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# GEOLOGY AND STRATIGRAPHY OF HOD (ARTVİN) REGION, EASTERN PONTIDES, NE TURKEY

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**Abstract**

*This study reports a revised geological map and a stratigraphic section of the Hod region. It represents a synthesis of new data and earlier work. New results gathered from field geological mapping and petrographic investigation have clarified the lithological boundaries, textural characteristics, the stratigraphical relationships between various rock formations and spatial distribution and behavior of structural elements. Hod region, located in the eastern part of the eastern Pontides (Artvin district), comprises Jurassic to Cretaceous volcanic and sedimentary sequences with a roughly north-north-east trending, steeply east dipping stratigraphy. These lithological units are Liassic Berta Formation, Dogger Kırgülü Formation and Hızarlıdere Formation, Malm-Lower Cretaceous Öğdem Formation and İnanlı Member, Lower Cretaceous Aşağımaden Formation, Turonian Çatak Formation, Santonian Kızılkaya Formation and Santonian-Campanian Evliyatepe Formation. Among these formations, intermediate to felsic volcanic and volcanosedimentary rocks of Kızılkaya Formation are significant as they host several volcanogenic massive sulfide (VMS) and epithermal deposits throughout eastern Pontides. Hod Maden Au-Cu deposit which represents one of the highest-grade gold and copper discoveries made globally in recent years is also located in Hod region. Therefore, the revised geological map and stratigraphy presented here are important contributions to the regional geology and essential tools for exploration geologists working in the region.*

**Keywords: Geological mapping, Stratigraphy, Volcanic-sedimentary sequences, Hod, Hod Maden, Artvin, Eastern Pontides**

# HOD (ARTVİN) YÖRESİNİN JEOLOJİSİ VE STRATİGRAFİSİ, DOĞU PONTİDLER, KD TÜRKİYE

**Özet**

*Bu çalışma Hod yöresinin revize edilmiş jeolojik haritasını ve stratigrafik kesitini sunar. Eski çalışmalardan derlenmiş ve yeni verilerin bir sentezidir. Arazide gerçekleştirilen jeolojik haritalama ve petrografik analizler sonucu elde edilen yeni sonuçlar, litolojik sınırları, dokusal karakteristikleri, birçok kayaç formasyonu arasındaki stratigrafik ilişkileri ile yapısal elementlerin mekânsal dağılımı ve davranışını netleştirir. Doğu Pontidlerin doğusunda (Artvin) yer alan Hod yöresi, yaşları Jura'dan Kratese'ye uzanan, kabaca kuzey-kuzey-doğu yönlü ve doğuya dik açıyla dalan volkanik ve volkanosedimanter sekansları içerir. Bu litolojik birimler, Lias yaşlı Berta Formasyonu, Dogger yaşlı Kırgülü Formasyonu ve Hızarlıdere Formasyonu, Malm-Alt Kretase yaşlı Öğdem Formasyonu ve İnanlı Üyesi, Alt Kretase yaşlı Aşağımaden Formasyonu, Turoniyen yaşlı Çatak Formasyonu, Santoniyen yaşlı Kızılkaya Formasyonu ve Santoniyen-Kampaniyen yaşlı Evliyatepe Formasyonudur. Bunların arasında, Kızılkaya Formasyonunun ortaç-felsik kompozisyonlu volkanik ve volkanosedimanter kayaçları Doğu Pontidler boyunca barındırdığı volkanojenik masif sülfit (VMS) ve epitermal yataklar ile öne çıkar. Son yıllarda dünya çapında gerçekleştirilen en yüksek tenörlü altın-bakır keşfi olan Hod Maden Au-Cu yatağı da Hod yöresinde yer alır. Bu nedenle, bu çalışmada sunulan revize edilmiş jeolojik harita ve stratigrafi, bölgesel jeolojiye önemli katkılar sunduğu gibi bölgede çalışan maden arama jeologları için de esaslı bir araç olma özelliğindedir.*

**Anahtar Kelimeler: Jeolojik harita, Stratigrafi, Volkanik-sedimanter sekanslar, Hod, Hod Maden, Artvin, Doğu Pontidler**

**Cite**

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## 1. Introduction

The study area (Hod Maden) lies in the Yukarımaden village, 50 km away from Artvin, northeastern part of Turkey (Figure 1). The Hod region comprising the Jurassic and Cretaceous volcanic and sedimentary sequences, is one of the ideal locations to study the main lithologic and volcano-stratigraphic features of the eastern part of the eastern Pontides (Artvin District). To gain a better understanding of the geological features of the region, a revised geological map and a stratigraphic section of the study area are prepared and characteristic features of lithological units are reported.

Prior to this study, Hod (Artvin) region was investigated by the Turkish Mineral Research and Exploration Directorate (MTA) in several studies, including [1-5]. From 1991 onwards, mining companies such as Anglo American, Teck (Cominco), and AMG (later Aegean Metals and Mediterranean Resources) have been involved in exploration activities in the region. In 2014, Lidya Madencilik discovered one of the most significant gold-copper deposits (~4 Moz @ 11.1 g/t AuEq), Hod Maden, in the world in recent years. Since then, the Hod region gained considerable attention from mining companies' exploration departments, leading to a surge in interest in the area.

