Depositional setting of the Upper Cretaceous rudist-bearing carbonate-platforms along the Pontides magmatic-arc complex, Turkey

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The Pontide orogenic belt consists of three zones (or terranes) showing the Laurussian affinities such as the Strandja, İstanbul and Sakarya located north of the northern branch of the Neo-Tethys and is comparable to the tectonic units in the Balkans and the Caucasus. The Strandja Massif is bounded in the south by a Tertiary Thrace Basin and in the east West Black Sea Basin. The İstanbul zone is separeted from the Sakarya zone along the Intra-Pontide suture in the south. The Pontide belt is separated by the İzmir-Ankara-Erzincan suture from the Kırşehir Massif and the Anatolide-Tauride Block. Due to the closure of the Intra-Pontide ocean and opening of the Black Sea, these three zones were amalgamated into a single plate and also a very large body of ophiolite and ophiolitic melange were emplaced over the Anatolide-Tauride block presenting a highly sheared Cretaceous accretionary complex during the mid Cretaceous. The Black Sea formed as an oceanic backarc basin during the Cretaceous in the north of the Pontide magmatic arc because of the subduction of the northern Neo-Tethyan ocean. Although the Strandja and İstanbul Zones consist of volcanic rocks and volcanoclastic sequences, the well-developed outcrops of the pyroclastic rocks, submarine lavas intercalated with the pelagic sediments can be observed in the Eastern Pontides.

The objective of this study is to represent the depositional settings of the rudist-bearing carbonate sequences related with the Pontides volcanic-arc complex. Although, the geological maps of the rudist-bearing formations are prepared, the study is mainly based on the detailled measured stratigraphic sections.

The Strandja Massif in Turkey consists of a late Variscan-crystalline basement unconformably overlain by a Triassic-Jurassic metasedimentary continental to shallow marine carbonates sequences. The metamorphic rocks of the Strandja Massif are unconformably overlain by Upper Cretaceous neritic and pelagic sedimentary rocks, volcaniclastics and volcanic rocks, which exposed around İğneada (Black Sea coast) and north of the Strandja Zone, very close to the Turkey-Bulgarian border. The base of the Upper Cretaceous sequence consists of reddish-brown alluvial conglomerates, sandstones and mudstones passing upward dark grey, greyish-blue, shallow-marine sandstones. The lower part of the sandstones contain grey, greyish-blue, rudist-bearing limestones. The carbonate-rich levels of the sandstones yield benthic foraminifers (especially Orbitolina) suggesting a Cenomanian (probably early) age. They are followed up greyish, pelagic mudstones, siltstones and micritic limestones. The preliminary results of the planktonic foraminifers suggest a Senonian (?Turonian-Santonian-Campanian) age for the pelagic sediments, which also contain Radiolaria sections. Up section of the sequence consists mainly of andesitic tuffs, agglomerates and basalts interclated with the pelagic mudstones, volcanic sandstones showing the lamination, cross-bedding, slumps and bioturbation structures indicating turbiditic activity during the deposition of the volcanosedimentary sequnce. Towards the upper part of this sequnce, the shallow marine sandstones and sandylimestones with rudist fragments showing a very limited lateral extension and thickness can be observed above the basalts.

The Upper Cretaceous volcanosedimentary sequence of the Strandja Zone was deposited in an intra-arc basin, together with its western continuation Srednogorie Zone, above the northward-subduction Vardar-Intra-Pontide ocean. The lithologic and sedimentologic features show that the Upper Cretaceous sequence of the Strandja Zone started to develope on the low relief of the carbonate ramp

