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Geology, mineralogy and geochemical signatures of carbonate-hosted Pb-Zn Deposit in margin fold belt: Dadağlı-Kahramanmaraş, Türkiye

Yusuf Barbaros Akben[1], Cihan Yalçın [*2], Yusuf Uras [1]

[1]Kahramanmaraş Sütçü İmam University, Geological Engineering, Kahramanmaraş, Türkiye, bakben@gmail.com, yuras@ksu.edu.tr

[2]Ministry of Industry and Technology, General Directorate of Industrial Zones, Ankara, Türkiye, cihan.yalcin@sanayi.gov.tr

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Abstract

It may be observed in the Kahramanmaraş region in conjunction with the Taurus Orogenic Belt and Arabian Plate units, according to Neothetys' closure. One of these bands, the Arabian plate's marginal fold belt, is where the Dadağlı Pb-Zn mineralization can also be observed. The Seydişehir formation provides the oldest lithology in this area. This unit is overlain by a Mesozoic carbonate angular unconformity. There are vein-type and epigenetic Pb-Zn mineralizations in the fractures and fissures of carbonate rocks to the north of Dadağlı. The paragenesis consists of galenite, sphalerite, barite, goethite, pyrite, cerussite, smithsonite, quartz, and calcite respectively. Galena-cerussite and sphalerite-smithsonite transformations have been observed in ore microscopy studies. Pyrite inclusions are rare in galenites. The pyrite-goethite transformation is particularly prevalent. The average concentration of PbO is 30.99%. This concentration can reach as high as 60.70%. The range of BaO values is 0.22-10.30%. Iron-deficient results were obtained in general, with an average CaO concentration of 11.54%. The main oxide values did not include ZnO values, but trace element analysis revealed Zn values ranging from 77.19 ppm to 1200.10 ppm. The concentrations of rare earth elements in the ore zone are extremely low. There were no significant differences in trace element concentrations. When the data obtained in previous studies combined with the data obtained as a result of this study, it was determined that the vein type Pb-Zn mineralization has a distinctive structure.

1. Introduction

With the closure of the Neotethys Ocean, Arabian plate lithologies and units from the Taurus Orogenic Belt collided in the Kahramanmaras region [1]. With the depletion of the ocean floor, the allochthonous units were pushed onto the Arabian platform in the south, and the margin and suture belts were observed between these two continents [2-3]. Gül [4] stated that the collision of the Anatolian and Arabian plates occurred in the Late Cretaceous and the compression regime was active in the region during the Paleocene-Early Eocene period. Yilmaz and Yigitbas [5] stated that as a result of the movement of the Arabian continent towards the Anatolian plate between the Late Cretaceous and Miocene, the region acquired a napped characteristic. Rigo De Righi and Cortesini [6] and Gül [7] divided the tectonostratigraphic units in this region into orogenic belts because of the presence of rocks with various different tectonic characteristics.

Lead and zinc deposits are generally characterized as volcanogenic massive sulphide (VMS), sedimentary-exhalative (SEDEX), and Mississippi valley type (MVT), but also occur in skarn and epithermal deposits [8].

Tectonically, they are found in areas that contain carbonate platforms, non-deformed orogenic foreland formations, foreland thrust belts, and rift zones [9].

Pb-Zn deposits observed in carbonate rocks in Turkey are part of the Alpine-Himalayan Orogenic Systems [10]. With the effect of this orogenic belt, lithologies belonging to different tectonic belts are observed together in Turkey and Pb-Zn mineralizations are quite common in carbonate successions.

The study area is located in the Dadağlı region in the south of Kahramanmaraş province in the Eastern Taurus Orogenic Belt. This region and its vicinity were named the marginal fold belt at the northern end of the Arabian plate by Gül [7] (Figure 1).

