ON THE NEOGENE AGE OF THE EVAPORITES OF PALASA: A REVIEW[1]

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ABSTRACT

The present paper aims at dating the Palasa evaporites based of paleopalynological analyzes carried out in China from 1970-1971 without providing any conclusion, but complemented with additional data from current publications. Here, even a limited number of samples as there isn't any geological section would be sufficient. Evaporites are presented as tectonic blocks. Being situated at the foot of Çika Mountain (or West of Çika tectonic Belt), Palasa evaporites usually have been considered as part of Ionian tectonic zone. They have been reported to be from Permian-Triassic to Oligocene in age.
Keywords: Evaporites, Palasa, Neogene, Miocene, Pliocene, paleopalynology, microfauna

1. INTRODUCTION

The evaporitic formation could be found in the Ionian tectonic zone, the Peri-Adriatic Depression and in the Korabi tectonic Zone. The evaporites of the Ionian Zone that are exposed to the surface, especially in the Kurveleshi tectonic Belt, are Upper Triassic (Carnian) in age. The evaporites of the Peri - Adriatic Depression belong to the upper Miocene, while the evaporites in the Korabi tectonic zone are Triassic in age (Diamanti F., *et al*., 1999).

[1] The photos of the microfossils are copies from the catalog compiled by the Chinese scholars.
* Retired from the National Hydrocarbon Center.

Fig. 1: The Llogara Pass: The fault between Ionian tectonic zone (East) and Sazani-Karaburuni tectonic zone (West). Photo credited to the author (1968).

Palasa evaporite deposits emerge in the west of the Çika tectonic belt and extend from the Dhikle spring to the vicinity of Palasa. They appear in form of lenses (Shushkov and Tkaciev 1960) and small isolated blocks often covered by slope rubbles, which make them difficult to locate. Consequently, proving their existence in surface was impossible.

Although the location of the outcrop 511 described in (Shushkov and Tkaçiev 1960) was not found, the authors offer a compelling argument by providing a detailed information about microfauna (see the list of 511 outcrop determinations, volume II, dealing with a middle Miocene age). This new fact is upholding the age previously supposed by the presence of genus Tsuga in the published pollen determinations (Gjikopulli and Rama 1973), sample Nr 15, see below, and a means to address palynological studies to foster the age determination of these evaporitic deposits.

The samples Nr., 15; 16; 511 (microfaune) and the sample named *Burimi i Dhikles* (spring) and Vuno-1 have been analyzed. The samples nr. 15, and 16 have unknown coordinates. They were sampled in 1969, and information about them could be found in (Gjikopulli and Rama 1973). Although the coordinates of sample 511 are known, the author has not found it (the slope rubbles might be the source). The sample named, *Burimi i Dhikles*, (Fig. 5), was collected in 1972 (Muhameti P., Pejo I., 1974), from the spring with the same name (Fig. 2). The Fig. 6 depicts the position of the sample Vuno-1 as defined by the author .

Palasa region is geologically complex. In addition, different surfaces are covered by slope robbles making it even more complex. The complexity relates to the fault between Ionian and Sazani-Karaburunu Zones (Fig.1 and 2)

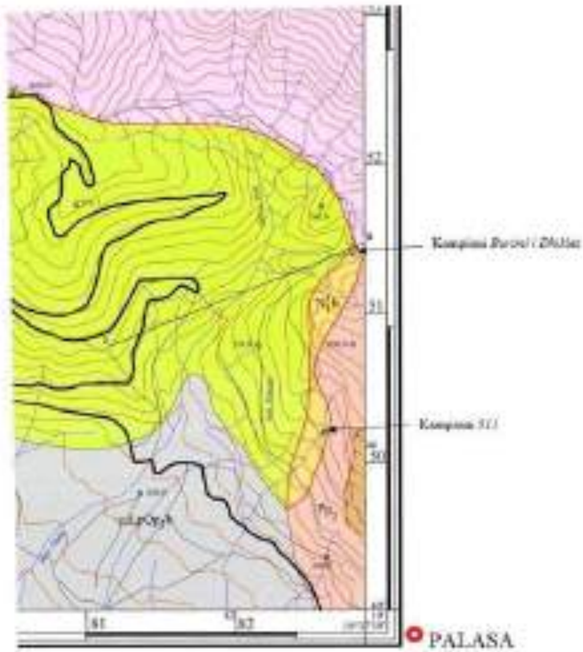

Fig. 2 Geological map NW of Palasa Village. (Albanian Geologic Service 2010), complemented by the author with the location of the sample named, *Burimi i Dhikles* (Muhameti and Pejo 1974) and the sample 511 (Shushkov and Tkaçiev, 1960).

