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Mineralogy and geochemical signatures of the Mn mineralization in Taşdemir (Pazarcık, Kahramanmaraş, Türkiye)

Cihan Yalçın *1, Mustafa Tekin Akkütük 2, Yusuf Uras 2

[1] Ministry of Industry and Technology, General Directorate of Industrial Zones, Ankara, Türkiye, cihan.yalcin@sanayi.gov.tr
[2] Kahramanmaraş Sütçü İmam University, Department of Geological Engineering, Türkiye, mtekinakkutuk@gmail.com; yuras@ksu.edu.tr

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Abstract

Along the Southeast Anatolian Orogenic Belt, units on the Arabian plate and a series of Ophiolitic Melange overlain by tectonic contact are observed. In the Upper Cretaceous thrust belt, the Koçali Complex is situated at the base and the Karadut Complex at the top, respectively. Throughout this belt, Mn mineralization is identified in the lithologies of the Karadut Complex. Around Taşdemir Village (Pazarcık-Kahramanmaraş), units existing in the Koçali and Karadut Complex are frequently observed. Haydar and Germav formations overlie these units with angular unconformity. All units are consequently covered with Middle-Upper Eocene aged limestones existing to the Midyat Group with angular unconformity. In this district, Mn mineralizations linked with the radiolarites of the Karadut Complex are observed. Stratiform-type Mn mineralization is observed through lenses between the layers. Reddish brown and dark grey forms have been identified. Pyrolusite and manganite minerals are identified in XRD analysis. Major oxide and trace element analyses of samples gathered from the ore zone were carried out. As a result of the analysis, the MnO range was detected as 7.42-32.76% (average 20.65), and the SiO_2 range was detected as 60.68-83.52% (average72.88). Fe/Mn rate is considerably lower than 0.1. On average, the MnO/TiO_2 ratio of Taşdemir Mn mineralization is 483.65, indicating a pelagic environment. In addition, the Fe_2O_3-Al_2O_3/(Al_2O_3+Fe_2O_3) diagram supports this conclusion. Major and trace elements are evaluated in the diagrams to highlight the origin of manganese mineralization. These evaluations indicate that the mineralization is of hydrothermal origin.

1. Introduction

In addition to being a strength-enhancing substance in the iron and steel industry, manganese is also widely used in battery technology concerning green energy growth in recent years. The need for manganese, which contains significant physical and chemical properties, is increasing daily. For this reason, mineral deposit exploration is also widespread.

Mn deposits observed in many geological environments correspond to their geological, tectonic, mineralogical, and geochemical properties. These are; (1) hydrogenous, (2) hydrothermal, and (3) diagenetic deposits, respectively [1-3]. In these classifications, Fe/Mn contents also offer significant clues about the origin of the deposit [4]. Since manganese deposits in Turkey are related to the evolution of the Tethys Ocean, the deposits have been described in different geological environments [5-9]. The belts that stand out from these deposits are the İzmir Ankara Erzincan Suture Belt and the Southeastern Anatolian orogenic belt. These belts contain hydrothermal and hydrogenetic manganese deposits associated with radiolarian cherts [7, 9]. There are many manganese mineralizations in the Southeastern Anatolian Orogenic Belt, where the study area is located, in the literature [10-11].

Kahramanmaraş has attracted the attention of many geoscientists due to its geological features. Important geological structures are observed in the Kahramanmaraş region, an important area where the Taurus Orogenic Belt and the Arabian Plate are sutured. Because of this complex structure, Gül [12] defined these regions as the Orogenic belt and the Arabian plate belt and divided the units belonging to these two belts into sub-belts. Taşdemir (Pazarcık, Kahramanmaraş) manganese mineralization is orogenically located in two important tectonic units, the Southeast Fold Belt and the Eastern Taurus Orogenic Belt (Figure 1a). According to Gül [12], the study area is located in the margin fold belt at the northern end of the Arabian plate (Figure 1b). Mn mineralization is observed in the sedimentary rocks outcropping in the Taşdemir (Pazarcık) region. This paper reveals the geological, mineralogical, and geochemical characteristics of mineralization.

