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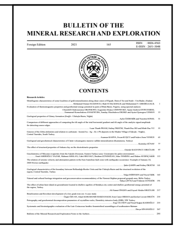

Genesis of the Zebra dolomites and relation to carbonate - hosted Au - Ag - Zn ± Pb deposits in the Maden village (Ulukışla - Niğde), Central Taurides, South Turkey

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ABSTRACT

Zebra dolomites and carbonate - hosted Au - Ag - Zn ± Pb deposits of Maden village is located in the shelf type carbonate rocks of the Bolkar Mountains. The Zebra dolomite (ZD) locally form and there is no evidence for relation between dolomitization and mineralization. Maden village ZD is characterized by parallel light and dark bands that have similar mineralogy and chemistry by petrographic and SEM + EDX investigation. The $\delta^{13}C$ (V - PDB) composition of the Zebra dolomite from 2.59‰ to 2.72‰ and the $\delta^{18}O$ (V - PDB) values of the Zebra dolomite from -11.39 ‰ to -14.88 ‰. These isotopic values show that the source of oxygen and carbon was derived from marine carbonates and freshwater carbonates. Fluid inclusion studies on Zebra dolomite show homogenization temperatures of 80 °C - 180 °C. Based on petrographic, isotope values and fluid inclusion study, we can say that the dolomitization occurred during the late diagentic conditions prior mineralization.

1. Introduction

Zebra dolomites have been defined as an interesting lithology, characterized by a repetition of mm - scale dark gray (a) and light (b) colored dolomite sheets that make up the abbabba - sequences (Nielsen et al., 1998). The term has differently been described as diagenetic crystallization rhythmites (Levin and Amstutz, 1976; Fontbote, 1981; Fontbote and Amstutz, 1983; Wallace et al., 2018), banded or ribbon ores (Sass Gustkiewicz et al., 1982; Tompkins et al., 1994; Wallace et al., 2018), Zebra rocks or textures (Beales and Hardy, 1980; Wallace et al., 1994; Zeeh, 1995), expansion structure (Beales and Hardy, 1980; Wallace et al., 2018), and Zebra rock / texture / fabric / dolomite (Beales and Hardy, 1980; Wallace et al., 1994; Nielsen at al., 1998; Diehl et al., 2010; Morrow, 2014). The origin of the Zebra texture is uncertain and debated (Wallace et al., 2018 and Nielsen et al., 1998). The interpretations of origin Zebra dolomite vary from synsedimentary (Fontbote and Amstutz, 1983) to epigenetics (Arne and Kissin, 1989). Beales and Hardy (1980) explained that the White Zebra dolomite sheets are pseudomorphs after evaporate minerals. This interpretation was followed by Tompkins et al. (1994) for the rhythmically banded ores at Cadje but (Canning basin, Western Australia), which appear to be laterally porous, gypsiferous laminated limestone. Wallace et al. (1994) proposed that Zebra textures are not always hosted by evaporatic sediments, Zebra fabric is generally associated with sulfides or sulfide associated phases. Some authors stated that Zebra

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textures occur in a variety of different geological settings and are associated with both carbonate - hosted ore deposits (Mississippi Valley type mineralization, intrusive - related lead - zinc deposits and Carlin - style gold deposits) and hydrothermal dolomite reservoirs (Fontbote, 1993; Davies and Smith Jr, 2006; Diehl et al., 2010; Morrow, 2014; Hiemstra and Goldstein, 2015; Wallance, 2018). Dolomitization occurs as a result of various geological processes involving evaporatic, normal marine and meteoric water (Morrow, 1998) which including diagenesis of limestone, and hydrothermal alteration (Wilkinson et al., 2005; Zentmyer et al., 2011; Bouabdellah et al., 2012; Gomez - Rivas et al., 2014). Many researchers have been investigated the nature (diagenetic or hydrothermal) and the timing of dolomitization with respect to associated sulfide mineralization in order to define the type of ore deposit (Wilkinson, 2003; Wilkinson et al., 2005; Leach et al., 2006; Johnson et al., 2009; Bouabdellah et al., 2012; Wilkinson, 2014).

The study area is located in the foothills of Bolkar Mountains, which is a part of the Tauride block including Lower Paleozoic to Upper Cretaceous recrystallized limestone, dolomite, marble, and calc-schist (Figure 1; Özgül, 1976; Demirtaşlı et al., 1984; Alan et al., 2007). This belt is one of the major Pb - Zn mining areas in Turkey and is known for hosting carbonate - hosted Pb - Zn deposits (Koptagel et al., 2007). Near the investigated Zebra dolomite, there is a Maden village carbonated hosted Au - Ag - Zn ± Pb deposit which is hosted in the

