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CRETACEOUS AND TERTIARY TECTONOMETAMORPHIC EVENTS IN RHODOPE ZONE (GREECE). PETROLOGICAL AND GEOCHRONOLOGICAL EVIDENCES

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ABSTRACT

The Rhodope zone comprises pre-Alpine and Alpine lithologies and is conventionally divided in two tectonostratigraphic units: the lower and the upper ones.The Upper tectonic Unit was involved in a compressional tectonic event in the Early Cretaceous. Parts of this unit reached a maximum depth of ≈ 57km (16 kbar) and were heated to a temperature of ≈ 750°C, at that time. Exhumation was initially relatively slow accompanied by continuous cooling. The exhumation rate increased during Early Paleocene time. The Upper tectonic Unit reached the surface earlier than the Middle Eocene. The Lower tectonic Unit was involved in a compressional tectonic event in the Tertiary (early Eocene?). During this event it reached a maximum depth of ≈ 53 km (15 Kbar) in eastern Rhodope and more than 68 km (minimum pressure 19 kbar) in central Rhodope (Thermes area) and was heated up to a temperature of ≈ 550°C and > 700°C respectively. A fast exhumation is indicated by the isothermal uplift path from its maximum depth up to a depth of < 25 km. In both tectonic units uplift is earlier in their eastern part than in their western ones.

KEY WORDS: Cretaceous, Tertiary, tectonometamorphic events, petrological, geochronological data, Rhodope zone.

1. INTRODUCTION

The Rhodope zone represents an assemblage of fault-bounded metamorphic terrains containing pre-Alpine continental lithologies, intensely reworked during Alpine events by plastic deformation.

The Greek part of the Rhodope has been subdivided into an Upper and a Lower tectonic Unit (Papanikolaou and Panagopoulos, 1981; Mposkos, 1989; Mposkos and Liati, 1993). The two units record three successive metamorphic events: a high-P metamorphism, followed by medium-P and low-P metamorphism (Mposkos, 1989, 1994; Liati and Mposkos 1990; Mposkos and Liati, 1993). The medium-P metamorphism in the Upper tectonic Unit (U.T.U.) is chatacterised by upper amphibolite facies conditions while in the Lower tectonic unit (L.T.U.) by upper greenschist-lower amphibolite facies conditions.

In eastern Rhodope the HP-metamorphism of the U.T.U. occurred during the Early Cretaceous. This is evidenced by a Sm-Nd garnet-clinopyroxene-whole rock age of 119 Ma of a spinel-garnet-pyroxenite (Wawrzenitz and Mposkos, 1997). A MP-metamorphism in the Early Paleocene, is evidenced by a Rb-Sr muscovite age of 65 Ma from a pegmatite of the same area (Mposkos and Wawrzenitz, 1995). In the L.T.U., a Rb-Sr phengitic white mica age of 37 Ma from a mylonitic orthogneiss (Wawrzenitz and Mposkos, 1997) constrains the minimum age for the Alpine HP-metamorphism. Gebauer and Liati (1996), based on U-Pb SHRIMP data of zircons from a kyanite eclogite and the hosting gneisses from Thermes

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area, proposed a Late Eocene age (40 Ma) for the HP-metamorphism in central Rhodope. The area of Thermes was supposed to belong to the U.T.U. (Sideronero unit) of the western Rhodope (Papanikolaou, 1984; Mposkos and Liati, 1993). However U-Pb monazite ages of ca 55 Ma from migmatitic gneisses of the U.T.U. from central Rhodope (Jones et al., 1994) and Rb-Sr muscovite age of ca 50 Ma from a pegmatite of the upper plate (U.T.U.) of Thasos island (Wawrzenitz et al., 1994), give an Early Eocene age for the MP-metamorphism.

The geochronological data indicate that the tectonometamorphic evolution of the U.T.U. and L.T.U. from eastern Rhodope comprises two distinctive events and that the U.T.U. from western and central Rhodope (Sideronero Unit of Papanikolaou, 1984), shows a more complex tectonometamorphic history. It includes lithologies recording a MP-metamorphism in Early Eocene time and other lithologies recording a HP-metamorphism in Late Eocene time. The geochronological data from Gebauer and Liati (1996), support a contemporaneous tectonometamorphic evolution of Thermes area (previously U.T.U.) and the L.T.U. from eastern Rhodope. The petrological data presented in this study support, this view.

