LESSER CAUCASUS – EAST IRAN, MIDDLE EAST: SOME MATERIALS ON GEOLOGY AND METALLOGENY, "HOT" TECTONICS DUE TO THE AFRICAN SUPERPLUME ACTIVITY, MELT AND FLUID INCLUSIONS; DIFFERENT DATA ON HYDROCARBONS (HC), PROBLEMS, AND CONSTRAINTS

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Cenozoic tectonic-magmatic-metallogenic events in the Lesser Caucasus and East Iran, Middle East 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 lithospheric mantle 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 the enriched African superplume-related mantle sources being enriched in HFSE - Nb, Ta, Zr, Y, P, Ti etc. 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 (Pg^2) shoshonite – latite series rocks formed during known subduction of Arabian plate beneath the Central Iran.

Key words: Central part of the Alpine-Himalayan mobile belt, Lesser Caucasus – East Iran, Middle East, geology, geochemistry, tectonics, magmatism, metallogeny, African superPlume, delamination, mineralogy, melt and fluid inclusions, northeastern (NE) tectonic-magmatic-metallogenic +- oil / hydrocarbons (HC) zoning.

Introduction

Central part of the famous and fantastically interesting Alpine – Himalayan mobile belt is geologically, economically… extremely important, however, very irregular investigated region. Great importance of its regional study is obvious, surely. Lesser Caucasus is geologically better known versus East Iran. Poorly studied East Iran close to the very Alpine – Himalayan tectonic junction (Khain, Leonov, 1988; also in many other works as follows: Stocklin et al., 1965; Nogole-Sadat, 1985; Houshmandzadeh et al., 1986;Imamverdiyev, 2000; E. Romanko et al, 1984; Milanovsky, Koronovsky, 1973 etc. and etc.) studied by us under the leadership of outstanding metallogenic trio – known regional specialists Dr. E. Romanko, Dr. A. Houshmandzadeh, and Dr. M.A.A. Nogole-Sadat. We present some new data on this intriguing region.

Review of Geology and Results

General geology and tectonics of this economically and geologically interesting region were described in such works as follows: (Khain, 2001; Imamverdiyev, 2000; Milanovsky, Koronovsky, 1973; Leonov et al, 2010; Trifonov, Ruzhentsev, 1984, etc., fig. 1-2).

Two groups of magmatic rocks were revealed here as: mainly Eocene shoshonitic-latitic etc. rocks of the first group and principally other rocks - Neogene – Quaternary intraplate subalkaline and alkaline ones, second group.

Rocks of the first group (subduction-related differentiated rocks) are the products of a large 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 (Imamverdiyev, 2000; Romanko et al., 2013; etc., fig. 1) etc. Catastrophic earthquakes as 8 M and more by the Richter scale, unfortunately, are not rare here. A recent catastrophic example is 2003 Bam earthquake in East Iran with a lot of casualties.

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 1-10, fig. 1-2, 9-11; Bogatikov et al., 1987; Luchitsky, 1985, Yarmolyuk et al., 2001, Knipper et al., 1992 etc.).

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.

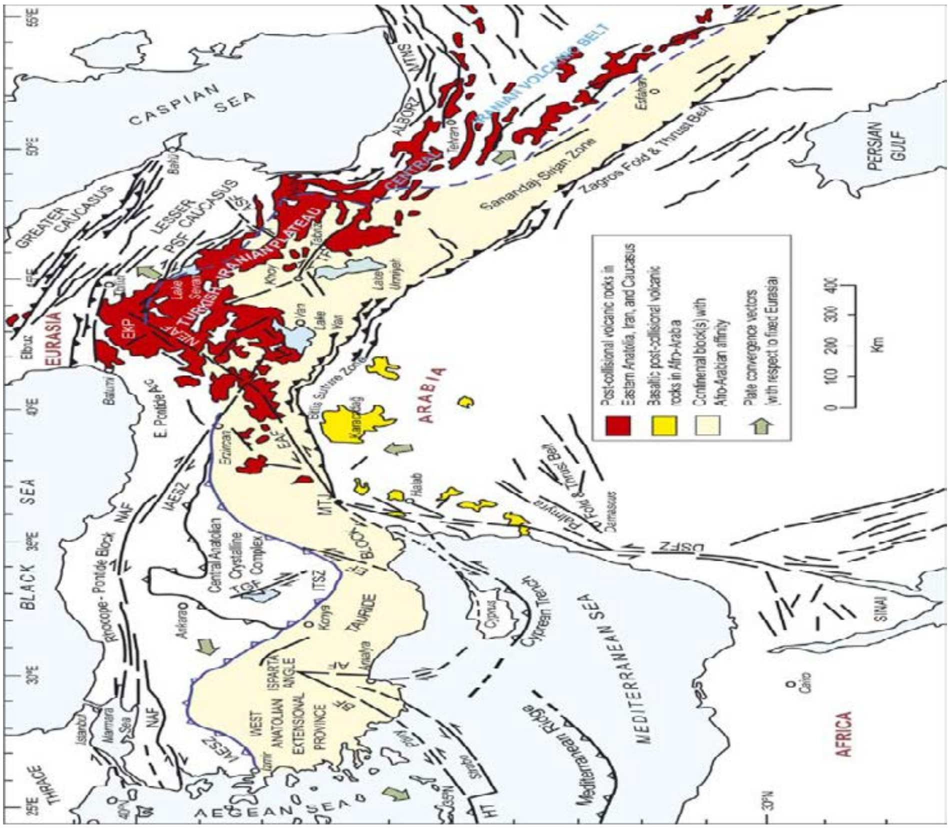

Fig 1. Magmatic complexes in Lesser Caucasus using
(Dilek, Imamverdiyev, Altunkaynak, 2010)

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).