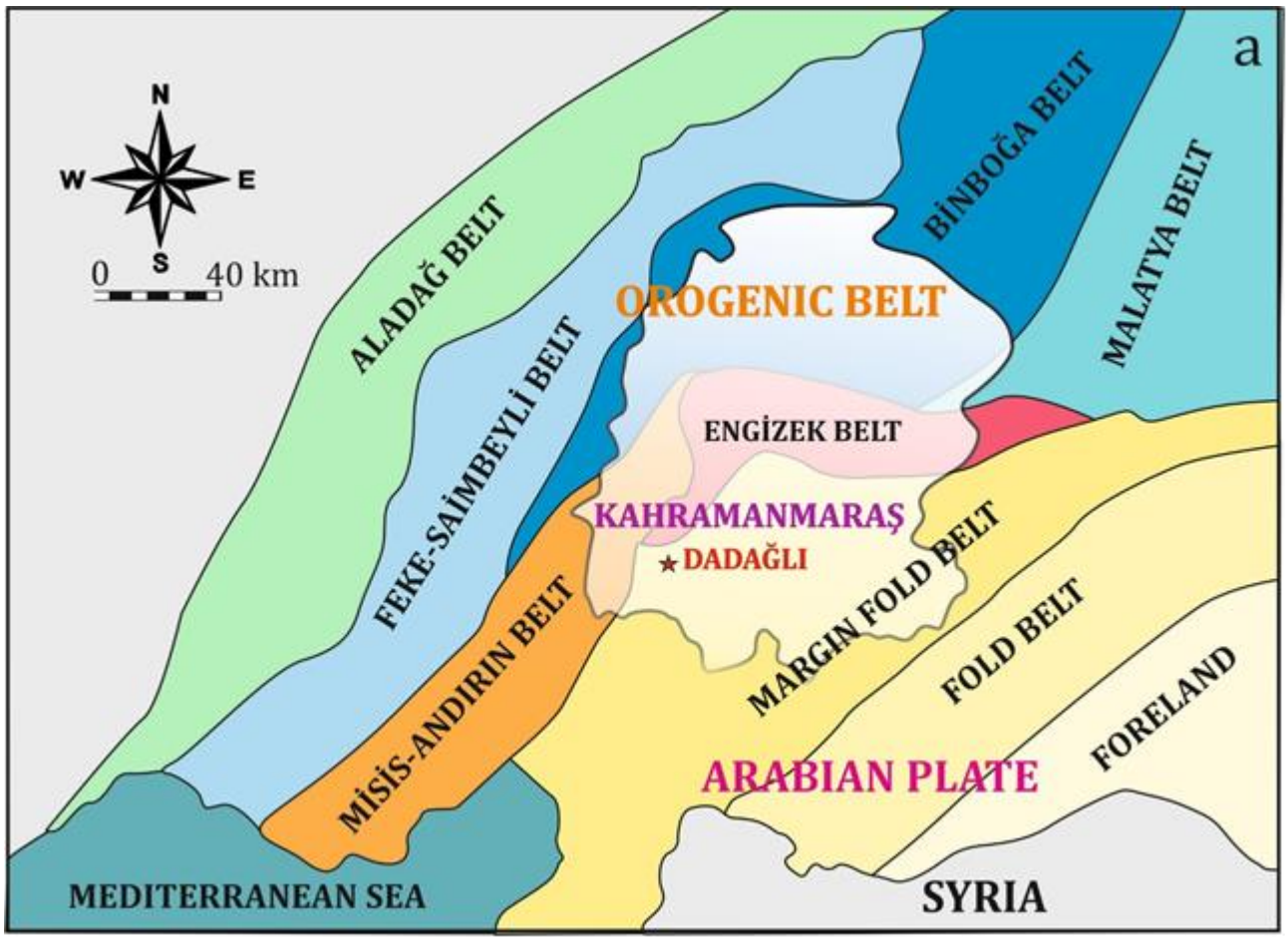

Figure 1. Tectonic location of the study area [7]

Cansu and Öztürk [11] identified barite mineralization in Paleozoic-aged sedimentary rocks in this area, as well as ore paragenesis containing galenite and sphalerite. According to Akben et al. [12], this area has Pb-Zn mineralization associated with barite and quartz veins.

Yalçın [13] presented preliminary data on the occurrence of barite lead zinc associated with carbonate rocks in the north of Dadağlı. He stated that BaO values reached up to 65.07%, SrO-rich mineralization was in the form of vein type and smithsonite and cerussite minerals were also found with the carbonatization of galenite and sphalerite minerals in the paragenesis [14]. Uras and Yalçın [15] determined chlorite-carbonate-pyrite index (CCPI) values; 57.02-93.24 (average: 81.26), chemical index of alteration (CIA) values; 4.57-81.92 (average: 30.80) and alteration index (AI) values; 4.81-94.33 (average: 45.06) in order to reveal the trend of alteration in the region. In the alteration geochemistry diagrams, it was determined that the common alteration types are carbonatization, sericitization, and rare pyritization. Yalçın and Uras [16] performed microthermometric measurements from barite and quartz in the paragenesis. They reported that low salinity and low homogenization temperatures indicate epithermal mineralization.

This paper reveals the geology, mineralogy, and geochemical concentrations of this region's mineralization zone. For this investigation, the geological map of Herece [17] was taken as a basis, and observations were done in the field. Thin and polished sections were prepared for petrographic and mineralogical investigations of the samples taken from the ore zone. Samples were also collected from the ore and host rocks. Major oxide concentrations of the collected samples were presented by Uras and Yalçın [15]. In addition, trace element and Rare Earth Element analyses were performed for this study.

2. Material and Method

Uras and Yalçın [15] analyzed the major oxides of 10 samples by X-ray fluorescence (XRF) method (Table 1). The same 10 samples were analyzed in the ore zone at Istanbul Technical University's Geochemistry Research Laboratory using the ICP-MS method on a BRUKER S8 TIGER model instrument for trace and REE analysis (Table 2-3).

