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Geochemistry and genesis of Darb-e-Behesht porphyric copper index, South Kerman, Iran

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The Copper Deposit area of Darb-e Behesht is located in south of Kerman province, at a 45 km distance from South Rayen. In terms of structural states the study area is considered as a part of the magmatic Urmia-Dokhtar belt. Main rocks of the region include Andesite, Andesite Tuff and Granodiorite. In some areas, Copper mineralization is observed as Malachite, Azurite, Chalcopyrite and Colic in Granodiorites and rocks in their contact zones. Field and geochemical studies indicated that Darb-e-Behesht Copper index is most similar to Porphyry type deposits because copper mineralization in granitoid intrusive rocks has happened along with propylitic, argillic and sericitic alterations. In addition to this, the geochemical combinations of studied rocks fall under the sub-alkaline, calc-alkaline type rocks category. This matter along with their geological environment, are recognized as the plates 'convergent boundaries are among the most important geochemistry reasons to introduce this deposit as a propylitic one.

Key words: Urmia-Dokhtar, Darb-e-Behesht, Porphyric Copper, Geochemistry, Genesis

INTRODUCTION

Porphyric copper deposits have always been under earth science researchers due to their high importance. Guilbert&Park [6] introduce porphyric copper deposits as deposits with high tonnage, low-grade non-twin which are generally associated with acidic to intermediate plutonic igneous rocks. Sawkins [10] has analyzed time and place of the geological formation of porphyry deposits. He believes that although porphyry deposits have always had a chance to be formed in geological times, their most important has been from the Late Cretaceous until now. Also, on the geological environment of these deposits' formation, Sawkins [10] believed that the malicious borders of the layers have been most likely to form these deposits and in fact, areas with subduction are the geological environment position for porphyric deposits; thus, identification and exploration of porphyry deposits are most likely in the magmatic or island arcs. Copper mineralization in the magmatic belt of Urmia-Dokhtar in central Iran has long been of interest to geologists because many of them believe the magmatic belt of Urmia-Dokhtar is in fact a magmatic arc which's most activity has occurred during the Eocene [3]. As an example, Waterman& Hamilton [12] have evaluated the Sarcheshmeh copper deposit in the magmatic belt of Urmia-Dokhtar and concluded that this deposit is Porphyric type. Shahabpour [11] has studied the alteration and mineralization of copper – molybdenum in Sarcheshmeh's copper mine and concluded that it is a porphyric copper deposit. Aftabi and Ataapour [1] have studied the magmatic activities' geochemistry and petrologic characteristics in Sarcheshmeh and DehSiahan regions in the magmatic belt of Urmia-Dokhtar and concluded that the deposits have similar conditions to Porphyricdepostis. Hezarkhani [7] has investigated the evolution of hydrothermal systems in Midook copper mine of Urmia-Dokhtar magmatic belt and concluded that copper mineralization in Midook has the conditions of Porphyric deposits. Copper deposit of Darb-e-Beheshtis located in south Rayen and the magmatic belt of Urmia-Dokhtar. Geochemistry and genesis of this deposit has been studied for the first time which's results will be presented separately but before that the geology of the region is described.

GEOLOGICAL SETTING

Darb-e-Behesht area is located in central Iran and magmatic belt of Urmia-Dokhtar in terms of Iran's structural state divisions [5] (cf. Figure 1) and is also considered as a part of Dehaj-Sarduiehbelt based on Kerman area divisions. The Dehaj-Sarduiehbelt with a length and width of 450 km and 90km respectively begins from northwest and west of Kerman, Anar and Dehajareas, and continues to southeast of the province (Jabālbārez Jiroft). Wide parts of this layer are covered by Eocene volcanic complex including Andesitic, Andesitic- Basaltic, Basaltic- Trachyte, Rhyolite, Trachyte- Andesitic, Trachyte- Basaltic along with related pyroclastic. This volcanic complex is penetrated by granite and granodiorite

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intrusive and hydrothermal solutions have caused extensive alterations and copper mineralization in the area. Volcanic-plutonic belt of Dehaj-Sarduieh is a part of the Sahnd-Bazman zone in Kerman province which is formed from extrusive (basalt, track basalt, andesite, dacite and rhyolite) and intrusive igneous rocks (diorite, granodiorite, quartz and granite) of Eocene and Neogene which are cut by granitoid masses with combination of diorite, granodiorite-quartz, quartz and granite oligomiocene.

