Mineral Res. Expl. Bull., 140, 73-79, 2010

PRELIMINARY FINDINGS ON THE FOSSIL TRACES IN THE MASSIVE SULPHITE DEPOSITS OF EASTERN BLACK SEA REGION (LAHANOS, KILLIK AND ÇAYELI)

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ABSTRACT.- Tube worm fossils have been found in the Upper Cretaceous aged massive sulphite deposits of the Eastern Black Sea Region. Similar ones of these tube worm fossils have been found in the massive sulfide deposits of Umman, Cyprus, Ireland and Urals. This fossil community defined in very few massive sulfide deposits in the world is the important evidences of the sea floor hydrothermal vents in Pontids. These worm-like forms can be considered as the ancestral forms of the unusual vent communities defined in places where modern hydrothermal vents are observed such as East Pacific Rise, Galapagos and Juan de Fuca Ridge.

Key Words: Eastern Black Sea, massive sulphide, fossil, hydrothermal vent

INTRODUCTION

Discovery of the faunas living around the hydrothermal sulfur vents on the sea floor drew the interest of the researchers. Some of the most impressive of the unusual organisms are the tube-worms which live in a symbiotic relationship with bacteria. Modern deep-sea hydrothermal vent fields where the present-day deposit occurrences are observed and unusual organisms live extensively have been studied and defined in detail (Hannington et al. 2005; Little, 2002; Rona et al. 1983; Rona, 1984) in several places in the world (for example, East Pacific Rise, Juan de Fuca ridge, Galapagos Ridge). Various researchers stated that iron, zinc and copper sulfide mineral deposit to the sea floor and create massive sulphite deposits because of sudden cooling of the metal and sulfur rich hot fluids by mixing with the sea water while being discharged to the sea floor from the vents (Spooner and Fyfe, 1973; Hebert and Constantin, 1991; Haymon et al. 1984; Qudin and Constantinou, 1984). The reduced sulfur in the hydrothermal solutions constitute the base of a food chain for unusual organisms clustered around the vents. Most common communities observed in the modern hot spring fields include mussel, crab, vestimentiferan tube worm and several fish species. Living areas of the species mussels, anemones, barnacles, limpets and siphonophores are restricted to some hot spring fields (Haymon et al. 1984). It has been observed that some species of vent worms live in fields very close to hydrothermal solutions rising along with these hot spring vents with a temperature of up to 350 ºC (Haymon et al. 1984). Among the relicts of these tube worms, only those that are replaced by the sulphite and sulphate minerals can be preserved. Traces of ecological actualism of these unique organisms that found near present-day vents are rarely encountered in the massive sulfide paleohydrothermal fields (Kuznetzov et al. 1988; Little et al. 1997). Therefore the finding of these fossil traces in the Upper Cretaceous aged massive sulfide deposits in the Eastern Black Sea Region (Figure 1) is a significant data.

STUDY METHOD

Macro structure, texture and mineralogical definitions of the fossil ore samples collected in the Lahanos, Killik and Çayeli beds by cutting to obtain equatorial and axial cross sections and correcting their surfaces in the abrasive machine. In order to determine the opaque and gang mi-

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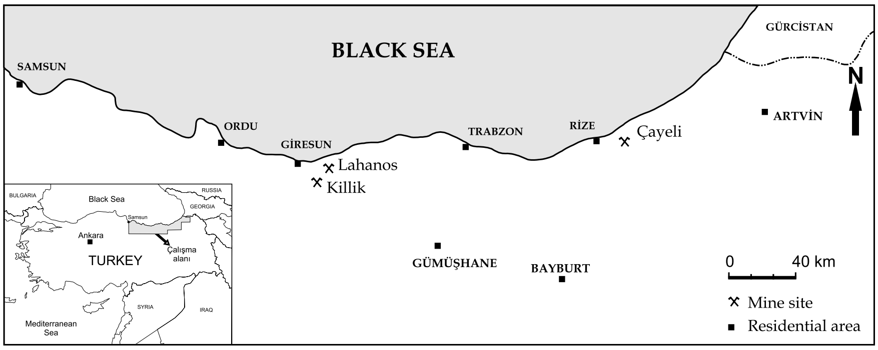