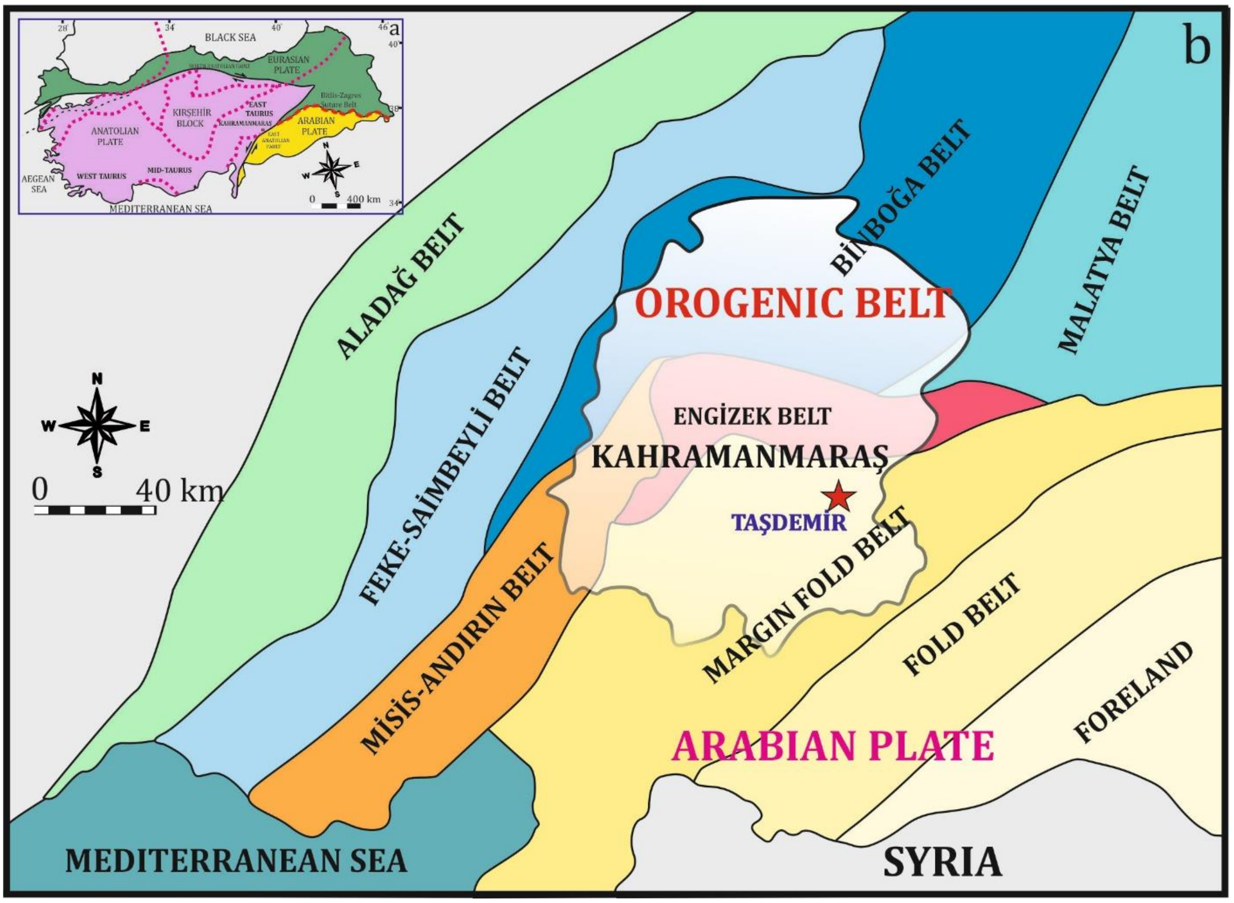


Figure 1. a. Tectonic location of the Kahramanmaraş (modified from Işık [13]), b. Tectonic location of the study area according to Gül [12].