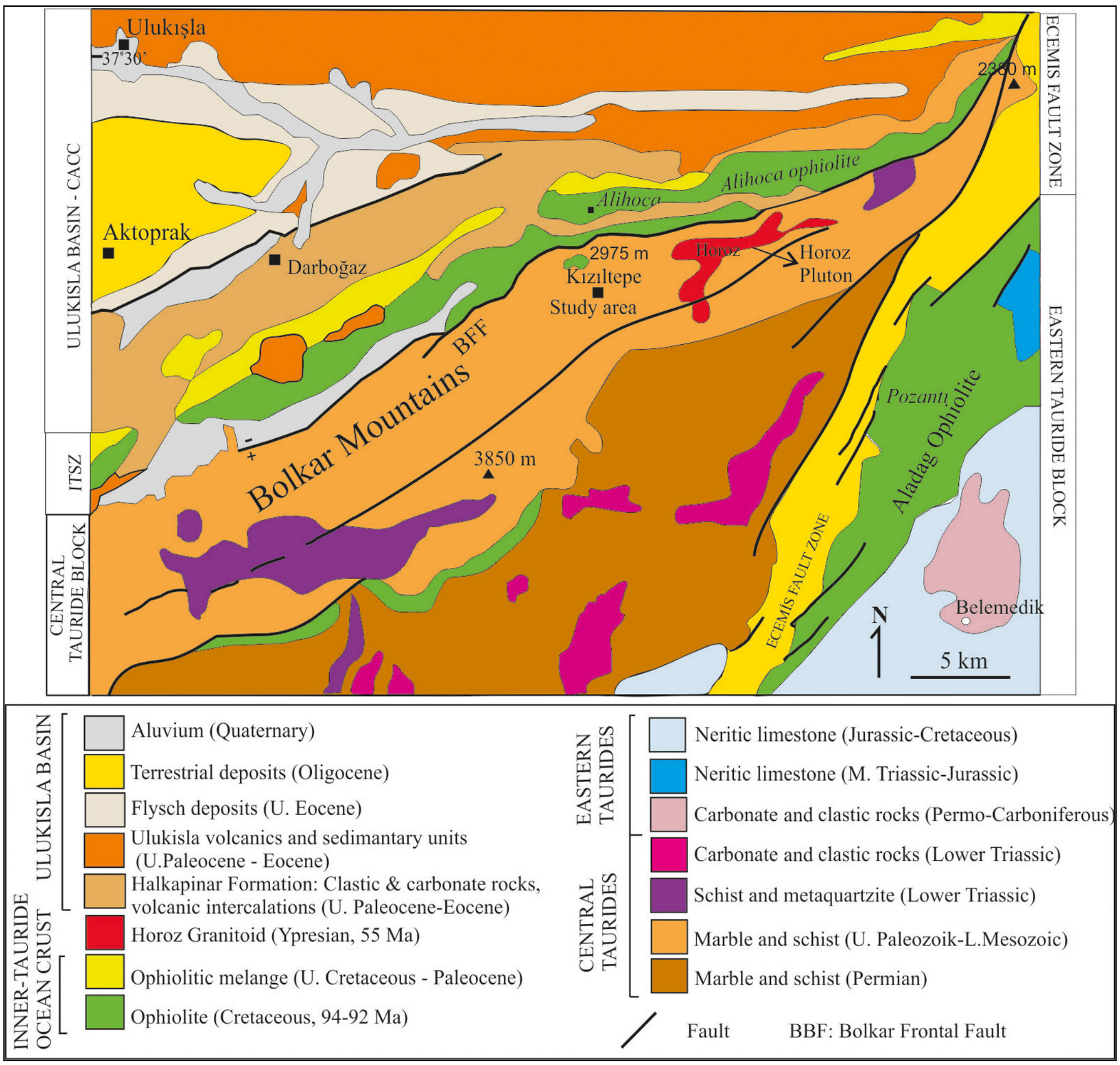

Figure 1- Geologic map of south - central Turkey, showing the distributions of major tectonic units, faults, and the Horoz pluton in the Central Tauride block. BBF, Bolkar Frontal Fault (Kadıoğlu and Dilek, 2010).

Jurassic-Cretaceous marbles of the northern flank of the Bolkar Mountains anticline, mostly close to near vertical E - W and N30°W trending faults. The Maden village deposits, are one of the most important economic sources of Au - Ag - Zn ± Pb in Turkey, with average grades of 7.37 g/t Au, 813.71 g/t Ag, 31.06% Pb, and 5.94% Zn (Gümüştaş Company AŞ, 2014). The mineralization in the study area is placed in Jurassic - Cretaceous recrystallized limestone which both relicts of hypogene and supergene ore are found. The supergene non - sulfide ore occurs in dissolution cavities within marble, mainly along joint planes and fractures (tension gashes). The hypogene sulfide mineralization is a relicts of cave wall / floor, and tectonic contacts between marble and melange. The sulfide mineralization (hypogene) in the area is extensively oxidized as a result of uplift the Tauride block during Oligo - Miocene, progressive erosion of landscape, development of fractures (tension gashes) under extensional conditions, and consequently weathering of the protore (Kahya et al., 2019). Locally occurred Zebra Dolomite (ZD) near the Maden village carbonated hosted ore deposit. So far the ZD has not been studied. Therefore, isotopic data, detailed mineralogic studies, and fluid inclusion studies were used in this study to find the source of dolomitizing fluids and their relationship with the Maden village carbonate - hosted deposits.

