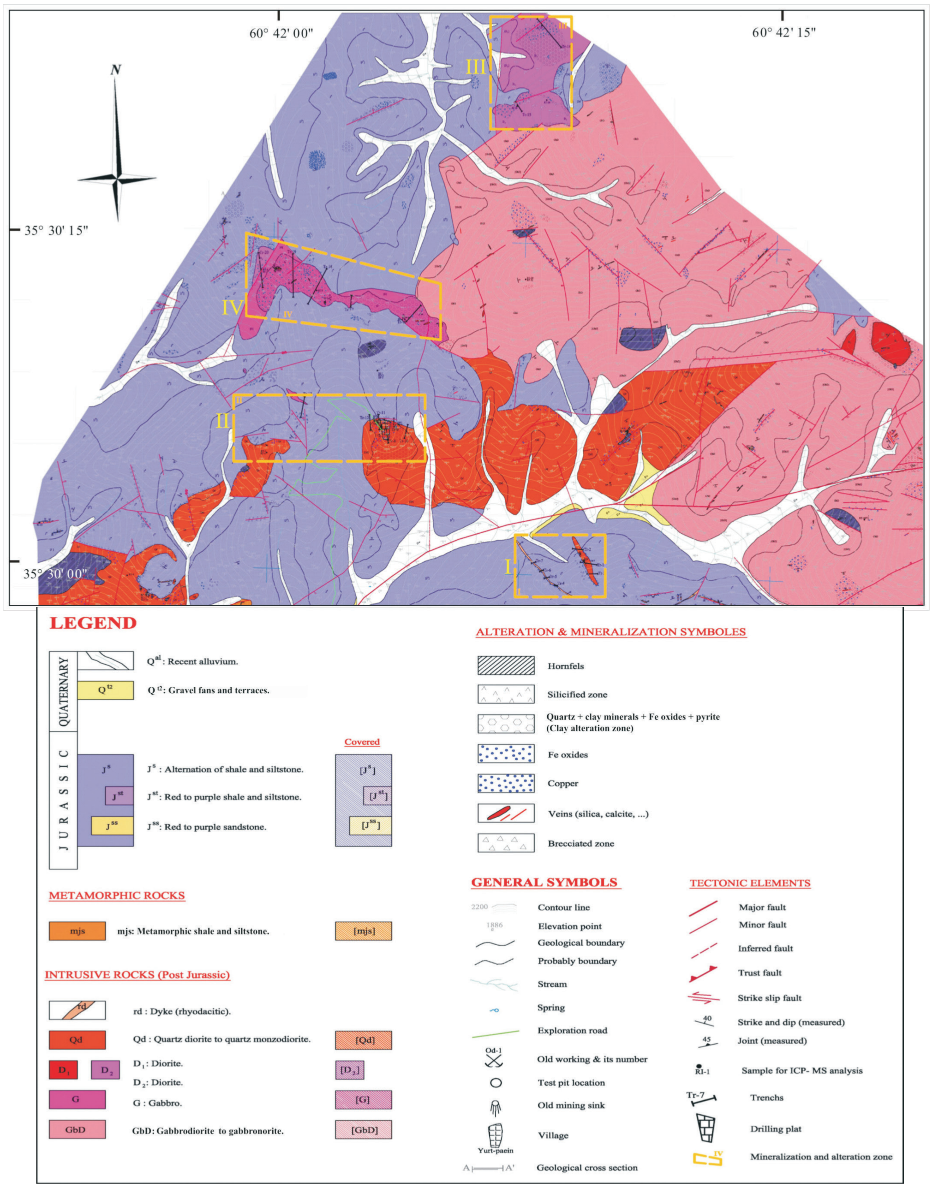

Figure 3: The (reduced) 1:1,000 mining-geological map of the Tareek Darreh gold deposit showing the four mineralization zones and the trenches dug in the area.

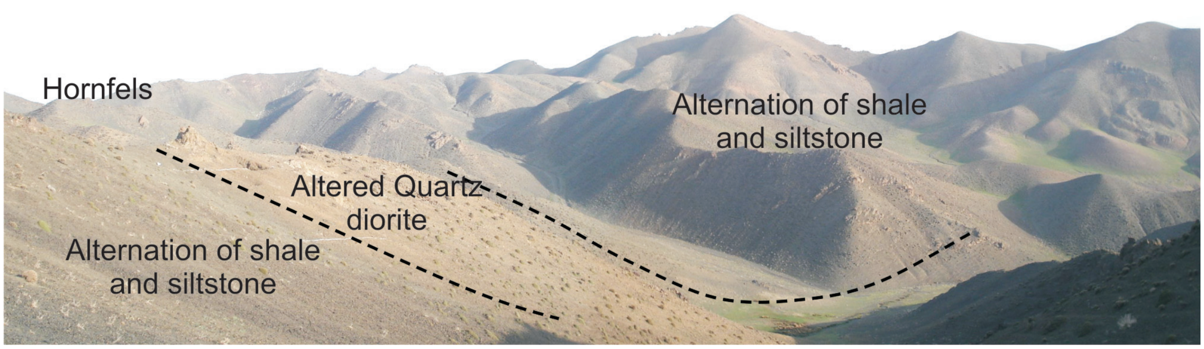

Figure 4: An overview of the sedimentary, metamorphic, and intrusive rocks in the center of the Tareek Darreh gold deposit (looking to the south, location: zone four on Fig. 3).