Granitoids generally have the condition for potassic, sericitic and propylitic alteration. Being tourmaline is also seen in a large number of samples. The abundance of alkali feldspar in field and microscopic observations indicate that these rocks are rich in potassium.

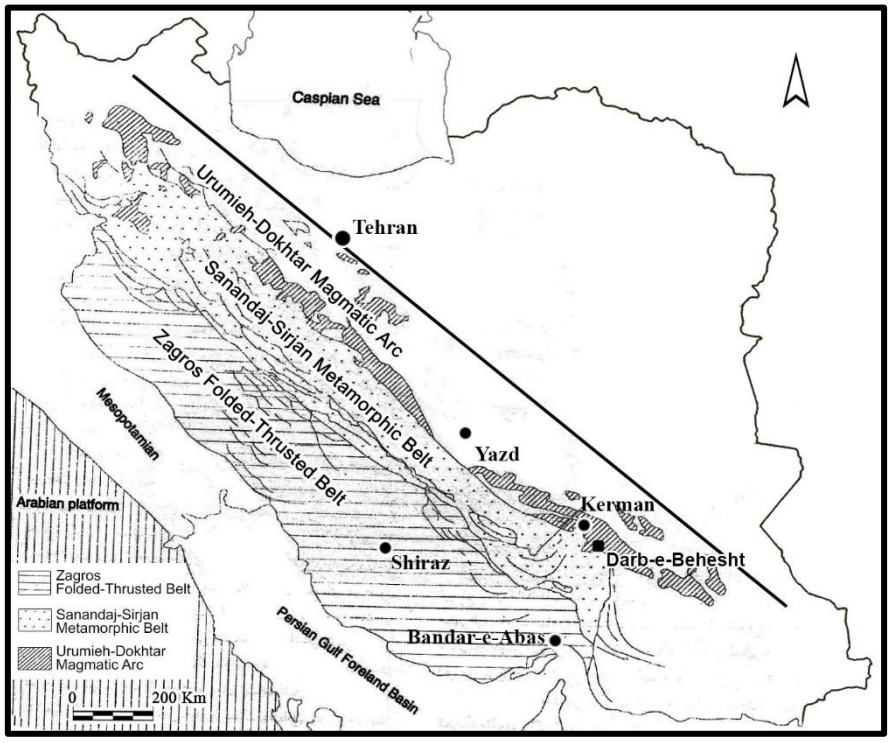


Fig. 1. Condition of Darb-e Behesht area in the Magmatic Arc or Urmia-Dokhtar in the Structural States Map of Iran, (Base Map from Ghorbani [5]).

