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GEOCHEMISTRY DIVISION

Geochemical Exploration for Gold and Minerals of Wadi Sabra

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ABSTRACT

Geochemistry Division of NRA carried out geochemical prospecting for minerals in the Wadi Sabra (ARAGEO4 Sector) area, in southwestern part of Jordan.

The study area covers 2 km^2 approximately, covered by geological map of 1:100,000 scale.

The geochemical exploration for the area was carried out through rock and heavy mineral concentrate samples. The work was executed for multi-element and gold analysis. 28 chip rock samples and 19 heavy mineral samples were collected. These were analysed for gold using Atomic Absorption Spectrometry (AAS), and for multi-element by using Inductive Coupled Plasma Emission Spectrometry (NRAs - ARL - ICP)

Native gold grains (nuggets) were detected under microscope. The gold content amounted up to 5.79 g/ton from heavy mineral concentrate samples. Also, it gave 269 mg/ton in rock samples.

The maximums value for manganese (MnO) reached to 15% , Iron oxides (Fe_2O_3) occurrences with highest value of 18.9% in the rock samples have been identified in the study area.

The results obtained from this geochemical work indicate that gold (Au) mineralization, should be investigated extensively in order to trace and identify the source in Wadi Sabra. In addition of geochemical investigation for manganese and iron occurrences with their associated elements, in order to determine their origin and importance in the area.

1. INTRODUCTION

1.1 Location and Access

The study area covered 2km^2 approximately and situated at 95 km. north-northwest of Aqaba in southern Jordan (Fig.1).

The area lies some 13 km. east of the Amman-Safi-Aqaba highway, through Wadi Abu Khusheiba off Wadi Araba. Access by 4- wheel drives vehicle.

1.2 GEOLOGY

The area composed mainly of igneous rocks (Fig.2), and it forms apart of northernmost outcrops of the Arabian Shield, which extends to southward into Yemen.

The study area is covered by undifferentiated Precambrian eruptive rocks, biotite and biotite-muscovite aplitic granite, quartz porphyry, porphyrite, pegmatite, schist, also sedimentary rocks of Cretaceous age, with gypsum and oil shale fragments observed adjacent to the study area.

The area affected by alteration, and contains iron oxide outcrops, spots of manganese oxides and epidote filling the vesicular of some eruptive rocks. The area intersected by many faults of deferent directions.

1.3 Previous Work

1.3.1 Geological surveys

The First detailed study of the basement rock were made by Qunnel who defined the Aqaba Granitic Complex (1951) and compiled three geological maps at 1:250,000 scale, to accompany the first synthesis on geology of Jordan by Burdon (1959). In 1968, F. Bender published geological maps covering Jordan at 1:250,000 scale, and in 1974 the German Geological Mission, still with F. Bender, published three maps at 1:100,000

Figure (1) : Location Map of Study Area, Wadi Sabra

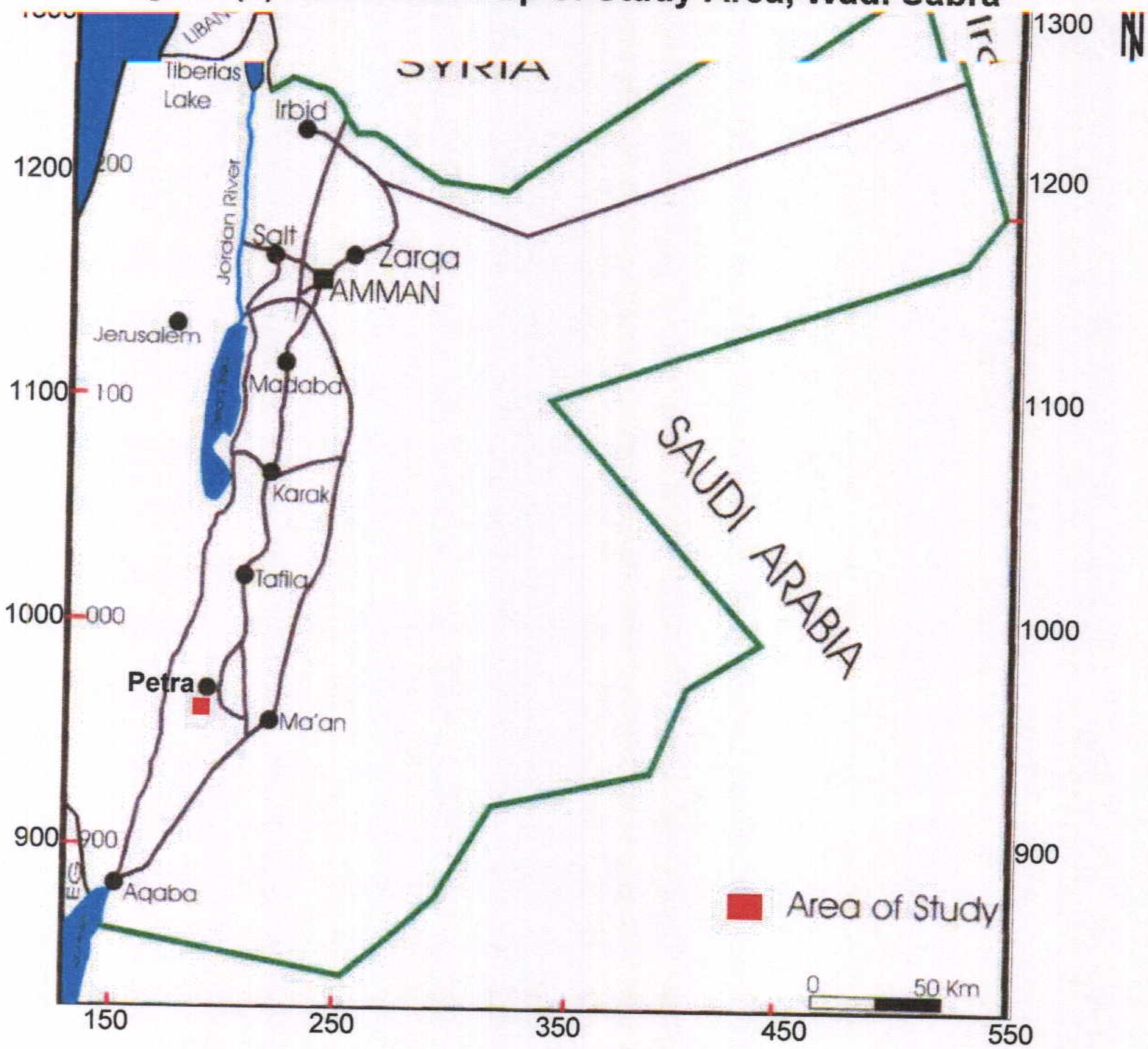
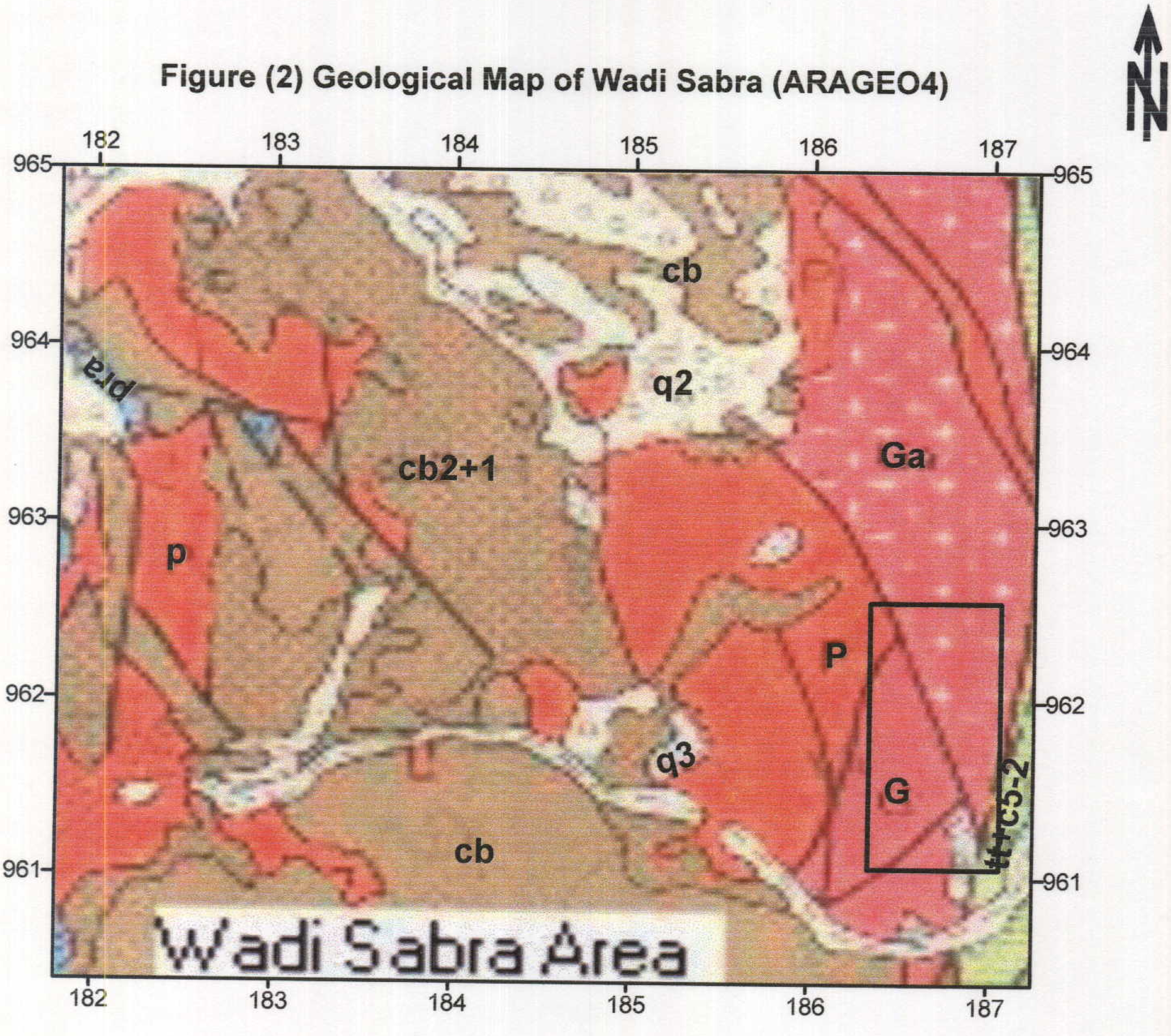


Figure (2) Geological Map of Wadi Sabra (ARAGEO4)



Scale 1:33,000

Study Area

q3	**Alluvial fans**
q2	**Fluviatile conglomerate**
tt+c5-2	**Upper Cretaceous & Lower tertiary sedimentery rocks**
cb	**Massive, brownish weathered sandstone**
cb2+1	**White fine sanstone**
pra	**Saramuj-Conglomerate**
p	**Qurtz porphyry, porphyrite, ignimbrite**
G	**Precambrian eruptive rocks, undifferentiated**
Ga	**Biotite & biotite-muscovite aplitic granite**

scale for the southwest region. Vanden Boom and Lahloub (1964), Vanden Boom and Rosche (1969) carried out the subdivision of the basement for these maps. Also, the area covered by landsat image.

1.3.2 Geochemical Exploration

The geochemical and mineral exploration, was carried out over financed by the Commission of European Communities (CEC). The geochemical exploration undertaken in the Aqaba and Araba complexes has been detailed in NRA report entitled Geochemical and mineral exploration of Aqaba-Araba Complex - Final report (NRA & BRGM Project stuff 1994). This report included the study area (ARAGEO4).

2. EXPLORATION METHODS

2.1Field Work

2.1.1 Rock Samples

A total of 28 chip samples were collected. These samples are about 2 kg each. These were collected from the rocks outcropping in the area. The samples were crushed and sieved to grain size > 1mm. Figure (3) shows the sample locations.

2.1.2 Heavy Mineral Concentrate (H. M. C.) Samples

A total of 19 heavy mineral samples were collected from the alluvium in stream sediment. Figure (4) shows the sample location. The samples sieved at the sampling site to get about four liters volume of alluvium with grain size less than 1mm. The samples were placed in 8 liters stainless-steel pans, and washed in seawater close to Aqaba, to eliminate the material of

Figure (3) : Rock Sample Location Map

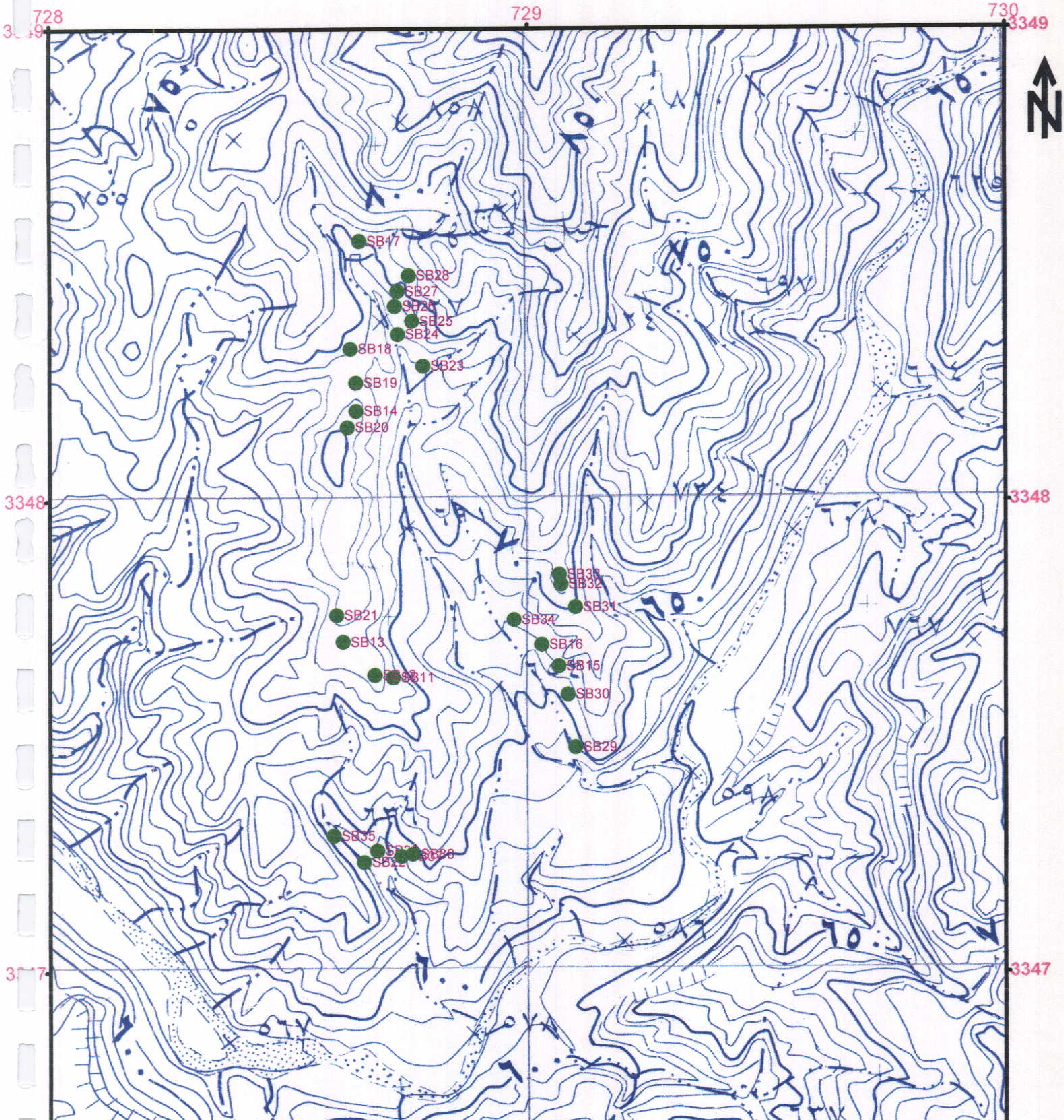
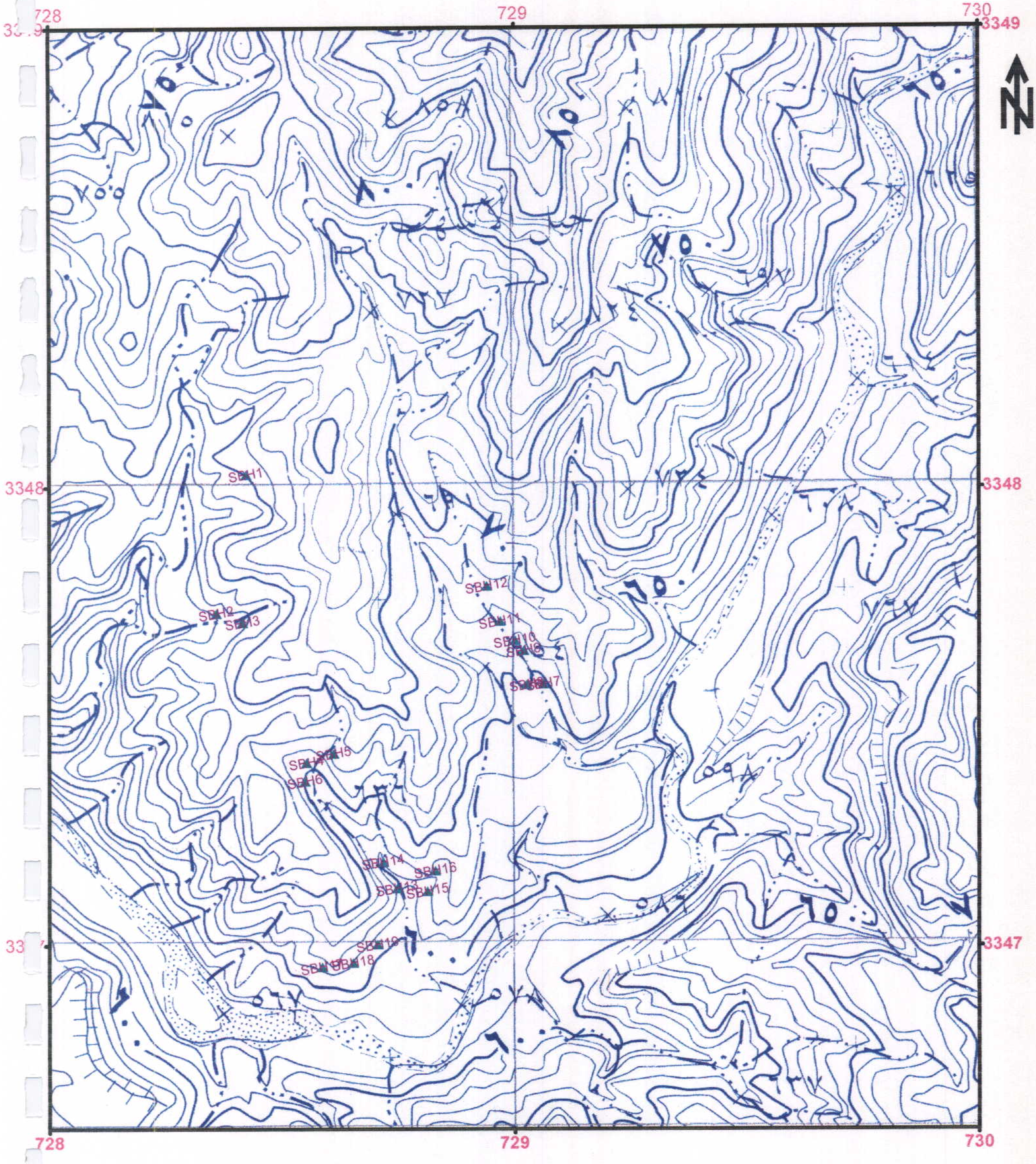