Thin and polished sections were prepared for petrographic and mineralogical investigations of the samples taken from the ore zone. They were then examined and photographed under a NIKON microscope at the Geochemistry Research Laboratory of Istanbul Technical University.

2.1. General geology

In the study area (Dadağlı, Kahramanmaraş), units belonging to the Arabian Plate are observed. The oldest unit in this region is the Cambro-Ordovician-aged Seydişehir Formation consisting of shale, siltstone, sandstone, and quartzite. The Upper Triassic-Lower Jurassic aged Küreci dolomitic limestones and Karadağ limestones overlie the Paleozoic-aged units with angular unconformity. These units are intruded by Yavuzeli basalts observed in the north of the study area. Quaternary-aged alluvium covers all these 4 units with angular unconformity (Figure 2).

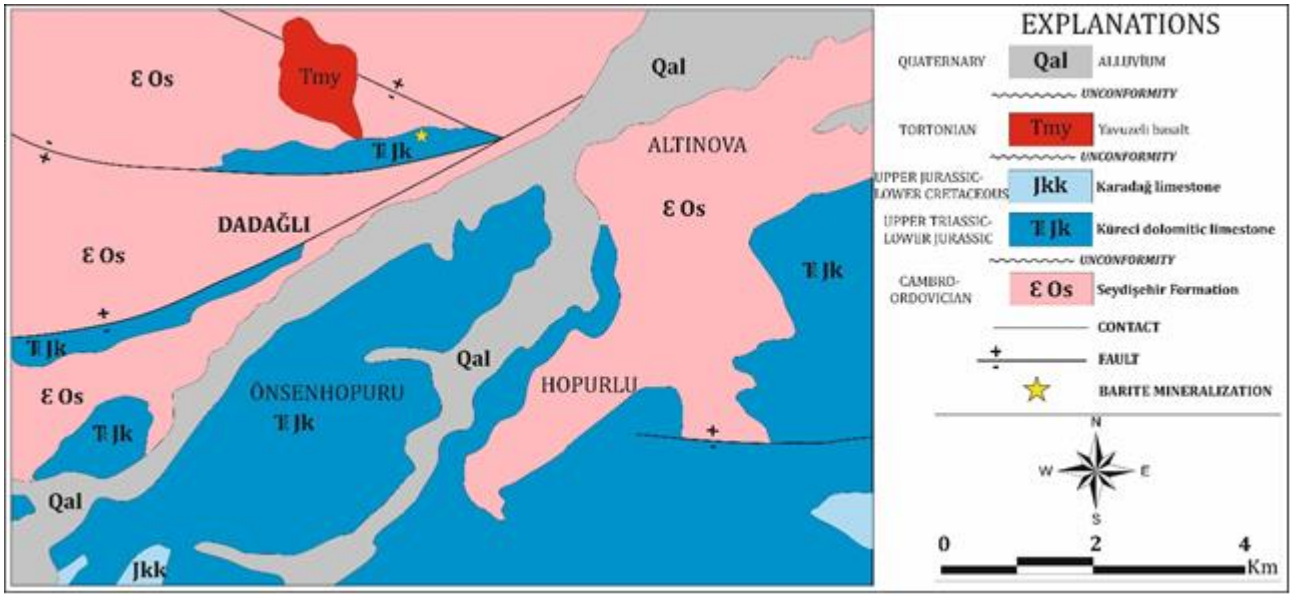

Figure 2. Geological map of the study area (modified from [17])

Seydisehir Formation: Named by Blumenthal [18] for the first time, the unit consists mainly of metasandstone, quartzite, slate, and siltstone respectively. Units belonging to this unit are exposed around Dadağlı and Altınova. The age of the unit was determined as Cambro-Ordovician in previous studies [19].

Küreci dolomitic limestone: Küreci dolomitic limestones overlying the basic unit with angular unconformity are exposed in the north and south of Dadağlı. It consists mainly of limestones. Since the Upper Triassic-Lower Jurassic-aged unit is dolomitic, it can be easily distinguished from Mesozoic-aged carbonates [20-21].

Karadag Limestone: This unit, which is observed at the uppermost levels of the Mesozoic sequence, is concordant with the Küreci Dolomitic limestone. It mainly consists of light-colored limestones. The age of the unit, which is exposed in limited areas in the southernmost part of the study area, is determined as Upper Jurassic-Lower Cretaceous [20-21].

Yavuzeli Basalt: The unit outcrops in the north of Dadağlı and consists mainly of dark-colored basalts. The age of the basalts, which are very hard and robust, was determined as Upper Miocene [20-21].

Alluvium: This Quaternary-aged unit consisting of unconsolidated gravel, sand, silt, and clay represents the youngest lithologies.

