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Stratigraphy and Paleontology of the Upper Paleozoic Sequences in the Pulur (Bayburt) Region, Eastern Pontides

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Abstract: The Pulur Paleozoic sequence consists of two formations. At the base there is a 1100 m thick heterogeneous series of sandstone, limestone, quartzite, siltstone and shale called the Çatalçeşme Formation. Foraminifera from the limestones of the Çatalçeşme Formation conclusively indicates a Late Carboniferous (Late Kasimovian-Early Gzelian) age. The Çatalçeşme Formation is conformably overlain by approximately 1000 m thick terrigenous reddish sandstones of latest Carboniferous and possibly earliest Permian in age. The Pulur Upper Paleozoic sequence represents a molasse-type deposition at the end of the Hercynian orogeny. Similar Upper Carboniferous and Lower Permian sequences are described from the Greater Caucasus. This and the Euramerian affinities of the plant fossils in the Çatalçeşme Formation suggest that during the Late Paleozoic the Eastern Pontides were located along the southern margin of the Laurasia.

Doğu Pontidlerde Pulur (Bayburt) Bölgesindeki Üst Paleozoyik İstiflerin Stratigrafi ve Paleontolojisi

Özet: Pulur Palezoyik istifi iki formasyondan oluşur. Altta 1100 metreyi aşkın kalınlıkta kumtaşı, kireçtaşı, kuvarsit, silttaşı ve şeyl-den oluşan Çatalçeşme Formasyonu yer alır. Çatalçeşme Formasyonu içindeki kireçtaşlarında saptanan foraminiferler Geç Karbonifer (Geç Kasimoviyen-Erken Gzeliyen) yaşını vermektedir. Çatalçeşme Formasyonunun üzerine uyumlu olarak 1000 m kalınlıkta başlıca kırmızı karasal kumtaşlarından oluşan Hardişi Formasyonu yer alır. Bu iki formasyon arasındaki uyumlu ilişki Hardişi Formasyonunun en geç Karbonifer ve muhtemelen erken Permiyen yaşında olduğunu gösterir. Pulur Paleozoik istifi Hersiniyen orojenezi sonunda molas tipi bir çökelmeyi temsil eder. Benzer Üst Karbonifer ve Alt Permiyen istifleri Büyük Kafkaslar'da yaygın olarak bulunur. Bu durum, ve Çatalçeşme Formasyonundaki bitki fosillerinin Avroamerika tiplerine yakınlık göstermeleri, Doğu Pontidlerin Geç Paleozoyik'te Lavrasya'nın güney kenarında yer aldığına işaret etmektedir.

Introduction

The geology of the Eastern Pontides is dominated by an Upper Cretaceous magmatic arc which developed above the northward subducting Tethyan ocean. Rare outcrops of pre-Mesozoic rocks in the Eastern Pontides are restricted to their southern margin. One such outcrop is in the Pulur (Bayburt) region, where a regular Permo-Carboniferous sedimentary sequence with fusulinids was first described by Ketin (1951). Later Ağar (1977) Akdeniz (1988), and Robinson et al. (1995) provided more information on the stratigraphy and paleontology of this Paleozoic sequence, which is geologically interesting as it is the only known Paleozoic sedimentary series in the Eastern Pontides, and thus provides evidence about the Late Paleozoic evolution of this region. Here we provide new data on the stratigraphy and paleontology of the Pulur Paleozoic and discuss its significance in the Tethyan tectonic framework.

Tectonic Setting

The Pulur region is located in a north-vergent Alpide thrust belt in the Eastern Pontides. The thrust belt, which can be followed for over 250 km in an east-west direction, developed during the Late Paleocene-Early Eocene continental collision between the Eastern Pontides and the Anatolide-Tauride platform (e.g., Bergougnan, 1987; Okay and Şahintürk, 1996). In the region studied there are three north-vergent thrust sheets and a relative authochthon (Figure 1). These are named from top downwards: the İmalidağ, the Aşutka and the Hamurkesen thrust sheets, and the Cebre relative authochthon. The thrust sheets are composed largely of Jurassic-Cretaceous rocks; the pre-Mesozoic basement is exposed sporadically in the