Figure (4) : Heavy Mineral Sample Location Map



law specific gravity, and to get about 200 g. of heavy mineral concentrates.

The concentrates were well rinsed in fresh water and dried on plates in the sun.

2.2 LABORATORY WORK

Rock and heavy mineral concentrates samples quartered to obtain about 100 gr. of each sample, and then ground to grain size >100 µm. for multi-element (ICP) and Au (AAS) analysis in ARA Laboratories.

2.2.1 Multi-element analysis by ICP

The ICP - AES (Inductively Coupled Plasma Atomic Emission Spectrometry) method, was used for 32 elements analysis. These are 8 major elements, (SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, MnO, TiO_2, K_2O), and 24 trace elements (P_2O_5, Li, Be, B, V, Cr, Co, Ni, Cu, Zn, As, Sr, Y, Nb, Mo, Ag, Sn, Ba, La, Ce, Pb, W, Bi, Zr). The digestion was with Sodium Peroxide.

2.2.2 Gold (Au) analysis by AAS

Atomic Absorption Spectrometer, Perken Elmer 3030 AA Spectrometer with Zeeman background correction, was used for Au analysis.

The analytical method consisted in dissolving the Au in the sample through heating with aqua-regia plus iron, then extracting the Au with a methyl isobutylceton (MIBK) solution by taking the organic phase which is then introduced in a pyrocoated graphite furnace and analysed for gold by atomic absorption.

3. INTERPRETATION OF GEOCHEMICAL DATA

ARAGEO4, the gold anomaly with one sample point of 1800 ppb, obtained from heavy mineral concentrates, was first detected during the NRA / BRGM collaborative project, close to Wadi Sabra in the Ras en Naqab sheet, and the area termed ARAGEO4 sector.

In the ARAGEO4 sector a geochemical prospecting program was carried out by the NRA Geochemical Division, to follow up the gold geochemical anomaly, using rock and heavy mineral concentrate samples for gold and multi elements analysis.

3.1 Geochemical Analysis for Gold (Au)

3.1.1 Gold from heavy mineral concentrate

The result of AAS chemical analysis of the heavy mineral concentrate samples for gold (table 1) shows Au content with maximum value 5.790 g/ton. Table (2) shows the elementary statistical parameters.

The correlation matrix (table 3) shows that Au is positively correlated with W, Ag & Zn. Grains of native gold have been detected and picked up under stereomicroscope by the authors, from heavy mineral concentrates, it is found in thin laminae.

The source of gold could be confined to cracks, or associated with intrusion of acidic igneous rocks, and may be associated with quartz, pegmatite and auriferous sulphides or the oxides produced by their alteration specially pyrite, arsenopyrite, chalcopyrite, or sphalerite. Figure (5), shows gold mineralization areas with associated elements from H. M. C. samples.

Table (1) **Results from Heavy Minral Concentrate**

x - axis	y - axis	s. No.	Sio2	Al2O3	Fe2O3	CaO	MgO	MnO	TiO2	K2O	P2O5	Au	Li	Be	V	Cr	Co	Ni	Cu	Zn	As	Sr	Y	Nb	Mo	Ag	Sn	Ba	La	Ce	Pb	W	Bi	Zr
			%	%	%	%	%	%	%	%	ppm	mg/Ton	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
728.4234	3348.027	SBH1	66.33	10.88	9.1	4.6	1.15	0.25	0.73	5.3	1344	45	18	3	32	329	27	95	65	215	44	139	39	19	14	0	20	3311	46	154	31	26	24	673
728.3587	3347.725	SBH2	64.3	9.13	10.1	4.1	1.15	0.4	0.91	5	2006	10	16	3	25	237	17	49	32	82	19	117	35	21	10	0	0	2889	43	143	0	24	18	847
728.4149	3347.705	SBH3	68.5	8.5	10.2	4.2	1.3	0.25	1.1	4.1	2131	100	19	3	59	412	38	68	672	108	54	142	42	30	21	0	69	2284	48	104	704	31	27	1331
728.5522	3347.399	SBH4	64.5	9.4	13.4	4.7	1.3	0.37	1.2	4.6	1891	20	20	4	31	447	48	96	32	113	59	131	41	30	32	1	84	2325	59	196	39	31	30	811
728.6105	3347.419	SBH5	67.6	7.7	13.5	5.4	1.3	0.4	1.3	3.7	1811	15	21	4	34	471	57	81	23	115	69	126	39	44	41	1	94	1516	60	167	85	34	32	1011
728.5488	3347.358	SBH6	67.7	8.3	12.4	4.1	1.3	0.39	1.05	4.2	1697	105	18	4	36	710	78	106	35	118	106	138	40	36	56	3	145	1698	62	164	86	41	40	910
729.0623	3347.571	SBH7	57.6	9.9	11.1	3.1	1.77	0.54	1.5	3.7	6037	130	42	4	122	237	19	43	26	163	124	388	33	21	8	0	6	1745	51	136	62	45	17	368
729.0267	3347.569	SBH8	57.73	9.9	5.97	7.1	2.55	0.23	0.66	2.6	2171	5790	48	3	94	297	28	52	38	249	104	247	25	13	7	3	7	813	43	111	35	840	19	338
729.0197	3347.644	SBH9	60.6	9.1	8.3	5.2	1.9	0.3	0.8	2.7	1698	550	44	3	72	663	35	60	27	146	101	174	38	25	19	1	58	811	49	131	43	43	19	648
729.0009	3347.666	SBH10	61.44	10.6	7.2	2.6	2.2	0.47	0.65	2.4	1894	330	53	3	94	349	53	76	29	139	124	206	44	18	25	3	51	925	41	110	66	52	24	276
728.9688	3347.708	SBH11	61.03	11.11	8.6	5	3.13	0.46	0.8	2.3	1935	210	68	3	123	528	71	105	57	199	193	223	43	25	42	4	79	831	46	117	190	67	26	409
728.9396	3347.785	SBH12	63.5	10.4	8.6	4.1	2.9	0.32	0.82	2.3	1906	500	59	4	123	592	88	118	44	197	208	178	29	42	52	5	103	804	54	158	83	77	31	367
728.7466	3347.126	SBH13	65.2	5.4	11.9	5.2	1	0.33	1	2.2	1712	425	15	4	42	879	82	105	21	120	155	117	40	60	56	2	141	824	75	183	70	61	30	1645
728.7164	3347.183	SBH14	66.3	8.7	7.2	3	0.7	0.12	0.52	4.8	4773	10	14	3	14	230	10	39	13	83	16	84	44	32	7	0	26	615	58	79	0	12	27	716
728.8118	3347.12	SBH15	76.2	9.1	3.1	3.1	0.49	0.08	0.31	5.7	4372	10	12	3	14	295	14	50	9	57	0	89	65	33	10	0	51	309	66	162	0	12	29	938
728.8287	3347.165	SBH16	72.3	7.8	3.2	3.6	0.53	0.12	0.31	4.5	4423	15	10	3	12	154	22	47	16	51	30	97	62	31	15	0	19	314	69	106	0	9	28	743
728.5856	3346.954	SBH17	93.1	1.5	1.7	2	0.24	0.03	0.27	0.66	4514	20	4	1	11	708	22	88	7	27	0	82	16	13	19	0	72	94	21	34	0	0	24	590
728.652	3346.963	SBH18	84.7	3.9	1.7	2.6	0.61	0.05	0.35	1.7	3933	10	17	2	10	337	33	79	14	140	0	123	25	17	39	2	79	293	40	60	0	0	28	438
728.7044	3347.003	SBH19	93.8	1.4	1.1	1.1	0.16	0.02	0.2	0.7	461	20	6	1	10	578	31	48	3	0	12	85	16	13	27	1	58	64	21	37	0	11	32	548

Table (2) Elementary Stastical parameters from Heavy Mineral Samples Analyses

Variable	Sio2	Al2O3	Fe2O3	CaO	MgO	MnO	TiO2	K2O	P2O5	Au	Li	Be	V	Cr	Co	Ni	Cu	Zn	As	Sr	Y	Nb	Mo	Ag	Sn	Ba	La	Ce	Pb	W	Bi	Zr
	%	%	%	%	%	%	%	%	ppm	mg/Ton	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Mean	69.23	7.88	7.74	3.90	1.36	0.27	0.76	3.21	2742.50	459.44	27.00	3.06	51.44	451.33	41.44	72.78	61.00	117.06	76.33	152.61	37.61	28.00	27.00	1.44	63.44	1064.11	50.33	122.11	81.28	77.22	26.72	718.56
Standard Dev.	10.98	2.92	4.14	1.43	0.89	0.17	0.39	1.47	1502.35	1342.75	19.68	0.94	42.36	203.68	24.80	25.58	153.10	62.66	66.63	76.52	12.96	12.39	17.06	1.58	42.31	828.69	14.61	47.36	163.06	191.71	5.87	363.13
Range	36.20	9.71	12.40	6.00	2.97	0.52	1.30	5.04	5576.00	5780.00	64.00	3.00	113.00	725.00	78.00	79.00	669.00	249.00	208.00	306.00	49.00	47.00	49.00	5.00	145.00	2825.00	54.00	162.00	704.00	840.00	23.00	1369.00
Minimum	57.60	1.40	1.10	1.10	0.16	0.02	0.20	0.66	461.00	10.00	4.00	1.00	10.00	154.00	10.00	39.00	3.00	0.00	0.00	82.00	16.00	13.00	7.00	0.00	0.00	64.00	21.00	34.00	0.00	0.00	17.00	276.00
Maximum	93.80	11.11	13.50	7.10	3.13	0.54	1.50	5.70	6037.00	5790.00	68.00	4.00	123.00	879.00	88.00	118.00	672.00	249.00	208.00	388.00	65.00	60.00	56.00	5.00	145.00	2889.00	75.00	196.00	704.00	840.00	40.00	1645.00
Geom. Mean	68.37	7.11	6.33	3.66	1.05	0.20	0.66	2.88	2287.23	67.16	20.45	2.86	35.09	402.52	34.07	69.73	26.07	#NUM!	#NUM!	139.00	35.51	25.17	21.12	#NUM!	#NUM!	775.89	47.76	112.43	#NUM!	#NUM!	25.97	641.90