2. Material and Method

Mineralogical and petrographical studies were carried out on dolomite. X - ray diffraction (XRD) studies were made on dolomite to determine the mineral contents using XRD analyzer Philips PW 3710 / 1830 in MTA (General Directorate of Mineral Research and Exploration, Turkey). Minerals were determined by optical microscopy at MTA using Leica DM2500P polarizing microscope. Petrographic observations (optical microscopy and scanning electron microscopy (SEM + EDX) of thin sections and fresh samples were used to establish textural properties and to identify mineral species. SEM + EDX analyses used a FEI Quanta 400 MK2 SEM and EDAX Genesis XM4i EDS detector at MTA. Fluid inclusion studies were carried out on the two surface polished thin section of dolomite sample and 14 fluid inclusion analyses were made and measurements were performed with a Linkam MDSG 600 heating - freezing stage mounted on the Leica DM 2500 microscope at MTA. The O and C isotope compositions were measured on 4 clear dolomite samples in the Isotope Geochemistry Laboratory of Arizona University. The $\delta^{18}O$ is given in per mil (‰) V - SMOW (Vienna Standard Mean Ocean Water); $\delta^{13}C$ values are in per mil (‰) V - PDB (Vienna Standard Pee Dee Belemnite). All measured isotopic compositions are given in Table 1. The O and C values of carbonates were measured using an automated carbonate preparation device (KIEL - III) coupled to a gas-ratio mass spectrometer (Finnigan MAT 252). Powdered samples were reacted with dehydrated phosphoric acid under vacuum at 70 °C. The isotope ratio is calibrated using repeated measurements of NBS - 19 and NBS - 18 with precision of ±0.1‰ for $\delta^{18}O$ and ±0.06‰ for $\delta^{13}C$ (1sigma).

3. Regional Geological Setting and Local Geology

The study area belongs to the Bolkar Mountains Units, which are part of the Tauride block south of the ITSZ (Inner - Tauride Suture Zone). The Bolkar Mountains Units comprises carbonate, siliciclastic, and volcanic rocks and their metamorphic equivalents with ages ranging from Upper Permian to Late Cretaceous (Demirtaşlı et al., 1984; Özgül, 1976). This unit is interpreted as a ribbon shaped continent rifted off from Gondwana (Özgül, 1976, 1984; Görür et al., 1998; Garfunkel, 1998). Platform carbonates in the Bolkar Mountains have multiple folds and are imbricated along thrust faults, which caused substantial shortening and crustal thickening

Table 1- Oxygen ($\delta^{18}O$) and carbon ($\delta^{13}C$) isotope analyses of the Zebra Dolomites.

Sample	$\delta^{13}C$ (V - PDB) ‰	$\delta^{18}O$ (V - PDB) ‰	$\delta^{18}O$ (V - SMOW) ‰
WHITE Zebra dolomite	2.60	-14.87	15.58
WHITE Zebra dolomite	2.59	-14.86	15.59
DARK Zebra dolomite	2.72	-11.39	19.17
DARK Zebra dolomite	2.71	-11.38	19.16
Host rock limestone	2.81	-6.58	24.12

within the platform. These contraction structures and the crustal - shortening first developed during the obduction of the ITO (Inner Tauride Ophiolites) from the north in the Late Cretaceous and subsequently during the collision of the Tauride Block with the CACC in the Late Paleocene - Eocene (Dilek et al., 1999*b*; Kadıoğlu and Dilek, 2010). The Tauride Block experienced a gradual uplift in the footwall of a north-dipping frontal normal fault system along its northern edge starting in the Miocene, and it developed a southward - tilted, asymmetric mega - fault block with rugged, Alpine topography (Dilek et al., 1999*b*; Kadıoğlu and Dilek, 2010, Kahya et. al., 2019). These fault system is important for dolomitization. The Horoz Granitoid and quartz porphyries intrude into the Lower Paleozoic - Upper Cretaceous Tauride Block rocks in the Bolkardağ (Dilek and Whitney, 2000; Kadıoğlu and Dilek, 2010). The Horoz Pluton was unroofed by the Early Miocene as a result of both crustal uplift and erosion (Kadıoğlu and Dilek, 2010). The age of the Horoz Granitoid is determined as Paleocene - early Eocene (Alan et al., 2007). The Ulukışla basin formed after the emplacement of the ITO (Inner Tauride Ophiolite) and melanges on the Tauride platform during the Late Cretaceous period and underwent late Eocene emergence, deformation, and onset of Oligo - Miocene non - marine deposition (Blumenthal, 1956; Demirtaşlı et al., 1984; Atabey et al., 1990; Görür et al., 1998; Clarc and Robertson, 2002; Kadıoğlu and Dilek, 2010). The Ulukışla basin filled with Upper Cretaceous to Oligo - Miocene volcanic and sedimentary materials and became part of a larger, shallow intra - continental basin consisting mainly of lacustrine and fluvial deposits that covered much of Central Anatolia throughout the Miocene and Quaternary period (Kadıoğlu and Dilek, 2010).