2.2. Mineralization

Epigenetic vein-type Pb-Zn mineralization is observed in the fractures and cracks of the dolomitic limestones exposed around Dadağlı. In the study area, discordant ore veins are observed in unconformable ore veins with the layers in the succession stacks with clayey limestones (Figure 3a). Altered levels are also observed in the side rocks of these veins (Figure 3b). Galenite, sphalerite, and smithsonite are commonly observed in hand samples (Figure 3c, 3d). The mineralization observed in this area is approximately 1 meter thick and 200 meters long. This thickness reaches centimeter scales in places.

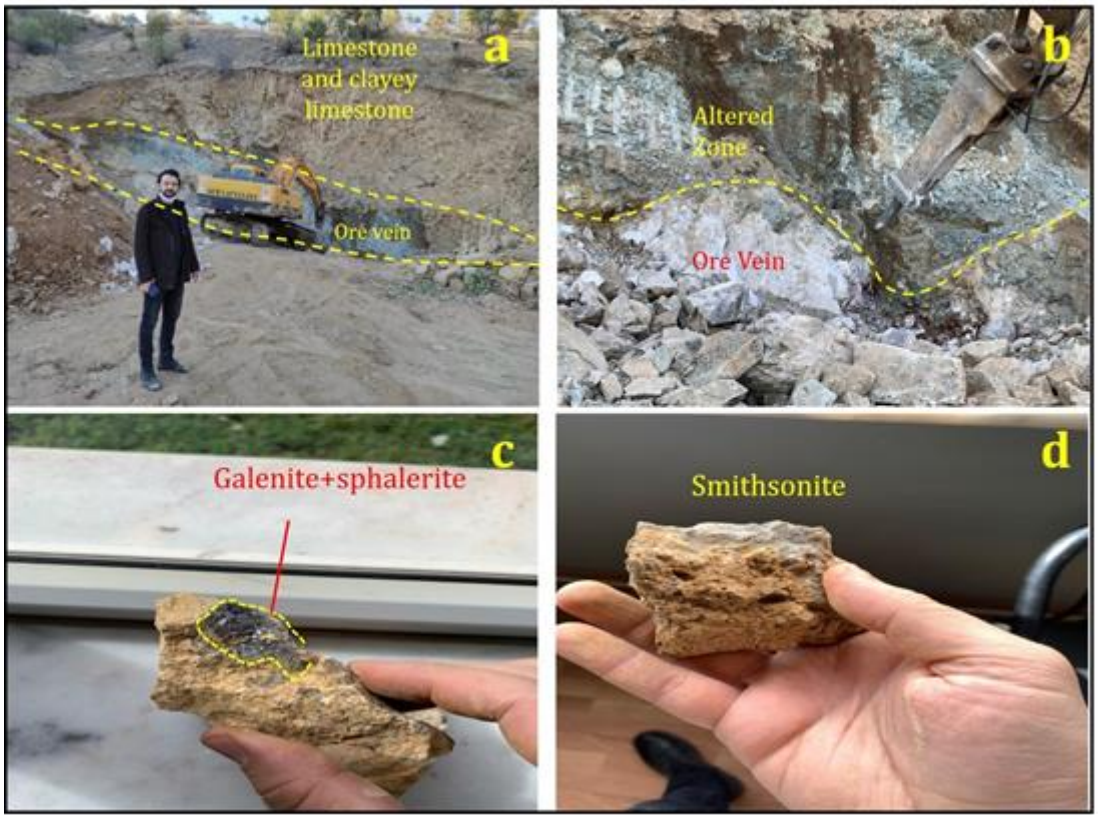

Figure 3. General view of ore zones and samples

Table 1. Major-oxide concentrations of the mineralization area [15]

OXIDE (%)	DK-1	DK-2	DK-3	DK-4	DK-5	DK-6	DK-7	DK-8	DK-9	DK-10
SiO_2	35,35	26,26	27,10	32,77	39,38	20,15	23,15	25,20	27,30	18,15
Na_2O	0,04	0,01	0,02	0,03	0,01	0,02	0,01	0,03	0,01	0,04
MgO	5,47	5,14	0,47	2,32	8,60	4,30	3,23	1,20	7,45	3,56
Al_2O_3	2,45	4,39	4,03	7,10	2,39	2,62	4,10	2,30	2,20	3,40
P_2O_5	0,27	0,23	0,18	0,17	0,23	0,10	0,10	0,12	0,24	0,10
SO_3	2,87	2,81	10,64	5,65	0,47	3,41	3,20	3,50	6,20	8,80
K_2O	0,90	1,82	0,74	2,78	0,77	0,90	0,98	1,28	0,82	1,45
CaO	14,05	15,11	0,27	5,20	21,41	0,29	0,40	10,20	25,10	23,40
TiO_2	0,21	0,33	0,12	0,45	0,22	0,16	0,11	0,21	0,22	0,32
MnO	ND	0,10	0,11	0,09	0,13	0,10	0,10	0,10	ND	0,01
Fe_2O_3	1,31	2,07	2,27	1,56	2,29	1,07	2,20	1,45	12,20	12,30
Cr_2O_3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PbO	23,86	20,39	45,64	34,93	4,49	60,70	56,28	38,20	7,20	18,20
BaO	0,22	3,57	6,96	3,90	0,52	0,25	2,30	3,30	10,30	8,72
LOI	12,80	17,55	1,06	2,34	18,89	9,81	3,58	12,60	0,60	1,20
TOTAL	99,98	99,98	99,98	99,98	99,98	99,98	99,80	99,70	99,90	99,70