The main objectives of this study are to delineate the lithological units, define textural characteristics, clarify stratigraphic relationships and elaborate descriptive implications between volcanic activities and ore formation processes. In addition to these, this work aims at revising the existing data on the regional geology with new data obtained from field geological mapping and petrographic investigation carried out during this research. We believe that these would provide practical tools for the field geologists, and build methodologies and vectors for the exploration. According to [6-10], there is a close connection between the Cretaceous magmatic (particularly submarine volcanism) and metallogenic evolutions in the northern Lesser Caucasus and the eastern Pontides of Turkey. Hence, the results of this study will be crucial in completing the geologic and metallogenic picture of the Lesser Caucasus and the eastern Pontides.

## 2. Geology of the Artvin District

Eastern Pontides is an east-west trending orogenic belt and represents a well-preserved major fossil extensional submarine arc [11]. It was developed due to the closure of the NeoTethyan oceanic lithosphere during the Late Mesozoic-Cenozoic [12,13]. According to [11,14], the arc magmatism in the Artvin district took place between the Turonian and Late Campanian as a submarine volcanic-sedimentary sequence. In response to subduction, collision and post-collisional events, various magmatic suites Late Cretaceous to Middle Eocene in age were emplaced into the heterogeneous pre-Jurassic basement and Jurassic to mid-Cretaceous volcanic and sedimentary sequences (Figure 1). The Late Cretaceous and Eocene magmatic rocks represent a segment of world famous Western Tethyan Metallogenic Belt which is characterized by the volcanogenic massive sulfide (VMS) deposits (Cu, Pb, Zn, ±Au), porphyry Cu and porphyry Cu-Mo and epithermal Au and epithermal Au-Ag-Pb-Zn deposits [15-22]. The study area comprises Jurassic and Cretaceous volcanic and sedimentary rocks and this research is focused on the Late Cretaceous arc sequences as they host the major ore deposits throughout the eastern Pontides.

Here, we introduce the revised stratigraphy (Figure 2) and its correlation with the surrounding regions. In addition, we present a geological map (Figure 3) that illustrates the spatial distribution of structural elements.

## 3. Geology and Stratigraphy of Hod Region

The most striking feature of the Hod region is the steeply dipping stratigraphic sequences, even visible from the satellite images. This stratigraphic succession comprises (i) Liassic Berta Formation, (ii) Dogger Kırgülü Formation, (iii) Dogger Hızarlıdere Formation (Hızarlıdere volcanics), (iv) Malm-Lower Cretaceous Öğdem Formation, (v) Malm-Lower Cretaceous İnanlı Limestone Member, (vi) Lower Cretaceous Aşağımaden Formation, (vii) Turonian Çatak Formation, (viii) Santonian Kızılkaya Formation and (ix) Santonian-Campanian Evliyatepe Formation. [23] briefly explains the geology as follows: The initial succession, Liassic-Dogger in age, is composed of pelitic rocks and lava flows with pyroclastic interlayers. Malm-Lower Cretaceous conglomerate and sandstone unconformably overlie the volcanic rocks, and intercalated with limestone lenses. Upper Cretaceous volcanic rocks and volcanosedimentary units bearing limestone and mudstone interbeds are situated on the top of the whole stratigraphic succession.

### 3.1 Berta Formation

The Berta formation in Hod region consists of steeply northeast dipping black slates (low degree metamorphics) intercalated with black siltstones and fine-grained black sandstones, now visible along the road cut which is parallel to A-A' section shown in Figure 3A. The sequence is strongly deformed by shear zones and exhibit small scale folds. Despite the basalt and andesites dominate at the lower stratigraphic levels of the road cut section, towards east most of the section consists of sedimentary rocks. According to [24] they represent turbiditic series deposited within anoxic environment. In the easternmost part of the study area, red to green, medium bedded radiolarian cherts and siliceous mudstones overlie the greyish green siltstones and shale. The mudstones and cherts in this section of the Berta formation contain radiolarian faunas giving the Late Bajocian age [25]. The radiolarian cherts are overlain by the volcanic rocks which dominate the upper part of the Lower to Middle Jurassic sequence and named as Hızarlıdere Formation (or Hızarlıdere volcanics).

