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Sistan and Baluchestan Province, East Iran, Middle East: Some New Data On Alpine Magmatism And Tectonics, Melt And Fluid Inclusions; Some Data On Metallogeny, Hydrocarbons (HC, OIL) in The Region, And Constraints

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Abstract.
Cenozoic tectonic-magmatic-metallogenic events in East Iran, Middle East and also in Lesser Caucasus (data by N.A. Imamverdiyev et al.) have some common similarities. Important geological – metallogenic +- OIL / HC correlation for the Alpine time exists (metallogeny of East Iran led by outstanding regional trio: E. Romanko, A. Houshmandzadeh, and M.A.A. Nogole-Sadat). Geological northeastern (NE) zoning and “hot” tectonics due to the African superplume activity including, probably, known delamination of lithosphere during collision of mantle lithosphere ca. 13 Ma is principal here. Intraplate alkaline-subalkaline rocks of the region studied including Quaternary real carbonatites of Hanneshin, Afghanistan were derived from enriched African superplume-related mantle sources being enriched in HFSE - Nb, Ta, Zr, Y, P, Ti. Late Cenozoic High-K calc-alkaline rocks in the Lesser Caucasus could be deal with African superplume activity too despite their subduction-related rock geochemistry. Important data exist about a general meridianal-close (ca. N-S) zoning of oil / hydrocarbons (HC), muds, salts etc. here. This is one of arguments in favor of deep HC input alongside to traditional HC interpretation too. Large regional economic Cu-Au porphyry etc. metallogeny deals mainly with Eocene (Pg2) shoshonite – latite series rocks formed during subduction of Arabian plate beneath the Central Iran.

Keywords: East Iran, Middle East, conjunction in Alpine-Himalayan mobile belt, geology, geochemistry, tectonics, magmatism, metallogeny, African superPlume, delamination, mineralogy, melt and fluid inclusions, northeastern (NE) tectonic-magmatic-metallogenic +- oil / hydrocarbons (HC) zoning.

Introduction

Studied territory is a part of the famous Alpine and Himalayan amazing structures the very conjunction in one mobil belt (Stocklin et al., 1965; Milanovsky, Koronovsky, 1973; Nogole-Sadat, 1985; Houshmandzadeh et al., 1986; E. Romanko et al, 1984; Khain, Leonov, 1988; etc. and etc.). This region is geologically, economically extremely important, surely. Its geo-investigation is irregular and sometimes even poor. Poor studied east Iran area was investigated under the leadership of outstanding geo-trio as known regional geologists Dr. E. Romanko, Dr. A. Houshmandzadeh, and Dr. M.A.A. Nogole-Sadat. We present some new different and literary materials.

Geological and tectonic data

General geology and tectonics of this geologically very interesting region were described in such works as follows: (Stocklin et al., 1965; Nogole-Sadat, 1985; Houshmandzadeh et al., 1986; Khain, 2001; Leonov et al, 2010; Trifonov, Ruzhentsev, 1984, etc., fig. 1-2).

Two groups of magmatic rocks were revealed here by our team as: mainly Eocene shoshonitic-latitic etc. rocks of the first group (subduction-related one) and principally other rocks - Neogene – Quaternary intraplate subalkaline and alkaline ones, second group (Romanko et al., 2005).

Differentiated rocks of the **first group** are the products of a large mainly Paleogene subduction of the Arabian plate beneath the Central Iran block (Fig. 1). This subduction is confirmed by the regional tectonic analysis (Khain 2001; Leonov et al., 2010), High-resolution tomography by known J. Ritsema's team (Bull et al., 2009 etc.), geochemistry (Romanko et al., 2013; etc., fig. 1) etc. Catastrophic earthquakes up to 8M and more, eunfortunately, are not rare here. A recent catastrophic precedent is 2003 Bam earthquake in East Iran with a lot of casualties. Strong seismic hazards in Pakistan, Agfghanistan, Turkey etc. including the very 2015 year bring civilian and economic damage.

Antipodes of the **second group** related to African superplume activity are: intraplate K-Na subalkaline and alkaline rocks – High-Ti trachybasalts, trachyandesites, real Quaternary carbonatites of Hanneshin, Afghanistan, Late Cenozoic carbonatites of Arabia, also Neogene lamproites of Algeria etc. by E. Romanko et al., 1988 and Romanko et al., 2013 (tables 1-11, fig. 1-2, 9-11; Bogatikov et al., 1987; Luchitsky, 1985; Shilov, 1997; Yarmolyuk et al., 2001; Knipper et al., 1992 etc.).

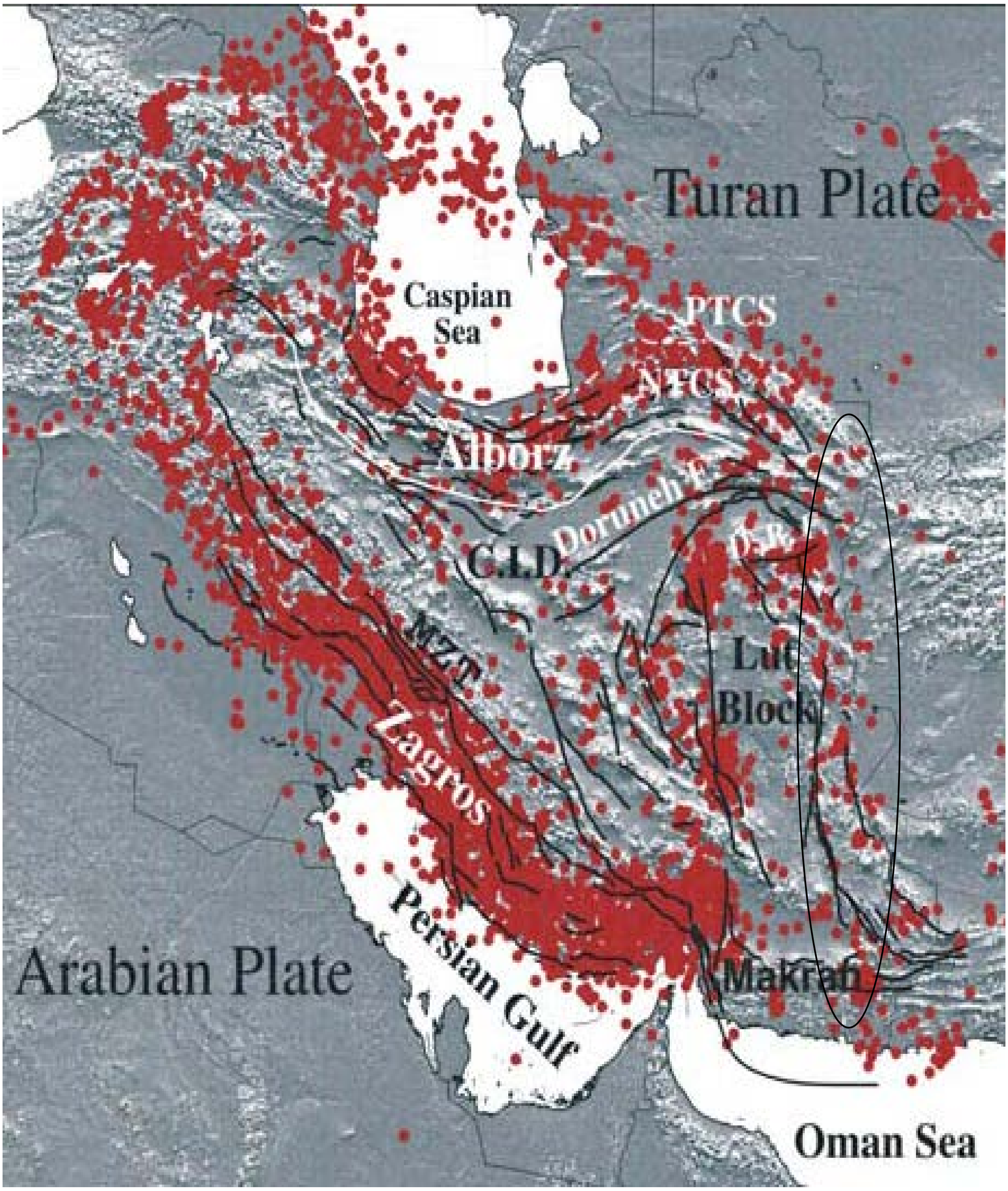

Fig. 1. Distribution of earthquake epicenters - red circles - in the Middle East after (Alinaghi et al., 2007). We can see known Lut Block and immediately next to the east - studied East Iran zone and adjacent structures marked by oval.

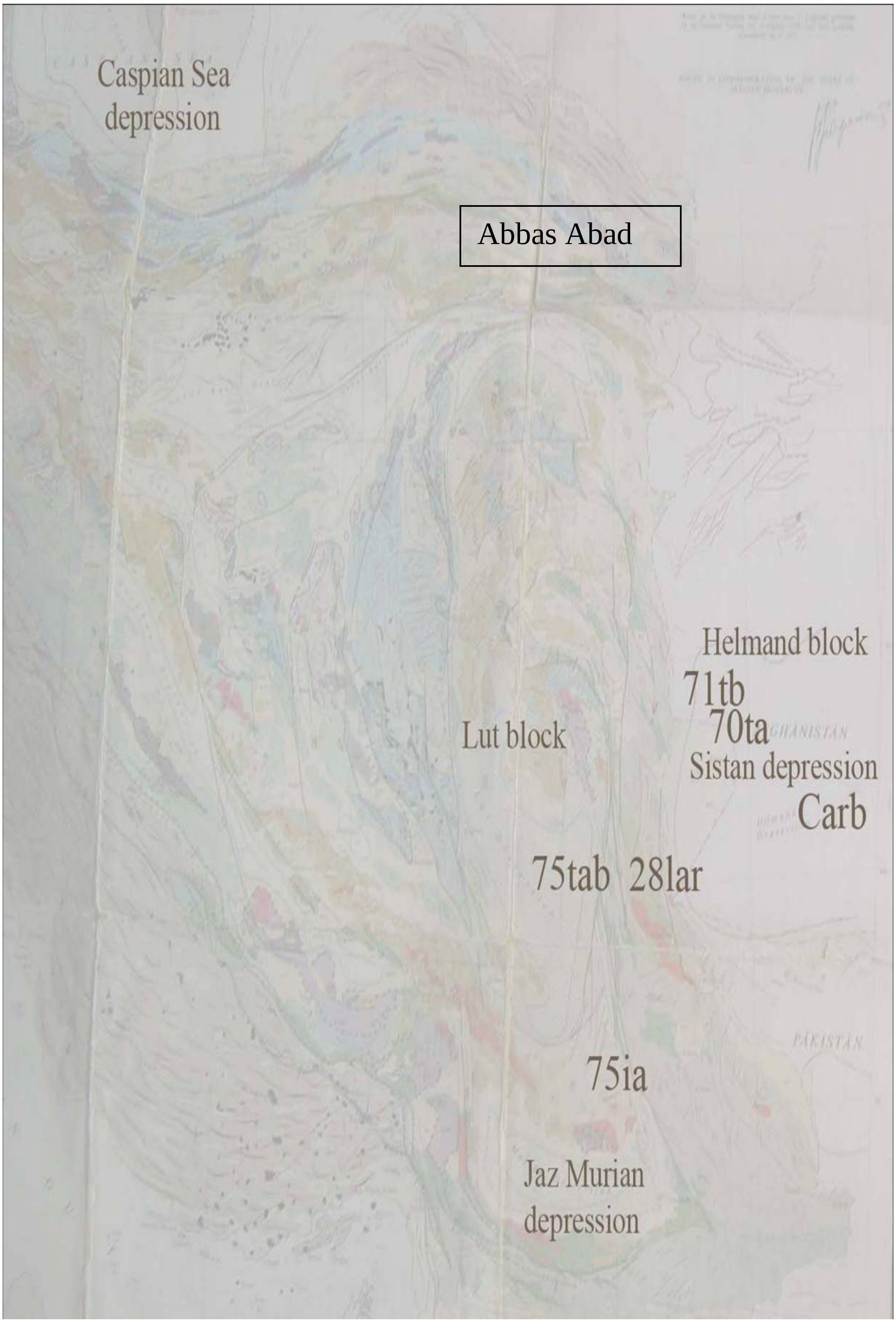

Fig.1-2. Magmatic samples position in East Iran using Geological map scale 5: 000 000. R-70, R-71 – intraplate rocks in Sistan, R-75ia - High K-dacite with a high crystallization temperature as shown in text, Carb = carbonatites of Hanneshin, Afghanistan, R-28 – Lar alkaline intrusion with Cu-Au porphyry mineralization, Abbas Abad – important area with Cu deposits, tab = basic trachyandesite, tb = trachybasalt.