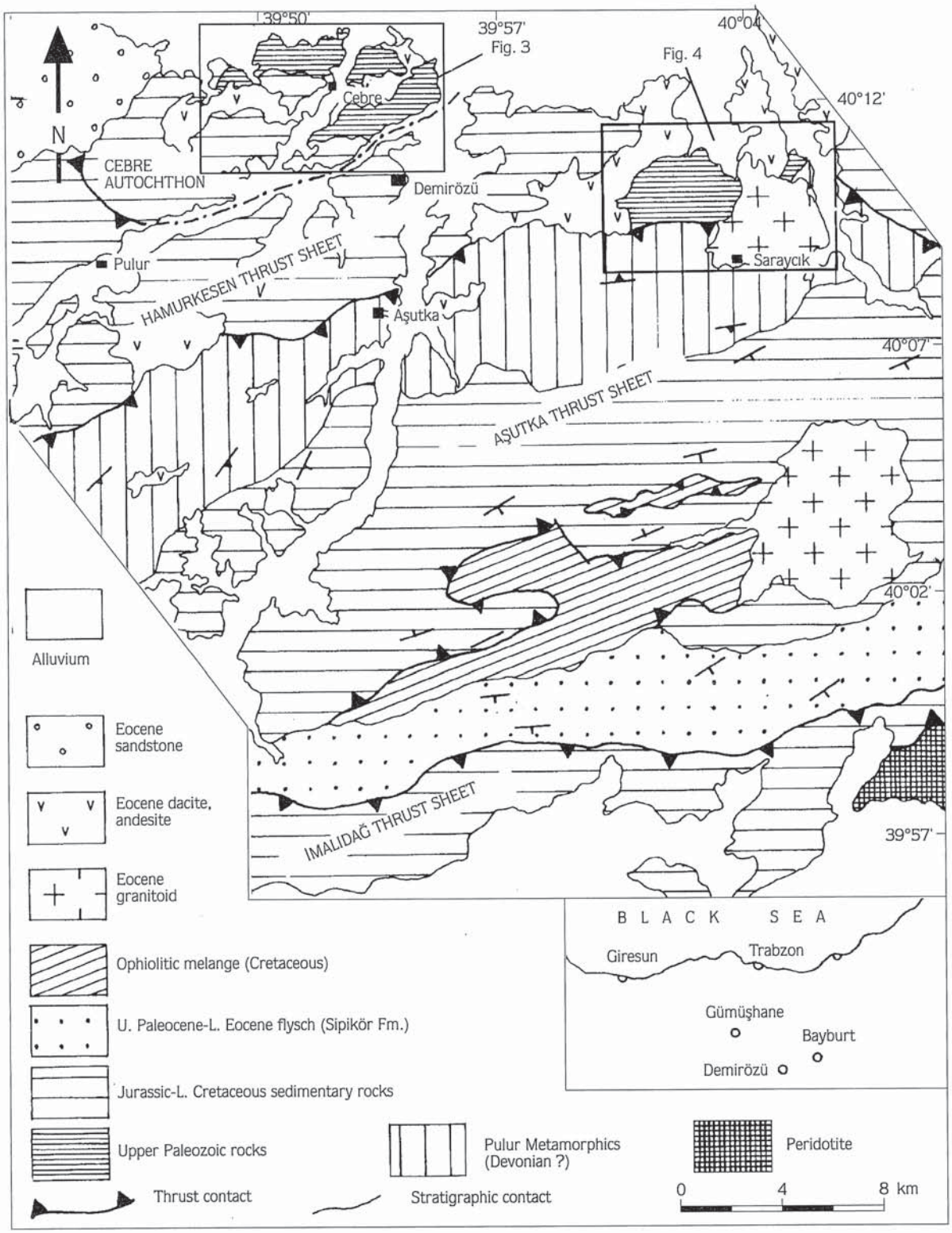

Figure 1. Tectonic map of the Pulur region showing the location of the Upper Paleozoic sequences.

relative authochthon and in the lower two thrust sheets (Figure 1). The Cebre relative authochthon has a Paleozoic sedimentary basement, which is unconformably overlain by the Jurassic limestones (Ketin, 1951; Ağar, 1977; Akdeniz, 1988). In the Hamurkesen thrust sheet a similar Paleozoic sedimentary sequence is exposed in a small region, while the basement of the Aşutka thrust sheet is composed of high-grade Pulur metamorphic rocks. All pre-Mesozoic rocks in these units are unconformably overlain by the Jurassic sedimentary rocks and all are intruded by andesitic dykes, sills and shallow intrusions probably of Mid-Eocene age. Middle to Upper Eocene conglomerate and shallow water limestones unconformably cover the thrust contacts between the tectonic units (Figure 1).

Previous Work on the Paleozoic Stratigraphy of the Pulur Region

There are major disagreements between Ketin (1951), Ağar (1977), Akdeniz, (1988), and Robinson et al. (1995) regarding the stratigraphy and age of the Upper Paleozoic sequence in the Pulur region (Figure 2). Ketin (1951), who first described these rocks, separated the Upper Paleozoic sequence into two lithological units, namely over 700 m thick red terrigenous sandstones overlain by a 800 m thick heterogeneous sequence of intercalated sandstone, quartzite, limestone, shale and andesite. He assigned a Permo-Carboniferous age to the whole sequence based on the presence of fusulinids, although no determination of the fusulinid species or genera was made. Ketin (1951)'s stratigraphy was inverted by Ağar (1977), who placed the heterogeneous series, which he named as the Çatalçeşme Formation under the terrigenous sandstone sequence. Although Ağar (1977)'s modification of the stratigraphy was correct, he mistakenly put an unconformity between the Çatalçeşme Formation and the overlying terrigenous sandstone sequence (Figure 2). Ağar (1977) assigned a broad Permo-Carboniferous age to the Çatalçeşme Formation based on micro and macrofossils and plant remains, and regarded, without any paleontological evidence, the red terrigenous sandstone sequence as of Triassic age. A third change in the Upper Paleozoic stratigraphy of the Pulur region was introduced by Akdeniz (1988). Akdeniz (1988) divided the Upper Paleozoic sequence into three conformable formations: Çatalçeşme formation at the base, red sandstones in the middle and a sequence of intercalated sandstone, quartzite, limestone and shale (Büyükcücüge Formation), very similar to the Çatalçeşme Formation, at the top (Figure 2). He assigned a Late Carboniferous (Gzelian) age to the

