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MINERALOGY AND GEOCHEMISTRY OF THE HEMATITE MUSCOVITE SCHISTS OF MALATYA, TURKEY: COULD IT BE THE FIRST KNOWN BANDED IRON FORMATION (BIF) IN THE TAURIDS AND ANATOLIA?

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Abstract: The Hematite Mica Schist (HMS) of Malatya outcrops as a thrust slice between the Permian Malatya Metamorphics and the Eocene Maden Complex and probably as a portion of the Neoproterozoic-Paleozoic Pütürge Massif. The HMS is composed of laminae of quartz, mica-disthene (kyanite)-diopside –garnet and specular hematite. The Fe_2O_3 contents (>20 %) of the HMS and the Al_2O_3 contents (average 22 % are different from those of Proterozoic BIFs. The TiO_2, K_2O, MgO, CaO and Na_2O contents are much higher than BIFs and average crust values, indicating detrital origin. Trace element and V, Sr, Y, Zr, Nb and Ba contents are higher than in BIFs. Total REE contents of the HMS are also much higher than those of BIFs of Proterozoic age, and the LREE concentrations are significantly higher than HREE concentrations, both of these indicators can be taken as evidence of detrital origin. Malatya HMS show strong positive Eu anomalies (Eu/Eu*=0.99-1.03) probably originating from a detrital feldspar contribution. The Ce anomalies (Ce/Ce*= 0.003-0.06) of HMS are low positive, indicating a low oxidation state. Data obtained from the studies suggest that the HMS was formed in glaciomarine settings (Raptian Type) with a low oxidation state, high detrital contribution, low or no hydrothermal contribution. Despite some contradictions in the geochemistry; the HMS show similarities to Raptian Type Neoproterozoic BIFs/IFs of Egypt and Saudi Arabia. As the cores of the Anatolian massifs are accepted northern margins of African/Arabian plate, the HMS may be related to the African/Arabian plate and their Raptian Type neoproterozoic iron formations. Banded Iron Formations (BIFs) are not known in Anatolian geologic environment, and the HMS of Malatya constitute evidence resembling Neoproterozoic BIF .

Key words: Hematite mica schist, banded iron formations, Neoproterozoic, Taurids-Turkey, Pütürge Massif

1. INTRODUCTION

This research investigates the mineralogy and geochemistry of hematite-mica schist of Malatya, Eastern Taurid, and compares the schist with Banded Iron Formations. The existence potential of Banded Iron Formations in Eastern Taurid Region is discussed. The hematite-muscovite schist (HMS) outcrops in a narrow area in front of a thrust zone which thrust Permian Malatya Metamorphics over the Eocene Maden Complex. The HMS does not exhibit features of Malatya Metamorphics instead it bears clear evidences of high grade metamorphic conditions. The only high grade metamorphic unit in the vicinity is the Pütürge Massif and the HMS probably is a portion of this unit.

Prior to the 1990s the "massif"s of Turkey were believed to be of Paleozoic age (Yılmaz, 1991; Yazgan, 1984; Özgül, 1976). However, recent studies (Candan et al., 2011; Oberhansli et al., 2010; Bozkurt et al., 2008; Bozkurt et al., 2006; Anders et al., 2006; Ustaömer et al., 2005; Gessner et al., 2004; Oberhansli et al., 1997; Bozkurt et al., 1993) on the geology of Turkey show that the so called "massif"s are not Paleozoic as a whole and that they have Neoproterozoic cores. Therefore, it is reasonable to assume that they may include economic deposits formed in Precambrian geological environments, i.e. Banded Iron Formations.

Banded Iron Formations (BIFs) occur in the Precambrian sedimentary (Superior Type) and volcano sedimentary (Algoma Type) successions. Recent studies (Basta et al., 2011; Bekker et al.,

2010; Gutzmer et. al., 2008) describes glacial association BIFs of Raptian Type. Because of their vast ore reserves, they have economic value as prime resources of iron ore. Most of the BIFs show fine laminations and micro bandings of chert and iron oxides (carbonates). The BIFs deposition begin at 3.8 Ga, the formations reach a maximum at about 2.5 Ga, disappear at 1.8 Ga and briefly reappear between 0.8- 0.6 Ga. (Basta et al., 2011; Ilyin, 2009; Klein, 2005; Klein & Laderia, 2004). Major BIF depositions formed as a result of the first great rise in atmospheric oxygen, the Great Oxidation Event (GEO) that is thought to have occurred between 2.4 and 2.2 Ga ago and after billions of years of oxygen deficient or low oxygen bearing atmosphere (Bekker & Kaufman, 2007; Kump & Seyfried, 2005; Morris, 1993; Holland, 1984).