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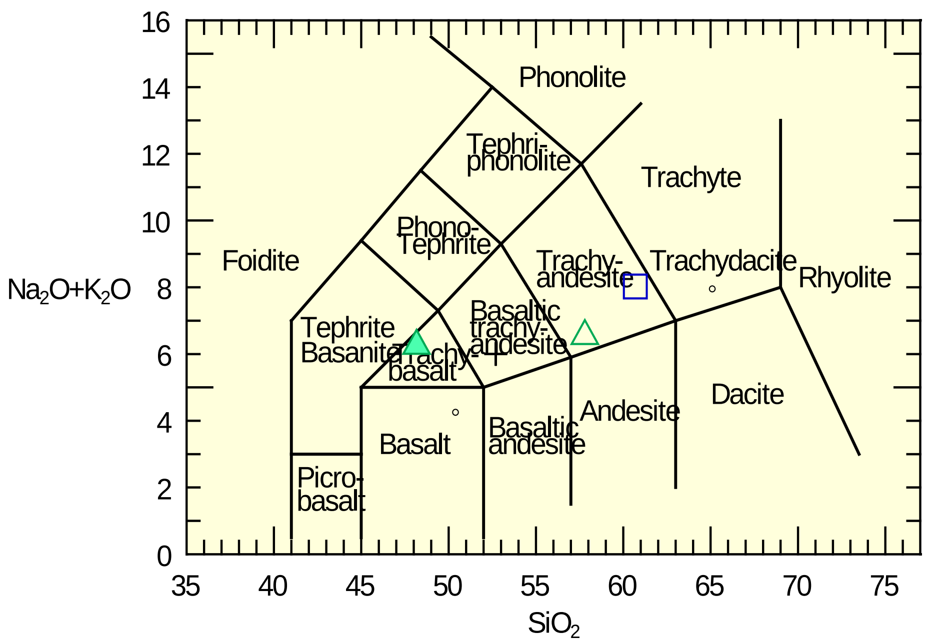

Fig.2-1. Na_2O+K_2O (wt %) versus SiO_2 (wt %) or TAS diagram. Triangles - intraplate rocks of East Iran, N? age, quadrangle – Lar alkaline intrusive massif with Cu-Au mineralization, Pg3? age, E. Iran/ W. Afghanistan border. Dot – trachydacite of shoshonite – latite series, Kurama zone, Tien-Shan, C3-P1, analogue of Pg2 shoshonite – latite series (Lesser Caucasus - Central Iran - East Iran).

LeBas et al 1986

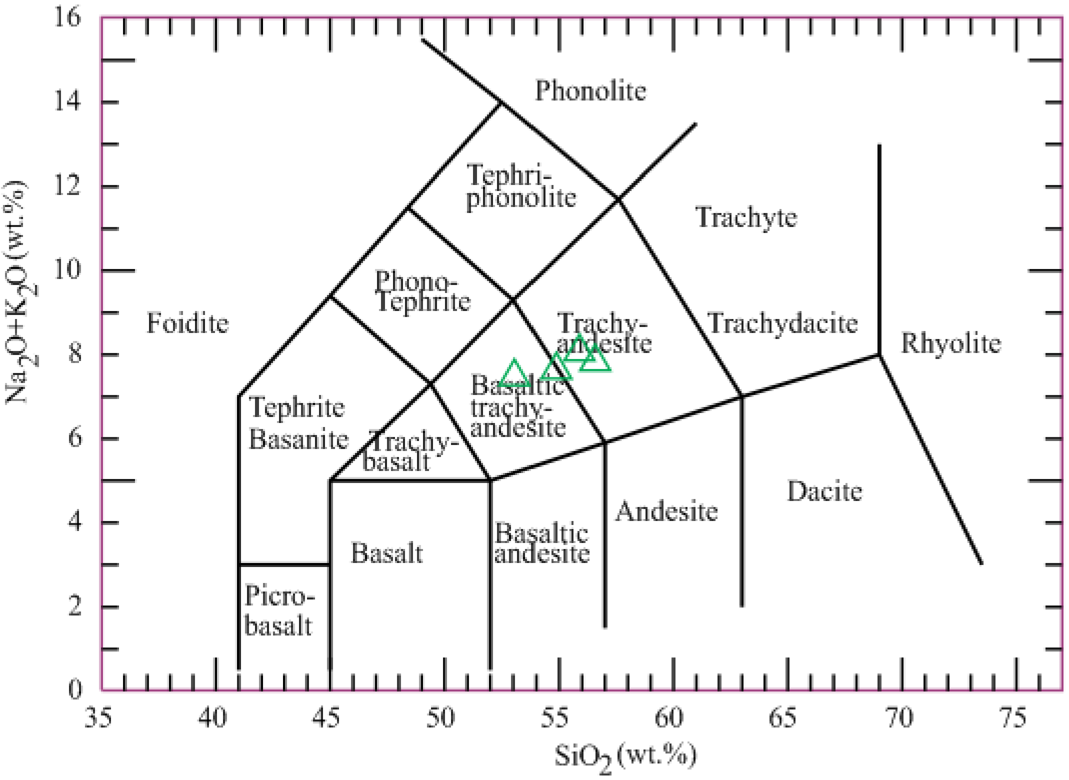

Fig.2-2. Na_2O+K_2O (wt %) versus SiO_2 (wt %) or TAS diagram for the Abbas Abad Cu-mining area, Central Iran (NE Iran by a formal geography), Pg2? age. Samples of M. Heidari et al.

These intraplate rocks, in contrast to subduction-related calc-alkaline and other rocks, are characterized by an enrichment in both LILE - K, Rb, Ba, Cs and HFSE - Nb, Y, Ta, Zr, Ti, P, etc. (Tables or tab. 1, 5-11, fig. 3) with a characteristical positive Eu/Eu* - more than 1.0-1.1. Also, increased content of P_2O_5 - sometimes more than 1.0% (very high) - is a characteristic feature of intraplate rocks.

We have received fair low isotopic data $^{87}Sr/^{86}Sr$ (ISr) in two samples of intraplate rocks of the second type - trachyandesites R70-2 – 0.7039 ÷ 0,2 (high K/Rb=393) and trachybasalt R71-4 – 0.70489 ÷ 0,18 (K/Rb=375, fig. 4). For subduction-related calc-alkaline andesite of stratovolcano Bazman, sample R-25 was determined a rather low value ISr = 0.70456 ÷ 0.05, K/Rb=250 (tab. 1). Isotopic data of these our intraplate rocks differ from collisional and subduction-related rocks from Anatolia, Turkey (Khain, 2001; Imamverdiyev, 2008 etc.). Igneous rocks of the volcanic rocks are fully differentiated series of the regional known Sahand – Bazman belt. Known mainly andesite stratovolcanoes in this belt are: Bazman with a height 3490m and Taftan - 3940m (old mark was 4042m). Old 0.7049 isotopic date for a ‘volcanite’ of an unnamed volcano in a desert was reported by Canadian team (Camp, Griffis, 1982).

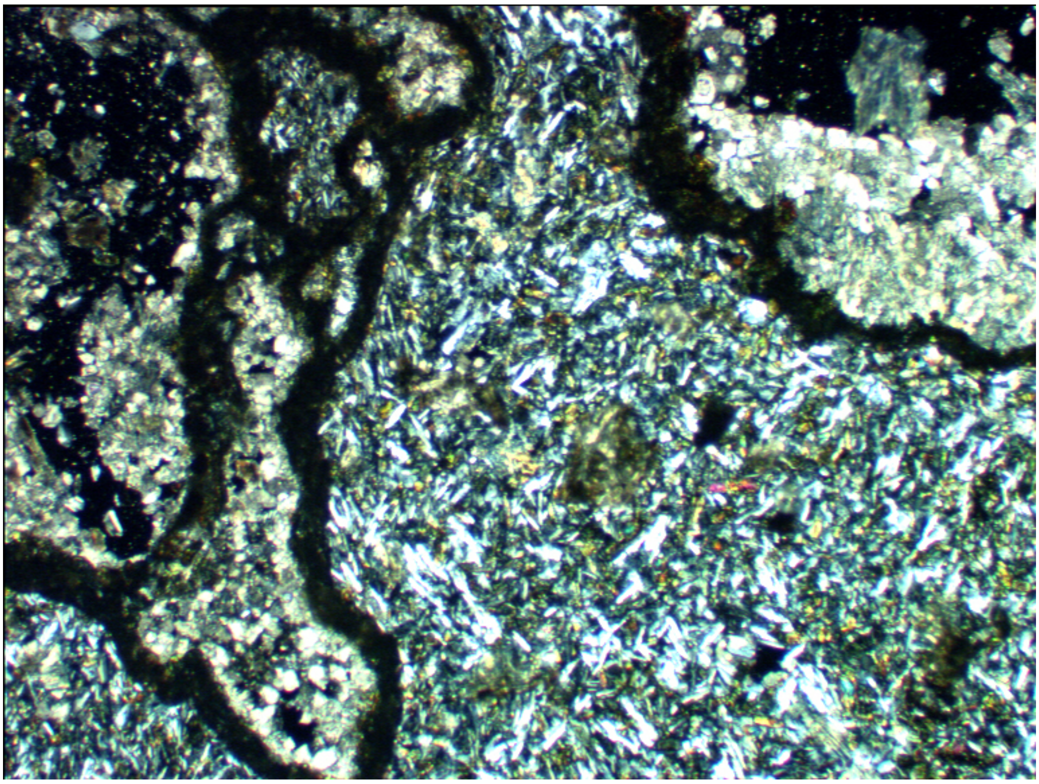

Fig. 3. Thin section in XPL. R-70 sample. Carbonate-bearing volcanite in Zabol area associated with real carbonatite in Hanne shin structure, Afghanistan. Carbonate is in individual areas of thin section, left and upper right. Up to 33.0 wt.% of CaO in same R-70 group volcanites.