Table (3) Correlation Matrix Of Heavy Mineral Samples, Wadi Sabra

	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	CaO %	MgO %	MnO %	TiO_2 %	K_2O %	P_2O_5 ppm	Au mg/Ton	Li ppm	Be ppm	V ppm	Cr ppm	Co ppm	Ni ppm	Cu ppm	Zn ppm	As ppm	Sr ppm	Y ppm	Nb ppm	Mo ppm	Ag ppm	Sn ppm	Ba ppm	La ppm	Ce ppm	Pb ppm	W ppm	Bi ppm	Zr ppm
SiO_2 %	1																															
Al_2O_3 %	-0.887	1.000																														
Fe_2O_3 %	-0.713	0.540	1.000																													
CaO %	-0.710	0.555	0.582	1.000																												
MgO %	-0.745	0.704	0.414	0.574	1.000																											
MnO %	-0.795	0.660	0.814	0.446	0.686	1.000																										
TiO_2 %	-0.672	0.477	0.930	0.499	0.432	0.836	1.000																									
K_2O %	-0.429	0.607	0.405	0.253	-0.104	0.197	0.297	1.000																								
P_2O_5 ppm	0.103	-0.061	-0.303	-0.340	-0.284	-0.212	-0.128	0.179	1.000																							
Au mg/Ton	-0.317	0.190	-0.077	0.584	0.416	-0.007	-0.038	-0.162	-0.124	1.000																						
Li ppm	-0.657	0.637	0.244	0.405	0.964	0.615	0.302	-0.209	-0.170	0.355	1.000																					
Be ppm	-0.807	0.696	0.842	0.603	0.480	0.731	0.784	0.524	-0.061	0.031	0.353	1.000																				
V ppm	-0.671	0.599	0.339	0.376	0.923	0.680	0.462	-0.198	-0.087	0.339	0.939	0.420	1.000																			
Cr ppm	0.187	-0.392	0.187	0.082	0.060	0.051	0.104	-0.551	-0.462	-0.107	0.017	-0.005	0.055	1.000																		
Co ppm	-0.267	0.140	0.484	0.325	0.519	0.471	0.377	-0.297	-0.542	-0.045	0.432	0.482	0.426	0.674	1.000																	
Ni ppm	-0.079	0.069	0.379	0.246	0.361	0.296	0.252	-0.239	-0.442	-0.156	0.261	0.298	0.236	0.649	0.839	1.000																
Cu ppm	-0.083	0.117	0.198	0.109	0.064	0.034	0.263	0.150	-0.132	-0.041	-0.029	0.035	0.112	-0.041	0.017	-0.001	1.000															
Zn ppm	-0.710	0.669	0.391	0.684	0.811	0.518	0.410	0.043	-0.198	0.527	0.749	0.479	0.719	-0.063	0.346	0.361	0.036	1.000														
As ppm	-0.648	0.497	0.496	0.470	0.859	0.698	0.491	-0.231	-0.299	0.213	0.823	0.582	0.863	0.390	0.777	0.549	-0.013	0.651	1.000													
Sr ppm	-0.616	0.503	0.316	0.277	0.678	0.664	0.545	-0.074	0.189	0.351	0.720	0.384	0.844	-0.181	0.094	-0.052	0.013	0.648	0.596	1.000												
Y ppm	-0.359	0.524	0.180	0.166	-0.026	0.142	0.052	0.727	0.212	-0.248	-0.034	0.461	-0.088	-0.361	-0.057	-0.143	0.089	-0.074	-0.011	-0.127	1.000											
Nb ppm	-0.290	0.136	0.546	0.339	0.048	0.252	0.402	0.236	-0.117	-0.238	-0.057	0.681	0.002	0.396	0.595	0.404	0.050	-0.004	0.392	-0.199	0.427	1.000										
Mo ppm	0.026	-0.149	0.339	0.128	0.224	0.249	0.244	-0.357	-0.456	-0.222	0.158	0.317	0.134	0.711	0.924	0.819	-0.057	0.124	0.531	-0.120	-0.131	0.589	1.000									
Ag ppm	-0.289	0.243	0.128	0.291	0.733	0.338	0.072	-0.437	-0.418	0.327	0.716	0.257	0.614	0.383	0.791	0.617	-0.162	0.553	0.773	0.286	-0.202	0.177	0.665	1.000								
Sn ppm	0.141	-0.259	0.303	0.070	0.042	0.102	0.196	-0.313	-0.370	-0.261	-0.023	0.249	-0.023	0.816	0.823	0.764	0.042	-0.053	0.374	-0.262	-0.069	0.626	0.924	0.488	1.000							
Ba ppm	-0.473	0.505	0.697	0.364	0.161	0.538	0.649	0.593	-0.294	-0.113	-0.010	0.454	0.079	-0.198	0.008	0.160	0.344	0.333	0.037	0.182	0.092	0.029	-0.097	-0.227	-0.164	1.000						
La ppm	-0.506	0.440	0.507	0.444	0.065	0.287	0.381	0.602	0.130	-0.097	-0.023	0.801	-0.002	-0.040	0.295	0.126	-0.025	0.124	0.263	-0.033	0.756	0.819	0.251	0.021	0.275	0.130	1.000					
Ce ppm	-0.657	0.616	0.785	0.607	0.340	0.627	0.670	0.571	-0.252	-0.028	0.196	0.887	0.230	0.109	0.449	0.384	-0.051	0.375	0.439	0.175	0.481	0.648	0.312	0.160	0.286	0.539	0.744	1.000				
Pb ppm	-0.168	0.174	0.298	0.175	0.217	0.184	0.364	0.073	-0.182	-0.054	0.126	0.133	0.262	0.073	0.200	0.128	0.968	0.115	0.181	0.113	0.102	0.144	0.101	-0.000	0.177	0.302	0.026	0.018	1.000			
W ppm	-0.337	0.219	-0.037	0.598	0.432	0.031	0.002	-0.128	-0.127	0.996	0.360	0.063	0.350	-0.132	-0.033	-0.143	-0.031	0.541	0.223	0.370	-0.235	-0.231	-0.214	0.333	-0.263	-0.071	-0.084	-0.000	-0.038	1.000		
Bi ppm	0.332	-0.264	0.094	-0.160	-0.245	-0.175	-0.057	-0.009	-0.287	-0.334	-0.312	0.143	-0.340	0.416	0.549	0.483	0.002	-0.297	0.020	-0.506	0.141	0.513	0.707	0.283	0.763	-0.172	0.318	0.168	0.067	-0.314	1.000	
Zr ppm	0.017	-0.165	0.402	0.222	-0.395	-0.024	0.278	0.315	-0.172	-0.262	-0.535	0.290	-0.419	0.340	0.182	0.129	0.399	-0.324	-0.128	-0.458	0.340	0.699	0.258	-0.340	0.431	0.240	0.541	0.403	0.384	-0.259	0.357	1.000

Figure (5) : Gold (Au) Mineralization with Associated Elements from H. M. C. Analysis, Wadi Sabra

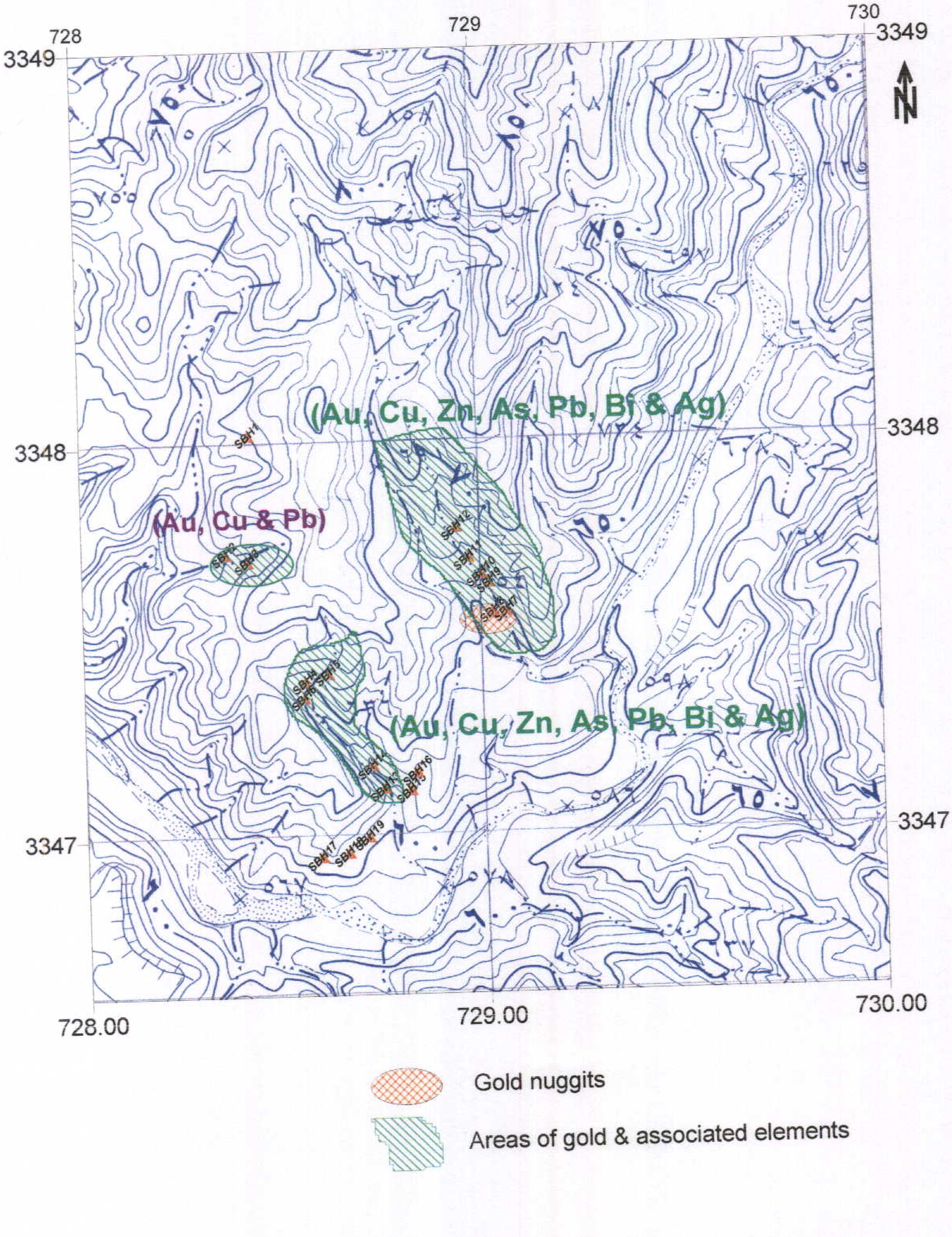
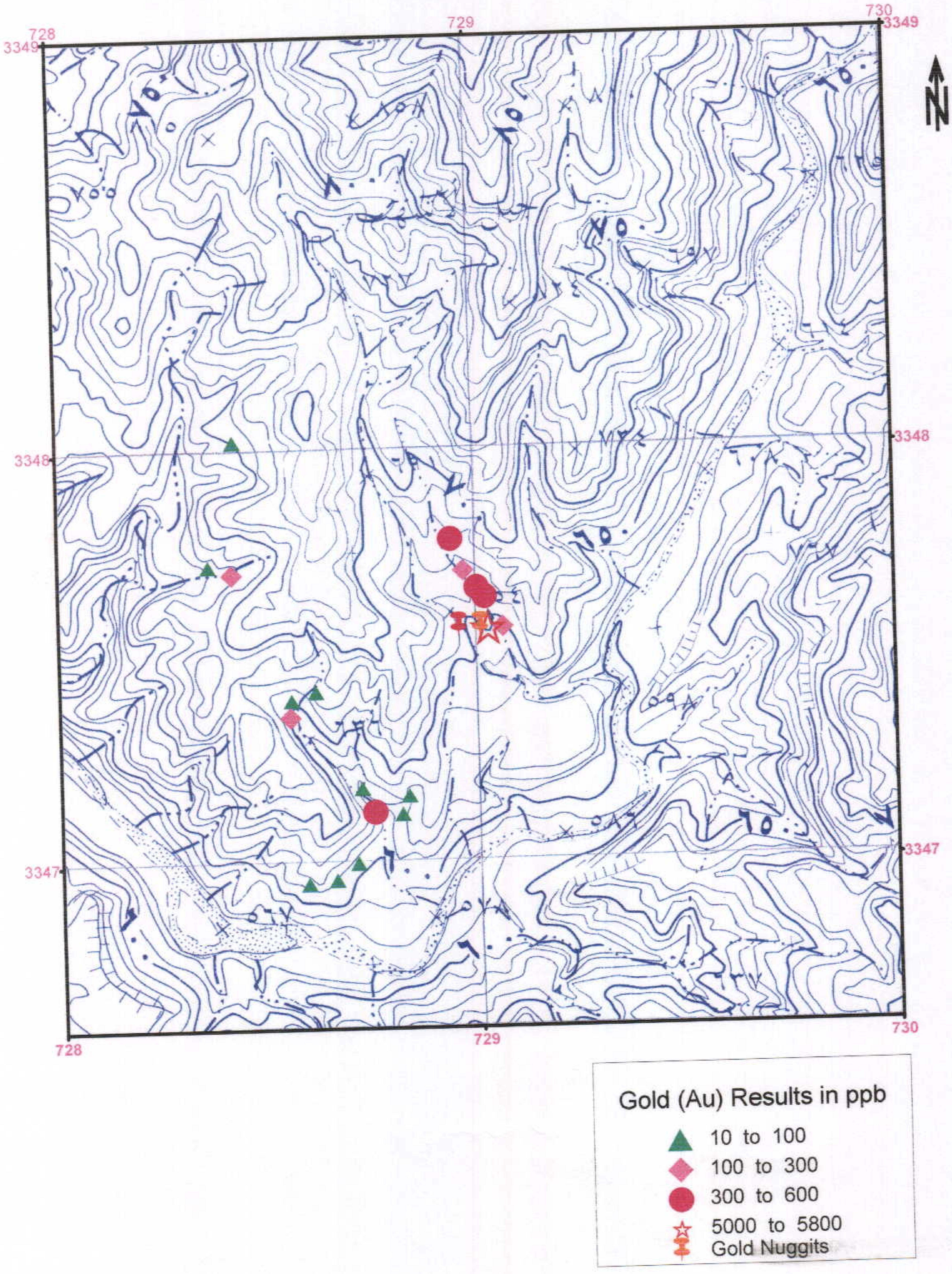


Figure (6) : Gold occurrences & distribution from H. M. C. , Wadi Sabra



The gold in heavy mineral concentrate could be primarily the result of the weathering conditions (chemically or physically) removal of a large part of the gangue minerals, if this is the case, gold migrates slowly downward by gravity or water and left behind as residual component. Figure (6) shows gold mineraliztion and distribution in the study area.

3.1.2 Gold from rock sample analysis

The results of AAS analysis of the rock samples for gold (table 4), show maximum value of gold content 260 ppb. The elementary statistical parameter shows in table (5). The gold shows positive correlation with Zn (table 6), gold mineralization and distribution, shown in figure (7)

The geochemical interpretation of the results of gold and multi-element chemical analysis of the rock samples shows that the disseminated gold in the area could be associated with elements As, Bi, Zn which are originated from Arsenopyrite ($FeAsS$), Bismuthite (Bi_2S_3), Sphalerite (ZnS). Figure (8) shows gold mineralization areas with associated elements from rock samples.

3.1.3 Area of gold potential

The area of gold mineraliztion potential, from a combination (complementary) of results from heavy mineral concentrates and rock samples, for gold analysis shown in figure (9).

3.2 Geochemical Analysis for Multi-Elements

3.2.1 Multi-elements from rock analysis

The results of rock sample analysis are given in table (4), and the results of geochemical exploration are the following:

Table (4) **Results from Rock Samples**

x - axis	y - axis	s. No.	Sio2	Al2O3	Fe2O3	CaO	MgO	MnO	TiO2	K2O	P2O5	Au	Li	Be	V	Cr	Co	Ni	Cu	Zn	As	Sr	Y	Nb	Mo	Ag	Sn	Ba	La	Ce	Pb	W	Bi	Zr
			%	%	%	%	%	%	%	%	ppm	mg/Ton	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
728.7166	3347.626	SB11	34	8.1	0.9	20.1	7.8	1.9	0.06	5.8	413	10	8	1	102	8	2	26	9	19	103	136	4	0	0	0	0	4835	28	26	0	39	15	389
728.6783	3347.631	SB12	67.6	9.3	7.1	4	1.2	0.27	0.52	5.6	1022	15	15	2	38	25	0	25	18	48	28	111	29	11	0	0	1	1772	42	114	0	34	17	461
728.6121	3347.702	SB13	41.8	4.4	2.8	17.7	0.65	15	0.24	2.6	743	10	12	4	25	14	15	33	83	47	281	549	15	9	0	0	142	12935	25	45	22	4	20	408
728.64	3348.191	SB14	38.3	4.8	3.8	31.3	0.53	1.2	0.29	3.32	929	15	7	2	22	10	8	27	40	58	64	121	16	8	0	0	20	1815	3	41	10	39	24	397
729.0641	3347.65	SB15	71.85	11.44	2.5	0.8	0.58	0.18	0.25	4.8	463	10	19	2	37	47	5	42	2111	113	31	126	25	9	0	0	10	1182	42	114	0	28	18	476
729.0285	3347.696	SB16	59.5	14.7	7.6	1.3	3	0.21	1	3	2378	15	86	3	121	105	20	89	107	103	70	222	21	8	0	0	0	858	29	62	3	41	20	427
728.647	3348.551	SB17	53.7	9.4	9.8	5.8	0.34	3.97	1.6	7.11	6296	10	7	8	121	39	28	250	155	124	140	184	49	33	4	0	34	2898	63	198	149	0	18	514
728.6282	3348.323	SB18	57.28	11.62	9.6	2.1	2.7	0.41	0.73	6.66	1769	10	42	3	38	25	15	48	165	254	87	104	37	17	6	0	14	1819	38	91	4	42	20	582
728.6396	3348.251	SB19	15.2	3.02	2.6	37.3	3.2	2.7	0.2	2	1320	10	3	2	51	46	40	88	192	53	122	267	13	12	0	1	43	2423	0	68	30	40	18	639
728.6215	3348.156	SB20	36.03	4.07	3.8	29.7	0.55	2.02	0.28	2.8	1008	1	7	2	19	22	39	61	30	77	115	150	16	14	4	2	52	5353	1	75	21	37	23	440
728.5983	3347.759	SB21	44.4	6	4.2	14.6	1.2	10.9	0.33	3.7	1061	20	7	4	22	17	42	86	36	30	291	242	20	17	20	2	110	11649	82	218	23	41	30	420
728.6552	3347.234	SB22	40.7	2.2	1.6	33.2	0.41	3.4	0.06	1.7	425	5	10	2	18	31	52	93	20	14	154	259	16	18	10	3	78	879	9	92	16	45	31	392
728.7802	3348.286	SB23	71.1	11.1	10	0.9	0.29	0.1	0.74	5.7	1191	20	13	4	38	22	45	71	28	32	107	216	41	25	25	2	52	1185	80	254	24	52	34	556
728.7269	3348.354	SB24	58.3	10.2	18.9	2.4	0.18	0.15	2.1	6.8	1255	1	8	4	87	27	58	84	15	62	112	330	42	43	34	2	51	937	65	251	119	55	32	627
728.7565	3348.382	SB25	72.2	3.4	15.9	5.5	0.13	0.28	0.1	0.18	848	20	28	10	112	43	58	97	40	42	133	133	23	21	44	7	62	184	102	226	83	109	32	211
728.7205	3348.414	SB26	70.6	10.5	4.6	1.2	0.09	0.07	0.15	6.97	324	0	19	5	25	21	2	42	15	53	15	79	39	24	0	0	2	399	44	115	0	15	16	407
728.7261	3348.445	SB27	53.64	13.07	15.5	2.3	0.24	0.09	2.7	8.5	1072	0	9	3	161	23	4	36	9	29	19	290	26	31	0	0	1	1039	79	261	0	34	16	567
728.7499	3348.478	SB28	76.5	9.8	3.4	3.3	0.16	0.05	0.19	0.24	461	10	79	4	25	18	3	57	54	260	0	112	77	42	0	0	10	89	84	189	0	17	20	739
729.0988	3347.478	SB29	54.6	11.6	8.3	2.5	3	0.3	1.6	5.8	5474	260	63	4	49	15	0	3	45	455	84	116	36	15	0	0	0	1014	36	102	6	48	16	302
729.0834	3347.59	SB30	65.6	9.6	1.2	5.4	0.9	0.26	0.18	2.8	438	20	15	2	42	22	0	7	12213	358	37	193	18	5	0	0	0	5935	57	121	11	43	18	212
729.0988	3347.776	SB31	72.7	12.2	6.3	1.5	2.3	0.16	0.73	1.7	2085	40	85	2	96	79	7	46	91	138	64	233	21	3	0	0	0	496	19	32	0	55	26	160
729.0685	3347.824	SB32	65.2	10.8	5.2	1.1	2	0.16	0.65	2.1	1189	40	55	2	84	67	2	40	82	61	55	176	15	3	0	0	0	559	19	35	0	47	23	168
729.0652	3347.844	SB33	75.6	6.8	6.1	0.71	1.4	0.13	0.31	1.35	1108	95	37	1	59	51	0	21	306	66	211	171	7	1	0	0	0	350	8	4	0	31	23	128
728.9695	3347.749	SB34	69.4	13.2	1.4	4.3	0.33	0.46	0.06	3	1459	10	13	5	23	24	0	14	33	30	64	103	11	51	0	0	15	212	8	6	18	51	23	62
728.5918	3347.29	SB35	54.3	3.9	2.2	13.4	1.6	3.4	0.13	2.7	597	10	15	5	21	26	3	21	121	46	107	115	20	7	0	0	19	505	25	48	15	37	22	238
728.6823	3347.258	SB36	62.5	10.5	5	1.2	0.48	0.05	0.41	7.4	958	20	26	5	12	11	1	92	7	137	19	77	65	33	0	0	7	689	54	134	0	22	15	932
728.7332	3347.246	SB37	76.3	8.5	2.1	2.1	0.18	0.03	0.24	5.7	11189	20	21	4	10	16	8	97	7	41	25	154	41	23	3	0	13	285	104	205	0	15	20	630
728.7572	3347.251	SB38	74.6	10.8	2.1	1.1	0.35	0.03	0.35	8.22	706	30	17	5	14	14	14	44	8	68	30	95	61	40	5	0	18	485	42	144	0	14	30	903

Table (6) **correlation matrix of rock samples, Wadi Sabra**

Sio2 %	1.000																														
Al2O3 %	0.554	1.000																													
Fe2O3 %	0.163	0.236	1.000																												
CaO %	-0.870	-0.780	-0.370	1.000																											
MgO %	-0.416	0.043	-0.201	0.200	1.000																										
MnO %	-0.482	-0.481	-0.220	0.410	-0.003	1.000																									
TiO2 %	0.001	0.472	0.754	-0.335	-0.075	-0.159	1.000																								
K2O %	0.072	0.478	0.269	-0.345	-0.021	-0.175	0.520	1.000																							
P2O5 ppm	0.152	0.152	0.049	-0.203	-0.048	-0.084	0.231	0.236	1.000																						
Au ppb	0.099	0.157	0.067	-0.209	0.222	-0.127	0.222	0.006	0.308	1.000																					
Li	0.423	0.472	0.073	-0.452	0.194	-0.307	0.090	-0.320	0.113	0.392	1.000																				
Be	0.275	-0.037	0.386	-0.283	-0.417	0.078	0.089	0.115	0.219	-0.041	-0.079	1.000																			
V	-0.025	0.309	0.633	-0.230	0.290	-0.183	0.646	0.086	0.044	-0.004	0.222	0.119	1.000																		
Cr	0.163	0.261	0.165	-0.201	0.158	-0.203	0.117	-0.388	0.007	-0.005	0.598	-0.120	0.510	1.000																	
Co	-0.323	-0.444	0.424	0.369	-0.202	0.229	0.094	-0.149	-0.064	-0.247	-0.298	0.309	0.110	0.073	1.000																
Ni	-0.106	-0.108	0.278	0.050	-0.216	0.134	0.223	0.145	0.416	-0.275	-0.128	0.512	0.273	0.177	0.522	1.000															
Cu	0.116	0.068	-0.217	-0.081	-0.054	-0.095	-0.135	-0.116	-0.125	-0.029	-0.088	-0.182	-0.058	-0.041	-0.188	-0.218	1.000														
Zn	0.164	0.323	0.003	-0.280	0.108	-0.222	0.172	0.011	0.169	0.613	0.482	-0.033	-0.063	-0.057	-0.319	-0.184	0.477	1.000													
As	-0.431	-0.554	0.020	0.382	0.085	0.803	-0.106	-0.316	-0.091	0.060	-0.260	0.059	-0.023	-0.010	0.476	0.186	-0.159	-0.256	1.000												
Sr	-0.372	-0.226	0.185	0.252	-0.056	0.672	0.273	-0.152	-0.059	-0.152	-0.147	-0.119	0.231	0.121	0.369	0.109	0.009	-0.224	0.597	1.000											
Y	0.443	0.346	0.191	-0.458	-0.402	-0.257	0.207	0.427	0.209	0.009	0.211	0.430	-0.187	-0.276	-0.038	0.333	-0.131	0.313	-0.437	-0.291	1.000										
Nb	0.283	0.298	0.281	-0.280	-0.531	-0.168	0.274	0.372	0.109	-0.177	-0.150	0.541	-0.092	-0.347	0.190	0.306	-0.223	-0.043	-0.257	-0.123	0.656	1.000									
Mo	0.103	-0.222	0.633	-0.066	-0.261	0.032	0.130	-0.059	-0.077	-0.122	-0.196	0.517	0.175	-0.041	0.805	0.309	-0.117	-0.225	0.320	0.158	0.088	0.278	1.000								
Ag	-0.072	-0.490	0.419	0.222	-0.219	0.062	-0.111	-0.340	-0.160	-0.121	-0.190	0.464	0.132	0.029	0.805	0.275	-0.107	-0.257	0.337	0.102	-0.116	0.098	0.860	1.000							
Sn	-0.416	-0.592	0.029	0.455	-0.251	0.840	-0.144	-0.228	-0.128	-0.219	-0.403	0.241	-0.215	-0.220	0.659	0.266	-0.163	-0.331	0.795	0.678	-0.154	0.057	0.467	0.496	1.000						
Ba	-0.482	-0.353	-0.232	0.365	0.117	0.876	-0.149	-0.092	-0.141	-0.123	-0.337	-0.104	-0.150	-0.273	0.159	-0.002	0.210	-0.046	0.689	0.587	-0.307	-0.269	0.011	0.015	0.703	1.000					
La	0.453	0.201	0.445	-0.502	-0.340	-0.068	0.261	0.279	0.336	-0.098	-0.008	0.546	0.173	-0.229	0.197	0.337	0.081	0.074	-0.133	-0.030	0.548	0.411	0.518	0.311	0.081	-0.019	1.000				
Ce	0.233	0.123	0.592	-0.304	-0.466	-0.065	0.468	0.400	0.224	-0.150	-0.205	0.488	0.193	-0.265	0.459	0.451	-0.003	-0.014	-0.084	0.090	0.566	0.538	0.614	0.399	0.206	-0.032	0.882	1.000			
Pb	-0.127	-0.182	0.553	0.038	-0.237	0.154	0.372	0.082	0.192	-0.147	-0.301	0.594	0.368	0.029	0.617	0.721	-0.061	-0.101	0.317	0.249	0.131	0.352	0.585	0.438	0.357	0.065	0.271	0.435	1.000		
W	0.010	-0.112	0.528	0.007	0.081	-0.240	0.120	-0.325	-0.093	0.103	0.077	0.341	0.455	0.310	0.508	0.138	0.029	-0.002	0.126	-0.085	-0.299	-0.052	0.674	0.735	0.048	-0.218	0.132	0.155	0.437	1.000	
Bi	0.132	-0.254	0.268	0.073	-0.340	0.084	-0.068	-0.256	-0.172	-0.137	-0.092	0.224	-0.085	0.081	0.707	0.141	-0.167	-0.346	0.366	0.194	-0.019	0.202	0.750	0.647	0.485	-0.021	0.148	0.296	0.310	0.468	1.000
Zr	-0.051	0.107	0.077	-0.030	-0.175	-0.063	0.172	0.553	0.098	-0.237	-0.147	0.115	-0.198	-0.351	0.140	0.336	-0.209	-0.004	-0.276	-0.047	0.749	0.481	0.030	-0.115	0.045	-0.062	0.351	0.500	0.031	-0.459	-0.075	1.000
	Sio2 %	Al2O3 %	Fe2O3 %	CaO %	MgO %	MnO %	TiO2 %	K2O %	P2O5 ppm	Au ppb	Li	Be	V	Cr	Co	Ni	Cu	Zn	As	Sr	Y	Nb	Mo	Ag	Sn	Ba	La	Ce	Pb	W	Bi	Zr

Figure (7) : Gold (Au) Concentration & Distribution From Rock Analysis, Wadi Sabra

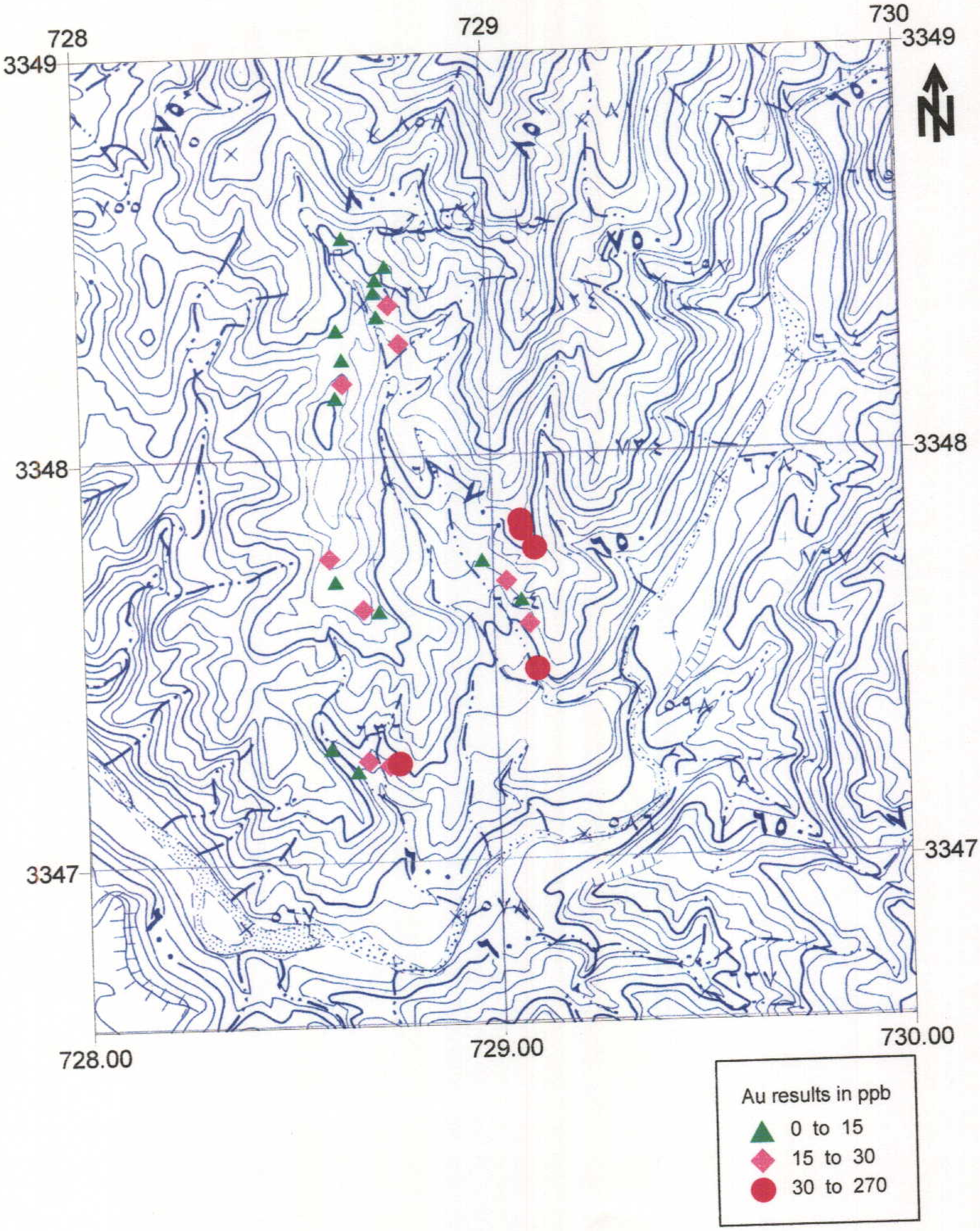


Figure (8) : Gold (Au) Mineralization with Associated Elements from Rock Analysis, Wadi Sabra