The study area is located in Maden village, south of the Ulukışla (Niğde) town, in the eastern part of the Central Taurus Mountains of Turkey. In the study area, the Namrun Tectonic Slice, the Bolkar Mountain Unit, the Bozkır Unit, and the Tertiary cover rocks of the Ereğli - Ulukışla basin are exposed (Figure 2). Bolkar Mountains Units forms the basement of the study area. The Middle - Late Triassic Tozlutepe formation is located at the bottom of this. This formation is conformably covered by the Late Triassic Metrisyayla formation which is unconformably overlain by the Jurassic - Cretaceous Koçakkale formation, and consists of recrystallized limestone and dolomite (Alan et al., 2007). The mineralization and studied Zebra Dolomite is located in the recrystallized limestone of the Koçakkale formation reffered to as the Bolkar Mountains Marble by Şişman and Şenocak (1981). The Late Cretaceous Kaledere formation overlies the Koçakkale formation with a transitional contact (Alan et al., 2007). Çiğdemgölü formation of Namrun tectonic zone is overthrusted onto the Bolkardağ unit. The Namrun unit in the study area is composed of the Early Permian Çiğdemgölü formation, the Late Permian Karlığıntepe formation, and the Early - Middle Kocatepe formation. The Kocatepe formation overlies the former units with a transitional contact. The Kızılcadağ Ophiolitic melange and the olistostromes of the Bozkır unit tectonically overlie the Namrun tectonic unit. In the study area, the units are overlain by the units of the Ereğli - Ulukışla basin. The Paleocene - Middle Eocene Halkapınar formation and the Middle Eocene Delimahmut formation are units of the Ereğli Ulukışla basin (Alan et al., 2007, Figure 2). Furthermore, in the region, the Paleocene - Early Eocene Horoz Granitoid crosscuting the pre - Middle Eocene units. All of these units are uncomformably overlain by younger alluvial deposits (Figure 2).

4. Petrography

The study area ZD have been locally occurred. The host rock is recrystallized limestone and contact with the ZD are sharp (Figure 3a). We have been done XRD analysis to determine the ratio of calcite and dolomite as %. Petrographically the ZD is microcrystalline texture and consist of > 90 % dolomite and little calcite (Figure 3c). The ZD has geopatic fabric (Figure 3b) and has been characterized by parallel light and dark bands that occur at a millimeter to centimeter scale. The light and dark bands of the this have similar mineralogy and chemistry by petrographic and SEM investigation results. Gray dolomite commonly lines the base of the white coarsely crystalline dolomite (Figure 3b, c). In thin sections fine grained dolomite crystals in the gray layers are generally fine grained - anhedral, with fitted irregular intercrystalline boundaries. Dolomite crystals in the white layers are medium - coarse grained, subhedral to euhedral with straith intercrystalline boundaries (Figure 3c, d). Geopetal textures are common in the Zebra fabric and show that the horizontal deposition. Cavities and layered mineral fillings within them indicate the fluctuations in chemistry of the dolomitizing solutions during the form of ZD, which alternate between corroding and