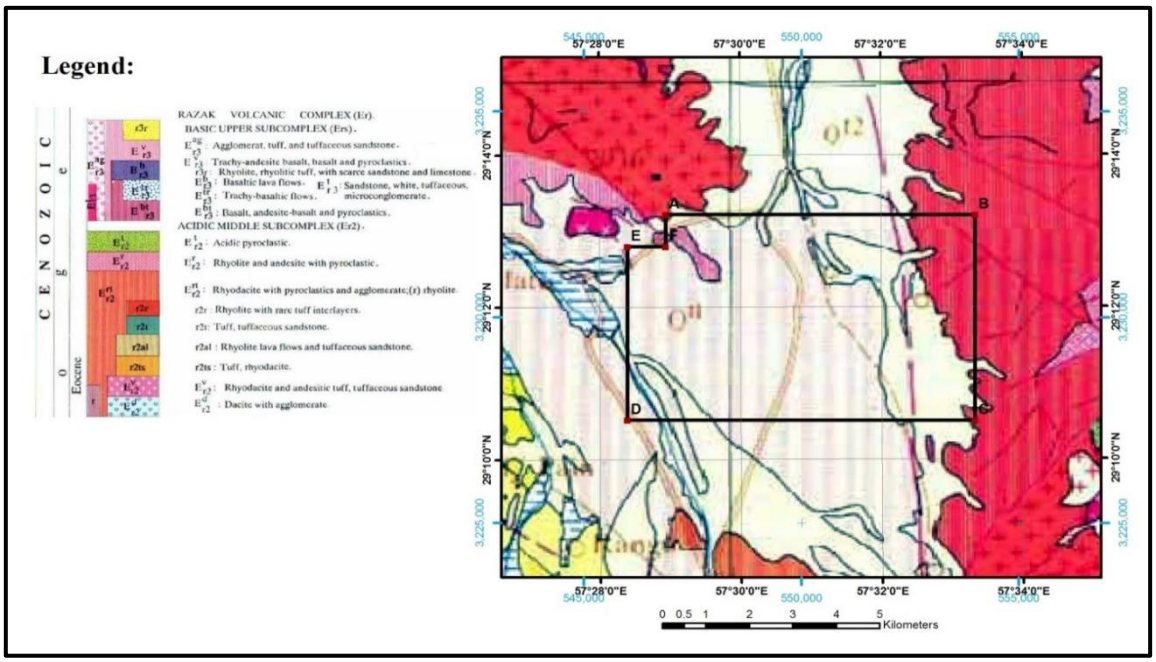


Fig. 2. - Geological map of copper deposit of Darb-e Behesht area (derived from 1: 250,000 map of Bam [4]).

Figure 2 shows a slice of the geological map of the area. Large parts of this layer is covered by volcano-sedimentary complex of Eocene including andesitic, andesitic- basaltic, basaltic- trachyte, rhyolite, trachyte- andesitic, trachyte- basaltic along with related pyroclastic. This volcanic complex is penetrated by granite and granodiorite intrusive and hydrothermal solutions have caused extensive alterations and copper mineralization in the area.

According to field studies conducted in the region it was concluded that the main stones in the area include andesite (Fig.3), granodiorite (Fig. 4) and andesitic tuffs (Fig.5).Surface copper mineralization is often seen as malachite (Fig. 6) but sometimes azurite and a less amount of chalcopyrite are also observed on the surface. Studying the microscopic sections has also confirmed the existence of copper minerals such as malachite (Fig. 7).

Fig. 3. Outcrop of andesitic rocks in Darb-e Behesht area.

Fig. 4. Close-up of granodioritic intrusive rocks in Darb-e-Behesht deposit.

Fig. 5. Andesitic tuff outcrop in Darb-e-Behesht area with propylitic alteration.

Fig. 6. Mineralization as malachite in epidotic alteration zones.

CHEMICAL STUDY OF ROCK SAMPLES

In order to complete geological studies, analysis of rock samples of Darb-e-Behesht area was on the agenda. Chemical analysis took place by XRF method in Kansaran Binalud laboratory in Tehran. Table 1 shows the results of the chemical analysis. The results of chemical analysis of rocks were processed by Minpet software which will be presented separately later.

Chemical Nomenclature of Rocks

For this purpose, the charts of Cox et al. [2] were used. On this basis, the volcanic rocks of Darb-e-Behesht, according to Figure 8, are located in in the andesite, dacite to rhyolite range. Also, Figure 9 displays the positions of studied inner rocks which indicate that the inner rocks of Darb-e-Behesht match with microscopic studies in granite, granodiorite, tonalite to diorite range.