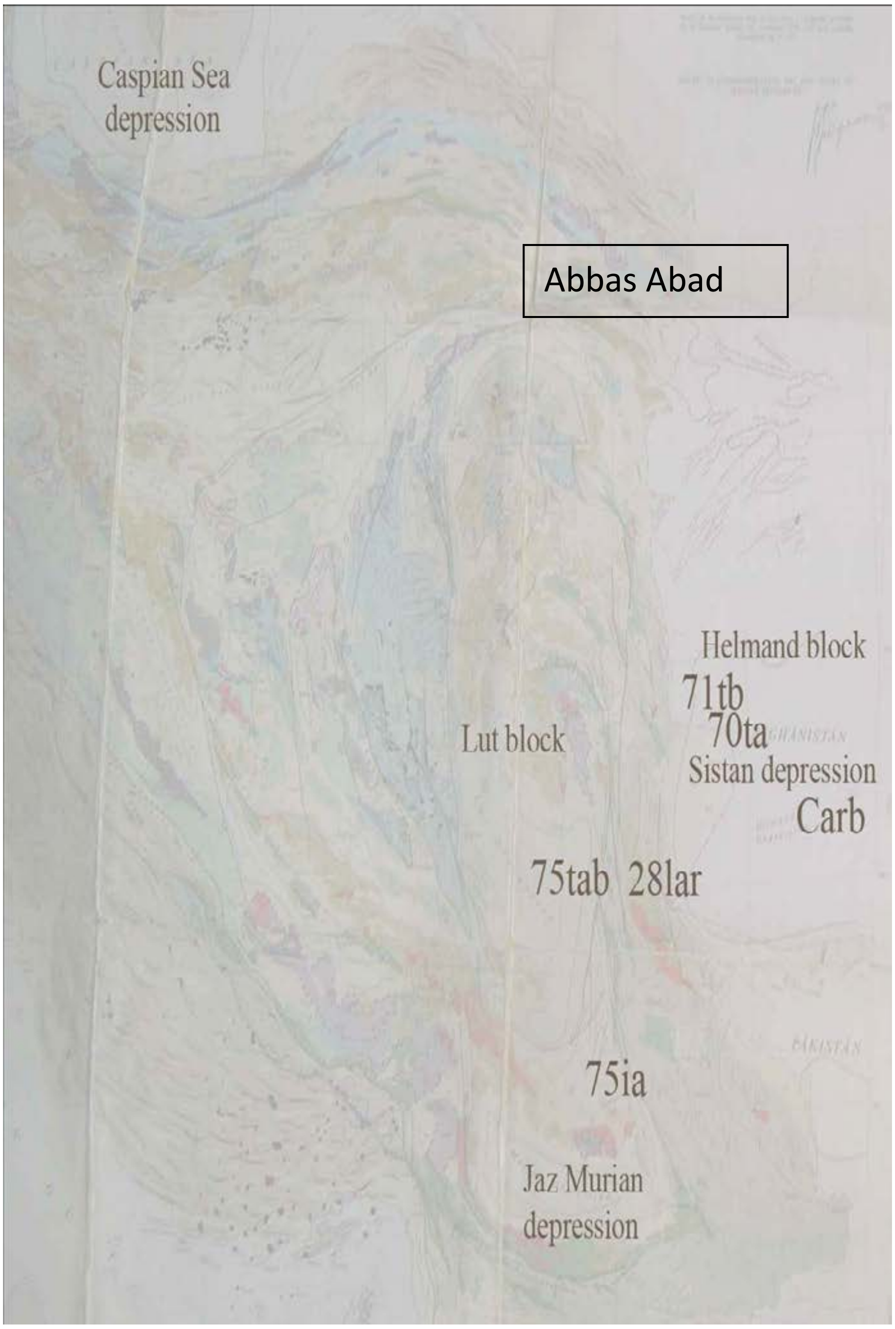

Fig. 2. Magmatic rocks sample position in East Iran using Geological map scale 5: 000 000. R-70, R-71 – intraplate rocks in Sistan, R-75ia - High K-dacite with a high crystallization temperature as shown in text, Carb = carbonatites of Hanneshin, Afghanistan, R-28 – Lar alkaline intrusion with Cu-Au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