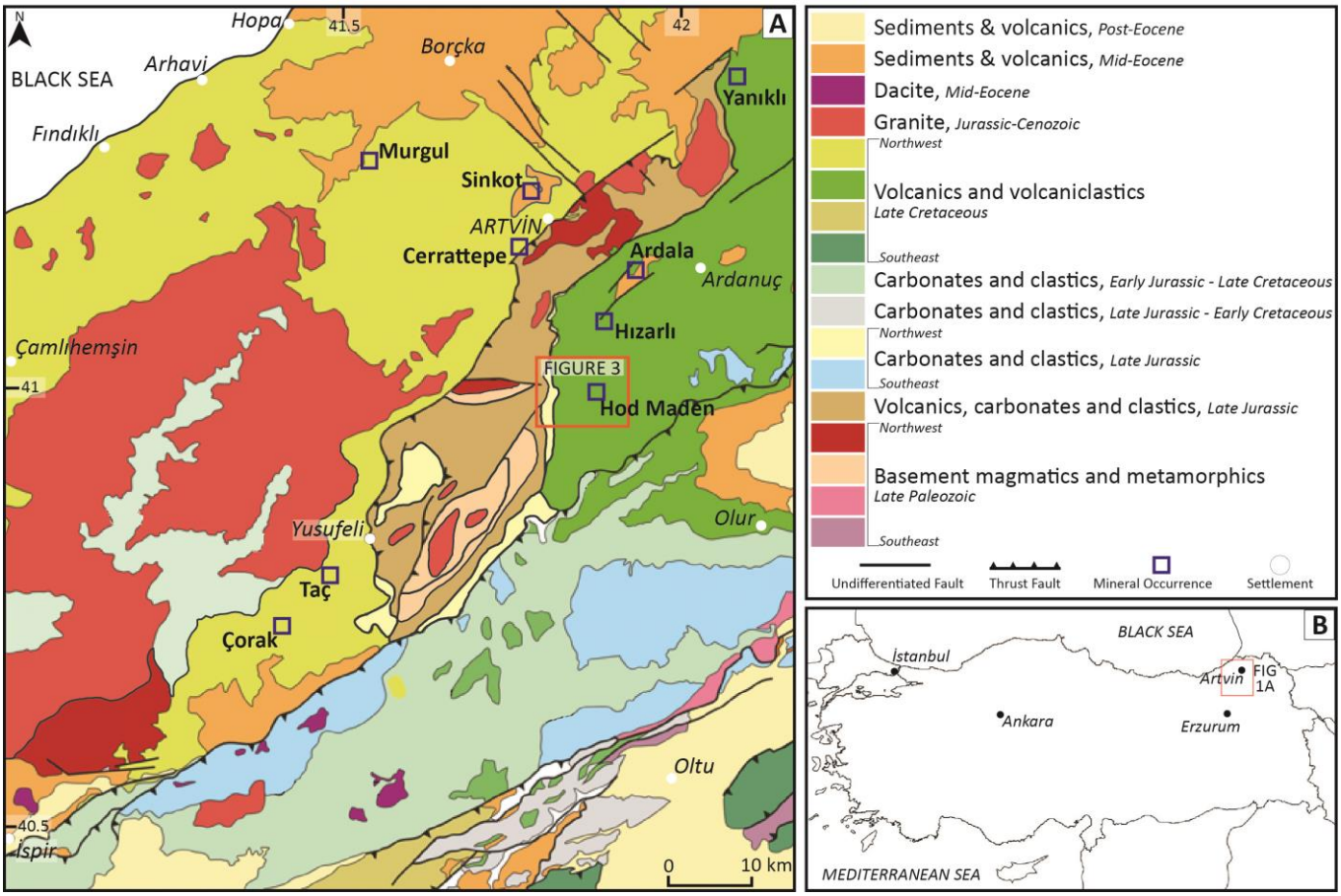

Figure 1. A) Geological map of the Artvin district (1:500,000 scale; modified after [26,27]), B) Inset map and location of major cities and Artvin district

### 3.2 Kırgülü Formation

The formation is named after Kırgülü Village located south to the study area. [23] reports that Kırgülü Formation is characterized by thin-moderately bedded, grey-green colored, turbiditic sandstone-siltstone alternations with intercalations of basaltic lava flow and pyroclastics formed in a submarine slope. Sandstones are moderately bedded, occasionally thick-bedded and formed by volcanic clasts. The unit comprises grey and red chert, and marn with chert intercalations as well as basalt, spilitic basalt and pyroclastics at the upper part. However, in the study area, the contact between Kırgülü Formation and Hızarlıdere volcanics is tectonic. The age of the unit is stated as Callovian or older based on radiolarian faunas and stratigraphic relationships [23].

### 3.3 Hızarlıdere Formation (Hızalıdere Volcanics)

The formation is named after Hızarlıdere Valley (where it is observed best) that is located north to the study area. The unit is mainly composed of mafic lava flows and pyroclastics and spilitic basalts. In addition, chert bands are present locally. [28] reports that cherts are red, dark grey-blackish and forms thin bands (2-3 cm) within the lava flows. The greenish and brownish color indicates weak chlorite and iron-oxide alteration. It is also reported that in Hızarlıdere Valley, pillow basalts are observed with pillow sizes changing from 10-60 cm [28]. The presence of pillow basalts reveals that the volcanic activity occurred in submarine environment. Basalts display porphyritic texture (Figure 4A) with plagioclase and clinopyroxene phenocrysts. [29] states that the volcanic rocks are calc-alkaline-tholeiitic in composition and the age of the unit is Liassic-Dogger. The unit is overlain by Öğdem Formation unconformably.

### 3.4 Öğdem Formation

Volcanic rocks of the Hızarlıdere Formation are unconformably overlain by thickly bedded conglomerates which are red-crimson colored, thick bedded, poorly sorted and clast to matrix supported. Clasts are originated predominantly from basalts and andesites of Hızarlıdere volcanics (Figure 4A). The unit is occasionally cut by mafic dikes and sills. The conglomerates are intercalated by sandstones and shales (Figure 4B) which are regarded to be formed in a shallow marine environment. Therefore, it is suggested that the Öğdem Formation was formed during a transition from a continental to a shallow marine environment during Malm-Early Cretaceous [24]. Limestone bands and lenses are present in both the lower and upper parts of the Öğdem Formation. According to [23], the reefal limestones in the lower and upper part of the Öğdem Formation are defined as the İnanlı Limestone Member, while the neritic limestones in the most upper part are referred to as the Aşağımaden Formation.