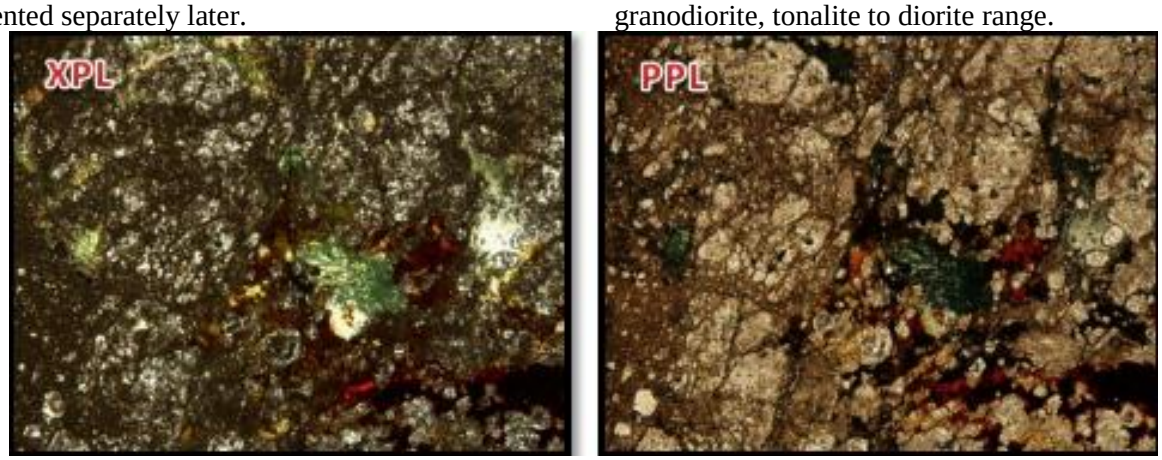


Fig. 7. Malachite (green) in altered volcanic rocks, Darb-e-Behesht area (Magnification x40).

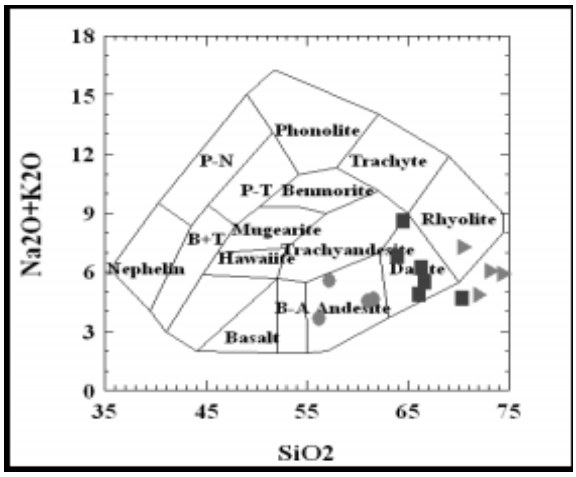


Fig. 8. Position of Darb-e-Behesht volcanic rocks in Cox et al. charts [2].

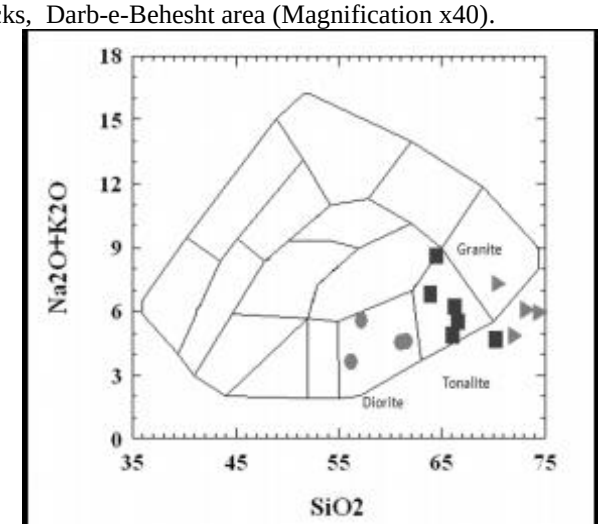


Fig. 9. Position of Darb-e-Behesht Plotunic rocks in Cox et al. charts [2].

Geochemistry Study

After chemical classification of rocks, a geochemical study was on the agenda to determine their magmatic series. According to the plotted graphs it was found that decomposed rocks are in the magmatic sub-alkaline series (Fig. 10); also, geochemical studies demonstrated that the majority of the analyzed samples are within the calc-alkaline series (Fig. 11).