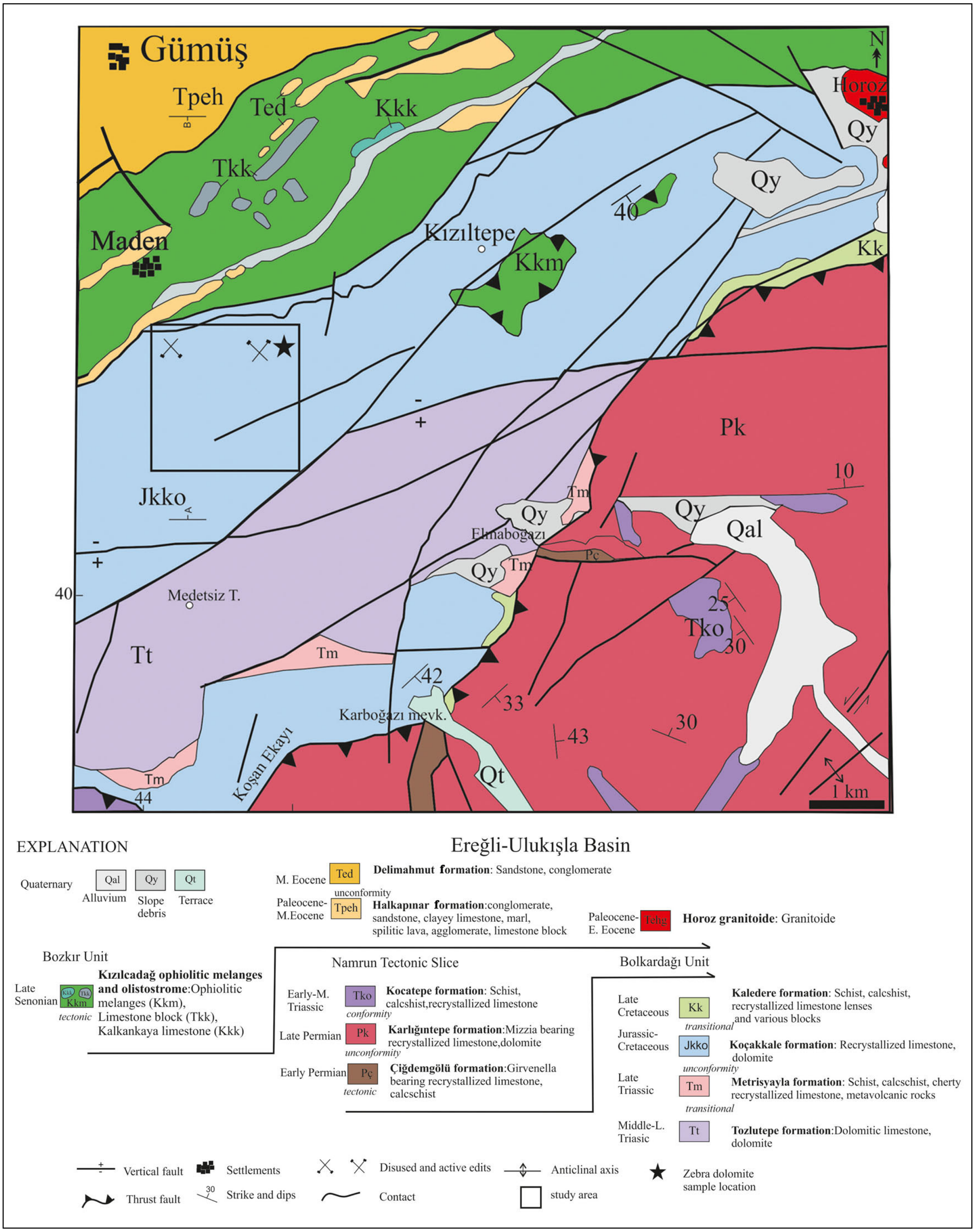

Figure 2- Geologic map of the study area modified from Alan et al. (2007).

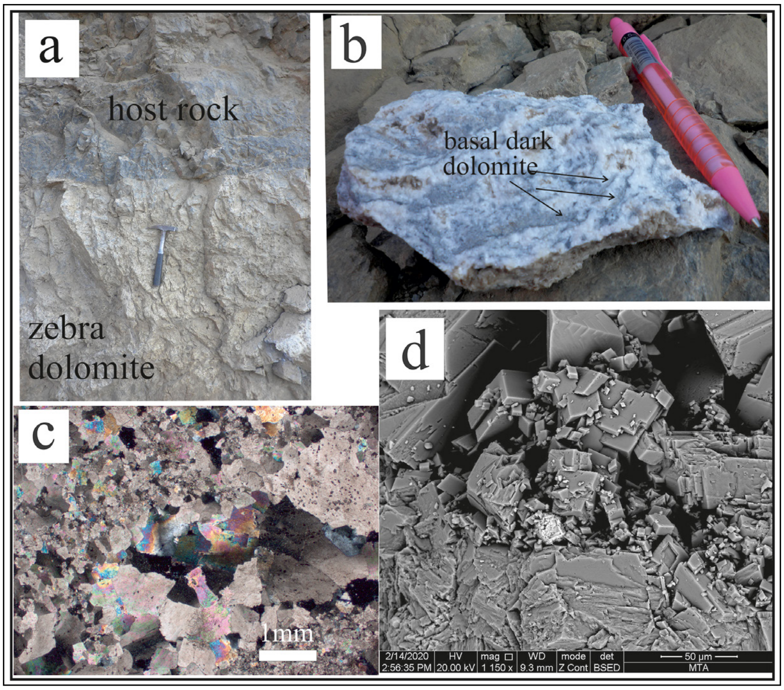

Figure 3- a) Contact between the ZD and limestone, b) Hand spicemen at the study area ZD showing the detailed appearance of the ZD layers. The dark dolomite alternates with light layers, c) Photomicrographs of ZD layer. Coarse grained band between the fine grained dolomite level (dense dolomite, crossed polar), d) SEM image of the fine and coarse grained dolomite.

dissolving, and precipitation and deposition (Bray, 1983).

5. Fluid Inclusion Study

Microtermometric measurement were performed on fluid inclusions in dolomite and primary inclusions were observed. Based on fourteen measurements, homogenization temperatures range from 80 to 180 °C (n=14, all data graphically display in Figure 4). Most of the primary inclusions consist of a single phase (gas) (Figure 5a) or two - phase (liquid + gas) (Figure 5b). Primary origin inclusions are seen generally like square, rectangular, elongated, rod - shaped, tube - shaped, round - shaped and/or irregular shape. The diamensions of the primary inclusions range from <1 to 1 µm (Figure 5). Because the two - phase (liquid

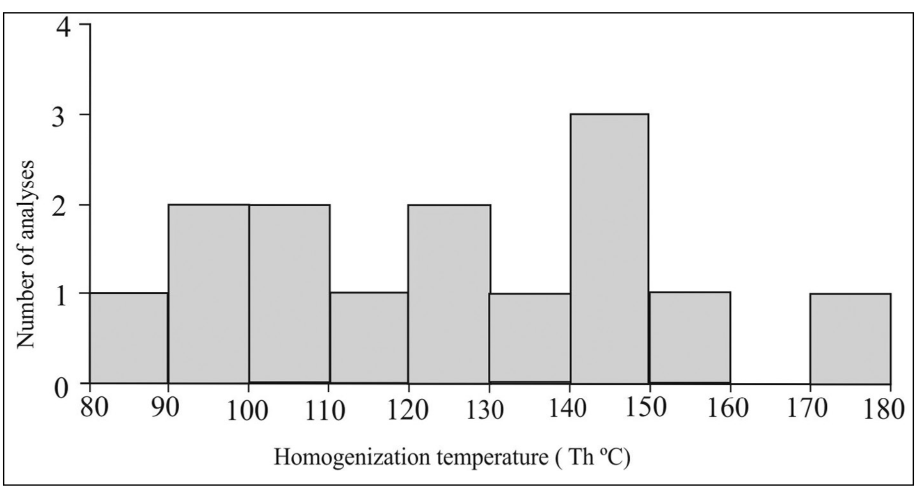

Figure 4- Histogram of the thermometric measurement of fluid inclusions in Zebra Dolomite.