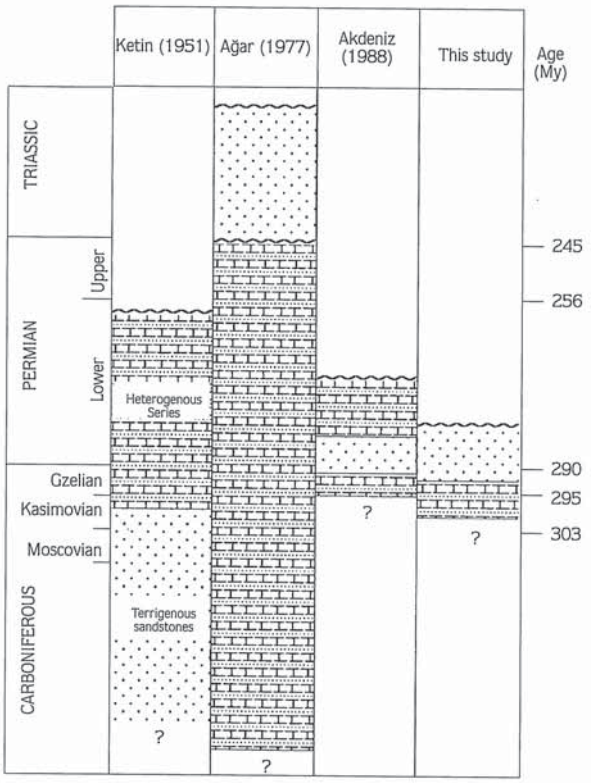

Figure 2. Stratigraphic schemes and ages proposed for the Upper Paleozoic sequence of the Pulur region by the various authors.

Çatalçeşme formation and an Early Permian age to the Büyükcücüge Formation at the top. Our studies have demonstrated that Akdeniz (1988)'s Çatalçeşme and Büyükcücüge formations are both of Late Carboniferous age and belong to a single formation, which is repeated because of faulting. Akdeniz (1988) correctly recognised that the andesites, which were regarded as part of the Upper Paleozoic sequence by Ketin (1951), were in fact intrusive and probably of Eocene age. A further confusion in the Pulur Paleozoic sequence came with Robinson et al. (1995), who without any sound field basis divided the Upper Paleozoic sequence into three formations: red sandstones at the base a heterogeneous series in the middle, and red sandstones and mudstones at the top. They assigned an Early Permian age to the heterogeneous series based on the probably mistaken determination of a single foraminifer genus.

Detailed geological mapping and paleontological study have shown that the Upper Paleozoic sequence in the Pulur region consists of two conformable formations: a heterogeneous series of Upper Carbonifer-

ous sandstone, quartzite, conglomerate, limestone and shale, named as the Çatalçeşme Formation at the base, and red terrigenous sandstones, the Hardişi Formation at the top. These formations will be discussed separately in the relative autochthon and the overlying thrust sheet.

Upper Paleozoic in the Cebre Relative Autochthon

Çatalçeşme Formation: The Çatalçeşme Formation was named by Ağar (1977) after the Çatalçeşme (Yukarıhinzeverek) village five kilometres north of Pulur (Figure 3). The type section, where the upper contact