DETERMINING THE GENESIS

In order to determine the geology environment of Darb-e-Behesht magmatic rocks' genesis, the results of chemical analysis of rock samples were used. For this purpose, the results of these analyses were processed in Minpet environment and using Pierce rock samples of Darb-e-Behesht copper

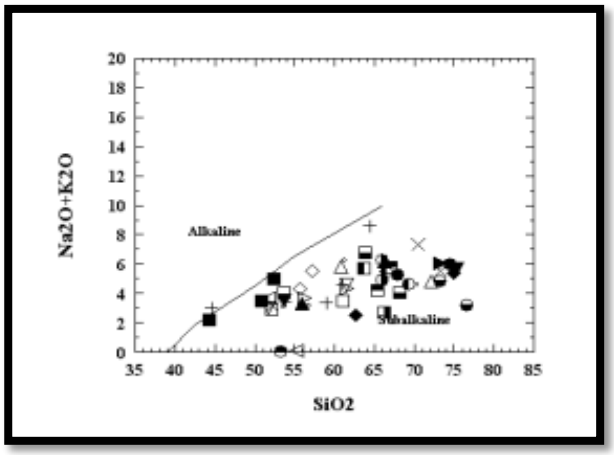


Fig. 10. Situation of Darb-e-Behesht rocks in Irvine and Baragar, chart [8].

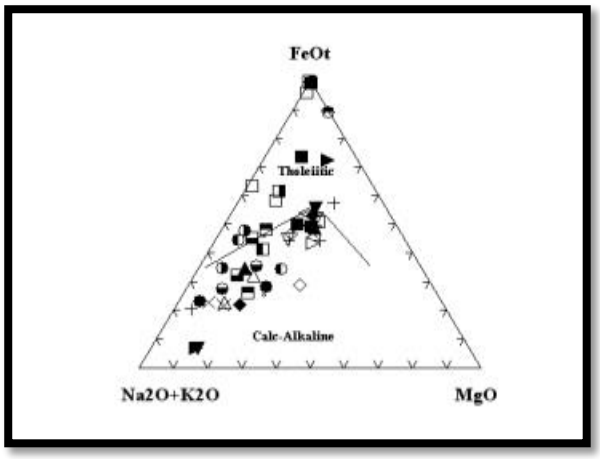


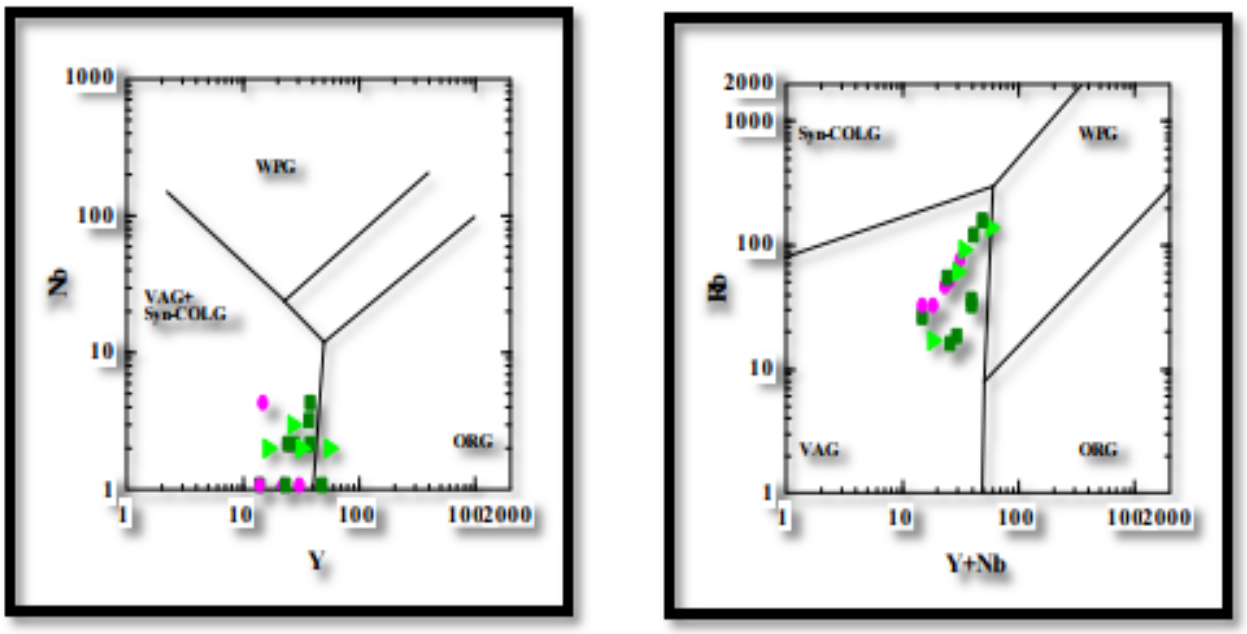
Fig. 11. Situation of Darb-e-Behesht rocks in AFM chart.