characterizing by the shallow marine clastics grading to low energy basinal mudstones. Due to the submarine volcanic activity, this basin was filled by the volcanic rocks interclated with the pelagic sediments. The presence of the sandy limestones with rudists above the basalts indicate that the development very limited shallow marine conditions due to the pausing of the volcanic activity. The carbonate-platform sequences are very limited in the Strandja zone because of the intense volcanic activity and/or rapid subsidence inhibiting the carbonate sedimantation and the steep bathymetric profiles of the basin resulting the little available substrate for shallow-marine carbonate sedimantation. The absence of the shallow-marine carbonates in the Srednogorie Zone-Bulgaria, which is the western continuation of the Strandja Zone, may be support this assumption.
The rudist-bearing Upper Cretaceous sequences are observed around Hereke (Kocaeli Peninsula), Düzce and Bolu areas in the İstanbul Zone. The transgressif systems tract of the uppermost Senonian are well-exposed in the Kocaeli Peninsula and unconformably overlie the Triassic and Lower Cretaceous limestones and conglomerates. The lower part of the sequence consists of reddish conglomerates, sandstones and mudstones showing vertical and lateral transition with rudist-bearing limestones. The rudist fauna consists of essentially by the radiolitids, life in position, however the hippuritids are also observed, indicating a late Campanian age. The rudist-bearing limestones pass upward the pelagic mudstones containing some tuff levels. The pelagic part of the sequnce is very thick and yields a planktonic fauna ranging from latest Campanian-Maastrichtian-Danian to Tanetian. In the Düzce area, around Konuralp, same transgressive sequence can be observed, but Danian and Tanetian are absent, while in the north of the Bolu area, around Yığılca, the late Campanian-Maastrictian rudist-bearing limestones developed above the Santonian-Campanian volcaniclastics and pelagic mudstones.
The transgressive facies of the Kocaeli Peninsula and also Düzce area show an energy gradient on the distally steepened carbonate ramp ranging from high energy shore to shallow marine, which was formed along a very narrow belt probably on the topographic uplift of the backarc basin and low energy basin environments, but containing minor products of the volcanic activity. However, the Upper Cretaceous submarine volcanics and pelagic sediments of the Yığılca (Bolu) area indicate the presence of the basin, may be a graben, towards to north, in filled depocenters can provide some substrate for shallow-marine rudist-bearing carbonate sedimentation.

The Upper Cretaceous carbonate platforms with rudists are widely exposed in the central and eastern Pontides of the Sakarya Zone when compared with those of Strandja and İstanbul Zones, deposited at three different settings in the forearc basin as follows:
a) carbonate platforms on accretionary complex: Amasya area is the best example of the rudist-bearing carbonate platforms, which developed on the accretionary complex in the Pontides. The basement rocks in the Amasya and surroundings area consists of metamorphic rocks, Jurassic-Lower Cretaceous platform type carbonates, Lower Cretaceous pelagic carbonates and Upper Cretaceous ophiolitic mélange composed of spilitic basalts, olistostromes, peridodites and Jurassic to Lower Cretaceous shalow-marine huge carbonate blocks showing imbricated structure. A transgressive sequence starts with fluvial reddish clastics over this basement and grades into sandstones and rudist-bearing limestones. The biostromes constucted by hippuritids are common; the corals, red algae and some bivalvias are also observed. Strontium-isotope analysis of the rudist shells suggest an early Campanian age, which is the oldest age for the transgressif sequence in the central and eastern Pontides. The shallow-marine limestones pass upward to volcanogenic flysh type rocks consisting of alternation of sandstones-pelagic mudstones and limestones, which include volcanic interclations and blocks of limestones with rudists. The planktonic foraminifers indicate a late Campanian-Maastrichtian age for the volcanogenic flysch type rocks. The upper part of the sequence is

characterized by volcanic breccias, volcanic rocks, tuffs and pyroclastic rocks showing very wide distribution in the Amasya area.
In the eastern of Kastamonu, over the accretionary complex determined, the similar lower part of the transgressif sequence of the Amasya area, consisting of clastics and rudist-bearing limestones, can be recently observed.
The stratigraphic and sedimentologic features indicate that the tectonic uplift of the accretionary complex in the central Pontides, allowed to development of the fluvial clastics and the shallow-marine carbonates passing to pelagic mudstones during the early Campanian. This transgressif sequence was developed on a gently sloping, distally steepened carbonate ramp on the northern part of the accretionary complex. However, the carbonate sequnces on the accretionary complex are not thick reflecting the relatively a very short life of the carbonate ramp changing a very thick to the volcaniclastic rocks of the volcanic arc filling the forearc basin due to the subsidence and uplift.
b) carbonate platforms on basin deposition: In the Sinop, Tokat, Trabzon and Bayburt areas, 20 to 120 m thick, 100 to 500 m wide and 500 to 2000 m long platform type carbonate successions developed over the volcaniclastics and pelagic sediments, are observed. These carbonates characterize by the canaliculate rudist biostromes, patch reefs and buildups causing the high porosity and pass upward and also laterally to pelagic mudstones and carbonates. These data indicate that the forearc basin is largely filled with sediment and generally flat and broad substrates developed allowing to form isolated carbonate platforms.
c) small carbonate platforms above volcanic rocks/edifices: Some meters thick, lenticular rudist-bearing shallow marine carbonates developed on the volcanic rocks can be observed in the north of Amasya, around of Gölköy-Ordu and Şebinkarahisar-Giresun. The presence of canaliculate rudists life in position and benthic foraminifers red algae, gastropods and echinids indicate that when the arc volcanism diminishing the limited shallow marine conditions and rudist buildups can be developed above the volcanic edifices.
These data show that the rudist-bearing Upper Cretaceous carbonate-platforms develop in the three zones of Pontide orogenic belt showing different depositional settings and platform types.

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