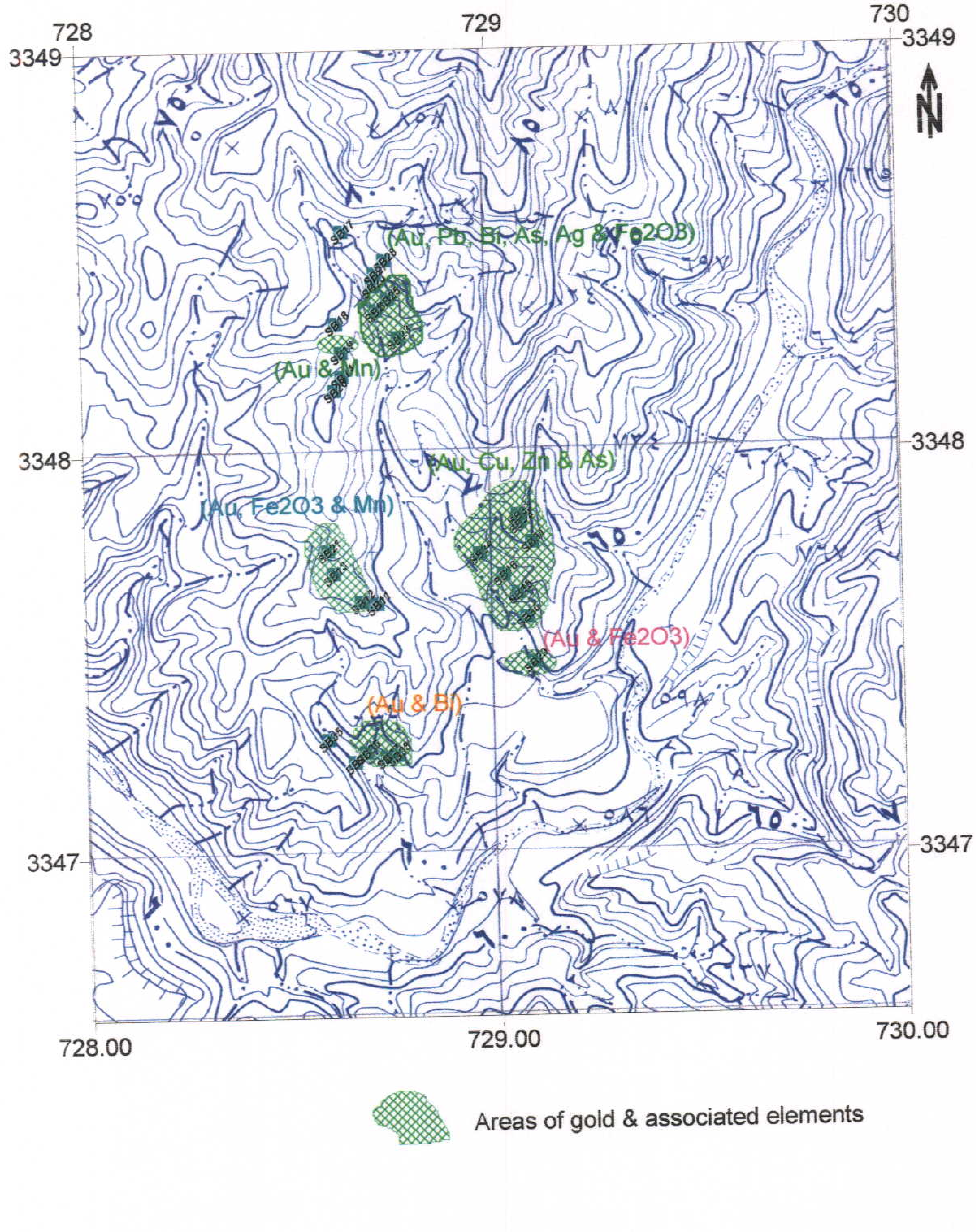
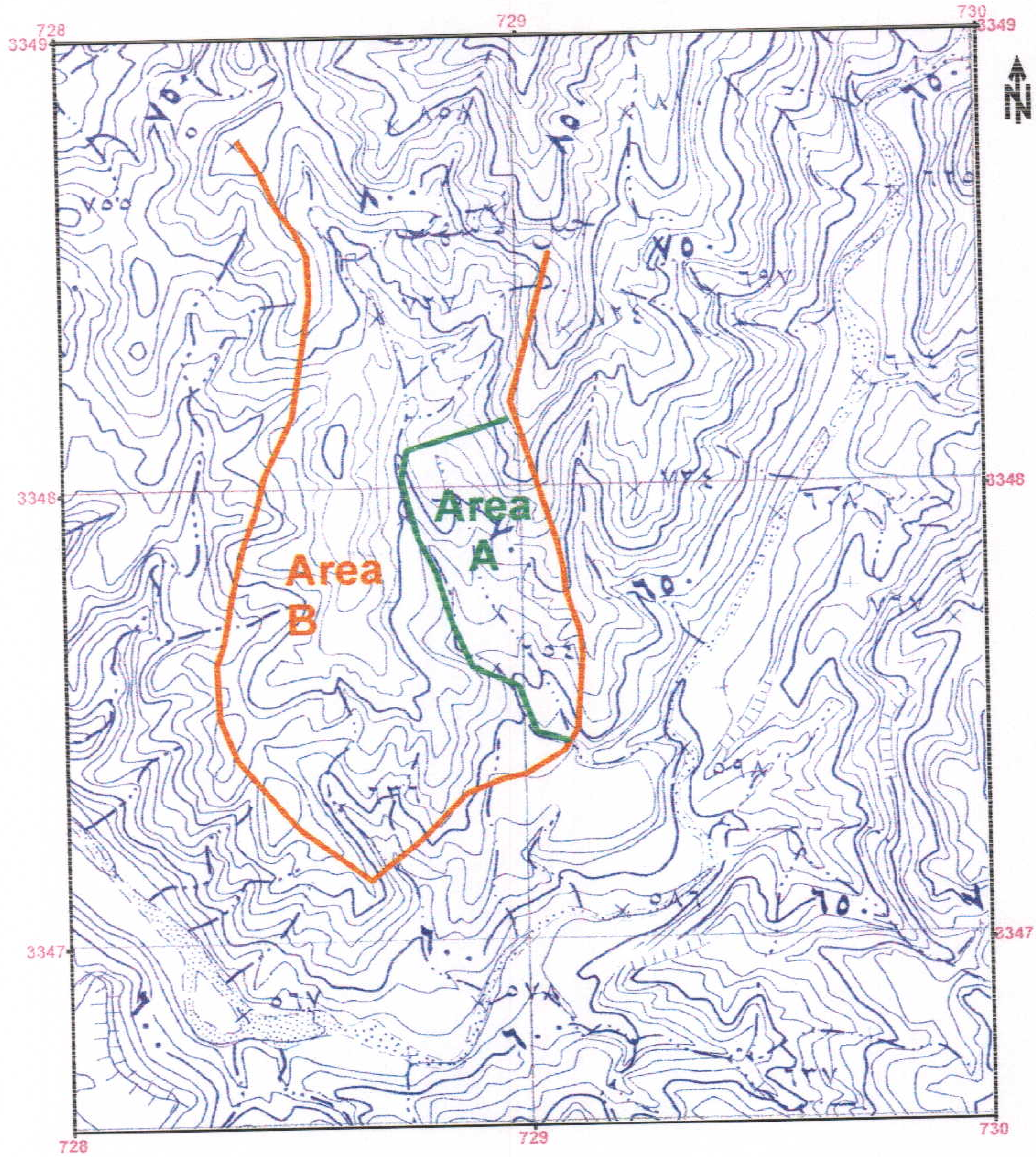


Figure (9) : Areas of Gold Mineralization potential from H. M. C. & Rock Analysis, Wadi Sabra.



3.2.1.1 Iron

The result of ICP chemical analysis of the rock samples (table 4) shows maximum value with 18.9% of iron oxides (Fe_2O_3). The statistical parameters are shown in (table 5).

Iron oxides show good positive correlation with TiO_2 and fair positive correlation with W, Pb, Ce, Mo and V.

The iron oxide occurrences, outcropping in the area, could be associated with a fault zone. Figure (10) shows the iron occurrences and distribution.

3.2.1.2 Manganese

The result of ICP chemical analysis of the rock samples (table 4) shows maximum value of 15% of manganese oxides (MnO). The statistical parameters are shown in (table 5)

Manganese shows good positive correlation with Ba, Sn, As (table 6). In some samples it is found associated with iron oxide.

In the area; manganite [$MnO_2.Mn(OH)_2$] found as druses of crystal, it is associated with quartz, calcite, barite, and sulfur SO_3, this is might be an indication of hydrothermal manganese occurrences, which is the last mineral to be formed in this state. Also, traces of gold are found associated with manganese may be occur in rock - forming silicates, which carry manganese, or precipitation of gold with manganese (Robert W. Boyle 1987). Figure (11) shows the manganese occurrences and distribution.

3.2.1.3 **Copper** (Cu)

Copper shows three points with values of 306 ppm, 2111 ppm and 12213 ppm, reflecting spots of copper mineralization. Figure (12) shows Cu concentration and distribution from rock sample analysis.

3.2.1.4 **Silver** (Ag)

Silver shows one point with value of 7 ppm, associated with iron occurrence, may be related or trapped within iron oxides. Figure (13) show silver concentration and distribution from rock sample analysis.

3.2.1.5 Trace Elements

Lead (Pb), **Zinc** (Zn), **Bismuth** (Bi) and **Arsenic** (As) these trace elements generally distributed in the area within the rocks. Figures (14,15,16,17) show the elements concentration and distribution from rock sample analysis.

3.2.1.6 Epidote

Epidote mineral has been distinguished during the field work in the area filling the vesicular of hosted eruptive rocks.

3.2.2 Multi-Elements from Heavy Mineral Concentrate Analysis

Copper (Cu), **Zinc** (Zn), **lead** (Pb), **Silver** (Ag), **Arsenic** (As) and **Bismuth** (Bi), these elements were detected in the most heavy mineral concentrate samples. One sample number SBH3 show high value of Cu (672 ppm), Pb (704 ppm), Zn (250 ppm) and Au (100 ppb), this may reflect the occurrences of polymetallic mineralization close to the sample site, the area should be checked.

Figures (18,19,20,21,22,23) show the elements concentration and distribution in the study area, and table (1) shows the chemical analysis results.

Figure (10) : Iron Fe2O3 concentration & Distribution from Rock Analysis, Wadi sabra

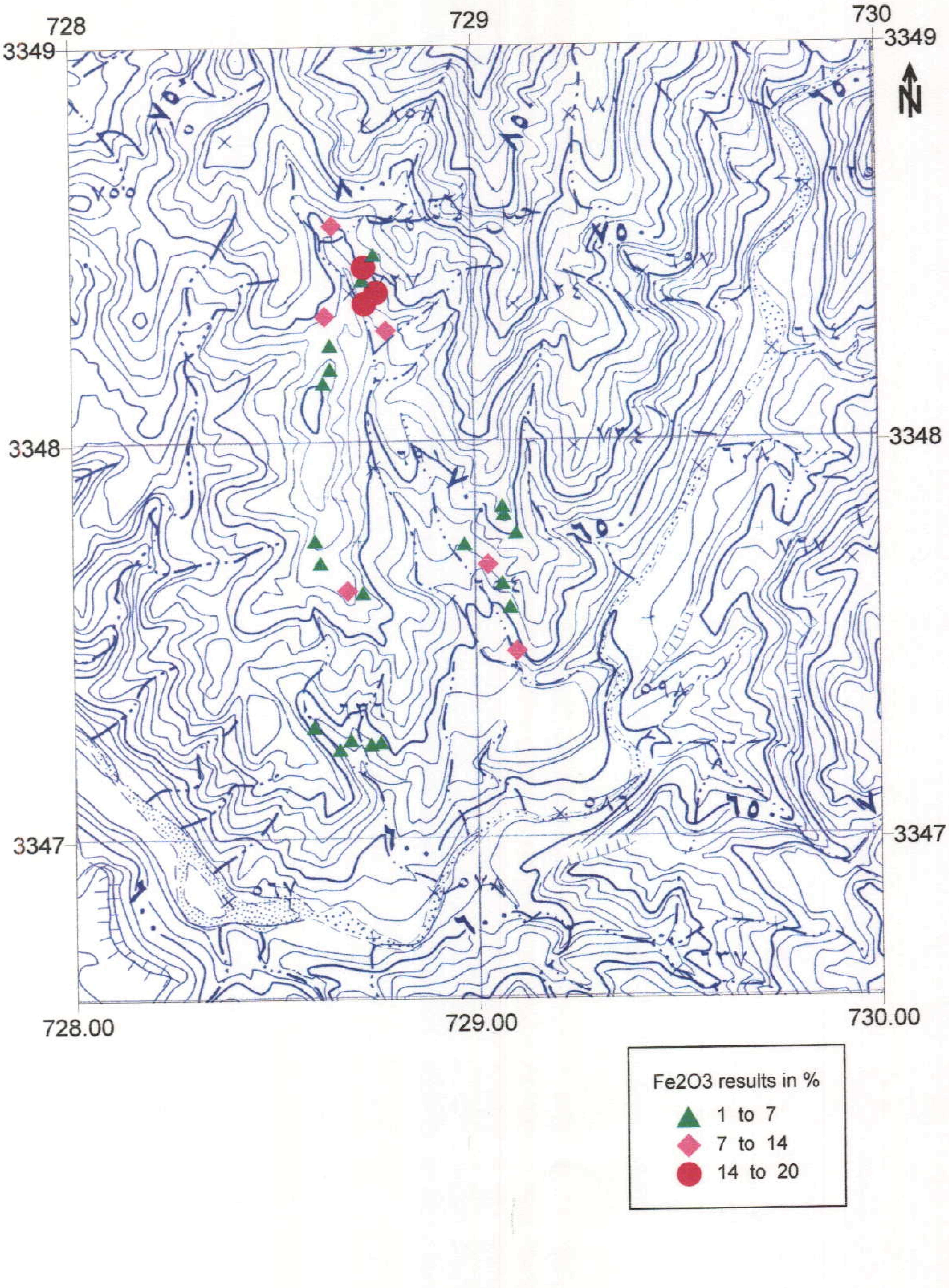


Figure (11) : Manganese (MnO) Concentration & Distribution from Rock Analysis, Wadi Sabra

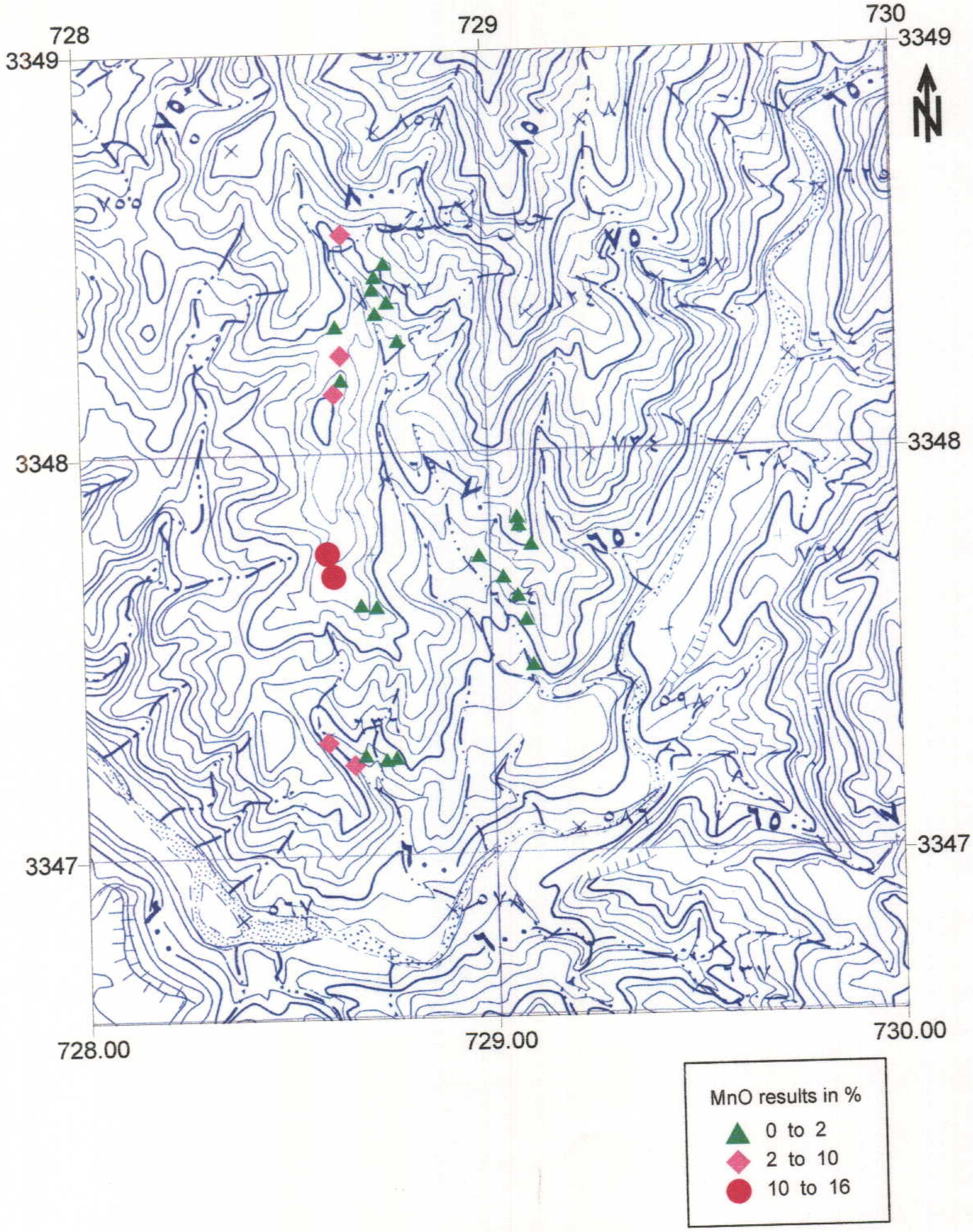


Figure (12) : Copper (Cu) Concentration & Distribution from Rock Analysis, Wadi Sabra