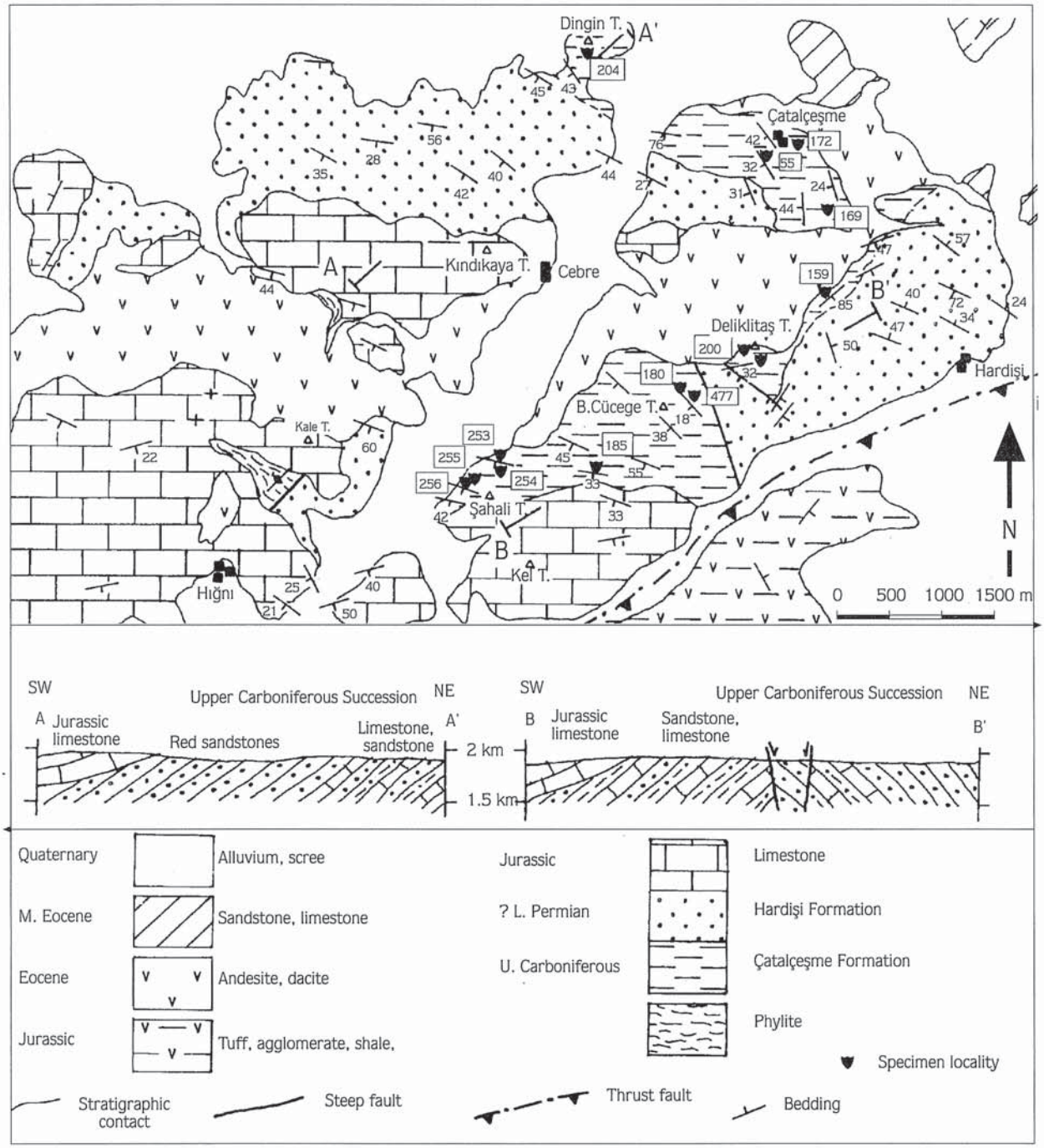

Figure 3. Geological map and cross-sections of the Cebre region. For location see Figure 1.

is observed, is along the unnamed valley to the Deliklitaş Hill, which runs parallel to the Demirözü-Cebre road. Additional good sections exist along the ridge between the Büyükcücüge and Şahali hills, and around the Çatalçeşme village (Figure 3). The type section of the Çatalçeşme Formation along the valley towards the Deliklitaş hill is shown in Figure 4; additional measured stratigraphic sections of the Çatalçeşme Formation are given in Ketin (1951) and Akdeniz (1988).

In the Cebre relative autochthon the Çatalçeşme Formation is made up of sandstone, pebbly sandstone, quartzite, dark limestone, siltstone, shale with rare thin coal seams, which are closely intercalated on a few metre to few ten metre scale (Figure 4). The sandstones are medium to coarse grained, medium to thickly bedded, beige, grey, yellow, pale pink arkosic arenites with well-rounded pebbles of acidic magmatic rocks. They are intercalated with medium to thickly bedded, dark grey to black limestones locally rich in brachiopod, coral, gastropod, algae and fusulinids. The thickness of the indivudual limestone horizons ranges from a few ten centimetres to few ten metres. There are more than 20 limestone horizons in the sequence. Thinly bedded, bioturbated siltstones with plant fragments and black, grey shale, with discontinuous coal seams a few centimetres thick, occur locally between the limestone beds.

The stratigraphic base of the Çatalçeşme Formation is not observed while it is overlain conformably the Hardişi Formation and unconformably by the Jurassic Çaltepe limestone. The maximum thickness of the Çatalçeşme Formation, observed between the Büyükcüceğe and Şahali hills, is about 1100 metres.

In the Cebre relative autochthon the Çatalçeşme Formation outcrops in two major areas separated by an andesite-dacite intrusion (Figure 3). In the area to the north of the intrusion, the Çatalçeşme Formation lies clearly below the red sandstones (Figure 2), as also shown by Ağar (1977) and Akdeniz (1988). Five fossiliferous limestone samples (53, 55, 169, 172, 204) from this region have yielded an Upper Kasimovian-Lower Gzelian fusulinid assemblage of *Eostaffella* sp., *Ozawainella* sp., *O.* cf. *angulata* (Colani), *Pseudoendothyra* sp., *P.* cf. *timanica* (Rauser), *Schubertella* sp., *S. obscura* Lee & Chen, *Quasifusilina* sp., *Q.* cf. *praecursor* Rauser, *Triticites* sp., *T. gissaricus* Bensch, *T.* cf. *sinuosus* Rosovskaya, *T.* aff. *simplex* Schellwien (Table 1, Plate 1). In the region south of the intrusion, the Çatalçeşme Formation occurs in two subareas. It forms a narrow belt extending north-