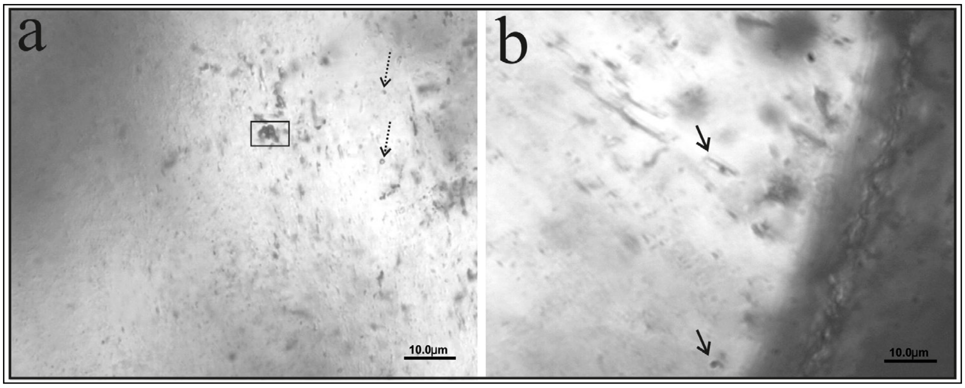

Figure 5- Photomicrographs of typical fluid inclusions; a) dotted arrows highlight primary single - phase aqueous inclusions, most fluid inclusions are submicron in size and vapor bubble (inside rectangle), b) arrows highlight two phase aqueous inclusions (liquid + gas).

+ gas) primary inclusions are very small, phase transitions cannot be clearly detected at a lower temperature (<0 °C).

6. Oxygen and Carbon Isotopes Results

The $\delta^{18}O$ values of the ZD range from -11.39 ‰ and -14.88 ‰ VPDB while the $\delta^{13}C$ values of the ZD range from 2.59‰ and 2.72 ‰ V - PDB (n = 4, Table 1, Figure 6). Figure 7 shows a plot $\delta^{18}O$ versus $\delta^{13}C$ where, the data of the ZD display positive correlation. The light and gray layer of ZD have similar stable isotope data and mineral composition (based on SEM data). The ZD $\delta^{13}C$ values close to the values of the host rocks (host rock $\delta^{13}C$ values is 2.81 V - PDB, Table 1, n = 1).

Equilibrium isotopic composition (the dolomite - water fractionization) of the solution was calculated by the equation $1000\ln\alpha_{D-H_2O}=3.06x10^6T^{-2}-3.24$ (Matthews and Katz, 1977) and using the fluid inclusion T° (between 80 °C and 180 °C). Therefore, the $\delta^{18}O$ composition of precipitating fluids of dolomitization was found to be between 1.1 and 1.6 ‰ V - SMOW. According to these values, the source of the solution of precipitating ZD may be similar to marine water. Tucker and Wright (1992) stated that the dolomite $\delta^{18}O$ isotope data between +1.2 and 2.2 ‰ indicate that precipitation from near - normal marine water, rather than hypersaline or brackish water. If the $\delta^{13}C$ is 2 to 4 ‰, well within the field of marine $CaCO_3$ the dolomite replaced, or it is derived from dolomitizing fluids (modified seawater) that have a similar $\delta^{13}C$ values to the seawater from which the $CaCO_3$ grains are precipitated (Tucker and Wright, 1992). It is noted that the source of carbon is typically of marina origin when $\delta^{13}C$ values between 0 and +4 ‰ V - PDB (Irvin et al., 1977). Accordingly, based on the $\delta^{13}C$ and precipitating fluids $\delta^{18}O$ values of the ZD, we can say that the source of dolomitization fluids is derived from marine water.

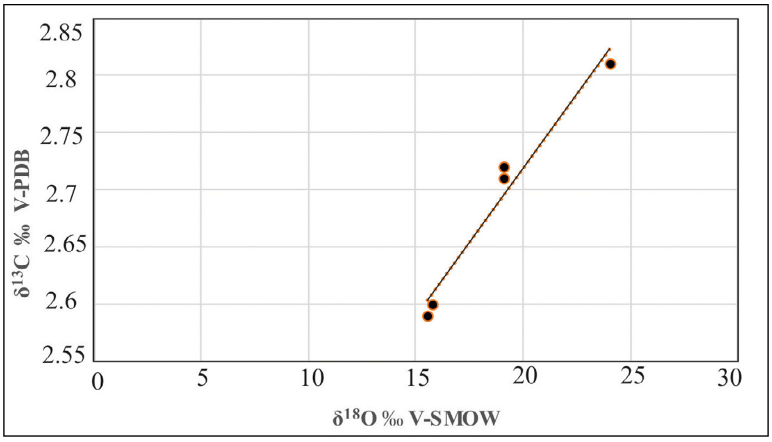

Figure 6- Diagram of $\delta^{18}O$ versus $\delta^{13}C$ (V - PDB) of the study area ZD.