In the present work the implication of the various tectonic units extending eastwards of Xanthi in the tectonometamorphic history of the Rhodope zone, is studied, based on the available petrological and geochronological data. The area extending between Iasmos and Kardamos (Fig. 1), is especially studied. This area was previously included in the U.T.U. (Mposkos and Liati, 1993), but here is treated as a separate tectonic unit. New petrological data, presented in this work, suggest a separate tectonometamorphic history for the Iasmos-Kardamos area and the overlying U.T.U.

2. PETROLOGY OF THE UPPER TECTONIC UNIT

A simplified geological map of eastern and central Rhodope showing the various tectonic units is presented in figure 1. The U.T.U. consists of migmatitic gneisses and metapelites, with intercalations of amphibolites, eclogite-amphibolites and marbles. Small ultramafic bodies occur in many places. Widespread muscovite-bearing pegmatites cross-cut all lithologies.

In eastern Rhodope the HP-metamorphism is constrained by the presence of spinel-garnet-metaperidotites with the HP-assemblage Grt (Grs_{13-15} Prp_{58-66} Alm_{21-29} $Sps_{0.4-1.6}$)-Cpx-Ol($Fo_{0.9}$)-Cr-Spl (abbreviations after Bucher and Frey, 1994), and eclogite-amphibolites with relics of the HP-assemblage Grt-Cpx(Jd_{25})-Qtz-Czo-Rt±Ky. P-T conditions of 13.5-16 kbar and 750-775°C are estimated for the HP-event (Mposkos, 1994). Sm-Nd garnet-clinopyroxene-whole rock geochronology from a garnet-spinel-pyroxenite from the Kimi area (Fig. 1) yield a Lower Cretaceous age (119 Ma) for the HP-event (Wawrzenitz and Mposkos, 1997). The successive stages of decompression (Fig. 3) are recorded in the various hydration reactions observed in metapelites, gneisses, metabasites and metaperidotites (Mposkos, 1994; Mposkos and Liati, 1993). Decompression was relatively slow as is evidenced by the Rb-Sr muscovite age of a pegmatite of 65 Ma (Mposkos and Wawrzenitz, 1995), recording the MP-amphibolite facies overprint.

In Iasmos area, the HP-metamorphism is documented in a partially alltered eclogite (Fig. 1 locality A) associated with a serpentinised peridotite. The HP-relics are Grt-Zo-(high Al)Ttn-Rt. Depending on the bulk rock composition the composition of garnet varies from Grs_{28} Prp_{29} Alm_{40} Sps_3 to Grs_{20} Prp_{40} Alm_{37} Sps_3 with higher pyrope component in the more Mg-rich samples. Garnet shows resorbed edges and is replaced by hornblende. Clinopyroxene is completelly consumed by the overprinting hornblende. High-Al titanite with a chemical composition SiO_2 31.31-31.59%, TiO_2 28.37-28.50%, Al_2O_3 7.92-8.32%, Cr_2O_3 0.8-1.06%, CaO 29.11-29.36% is present as inclusions in hornblende. High-Al titanite is known as a HP-mineral (Smith, 1988). It is recorded for the first time in the HP-rocks of Rhodope.