Figure 1 - The location map of mine sites where the fossil findings were detected.

neral content of the fossil traces and fillings, polished and thin sections have been prepared from the samples representing each deposit. Polishing and opaque mineral studies have been carried out in the Ore Microscopy Laboratory of the Geological Engineering Department of the Hacettepe University. Gang minerals that can not be defined with the ore microscope have been determined in the form of dot based mineralogical analyses by using high resolution, analytical Raman microscope Horiba Jobin Yvon Brand Labraun HR (633 laser power) Konfokal Raman Spectrometer in the laboratories of the Geological Engineering Department of Ankara University.

Mineralized fossil traces observed in the massive sulphite deposits of Lahanos, Killik and Çayeli

The dimensions of the of the tube worm fossil traces defined in the Lahanos, Killik and Çayeli deposits reach up to 25 mm diameter and 8 cm length. Worm fossil traces are preserved in the black ore usually consisting of the pyrite and sphalerite (Figure 2B, C, D).

In all three deposit, mineralized tube worm samples are preserved in a sulfide matrix. It has been observed that few fossil traces are replaced by opaque and gang mineral from the exterior to the interior while the inside of the tube fossil traces is filled with mineral fragments such as pyrite, sphalerite, chalcopyrite and galena. As much as it can be observed from the axial and equatorial sections, these replacement cover all of the fossil trace in some samples while it is only in the side sections and the internal part of the fossil trace is left in the shape of a cavity (Figure 3A). In some samples however, side sections of the fossil traces, are replaced by opaque minerals (pyrite and galena), while internal sides are filled by opaque mineral clasts like pyrite, sphalerite, chalcopyrite and galena.

In Lahanos samples, in the fossil traces replaced by opaque minerals from the sides, the sequence of mineral zoning, from the exterior to the interior, is sfalerit + pyrite >> chalcopyrite + pyrite.

The mineral zoning sequence observed in Çayeli samples, from the exterior to the interior is pyrite >> galena (Figure 2B).

In some samples of Killik mine, outer sections of the tube fossil traces are replaced by barite, while the internal sides are infilled by clasts consisting of sulphite minerals (Figure 3B). In a sample taken from Lahanos, whole of the tube worm fossil trace is infilled with barite. This sample contains only barite in the outer sections