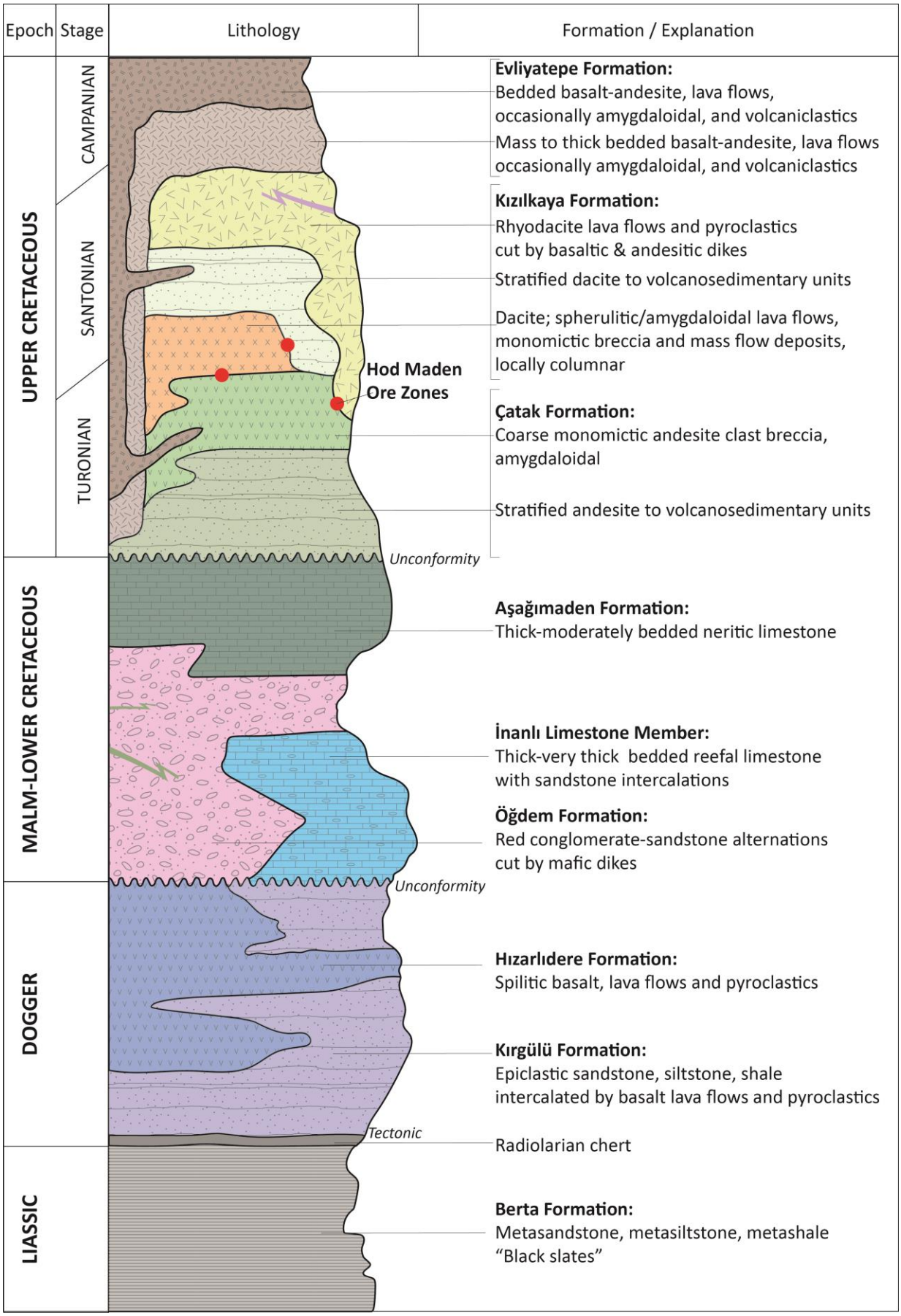


Figure 2. Generalized stratigraphic section of Hod region (modified after [23, 28])

### 3.5 Aşağımaden Formation

The formation is named after Aşağımaden Village which is located in the lower central part of the study area. It is almost vertically dipping towards the east, moderate to thick bedded and is characterized by dark grey color. Occasionally, karstic features are present. [28] and [23] reports that Aşağımaden Formation is formed in beach-shelf environment during Valanginian based on the fauna. The unit overlies Öğdem Formation conformably and it is overlain by Çatak Formation unconformably.

### 3.6 Çatak Formation

The units forming the Çatak Formation are (i) stratified basalt, andesite and volcanosedimentary rocks overlying the Aşağımaden Formation unconformably and (ii) amygdaloidal andesite porphyry and monomictic andesite clast breccia forming the western margin of Hod Maden mineralization. They define the onset of Late Cretaceous arc volcanism during Turonian-Santonian [11]. Çatak Formation overlies red conglomerates of the Öğdem Formation and neritic limestones of the Aşağımaden Formation, unconformably. [27] reports that this unconformity is transgressive and the unit is formed in a continental to shallow marine environment. The succession starts with well-stratified, volcanogenic, green-purple colored (Figure 4C), carbonate-bearing claystone and basalt-andesite intercalations. As volcanic activity soars, the succession is dominated by basaltic and andesitic lava flows. The most significant characteristics of these rocks are amygdaloidal texture, chlorite and zeolite alteration accompanied by weak silicification and pervasive pyrite dissemination (Figure 4D). The unit is observed as monomictic andesite clast breccia towards east where the deformation and hydrothermal alteration intensity increases closer to Hod Main Fault Zone. High-grade gold and copper mineralization of Hod Maden deposit is hosted by jasper-hematite-bearing andesitic breccia with intense chlorite alteration (Figure 4E). While chlorite-altered andesite breccia is considered a favorable host for mineralization, the causative volcanic activity is thought to be the dacitic units of Kızılkaya Formation.