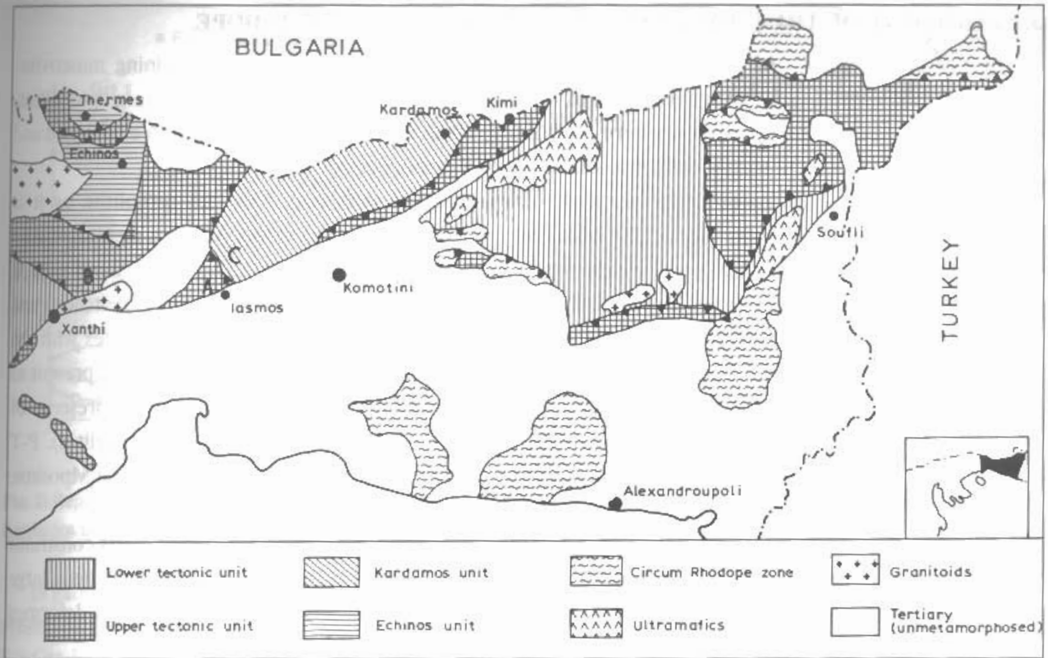

Fig. 1: Simplified geological map of Rhodope showing the various tectonic units east of Xanthi. In the area north of Xanthi, the U.T.U. corresponds to the Siroko nappe, and the Echinos unit corresponds to the nappes of Echinos, Konstantini and Kidari of Koukouvelas and Doutsos (1990).

NE of Xanthi, the HP-metamorphism of the U.T.U. is documented by the presence of eclogite-amphibolites (Liati, 1986) occurring as lensoidal bodies within migmatitised kyanite-bearing metapelites. In this area the metaperidotite near the Gorgona village (Fig. 1, locality B) with the mineral assemblage Ol-Opx-Tr-Chl-Spl-Tlc-Dol-Mgs-Chr records the prograde stage of the HP-event and successive stages of decompression. Olivine (Fo0.9) and orthopyroxene (En0.94) form cm scale crystals, containing tremolite and chromite inclusions. Orthopyroxene also often contains inclusions of olivine (with rosorbed edges) and chlorite. Chlorite inclusions in orthopyroxene are Cr-bearing penninite (chlorite1) having a chemical composition $(Mg_{9.76}\ Fe_{0.46}\ Cr_{0.48}Al_{1.28})\ (Si_{6.25}\ Al_{1.75})O_{20}\ (OH)_{16}$. Tremolite is often aluminous with Al_2O_3 content ranging from 0.41-3.83%. A second chlorite generation (chlorite2) associated with spinel, tremolite and dolomite is formed replacing olivine and an aluminous phase, probably garnet. Chlorite2+spinel are often found as rounded aggregates pseudomorphosing a previous garnet. Clinopyroxene is not present in the metaperidotite. The composition of chlorite2 is $(Mg_{9.36}\ Fe_{0.38}\ Cr_{0.12}\ Al_{2.18})\ (Si_{5.61}\ Al_{2.39})\ O_{20}\ (OH)_{16}$ and that of spinel $Mg_{0.60}\ Fe_{0.40}\ Cr_{0.29}\ Al_{1.71}\ O4$. Textures and mineral assemblages in the metaperidotite indicate that prograde metamorphism reached the P-T field of garnet peridotite, within the stability field of chlorite and tremolite+olivine. Minimum pressure of 13 kbar is constrained from the maximum jadeite component $(Jd_{0.25})$ in associated, partially amphibolitised eclogites (Liati, 1986). Minimum temperatures of 650°C (for P=13 kbar) are calculated with the GEO-CALC program for orthopyroxene formation according to the reaction $Fo_{0.9}$ + Tlc ° $En_{0.95}$ + H_2O. Maximum temperatures of 750°C are constrained from the presence of tremolite+olivine inclusions in orthopyroxene (Jenkins, 1981). Chlorite2+spinel intergrowths are replacing olivine and probably garnet during decompression. Talc is often associated with dolomite and is replacing olivine, tremolite and orthopyroxene in a retrograde stage.

In the area NE of Xanthi the successive stages of decompression of the U.T.U. are well recorded in staurolite and sillimanite forming reactions in the associated kyanite bearing metapelites (Mposkos and Liati, 1993). The uplift path of the U.T.U. in Xanthi area is shown in Figure 3.