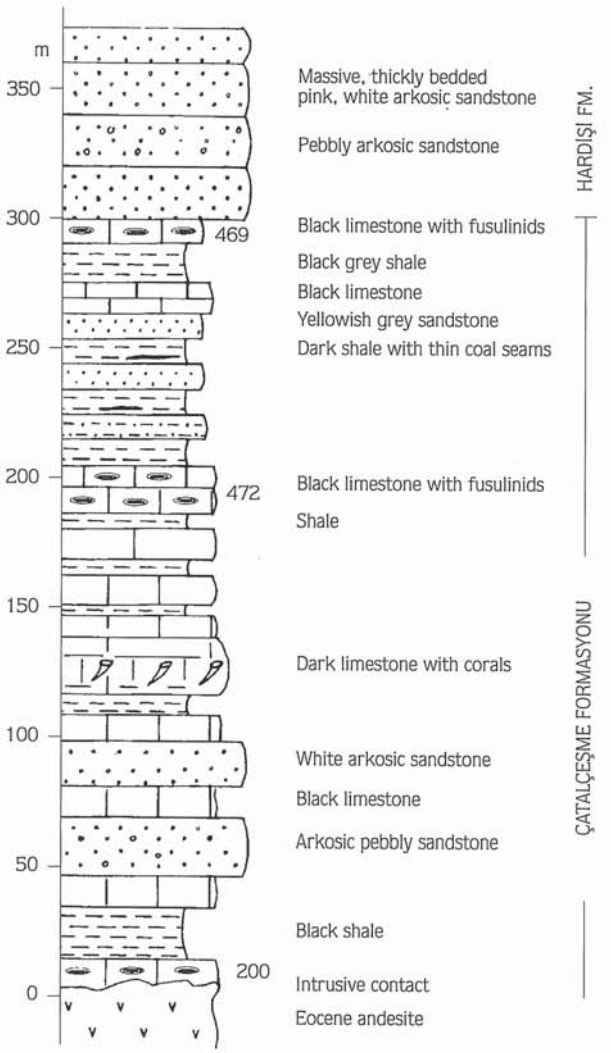

Figure 4. Type section of the Çatalçeşme Formation along the unnamed valley towards the Deliklitaş Hill (Figure 3).

eastward from the Deliklitaş Hill (Figure 3). Along this belt the Çatalçeşme Formation is stratigraphically overlain by red sandstones of the Hardişi Formation (Figure 4). Two fossiliferous limestone samples from this belt (159, 200) also yielded a Kasimovian-Gzelian fusulinid fauna of *Eostaffella* sp., *Ozawainella* sp., *O.* cf. *angulata* (Colani) sp., *Pseudoendothyra* sp., *P.* cf. *timanica* (Rauser), *Schubertella* sp., *S. obscura* Lee & Chen, Fusiella? sp., *Quasifusilina* sp., *Triticites* sp., *T. gissaricus* Bensch, *T.* cf. *sineosus* Rosovskaya, *T.* aff. *simplex* Schellwien, *Rugofusulina* sp., *R.* cf. *praevia* Shlykova (Table 1, Plate 1). The heterogeneous sequence in the second subregion from Büyükcücüge to

Table 1. Fusulinid assemblages from the Pulur region. For location of samples see Figures 3 and 4.

	Çatalçeşme region					Cebre relative autochthon Büyükcücüge Tepe region									Hamurkesen thrust sheet Hakiğ region		
Sample numbers	53	55	169	172	204	159	200	180	185	253	254	255	256	477	563	565	827
Fusulinids:																	
Eostaffella sp.				X	X	X			X								
Ozawainella sp				X	X					X	X		X			X	X
O. cf. angulata (Colani)		X	X			X											
O. nikitovkensis (Brazhnikova)										X							
Pseudoendothyra sp.	X					X											
P. cf. *timanica* (Rauser)				X													
Schubertella sp.	X	X	X	X	X	X		X	X				X	X		X	X
S. obscura Lee & Chen				X			X			X							
S. cf. *pseudomagna* Putrya & Leont											X						
S. paramelonica minor Suleimanov															X		
S. lata Lee & Chen															X		
S. parvifusiformis Lin													X				
Fusiella? sp							X										
Quasifusulina sp					X	X					X					X	X
Q. ex gr. *longissima* (Moeller)											X						
Q. cf. *praecursor* Rauser					X												
Triticites sp		X		X	X	X					X	X		X			
T. gissaricus Bensch						X											
T. cf. *sinuosus* Rosovskaya				X	X	X				X							
T. aff. *simplex* Schellwien						X											
T. ex gr. *variabilis* Rosovskaya									X								
T. petschoricus Rauser										X							
T. ex gr. *karlensis* Rosovskaya													X				
Rugofusulina sp						X											
R. prisca ovoidea Bensch														X			
R. cf. *aktjubensis* Rauser		X															
R. cf. *praevia* Shlykova						X											
Schwagerinidae gen. indet							X	X								X	X

Şahali hills was assigned by Akdeniz (1988) to the Büyükcücüge Formation of Early Permian age and was claimed to stratigraphically overlie the red sandstones. However, the relation between the heterogeneous series and red sandstones in this subregion is not stratigraphic but is constituted by a NNW trending steeply east-dipping normal fault (Figure 3). Six limestone samples from the heterogeneous series from this subregion (180, 185, 253, 254, 255, 256, 477) comprise an Upper Kasimovian-Lower Gzelian foraminifer fauna virtually identical to that of the Çatalçeşme Formation north of the andesite intrusion: *Eostaffella* sp., *Ozawainella* sp., *O. nikitovkensis* (Brazhnikova), *Schubertella* sp., *S. obscura* Lee & Chen, *S. pseudomagna* Putrya & Leont, *S. parvifusiformis* Lin, *Quasifusilina* sp., *Q.* ex gr. *longissima* (Moeller), *Triticites* sp., *T. gissaricus* Bensch, *T.* cf. *sinuosus* Rosovskaya, *T. petschoricus* Rauser, *T.* ex gr. *karlensis* Rosovskaya, and *Rugofusulina prisca ovoidea* Bensch (Table 1, Plate 1). This shows that the heterogeneous series between the Büyükcücüge and Şahali hills clearly belong to the Çatalçeşme Formation, which stratigraphically underlies the red sandstones of the Hardişi Formation.

Limestone samples from the base (e.g., samples 477, 180) and from the top (e.g., sample 159) of Çatalçeşme Formation contain a similar fusulinid assemblage (Table 1) indicating a rather restricted Late Kasimovian-Early Gzelian age for the Çatalçeşme formation.