After a hiatus of over a billion year, BIFs re-appeared in Neoproterozoic successions (Bekker et al., 2010; Pecoits et al., 2008; Scott et al., 2008; Pelletier et al., 2006). Freitas et al., (2011) called Neoproterozoic Iron Formations (NIF) and studies on the subject (Freites et al., 2011; Eyles & Januszczak, 2004; Klein & Beukes, 1993) concluded that NIFs occurred as a result of oxygenation of the hydrosphere after the melting of ice cover on the oceans. According to Basta et al., (2011) Neoproterozoic Algoma type (of volcanic association) NIFs occur in African and Arabian shield, whereas Raptian types (of glacial association) are present on all over the continents.

2. GEOLOGICAL SETTING

The Malatya HMS studied here is situated about 15 kms southeast of Malatya township, by the Malatya- Sincik highway and exist as a small tectonic slice in front of the thrust zone that pushed the Carboniferous-Triassic (Bozkaya et al., 2006, 2007; Özgül, 1976) Malatya Metamorphics over the Eocene Maden Complex (Fig. 1). The Malatya Metamorphics form one of the three structural units (the other two are Bitlis –Pütürge and Keban Metamorphics) of the Southeast Anatolian Metamorphic Complexes. The Malatya Metamorphics are dominated by metacarbonates, and metapelites (shale, calc schist) are subordinate. These two groups of lithologies were metamorphosed under sub-greenschist facies conditions (Bozkaya et al., 2007).

Precambrian-Permian Pütürge Metamorphics are overlain by the Maden Complex and are composed of high grade metamorphic rocks. The Eocene Maden Complex is composed of volcanic, volcano sedimentary and sedimentary units and overlies the Pütürge Massif with a basal conglomerate.

The HMS was emplaced between the Maden Complex and the metacarbonates of the Malatya Metamorphics and only a small portion of it is exposed by newly opened road cuts. It covers an area of 200-300 sq meters. The rock is fragmented, probably due to thrust movement, and the original texture is observable only in blocks. Laminated texture is clearly visible to the naked eye (Fig. 2a).

3. PETROGRAPHY

The hematite mica schist is composed of alternating laminae of chert, hematite and mica-kyanite (Fig. 2b). The chert bands are thicker than the other two and this feature is reflected in the geochemistry of the schist with SiO_2 contents in excess of 40 %. The iron rich bands are composed of specular hematite (specularite) laths what are elongated along schistosity and show microfoldings (Fig. 2c). The mica is muscovite and has a pale green color under the microscope. The mica bands also include kyanite, clinopyroxene (diopside), garnet (almandine), feldspars and titanite. Kyanite is prismatic and the prisms are elongated parallel to the banding/schistosity. Muscovite bands show micro-folding and schistosity. Zircon is present in all bands and occurs as short prismatic crystals.

Mineral assemblage of the hematite mica schist represents amphibolite facies metamorphism of clayey sediments.

4. GEOCHEMISTRY

Since the hematite-schist exposures cover only a few hundreds of square meters, four samples representing the exposure were chosen and analyzed at ACME Labs Canada using ICP-MS techniques. The same samples were also analyzed using XRF techniques at Analytical Labs, Mersin University, Turkey.

The major, trace and REE data of the Hematite-Schist are given in Tables 1, 2 and 3, respectively. The SiO_2 contents are paramount as is to be expected from the petrography of the HMS. The Fe_2O_3 contents are at the lower limits of BIF and vary between 17 and 23 % and the Al_2O_3 contents are remarkably high probably due to the presence of large amounts of aluminous-silicates in mica bands. The TiO_2 contents are also high and vary about 4% as expected from the common presence of titanite. The HMS contains large amounts of REE and exhibits different features what are discussed below, than BIFs. V, Sr, Zr, Nb and Ba

contents of the HMS are much higher than those of similar iron formations in the literature.