3. PETROLOGY OF THE LOWER TECTONIC UNIT IN EASTERN RHODOPE.

In eastern Rhodope, the L.T.U. consists of orthogneisses, metamigmatites (containing muscovite-metapegmatite lenses), pelitic gneisses, high alumina metapelites, eclogites, eclogite-amphibolites, amphibolites and marbles. Marbles are very rare. Large ultramafic bodies associated with eclogitised and amphibolitised gabbros are tectonically intercalated within orthogneisses and metapelites.

The orthogneises, the metamigmatites and metapegmatites represent Variscan protoliths, as it is verified by the Rb-Sr muscovite age of 334 Ma from a metapegmatite occurring within a metamigmatite (Mposkos and Wawrzenitz, 1995), and by the Rb-Sr whole rock age of 308 Ma and U-Pb zircon ages of 319-296 Ma from orthogneisses of the Bulgarian part of the L.T.U. (Peitcheva et al., 1992; Peitcheva and Quadt, 1995). In the L.T.U. the HP-metamorphism is documented by the presence of eclogites with the mineral assemblage Grt+Omp(Jd_{35-55})±Ky+Tr+Hbl+ Czo+Qtz+Rt±Phe. Blue amphibole is only present as inclusions in garnet. In the orthogneisses and metapelites the HP-event is documented by the presence of phengite (up to 7 Si atoms p.f.u. in orthogneisses and up to 6.85 Si atons p.f.u. in metapelites). P-T conditions of 14-15 kbar and ca 550$^{\circ C}$ are estimated for the HP-event (Mposkos, 1989; Liati and Mposkos, 1990).

A Rb-Sr age of white mica (sieve fraction > 500 μm) of 37 Ma from a mylonitic orthogneiss constrains the minimum age of Alpine HP-metamorphism (Wawrzenitz and Mposkos, 1997). In the orthogneiss large metamorphic pre-mylonitic phengites (>500 μm) crystallised during the HP-stage and were deformed during MP-mylonitisation (Mposkos, 1989).

The uplift path (Fig. 3) is well constrained by staurolite and andalusite forming mineral reactions in the metapelites (Mposkos, 1989; Mposkos and Liati, 1993). Decompression was nearly isothermal, indicating a rapid uplift.

4. KARDAMOS UNIT

The area extending between Iasmos and Kardamos is studied in the present work as a separate unit temporarilly called "Kardamos unit". It is overlain tectonically to the east as well as to the west by the U.T.U. (Mposkos, 1989), (Fig. 1). In the Kardamos unit, large bodies of orthogneisses accompanied by paragneisses and metapelites represent the lower lithologies. They are overlain by alternating pelitic gneisses amphibolites and marbles. The paragneisses and the associated metapelites probably represent pre-Alpine migmatites intensely reworked during Alpine orogenesis. Despite intense and penetrative deformation and recrystallisation leucocratic quartzofeldspathic and melanocratic bands of the previous migmatites are still visible. Deformed metapegmatites are also present. Along the Kompsatos river, NE of Iasmos, pre-Alpine pegmatites are isoclinally folded with the hosting gneisses.

In western part of the Kardamos unit a lower amphibolite facies of the Alpine overprinting metamorphism is observed, indicated by the mineral assemblages Grt-Ms-Bi-Ab(An_{0-3})-Olg(An_{14-18})±Kfs+Qtz in pelitic gneisses, Grt-St-Chl-Ms-Bi-Qtz±Pl in metapelites and Grt-Hbl-Bi-Czo-Ab(An_{1-4})-Olg(An_{17-21}) in metabasites. Albite appears as porphyroblasts having numerous inclusions of garnet, muscovite, clinozoisite and quartz. It is commonly surrounded by a thin zone of oligoclase (An_{18-25}). Albite coexisting with oligoclase is a common feature in many lithologies of the L.T.U.

In garnetiferous migmatitic gneisses NE of Iasmos (Fig. 1, locality C) the pre-Alpine paragenesis is still preserved. It is represented by the mineral assemblage: Grt(Grs_7 Alm_{72} Pyr_{18} Sps_3) - Bi±Ky-Cum-Pl($An4_{0-33}$)-Kfs-Qtz-Rt. The paragenesis Grt-Bi-Ky-Kfs and the presence of cummingtonite indicate upper amphibolite facies conditions (Bucher and Frey, 1994). Alpine overprinting is indicated by the growth of new garnet, kyanite, zoisite, staurolite, chlorite, plagioclase (An_{19-25}), anorthitic plagioclase (An_{78-96}) ± margarite. Alpine garnet has a grossular content two to five times higher than the pre-Alpine one (Fig. 2).