Hardişi Formation: The Hardişi Formation, which lies conformably over the Çatalçeşme Formation, consists mainly of uniform red terrigenous sandstones. The contact between the Çatalçeşme and Hardişi for-

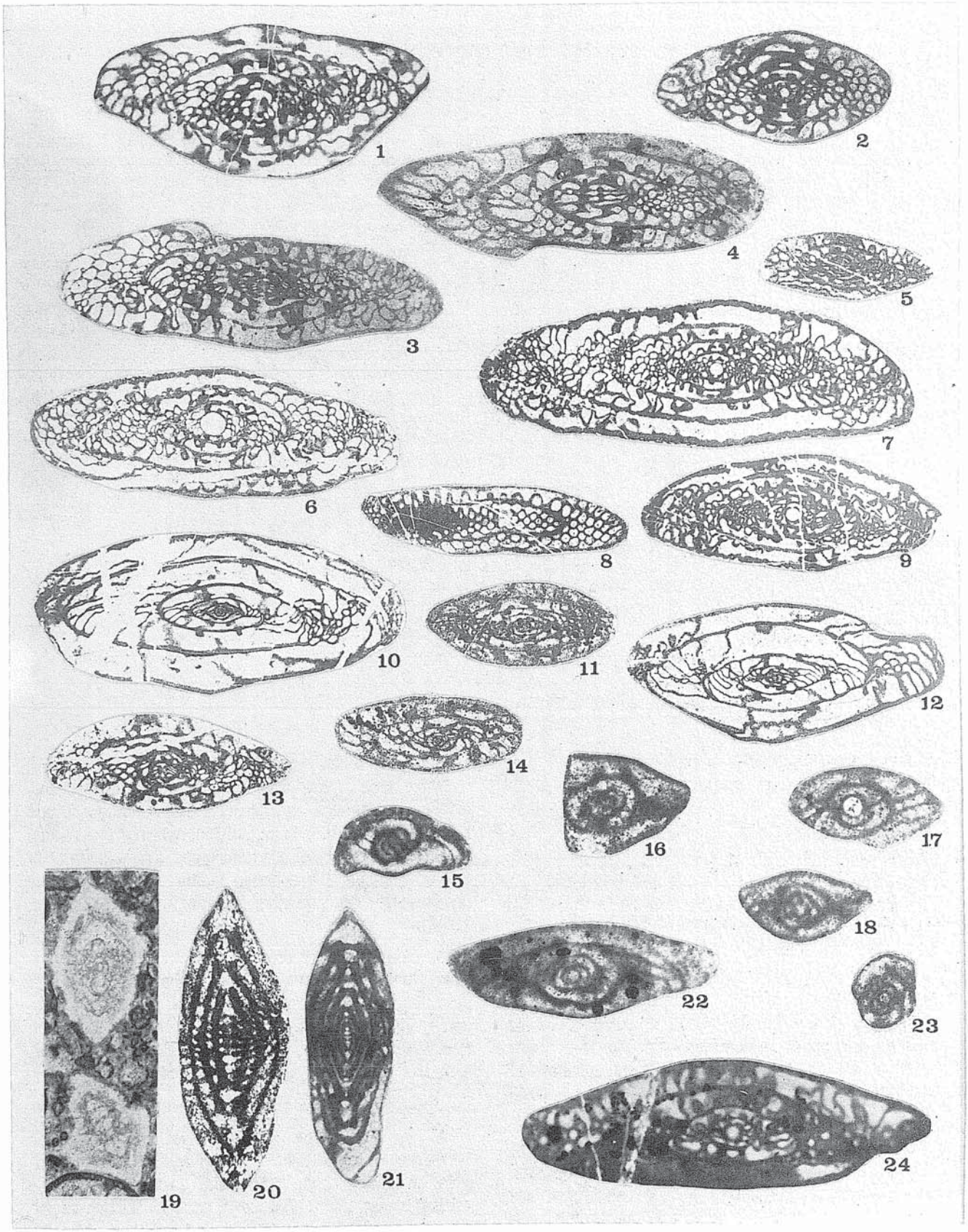
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Plate 1. Upper Carboniferous foraminifera from the Pulur region. For sample locations see Figures 3 and 5.

Figude 1. *Triticites* sp., sample No. 477, x 15.

Figure 2. *Triticites petschoricus* Rauser, sample No. 253, x 15.

Figures 3, 4. *Triticites* cf. *sinuosus* Rosovskaya x 15; samples 253B (Figure 3) and 159F (Figure 4).

Figure 5. *Triticites* cf. *primitivus* Rosovskaya, sample 159F, x 15.

Figures 6, 7, 9. *Rugofusulina prisca ovoidea* Bensch, sample 477, x 10.

Figure 8. *Quasifusulina* sp., sample 159F, x 15.

Figure 10, 12. *Triticites gissaricus* Bensch, sample 159C, x 11.

Figures 11, 13, 14. *Triticites* ex gr. *karlensis* Rosovskaya, sample 256B, x 15.

Figures 15, 18. *Schubertella paramelonica minor* Suleimanov, sample 563, x 80.

Figure 16. *Schubertella lata* Lee et Chen, sample 563, x 80.

Figure 17. *Schubertella* aff. *primitiva* Putrya, sample 563, x 80.

Figure 19. *Pseudoendothyra* cf. *timanica* (Rauser), sample 172F, x.

Figure 20. *Ozawainella* ex gr. *angulata* (Colani), sample 159F, x 50.

Figure 21. *Ozawainella nikitovkensis* (Brazhnikova), sample 253B, x 40.

Figure 22. *Schubertella parvifusiformis* Lin, sample 256B, x 80.