5. DISCUSSIONS

Apart from a vague description by Küpeli et al., (2007) as "Precambrian sedimentary Fe-sulfides and oxides observed at the basement of the Attepe Formation", any formation with features similar to BIF has not been documented in Turkey before. In fact, until the late 1990s Precambrian formations were not known in Turkey and the oldest geological units, massifs, were estimated as Paleozoic age and BIFs and similar Precambrian formations have not been sought in the massifs. Recent absolute age determinations (Menderes Massif 699-713 my, Anders et al., 2006; Istanbul Zone Magmatics 575-700 my, Sunal et al., 2008; Bolu Massif 565-576 my, Ustaömer et al., 2005) proved that the massifs have, at least, Proterozoic cores. The hematite schist studied here is probably a portion of the Proterozoic core of the Pütürge Massif of which exposed parts are composed of mica schist, amphibole schist, amphibolite, gneiss, augen gneiss and marble. Any formation resembling the HMS has not been documented in the exposed parts of the Pütürge Massif. The only unit with comparable features to the HMS is the mica gneiss which contains abundant kyanite and pyrophyllite, but no hematite, and covers large areas in south of Pütürge township. Pyrophyllite is formed in the shear zones of the mica schist and probably as product of retrograde metamorphism.

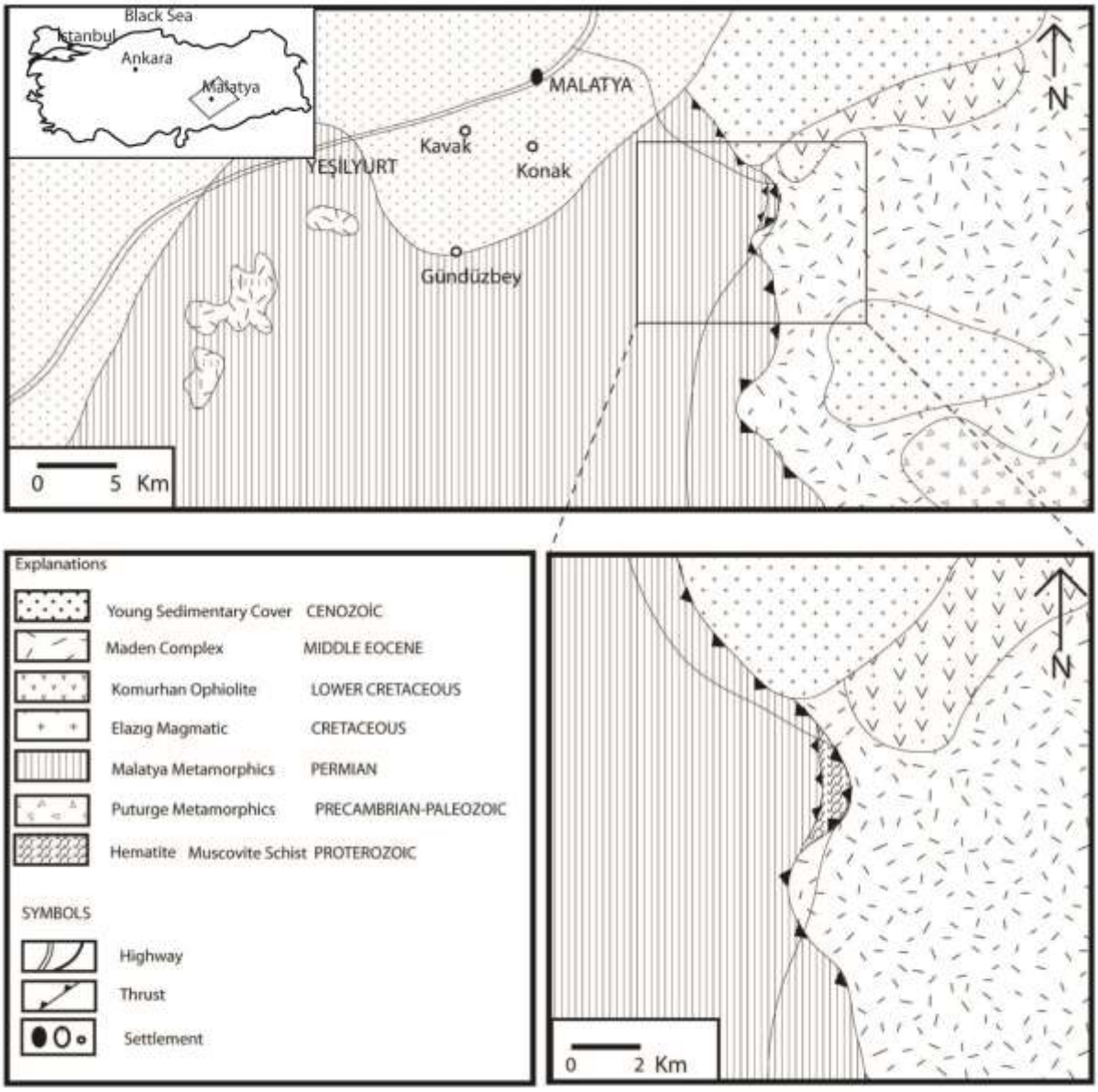

Figure 1. Simplified geological map of the hematite- muscovite-schist and surroundings (based on MTA 2002).

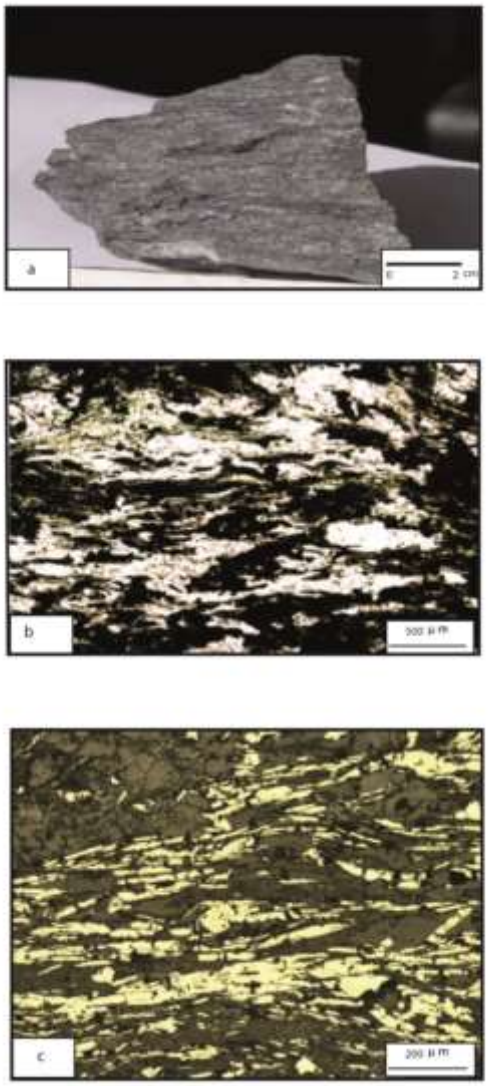