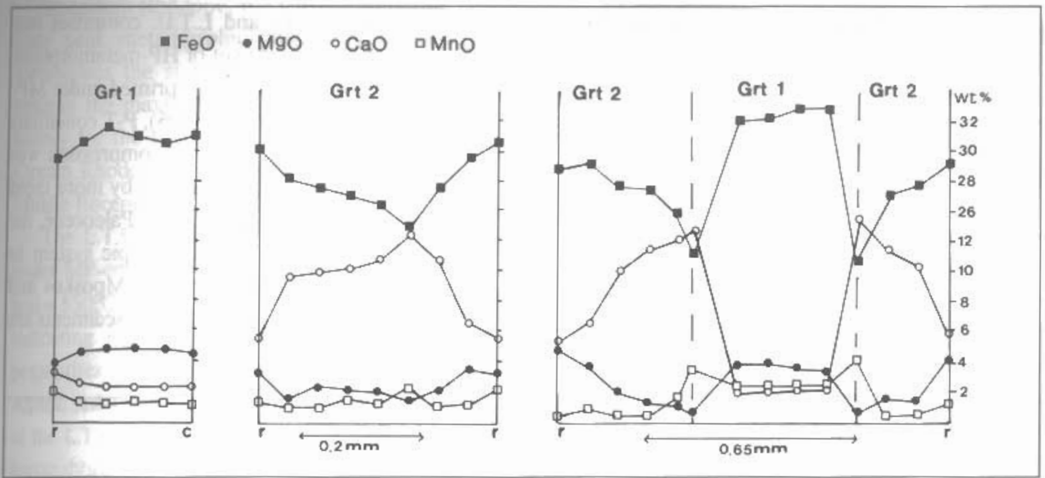

Fig. 2: Representative zoning profiles of pre-Alpine (Grt1) and Alpine (Grt2) garnet from pelitic metamigmatites of the Kardamos unit (Fig. 1, locality C). Alpine garnet shows a typical "growth zoning" patern. c=core, r=rim.

In garnetiferous migmatitic gneisses NE of Iasmos (Fig. 1, locality C) the pre-Alpine paragenesis is still preserved. It is represented by the mineral assemblage: Grt(Grs_7 Alm_{72} Pyr_{18} Sps_3) - Bi±Ky-Cum-Pl(An_{40-53})-Kfs-Qtz-Rt. The paragenesis Grt-Bi-Ky-Kfs and the presence of cummingtonite indicate upper amphibolite facies conditions (Bucher and Frey, 1994). Alpine overprinting is indicated by the growth of new garnet, kyanite, zoisite, staurolite, chlorite, plagioclase (An_{19-25}), anorthitic plagioclase (An_{78-96}) ± margarite. Alpine garnet has a grossular content two to five times higher than the pre-Alpine one (Fig. 2). It shows a compositional zoning with increasing FeO and MgO content and decreasing CaO content from the core to the rim, indicating garnet growth with increasing grade of metamorphism. The composition of garnet core is Grs_{38} Alm_{50} Prp_7 Sps_5 and that of the rim is Grs_{17} Alm_{64} Prs_{16} Sps_3. Alpine garnet often overgrows pre-Alpine garnet, as it is well demonstrated in compositional garnet profiles (Fig. 2). Similar zoning patterns of garnet are observed in Variscan migmatites from the L.T.U. in eastern Rhodope overprinted by the Alpine metamorphism (Mposkos and Wawrzenitz, 1995, Fig. 3A).

Garnet-plagioclase geobarometry yielded pressures between 13 and 16 kbar for an assumed temperature of 600°C (Mposkos, in preparation), indicating that Alpine overprinting occurred at high pressures. The presence of staurolite+chlorite+garnet limits the peak temperature above 560°C and below 620°C (Vuichard and Ballevre, 1988; Bucher and Frey, 1994). Decompression crossed the stability field of anorthitic plagioclase (An_{78-96}) and that of margarite+anorthite. Anorthitic plagioclase (An_{80}) is observed in mutual contact with corroded grains of kyanite and zoisite, supporting formation of anorthite by the reaction Zo+Ky+Qtz —> An+W. This reaction occurred at pressures of ≈ 8 kbar within the stability field of Grt+St+Chl (Fig. 3) indicating a nearly isothermal decompression of the Kardamos unit. At still lower pressure anorthite+margarite are formed possible according to reaction Zo+Ky —> Mar+An.