2. Material and Method

The 1/25,000 scaled geological map of the study area prepared by MTA on the M39d4 sheet was used. The geological structures in the region were evaluated based on this map. Samples were collected from a 50-meter-long trench opened in the study area for ore work.

Observational geological investigations were carried out in the ore zone. As a result of the observations, sampling was made in the ore zone to conduct mineralogical and geochemical studies. These samples' major oxide and trace element analyses were performed at ITU-JAL using XRF and ICP-MS methods. XRD analyses were also performed for mineralogical identification.

2.1. Geological Background

Around Taşdemir Village (Pazarcık-Kahramanmaraş), units belonging to the Koçali and Karadut Complexes are commonly observed (Figure 2). Haydar and Germav formations overlie these units with angular unconformity. All units are covered with Middle-Upper Eocene aged limestones belonging to the Midyat Group with angular unconformity (Figure 2). The contacts of the melange in the study area are generally tectonic. Dip-slip faults cut thrust zones in places and strike-slip faults in places. In this region, Mn mineralization associated with the radiolarites of the Karadut Complex are observed.

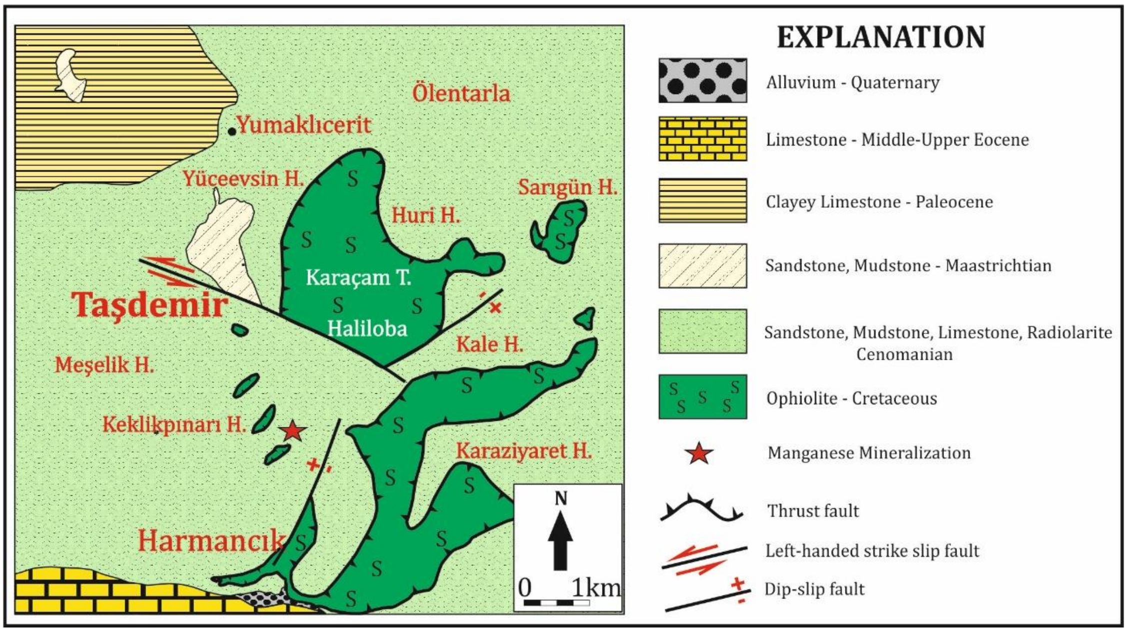


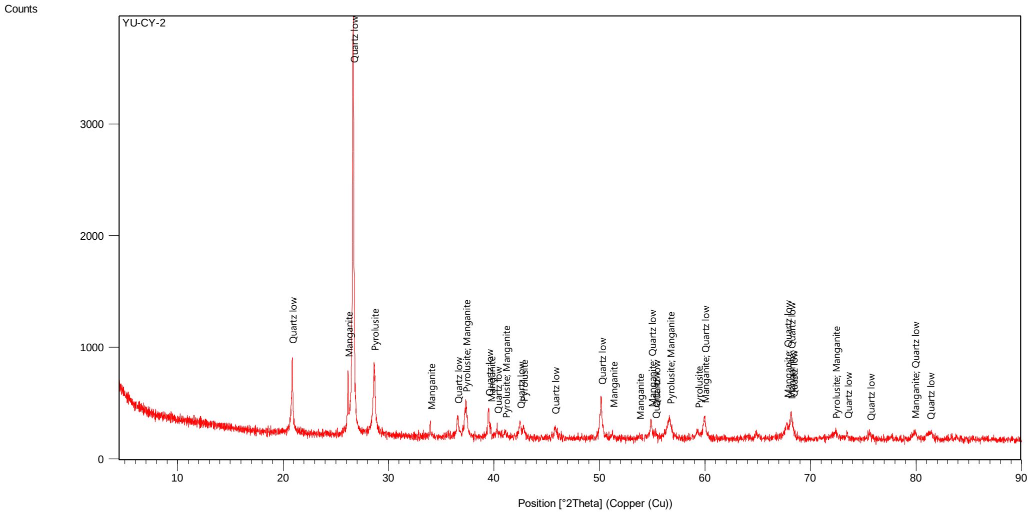
Figure 2. Geological map of the study area [14]

2.2. Ore Geology