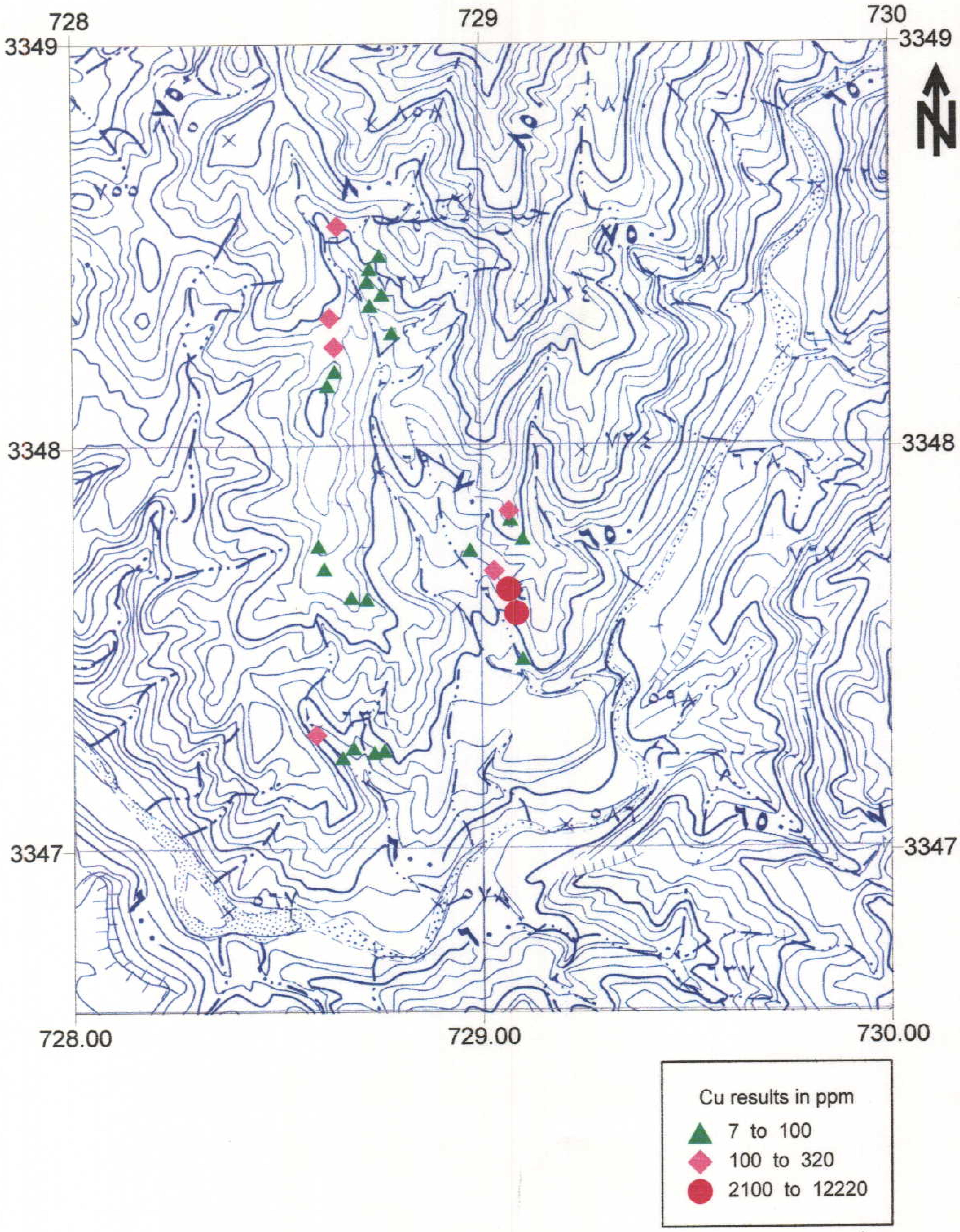


Figure (13) : Silver (Ag) Concentration & Distribution from Rock Analysis, Wadi Sabra

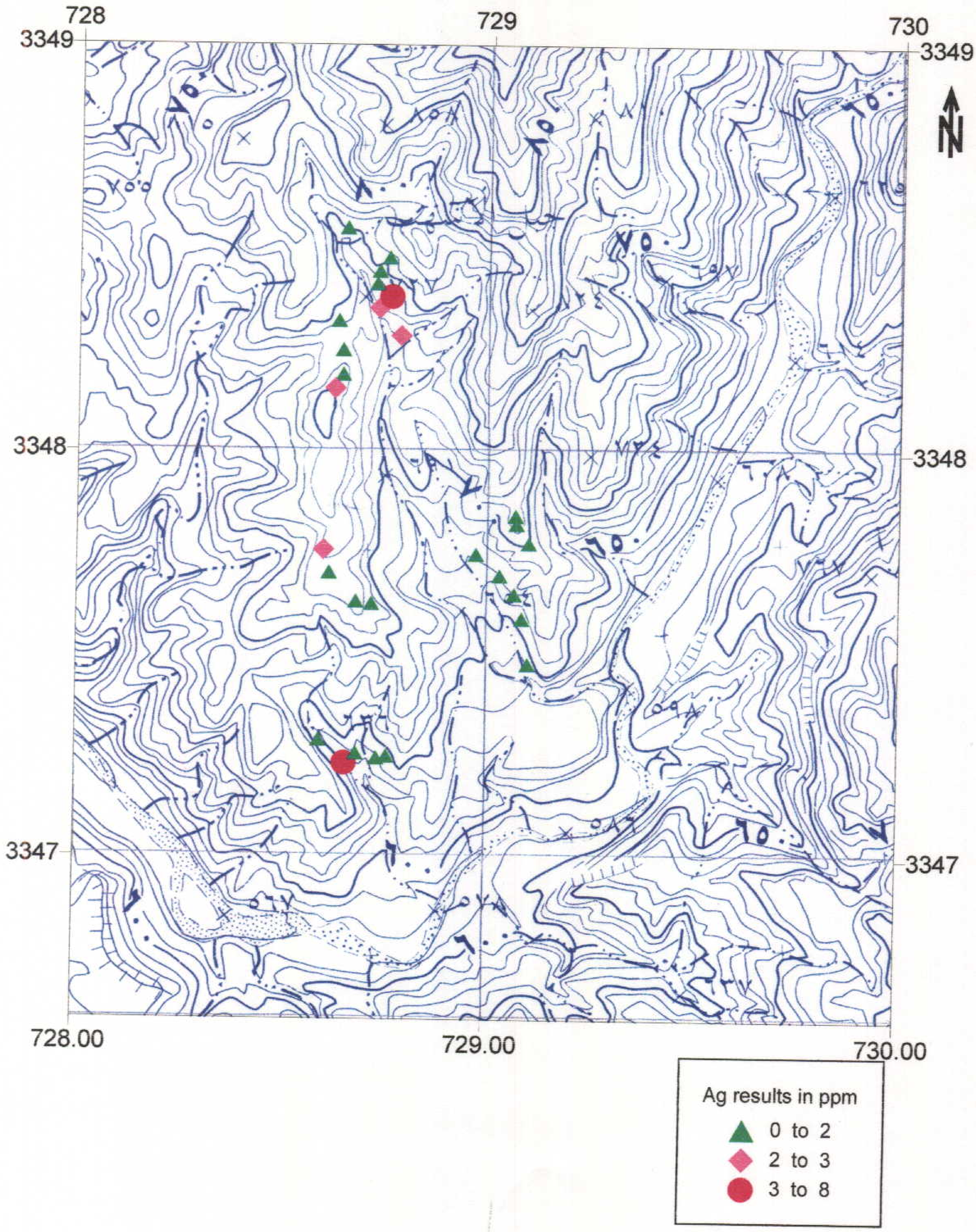


Figure (14) : Lead (Pb) Concentration & Distribution from Rock Analysis, Wadi Sabra

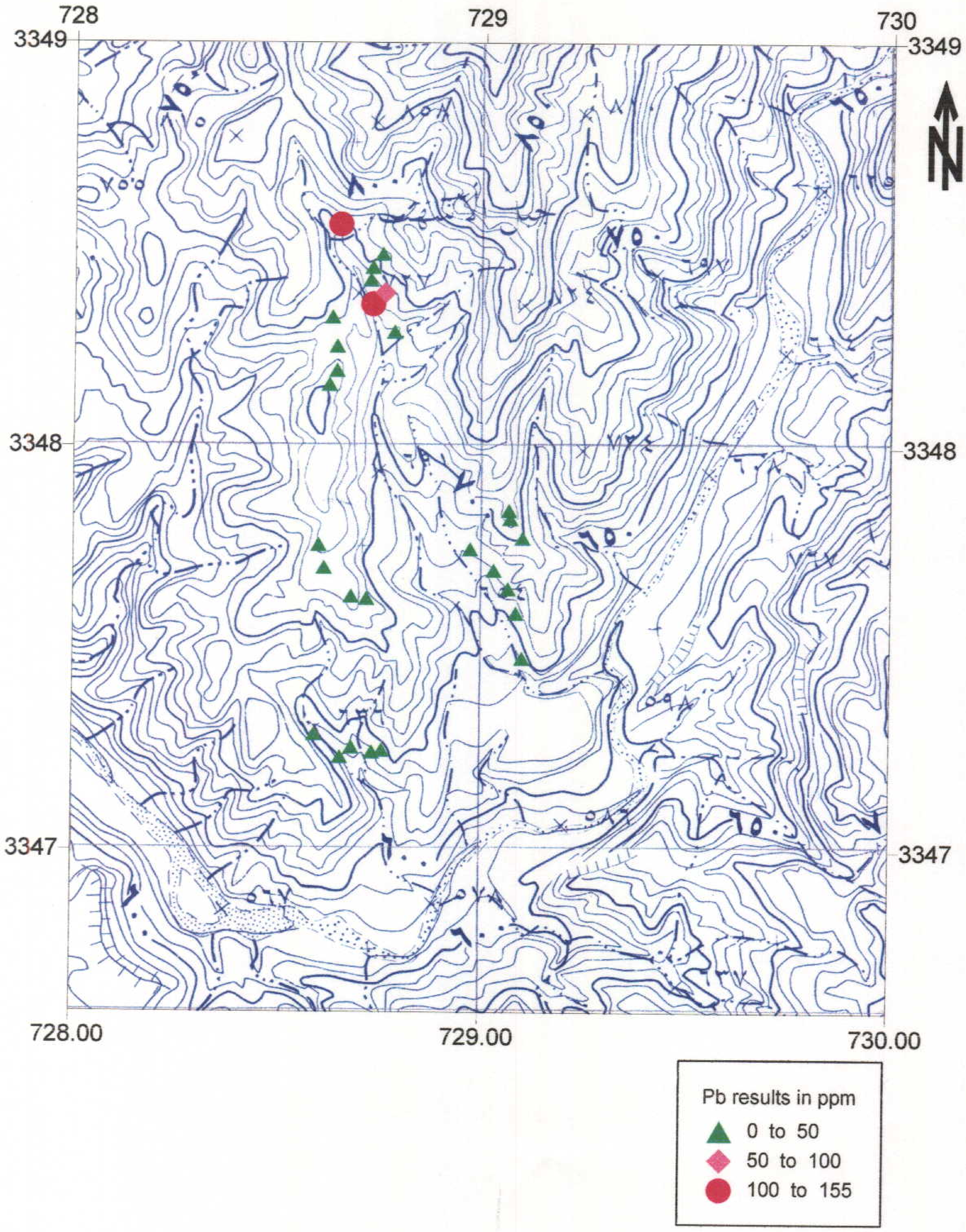


Figure (15) : Zinc (Zn) Concentration & Distribution from Rock Analysis, Wadi Sabra

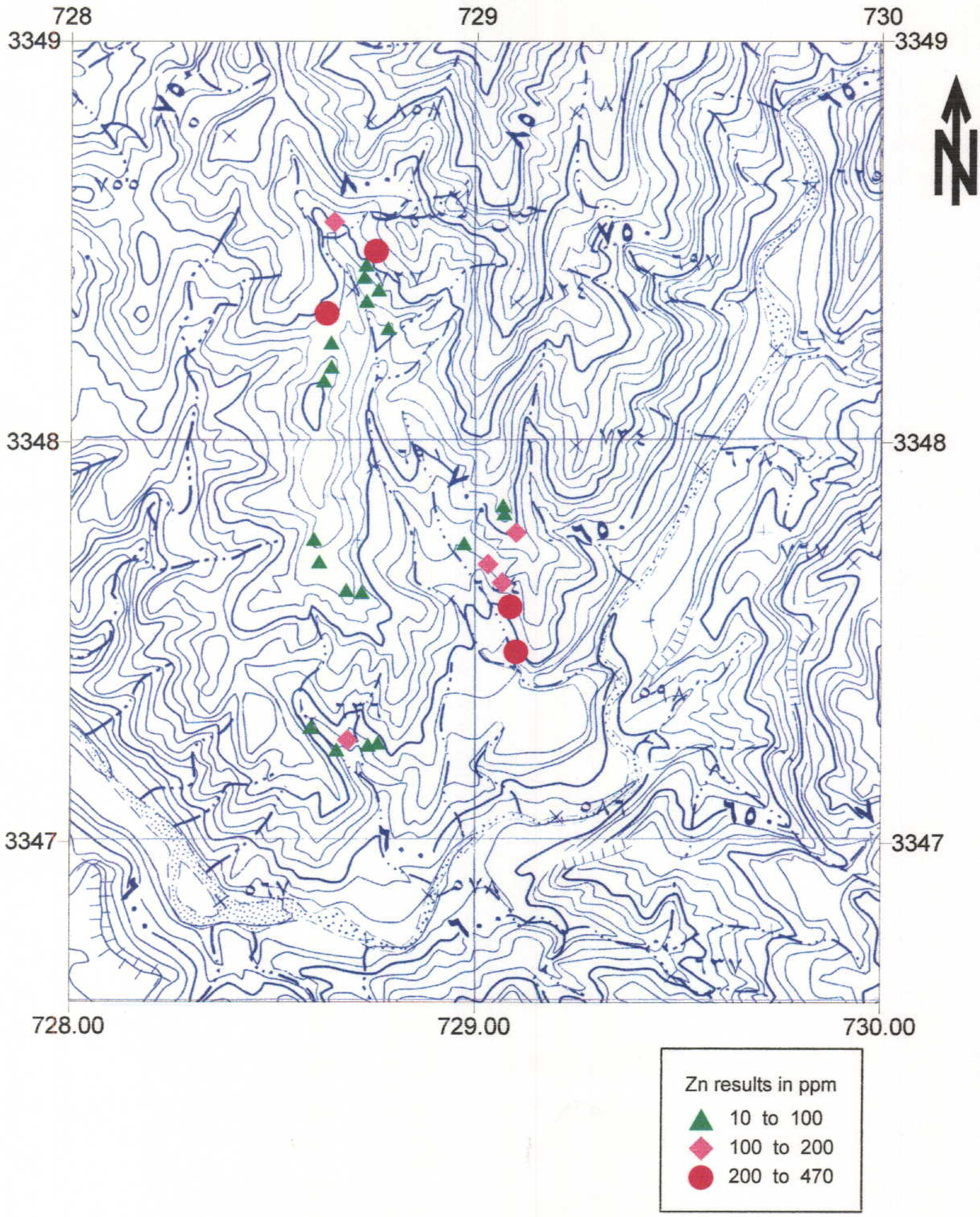


Figure (16) : Bismuth (Bi) Concentration & Distribution from Rock Analysis, Wadi Sabra