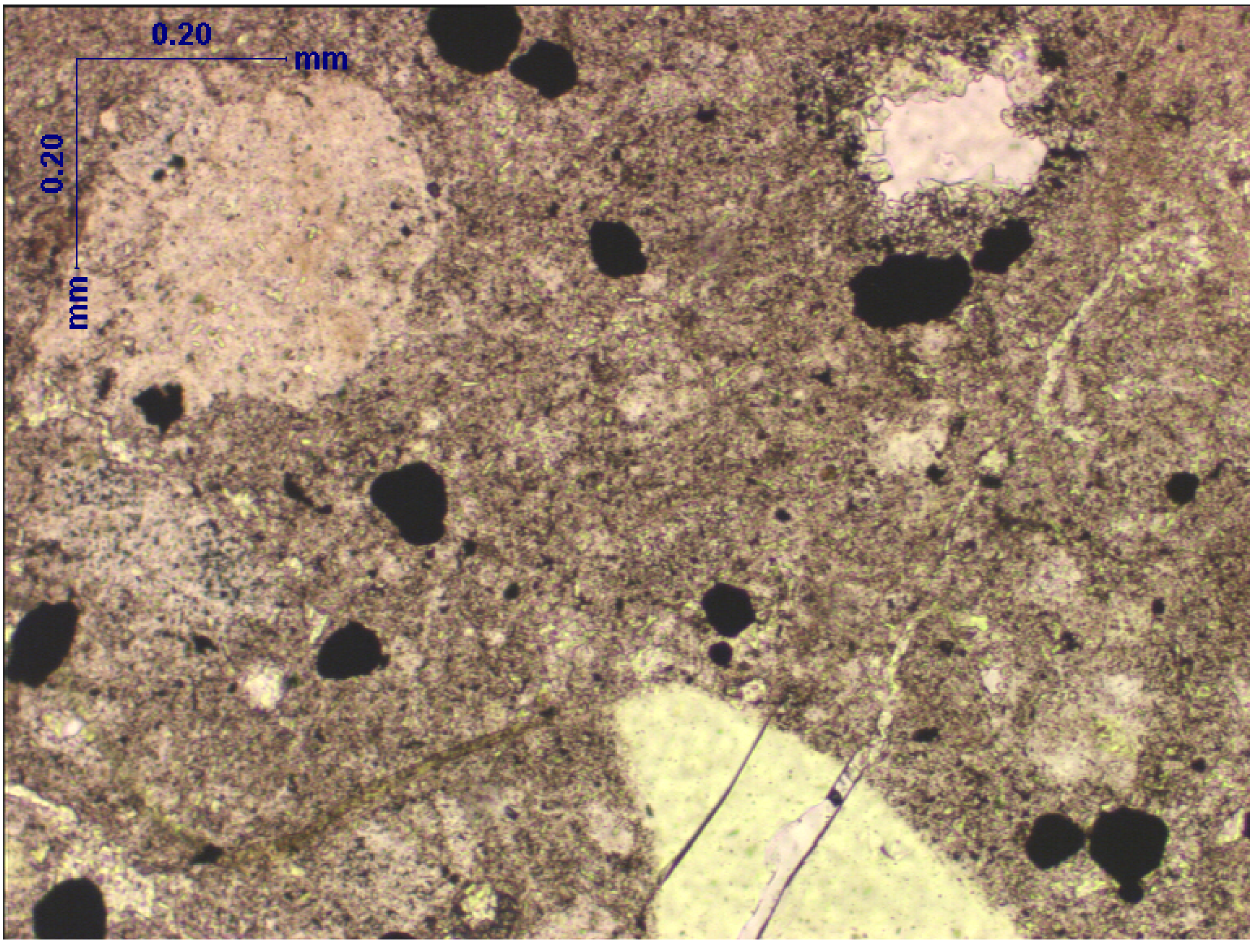

Fig. 4. Thin section in PPL. R-82 sample, Quaternary? calk-alkaline rhyolite. Bazman stratoVolcano (N-Q age). Quartz – down of thin section. Dark grains - ore minerals.

Table 1. Major- and trace-element composition in the rocks studied

Sample	1	2	3	4	5	6	7	8	9
SiO_2	48.17	57.80	54.50	54.00	60.69	65.39	65.10	85.00	58.67
TiO_2	2.20	1.31	1.87	1.52	0.36	0.42	0.51	0.60	1.70
Al_2O_3	3.80	17.48	15.94	-	15.32	13.71	15.54	4.00	15.13
Fe_2O_3	9.32	4.37	6.39	6.25	2.70	3.25	2.42	3.21	6.69
FeO	2.56	1.07	0.40	-	2.07	-	2.32	1.10	2.19
MnO	0.14	0.09	0.09	0.08	0.09	0.057	0.13	0.02	0.09
MgO	5.75	2.27	3.37	-	3.65	1.39	1.72	0.52	2.28
CaO	8.98	7.10	7.58	7.40	3.90	2.08	2.80	0.29	1.77
Na_2O	4.93	5.11	5.81	-	3.64	2.87	3.36	0.28	5.06
K_2O	1.31	1.42	1.73	1.09	4.38	4.51	4.59	0.21	2.05
P_2O_5	0.23	0.61	1.05	-	0.31	0.11	0.20	0.09	0.30
Rb	30	19	20	15	145	117	109	7	47
Ba	375	293	-	292	1230	577	1597	390	557
Sr	1185	912	4470	950	870	232	359	440	263
Ni	86	53	58	59	50	7	13	10	44
Co	33	14	-	-	12	5	6	4	21
Cr	64	60	38	<64	50	16	18	11	72
V	220	95	-	-	81	63	54	55	107
Cu	63	65	64	77	69	15	11	17	33
Zn	113	88	113	98	32	40	57	8	82
Pb	5	20	51	5	20	27	22	20	10
Zr	283	232	339	217	96	158	246	136	219
Y	25	19.5	25	15	15	11	29	13	23
Nb	23	17	19	-	5.8	8	12	6	30
Sc	19	10.7	-	26.2	10	-	-	6.5	10
Th	3	3.65	-	4.84	12	-	16.7	1	12
U	1.2	0.99	-	1.31	1	-	4.62	3	3
La	44	32.4	-	30	18	-	34.0	15	35.2
Ce	101	68.3	-	63	32	-	64.5	28	64.2
Nd	-	31.4	-	-	-	-	27	-	25.0
Sm	-	6.00	-	-	-	-	5.6	-	5.1
Eu	-	2.11	-	-	-	-	1.3	-	1.9
Gd	-	5.08	-	-	-	-	4.1	-	4.8
Tb	-	0.78	-	-	-	-	-	-	0.9
Er	-	1.64	-	-	-	-	1.9	-	1.6
Yb	-	1.26	-	-	-	-	1.7	-	1.6
K/Rb	560	620	586	581	245	307	350	230	350

1 and 2 - trachybasalt (sample R71-4) and trachyandesite (sample R70-2) correspondently, Haji lake, Neogene (?), Afghan block, 3 - trachyandesite, Baluchestan, Iran (Camp, Griffis, 1982), 4 - trachyandesite, R75wp, Lut block, 5 - syenite, Lar intrusiion with Cu-Au mineralization, Miocene(?) 6 – K-dacite, R75, Lut block, and 7 - trahydacite, standard, Kurama Ridge Middle Tien Shan, Karamazar, Tajikistan, Late Carboniferous - Early Permian, using data and

extrapolation from (Rusinov, Kovalenker, 1991; Razdolina, Moralev et al., 1993; Mamajanov, 2005; Romanko et al., 1989) 8 - leucorhyolite, R-82, East Bazman volcano, Quarternary(?), 9 - trachyandesite, continental rift, standard, Proterozoic, Pechenga area, Fennoscandian or Baltic shield, by Romanko et al., 1989.

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Table 2. Chemistry of melt inclusions glass (wt %) in plagioclase (1, 3), host mineral (2, 4), host acid K-volcanite (5), rhyolite from Bazman stratovolcano, and plagioclase standards (7-9) due to A. Betekhtin, 1953.

Sample	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Cl	S	Sum
1	74.77	0.19	12.94	0.58	0.08	0.12	1.52	3.88	3.93	0.26	0.00	0.01	98.28
2	58.69	0.01	24.77	0.23	0.00	0.01	6.68	7.22	0.49	0.00	0.00	0.01	98.11
3	74.48	0.15	14.53	0.53	0.04	0.10	1.69	3.02	4.10	0.00	0.01	0.01	98.66
4	58.36	0.00	24.71	0.28	0.02	0.05	7.15	6.90	0.46	0.04	0.00	0.01	97.98
5	65.39	0.42	13.71	2.93	0.06	1.39	2.08	2.87	4.51	0.11	-	-	-
6	85.00	0.60	4.50	3.98	0.02	0.52	0.29	0.28	0.21	0.09	-		-
7	58.16	-	26.57	-	-	-	8.35	6.92	-	-	-		-
8	56.05	-	28.01	-	-	-	10.1	5.89	-	-	-		
9	62.43	-	23.70	-	-	-	5.03	8.84	-	-	-		

1, 3 - melt inclusions glasses in plagioclase, 2, 4 - host minerals, 5 – hosted Hi-K-volcanite, sample R-75, 6 – leucorhyolite from stratovolcano Bazman, Quaternary(?), 7-9 plagioclase standards: 7 - andesite, SiO_2 = 58.16, empirical formula - $Na_{0.6}Ca_{0.4}Al_{1.4}Si_{2.6}O_8$, chemical formula andesite - (Na, Ca) $(Si, Al)_4O_8$, Webmineral.com, 8 - 9 - plagioclase theoretical composition: An_{50} (8) and An_{25} (9), by A. Betekhtin, Moscow, 1953**.**

Table 3. Sum of gases by thermobarogeochemistry (cub. cm / kg)

Sample	Sum of gase (Cubic cm/kg)	Rock, age, notes
1. R26	0.933	subvolcanites and shallow intrusions, West Taftan volcano, diorites, probably Miocene
2. R38	1.022	Lar intrusion, Oligocene-Miocene
3. R61	0.401	ophiolites, Cretaceous
4. R85	0.655	ophiolites, Cretaceous
5. R35	**12.942**	Subvolcanites intruding CARBONATIC rocks, West Taftan stratovolcano, maximal contain, probably Oligocene-Miocene. Highest content.
6. R66	1.262	Young Cu-Zn-Pb mineralization with Au and Ag, Taftan stratovolcano, probably Quaternary

Sum of gases includes H2, O2, N2, CO2, CH4, C2H6, C3H8, C4H10, C5H12, and C6H14. Temperature of Au mineralization is 220 – 278oC, Oligocene-Quaternary, important Lar intrusive massif with Au up to 25.4 ppm, T = 220–226oC by analyst R. Mudrogova, VNIIYG GB or Nuclear geophysics Institute, Moscow region (E. Romanko et al., 2000). Maximum of gases are in subvolcanites intruding CARBONATIC rocks. Minimum of gases are in ophiolite mélange rocks.

Table 4. $^{87}Sr/^{86}Sr$ (ISr) isotopic data from the rocks

Sample	$^{87}Sr/^{86}Sr$	Rock, mineral, age, notes
1.	0,7039+-0,0002	Trachyandesite, sample R-70-2, Hilmand (Afghan) block, maybe Neogene
2.	0,70489+-0,00018	trachybasalt, R71-4, lake Haji area, Hilmand (Afghan) block, maybe Neogene
3.	0,70456+-0,00005	calk-alkaline basic andesite, R-25-1, East Bazman volcano,

		Neogene-Quaternary
4.	**0,7049**	**'volcanite' by Camp and Griffis, 1982, No data about age**
5.	**0,7047+-0,0003**	**biotite from trachybasalt, sample 64, Shurab - Galecha, Eo-cene**
6.	**0,7048+-0,0003**	**dacite, sample 166, Eocene**
7.	**0,7051**	**andesite, sample 206, Eocene**
8.	**0,7055**	**biotite from andesite, sample 203, Cheh-meh-Huri, Eocene**
9.	**0,7059**	**andesite, sample 193-A, no age data**
10.	**0,7051**	**biotite from dacite, sample 143, Gazu area, no age**
11.	**0,7043**	**granodiorite, sample 146, no age data**
12.	**0,7045**	**granodiorite, sample 151, no age data**
13.	**0,7051+-0.0003**	**biotite from granodiorite, Gazu area, Campanian**

14.	**0,7048+-0,0003**	**biotite from dacite, Shurab-Galecha, Eocene**
15.	**0,7056+-0.0002**	**plagioclase from dacite, Eocene**
16.	**0,7065+-0.0003**	**biotite from dacite, Kuh-Berg, Eocene**
17.	**0,7070+-0.0003**	**granodiorite, Sor-Kuh, Middle Jurassic**
18.	**0,7041+-0.0001**	**Late Cenozoic magma, ENd= +4.1 +- 0.2, Great Caucasus**
19.	**0,7040**	**Late Cenozoic magma, ENd= +3, Great Caucasus**

1-3 - author's data, 4 - after (Camp, Griffis, 1982), 5-9 – Lut block, immediately west from

East Iranian zone, after Sandwall E., Turkell N. Zor E. et al., 2003;

18-19 – Geat Caucasus, courtesy of I. Chernyshev, S. Bubnov, A. Lebedev et al., IGEM, RAS, Moscow.