Figure 2. Photos of hematite-muscovite-schist. (a) Hand specimen of the HMS. Laminae of hematite (bright levels) and mica are visible with naked eye. (b) Transmitted light photomicrograph; light green colored minerals are mica, quartz levels are white and dark minerals are hematite. (c) Reflected light photomicrograph, bright crystals are hematite laths and prisms. Note the micro foldings.

Major element contents of the HMS show differences in comparison with BIFs. Fe contents are very low, just above the lower limit of BIF's (Table 1).

SiO_2 contents are within the range of those of BIF. Al_2O_3 contents are significantly higher than Al_2O_3 contents of BIF but similar to those of schists underlying and/or overlying Eastern India BIF zones (Roy & Venkatesh 2009). Large alumina contents may be attributed to the detrital material input to the sedimentary basin where the HMS was deposited. Therefore, any hydrothermal contribution to the HMS deposition was unlikely. The MgO, CaO, Na_2O, K_2O and especially TiO_2 contents are all higher than those of BIFs and support a sedimentary origin. High contents of Na_2O and K_2O indicate that pyroclastic debris was present during the sedimentation of the HMS. Plots of crust-normalized major elements (Fig. 3) show strong positive anomalies, specifically for Fe, Al and Ti. Trace element contents (Table 2) are generally higher and V, Sr, Y, Zr, Nb and Ba contents significantly higher than trace element contents of BIFs (Fig. 4). From Table 2 and Figure 4, it can be seen that the total amount of trace elements of the HMS is many times higher than that of BIFs. (Co+Cu+Ni)/∑REE plots can be used to differentiate hydrothermal from hydrogenous deposits (Bhattacharya, et al., 2007).