### 3.7 Kızılkaya Formation

The contact between Kızılkaya and Çatak formations is observed as either magmatic superimposition or as tectonic. Kızılkaya Formation is characterized by felsic to intermediate subvolcanic intrusions, lava flows and volcaniclastics including volcanosedimentary sequences and pyroclastics. Stratified clastic volcanosedimentary rocks of dacitic origin with local limestone beds develop in the upper part of the sequence as volcanic activity ceases. The volcanic rocks of Kızılkaya Formation in the study area comprise (i) spherulitic/amygdaloidal dacite lava flows, as well as monomictic dacite breccia and mass flow deposits; (ii) columnar dacite; (iii) well-stratified dacite to volcanosedimentary units with local limestone beds; and (iv) flow-banded (locally spherulitic) rhyodacitic lava flows and pyroclastics.

#### 3.7.1 Spherulitic Dacite Flows and Breccia

The spherulitic dacite lava flows and breccia are exposed at the surface between andesite breccias of the Çatak formation and stratified dacite to volcanosedimentary unit of the Kızılkaya formation. It hosts high-grade gold-copper mineralization and is considered to be the causative volcanic rock. The spherulitic texture is significant as it represents quenching of dacitic lava flow due to sea-water interaction and formation of very thin radiating arrays of K-feldspar and plagioclase. The feldspars are either altered into sericite or replaced completely by hydrothermal quartz, carbonates and sulfides (Figure 4F). The alteration consists of an assemblage of sericite (fine-grained muscovite, K- illite), clay minerals (dickite, kaolinite, halloysite, montmorillonite) and late calcite, dolomite and anhydrite overprint.

#### 3.7.2 Columnar Jointed Dacitic Lava Flows and Pyroclastics Rocks

The columnar-jointed dacite lava flow and pyroclastic rocks are exposed in the southern part of the study area. Columnar dacites are considered to be formed either at a subaerial part of the Late Cretaceous sea environment, or at an active feeder zone in a submarine setting. The cooling surfaces of the dacite columns are near vertical and they are parallel to the stratification of volcanic and sedimentary sequences in the region (Figure 4G). Dacites display porphyritic texture with large quartz phenocrysts, plagioclases and mafic minerals (biotite, amphibole; Figure 4H). Sericitization on plagioclase phenocrysts and weak chlorite alteration on mafic minerals and groundmass are observed.

#### 3.7.3 Well-stratified Dacite to Volcanosedimentary Rocks

Volcanosedimentary rocks with local limestone beds are exposed in the central part of the Late Cretaceous succession (Figure 4I). The unit is characterized by volcanic siltstones and sandstones (Figure 6A), fine to coarse-grained lithic fragment-bearing and crystal-rich tuffs and dacitic lava flows. The dacitic lava flows display porphyritic and trachytic texture, embayment in quartz phenocrysts and sieve texture in plagioclase phenocrysts (Figure 6B). Selective sericite alteration on plagioclase and pervasive chlorite alteration on the groundmass are present. Thin limestone horizons locally occur in the sequence. [3] reports the inoceramus-bearing limestone bed in the succession along the Belizor stream. This volcanosedimentary unit is bounded by the Hod main fault zone in the west and Hod east fault zone in the east. Therefore, the rocks are intensely deformed and altered. High-grade gold and copper mineralization is confined with the andesitic and dacitic breccias; however, stratabound zinc mineralization is hosted by the volcanosedimentary rocks. The contact between the two is marked by an abundance of anhydrite which may provide insights into the paleogeographic location of the seafloor and the nature of the hydrothermal activity that led to mineralization.