3. Petrography and Geochemistry

In order to make the mineralization in the study area more understandable, thin sections were examined under a polarizing microscope (Figure 4). Iron oxide is commonly observed in the samples examined. In addition, quartz is dominant in some veins and barite in others. Opaque minerals are generally observed in these veins. Opaque minerals are more common and coarse-grained in barite-rich samples. Tectonic traces are also observed in the

veins. Breccia texture and pressure shadow structures in quartz were detected in the fractures and cracks that developed after ore formation.

Table 2. Trace element concentrations of the samples

TRACE ELEMENT (PPM)	DK-1	DK-2	DK-3	DK-4	DK-5	DK-6	DK-7	DK-8	DK-9	DK-10
Sc	ND	ND	40.44	9.51	ND	26.00	26.20	12.00	14.20	3.56
V	855.70	554.98	975.78	241.80	1307.08	90.76	130.20	145.60	230.48	268.20
Co	106.38	90.64	302.48	632.18	39.21	394.56	320.20	39.21	68.20	80.20
Ni	51.86	54.38	460.32	3691.15	38.05	485.68	32.20	50.30	200.30	180.30
Cu	9.95	105.60	89.55	363.92	113.80	666.73	220.40	128.30	340.30	120.60
Zn	77.19	127.31	768.70	93.70	86.26	1018.28	120.30	150.30	1200.10	980.50
Rb	59.55	97.22	79.67	125.45	29.26	72.71	34.60	58.20	68.20	76.15
Sr	266.35	677.39	672.18	776.16	328.47	169.33	268.90	320.20	468.48	530.78
Zr	315.06	308.49	618.38	536.12	98.55	769.74	120.45	150.80	96.00	98.00
Mo	6.25	6.05	16.78	11.58	1.31	20.48	5.20	6.20	4.58	15.20
Ag	20.46	20.39	59.17	37.69	6.20	55.20	32.40	17.40	20.10	40.30
Cd	1.31	31.47	44.71	26.01	7.86	6.62	16.80	7.45	3.23	4.30
Sn	5.58	49.00	82.83	53.35	7.60	6.42	18.70	25.30	4.30	5.20
Sb	20.20	33.02	74.96	48.31	9.99	39.14	23.25	26.40	35.40	38.90
Nd	64.99	ND	ND	39.76	ND	404.16	ND	32.30	ND	56.30
W	176.17	85.79	ND	ND	198.22	ND	ND	ND	ND	ND
Hg	29.32	241.90	178.29	415.78	20.67	395.15	250.30	310.20	178.20	86.78

Table 3. REE concentrations of the samples

REE (PPM)	DK-1	DK-2	DK-3	DK-4	DK-5	DK-6	DK-7	DK-8	DK-9	DK-10
Ce	10.41	12.10	10.06	9.62	5.52	31.37	26.80	17.40	18.80	23.30
Cs	0.85	3.41	0.92	4.08	0.93	0.35	2.10	3.23	0.90	0.46
Dy	0.48	0.99	0.73	0.68	0.86	0.81	0.30	0.29	0.68	0.82
Er	0.37	0.49	0.44	0.28	0.46	0.48	0.30	0.38	0.40	0.46
Eu	0.61	7.88	2.16	5.81	1.02	0.64	2.30	3.20	1.80	1.90
Ga	3.83	5.37	3.79	6.56	2.94	2.47	4.20	3.60	2.20	2.10
Gd	0.73	1.01	1.13	0.74	1.15	1.47	1.24	1.14	1.46	1.19
Ho	0.07	0.12	0.13	0.11	0.15	0.15	0.12	0.15	0.10	0.11
In	ND	ND	0.06	ND	0.01	0.01	ND	ND	0.01	ND
La	7.84	8.41	9.14	7.18	4.34	22.11	16.29	15.82	6.20	11.20
Lu	0.02	0.06	0.11	0.07	0.04	0.04	0.04	0.06	0.10	0.05
Nd	4.62	6.42	8.22	5.51	4.53	12.55	11.20	8.97	4.20	6.20
Pr	1.21	1.73	2.10	1.35	1.13	3.61	2.80	2.40	1.60	1.80
Rb	16.55	43.33	15.89	53.92	16.27	13.68	12.67	11.65	22.30	12.50
Sm	1.29	12.80	3.70	9.46	2.11	1.99	1.89	1.68	2.30	7.20
Tb	0.04	0.15	0.17	0.14	0.17	0.18	0.18	0.17	0.16	0.16
Tl	5.16	5.01	13.59	10.72	0.93	15.62	13.24	11.40	4.80	8.90
Tm	0.01	0.05	0.07	0.07	0.09	0.04	0.07	0.06	0.08	0.09
Y	2.83	4.70	3.22	3.83	6.34	4.94	2.90	3.68	4.80	5.20
Yb	0.14	0.35	0.52	0.33	0.40	0.29	0.36	0.38	0.36	0.34