The mineralization consists of short and medium-sized lenses conforming with the layers (Figure 3). It is commonly exposed at different levels of the layers of the succession. This formation continues along a zone of approximately 250 m. The ore lenses, which can be identified in the field with their blackish colour, have also been altered in places (Figure 3). The host rock is Cenomanian aged radiolarite, the upper layers of succession.

XRD study was carried out for the mineralogical identification of the samples taken from this ore zone. As a result of the analysis, pyrolusite and manganite minerals were determined (Figure 4).

Figure 3. General view of radiolarite-hosted manganese mineralization



Ref. Code	Mineral Name	Chemical Formula
98-000-5737	Pyrolusite	Mn1 O2
98-003-9931	Manganite	H1 Mn1 O2

Figure 4. XRD analysis of manganese mineralization

3. Geochemistry

Geochemical analyses of the samples collected from the ore zone were carried out (Table 1). According to the analysis, the amount of SiO_2 is rather rich. The reason for this is the intense exposure to radiolarites. MnO values at ore levels are between 7.42-32.76%. There is no substantial anomaly when the other major oxide values are examined. No alternative metallic enrichment is observed in samples with high manganese.

In the Si–Al discrimination diagram [15], the mineralization is distributed within the hydrothermal field due to low Al and high Si content (Figure 5). Likewise, in the triangular diagram [16], a different diagram in which trace elements such as Co, Zn, and Ni are compared relative to each other shows the distribution in the hydrothermal area (Figure 6).

