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Tectono-stratigraphic reconstruction of the Keban metamorphites based on new fossil findings, Eastern Turkey

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ABSTRACT

Keban metamorphites located at the orogenic belt of the Eastern Taurides is an allochtonous union metamorphized at the greenschist facies comprised of several nappes. Contrary to the massives around it, the aging of the union is not quite satisfactory due to the lack of fossil data. Permo-Triassic/Permo-Carboniferous ages have been used until now for the age of the metamorphites that are stated to be located only at a single location, the species of which have not been determined and which are based on two fossil data. However, for the first time in this study, "*microgastropods*" have been found at Early Triassic age related with The Great Dying at the end of the Permian inside the clastic limestones at the base levels of the Nimri Formation which is one of the lower nappes of the Keban metamorphites. Again, trace fossils *Planolites*, *Rhizocorallium*, *Thalassinoides*, *Helminthopsis* and *(?)Protovirgularia* have been determined for the first time in the layered crystallized limestones at the medium levels of the Nimri Formation. This ichnofabric is frequently observed in the Middle Triassic aged limestones at Germany, Poland, Austria, Italy and the Taurides and is known as the "vermicular limestone facies". The ages of Keban marble, Delimehmet and Süleymanlı Formations, tectonically located on the Nimri Formation, are evaluated by regional correlations as Middle-Late Devonian, Late Devonian and Early Carboniferous, respectively. In addition, probably pre-Triassic aged, dark green colored metadiabase dykes have been inserted in the Delimehmet formation in relation with the Variscan Orogeny. Regional correlations with other units and massives indicate that the Keban metamorphites that have deposited at the farthest north of the south branch of the Neo-Tethys ocean paleogeographically may be the continuation of the Bolkardağı Union at the east rather than the Alanya and Geyikdağı Unions.

1. Introduction

Many studies have been carried out for solving the geological problems that date way back for mining (such as silver bearing lead deposits) around the study area located at the Eastern Taurides orogenic belt and its environs (Fischbach, 1900; Tolun, 1955; Zisermann, 1969; Balçık et al., 1978; Kipman, 1981; Yılmaz et al., 1992; Hanelçi, 1996). In addition, a detailed geological study has been carried out by the Electrical Works Survey Administration (EİEİ) geologists (1972) related with the engineering problems that developed during the construction of the Keban Dam located in the study area. In addition, it has also been the subject of studies that will contribute to the solution of structural and geological problems (Savcı, 1983; Kaya, 2001) due to its geological position (Fig. 1) near the orogenic collision zone between the Arabia and Anatolia continental plates. Keban metamorphites have been included by Özgül (1976) in the Alanya Unit with regard to the tectonic units of Turkey and in the Geyikdağı Unit by Bozkaya et al. (2007). Majority of the researchers working at the Keban metamorphites have claimed that the stratigraphic sequences that make up the Keban metamorphites are normal and that these metamorphic rocks are Permo-Carboniferous aged.

Keban metamorphites have lost their primary stratigraphic relations and fossil findings since they were subject to the effects of metamorphism and severe deformation. The only fossil finding until today is based on the *Glomospira* and *Ammodiscus* families by Kipman (1981). However, species of these families were not determined. The author has suggested the Permo-Carboniferous age for these fossils. However, he has also put forth that these fossil bearing units are Permian aged since the fossil bearing similar lithological units around the region are also Permian aged.

The fact that no fossil finding was determined in future studies carried out on the Keban metamorphites which can be used to age

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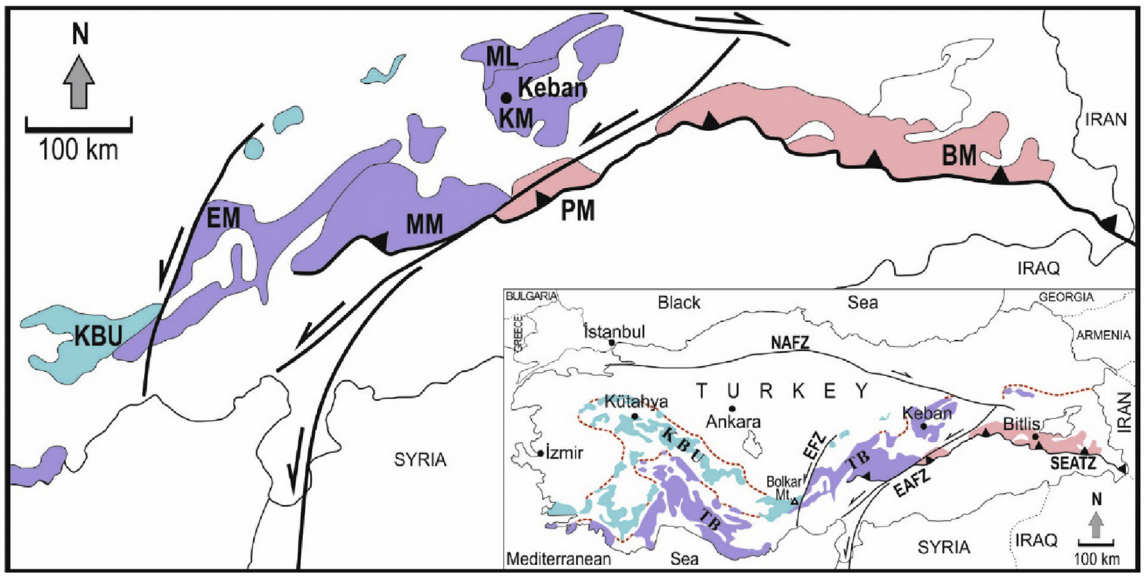