Table 5. Composition of rock-forming and accessory minerals

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13
SiO_2	55.45	54.11	55.20	43.79	44.65	46.25	46.87	53.86	54.54	64.49	68.94	68.61	0.018
TiO_2	0.26	0.19	0.22	1.88	1.71	1.84	1.36	-	-	0.26	-	0.13	29.79
Al_2O_3	1.51	1.52	1.50	11.37	7.88	7.69	6.40	29.51	28.22	17.82	17.20	17.85	0.02
Fe_2O_3	-	-	-	-	-	-	-	-	-	-	-	-	-
FeO	11.66	15.73	12.7	13.68	13.05	13.39	15.00	-	-	2.79	1.12	0.96	62.11
MnO	0.24	0.34	0.28	0.28	0.27	0.24	0.03	-	-	0.16	-	-	0.17
MgO	28.21	27.01	28.14	15.16	14.23	15.32	13.68	-	-	0.85	0.15	0.15	1.60
CaO	1.89	1.16	1.93	10.55	10.48	10.42	11.51	8.97	9.99	1.87	0.47	0.70	0.08
Na_2O	0.32	-	-	2.08	1.31	1.48	1.40	5.55	5.59	9.90	7.09	7.55	-
K_2O	-	-	-	0.49	0.38	0.44	0.75	0.28	0.34	1.78	4.96	3.71	-
P_2O_5	0.18	-	-	-	-	-	-	-	-	-	0.22	0.22	-

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1-3 – Orthopyroxenes, 2-3 – standard bronzites, orthopyroxenes, 2 – from andesite and 3 – from Hb-norite, by H. Kuno,1964; 4-7 – amphiboles; 8-9 – plagioclases; 10-12 – alkali feldspars; 13 – magnetite.

Table 6. Major elements composition in the rocks

Sample	1	2	3	4	5	6	7	8	9	10	11	12	13
SiO_2	48.17	49.0	52.76	54.50	56.95	57.80	35.10	44.26	46.10	56.7	60.69	61.79	85.00
TiO_2	2.20	1.69	1.11	1.87	1.27	1.31	0.74	0.81	0.49	0.60	0.36	0.52	0.60
Al_2O_3	13.80	14.1	17.44	15.94	16.40	17.48	13.48	12.70	10.30	11.1	15.32	17.10	4.05
Fe_2O_3	9.32	9.10	3.14	6.39	5.28	4.37	7.53	4.81	5.10	4.90	2.70	1.16	2.51
FeO	2.56	-	5.40	0.40	0.46	1.07	0.73	0.87	-	-	2.07	3.53	1.21
MnO	0.14	0.11	0.13	0.09	0.08	0.09	0.16	0.12	0.08	0.10	0.09	0.10	0.02
MgO	5.73	9.23	5.55	3.37	3.35	2.27	5.46	6.60	9.00	4.85	3.65	3.04	0.37
CaO	8.98	7.72	8.62	7.58	6.80	7.10	26.66	17.10	15.86	12.0	3.90	5.25	1.55

Na_2O	4.93	3.06	3.46	5.81	5.33	5.11	0.80	2.96	0.86	1.84	3.64	4.11	0.28
K_2O	1.31	1.84	1.31	1.73	1.50	1.42	0.10	0.42	2.36	1.95	4.38	1.58	0.21
P_2O_5	1.11	0.40	0.40	0.51	0.59	1.05	0.16	0.38	0.12	0.12	0.31	0.19	0.03

1-10 – Hilmand (Afghan) block: 1-3 – trachybasalts, 11 – syenite, Lar massif, 12 – 13 – Bazman volcano, Neogene – Quaternary, author's data;

2, 7,10 – data by A. Houshmandzadeh and M.A.A. Nogol Sadat et al., 3 and 4 – (Camp, Griffis, 1982), '–' not determined.

Table 7. Rare Earth Elements (REE) in the rocks studied and standards

Sample	1	2	3	4	5	6	7	8	9	10
La	32.4	32.1	44.8	18.6	35.2	34	63	78	31.3	23
Ce	68.3	69.3	91.9	37.7	64.2	71	115	50	50.8	43
Pr	8.23	8.05	9.80	4.32	-	-	-	-	-	-
Nd	31.4	32.9	37.8	17.7	25.0	43	70	63	21.3	
Sm	6.00	5.98	7.24	3.92	5.1	10	17	12	4.09	4.72
Eu	2.11	1.83	1.31	1.23	1.9	3.0	4.5	4.0	1.26	1.56
Gd	5.08	5.55	6.19	4.20	4.8	7.5	11	10	3.42	
Tb	0.78	0.71	0.70	0.54	-	-	-	-	0.55	1.93
Dy	3.20	3.13	3.76	3.50	-	-	-	-	-	
Ho	0.68	0.57	0.64	0.69	-	-	-	-	-	

Er	1.26	1.40	1.93	2.21	1.6	2.8	3.7	2.9	1.79	
Tm	0.31	0.26	0.26	0.32	-	-	-	-	-	
Yb	1.26	1.10	1.74	2.23	1.6	1.8	2.4	2.8	1.94	1.97
Lu	0.34	0.23	0.25	0.34	-	-	-	-	-	

1-4 - intraplate rocks in West Baluchestan: 1-2 – trachyandesites, Neogene (r70-2 and r70-23 samples, analytics by A. Housmandzadeh and M.A.A. Nogol Sadat support); Helmand basin, 3-4 – subalkaline rocks, Lut block (r75-1 and r75-2); 1-4 - analytics by A. Housmandzadeh and M.A.A. Nogol Sadat support; 5-trachyandesite, standard, continental rift, Paleoproterozoic, Kuetsjarvi unit, Pechenga zone, Fennoscandian Shield by A. Romanko et al.; 6-8 – basalt and dolerite (intraplate standard rocks), continental rift, Jurassic, Karoo formation, Save-Limpopo rift, Zimbabwe, E. and A. Romanko; 9 – trachyandesite, Eocene, subduction-related setting, sample BH-13 from a well, Talmessi deposit, Central Iran, courtesy of H. Bagheri, 10- trachybasalt, sill, sample Ta-39, Eocene, Lesser Caucasus, Imamverdiyev, 2010.

Table 8. Composition of glass in acid volcanite R-82, East Bazman stratovolcano, T crystallization = 690oC, content of H2O = 6 wt%.

Sample	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Cl	S	Sum	Rastr

1	72.70	0.10	10.88	0.68	0.05	0.08	0.68	2.49	3.69	0,04	0.11	0.02	91.52	12 x 12
2	72.78	0.14	11.39	0.75	0.07	0.12	0.74	2.63	3.69	0,02	0.13	0.04	92.50	12 x 12
3	72.59	0.14	11.40	0.71	0.05	0.12	0.72	2.22	3.74	0.03	0.12	0.03	91.87	20 x 20
5	71.44	0.07	11.10	0.71	0.06	0.13	0.77	2.64	3.57	0.04	0.16	0.01	90.70	12 x 12
6	71.96	0.09	11.17	0.62	0.00	0.16	0.74	2.78	3.70	0.14	0.13	0.03	91.52	12 x 12
7	72.03	0.13	11.12	0.72	0.07	0.13	0.79	2.88	3.71	0.15	0.15	0.01	91.89	12 x 12
8	72.61	0.06	11.31	0.72	0.00	0.13	0.71	2.83	3.75	0.12	0.16	0.02	92.42	12x 12

1-8 – composition of glass inclusion in Quartz of acid volcanite, rhyolite R-82, East Bazman stratovolcano, T of crystallization = 690oC, High content of H2O = 6 wt%. There are many sulfides in a sample correlated with higher content of Cu, Zn etc. in a sample R-82. Analyses led by V. Prokofiev.

Table 9. Rare, trace (ppm) and major (%) elements composition

sample	Ni Cu Zn	Ga Pb Rb Sr Y	Zr	Fe_2O_3t	K_2O	CaO	TiO_2	Cr_2O_3	MnO	Ba	La	Ce
1. 75-WP	**59 77 98 14 5 15 950 15**		**217**	**6.25 1.09 7.40 1.52 <64**					**0.08**	**292 30 63**		
2. 71-4	**77 75 113 13 6 18 1138 24**		**245**	**9.96 1.10 9.73 2.49 64**					**0.13**	**376 40 111**		

3. 71-42	87 63 197 14 5 14 1097 22	223	9.56 1.23 10.19 2.02 <64	0.12	375 44 101
4. 71-43	82 68 110 14 6 16 1115 23	234	9.8 1.16 9.73 2.49 64	0.13	376 40 106
5. 70-32	40 131 71 9 26 5 181 18	91	7.39 0.02 34.89 0.48 <64	0.12	40 13 14
6. 70-4	43 166 164 6 20 5 505 17	146	4.72 0.32 21.32 0.63 <64	0.09	155 20 37
7. 70-5	162 86 89 10 13 20 751 13	186	5.91 1.31 10.88 1.12 0.04	0.08	310 28 57
8. 70-6	136 65 79 11 10 22 782 18	180	5.86 130 10.47 1.14 0.03	0.07	304 23 55
9. 70-7	49 77 86 14 13 16 992 15	208	6.01 1.09 7.90 1.50 64	0.07	319 21 69
10. 70-8	42 77 87 13 5 13 1106 16	205	6.24 1.11 8.04 1.52 <64	0.07	334 35 64
11. 70-9	38 60 83 14 6 14 875 14	183	5.11 1.55 6.54 1.27 <64	0.07	270 30 69
12. 70-10	67 80 93 16 12 16 683 9	100	5.62 1.46 7.87 1.53 <64	0.08	318 31 68
13. 70-11	52 62 92 17 8 16 943 15	215	6.21 1.30 7.04 1.64 <64	0.08	273 30 58
14. 70-12	50 85 89 15 9 17 900 15	205	6.10 1.47 7.63 1.38 <64	0.08	324 32 68
15. 70-13	57 57 79 12 14 20 917 17	201	5.96 1.37 8.19 1.36 <64	0.08	379 35 67
16. 70-14	51 60 83 19 8 15 863 18	203	5.06 1.47 6.93 1.31 <64	0.06	292 28 64
17. 70-15	67 80 93 16 12 16 683 9	199	5.62 1.46 7.87 1.53 <64	0.08	318 31 68
18. 82-5	20 70 170 18 - 93 52 36	516	7.81 4.35 0.99 1.12 <64	0.12	781 56 104

1- 17 – intraplate rocks, Baluchestan and Sistan Province: 1- Lut block (R-75wp, sample of E. Romanko), 2-4 temporary Haji lake, north from Zabol, 5-17 – unnamed volcano in desert, 18 – important calc-alkaline rhyolite R-82, T crystallization = 690oC, H2O = 6 wt.%, east Bazman stratovolcano, Quaternary ?. “-“means below resolution concentration. XRF is by TEFA–3 techniques.