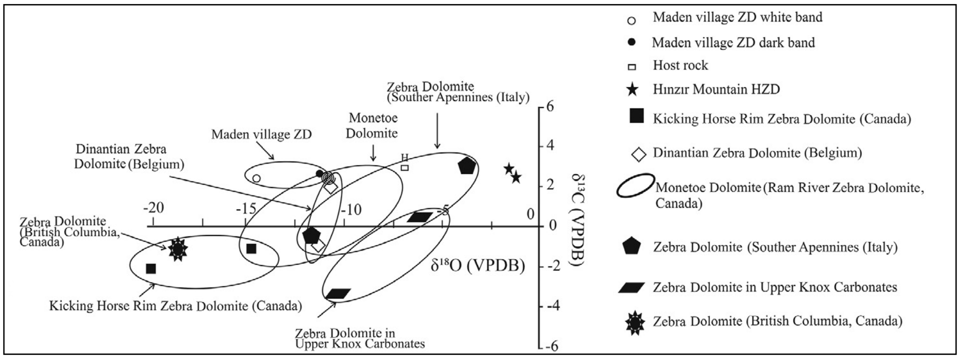

Figure 7- Values $\delta^{13}C$ (V - PDB) and $\delta^{18}O$ (V - SMOW) of the study area and of world Zebra Dolomite occurrences.

7. Discussion

The study area in the Bolkar Mountains Unit of Tauride Block. During the Miocene this area gradually uplifted along the normal faults (i.e. the Bolkar Frontal Fault, as a result of subduction processes), building a southward - tilted asymmetric mega-fault block with a rugged, Alpine topography (Dilek and Whitney, 1997, 2000; Dilek et al., 1999*b*; Kadıoğlu and Dilek, 2010). The fault system and uplifted may be lead to karstic development processes. The fault which is the normal fault, E - W trending and 36 - 45° S-dipping faults in the study area. The mildly acid meteoric water infiltrates and reacted with carbonate host rocks, dissolves the host limestone giving rise to a large karst throughout the Upper Triassic carbonate rock of the Bolkar Mountain (Kahya et. al., 2019). Tectonically deformed and uplifted terrains, characterized by moderate to high vertical and lateral permeabilities, may be the locale of deeply penetrating dilute fluids that mix with formation water or basinal brines (Garven, 1985; Bethke and Marshak, 1990). Therefore investigated dolomitization controlled by the fault. The carbonate - hosted Maden village ore deposits near the investigated ZD are in the same host rock. But the occurrences process are different.

The carbonate - hosted Maden village deposit occurred by supergene oxidation of primary sulfide minerals during complex interactions such as tectonic uplift, karst development (Kahya et.al., 2019), but the ZD may have occurred during the late diagenetic process. But what they have in common is that both of their formations occur after tectonic uplift. At first, we thought that the formation of the ZD was related to the carbonate - hosted Maden village ore deposits.

Based on $\delta^{18}O$ and $\delta\ ^{13}C$ data of the ZD, we determined that the source of oxygen is derived from marine limestone, clastic sediments, metamorphic rocks (Criss, 1999), and that the source of CO_2 is derived from marine limestone, freshwater carbonates, metamorphic CO_2 (Clark and Fritz, 1997). The ZD was formed from formation water derived from underlying and/or adjacent rocks. The $\delta\ ^{13}C$ composition of ZD range from +2.5 to +2.7, a little more positive than $\delta\ ^{13}C$ values of carbonate rocks of marine origin (0 to 2 ‰ PDB; Keith and Weber, 1964). These more positive $\delta\ ^{13}C$ values was explained by Friedman (1987) that subsurface diagenetic system in which the host rock subject to waters having salinities of marine or near marine $\delta\ ^{13}C$ values. Because it was involved in exchange reactions with heavier carbon derived from CO_2 / CH_4 exchange reactions in the host fluid (Mattes and Mountjoy, 1980). Dolomitizing fluids slightly greater than seawater due to slightly modification by water-rock interaction during progressively burial (Wang et al., 2015). The $\delta\ ^{18}O$ composition of the ZD range from -11.38 to -14.87 V - PDB and is highly negative. Very negative $\delta\ ^{18}O$ values were explained by Friedman (1987) as the late diagenetic dolomite occurrences. The $\delta\ ^{18}O$ values versus $\delta\ ^{13}C$ values of the ZD shows a positive correlation (Figure 6) and Tucker and Wright (1992) have explained that mixing-zone dolomitization have pozitive correlation of $\delta\ ^{18}O$ with $\delta\ ^{13}C$ because it consists of a mixture of two water of different isotopic composition. The calculated $\delta\ ^{18}O$ values for dolomitizing solution of the ZD indicate that it is a source of seawater effect (Tucker and Wright,1992; Irvin et al., 1977).

The $\delta^{18}O$ composition of precipitating fluids of studied ZD is between 1.1 and 1.6 ‰ V - SMOW (calculated with this equation 1000InαD-

H_2O=3.06x10^{6}T^{-2}-3.24, Matthews and Katz, 1977), and based on this result, we determined that the source of dolomitization fluids were derived from sea water (Tucker and Wright, 1992; Irvin et al., 1977). The oxygen isotopic composition of dolomite generally reflects the temperature of precipitation and isotopic composition of the dolomitizing fluids (Tucker and Wright, 1992). The next can be influenced by the isotopic composition of the CaO_3 minerals being replaced, however since pore - fluids have rich oxygen, generally precursor minerals solely have an effect in low water / rock ratio or closed diagenetic systems. Under the majority of condition, since dolomitization and recrystallization take place in the presence of water, the dolomite recipitated has a $\delta^{18}O$ value determined by the pore - fluid composition and temperature. On the contrary, the $\delta^{13}C$ value of dolomite is generally severely influenced by that of the precursor. Pore - fluids usually have low carbon contents at first, so that the $\delta^{13}C$ value of $CaCO_3$ being dolomitized is commonly retained by the dolomite (Tucker and Wright, 1992). However, based on the isotope data, in the dolomitiation fluids of the ZD have no meteor effect. Because of this reason the studied ZD formation not related to karstic formation processes. Possible sources for the dolomitizing fluids maybe related to pore waters squeezed out from the surrounding Triassic and Cretaceous formations. The studied ZD occurred locally, surface in a small area, and there is no evidence of hydrothermal origin. Diehl et al. (2010) explained that SEM data in hydrothermal ZD which related to Sedex, MVT Pb - Zn deposits and pluton-related polymetallic replacement deposits that Zn - and Pb - rich growth zones or rims are present (e.g. Blackwater and Queen of Sheba MVT, Death Valley and The Mineral Hill polymetallic vein and replacement deposits, Nevada). Since these mineral contents were not present in the studied ZD (SEM + EDX study), we determined that the ZD formations were not related to Maden village ore deposits.