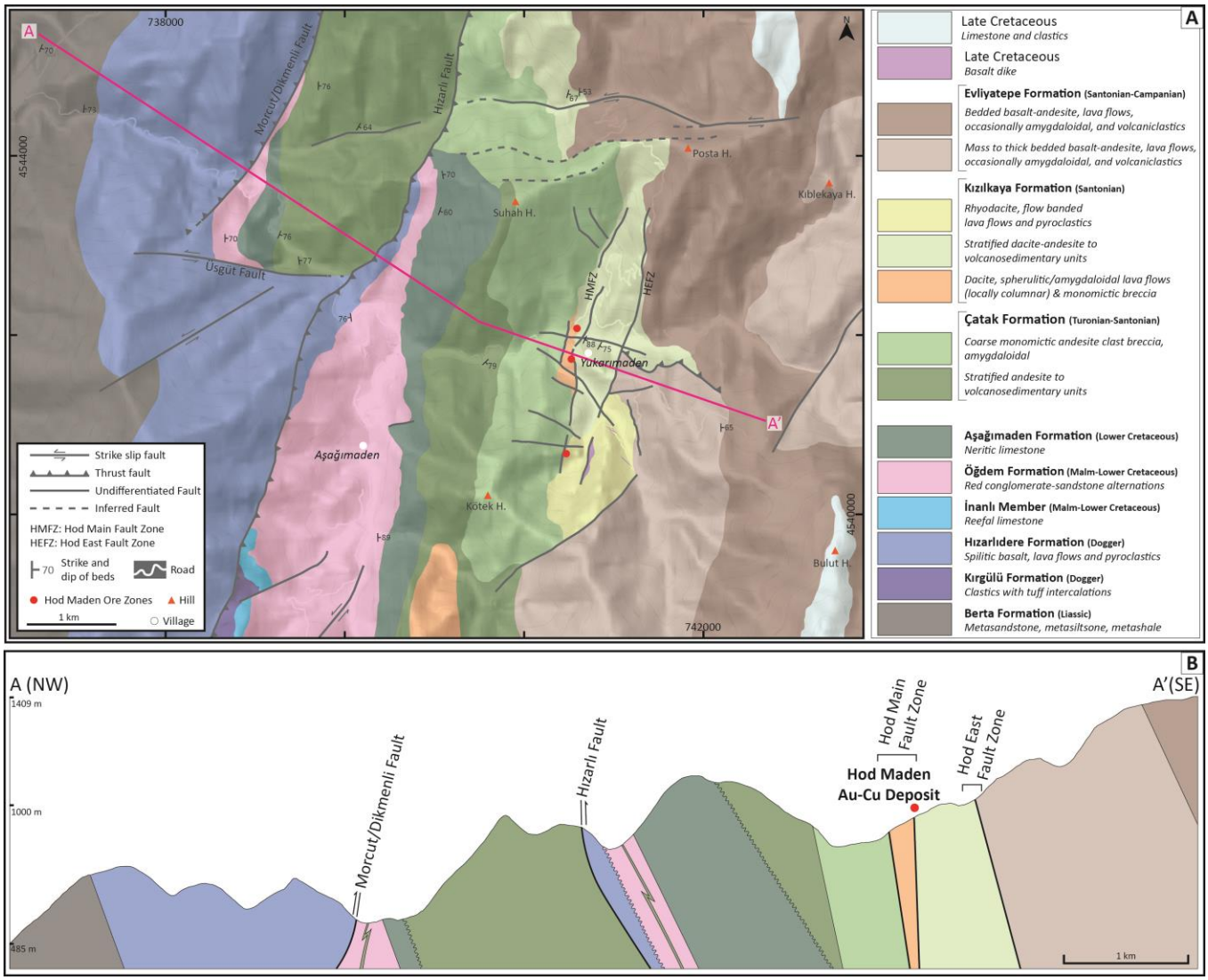


Figure 3. A) Geological map of the Hod region and B) the schematic A-A' cross section showing the stratigraphic and structural association of the main rock units in the Hod Maden Au-Cu deposit (modified after [3, 29, 30, 28, 31, 32])

### 3.7.4 Rhyodacite Dome

Flow-banded rhyodacite in part spherulitic with local auto-breccia facies and silicified pyroclastic rocks form a dome morphology. It is characterized by quartz phenocrysts and greenish color groundmass due to the chlorite, vermiculite and Mg-illite alteration (Figure 4J). The dome appears to intrude the stratified volcanosedimentary sequence and amygdaloidal andesite lava flows and breccias in the west. The contact between the andesitic rocks is an ore zone with significant copper, zinc and gold mineralization characterized by quartz-chalcopyrite-sphalerite-pyrite veins with accompanied chlorite (andesitic host), sericite (rhyodacite host), quartz, epidote, calcite and rhodochrosite alteration. In the northwestern flank of the dome, auto-breccia facies and pyroclastic products of rhyodacite volcanism are observed. Several andesitic to basaltic dikes cut the rhyodacite dome. They are characterized by relatively fresh euhedral pyroxene phenocrysts and pervasive sericite and carbonate alteration on plagioclase phenocrysts and on the groundmass (Figure 6D).

### 3.8 .Evliyatepe Formation

The Evliyatepe formation is named after Evliya Hill, located to the southeast of the study area. Precise age relations with the adjacent rhyodacite dome and volcanosedimentary stratigraphy are poorly constrained due to tectonic contacts and intense hydrothermal alteration along the fault zones (Figure 4I). The formation is characterized by basaltic to andesitic lava flows and volcaniclastics. Amygdaloidal texture is significant as the vugs are occupied by chlorite, quartz, vermiculite, zeolites and carbonates (Figure 4K, 6C). Plagioclase phenocrysts often display sieve texture and occasionally overprinted by sericite. Mafic phenocrysts such as pyroxene and amphibole, on the other hand, are either relatively fresh or completely overprinted by secondary minerals (Figure 6E). [23] reports this unit as spilitic basalt lava flows and agglomerate with an age of Santonian-Campanian.


Figure 4. Field photographs from the Hod region: A) Öğdem Formation, volcanic clast of Hızarlıdere Formation in the red conglomerate; B) Öğdem Formation, steeply east dipping sandstone and shale beds; C) Çatak Formation, well-stratified, volcanogenic, green-purple colored, carbonate-bearing claystone; D) Çatak Formation, amygdaloidal andesite with quartz (qtz), chlorite (chl), zeolite (zeo), vermiculite (vrm) and carbonate (ca) amygdales; E) intense chlorite altered andesite breccia hosting bands of black chlorite (chl), quartz (qtz), chalcopyrite (cp), pyrite (py), jasper (jas) and hematite (ht), HTD05-157m @ ~88g/t Au and 2.46% Cu, 13m interval between 150-163m; F) spherulitic dacite with pervasive sericite alteration and spherules replaced by chalcopyrite (cp), pyrite (py), quartz (qtz) and dolomite (dol); G) columnar-jointed dacite, notice the horizontal elongation of the columns; H) dacite porphyry with large quartz (qtz) phenocrysts accompanied by plagioclase (pl), amphibole (amph) and biotite (bt); I) northwest-looking view of volcanosedimentary sequence of Kızılkaya Formation in the west, Hod East Fault Zone (HEFZ) and Evliyatepe Formation in the east, notice the intense clay alteration along the HEFZ; J) quartz (qtz), chlorite (chl), epidote (ep), vermiculite (vrm) and Mg-illite (Mg-ill) altered rhyodacite (alteration assemblage was identified by SWIR work); K) Evliyatepe Formation, amygdaloidal basalt, notice concentrically zoned chlorite (chl) at the rim and quartz (qtz) at the core of the amygdale.