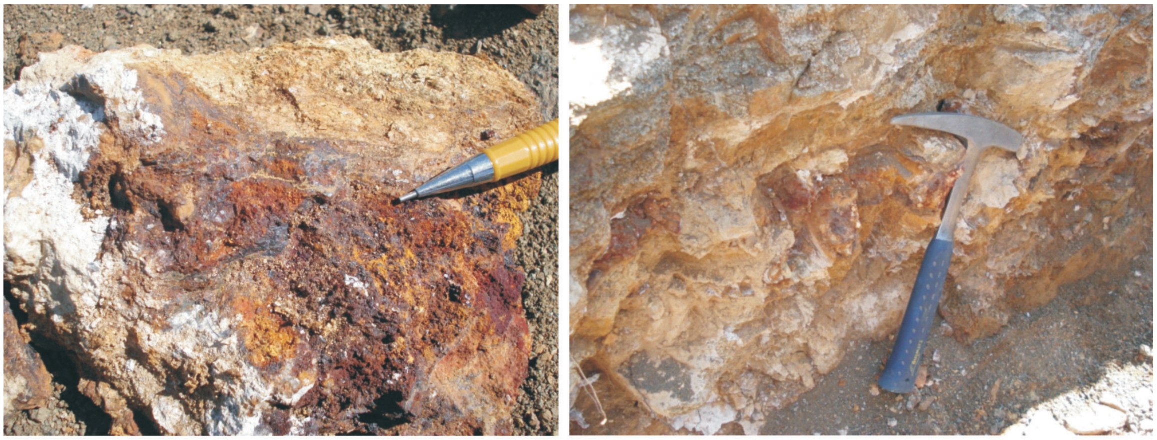

Figure 5: Right) Clay and sericitic alteration in the gabbro diorite contact, Left) Fe-oxide impregnation (goethite) together with clay alteration.

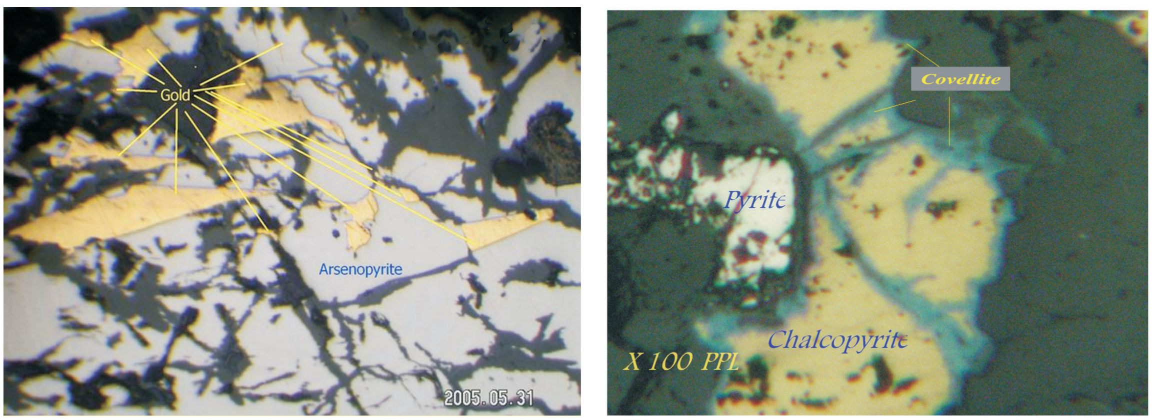

Figure 6: Pictures of some ore minerals of the deposit; right) Gold in arsenopyrite left) Pyrite, chalcopyrite, and secondary covellite

Table 1: XRD analysis results of the Tareek-Darreh samples from altered intrusives (diorite and quartzdiorite) for recognition of different types of alteration

ردیف	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.= Anortite; Hor.= Hornblende; Mos.-Ill.= Muscovite-Illite; Chl.= Chlorite; Orth.= Orthoclase; Ca.= Calcite; Mon.= Montmorillonite; Al.= Albite; Mos.= Muscovite; Goe.= Goethite.