Table 1. Major oxide concentration (%) of the manganese mineralization

SAMPLE	T 2	T 7	T 15	T 17	T 19	T 20	T 23
SiO_2	67,96	86,18	64,74	65,11	83,52	82,00	60,68
Al_2O_3	0,36	0,46	1,28	0,72	2,90	1,47	0,92
Fe_2O_3	0,15	0,21	0,73	0,34	1,43	0,63	0,44
MgO	0,01	0,04	0,42	0,15	0,59	0,28	0,19
CaO	0,22	0,15	0,41	0,19	0,42	0,31	0,22
Na_2O	0,01	0,08	0,06	0,04	0,12	0,09	0,05
K_2O	0,00	0,07	0,17	0,09	0,47	0,21	0,09
TiO_2	0,02	0,02	0,10	0,05	0,16	0,06	0,06
P_2O_5	0,14	0,05	0,10	0,00	0,08	0,09	0,10
MnO	27,12	8,88	27,30	29,05	7,42	12,09	32,76
Cr_2O_3	0,01	1,57	0,02	0,01	0,00	0,00	0,01
LOI	3,87	2,10	4,46	4,10	2,82	2,67	4,32
TOTAL	99,86	99,83	99,80	99,87	99,94	99,90	99,85
Co	59,79	110,04	40,39	41,79	26,04	37,42	38,42
Ni	58,00	823,69	59,22	30,74	25,07	28,86	39,57
Zn	54,24	20,98	50,59	31,77	21,89	24,00	41,64
MnO/TiO_2	1233,82	501,54	272,06	611,29	47,73	206,27	512,85
Fe/Mn	0,00	0,02	0,02	0,01	0,17	0,05	0,01

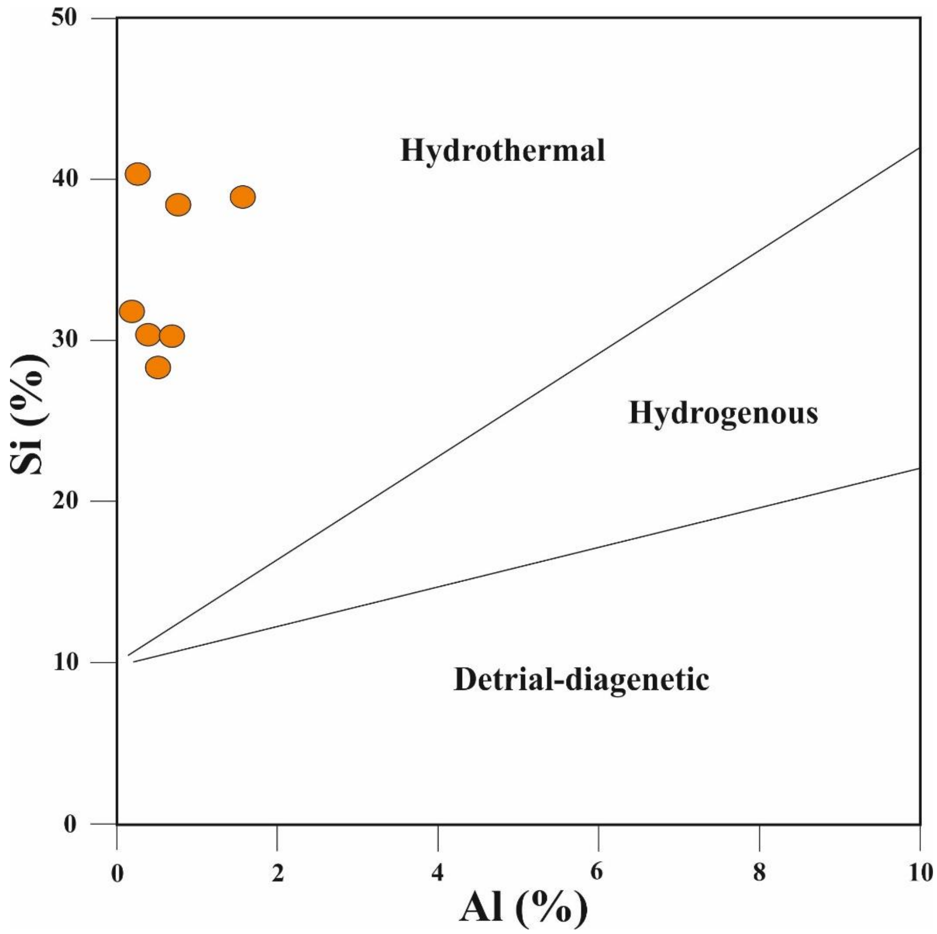


Figure 5. Si–Al discrimination diagram [15]