## 4. Discussion

### 4.1 Delineation of "Unnamed Volcanosedimentary Rocks"

Prior to this study, the eastern segment of the Hod stratigraphy, characterized by Late Cretaceous units, was vaguely reported. This may be due to several reasons: (i) the area is located at the intersection of four 1/25000 quadrangles of Turkey (F47c4, F47c3, G47b1 and G47b2); (ii) the lithological units are intensely altered, making it difficult to determine the rock type, to identify petrographic characteristics and to clarify lithological boundaries; (iii) the steeply dipping nature of lithologies and the structural framework of the area make it challenging to correlate the units and/or formations with their counterparts in the region; (iv) the morphology and vegetation of the region make some areas inaccessible for mapping and sampling. Earlier research provided beneficial, yet incomplete information on Late Cretaceous units, either reporting them as a package without thorough petrographic analysis or describing individual lithologies without regional geology context and proper stratigraphy. However, the detailed field data on the stratigraphical and structural features of the rock units and petrographical studies on the core samples in this study contributed much for the differentiation and proper stratigraphical position of the Late Cretaceous units into the Turonian Çatak Formation, Santonian Kızılkaya Formation, and Santonian-Campanian Evliyatepe Formation. The identification was achieved by comparing the morphological, compositional, and petrographic characteristics of these units with reported data and by considering their field relationships. For instance, Kızılkaya Formation comprises four distinct lithological units. Felsic to intermediate volcanism causes submarine spherulitic dacite breccia, stratified volcanosedimentary unit, and flow-banded rhyodacite dome in the central part, whereas, in the south, it forms columnar-jointed dacites with large quartz phenocrysts. On the other hand, the presence of amygdaloidal texture with chlorite, zeolite, vermiculite, and carbonate-bearing amygdales in mafic submarine and locally subaerial lava flows of Çatak and Evliyatepe formations provide excellent examples of textural interpretation on altered volcanic rocks and the significance of hydrothermal alteration assemblages.

### 4.2 Revised age of the dacitic units

"Maden Dasiti" (Mine Dacite) has been used to refer to the discussed dacitic units by [3, 23] because the Hod Maden mineralization is spatially associated with the dacite and rhyodacite units in the region. Additionally, they concluded that the dacitic units are Eocene in age, based on their observations of field crosscutting relationships. The fact that the dacitic rocks crosscut the volcanosedimentary rocks and andesite breccia of the Çatak Formation do not necessarily imply that the dacitic units are Eocene in age. Rather, their spherulitic texture (Figure 4F), which arose from the rapid cooling of lavas as a result of interactions with seawater, as well as the presence of local mass flow deposits containing sulfide clasts (Figure 5) resulting from a sequence of collapse and redeposition on the seafloor, suggest that the units were formed in a submarine environment during Santonian.


Figure 5. Volcaniclastic mass flow deposit with chalcopyrite (cp) and pyrite (py) clasts (Kızılkaya Formation); sample from drill hole HTD021-175.1m (740491E-4541728N, datum: WGS84)

### 4.3 Contribution to exploration programs conducted in the region

The eastern part of the eastern Pontides is an important province for mineral exploration, especially for VMS, porphyry Cu and epithermal systems. To conduct a successful exploration program, several essential characteristics of a particular area must be identified, including tectonic setting, stratigraphy, host rock type and age, structural kinematic association, deposit and commodity type, ore and gangue mineral assemblages and textures. This study offers detailed information on these features for the Hod region, including spatial and temporal distribution of lithological units and their stratigraphic relationships, host rock petrography, hydrothermal alteration assemblages including present ore and gangue minerals, and textural interpretation. One example is the spherulitic texture, observed in the dacite unit, which has been replaced by gold-bearing chalcopyrite and pyrite, as well as sericite, quartz, and dolomite (Figure 4F). This example suggests that the exploration target for this type of mineralization is localized to areas where Santonian dacitic units are stratigraphically confined by mafic lava flows and volcaniclastic rocks, showing spherulitic/amygdaloidal textures with pervasive sericite alteration.