In metapelites the pre-Alpine metamorphism is represented by the mineral assemblage Grt-Ky-Bi. Alpine staurolite replaces garnet and kyanite according to hydration reactions Grt+H2O —> St+Chl+Qtz or Ky+Bi+H2O —> St+Ms+Qtz (Mposkos and Liati, 1993).

In the eastern part of the Kardamos unit a higher grade of Alpine overprinting is recorded. In high-alumina metapelites, staurolite coexists with garnet and biotite, indicating middle amphibolite facies metamorphic conditions.

5. DISCUSSION AND CONCLUSIONS

The petrological and geochronological evidence revealed that the Rhodope zone comprises pre-Alpine and Alpine lithologies and shows a complex tectonometamorphic evolution during the Alpine orogeny.

In eastern Rhodope, the tectonometamorphic evolution of the U.T.U. and L.T.U. comprises two separate orogenic events. The U.T.U. was involved in an Alpine metamorphic event of HP-metamorphism in the Lower Cretaceous (Wawrzenitz and Mposkos, 1997) and was extensively overprinted under MP-conditions in Upper Cretaceous-Lower Paleocene time (Mposkos and Wawrzenitz, 1995). P-T conditions of 13,5-16 kbar and 750-775°C are estimated for the HP-event (Mposkos, 1994). Decompression was initially relatively slow and was accompanied by continuous cooling. It was then followed by more rapid uplift during MP-stage indicated by the steepening of the uplift path (Fig. 3). In the Lower Paleocene, the U.T.U. had a minimum temperature of 500°C (closure temperature of the Rb-Sr isotopic system in muscovite, Jager, 1979), verified by the Rb-Sr muscovite age of 65 Ma of a pegmatite (Mposkos and Wawrzenitz, 1995). The U.T.U. reached the surface before the Middle Eocene since Lutecian sediments are lying transgressively over it (Papadopoulos, 1997).