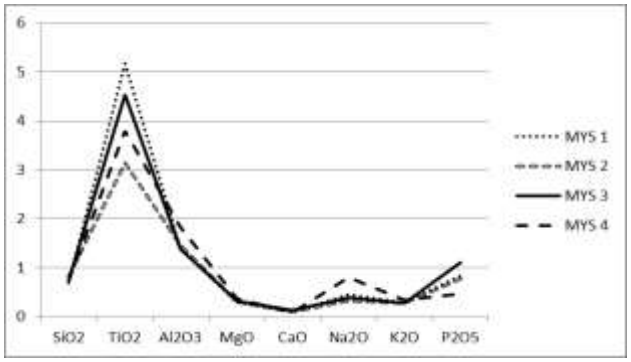

Figure 3. Plots of average crust normalized major elements of Malatya HMS. SiO2, TiO2 and Al2O3 contents much higher than those of crustal average,alkaline elements are lower.

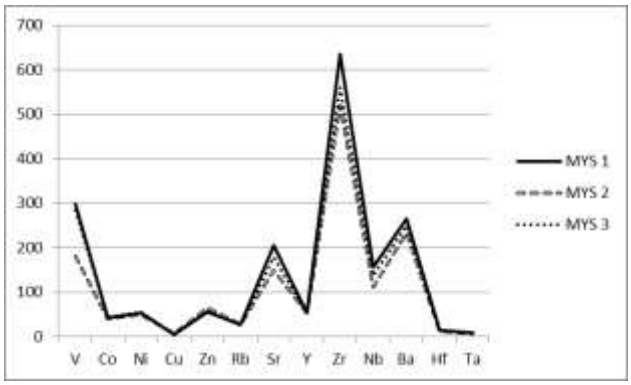

Figure 4. Plots of trace elements of Malatya hematite-muscovite-schist. Vertical axis show absolute contents as ppm.

Figure 5a indicates that ∑REE contents are very similar to those of Hydrogenous Deep-Sea Deposits. However, Co+Ni+Co contents are not as high and are similar to Hydrothermal Deep Sea Deposits. The SiO_2–Al_2O_3 plots, which may also be used discriminate between sources, fall in the area close to deep sea sediments area (Fig. 5b).

The total REE contents of the HMS are tens of times higher than those of BIFs of Proterozoic age (Table 3, Fig. 6).

Table 1. Major elements contents of the HMS compared with major BIFs of the world. First 4 data are of this study. Note the much higher Al_2O_3, TiO_2 and lower Fe_2O_3 values.

	MYS1	MYS2	MYS3	MYS4	Kuruman-Penge[1]	Urucum[2]	Brockman[3]	Sundur SB[4]	Carajas[5]	Superior type-BIF[6]
SiO2	41.89	48.76	43.95	44.33	51.68	34.30	45.76	40.60	41.50	47.30
TiO2	5.49	3.32	4.81	4.03	0.02	0.09	0.01	0.02	0.02	0.04
Al2O3	21.78	22.75	21.57	28.6	0.11	0.87	0.09	0.10	0.09	1.07
Fe2O3	23.21	17.70	22.37	16.36	39.79	56.6	49.17	58.70	57.70	43.10
MgO	1.05	1.09	1.13	1.35	5.14	1.10	2.85	0.26	0.03	5.68
CaO	0.55	0.53	0.63	0.45	5.65	2.63	1.75	0.05	0.02	3.03
Na2O	1.76	1.27	1.51	3.11	0.03	0.32	0.04	0.01	0.01	0.33
K2O	0.93	0.89	0.89	1.11	0.03	0.02	0.02	0.02	0.01	0.27
P2O3	0.25	0.23	0.33	0.14	0.09	0.29	0.22	0.04	0.02	0.10
LOI	2.70	3.20	2.50	N.A	N.A	N.A	N.A	0.04	0.04	N.A
Total	96.91	99.74	99.69	99.48	102.54	96.22	99.91	99.84	99.43	100.92

[1-3]Klein & Beukes, 1992; [2]Klein & Ladeira, 2004; [4]This study; [5]Figueiredo - Silva et al., 2008 and Klein & Ladeira, 2002; [6]McClung, 2006; N.A: not analyzed.