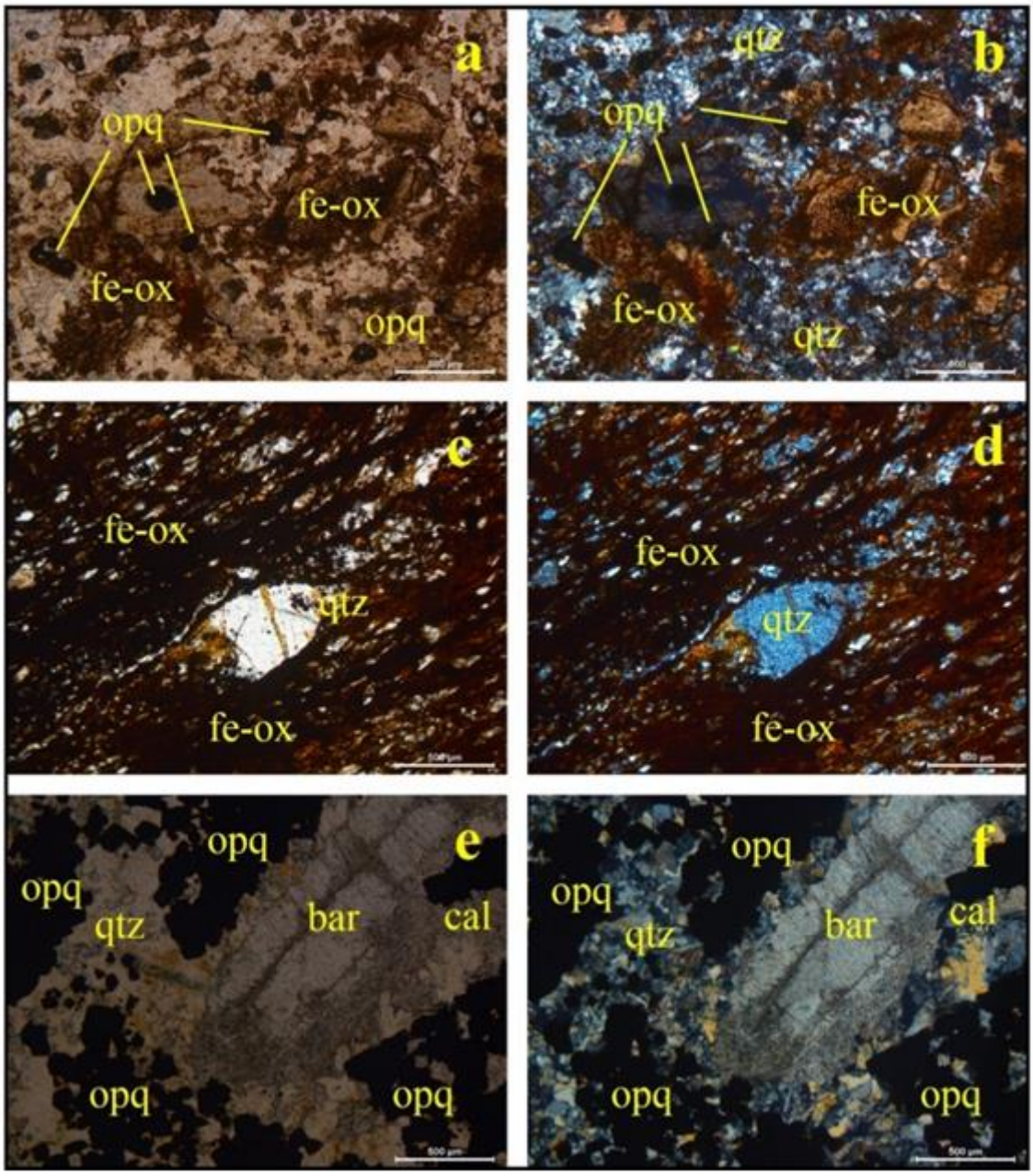

Figure 4. Polarizing microscope images of ore zone samples (opq: opaque mineral; fe-ox: iron oxide; qtz: quartz; cal: calcite, bar: barite)

Ore paragenesis consists of galenite, sphalerite, pyrite, cerussite, smithsonite, goethite, quartz, calcite and barite minerals. In ore microscopy studies, galenite-cerussite and sphalerite-smithsonite transformations are observed. Pyrite inclusions are occasionally formed in galenites. Pyrite-goethite transformation is quite common (Figure 5).