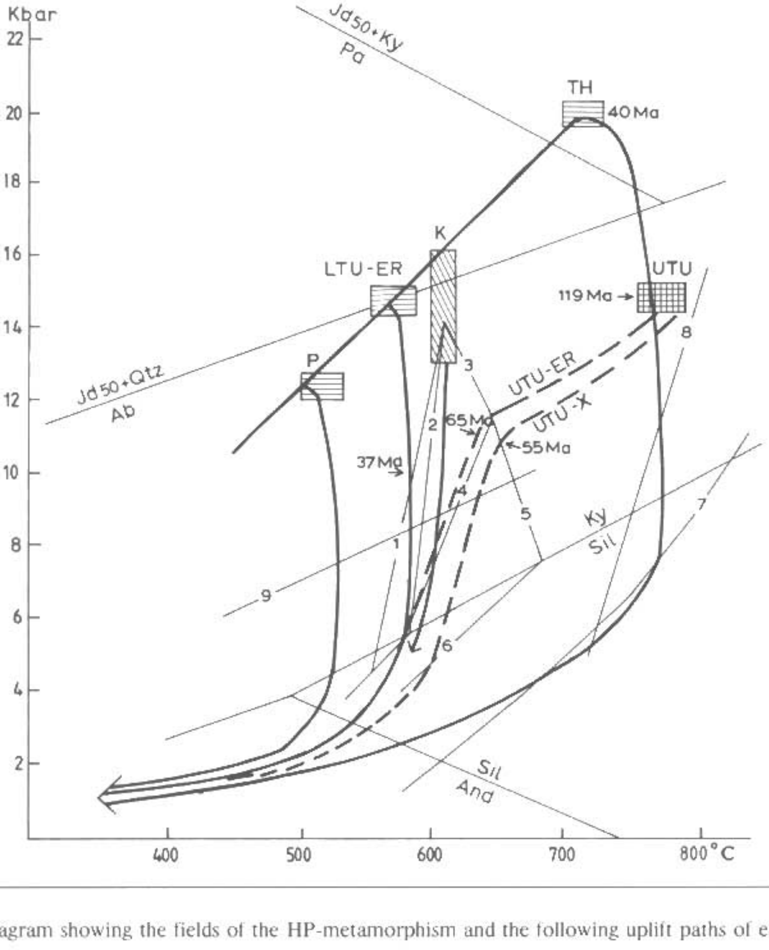

Fig. 3: P-T diagram showing the fields of the HP-metamorphism and the following uplift paths of eastern and central Rhodope during Lower Cretaceous and Tertiary orogenic phases. P=Pangeon unit, L.T.U.-ER=lower tectonic unit in eastern Rhodope, K=Kardamos unit, TH=Thermes area. U.T.U.-ER=Upper tectonic unit in eastern Rhodope, U.T.U.-X=Xanthi area. 1=Ctd+Ky—>St+Chl, 2=Ctd—>St+Grt+Chl, 3=St—>Grt+ Ky+Chl, 4=Grt+Chl+Ms—> St+Bi, 5=St+Ms—>Ky+Bi+Grt (from Vuichard and Ballevre, 1988), 6=St+Ms—>Grt+Sill+Bi (from Powell and Holland, 1991), 7=Ms+Qtz—>Als+Kfs+W (from Bucher and Frey, 1994), 8=Chl+Crn+Spl—>Spr+W (from Ackermand et al., 1975), 9=Zo+Ky+Qtz—>An80+W calculated with the GEO-CALC program. Ulpift paths of U.T.U.-ER, L.T.U.-ER, and P from Mposkos (1994).

In eastern Rhodope, the Circum Rhodope zone lies tectonically over the U.T.U. In Circum Rhodope zone peak metamorphic conditions reached the lower greenschist facies (Papadopoulos, 1997). In metabasites the stable mineral assemblage is Chl+Ep+Act+Ab and in metapelites Chl+Ms+Kfs+Qtz limiting the maximum temperature to ≈ 400°C. These data preclude a common tectonometamorphic history for the U.T.U. and the Circum Rhodope zone during Lower Paleocene time. Overthrust of the Circum Rhodope zone over the U.T.U. occurred in a time later than Early Paleocene and earlier than Middle Eocene, since Middle Eocene sediments lie transgressively over both units (Papadopoulos, 1997).

The L.T.U. of eastern Rhodope is involved in an Alpine event of HP-metamorphism, overprinted under MP-conditons in the Late Eocene (Wawrzenitz and Mposkos, 1997). P-T conditions of 14-15 kbar and ≈ 550°C are estimated for the HP-stage (Mposkos 1989, 1994). Decompression was nearly isothermal indicating a rapid uplift (Fig. 3). Pre-Alpine continental crust involving Variscan migmatites and pegmatites and large granitoid bodies (Mposkos and Wawrzenitz, 1995; Peitcheva et al., 1992) as well as Alpine sediments and oceanic crust and mantle are involved in the Tertiary tectonometamorphic history of the L.T.U. An Alpine age for the protoliths of the oceanic crust and mantle (pelitic metasediments and metagabbros associated with metaperidotites) is suggested from petrological data. These rocks contain only mineral assemblages from the Tertiary metamorphic cycle. No relic minerals or texrures indicating the pre-Alpine HT-metamorphism, like those observed in the metamigmatites and metapegmatites, are present in these rocks. The Rb-Sr age of white mica of 37 Ma from a mylonitic orthogneiss containing HP-phengites (Wawrzenitz and Mposkos, 1997), constrains the minimum age for the HP-event as Late Eocene. Since uplift of the L.T.U. was relatively rapid, as it is indicated by the isothermal decompression path, it is estimated that underthrusting of the L.T.U. under the northward located continental crust occurred in the Tertiary, possibly in the Early Eocene.

In Kardamos unit the pre-Alpine HT-metamorphism is still preserved in metamigmatites and metapelites. Alpine overprinting includes a HP-stage followed by a MP-stage. P-T conditions of 13-16 kbar and ≈ 600°C are estimated for the HP-stage in the western part of the Kardamos unit. Decompression was nearly isothermal (like that of the L.T.U.) indicating a rapid uplift (Fig. 3). For the MP-stage an increasing grade from lower amphibolite facies in west to middle amphibolite facies in north-east is recorded. The Kardamos unit is tectonically overlain to the east as well as to the west by the U.T.U. Therefore the geological boundary between the Kardamos unit and the L.T.U. is not visible. The petrological data presented, here, support the view that the Kardamos unit may represent the westward continuation of the L.T.U. from eastern Rhodope.