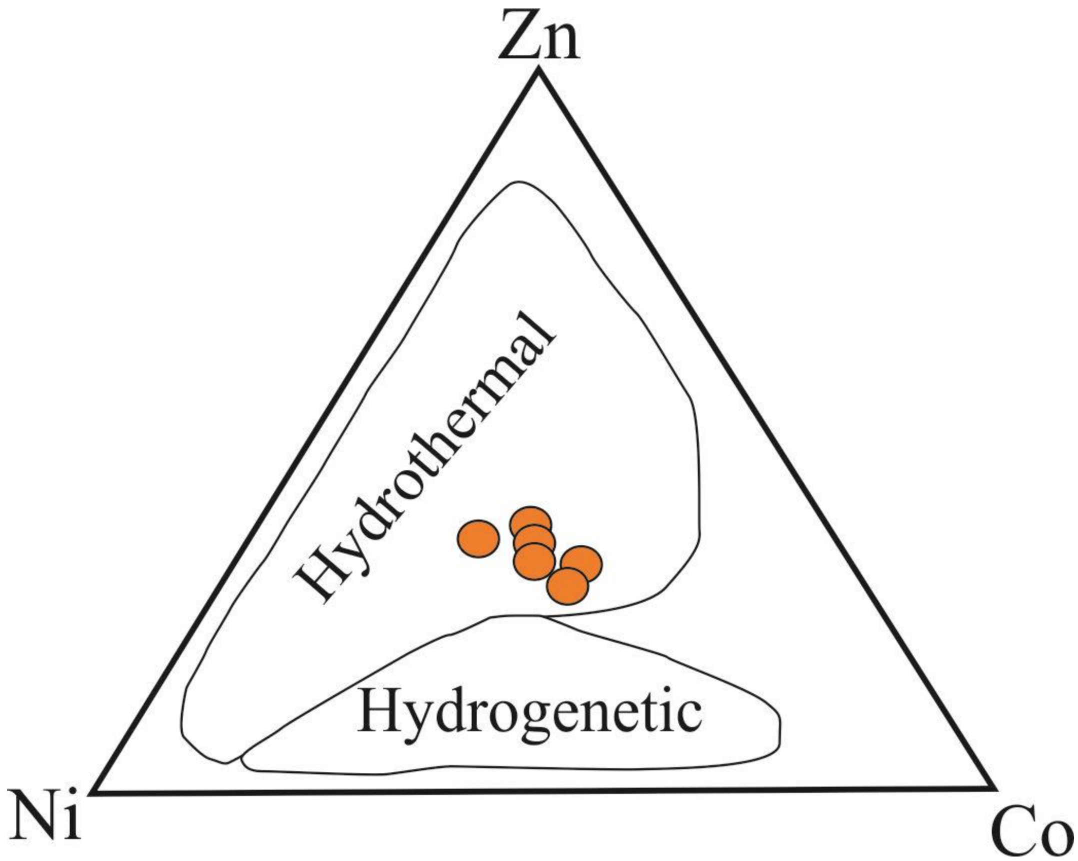


Figure 6. Zn-Ni-Co discrimination diagram [16]

In manganese formations associated with marine sedimentary rocks, the deposition environment is near the Spread ridge, pelagic (open ocean), and continental margin [17]. In order to explain the deposition environments of manganese formations associated with chert, radiolarian chert, and shale, the MnO/TiO_2 ratio is checked [18-19]. MnO/TiO_2 ratio < 0.5 indicates continental margin sedimentation environment and > 0.5 indicates pelagic environment. On average, the MnO/TiO_2 ratio of Taşdemir Mn mineralization is 483.65, indicating a pelagic environment. In addition, the Fe_2O_3-$Al_2O_3/(Al_2O_3+Fe_2O_3)$ diagram (Figure 7) used to reveal the storage environment still supports the above ratio [20].