Fig. 1. Location of the study area (EM: Engizek metamorphites, MM: Malatya metamorphites, PM: Pütürge metamorphites, KM: Keban metamorphites, BM: Bitlis Metamorphites, ML: Munzur limestones, KBU: Kütahya-Bolkardağı Union, TB: Tauride Belt, NAFZ: North Anatolian Fault Zone, EAFZ: East Anatolian Fault Zone, SEATZ: South East Anatolian Trust Zone, EFZ: Ecemiş Fault Zone). (Modified from Özgül, 1976; Moix et al., 2007 and Göncüoğlu, 2011).

the units along with the primary stratigraphic sequence that is disrupted by intensive tectonism have prevented a consensus on the relationships between the aging of the units that make up the Keban metamorphites as well as the stratigraphic relations.

Whereas it was concluded in the study carried out by Kaya (2001) on the tectonic evolution and structural analysis of the Keban metamorphites that the deformation structures observed on the formations located on the lower and upper levels of the sequence were not normal when the structural stills and deformation phases were considered. However, fossil findings the formations of which can be aged were discovered in later years as a result of long field studies. In this study, trace fossils such as *Planolites*, *Thalassinoides*, *Rhizocorallium*, *Helminthopsis* and (?)*Protovirgularia* which are observed commonly in the crystallized limestones at the medium levels of the Keban metamorphites in addition to the *microgastropod* fossils in the clastic units below this level that document Early Triassic have been determined for the first time. In addition, all formations that make up the Keban metamorphites have been examined in detail, after which their primary stratigraphic sequence was put forth as a result of the comparison with metamorphic and non-metamorphic units with known chronostratigraphy.

It was also determined for the first time in this study that the metadiabases observed in the clasts that make up the Middle-Late Devonian-Early Carboniferous aged upper nappe do not intersect the lower nappe aged Early-Middle Triassic-Jurassic. Thus, it was put forth that these diabases are most probably related pre-Triassic aged related with Variscan Orogeny.

It was put forth as a result of the data acquired in this study that the age of the Keban metamorphites vary from Middle-Late Devonian to Late Jurassic or even Early Cretaceous (?) and that it is made up of several nappes. In addition, according to these data it is thought that the Keban metamorphites are the extension in the east of the Bolkardağı Unit defined by Özgül (1976).

2. Geological setting

The units that make up the Keban metamorphites which are part of the Bolkardağ Unit located to the north of the Tauride platform may have deposited while still a probable part of the Cimmerian continent (Moix et al., 2007) next to Gondwana prior to the opening of the Neotethys Ocean during the Permian (Şengör and Yılmaz, 1981; Yazgan and Chessex, 1991).

The geodynamic evolution of the study area including the Keban metamorphites is directly related with the development of the Neotethys Ocean during the geological time. Keban metamorphic rocks underwent a metamorphism during Late Cretaceous related with the northward subduction of the southern branch of the Neotethys Ocean. Keban metamorphic rocks were subject to a low grade greenschist metamorphism throughout the Early Cretaceous. The oldest unit in the study area that was not affected by this metamorphism is the Late Cretaceous (Late Campanian-Early Maastrichtian) aged Sağdıçlar formation (Fig. 1).

Keban metamorphic rocks have gained characteristics that representing polyphase deformation structures. Structural data point out the existence of at least two penetrative deformation phases. The first phase deformation structures are represented by overturned/recumbent folds, schistosity, slaty cleavage and mineral elongation lineation, while the second phase deformation structures are represented by open folds, crenulation cleavage and crenulation lineation.

The oldest orogenic event in the Keban metamorphic is probably the Variscan orogenic event that took place most likely during Late Carboniferous. The indication of this orogeny event in the study area is the existence of the Bahçeli metadiabase dykes cutting the Delimehmet and Süleymanlı formations. This volcanism is related with the opening of a margin basin during Carboniferous to the north of the Tauride-Anatolide platform (Göncüoğlu, 2011).

No data could be determined about whether the Cimmerian orogeny phase (first phase of the Alpine orogeny) that developed in Late Triassic and was effective in many sections of the Taurides is effective on the study area or not. Whereas the subsequent most important orogeny event that affected the region is the Alpine orogeny event (Laramide orogeny) that took place in the Maastrichtian. The rocks that make up the Keban metamorphites underwent a severe deformation during this orogenic period. Structures such as NE-SW direction fold axes, thrust faults/reverse faults and elongation lineations developed on the metamorphic