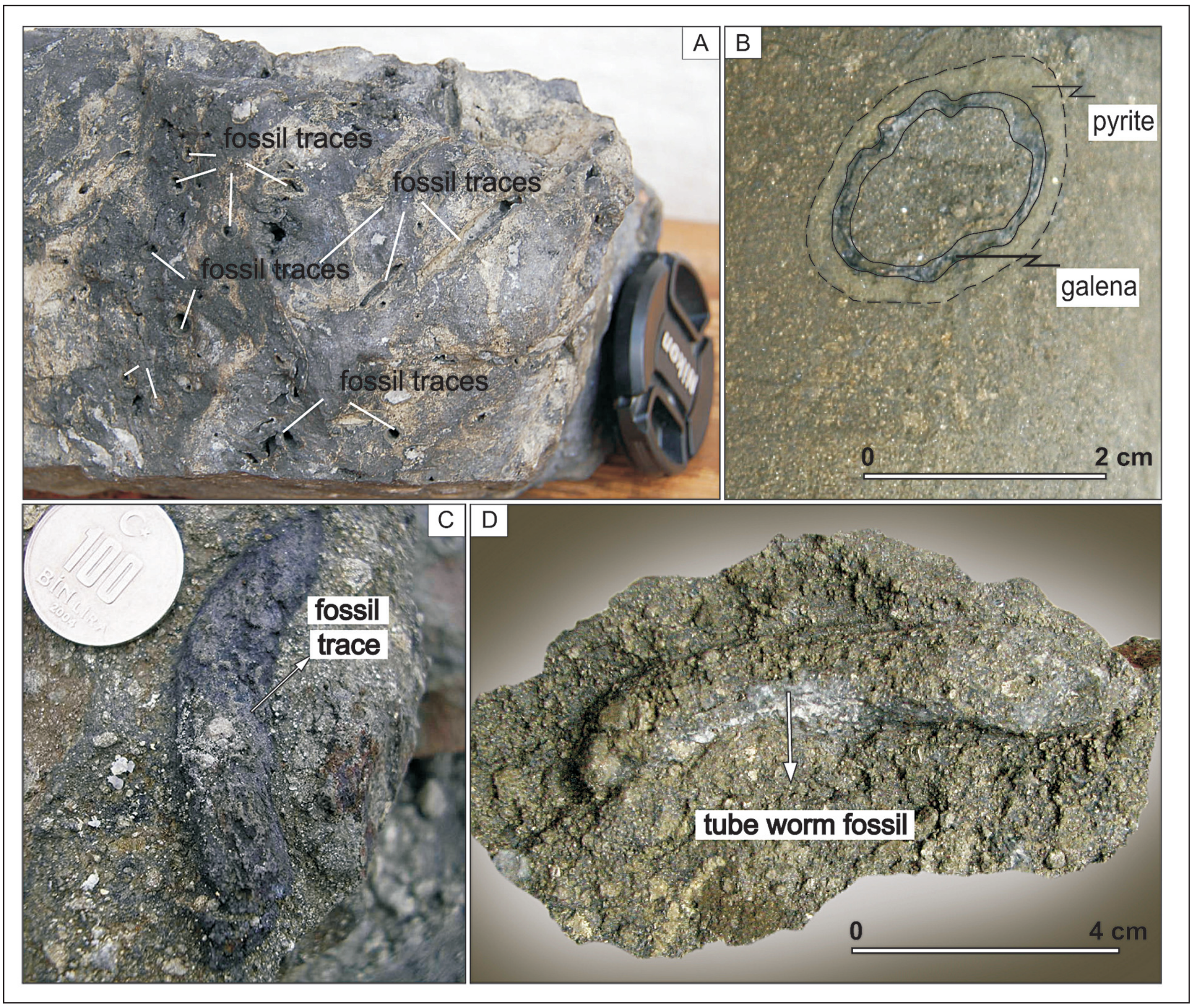

Figure 2 - A - Various forms of tube fossils found in the massive sulphide deposit in the Urals region. Different cross sections of the tube worm fossils in the brecciated sulphides found in massive sulfide deposits of B- Çayeli C- Lahanos and D- Killik.

while the inner sides contain sulphite minerals (pyrite, chalcopyrite, covellite, sphalerite) as well as barite. In the fossil trace fillings, apart from barite (Figure 4) the existence of secondary minerals such as goethite [FeO(OH)], serpierite [$Ca(Cu,Zn)_4(SO4)_2(OH)_6.3(H_2O)$], native sulfur [S] and jarosite [$KFe_3(SO4)_2(OH)_6$] and dolomite [$CaMg(CO_3)$] in amounts that cannot be differentiated by microscope, has detected by Raman Spectrometry (Figure 5).