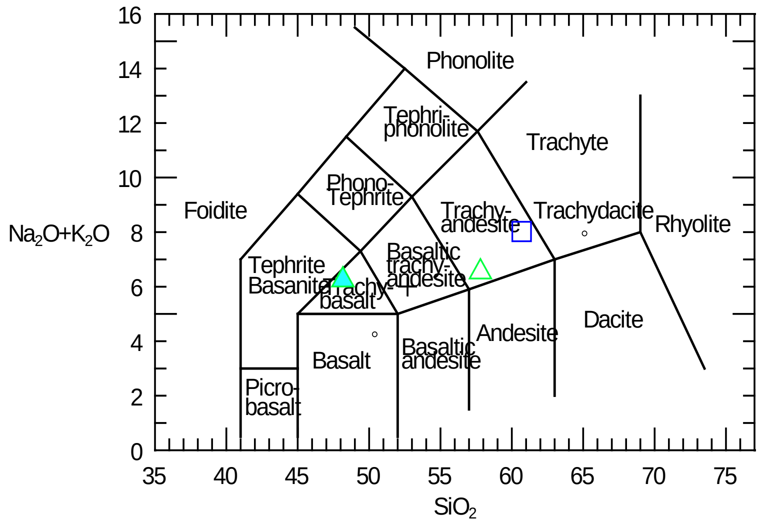

Fig.3. Na_2O+K_2O (wt %) versus SiO_2 (wt %) or TAS diagram. Triangules - intraplate rocks of East Iran, quadrangle – Lar Low-Ti intrusive massif with Cu-Au mineralization. Dot – trachydacite of shoshonite – latite series, Kurama zone, Tien-Shan, C3-P1, analogue of Pg2 shoshonite – latite studied series (Lesser Caucasus - East Iran etc.)

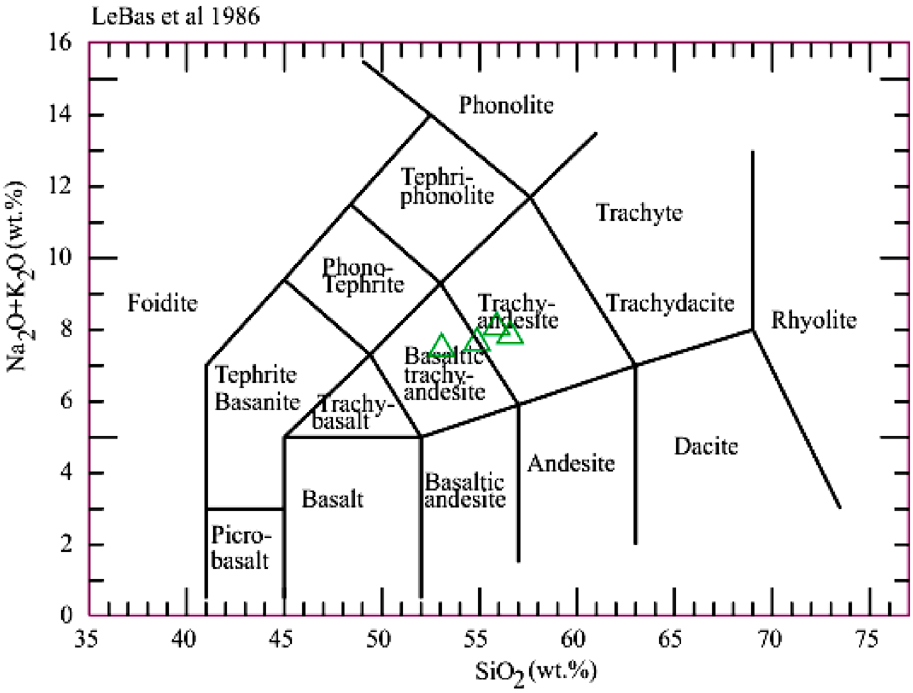

Fig.4. Na_2O+K_2O (wt %) versus SiO_2 (wt %) or TAS diagram for the Abbas Abad Cu-mining area, Central Iran (NE Iran by a formal geography), Pg2? Samples of M. Heidari et al.

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.

Table 2

Chemistry of melt inclusions glass (wt %) in plagioclase (1, 3), host mineral (2, 4), host acid K-volcanite (5), leucorhyolite from Bazman stratovolcano, and plagoclase 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 H_2, O_2, N_2, CO_2, CH_4, C_2H_6, C_3H_8, C_4H_{10}, C5H12, and C_6H_{14}. Temperature of Au mineralization is 220 – 278^{o}C, Oligocene-Quaternary, important Lar intrusive massif with Au up to 25.4 ppm, T = 220–226^{o}C 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

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 0.60	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	11.1 4.90	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	- 0.10 4.85	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	12.0 1.84 1.95	2.70	1.16	2.51
FeO	2.56	- 0.11 9.23 7.72 3.06	5.40	0.40	0.46	1.07	0.73	0.87	-	0.12	2.07	3.53	1.21
MnO	0.14	1.84 0.40	0.13	0.09	0.08	0.09	0.16	0.12	0.08		0.09	0.10	0.02
MgO	5.73		5.55	3.37	3.35	2.27	5.46	6.60	9.00		3.65	3.04	0.37
CaO	8.98		8.62	7.58	6.80	7.10	26.66	17.10	15.86		3.90	5.25	1.55
Na_2O	4.93		3.46	5.81	5.33	5.11	0.80	2.96	0.86		3.64	4.11	0.28
K_2O	1.31		1.31	1.73	1.50	1.42	0.10	0.42	2.36		4.38	1.58	0.21
P_2O_5	1.11		0.40	0.51	0.59	1.05	0.16	0.38	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 6

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 7

Composition of glass in acid volcanite R-82, East Bazman volcano,
T crystallization = 690°C, content of H_2O = 6 wt%.