Table10. ICP-MS data (ppm) on volcanites and ore sample

	1	2	3	4	5
Sample	5s12	1s59	9s66	3as1	9s15
Li	42	50	40	45	43
Be	1,9	2,3	2,1	1,6	2,8
Sc	10,3	11,3	9,7	12,1	9,7
Ti	3787	4097	3786	4060	3769
V	142	137	138	165	138
Cr	19	12	6,9	17	11
Mn	670	731	1025	786	671
Co	12	14	13	18	12
Ni	4,5	3,6	1,8	6,5	2,4
Cu	853	38	284	**13 709**	62
Zn	91	95	125	91	44
Ga	28	28	27	27	26
Rb	115	101	69	104	78
Sr	886	915	1309	814	938

Y	17	18	18	17	17
Zr	130	144	134	130	132
Nb	7,0	7,5	6,9	7,5	6,9
Mo	0,94	1,1	0,74	3,1	1,0
Cs	8,4	2,4	10	4,1	36
Ba	512	639	517	534	512
La	28	29	29	26	30
Ce	54	59	58	54	57
Pr	6,8	7,3	7,2	6,7	7,0
Nd	26	29	28	27	27
Sm	5,0	5,4	5,3	5,1	5,2
Eu	1,5	1,6	1,6	1,6	1,6
Gd	4,7	5,3	5,0	5,0	5,0
Tb	0,64	0,71	0,67	0,67	0,67
Dy	3,4	3,9	3,7	3,6	3,6
Ho	0,70	0,75	0,74	0,72	0,71
Er	2,0	2,2	2,2	2,1	2,1
Tm	0,28	0,32	0,31	0,30	0,31
Yb	2,0	2,2	2,2	2,0	2,1
Lu	0,29	0,33	0,32	0,30	0,30
Hf	3,2	3,6	3,4	3,2	3,3
Ta	0,44	0,47	0,42	0,45	0,43
W	0,71	1,8	0,49	0,82	0,73
Pb	14	16	14	14	15
Bi	0,03	0,003	0,022	0,091	0,085
Th	6,8	7,6	7,3	6,9	7,2

U	2,1	2,4	2,6	2,4	2,0

1-5 – volcanites including Cu-rich ones, Eocene (Pg2)?, Abbas Abad Cu mining area, samples of M. Heidari.

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Table 11. Trace elements in rocks (ppm)

Sample	Rb	Sr	Y Zr Nb Ba	V Ni Co Cr	Sc	As U Th
1.R71-4	16	1290	25 270 38 380	240 72 35 100	25	13 <1 <1
2.R70-8	16	970	14 220 15 380	95 32 14 53	14	8.9 <1 1.8
3.R70-28	17	970	16 220 16 340	100 36 13 54	13	10 <1 2.9
4.R70-27	3.8	510	12 130 11 140	89 26 12 72	16	19 <1 3.3
5.70.272	4.1	170	16 75 5.5 120	130 20 2.8 21	27	17 4.2 3.6
6.R28-59	145	1230	13 110 5.8 870	81 50 12 55	15	7.9 6.3 12
7.34-24	6.7	170	23 85 8.4 76	34 7 5.3 39	5	4.8 1 14

R-71-4 - trachybasalt, samples R-70 – trachyandesites and associated intraplate rocks, 28-59- syenite, Lar, intrusive massif, N1?, 34-24 – acid subduction-related dacite, N. Pamirs, Late Permian (P2), V. Novikov, A. Romanko et al, 1992, for comparing. XRF, ppm, Geological Institute, RAS.

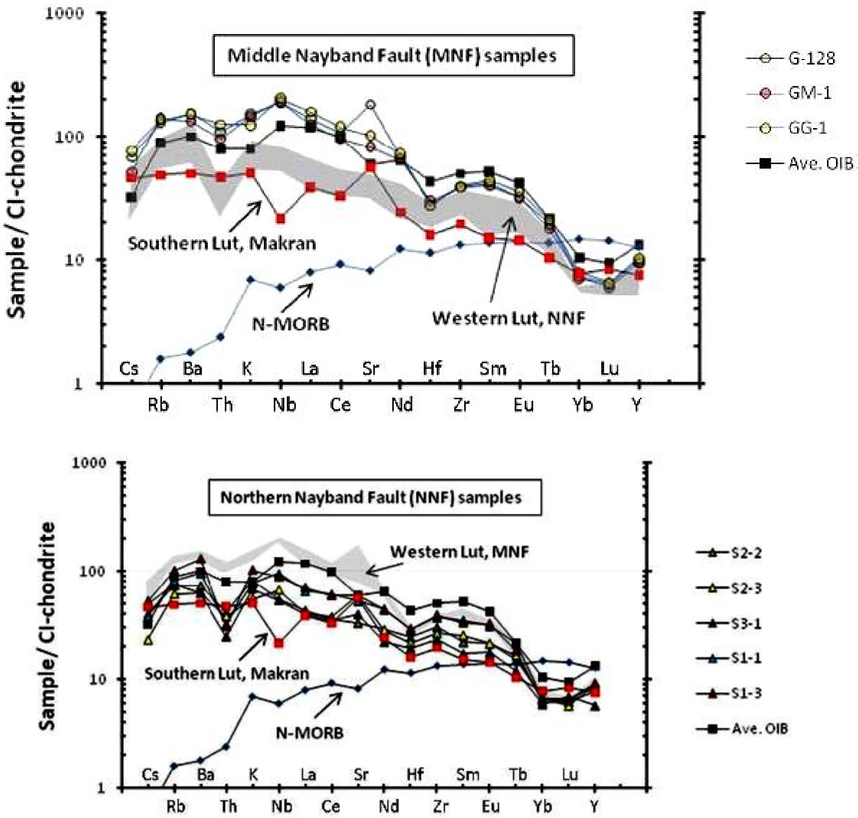
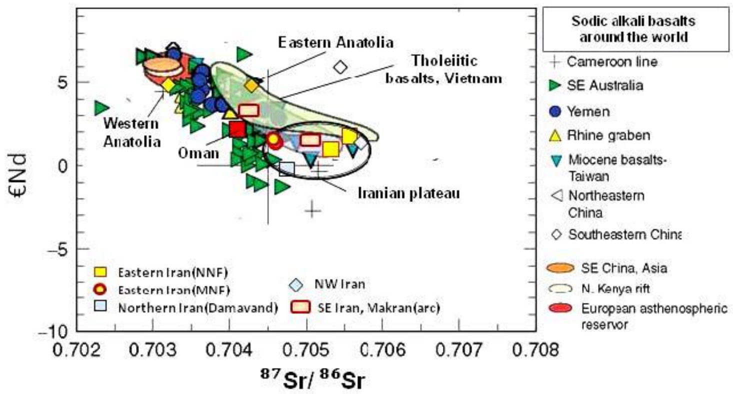


Fig. . The distribution of the contents of rare and trace elements normalized to chondrite composition (Sun, McDonaugh, 1989), using (Saadat S, Stern C.R., 2011).



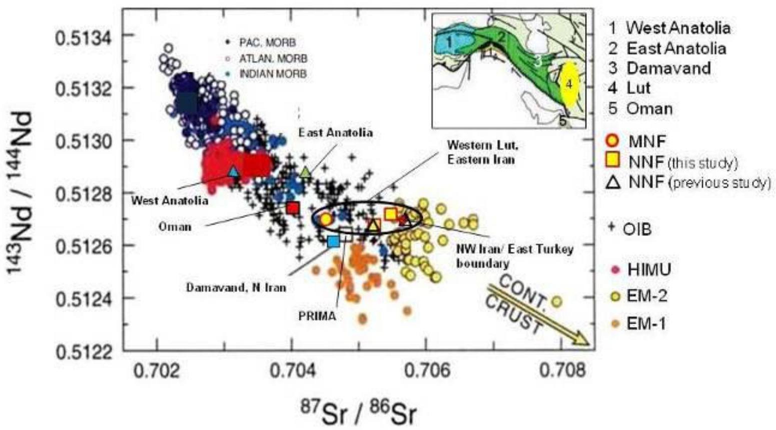


Fig. . Isotope systematics of igneous rocks in the region and standards using (Saadat S, Stern C.R., 2011).

Inclusions

Melt inclusions in this region were firstly investigated under the leadership of Prof. Prokofiev, IGEM RAS as well as fluid inclusions by E. Romanko et al. in 2000. Some notes and conclusions here are as folllows:

- Melt inclusions are not typical for the African super-plume-related intraplate igneous rocks. Intraplate rocks are confirmed by a tomography of known Ritsema's team (Bull et al., 2009 etc). Also, melt inclusions are not typical or rare for shoshonite series rocks of Abbas Abad area. T crystallization of melt inclusions in similar Eocene shoshonite series rocks with Fe-skarn mineralization, West Iran is fairly high - ca 300oC by V. Prokofiev et al.

- unusual fairly high temperature, 1150-1180º C - up to 1220º C melt inclusions were revealed in plagioclase of subduction-related K-dacite, sample 75-l by V. Prokofiev et al, 2011 (Prokofiev, 2000; Romanko et al., 2012, Fig. 5 and 6, Tables 2, 8.). This fairly deep, non-calc-alkaline rock was also affected by indirect (?) influence of a huge African super-plume, as proposed. Homogenization occurs under High T = 1150-1220º C (for comparing, for example, T much lower for acid volcanite of Quaternary Pektusan volcano, Korea, paper of O. Andreeva et al., IGEM RAS, Moscow, 2013). A higher viscosity of a glass provides more inclusions coexistence in a sample.

Maximal concentration on fluid CH_4 and other CH-based **fluid inclusions** were revealed in shallow intrusions on the contact with carbonate-rich host rocks in west Taftan zone; also in important Lar syenite massif with Cu-Au mineralization (Table 3, E. Romanko et al., 2000). Opposite, minimal data are in Cretaceous ophiolitic mainly melange rocks.