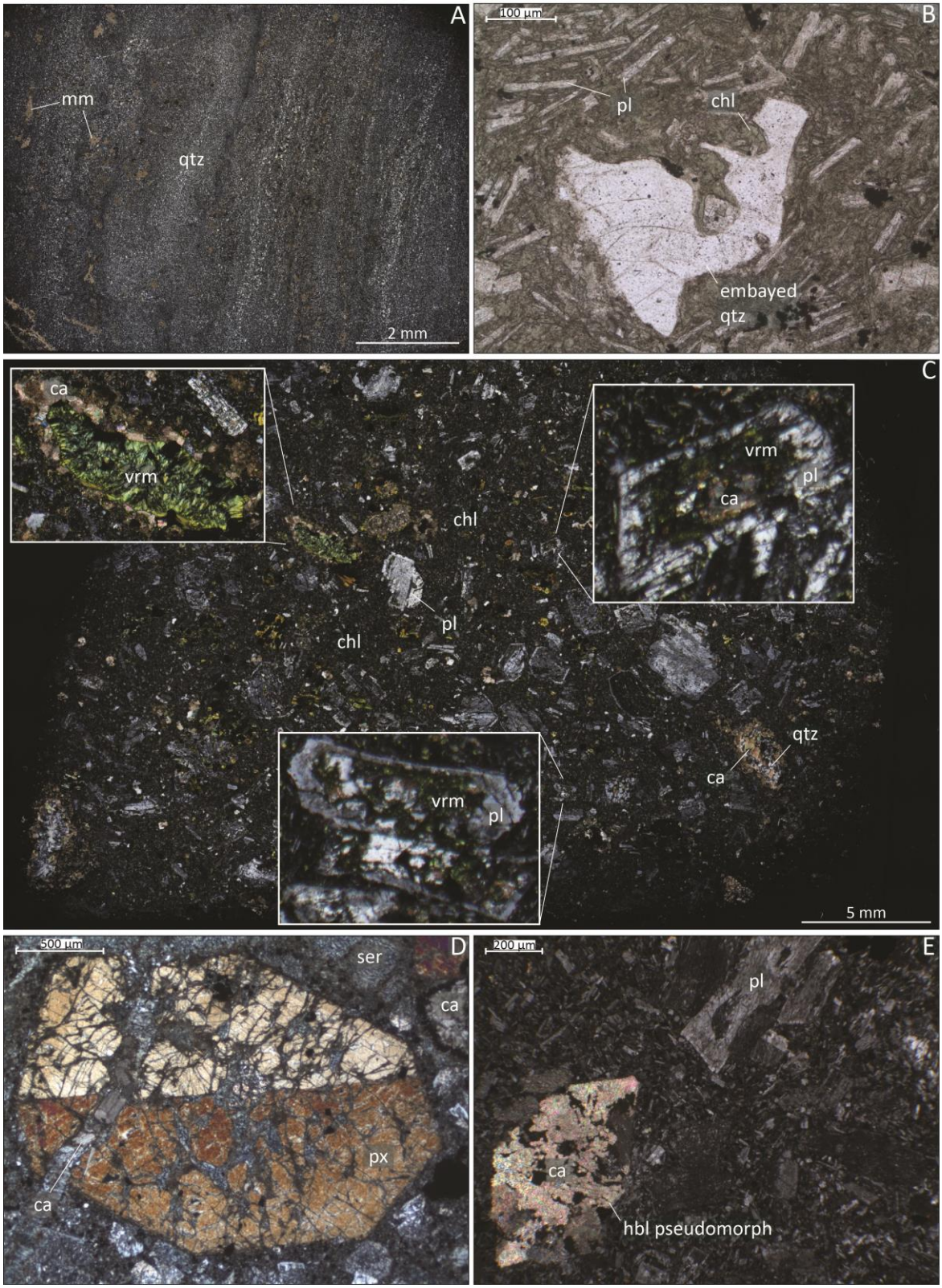


Figure 6. Thin section photomicrographs of selected lithologies from Hod region: A) pervasively silicified (qtz) and montmorillonite (mm) altered volcaniclastic rock of Kızılkaya Formation; B) dacite from the volcanosedimentary sequence of Kızılkaya Formation, displaying trachytic texture –plagioclases (pl) forming flow lines- and embayment in quartz (qtz), notice the chlorite (chl) alteration in the groundmass, C) amygdaloidal chlorite (chl) altered basalt from Evliyatepe Formation, notice that vermiculite (vrm) and calcite (ca) fills the amygdales and occupy the cores of plagioclases (pl) displaying sieve texture; D) Euhedral pyroxene (px), with simple twinning, of a basaltic dike displaying sericite (ser) and calcite (ca) alteration; E) pseudomorphic calcite (ca) after hornblende (hbl), and plagioclase (pl) from an andesitic rock of Evliyatepe Formation.

## 5. Conclusions

Field geological mapping, drill core logging and petrographic analyses generated new findings. This data was then compared with the earlier work (especially the technical reports prepared by MTA and mining companies) and correlated with the surrounding regions, resulting in a revised geological map and stratigraphy of the Hod Maden. Significant improvements include the reporting of field characteristics of Jurassic-Early Cretaceous formations as they are observed in the Hod region, the delineation of the Late Cretaceous volcanic package into Çatak, Kızılkaya, and Evliyatepe formations, and the revision of the age of dacitic units to Late Cretaceous (contrary to earlier suggestions of an Eocene age). Dacitic rocks of Kızılkaya Formation are delineated into four lithological units are defined as follows: (i) spherulitic/amygdaloidal dacite lava flows, as well as monomictic dacite breccia and mass flow deposits; (ii) columnar dacite; (iii) well-stratified dacite to volcanosedimentary units with local limestone beds; and (iv) flow-banded (locally spherulitic) rhyodacitic lava flows and pyroclastics. Moreover, the provision of information on textural interpretation and hydrothermal alteration assemblages of altered volcanic rocks can be useful for exploration geologists working on exploration programs hosted by Late Cretaceous volcanic sequences.

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