DISCUSSION AND COMMENTS

Traces of these unique organisms that found near present-day vents are rarely encountered in the massive sulfide paleo-hydrothermal fields. The tubular worm fossil relics were found for the first time by Ivanov (1947) among pyrite minerals in Sybai deposit (Urals). Later, the similar fossil findings were defined in the massive sulfide deposits in Umman (Haymon et al. 1984), Cyprus

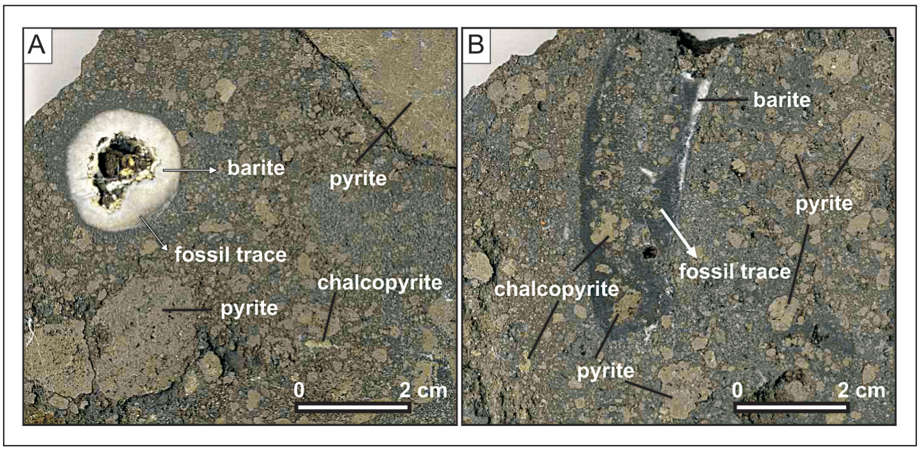

Figure 3 - A - In Killik mine, the worm fossil trace replaced by the sulphate mineral within the clastic ore, internal part is empty, doesn't contain filling; (B) The worm fossil trace filled with sulphide and sulphate mineral fragments.

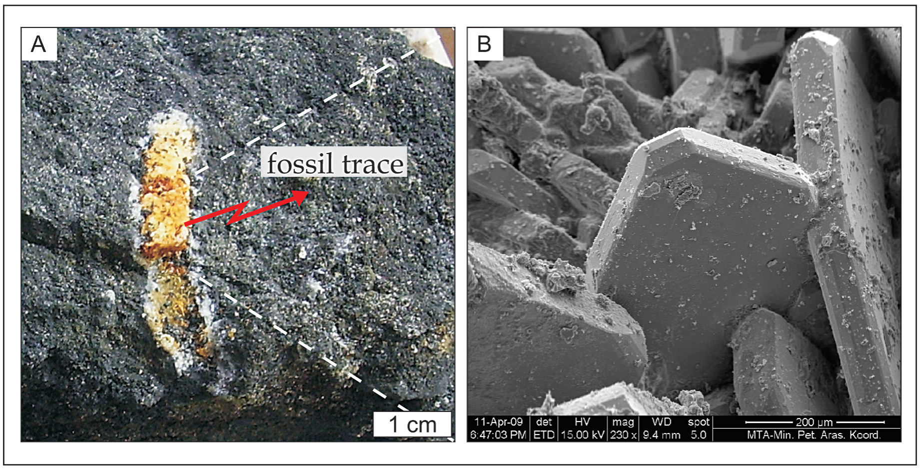

Figure 4- A- SEM image of barite minerals (B) from tube worm fossil replaced by sulphate and sulphide minerals. Sample is taken from black ore zone of Lahanos deposit.

(Qudin and Constantinou, 1984) and Ireland (Banks, 1986). Apart from these, findings and information (Kuznetzov et al. 1993; Zaykov et al. 1995) regarding the tubular worm fossil community (Figure 2A) have been obtained in the massive sulfide deposits in Urals (Yaman-Kasy, Buribaiskoye, Yubileinoye, Safyanovskoye, Komsomolskoye). However, the abundance and preservation of this mineralized fauna are dissimilar in different deposits (Prokin et al. 1985; Kuznetzov et al. 1993; Zaykov et al. 1995). The data obtained from the levels where the fauna fragments are located in massive sulfide deposits (Malahova, 1969; Bitter et al. 1992) indicate that the concerned faunas can survive in very special environmental conditions. In this environment, hydrosulfuric environment conditions which are inconvenient for the survival of