N	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Cl	S	Total
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
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
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
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
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
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
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

1-8 – composition of glass inclusion in Quartz of acid volcanite R-82, East Bazman volcano, T crystallization ca = 690oC, High content of H_2O = 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 Prof. V. Prokofiev.

Table 8

Rare, trace (ppm) and major (%) elements composition

Sample	Ni	Cu	Zn	Ga	Pb	Rb	Sr	Y	Zr	$Fe_20_3^t$	K_20	CaO	$Ti0_2$	Cr_20_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	56	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	0.09	310	28	57
8. 70-6	136	65	79	11	10	22	782	18	180	5.86	1.30	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			
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 = 690^0 C, H_2O = 6 wt.%, east Bazman volcano, Quaternary ?. “-“means below resolution concentration. XRF - by TEFA–3 techniques.

Table 9

ICP-MS data (ppm) on volcanites including ore-bearing ones

	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	13709	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 – Pg2(?) volcanites including Cu-rich ones, Abbas Abad mine, samples of M. Heidari.

Table 10

Trace elements in rocks (ppm)

Sample	Rb	Sr	Y	Zr	Nb	Ba	V	Ni	Co	Cr	Sc	As	U	Th
1.71-4	16	1290	25	270	38	380	240	72	35	100	25	13	<1	<1
2.70-8	16	970	14	220	15	380	95	32	14	53	14	8.9	<1	1.8
3.70-28	17	970	16	220	16	340	100	36	13	54	13	10	<1	2.9
4.70-27	3.8	510	12	130	11	140	89	26	12	72	16	19	<1	3.3
5.70-271	4.1	170	16	75	5.5	120	130	20	2.8	21	27	17	4.2	3.6
6.28-59	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	7.3	5.3	39	5.0	4.8	1	14

71-4 - trachybasalt, samples 70- trachyandesites, trachybasalts and associated intraoplate rocks, 28-59- syenite, Lar, intrusive massif, N1?, 34-24 – acid subduction-related dacite, Pamirs Late Permian (P2), for comparing. XRF, ppm, Geological Institute, RAS.

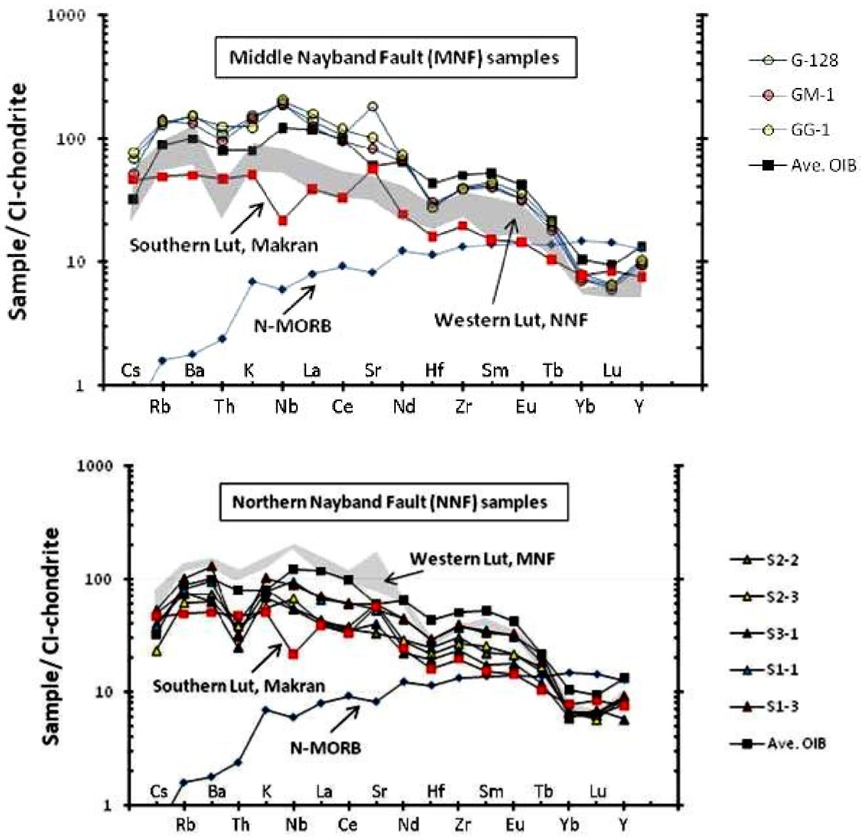

Fig.5. The distribution of the contents of rare and trace elements normalized to chondrite composition (Sun, McDonaugh, 1989), using (Saadat S, Stern C.R., 2011).