Figure 23. *Schubertella obscura* Lee et Chen, sample 200, x 80.

Figure 24. *Triticites* ex gr. *variabilis* Rosovskaya, sample 185, x 15.

mations is transitional over approximately 30-40 meters and is marked by an upward increase in sandstones at the expense of limestone. The Hardişi Formation is unconformably overlain by the Jurassic Çaltepe Limestone. The Hardişi formation was previously named by Ağar (1977) as the Karakaya Formation. This name has not been used to avoid confusion with the Karakaya Complex, a widespread, well-known tectonostratigraphic unit in the Pontides, and the formation was named after the Hardişi (Çiftetaş) village around which there are good exposures.

The type section of the Hardişi Formation, where the lower and upper contacts are exposed, is between the Dingin and Kındıkkaya hills. The total thickness of the Hardişi Formation in this section is about 1000 metres.

The Hardişi Formation consists of thickly bedded to massive, pale pink, white, red arkosic arenites and pebbly arenites. The pebbles in the sandstones are generally 2-5 cm large and consist of quartz and acidic magmatic rocks, such as microgranite, microdiorite, rhyolite, etc., These acidic magmatic rocks probably originated from the equivalents of the Gümüşhane and Köse plutons (e.g. Yılmaz, 1976), which have yielded a well-defined earliest Carboniferous (360±2 Ma) Rb/Sr isochron age (Bergougnan, 1987, and/or from the pre-Jurassic Olur dacites (Yılmaz, 1985; Bozkuş, 1992).

No fossils have been found in the Hardişi Formation. However, considering that even the uppermost parts of the Çatalçeşme Formation is of Late Kasimovian-Early Gzelian age, the conformably overlying Hardişi Formation should be latest Carboniferous (Gzelian) and possibly earliest Permian in age.

Upper Paleozoic in the Hamurkesen Thrust Sheet

In the Hamurkesen thrust sheet the Çatalçeşme Formation outcrops around the village of Hakiğ (Çamdere) in a fault zone below the basal thrust of the Aşutka thrust sheet (Figures 1 and 5). In this region the Çatalçeşme Formation has undergone a very low

grade metamorphism and strong deformation with steeply dipping to overturned bedding. The sequence starts with an over 500 m thick black slate and siltstone series with scarce sandstone, tuff and recrystallised limestone intercalations (Figure 5). The black slate series is stratigraphically overlain by a heterogeneous sequence of alternating sandstone, pebbly sandstone, dark limestone, siltstone and shale, very similar to that observed in the Çatalçeşme Formation of the Cebre relative autochthon. Three fossiliferous limestone samples (563, 565, 827) from this region comprise Upper Carboniferous foraminifera: *Ozawainella* sp., *Schubertella* sp., *S. paramelonica minor* Suleimanov, *S. lata* Lee & Chen and *Quasifusilina* sp. (Table 1, Plate 1). Keskin (1987) has also previously described a Late Carboniferous-Early Permian (Gzelian-Asselian) fauna from the limestones from this region.

Keskin (1987) has claimed that in the Hakiğ region the Carboniferous limestones lie unconformably over the Pulur metamorphic rocks. However, the Pulur metamorphic rocks in Keskin (1987)'s map are in fact slightly recrystallised sandstones and slates intercalated with limestones with Upper Carboniferous fossils, and all belong to the Çatalçeşme Formation. In the Hakiğ region the contact of the Carboniferous se-