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

Row	Sample ID	Rock type	Alteration	Au	As	S	K	Na	Ag	Bi	Te	Cu	Sb	Mo
1	T4RI-1	Siltstone & shale	Si,FeO	9	68400	6650	4940	2530	3.46	1540	209	58.8	26.2	32.1
2	T4RI-7	Diorite	Si,FeO	22	97.4	6190	9450	24400	0.37	0.8	0	87.2	2.1	4.2
3	T4RI-11	Quartz diorite	Si	36	204	280	21500	16700	0.28	1	0	2000	1.5	0.9
4	T4RI-13	Rhyodacite	Si,FeO	12	700	2440	53700	8210	0.42	1.1	0	890	2.9	2.5
5	T4RI-15	Siltstone & shale	Cal	55	200	1890	22200	3990	1.48	7.5	0	562	4.1	5.1
6	T4RI-16	Siltstone & shale	Si,FeO	6	586	80	8590	3840	0	1.6	0	43.6	2.1	2.7
7	T4RI-22	Quartz vein	Si, Epi	2300	41.4%	970	9270	20900	0.59	0.3	0	79.3	2.4	4.2
8	T4RI-25	Diorite	Si,FeO	267	1750	9010	12800	7790	0.42	9.3	1.7	1290	3.6	4.5
9	T4RI-27	Diorite	Si,FeO	28	247	0	12900	25000	0.25	2.6	0.4	269	1.1	1.3
10	T4SI-1	Quartz diorite	Si	14600	44600	111000	676	111	8.63	442	78.3	25000	78.1	35.7
11	T4SI-8	Quartz diorite	FeO	613	2710	220	18600	19700	1.06	34.4	2.3	1860	3.8	2
12	T4SI-9	Quartz vein	Si,FeO	4560	26500	17500	2980	1030	1.16	185	26.4	2830	26.2	9
13	T4SI-11	Metamorphed siltstone	Si,FeO	14	1830	21500	31500	1780	0.57	12.2	0	348	5.4	1.7
14	T4SI-13	Quartz diorite	Cal,Si,FeO	2	242	920	947	2960	0.06	0.9	0	37.5	8.2	6.1

Si= Silicification; FeO= Fe oxide alteration; Cal= Calcite; Epi= Epidote.

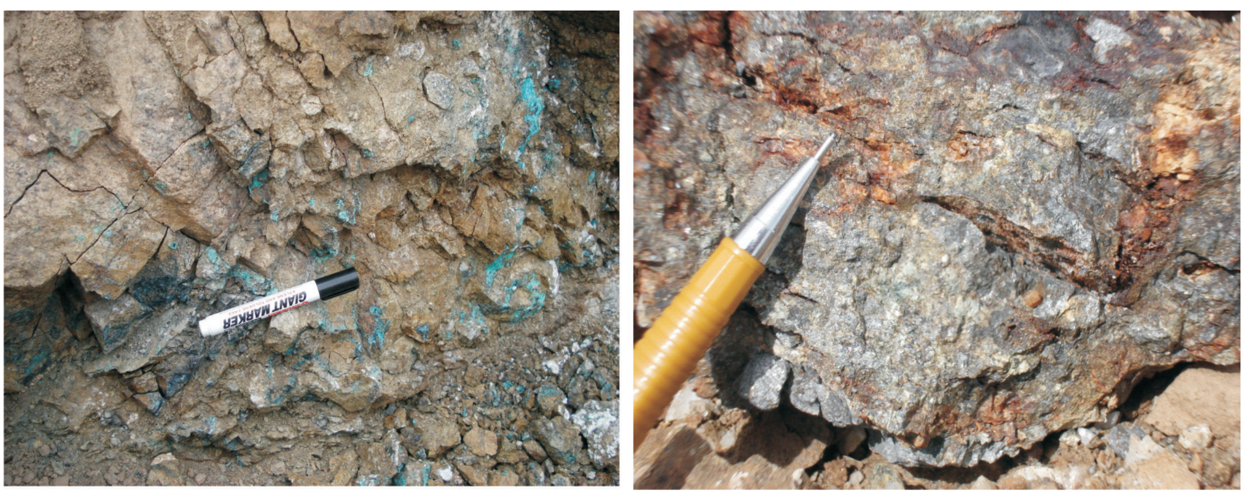

Figure 7: Right) Malachite mineralization in the fractured quartz diorite unit, Left) a close up of arsenopyrite mineralization together with quartz and Fe-oxides in fractures

Table 3: ICP-MS assaying and evaluation calculation of gold, copper, arsenic and other elements for the samples taken from trench 1. (i - ppm)