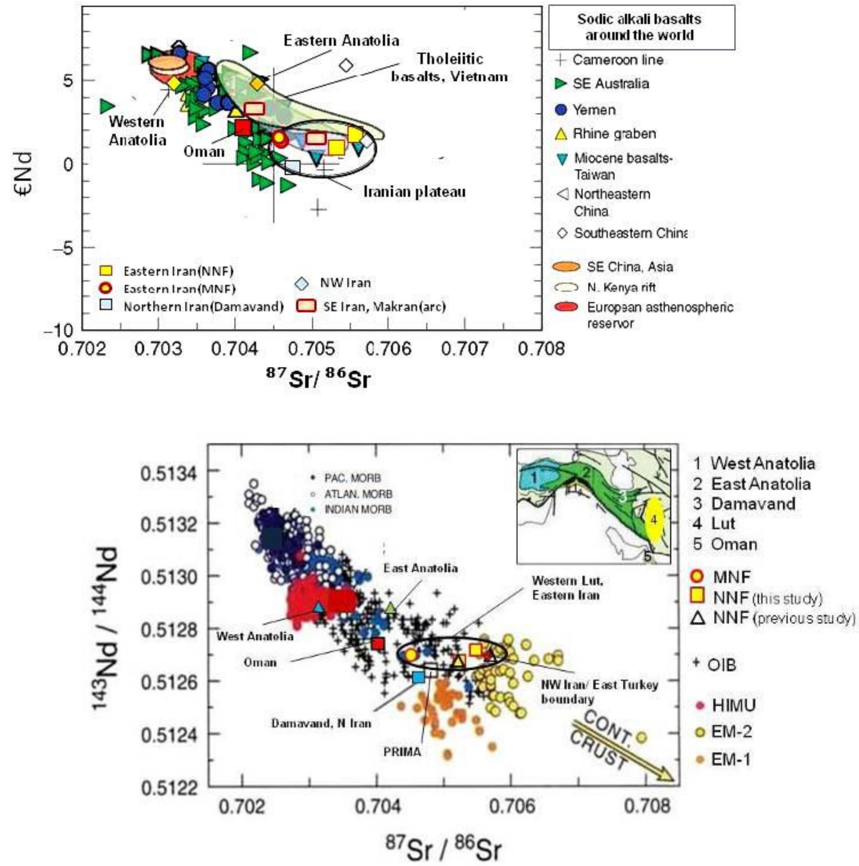

Fig. 6. Isotope systematics of igneous rocks in the region and standards using (Saadat S, Stern C.R., 2011).

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 300°C by V. Prokofiev et al.

- unusual fairly high temperature, 1150-1180° C - up to 1220° 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. 7 and 8, 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.

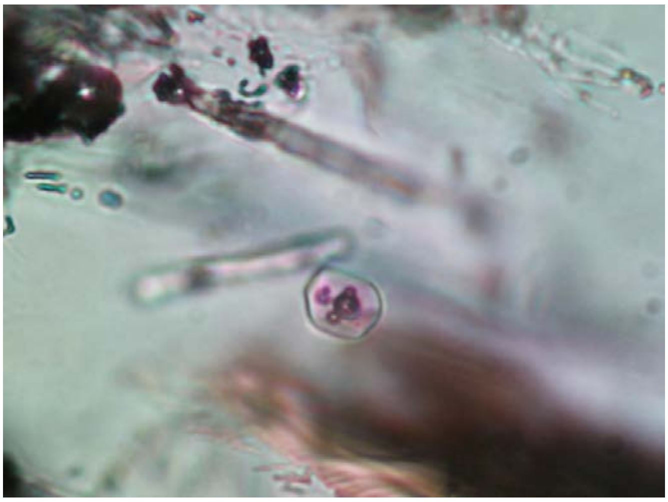

Fig 7. Sample R-75ia. East Iran. T=1150^{o}C.
View of melt inclusions in acid glass from Plagioclase

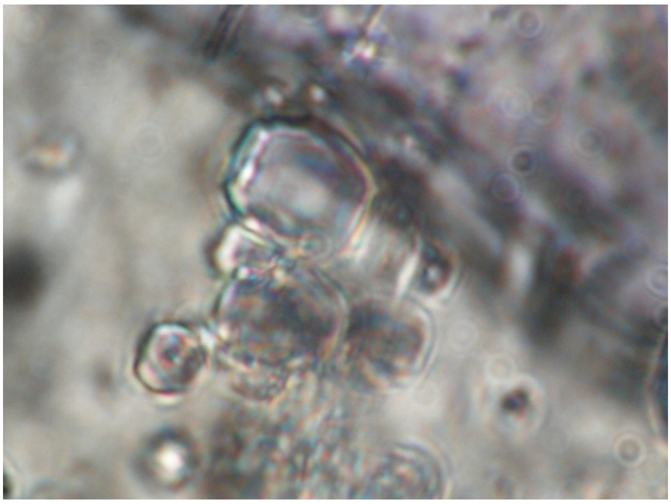

Fig 8. Sample R-75ia. Broad T interval in general is 1150-1220oC.
Homogenization of melt inclusions.