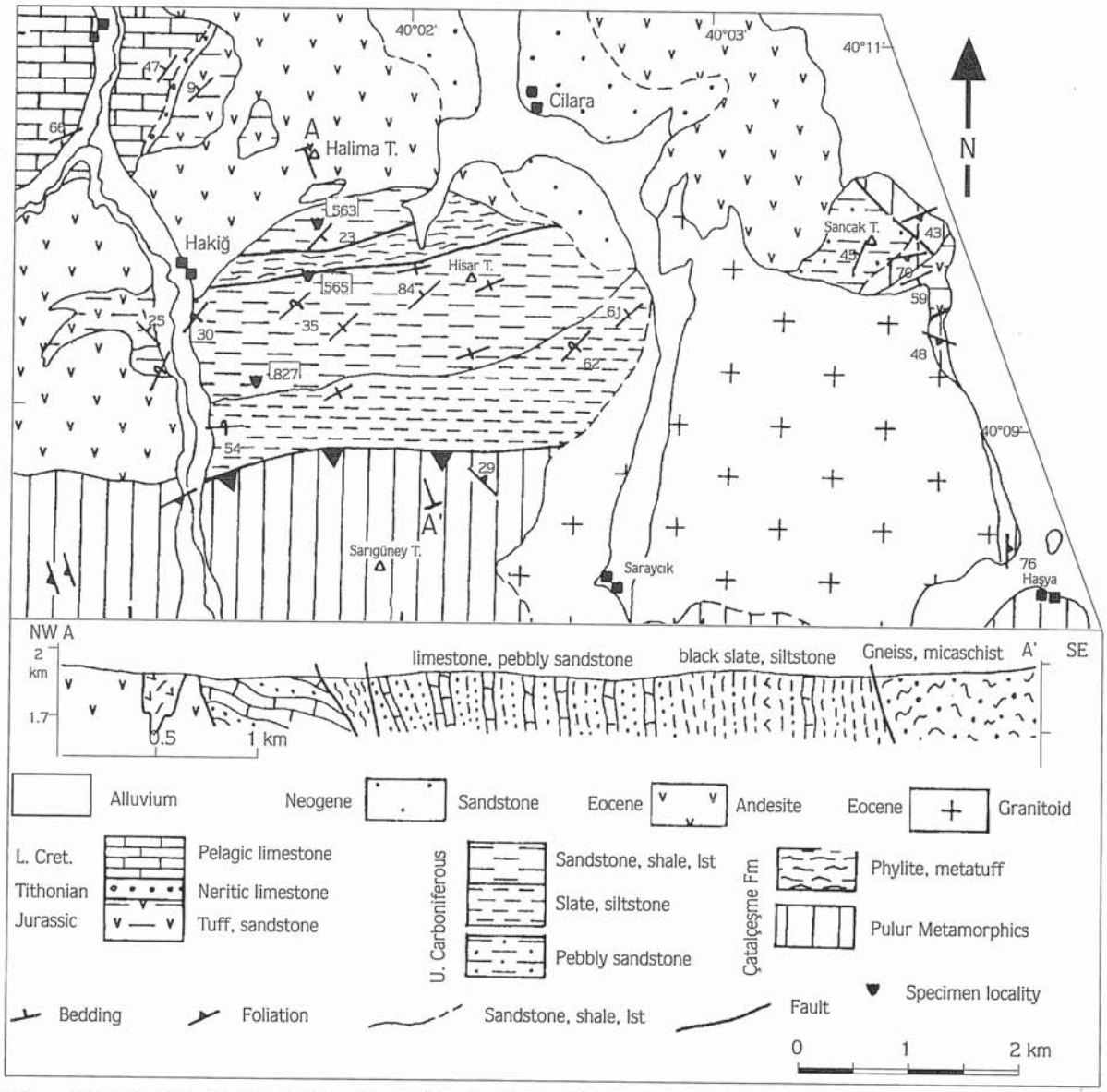

Figure 5. Geological map and cross-sections of the Hakiğ region. For location see Figure 1.

quence with the Pulur metamorphic rocks is constituted by the steeply-dipping Pulur thrust (Figure 5).

Age of the Fusulinid Assemblage from the Çatalçeşme Formation

Among the fusulinids the most precisely determined species are *Triticites gissaricus*, *Rugofusulina prisca ovoidea* and *Triticites petschoricus*. The first two fusulinids were described from the Fergana region (Bensh, 1972) and *Triticites gissaricus* also from the Gissar Range of south Tien Shan (Bensh, 1969) from beds, which were correlated by Bensch (1969, 1972) with the uppermost Kasimovian of the Russian platform. *Triticites petschoricus* is found in beds of the same age in Timan in the northeastern part of the Russian platform (Rosovskaya, 1950). Of the other fusulinid species *Triticites* cf. sinuosus is characteristic of the Upper Kasimovian, *T.* cf. *primitivus* of the Upper Kasimovian - Lower Gzelian, *T.* ex gr. *karlensis* of the Lower Gzelian and *T.* ex gr. *variabilis* of the Lower Gzelian of the Russian platform (Rosovskaya, 1958). Other foraminifera have a wider age range that includes Late Carboniferous.

The age of the foraminifer assemblage can be constrained to the Late Kasimovian - Early Gzelian. Certainly the assemblage is not younger than Early Gzelian. Some samples contain *Ozawainella* and primitive *Schubertella* similar to the forms of the Moscovian stage, however these genera may extend into the Upper Carboniferous.

Summary and Conclusion

The Pulur Paleozoic sequence consists of two formations. At the base there is a 1100 m thick heterogeneous series of sandstone, limestone, quartzite, siltstone and shale called the Çatalçeşme Formation. Foraminifera from the limestones conclusively indicates a Late Carboniferous (Late Kasimovian - Early Gzelian) age. The Çatalçeşme Formation is conformably overlain by approxiamately 1000 m thick terrigenous reddish sandstones of latest Carboniferous and possibly Early Permian in age. Although the base of the Paleozoic sequence is not exposed, it is likely that it overlies unconformably the high-grade metamorphic rocks of the Pulur Massif, which outcrops in the overlying Aşutka thrust sheet (Fig. 1). The Pulur Massif consists mainly of cordierite-sillimanite-garnet gneiss, micaschist and amphibolite. Although its metamorphic age is not known it is probable that the high temperature - low pressure metamorphism is related to the earliest Carboniferous thermal event, which produced the Gümüşhane and Köse granodiorites in the Eastern Pontides (Bergougnan, 1987), and thus, it is Devonian or earliest Carboniferous age. Similar early Hercynian sillimanite-cordierite-bearing gneisses and migmatites and intrusive plutons are reported from the Greater Caucasus (Forerange and Main Range zones) and from the Dzirula, Kharami and Loki salients of the Trans Caucasian Median Massif (Abesadze et al., 1982; Adamia et al., 1982; 1983). Furthermore Upper Carboniferous-Lower Permian fluviatile to terrigenous facies, similar to those of the Pulur region, are widespread in the Greater Caucasus (Khain, 1975; Adamia et al., 1982). Thus, the Upper Paleozoic Pulur sequence shows many affinities with those of the Caucasus realm, which represent molasse deposition at the end of the Hercynian orogeny and can be compared with the European Rotliegende. This, together with the Euramerian affinity of the Upper Carboniferous plant fauna from the Çatalçeşme Formation (R.N. Wagner in Şengör, 1990) suggest that the Eastern Pontides were located along the southern margin of Eurasia during the Late Paleozoic.

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