Hydrothermal dolomitization results from the circulation of fluids with higher temperature than the ambient host rocks, but late diagenetic Saddle dolomite/ZD is formed at temperatures between 60 °C and 160 °C (Davies and Smith, 2006). The studied ZD compared late diagenetic ZD, hydrothermal and MVT-related ZD occurrences in Table 2. The studied ZD homogenization temperature is range of 80 °C to 180 °C and similarities with late diagnetic

Table 2- Isotopic composition and fluid inclusion (Th °C) of ZD in the world.

Name	$\delta^{13}C$ (V - PDB) ‰	$\delta^{18}O$ (V - PDB) ‰	Th °C	Description	References
Zebra Dolomite (Souther Apennines (Italy)	3 to -1	-4 to -12	80 - 120 °C 2 - 6 wt % NaCl eq.	Late Diagenetic	Iannace et al., 2012
Zebra Dolomite in Upper Knox Carbonates (in Southern Appalachian Basin)	-3.8 to +0.9	-11.9 to -5.3	80 - 165 °C 13 - 22 wt % NaCl eq.	Late Diagenetic	Montanez, 1994
Zebra Dolomite (British Columbia, Canada)	-1.35 around	-18.0	80 - 200 °C	Late Diagenetic	Swennen et al., 2003
Kicking Horse Rim Zebra dolomites (Canada)	-2.2 to -0.1	-20 to -14	Th is 130 - 200 °C, with 20 - 30 wt. % $CaCl_2$,	Spatially associated MVT Pb - Zn deposits	Vandeginste et al., 2005
The Dinantian (Belgium) Zebra Dolomite	0.1 to 1.1	-10 to -11	114 to 130 °C 23.8 and 21.2 eq. wt % $CaCl_2$	Spatial relation with MVT type	Nielsen et al., 1998
Manetoe and Presque Dolomite (Ram River Zebra Dolomite)	-1.3 to -1.1	-11.7 to -13.4	153 to 205 °C 11.7 25.8 NaCl eq. wt. %	Hydrothermal	Morrow, 2014
In Turkey, the Hınzır Mountain (Kayseri) Zebra Dolomit	2.4 to 2.7	29.4 to 29.5	-	Origin of the fluids, either surface and / or ocean water, hydrothermal fluids	Aydal et al., 2008
Zebra Dolomite in Great Basin, Nevada	-	-	50 - 150 °C	Hydrothermal	Diehl et al., 2010
Zebra Dolomitization, Irankuh Mining District, Iran	Mean 2.39	Mean - 12.27	170 - 260 °C	Early diagenesis and hydrothermal	Konari and Rastad, 2018

dolomitization. The ZD compared with different formation Zebra Dolomite in the world in terms of $\delta^{18}O$, $\delta^{13}C$, it was determined that the carbon isotope value is slightly different, that is, it contains a slightly positive high value than late diagenetic occurrences (Table 2 and Figure 7). It is similar to the ZD in Iran in terms of carbon isotope value (range from + 0.54 to + 3.51 ‰ by Konari and Rastad, 2018). Konari and Rastad (2018) explained that the the state of these carbon isotopes is mainly influenced by precursor carbonates. The source of Mg^{+2}, which is necessary for zebra dolomite formation, may have originated from schist in the Late Cretaceous units (Kaledere formation) which overlies the Koçakkale formation, or ophiolites which tectonically overlie them. All of these features comply with generally accepted criteria for late diagenetic dolomitization formation (compare with Morrow et al., 1990 and Machel, 2004).

8. Results

The Jurassic - Cretaceous recrystallized limestone of the Bolkar Mountains host the locally occur dolostone bodies showing fabric and petrographic characteristics typical of late diagenetic dolomites displaying zebra like structures. The fluid inclusion of the ZD sample (homogenization temperature range from 80 °C to 180 °C) indicates that similarities with late diagenetic dolomitization from Italy, Canada, Iran (Table 2). The $\delta^{18}O$, $\delta^{13}C$ and calculated $\delta^{18}O$ composition of precipitating fluids of the ZD, in conjunction with fluid inclusions suggest that dolomitization fluids derives from sea water and dolomitization was accomplished by squeezing out of formation water from surrounding formation. Summarizing, the study area ZD occurs late diagenetic processes related to fault associated with the uplift of Tauride Block (in Miocene). Dolomitization may be occurred before secondary mineralization and related fluids derived from the formation fluids.

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