Samp. No.	Litho. Type	indication	Samp. Length (m)	Au	As	Cu	Bi	Te	W	Ag	Samp.Total Length (m)	Au average
TT1I-1	Js		3	0.002	80	45.2	0.4	0	4	0.43	7.2	0.002
TT1I-2	Js		2	0.002	116	55.6	0.5	0	4.4	0.39		
TT1I-3	Js		2.2	0.002	253	91.8	0.3	0	5.2	0.16		
TT1I-4	Qd	Fe	1.5	0.011	162	414	1	0	8	0.36	12	0.02913
TT1I-5	Qd	Fe	2	0.005	215	1320	1.1	0.3	9.3	0.49		
TT1I-6	Qd	Fe, Cu	2	0.022	701	3500	1.8	1.9	7.3	1.25		
TT1I-7	Qd	Fe, Cu	1.5	0.018	582	816	1.3	0.4	4	0.47		
TT1I-8	Qd	Fe, Cu	1.5	0.024	924	2570	1.9	0.6	3.4	1.14		
TT1I-9	Qd	Cu	1.5	0.026	422	9190	1.9	0.6	4.9	1.16		
TT1I-10	Qd	Fe, Cu	1	0.143	3460	4240	20.3	4.4	3.2	0.95		
TT1I-11	Qd	Cu, Si	1	0.034	1360	4560	3.8	1.1	6.6	0.88		
TT1I-12	Js + Qz vein	Si	0.8	0.447	4480	2890	55.4	12.6	3.3	2.32	0.8	0.447
TT1I-13	Js		3	0.008	101	1010	0.4	0	3.9	0.33	5.5	0.00891
TT1I-14	Js	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: The statistical parameters of the samples taken from the deposit (Au in ppb, the rest in ppm- C.V.= Coefficient of Variation).

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.	3.50	1.74	2.78	1.78	1.73	2.31	0.54	1.19	3.36	3.28	2.87	0.46	0.83	1.12	0.42	0.49	0.43

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.	0.23	1.82	0.77	0.40	0.37	0.46	0.37	4.12	3.09	0.78	0.64	1.90	0.39	0.77	1.56	0.49	0.63

Table 5: Correlation of the elements using Spearman method for the samples taken from the study area (High values in gray and low values in yellow-Using ICP-MS method for 44 elements at Amdel-Australia)

	Au1	Mn	Pb	Ba	Ti	Fe	Al	K	Mg	Na	P	S	Hg	Ag	As	Bi	Co	Cu	Mo	Sb	Zn	Sn	W	Te	Ce	Tl	Rb
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	0.26	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	0.09

Table 6: Comparison of the Tareek Darreh deposit with intrusion-related gold systems (Thompson *et al.* 1999; Lang and Baker 2001; Hart *et al.* 2001; Baker 2002; Blevin 2004; Baker *et al.* 2005)

Characteristic	***Intrusion-related gold systems*** (Thompson et al. 1999; Lang and Baker 2001)	***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 metaluminous felsic to intermediate intrusions*	*Quartz-diorite (the nature of the intrusive will be investigated in future)*
Fluids	*Carbonic fluids*	*To be investigated in future*
Alterations	*Locally restricted, commonly weak hydrothermal alteration*	*Local and non-pervasive hydrothermal alteration*
Metal assemblage	*Gold with high Bi, W, As, Mo, Te, and/or Sb*	*Gold with high W, Cu, Te, As, Fe, Bi, Sb*
Sulfide Content	*Low sulfide mineral content, mostly <5 vol%,*	*Mostly <5 vol%,*

Conclusions

The Tareek Darreh area (Fig. 1) is composed of an alternation of shale and sandstone of Jurassic age into which some intrusives (quartz diorite, diorite, gabbro and gabbrodiorite) have intruded. Diverse alterations (including clay, Fe-oxide, epidote alteration and silicification) 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 along the contact. The intrusives have been attributed to Jurassic age (based on the 1:100,000 geological map). 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 paragensis, 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 compatible with the Intrusion-Related Gold System model (Thompson *et al.,* 1999; Lang & Baker 2001; Hart *et al.,* 2001; Baker 2002; Blevin, 2004; Baker *et al.,* 2005; Tab. 6). The correlation of the gold mineralization with tellurium, arsenic, bismuth and antimony is another indication for high temperature of mineralization. Nevertheless, more investigations are needed (including study of the nature of intrusive bodies and mineralizing fluids) in order to consider this deposit as part of a true intrusion related gold system. Despite the presence of vast mineralization all over the study area, most of the mineralization is of minor economic importance due to small size. Mineralization is only considerable in four zones which have been proposed for further investigations (Fig. 3) and are as follows:

Zone No. 1: is located in the south of the study area. Seven trenches were dug in this zone from which a total 36 samples were taken for ICP analysis. The highest content of gold was recorded in one of the samples from this trench with 0.8 m length (0.45 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 among the other zones. Almost all samples that have been taken from the quartz diorite unit show high contents of gold. The average content of gold is 3.66 ppm 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 12.8 m length is 1.18 ppm.

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

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