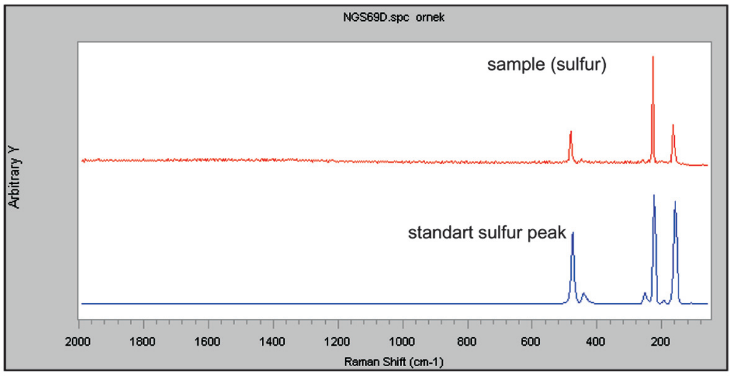

Figure 5- Raman spectrum of native sulphur from tube worm fossil replaced by sulphate and sulphide.

many other organisms except bacteria are dominant. These habitat conditions refer to sea environment deeper than 1300 meters (person. comm. Maslennikov, 2009). The organisms that survive in such a hydrothermal field have such special living conditions that it is almost impossible for them to maintain their lives in other environments (Lob'e, 1990). The existence of modern tube worms in the present-day oceans could presumably be evidence of evaluation of fossil tube worms detected in the paleo-massive sulfide deposits (such as Urals, Pontids and Samail Ophiolite) (Monroe and Wicander, 2005). However, it has not been proven yet that whether these fossil worms are ancestral forms that have evolved since the Cretaceous into the types of worms found at vents today (Haymon, et al. 1984).

The geologic setting where the Lahanos, Killik and Çayeli massive sulfide deposits formed and the mineralogical and textural features of the fossils they contain are the evidences of the existence of the hydrothermal vent on the bottom of paleo-ocean. Besides, the mineralogical findings obtained in this study demonstrate that, for the preservation of the tube worm fossils, the substitution of them by the sulfite and sulfate minerals starting from the sides is very important for the preservation of the forms. The replaced fossils became more resistant and could maintain their tube shapes. On the other hand, the existence of the microscopic and milimetric sized clastic opaque minerals filling the internal sides of the fossils indicates that the erosional effect under sea is significant and therefore they are mobile due to gravity, undersea currents or tectonic effects. The fact that the grain size of the clastic fossil fillings are in milimetric size refers to that the tube worms live relatively far away to the hot spring vent chimneys or that only fossils of the tube worms not living in a close environment to the hot spring vent chimneys can be preserved.

Within the scope of this study, Upper Cretaceous aged deposits in the Eastern Black Sea region are included in massive sulfide districts where findings of this unique fauna are found. The fossil fauna discovered in Pontid deposits are well- preserved when compared to the similar ones found in the other regions (person. comm. Valery Maslennikov, 2009).

ACKNOWLEDGEMENT

This study includes a special section of the findings related to the PhD thesis "Determining the Typical Features of the VMS Deposits of the

Eastern Black Sea Region" carried out by the first author under the supervision of the third author in the Geological Engineering Department of the Hacettepe University under the "Determining New Criteria in the Exploration of VMS Deposits" by the Department of the Mineral Research of the General Directorate of Mineral Research and Exploration (MTA)".

We would like to thank for their contribution and support to Halil Türkmen (MTA); to Şenol Karslı (MTA) and Prof. Dr. Valery Maslennikov (Russian Academy of Science) for their help in the field studies; to Okan Zimitoğlu (MTA), Dr. Okan Delibaş (MTA) and Prof. Dr. Yusuf Kaan Kadıoğlu (Ankara University, Geological Engineering Department); to Mining Engineer Hasan Yağcı working at the Lahanos Mine and to all mine employees.

Manuscript received January 18, 2010

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