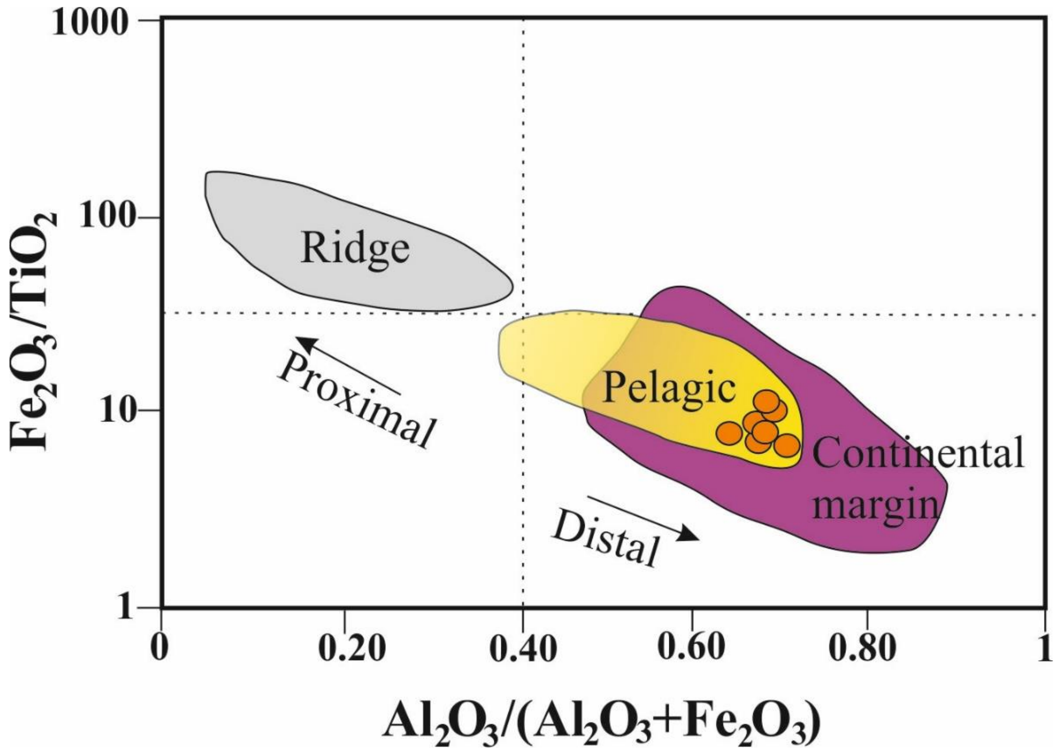


Figure 7. Plots of Fe_2O_3-$Al_2O_3/(Al_2O_3+Fe_2O_3)$ diagram [20]

4. Conclusion

One of the basic approaches for identifying manganese deposits is the Fe/Mn ratio of the ore. In studies on manganese mineralizations of various types [21-22], the Fe/Mn ratio of mineralization (Table 1) is 1 in hydrogenetic deposits that slowly precipitate from seawater. In the submarine hydrothermal deposits around the region, <0.1 (manganese-rich) and >10 (rich in iron) were determined. Very low Fe/Mn ratios are explained by the rapid precipitation of hydrothermal solutions in submarine hydrothermal centers. Fe/Mn ratios in this study are considerably lower than 0.1 and resemble submarine hydrothermal deposits.

The data obtained in this study determined that Taşdemir Mn mineralization is related to Cenomanian-aged radiolarites, and pyrolusite and manganite are found as manganese minerals. According to the results of geochemical analysis, mineralization characterizes a hydrothermal deposit associated with volcanism in the pelagic environment.

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Author contributions

Cihan Yalçin: Data curation, Methodology, Writing-Original draft preparation, Editing. **Mustafa Tekin Akkütük:** Petrography, Geochemistry. **Yusuf Uras:** Software, Visualization, Investigation.

Conflicts of interest

The authors declare no conflicts of interest.

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