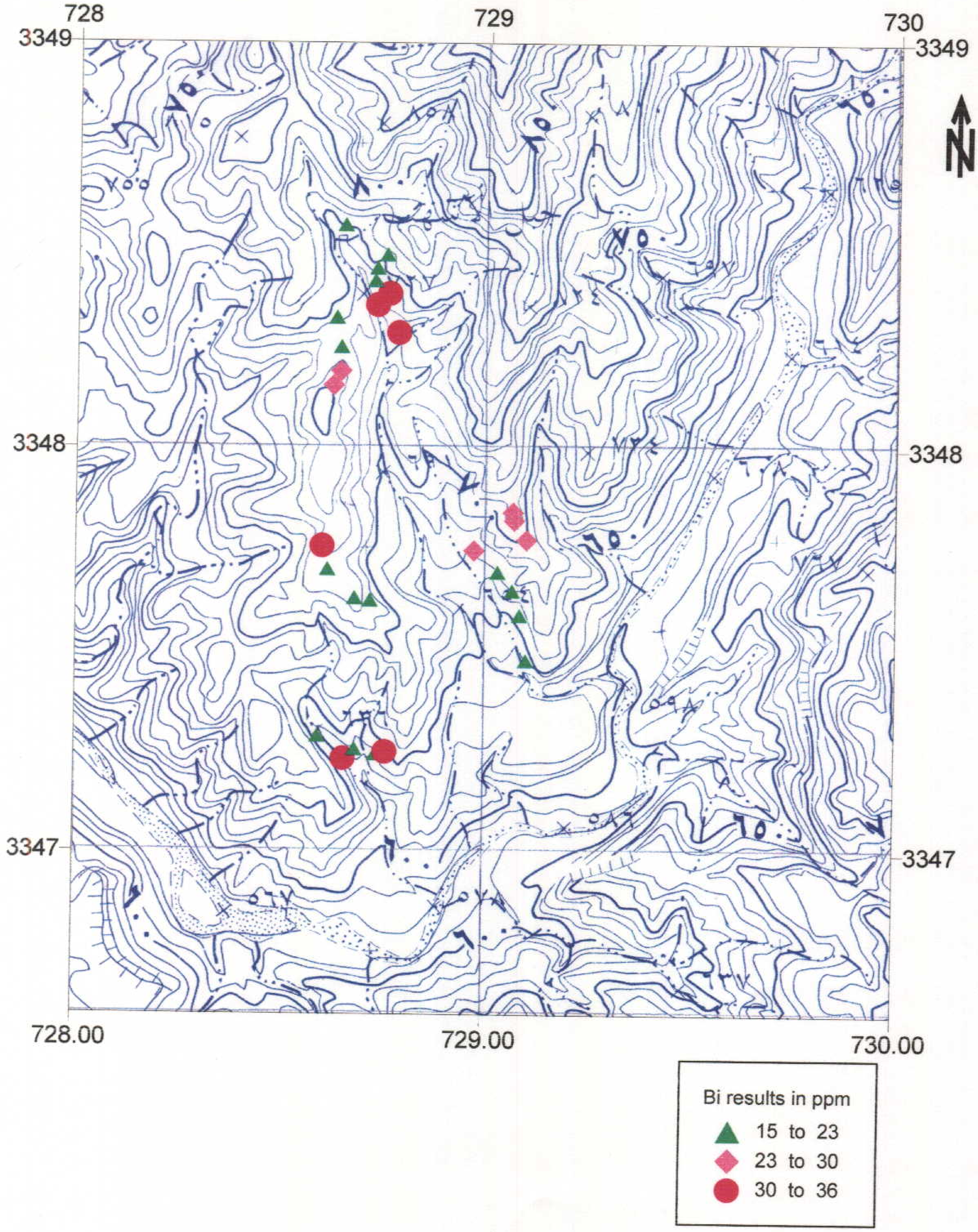


Figure (17) : Arsenic (As) Concentration & Distribution from Rock Analysis, Wadi Sabra

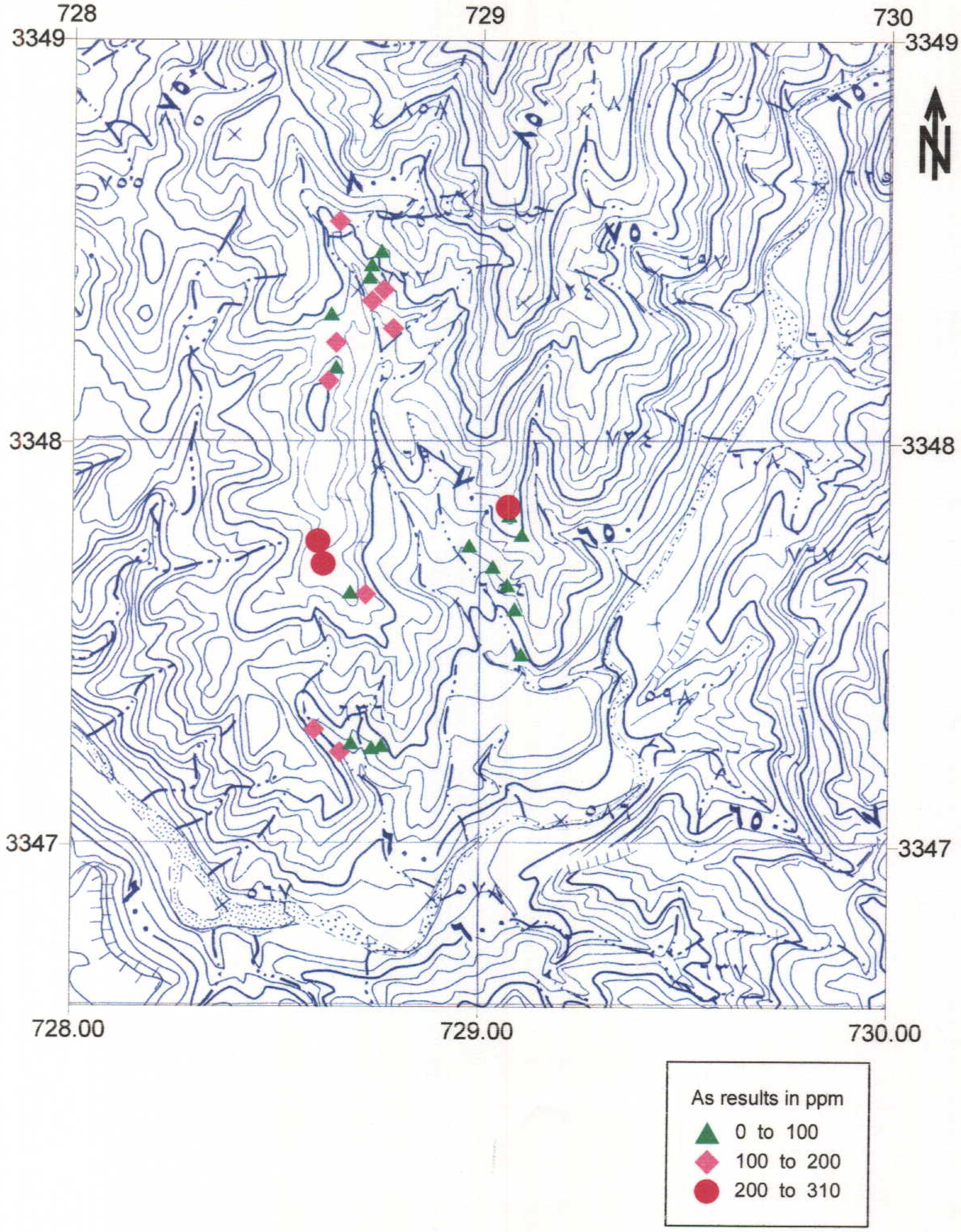


Figure (18) : Copper (Cu) Concentration & Distribution fron H. M. C., Wadi Sabra

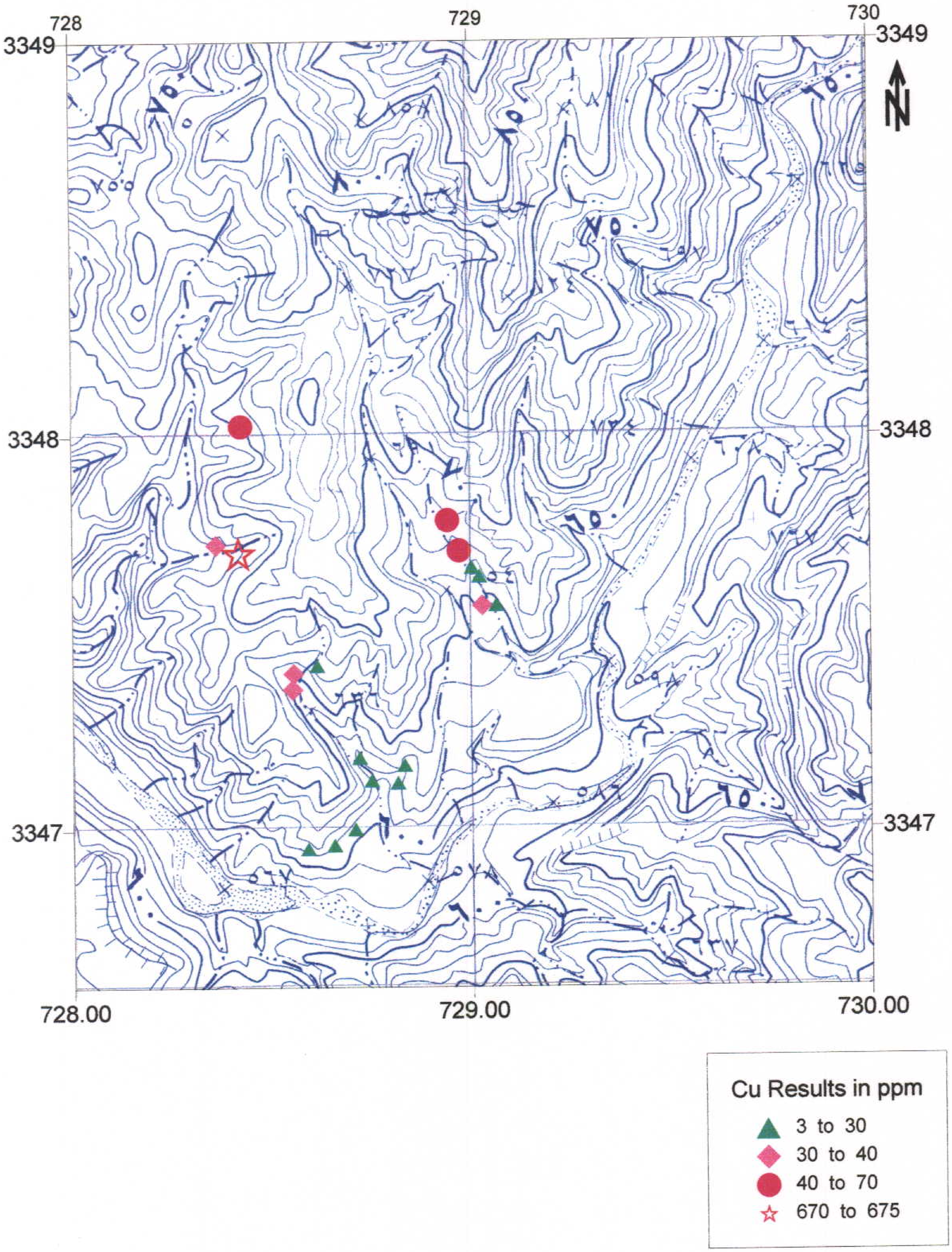


Figure (19) : Zinic (Zn) concentration & Distribution from H. M. C, Analysis, Wadi Sabra

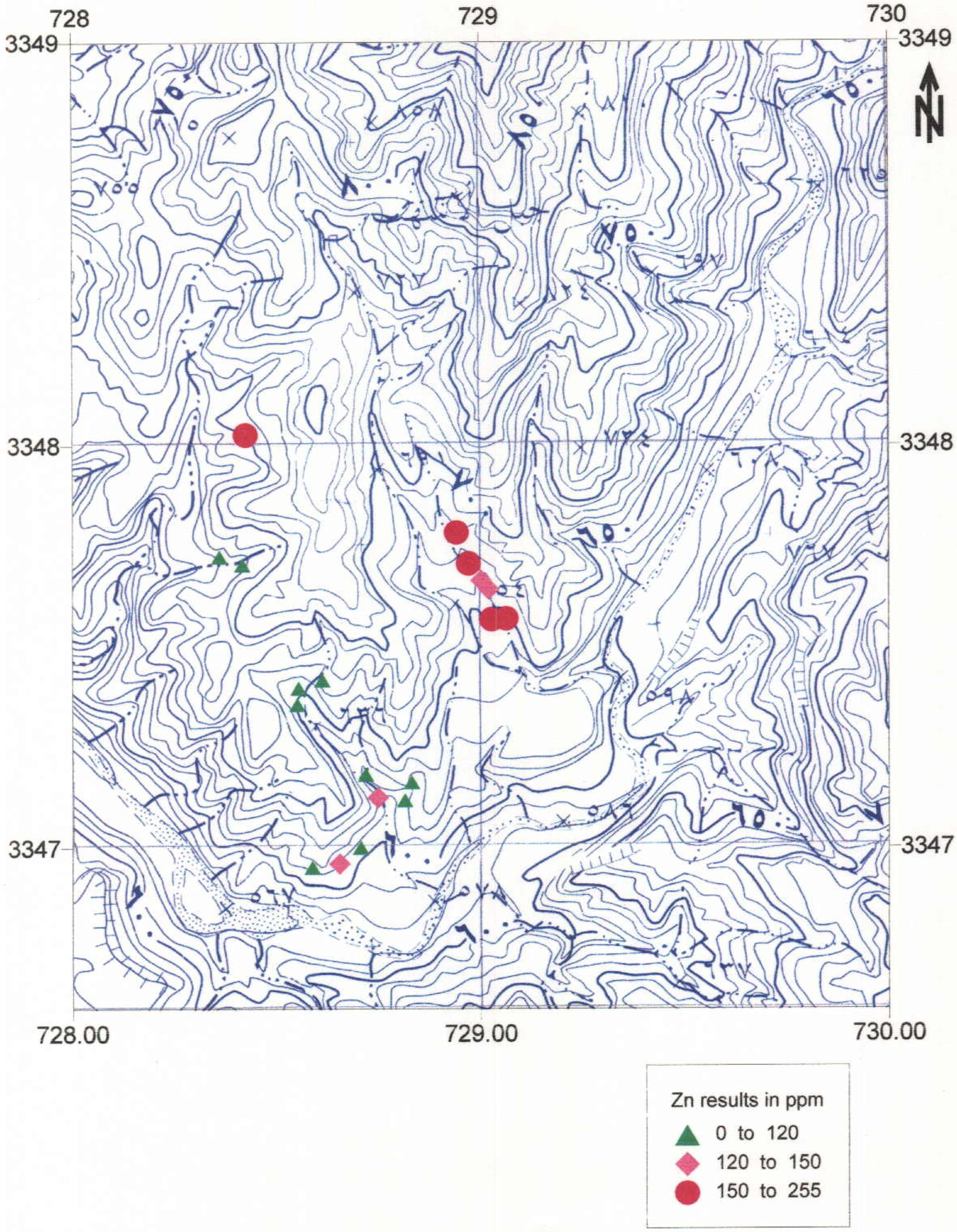


Figure (20) : Lead (Pb) Concentration & Distribution from H. M. C. Analysis, Wadi Sabra