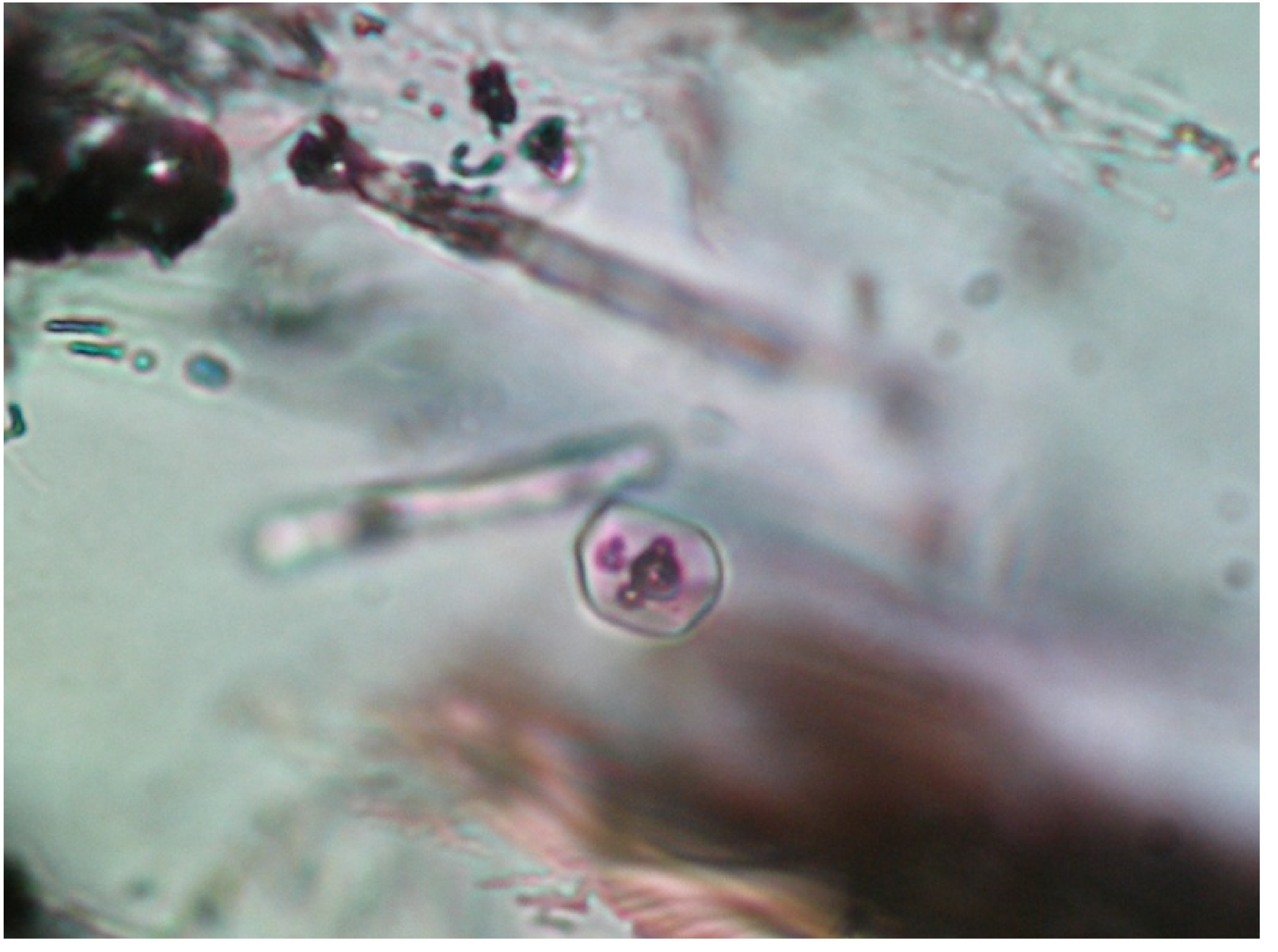


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Fig . Sample R-75ia. East Iran. T=1150^{o}C. View of melt inclusions in acid glass from Plagioclase

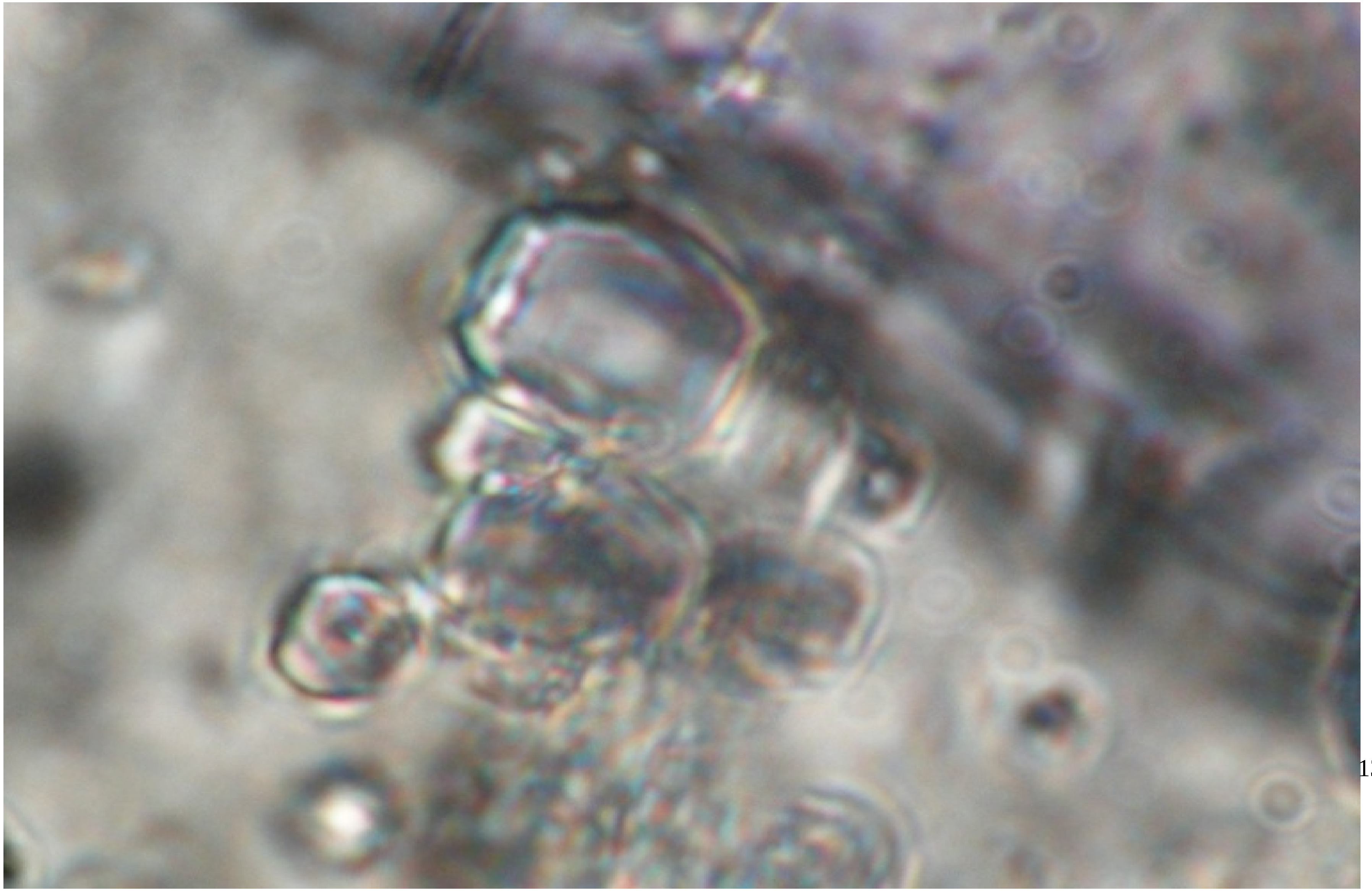

Fig . Sample R-75ia. Broad T interval in general is 1150-1220oC. Homogenization of melt inclusions.

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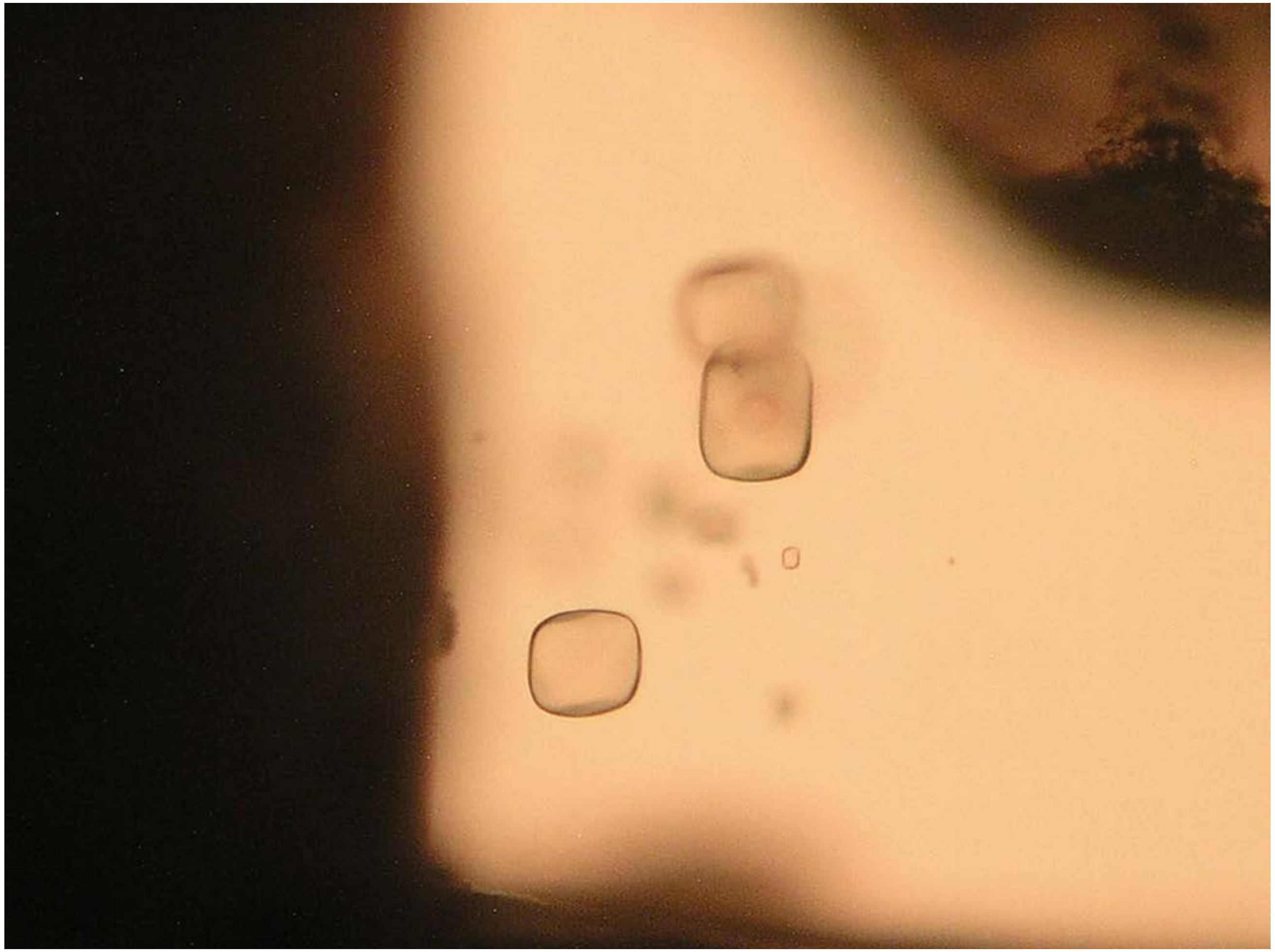

Fig . Sample R-82. Melt inclusions in Quartz, rhyolite, East Bazman volcano, T = 690oC. H2O content = 6 wt%. Naturally chilled melt inclusion. Maximal size of inclusion is ca 60 µm or microns.