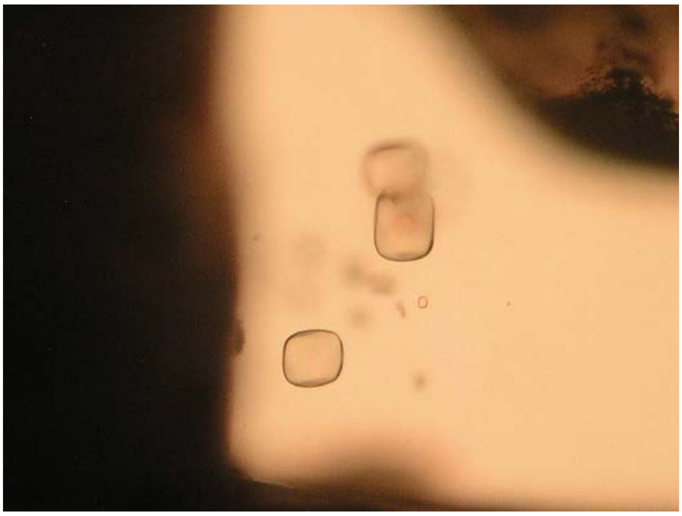

Fig 9. Sample R-82. Melt inclusions in Quartz, rhyolite, East Bazman volcano, T = 690oC. H2O content = 6 wt%. Naturally chilled melt inclusion. Maximal size of inclusion is ca 60 microns.

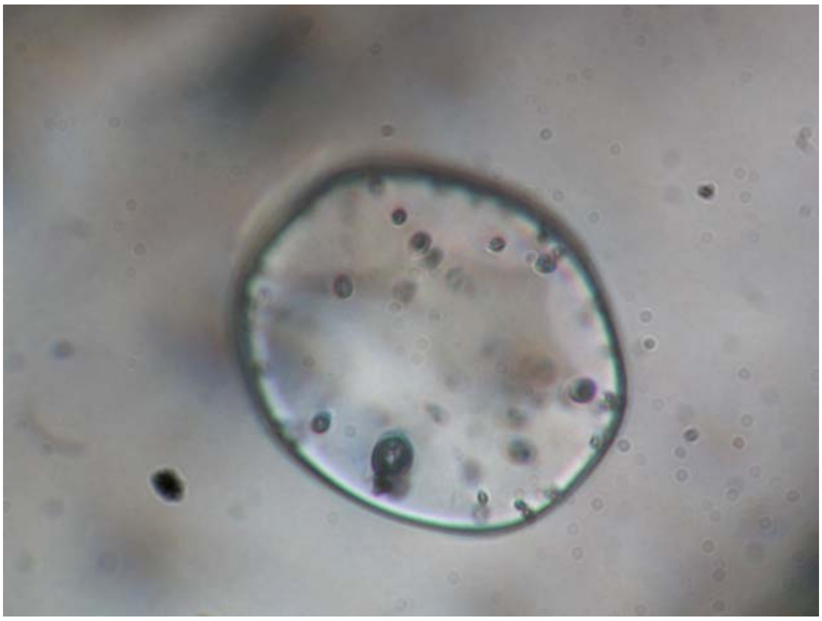

Fig 10. Sample R-82. Similar melt inclusion with gas bubbles in Quartz, rhyolite, East Bazman volcano, T = 630oC. After next T = 690oC gas bubbles will disappear. H2O content is up to 6 wt%.

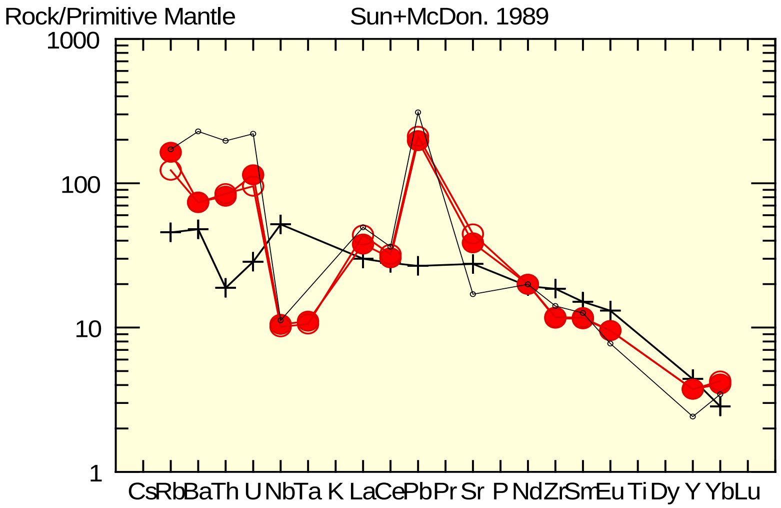

Fig. 11. Spider-diagram or polycomponent one for Non-intraplate rocks, principally other, probably - subduction-related rocks. Circles – shoshonite series rocks, Abbas Abad copper deposit, Central Iran, M. Heidari's samples, cross – intraplate rocks pf Lut block by Saadat et al, 2002, dots – Kurama Mt, 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.