XRF and ICP-MS analyses of 10 samples collected from the ore zone were performed at Istanbul Technical University Geochemistry Research Laboratory. The analyses revealed the major oxide (Table 1), trace element (Table 2) and rare earth element (REE) (Table 3) concentrations of the ore zone.

According to the analysis, the average PbO value is 30.99%. This value reaches a maximum of 60.70%. BaO values are between 0.22-10.30%. In general, iron-poor results were obtained and the average CaO concentration was 11.54%. ZnO values were not determined in the main oxide values, but Zn values between 77.19-1200.10 ppm were obtained in the trace element analysis results. Ag concentrations were between 6.20-59.17 ppm and Hg between 20.67-415.78 ppm. Sr content is 415 ppm on average and reaches a maximum of 677.39.

When we look at the REE analysis, it was determined that the concentrations of the samples were poor. When normalized according to the concentrations, it was determined that heavy REEs were enriched compared to light REEs (Figure 6).

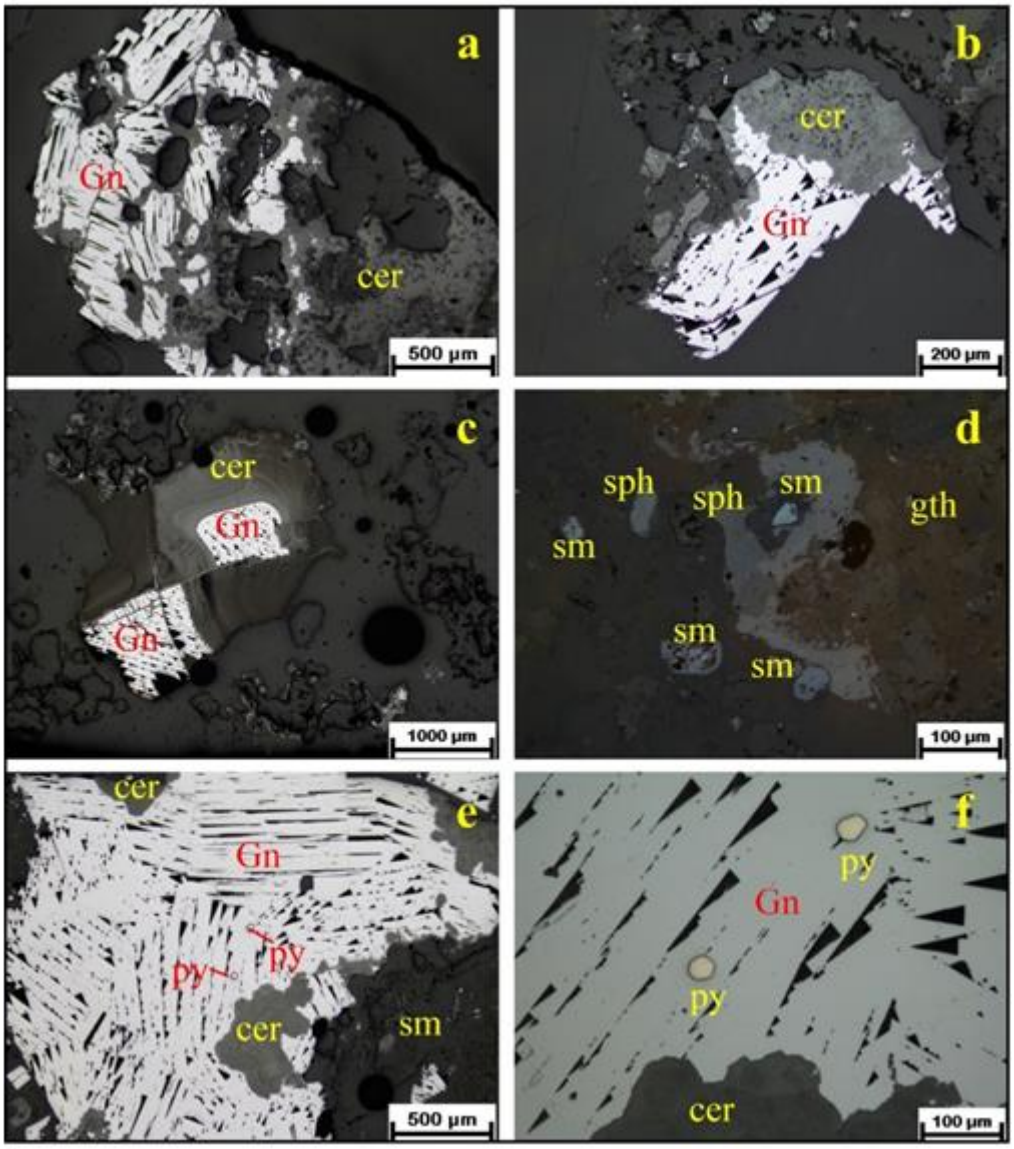

Figure 5. Ore microscope views of samples collected from the ore zone (Gn: galenite; cer: cerussite; sph: sphalerite; py: pyrite; sm: smithsonite; gth: goethite).