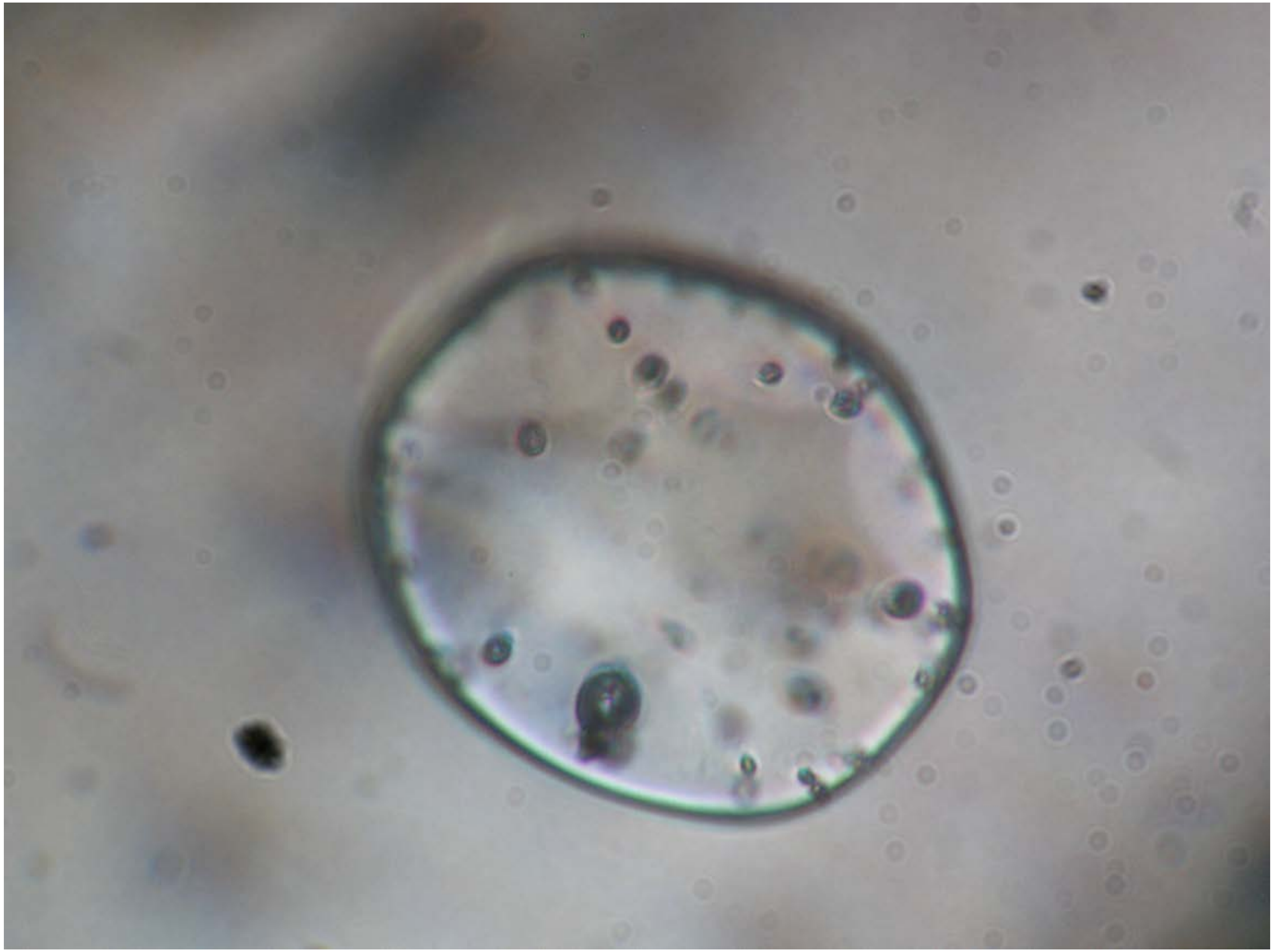

Fig . Sample R-82. Similar melt inclusion with gas bubbles in Quartz, rhyolite, East Bazman volcano, T = 630oC. After next T = 690oC gas bubbles will disappear. H_2O content is up to 6 wt%.

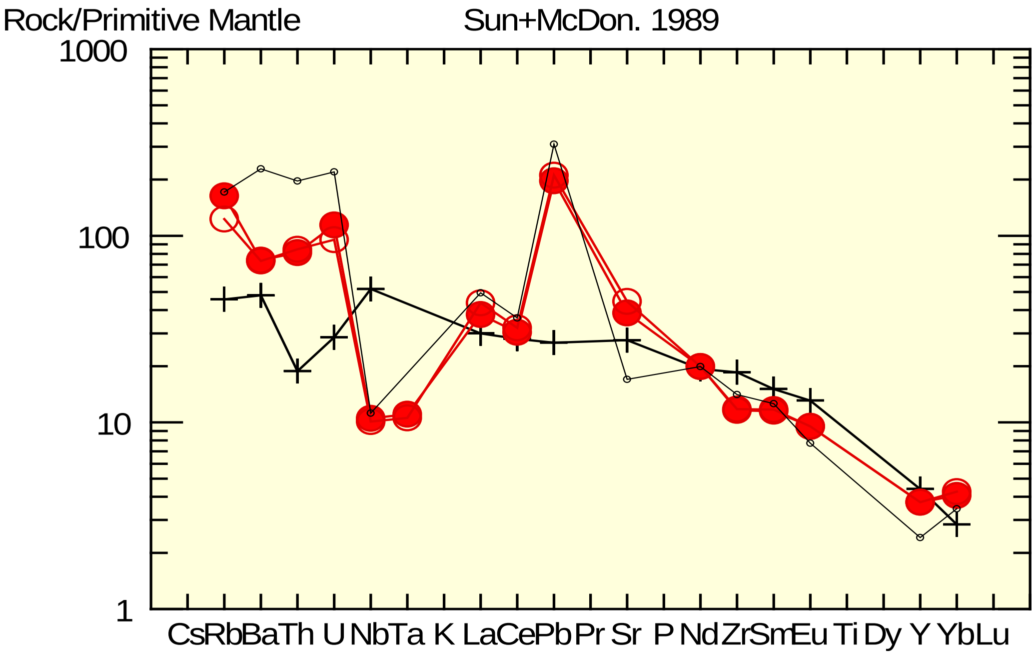

Fig . Spider-diagram for non-intraplate rocks, principally other, probably - subduction-related rocks. Circles – shoshonite series rocks, Abbas Abad copper deposit, Central Iran, M. Heidari's samples, cross – intraplate rocks pf Lut block by Saadat et al, 2002, dots – Kurama Mt, Tien

Shan, C3-P1 age, analogues of studied shoshonitic – latitic rocks. Usual positive anomaly by Pb. Ta – Nb deficit here is in subduction-related? rocks. For a comparison, example: Cross – principally OTHER intraplate rocks of Lut block by Saadat et al, 2002.

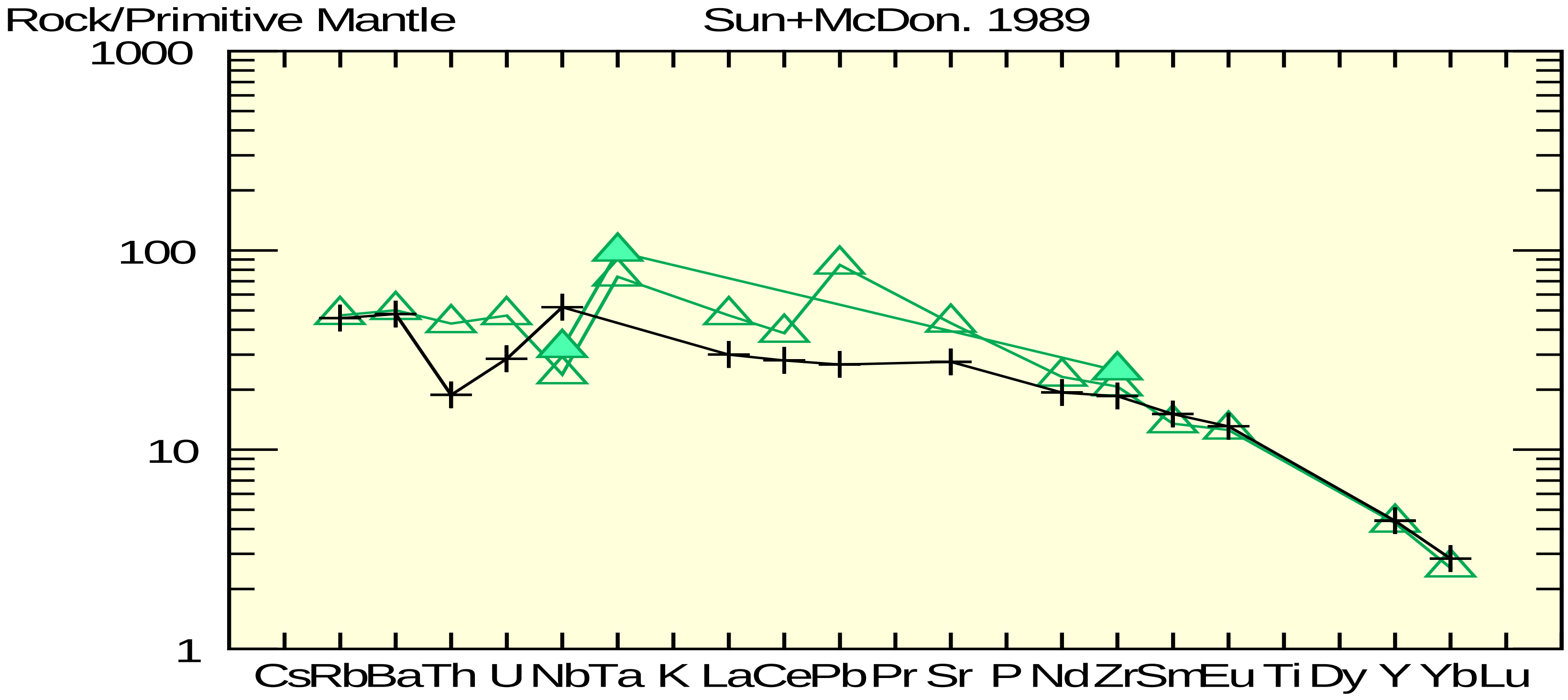
Rock/Primitive Mantle
Sun+McDon. 1989
1000
100
10
1
Cs Rb Ba Th U Nb Ta K La Ce Pb Pr Sr P Nd Zr Sm Eu Ti Dy Y Yb Lu

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Fig . Spider-diagram for intraplate rocks of East Iran, typical flat profiles. Sometimes -usual Pb positive anomaly. Triangiulars - R-70 – un-named volcano (full plot with usual Pb – positive anomaly), R-71 – Haji temporary lake in a desert, not-full profile, no Middle - HREE data here, cross – intraplate rocks of Lut block by Saadat et al, 2002.

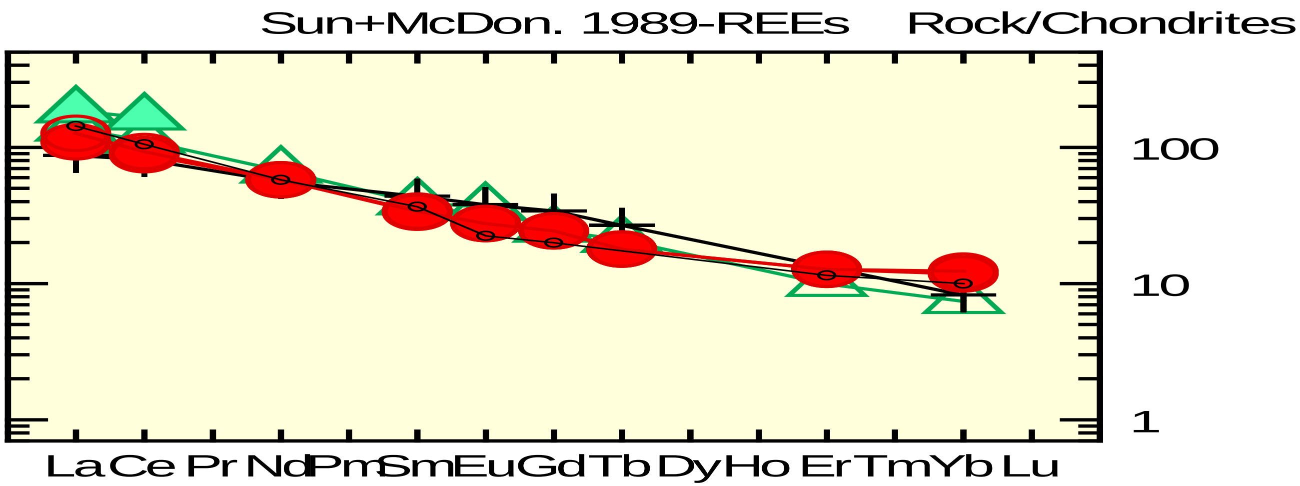

Fig . REE chondrite-normalized diagrams for Cenozoic intraplate rocks and Eocene subduction-related ones of Iran, N=6. Intraplate rocks are: R-70 (triangulars), R-71 (filled green triangulars), and crosses - sample from Lut block (Saadat et al., 2002). Circles – shoshonite – latite series rocks, Eocene (Pg2), Abbas Abad Cu mining area, N=2, samples of M. Heidari. Dots – rock of shoshonite- latite series, analogue, Kurama Mts, Middle Tien Shan, Late Carboniferous – Early Permian (C3-P1). Absent of Eu-deficit is typical for both intraplate and subduction-related rocks.