index are within Volcanic arc granitoids (Fig. 12 & 13). With such assumption, mineralization origin of copper can be considered the same as deposits related to magmatic arcs, that is Porphyry copper deposits.

DISCUSSION AND CONCLUSION

The results of this study can be summarized in the following cases:

- Copper deposit of Darb-e-Behesht is located in Dehaj-Sarduieh zone of Urmia-Dokhtar magmatic belt and thus it follows this region's lithology, mineralization and structural characteristics.
- In lithology terms, andesite, granodiorite and andesitic tuff are the most important occurrences of the region.
- Copper mineralization of this region is observed as chalcopyrite, malachite, azurite and sometimes covellite.
- The magmatic rocks of Darb-e-Behesht area are within calc-alkaline to sub-alkaline magmatic series.
- Granodiorites of Darb-e-Behesht area are within granodiorite groups related to magmatic arcs, that is layers' convergent boundaries. Thus, considering their magmatic series it can be assumed that copper mineralization in this area is related to copper porphyry deposits. Field evidences including alterations observed in this area, including the Sericitic and epidotic alterations confirm this matter. Epidotic alteration is considered a kind of propylitic alteration which occurs in copper porphyry deposits.



Figures 11 and 13 - Position of Darb-e-Behesht rocks in Pierce et al. [9] charts (VGA: Volcanic Arc granitoids).

Table 1- The results of chemical analysis of Darb-e-Behesht rock samples.

Sample	Cl	Ba	Sr	Cu	Zn	Pb	Ni	Cr	V	Ce	La	W	Zr	Y	Rb	Co	As	U	Th	Mo	Ga	Nb
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
T1S1	100	87	198	29	149	31	37	3	153	12	5	3	119	35	76	2	25	1	1	1	17	1
T1S2	272	146	361	53	89	13	33	1	213	7	4	2	103	23	35	2	64	1	1	1	15	1
T1S3	196	37	163	33	49	9	31	2	122	46	32	2	68	15	16	1	133	1	1	2	13	1
T1S4	362	173	965	110	123	16	39	1	132	20	7	1	160	27	51	4	79	1	1	1	13	1
T1S5	129	128	209	48	42	21	37	2	52	21	8	1	180	58	139	4	55	2	5	2	16	2
T1S7	219	77	294	6400	69	12	41	10	86	12	5	1	104	41	112	8	46	1	2	3	15	4
T1S10	113	129	283	8	58	19	34	4	60	32	11	4	297	64	111	3	67	1	1	1	15	1
T1S11	233	182	271	20	65	17	51	22	83	7	3	1	148	32	94	2	138	1	2	2	12	3
T1S12	216	97	419	116	47	24	37	33	127	29	12	1	139	19	26	1	126	1	1	1	14	1
T1S13	120	125	444	15	42	22	38	15	123	44	18	4	179	27	25	5	2	1	2	3	14	2
T1S14	136	103	391	26	43	15	38	2	126	25	11	2	159	27	24	2	20	1	1	2	16	1
T1S15	283	140	419	28	39	24	46	29	141	12	5	1	156	27	62	2	134	1	1	2	16	1
T2S2	183	41	381	30	50	35	37	4	83	19	12	5	136	18	18	1	31	1	1	1	13	3
T2S5	159	118	288	52	43	19	43	20	102	26	5	2	135	20	28	1	194	1	1	1	13	1
T3S4	125	153	184	32	34	14	34	2	42	32	21	3	115	39	105	1	67	1	2	1	18	1
T3S6	67	148	382	161	78	13	40	1	172	12	3	1	128	33	70	2	37	1	1	1	16	1
T3S8	113	113	444	12	48	10	35	1	120	29	15	1	146	24	41	4	87	1	1	1	13	1
T3S9	135	143	387	74	77	9	39	2	140	8	6	2	137	26	48	1	1	2	1	1	16	2
T3S10	97	55	570	23	41	27	37	1	31	5	3	1	293	30	17	3	2	1	1	2	17	2
T3S12	155	66	4	164600	86	34	18	1	57	11	5	1	9	2	15	2	58	1	7	48	2	1
T3S13	106	132	361	102	62	12	38	2	137	21	10	4	139	24	43	6	118	1	1	2	16	1