Table 2. Trace elements contents of the HMS compared with BIFs from the world. Generally trace element contents are higher than trace element contents of known BIF deposits.

Ppm	QF Hematite Itabirite		QF Itabirite	QF Itabirite	Superio BIF	Algoma BIF	Nigeria BIF	Orrissa IndiaBIF	Trace Elements This Study		
									MYS1	MYS2	MYS3
V	39.0	20.6	22.6	-	30.0	97.0	44.0	30.0	299.0	180.0	284.0
Co	9.0	21.6	-	249.0	27.0	38.0	100.0	35.0	42.1	40.9	44.6
Ni	5.5	11.3	10.5	20.0	32.0	83.0	<10	15.0	54.3	50.1	54.8
Cu	2.9	3.9	<1.0	33.8	10.0	96.0	<10	10.0	5.3	7.0	4.8
Zn	4.4	2.0	-	42.3	2.0	33.0	26.0	-	55.0	65.0	57.0
Rb	0.6	0.5	<1.0	32.9	-	-	20.0	-	27.1	27.1	26.7
Sr	3.7	4.6	5.0	10.3	42.0	83.0	51.0	15.0	205.7	149.5	178.6
Y	8.2	5.0	3.9	4.8	41.0	54.0	22.0	-	53.0	53.6	52.3
Zr	7.0	3.0	12.0	2.5	60.0	84.0	60.0	10.0	635.1	519.7	559.9
Nb	1.4	1.3	0.8	6.4	-	-	5.0	-	156.9	111.2	137.2
Ba	10.8	13.3	15.4	55.4	180.0	170.0	293.0	70.0	265.0	234.0	250.0
Hf	0.3	0.3	<0.1	0.1	-	-	-	-	15.4	12.5	12.7
Ta	0.1	0.3	-	0.1	-	-	-	-	8.7	6.3	7.6
ΣTE	92.6	87.9	72.3	457.3	424.0	738.0	621.0	185.0	1822.6	1456.9	1678.3

The LREE concentrations ofthe HMS are significantly higher than HREE concentrations, and that may be attributed to detrital origin (Klein & Laderia, 2004; Graf et al., 1994). Malatya HMS shows strong positive Eu anomalies (Eu/Eu*=0.99-1.03). This feature is similar to the shale Eu anomalies (Figs. 6a, b and c) and quite different from the non-distinguishable Eu positive anomalies of Neoproterozoic iron formations (Klein & Laderia, 2004). Positive Eu anomalies have been attributed to hydrothermal solutions or a detrital feldspar contribution (Campbell et al., 1988; Michard & Albarede, 1986). In the case studied a feldspar contribution is more likely.

La enrichments (La/La*=0.71-1.15) are not as high as La enrichments of BIFs (La/La*= 5.18, Basta et al., 2011; Roy & Venkatesh, 2009). The Ce anomalies are accepted as an indicator of the oxidation state of the sea water (Elderfield & Greaves, 1982; De Baar et al., 1985).The Ce anomalies (Ce/Ce*= 0.003-0.06) of HMS are very low positive indicating low oxidation state of the sea water during deposition.

6. CONCLUSIONS

The HMS tectonic slice outcrops in a very limited area and without any data of underlying and

overlying formations. Therefore the conclusions are limited to the findings on the HMS itself.

The mineral assemblage and textures of the HMS indicate that the rock was metamorphosed under amphibolite facies conditions and original material was clayey detritus. High Al, Ti and alkaline elements Mg, Na and K denote detrital material had continental origin and magmatic components. The features of the HMS are quite different fromthe Malatya Metamorphics, which were metamorphosed under sub-greenschist facies conditions and meta-carbonates are dominant.

Therefore, it is reasonable to relate the HMS tectonic slice to the Pütürge Massif, which is composed of high grade metamorphic rocks: gneiss, augen gneiss, amphibolite, mica schist and marble. The mineral assemblage, hematite-quartz mica kyanite pyroxene garnet, of the HMS is quite different from the mineral assemblages of the BIFs and IFs what usually have a simple mineral assemblage

Table 3. REE contents of the HMS and well-known BIFs of the world. The REE contents originating from detritus and autochthonous materials are not discriminated.