Intraplate rocks were derived from deeper mantle source versus subduction-related Eocene and Late Cenozoic rocks. This is supported by the following:

- Geological and petrographic and mineralogical data
- The general style of petrology and geochemistry of these rocks, we can the same on other regions
- Obvious geochemical materials, for example, the stable high K/Rb = 560-586-620 etc.

The region is expected to at least partial compensation of Pg2-Q aged compression and subduction-related Magmatism by intraplate magmatism. The latter, according to the imaging may be associated with the tail of the most powerful African superplume (Bull et al., 2009). There is also discussion in modeling - the partial screening of the plume push up plate, which is not an obstacle - it is known that plate moves may not stop movement of the tail superplume in lateral direction.

Metallogenic notes

Neogene rocks of the Lesser Caucasus is interesting for economic and non-economic metallogeny as:

- New Low-temperature Au-Ag, Hg, As, Sb, Cu-Mo with Au, Cu-Pb-Zn and Pb-Zn deposits and occurrences is proposed here,
- Non-ore raw – tuffs, slags, pumice etc. are of interest too.

Metallogeny of Cenozoic rock of East Iran was studied under the leadership of outstanding regional trio – Dr. Eugene Romanko, Dr. A. Houshmandzadeh, and Dr. M.A.A. Nogole-Sadat.

Calc-alkaline intrusive, extrusive, pyroclastic and volcanogenic-sedimentary rocks here are characterized by a common copper-gold (Cu-Au) metallogenic profile for Baluchestan and Sistan Province in East Iran, as in the whole Sahand – Bazman volcanic-plutonic belt of Iran. The overwhelming majority of occurrences the study area is associated with magmatic complexes. Such metallogenic types were revealed here as:

- Multi-sulfide (Au-Mo-Cu-Pb-Zn) subvolcanic porphyry type;
- Au-As-Hg-W-Mo-volcanic exhalation one;
- Low-sulfide gold-silver plutonic one;
- Gold-copper (Au-Cu) skarn and plutonic-hydrothermal one (E. Romanko et al., 2000; data by Pars Kani Co, 2003 by Daliran et al., 2005) using also known data on mineralization of different region including former USSR / CIS (Prokofiev et al., 2000; Vikentiev et al., 2004 etc.);
- Sulfide, sulfur, alunite exhalation, surface one;
- Native-copper-sulphide volcanogenic one with zeolites;
- Silver volcanogenic sulphide (+ gold?) one.

Thus, intraplate rocks are strongly specialized in REE, P (usual process), then in Sr, Ba, U, Th due to nowdays materilas. So, tectonic-magmatic, and as revealed E.Romanko – metallogenic zonation in the region was revealed in the region studied (at least in the Central – East Iran). Younger magmatic products are in the northeast of region due to lithosphere subduction and decreasing of Afrocan superplume activity in the same direction. Subduction-related (1 group of rocks) dominated calc-alkaline rocks and shoshonites-latites. , and, intraplate African superplume-related (Laverov et al., 2004; Yarmolyuk, personal communication, 2013, etc.) midalkaline – alkaline rocks including known Pleistocene carbonatites of Hanneshin, Afghanistan and, also, of one of Arabia are subordinated (2 group of rocks). Rocks of 1 and 2 groups are interpreted by us as a tectonic-magmatic couple due to one from physics etc. In this case, at least, partial compensation of subduction compression by the intraplate extension is possible. Cenozoic intraplate rocks intraplate carbonatite-derived depth of the melt - an argument in favor of the African superplume influence on the magma plume of a large region, which is in agreement with effective tomography of the well-known J. Ritsema's team (Bull et al., 2009).

Oil and gas, hydrocarbons (HC), some notes

There are known materials about of Caspian Sea OIL / HC resources or productivity decreasing in north – northeast (N - NE) tectonic direction or lineament as stressed by known Prof. V. Khain with co-authors in the Explanatory map of Caspian Sea region scale 1:2 500 000 etc. (Khain, 2001; Leonov et al., 2010). This decreasing is as follows: from extremely rich Persian Gulf to South – Middle – North Caspian Sea. It is in agreement with the increasing distance from the African superplume by effective tomography (Bull et al., 2010), tectonics etc.

More specifically, this HC super belt is as Persian Gulf – Russian Arctic coast, due to old Russian HC maps, ex., USSR oil structures map scale 1:2 500 000 etc. Also, important as HC traps salt domes in the east Persian Gulf are oriented due to this tectonic direction. Relation of HC field with faults is obvious. Other possibility for HC fields is combining of well-known H2 fluxes from the depth on faults with organic C in sediments.

Some experienced HC specialists believe that there are no strong contradictions in combined biogenic and abiogenic data now. HC fields are only of Cenozoic age, maybe the very Quaternary age for oil and younger age for the gas (not Riphean - Paleozoic – Mesozoic fields) due to a high mobility of HC. ex. There are data about ca 1 m/year HC migration. A. Timurziev (Timurziev, 2007, 2015 etc.), S. Marakushev, 2015; R. Seyful-Mulyukov, 2013 etc. think about the very deep abiogenic HC versus biogenic ones. In this context materials on mud-volcano-like structures on Mars comparing to known muds of Azerbaijan, Iran etc. by Skinner and Mazzini, 2009 etc. (fig.). It is well-known that mud-volcanoes or simply muds directly deal with HC fields.

No doubts about fault-related HC fluid input and also magmatic heat input sometimes. But biogenic factor is of great importance, surely. More data on HC peculiarities in the region studied needed.

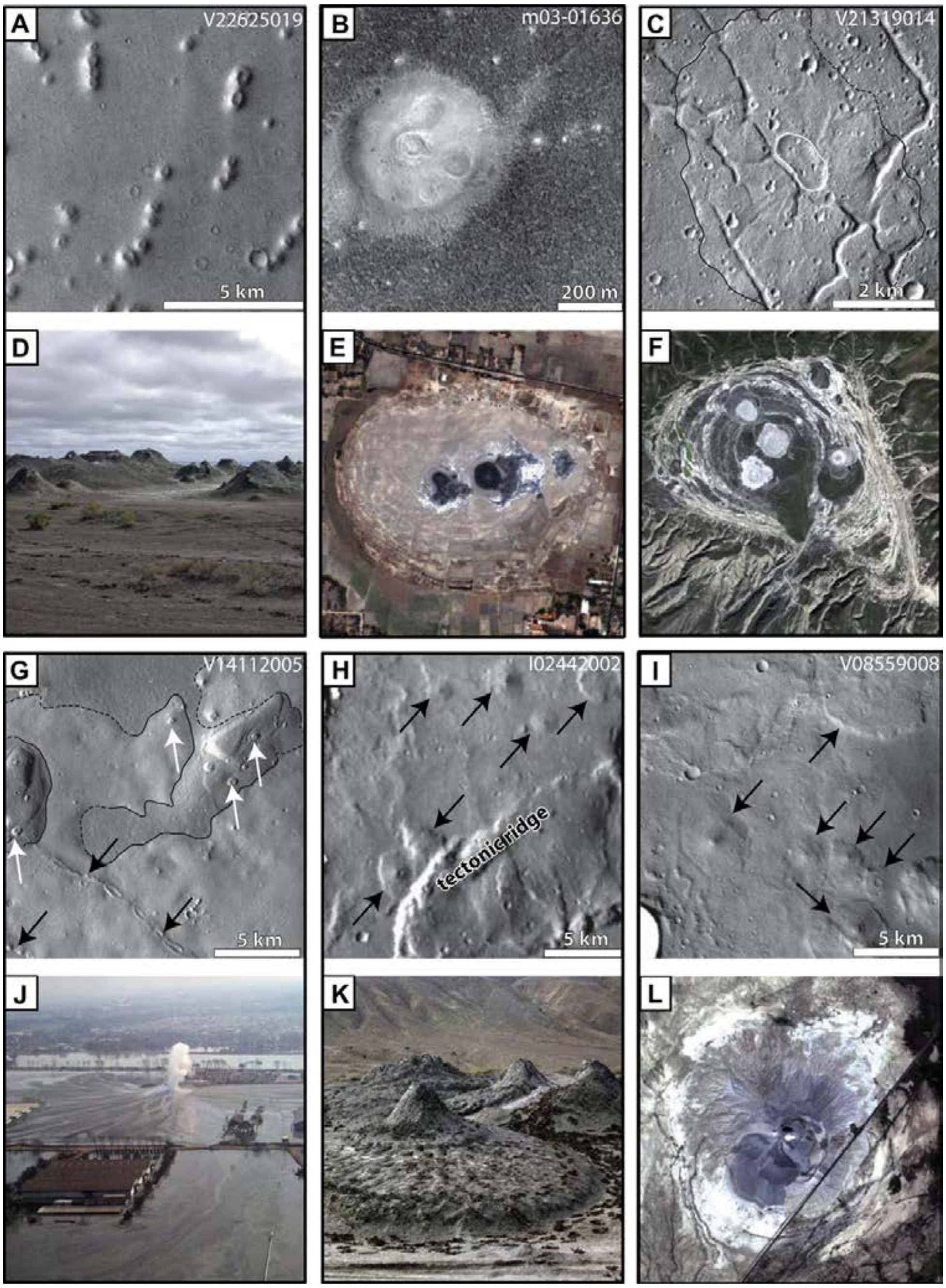

Fig . Comparison of Azerbaijan, Iran (L), Java mud-volcanoes (muds) with mud-like structures of Mars - after Skinner and Mazzini, 2009. Mud directly deals with OIL and other hydrocarbons.

Conclusions

1. Some common geo-similarities on Cenozoic events in the region studied were revealed. At least, in East Iran important north-east tectonic-magmatic zoning and partly, metallogenic one (metallogeny under the leadership of known regional trio as E. Romanko, A. Houshmandzadeh, and M.A.A. Nogole-Sadat) due to African superplume activity exists here. It caused directly by known subduction of the Arabian plate under the Central Iran. African superplume activity strongly controls magmatism, “hot” regional tectonic regime, and, at least, partly - metallogeny in the region studied. Also, African superplume closely deals with known Jurassic Karoo flood basalts event in Africa, Paleogene magmatism in East Africa, since mainly Eocene (Pg2) subduction in Iran – Turkey etc., Neogene 11-9 Ma opening of Red Sea etc., and probably, delamination of a mantle lithosphere in East Mediterranean in Miocene and as a result – lack of regional Cu-porphyry mineralization versus economic one in Eocene before important delamination.

2. Two different types of Cenozoic magmatic rocks exist in the region studied: 1 – **intraplate** alkaline and subalkaline rocks and 2 – shoshonite - latite series rocks and calc-alkaline ones mainly dealing with **subduction – collision events**. Low crystallization temperature – 690oC and High H2O content up to 6 wt. %, and natural melt chilling were revealed for a probably Quaternary subduction-related rhyolite of the Bazman volcano (all data on melt inclusions led by V. Prokofiev) Sudden high/very high crystallization temperature, up to 1220oC on melt inclusions in High-K probably subduction-related dacite of remnant subduction were received too. Otherwise, for intraplate rocks as well for shoshonite – latite subduction related ones melt inclusions are not typical due to proposed warm conditions.

3. Eocene (Pg2) subduction-related shoshonite – latite series rocks almost in the whole region are characterized by an economic Cu-Au mineralization with a subordinate different mineralization (Cu-Pb-Zn-Au-Ag, Hg-As, Au-Ag low-sulphide, Ag-sulfide with Au (?) etc.). Cu mineralization deals with deep basic enriched water-containing source. Cu mineralization disappears with time and higher in general magmatic section after disappears of relation with deep enriched source using (Haschke et al., 2010). Intraplate rocks bear, at least, REE, P, also Sr, Ba, Th, and U mineralization.

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