In central and western Rhodope, the metamorphic evolution and the grade of metamorphism in Pangaeon and Sideronero units of Papanikolaou (1984), is similar to that of the L.T.U. and U.T.U. of eastern Rhodope respectively. A HP- metamorphism followed by MP- and LP- metamorphism is recorded in both units (Mposkos and Liati, 1993; Mposkos, 1994). U-Pb monazite data from migmatitised gneisses from central Rhodope (Jones et al., 1994) and Rb-Sr muscovite data from a pegmatite from Thasos island (Wawrzenitz et al., 1994) yielded ages of ≈ 55 Ma and ≈ 50 Ma respectively for the MP-metamorphism of the Sideronero unit (U.T.U. according to Mposkos and Liati, 1993). These data record a younger age for the MP-metamorphism of the U.T.U. in central and western Rhodope than in eastern Rhodope, which was dated at 65 Ma according to Mposkos and Wawrzenitz (1995). An analogous evolution is recorded in the L.T.U. In Thasos island and Kavala area of western Rhodope, a Miocene age (23-18 Ma) is recorded for the MP-event by Rb-Sr dates of white mica (Wawrzenitz et al., 1994), U-Pb dates of titanite, and $^{40}Ar/^{39}Ar$ dates of hornblende (Dinter, 1994). In eastern Rhodope a Late Eocene age (39-37 Ma) is recorded for the same event by Rb-Sr white mica data (Peitcheva et al., 1992; Wawrzenitz and Mposkos, 1997).

Gebauer and Liati (1996), based on U-Pb SHRIMP data of zircons from a kyanite eclogite and its hosting gneiss from Thermes area (Fig. 1), proposed a Late Eocene age (40 Ma) for the HP-metamorphism in the U.T.U. of central Rhodope (Sideronero unit according to Papanikolaou, 1984). The age of 40 Ma indicates a tectonometamorphic history of Thermes area contemporaneous to that of the L.T.U. from eastern Rhodope. This arises the question whether the kyanite eclogite and the hosting gneisses belong to the Sideronero unit (U.T.U.) or represent the most deeper subducted part of the L.T.U. carried later tectonically over the Sideronero unit during exhumation. Koukouvelas and Doutsos (1990), distinguished in the broad area of Thermes four tectonic nappes; the dated kyanite eclogite belongs to their Echinos nappe. Liati and Seidel (1996), estimated minimum peak P-T conditions for the kyanite eclogite of Thermes at ≈ 19 kbar and 700°C. In the same locality Mposkos and Liati (1993), report the presence of prismatic sillimanite in pelitic gneisses having the mineral assemblage Grt-Ky-Sill-Bi-Pl-Kfs-Qtz-Rt indicating that the exhumation path of Thermes area crossed the stability field of sillimanite+K-feldspar (Fig. 3). The presence of sillimanite+K-feldspar in the metapelites indicates a nearly isothermal decompression from the maximum depth (>68 km) to a depth <25 km (see Fig. 3), supporting, a rapid exhumation. The fact that kyanite was not transformed to sillimanite, further supports a rapid uplift. A nearly isothermal decompression from the maximum depth of ≈ 53 km to ≈ 15 km and from ≈ 43 km to ≈ 15 km is also indicated from the uplift path of the L.T.U. in eastern and western Rhodope respecively (Fig. 3).

To sum up, the petrological and geochronological data indicate separate histories of subduction and denudation of the U.T.U. and the L.T.U. in Rhodope. The U.T.U. was involved in a compressional tectonic event in the Early Cretaceous reached at that time a maximum depth of ≈ 57 km (16 kbar) and was heated to a temperature of ≈ 750°C. Exhumation was initially relative slow accompanied by continuous cooling. It was then followed by more rapid uplift during the MP-stage. In eastern Rhodope the U.T.U. reached the surface later than the Early Paleocene and earlier than the Middle Eocene. The L.T.U. was involved in a compressional tectonic event in the Tertiary (early Eocene?) reached at that time a maximum depth of ≈ 53 km (15 kbar) in eastern Rhodope and more than 68 km (minimum P 19 kbar) in central Rhodope (Thermes area) and was heated to a temperature of ≈ 550°C and >700°C respectively. Exhumation was rapid as indicated by the isothermal uplift path from its maximum depth up to a depth of <25 km. In both tectonic units an earlier uplift is recorded in the eastern part of Rhodope than in the western one. The geochronological data from central and western Rhodope indicate that the "Sideronero" unit had not a single tectonometamorphic evolution during the Alpine orogeny. A combined detailed geochronological and tectonic work is needed to clarify which parts of the "Sideronero" unit were involved in the Cretaceous orogenic phase and which only in the Tertiary orogenic phase.

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