Ppm	QF[1]		QF[1] Itabirite	QF[2] Itabirite	Superior[3] BIF	Algoma[4] BIF	This Study		
	Hematite	Itabirite					MYS1	MYS2	MYS3
La	6.51	3.75	1.40	0.22	7.00	1.37	68.50	82.40	71.40
Ce	13.96	5.15	2.32	0.54	12.71	2.73	149.9	171.10	157.30
Pr	1.45	0.90	1.59	0.20	5.49	1.46	16.94	19.76	17.88
Nd	5.45	4.48	0.32	0.06	1.47	3.23	66.40	76.7	68.90
Sm	1.22	0.43	0.43	0.08	1.13	3.05	12.85	13.69	13.50
Eu	0.34	0.37	0.54	0.14	1.51	0.30	4.14	4.05	4.24
Gd	1.04	0.86	0.30	0.09	0.85	0.22	12.18	12.93	12.83
Tb	0.17	0.14	0.35	0.08	0.85	0.23	1.84	2.05	1.87
Ho	0.25	0.16	0.12	ND	0.26	0.07	1.88	2.04	1.87
Er	0.76	0.44	0.09	ND	0.19	0.06	5.15	5.31	5.03
Tm	0.16	0.09	0.56	1.10	1.16	0.34	0.76	0.78	0.75
Yb	0.48	0.43	0.05	ND	0.11	0.03	4.75	4.77	4.46
Lu	0.13	0.08	0.05	0.02	0.13	0.03	0.70	0.69	0.65
ΣLREE	23.64	15.23	6.05	1.10	27.80	11.84	314.59	363.65	328.98
ΣHREE	3.21	1.68	2.21	0.45	5.04	2.93	40.83	43.00	41.33
ΣREE	26.85	16.91	8.26	1.55	32.85	14.78	355.42	406.65	370.31
Eu/Eu*	1.50	1.60	1.49	1.33	1.45	2.13	1.01	0.99	1.04

[1]Spier et al., 2007; [2]Glikson et al., 2004; [3]Klein & Beukes, 1989; [4]Kato et al., 1996; N.D: not detected.

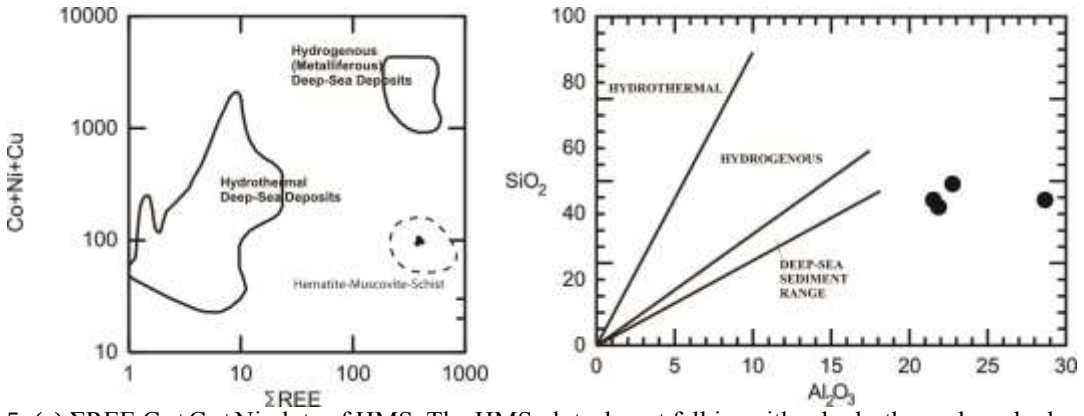

Figure 5. (a) ΣREE Co+Cu+Ni plots of HMS. The HMS plots do not fall in neither hydrothermal nor hydrogenous areas, instead in a distinct area. (b) SiO_2-Al_2O_3 plots of the HMS. Note that the samples fall close to deep sea sediments range.

of quartz and Fe-oxide/carbonate. The Fe mineral is hematite and magnetite is absent this may reflect a well oxygenated environment of formation. However, Ce anomalies show low oxidation state during sedimentation.