Sample	Cl	Ba	Sr	Cu	Zn	Pb	Ni	Cr	V	Ce	La	W	Zr	Y	Rb	Co	As	U	Th	Mo	Ga	Nb
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
T4S10	166	183	355	14	29	17	40	31	124	20	11	2	152	25	50	4	27	1	1	3	15	1
T4S13	141	10	29	21500	77	54	33	7	35	4	2	3	11	1	15	3	531	1	2	2	7	1
T4S14	128	3	2	5	32	35	34	9	104	5	3	1	4	2	16	4	200	1	2	1	6	1
T4S15	364	99	405	78	40	24	31	11	70	35	12	3	126	41	30	3	152	1	1	2	16	2
T4S23	828	205	404	25	32	10	48	34	149	9	4	1	150	52	147	3	2	2	1	2	16	1
T4S24	157	52	277	24	32	30	34	5	40	15	5	2	127	15	24	4	1	1	2	1	13	1
T4S26	381	186	646	261	74	18	42	3	79	18	11	1	233	41	75	1	173	1	1	2	18	3
T4S27	347	151	508	167	55	22	37	9	56	36	14	4	191	38	90	1	12	1	1	3	15	1
T5S1	74	136	317	60	98	14	83	64	135	26	10	5	162	35	72	2	2	2	2	2	15	1
T5S2	75	124	329	72	98	24	63	47	217	23	8	1	117	27	47	2	21	1	1	4	16	1
T5S3	98	105	542	97	78	7	36	7	170	3	2	2	102	16	22	3	69	1	1	2	16	1
T5S4	87	146	326	70	89	22	84	78	136	44	15	1	159	37	69	3	2	1	1	4	16	2
T5S7	115	58	514	27	71	2	52	28	111	7	4	1	126	16	30	4	126	1	1	2	16	4
T5S8	68	22	247	107	80	12	28	4	146	40	15	2	100	15	30	4	42	1	1	1	10	1
T5S9	95	155	388	64	107	25	77	65	129	57	21	2	156	33	63	4	19	1	1	1	14	1
T5S10	94	172	311	56	107	21	95	106	148	48	11	1	190	36	66	2	4	1	1	2	15	1
T5S11	98	141	450	62	85	19	57	48	120	9	5	1	157	29	58	1	1	1	1	2	15	2
T5S13	72	155	305	59	99	21	91	98	134	70	18	2	184	38	71	1	77	1	1	3	13	3
T6S1	113	163	387	46	80	16	77	55	106	7	3	1	163	30	61	1	1	1	1	1	15	1
T6S2	108	174	313	48	100	29	102	90	134	46	11	2	184	38	82	1	1	2	2	3	15	2
T6S3	103	179	306	52	90	25	103	98	125	10	5	1	189	39	75	2	17	1	1	5	14	2
T6S4	84	173	288	48	91	24	106	106	124	62	7	3	171	37	80	3	24	1	1	2	15	3

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