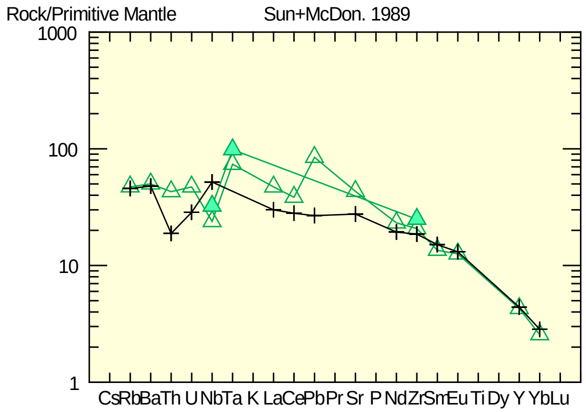

Fig. 12. Spider-diagram for intraplate rocks of East Iran, typical flat profiles. Sometimes -usual Pb positive anomaly. Triangiulars - R-70 – unnamed volcano (full plot with usual Pb – positive anomaly), R-71 – Haji temporary lake in a desert, not-full profile, no Middle - HREE data here, cross – intraplate rocks of Lut block by Saadat et al, 2002.

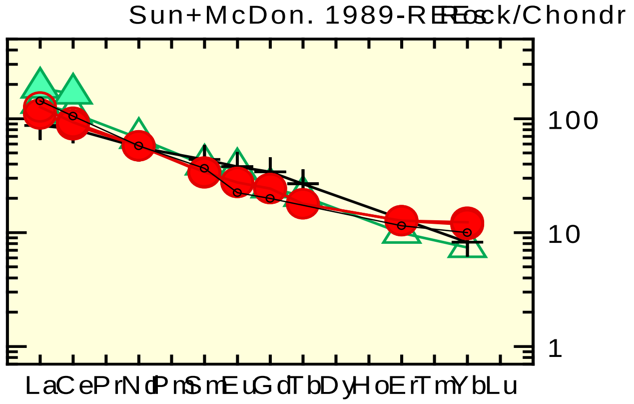

Fig 13. REE chondrite-normalized diagrams for Cenozoic intraplate rocks and Eocene subduction-related ones of Iran, N=6. Intraplate rocks are: R-70 (triangulars), R-71 (filled green triangulars), and crosses - sample from Lut block (Saadat et al., 2002). Circles – shoshonite – latite series rocks, Eocene (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. Houshmand-zadeh, 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.

Some HC scientists believe now that there are no strong contradictions in combined biogenic and abiogenic data and that HC fields and position is Cenozoic (not Paleozoic - Mesozoic) due to high mobility of HC, ex. ca 1 m/year. So we see obvious deep, fault-related HC fluid input here, but the biogenic factor including favorable climate maybe important too. More data on HC peculiarities in the region studied needed, surely.

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, strongly controls magmatism, 'hot' tectonics and at least partly - metallogeny in the region studied. Also, African superplume close deal with known Jurassic Karoo flood basalts event in Africa, Paleogene magmatism in the East Africa and Paleogene subduction, Neogene, 11-9 Ma opening of Red Sea etc., and probably, delamination of a lithospheric slab in East Mediterranean in Miocene and as a result – lack of the regional Cu-porphyry mineralization versus economic one in Eocene.

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 of remnant subduction-related dacite 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.

We are extremely grateful to outstanding regional trio - Drs. E.Romanko†, A. Houshmandzadeh, and M.A.A.Nogole-Sadat for their leadership in the field works and comprehensive care, also – to famous Prof. V. Khain from the Lomonosov MSU (consulting and advise), N.Bozhko, M. Goncharov, V.V.Slavinsky (long discussions), B. Zolotarev and V.Lyakhovich†, V.Yarmolyuk, V. Trifonov, V. Burtman, I. Pospelov, Yu. and M.Leonov, D.Alexeev; G.Karpova, M.Buyakayte, D.Astafiev, I.Gablina, Yu.Malinovsky, S. Palandzhyan and G.Nekrasov, A.Knipper†, S.Ruzhetsev†, G.Makarychev†, V.Rusinov†, I. Kravchenko-Berezhnoy, A.Girnis, A.Pertsev, A.Mokhov, V.Volkov, N.Tarasov; S.Bubnov, A.Gurbanov, and A.Dockuchaev; G. Moralev; also to A.Meskhi from Kazan, Russia; S.M.Tabatabaeimanesh, M.Hosseini, M. Ziaii, and more other geo-specialists for discussion, analytical help etc.

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МАЛЫЙ КАВКАЗ-ВОСТОЧНЫЙ ИРАН, БЛИЖНИЙ ВОСТОК: НЕКОТОРЫЕ МАТЕРИАЛЫ ПО ГЕОЛОГИИ И МЕТАЛЛОГЕНИИ, "ГОРЯЧАЯ" ТЕКТОНИКА, СВЯЗАННЫЕ С ДЕЯТЕЛЬНОСТЬЮ АФРИКАНСКОГО СУПЕРПЛЮМА, РАСПЛАВНЫЕ И ФЛЮИДНЫЕ ВКЛЮЧЕНИЯ, НЕКОТОРЫЕ ДАННЫЕ ПО УГЛЕВОДОРОДАМ, ПРОБЛЕМЫ И ОГРАНИЧЕНИЯ