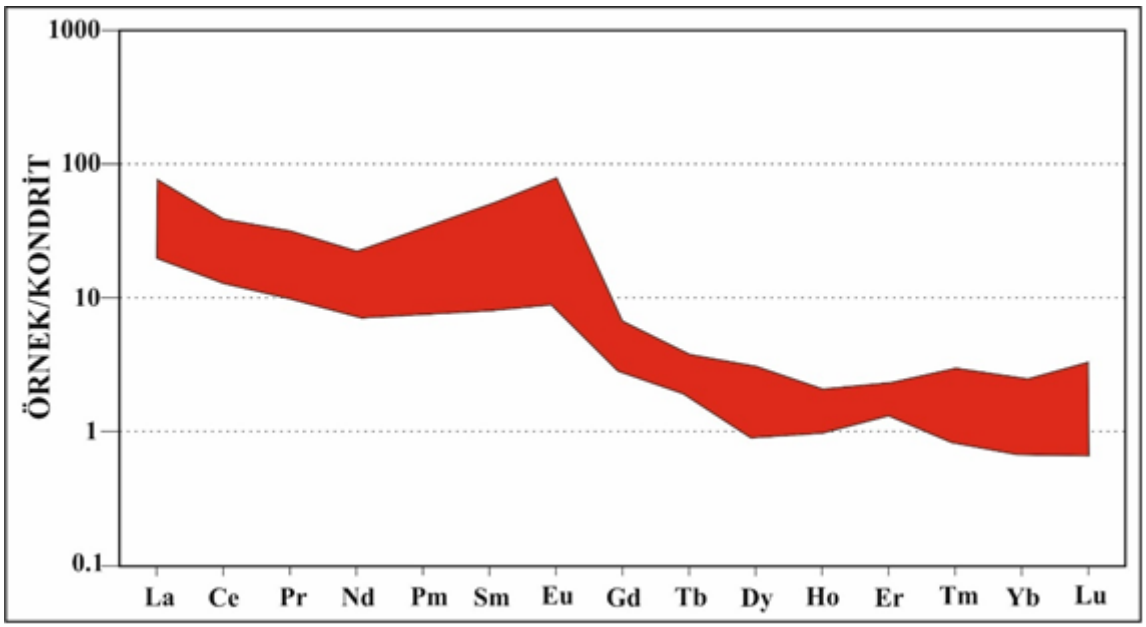

Figure 6. REE spider diagram of ore samples normalized by chondrite

4. Discussion

In the Kahramanaraş region, Pb-Zn mineralization is observed both in the Taurus Orogenic belt and in the Arabian plate. In the Taurus Orogenic belt, barite-bearing Pb-Zn mineralization associated with carbonate rocks is found in the Malatya metamorphites in the Helete province [22]. The mineralization observed in the fracture lines is vein-type and epigenetic. On the Arabian plate, Cansu and Öztürk [11] have reported that barite mineralization developed in the Paleozoic sequence in Dadağlı, Şekeroba, and Önsen regions and that galenite and sphalerite are observed in paragenesis. Uras and Yalçın [15] presented the alteration geochemistry of the Pb-Zn ore zones and Yalçın and Uras [16] explained the mineralization with microthermometric studies. There are similar ore zones in two different tectonic belts in this region.

5. Conclusion

1. Dadağlı region is located on the Arabian plate. There are vein-type epigenetic Pb-Zn mineralizations in Mesozoic-aged carbonates belonging to the Amanos Group. The mineralization observed in fractures and cracks in the carbonates in this region has an average thickness of 1 meter and a length of 200 meters.
2. Lead zinc minerals and their carbonatized forms are observed in the ore paragenesis. In addition, pyrite, hematite, goethite, quartz, barite, and calcite minerals are observed.
3. According to the analysis, the average PbO value is 30.99%. This value reaches a maximum of 60.70%. BaO values are between 0.22-10.30%. In general, iron-poor results were obtained and the average CaO concentration was 11.54%. ZnO values were not determined in the main oxide values, but Zn values between 77.19-1200.10 ppm were obtained in the trace element analysis results.
4. When we look at the REE analysis, it was determined that the concentrations of the samples were poor. When normalized according to the concentrations, it was determined that heavy REEs were enriched compared to light REEs.

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Author contributions

Yusuf Barbaros Akben: Mineralogy, Geochemistry. **Cihan Yalçın:** Data curation, Methodology, Writing-Original draft preparation, Software. **Yusuf Uras:** Geochemistry, Investigation, Writing-Reviewing, and Editing.

Conflicts of interest

The authors declare no conflicts of interest.

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