The major element contents reflect this difference as relatively higher Al, K, Na, and Ti contents, what may be interpreted as detrital origin. Fe contents of the HMS range from 17.70 to 22.75 % and are close to the lower limit (20 %, Klein, 2005) for BIFs accepted by previous works. SiO_2 contents (41.89-48.76) are within the range of BIFs' SiO_2 contents. Al_2O_3 contents are quite different from those of BIFs and vary between 21.78 and 22.75%. TiO_2 contents (3.32-5.49%) exhibit a similar pattern to Al_2O_3 contents, and they also disagree strongly from TiO_2 contents of BIFs. Al_2O_3 and TiO_2 contents of the HMS are close to the same contents of the upper shale of the iron ore deposits of the Singhbum-Orissa Belt, India described by Roy & Venkatesh (2009). High Al and Ti contents indicate large amounts of detrital contribution during sedimentation. MgO, Na_2O and K_2O are also higher than those of BIFs and suggest a continental source. High ∑REE and a positive Eu anomaly also support a large detrital contribution. Therefore a hydrothermal source for the HMS and its Fe contents is unlikely.

Trace element contents are also many times higher than those of BIFs and IFs. LREE enrichment is another proof of detrital origin. Positive Eu anomalies could be because of detrital feldspar contribution. ∑REE contents and SiO_2-Al_2O_3 plots indicate deep sea sediments origin. Laminated/banded texture is also accepted as deep sea sedimentation texture (Klein, 2005). The depth should be deeper than 200m which is accepted as the depth limit of wave effect.

Alternating bands/laminea of Fe and Si and major element composition of the HMS are similar features to those of Banded Iron Formations. As the HMS can be related Pütürge Massif the age of it should be Neoproterozoic, the age of the cores of the Anatolian Massifs.

Many Neoproterozoic BIFs are present on the African and Arabian Plates; ANS (Egypt and Saudi Arabia), Menhouhoy (Morocco), Unarab and Wadi Karim (Egypt) and Sawawin (Saudi Arabia) (Basta et al., 2011). They have either volcanic (Algoma Type) or glacial (Rapitan Type) associations (Basta et al., 2011). As the cores of Anatolian massifs are accepted as the northern margins of the Gondwana (Candan et al., 2011), the HMS may be one of the Neoproterozoic BIFs or IFs of the African Plate. High Al contents, LREE enrichment, positive Eu anomalies and high K, Ca and Na contents all indicate detrital contribution. Evidence of any volcanic and hydrothermal contribution is not present.

From all the above given data it can be concluded that the HMS may be a Neoproterozoic BIF of glacial association (Raptian Type). However, geochemistry of the HMS is quite different than the composition of the Raptian Type IFs. The Fe could have concerted in deep sea together with clayey sediments. The iron mineral of the HMS is hematite what forms in highly oxygenated environments and thus apparently does not fit to this model. However, hematite could have not formed in situ instead might have been transported to the depositional place from continental areas or shallow well aerated zones of sea as suspensions of FeO (OH) minute particles.

From the findings of this study, the geological history of the HMS can be summarized as: Hematite Mica Schist of Malatya formed as a detrital sedimentary formation in a basin where the oxidation state was very low due to ice cover, and Fe remained in the solution for long periods and accumulated. Oxidation was caused after the melting of ice cover of oceans and precipitation took place. Such formation models are postulated for Neoproterozoic Iron Formations and Banded Iron Formations what forms stratigraphic sequences of glaciomarine settings and they are the result of anoxic condition resulted from the stagnation in the oceans beneath ice cover (Lyons et al., 2009; Walde & Hagemann, 2007; Klein, 2005; Klein & Ladeira, 2004).The HMS has higher Sm/Lu values (18.35 - 20.76) and lower La/Ce and La/Sm values (0.45-0.48 and 5.29-6.02, respectively) than those of Proterozoic BIFs and these features can be taken as evidences of glaciomarine setting or low sea level (Graf et al., 1994; Kirschvink, 1992).

The HMS of Malatya was probably formed in a sedimentary basin where anoxic conditions were prevailing and iron was abundant in solution because of thick ice cover. Following the ice melt terrestrial sediment input in the basin increased and sediments and iron deposited as alternating layers. As its major element contents are rather similar to the upper shale or lower shale of the North Orissa, India BIF, it is also likely that the HMS is the upper or lower shale of the main BIF deposition. Unfortunately any other formation of the probable sequence of HMS does not surface in the vicinity and it is not possible to model a succession.

Although the Hematite Mica Schist of Malatya is exposed in a very narrow area and does not have any economic potential itself, it provides strong evidence that Banded Iron Formations may exist in the "Massifs" of Anatolia.

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