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РЕЗЮМЕ

Кайнозойские тектоно-магматические и металлогенические события Малого Кавказа и востока Ирана, Ближний Восток, имеют общие черты. Существует важная геолого-металлогеническая +- нефтяная или углеводородная корреляция для альпийского времени (металлогения востока Ирана – под руководством выдающегося регионального трио: Е.Ф. Романько, А. Хушманзаде и М.А.А. Ноголь Садат). Геологическая северо-восточная зональность и «горячая тектоника» (включая, возможно, и известную деламинацию литосферы в течение коллизии 13 млн. лет), обусловленная активностью Африканского суперплюма, важна для региона. Выяснена, что внутриплитные щелочные и субщелочные расплавы региона, включая четвертичные карбонатиты Ханнешина, Афганистан, генерировали из обогащенного мантийного источника Африканского суперплюма, богатыми высокозарядными литофильными элементами– HFSE (Nb, Ta, Zr, Y, P, Ti и т.д.). Позднекайнозойские высоко-калиевые известково-щелочные породы Малого

Кавказа могут быть также объяснены активностью указанного суперплюма, несмотря на формально субдукционные геохимические метки.

Имеются важные материалы об общей субмеридианальной зональности углеводородов здесь. Это может быть аргументом в пользу и глубинного вклада углеводородов, наряду с традиционной их трактовкой. Важная региональная Cu-Au порфировая и др. металлогения связана с породами шошонит-латитовой серии преимущественно эоценового возраста, формировавшимися в результате субдукции Аравийской плиты под блок Центрального Ирана.

Ключевые слова: центральная часть Альпийско-Гималайского пояса, Малый Кавказ-Восточный Иран, Ближний Восток, геология, геохимия, тектоника, магматизм, металлогения, Африканский суперплюм, деламинация, минералогия, расплавные и флюидные включения, северо-восточная (СВ) тектоно-магматическая-металлогеническая +нефть/углеводородная (УВ) зональность.

KİÇİK QAFQAZ-ŞƏRQİ İRAN, YAXIN ŞƏRQ: GEOLOGİYA VƏ METALLOGENİYA HAQQINDA BƏZİ MATERİALLAR, AFRİKA SUPERPLYUMİNİN FƏALİYYƏTİLƏ ƏLAQƏDAR OLAN "QAYNAR" TEKTONİKA, ƏRİNTİ VƏ FLYÜİD DAXİLOLMALARI, KARBOHİDROGENLƏR HAQQINDA BƏZİ MƏLUMATLAR, PROBLEMLƏR VƏ MƏHDUDİYYƏTLƏR

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XÜLASƏ

Kiçik Qafqazın və İranın şərqinin, Yaxın Şərqin kaynozoy tektono-maqmatik və metallogenik hadisələri ümumi xüsusiyyətlərə malikdirlər. Alp dövründə əhəmiyyətli geoloji-metallogenik+neft və ya karbohidrogen korrelyasiyası müəyyən edilmişdir (İranın şərqinin metallogeniyası görkəmli regional trio – Y.F.Romanko, A.Xuşmanzadə və M.A.A.Noqol Sadatın rəhbərlikləri altında aparılmışdır). Afrika superplyuminin fəallığı ilə əlaqədar olan geoloji şimal-şərqi zonallıq və "qaynar tektonika" (13 mln. il kolliziya dövründə məlum olan litosferin delaminasiyası da daxil olmaqla) region üçün əhəmiyyət kəsb edir. Müəyyən edilmişdir ki, Xanneşin, Əfqanıstanın dördüncü dövr karbonatitləri də daxil olmaqla regionun qələvi və mülayim qələvili ərintiləri yüksək nüvəli litofil elementlərlə HFSE (Nb, Ta, Zr, Y, P, Ti və b.) zəngin olan Afrika superplyuminin zənginləşmiş mantiya mənbəyindən generasiya etmişdir. Kiçik Qafqazın gec kaynozoy yaşlı yüksək kaliumlu kalsiumlu- qələvili süxurları formal olaraq subduksiya geokimyəvi nişanəsi olmasına baxmayaraq göstərilən superplyuminin fəallığı ilə izah edilə bilər. Burada karbohidrogenlərin ümumi submeridional zonallığı haqqında materiallar vardır. Bu tradision nəzəriyyə ilə bərabər karbohidrogenlərin dərinliklə əlaqəsinin xeyrinə arqument kimi istifadə oluna bilinər. Ərəbistan plitəsinin Mərkəzi İran blokunun altına subduksiyası nəticəsində əmələ gəlmiş regional Cu-Au porfir və başqa metallogeniya eosen yaşlı şoşonit-latit seriyasının süxurları ilə əlaqədardır.

Açar sözlər: Alp-Himalay qurşağının mərkəzi hissəsi, Kiçik-Qafqaz-Şərqi İran, yaxın Şərq, geologiya, geokimya, tektonika, maqamtizm, metallogeniya, Afrika superplyumi, delaminasiya, mineralogiya, ərinti və flyüid daxilolmaları, şimal-şərq (Şm-Ş) tektono-maqmatik-metallogenik+neft/karbohidrogen zonallığı.

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