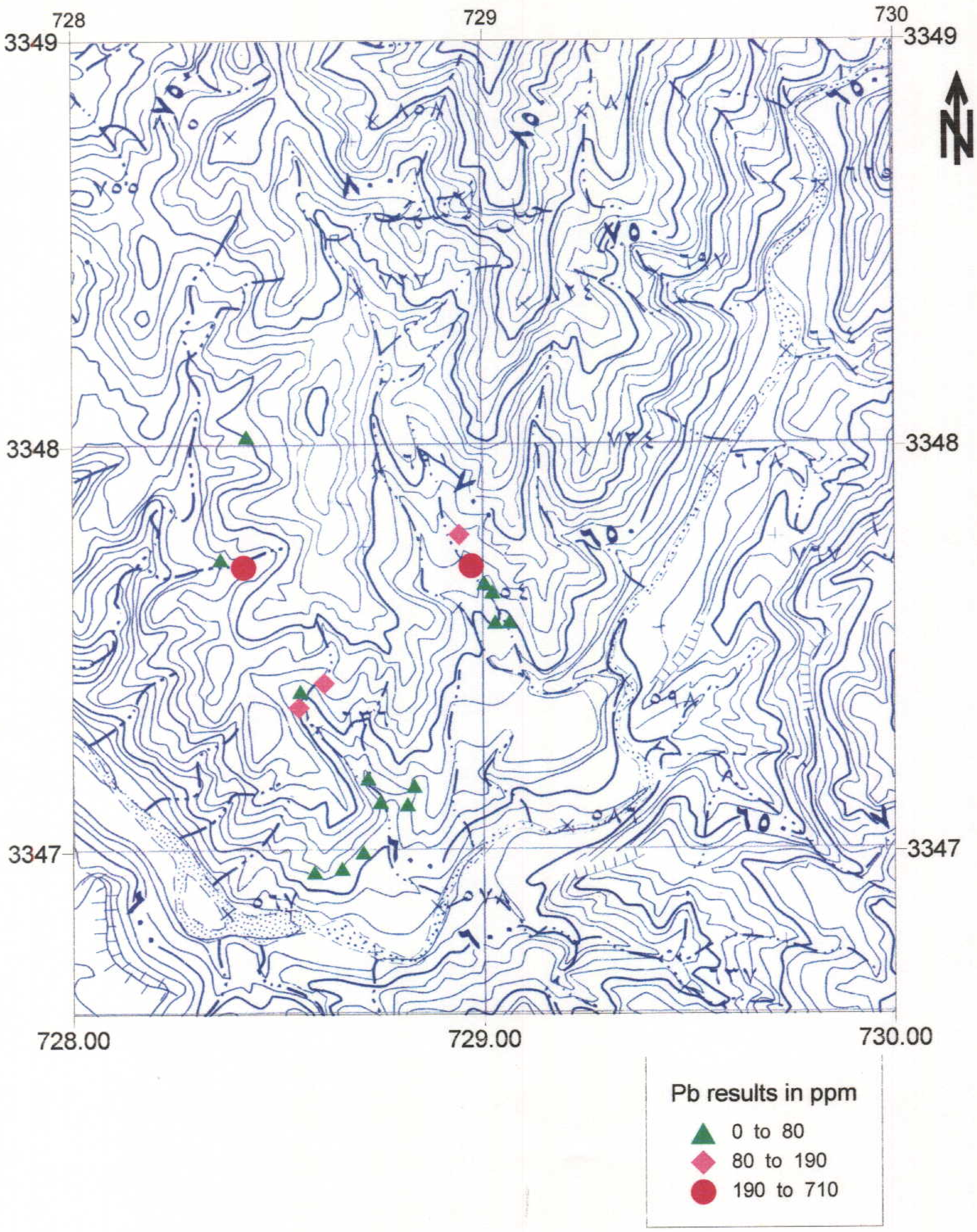


Figure (21) : Ag Concentration & Distribution from H. M. C. samples

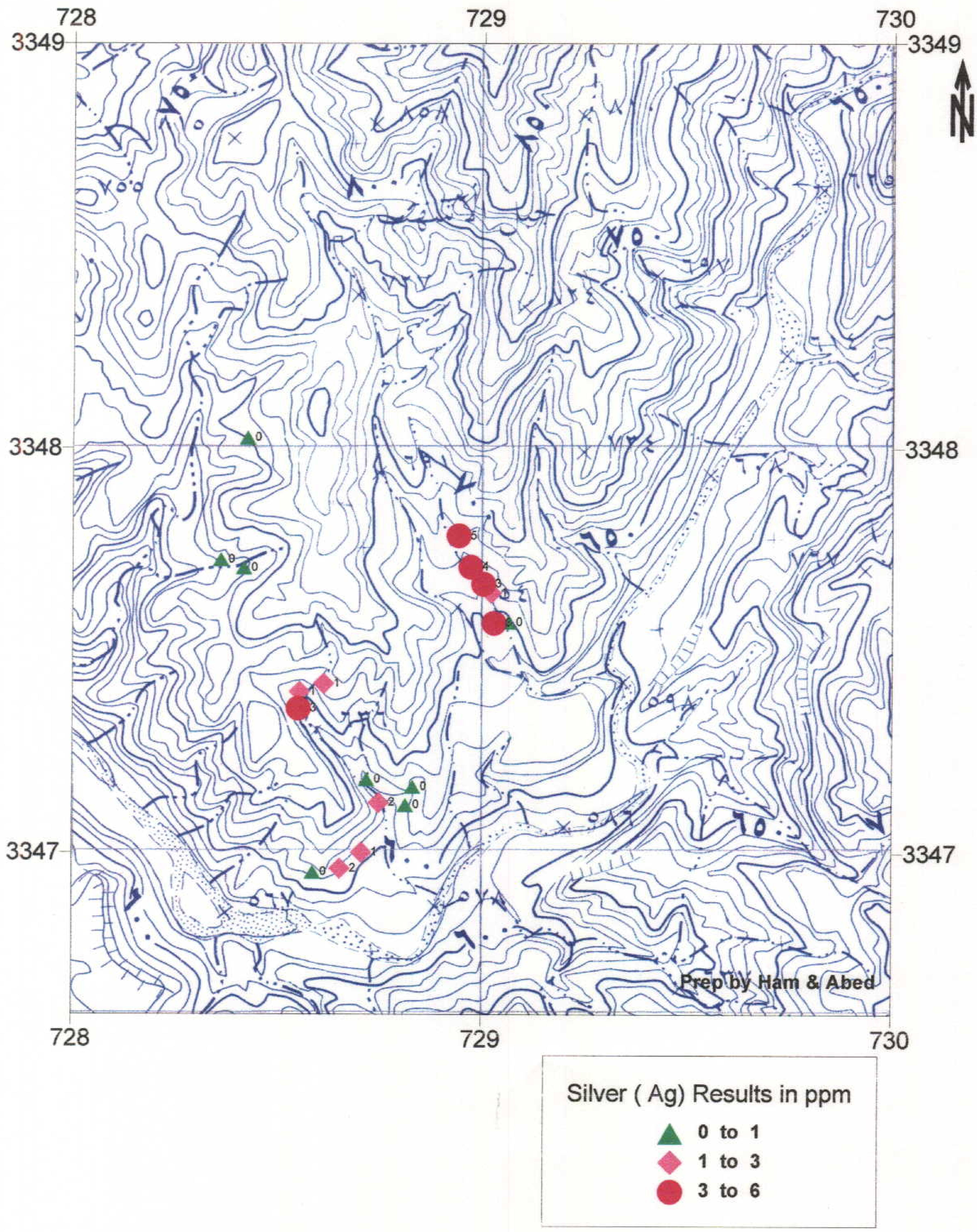


Figure (22) : As Concentration & Distribution from H. M. C. samples

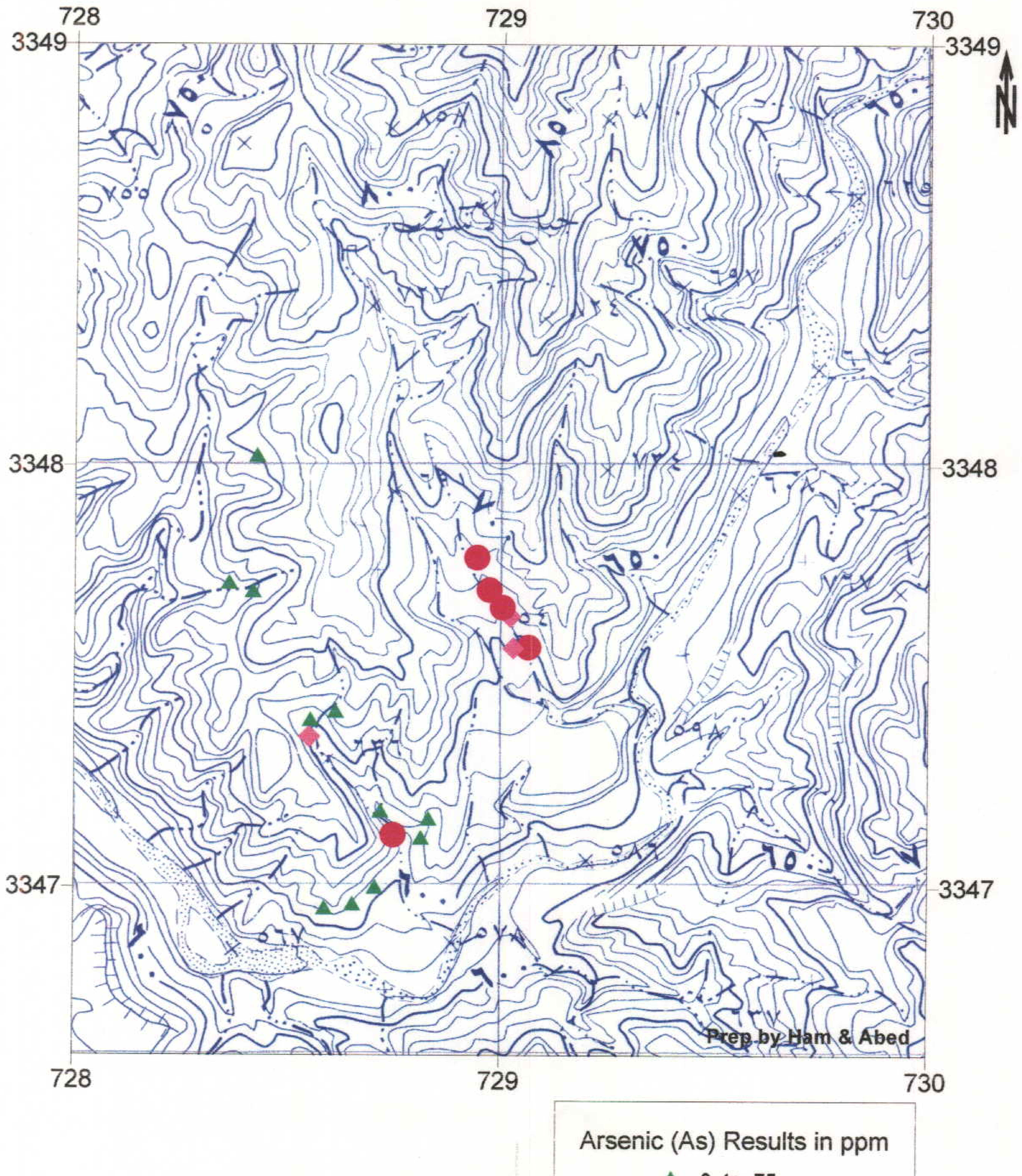
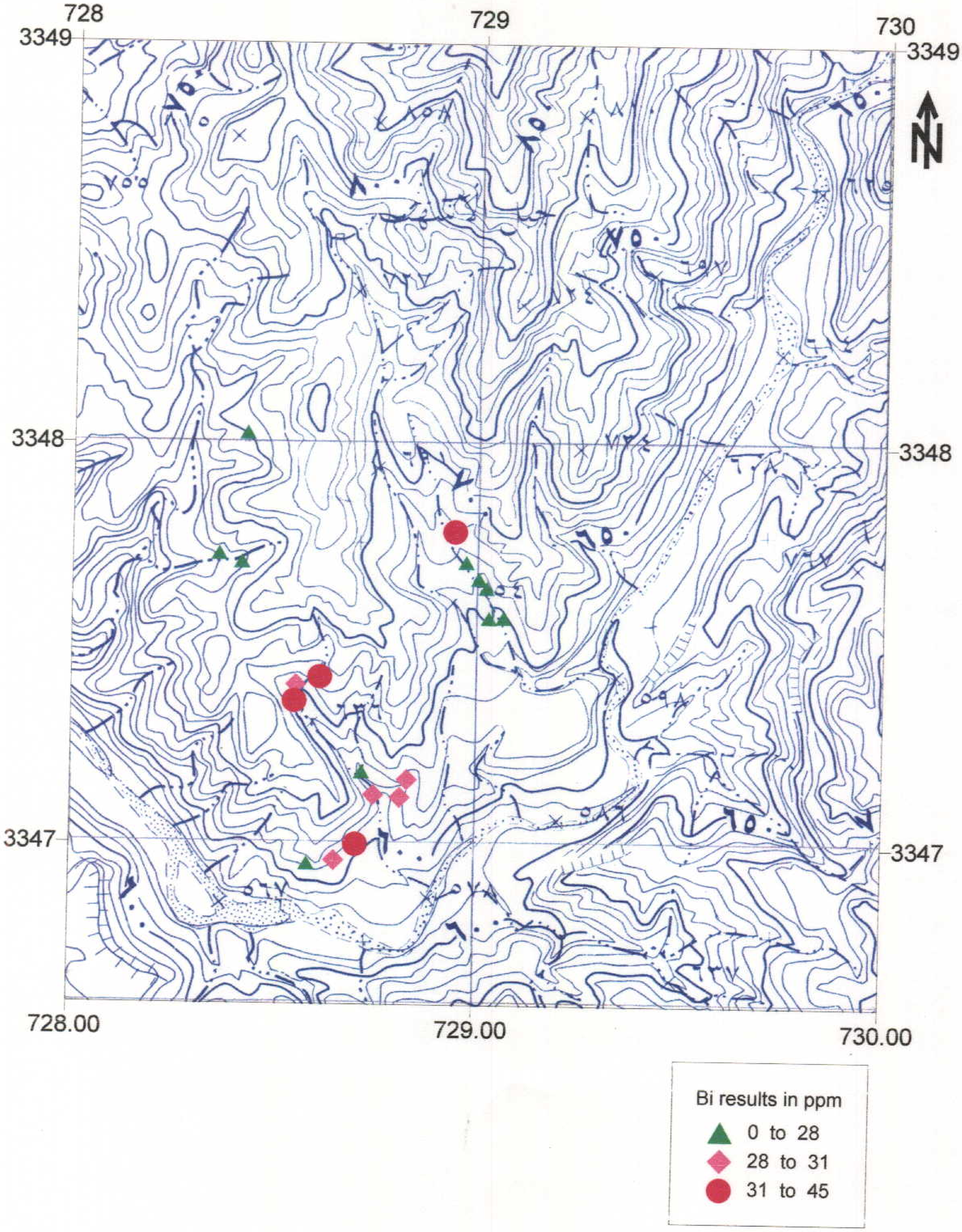


Figure (23) : Bismuth (Bi) Concentration & Distribution from H. M. C. Analysis, Wadi Sabra



4. CONCLUSIONS

Gold (Au) has been observed under the binocular microscope from heavy mineral concentration samples, and picked up as grains of native gold (nuggets). The highest value of gold analysis reach up to 5.69 g/ton, in H. M. C. where the gold content in rock samples reach up to 269mg/ton, disseminated in rocks.

Manganese (MnO) reached up to 15% from rock samples analysis, associated with quartz, calcite, and barium element reach up to 13,000 ppm. It is occur in a zone of Mn mineralization associated with traces of gold.

Iron (Fe_2O_3) associated with elements (Au, Bi, As, Pb & Ag) from rock samples analysis, occur with maximum value of total iron reach up to 18%, it is from iron oxides outcrops in the area.

5. RECOMMENDATIONS

Gold (Au)

In order to trace and identify the source rock of the Wadi Sabra gold occurrences, (which has been observed as native gold grains in heavy mineral concentrate samples) with low coasts, high efficiency and at the same time producing optimal results, the following geochemical exploration program is recommended.

- **Area A** (figure 9)

Rock sampling for gold analysis on 50 by 20-m. grid and heavy mineral concentrate samples should be taken from the small wadis located on the grid site. The area is about $0.2km^2$.

- **Area B** (figure 9)

Heavy mineral concentrate sampling for Au analysis from second and third order wadis of the area of Au contents, it should be taken on a closely spaced intervals. Some of collected samples should be study under the binocular microscope.

Manganese (MnO)

Rock sampling for the manganese mineralization zone, in order to determine the type of manganese occurrences and associated elements in particular the gold is recommended.

Iron (Fe_2O_3)

Rock sampling for the iron outcrop to study the associated elements (Au, Bi, As, Pb & Ag) and the type of iron occurrences in the area is recommended.

Geological map

Geological mapping with 1:10,000 scale should display the different alteration types and geological structures are recommended. Petrographic studies of thin section should be under taken to assist with alteration identification, in Wadi Sabra area.

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