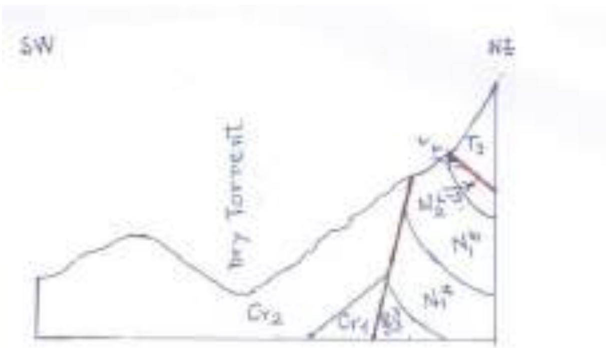

Fig. 3 B-B Cross-section, NW of Palasa Village
vvv Evaporites

History

In general, the Palasa evaporitic deposits are considered to have the same geological age with the evaporitic deposits of the Ionian zone (Mavrovi 2018), as they could be partly met near the fault between Upper Triassic dolomites and other different deposits.

Paleopalynological investigation of these evaporite deposits was first carried out in China in 1971, (samples 15, 16) without reporting their age. Information about some relevant analyses could be found in (Gjikopulli and Rama 1973) stating that the evaporitic deposits of Ionian zone (including those of Palasa) are Oligocene in age.

Due to the absence of flowering plants, our first paleopalynological study about the evaporitic deposits of the Ionian zone, defines the deposits of Palasa to be Jurassic-Lower Cretaceous in age, (but not reaching the Aptian age (Muhameti and Pejo 1974). We could explain by the time the only sample containing flowering plants as a result of contamination while collecting the sample for analysis.

Due to the lack of literature, the conclusion regarding their age remains unchanged (Muhameti *et al*., 1982; Diamanti *et al*.,1999).

Efforts have been made to define the age of Palasa evaporite deposits fifty years later. Table 1 is based on many papers from Italy and Greece (see below). The data in the Table 1 show that the appearance of *Dacrydium* in the region might date between the first appearance of Tsuga and the evaporitic thickness of Upper Miocene.

2. MATERIAL AND METHODS

The analytical investigation of samples 15 and 16 was carried out at the Palynologic Laboratory of the Institute of Mineralogy, Paywanchuang, Beijing, China. Laboratory investigation for pollen extraction involved the dark gray-dark green silts, avoiding colors resulting from oxidation processes as spores and pollen could be destroyed. The sample was collected from a depth of 20-25 cm to avoid any possible impact of water circulation and weathering processes' events. The laboratory extraction of the material from the rock required the use of hydrochloric acid (concentration rate not less than 10%) to eliminate the carbonate cement. Once rinsed by decantation to eliminate HCl, HF (concentration above 37%) was added to eliminate silica cement; rinsing by decantation; 200 microns mesh sieving. ZnCl2 heavy liquid centrifugation with specific gravity 2.1; 10 microns mesh sieving; rinsing and slide making was carried out. In concrete terms, for the samples of Butrinti-1/s that represented salt rocks mixed with clayey silt: the author applied the weight 800-1000gr (Shaffer 1964). Once the salt dissolved, the aforementioned procedure subsequently followed.

Detailed information about the aforementioned method could be found in (Shaffer 1964; Traverse 2007).

In addition, two other analyzes were carried out, but as the present paper aims at confirming the presence of flowering plants pollen although the negative outcome as reported in (Muhameti and Pejo 1974), these analyzes are not here reported.

Investigation on the samples collected from the wells was carried out:

Butrint-1 well, depths: 1703-1705m; 3020-3022, 1m; 3790-3791,7m; 3998-4000m. Pollen preparations were carried out at the Petroleum Geological Institute, Fier (1989) and used for the last interval. In addition, the author prepared new slides based on a greater weight for the first three intervals. Only at the interval depth 3020-3022.1m, a grain of *Corsinipollenites* was found.

Fig. 4: Geologic map at the scale 1:200 000, with the location of the wildcat Bu-1s.

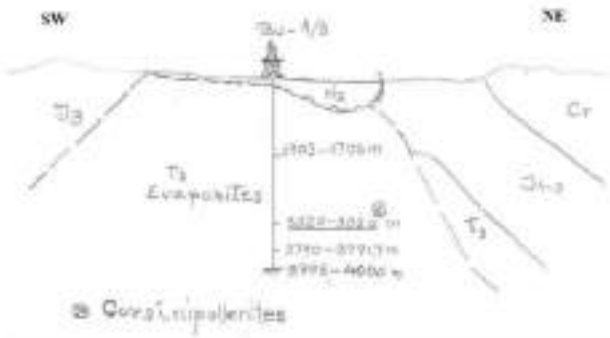

Fig.5: A-A Cross-section with evaporites penetrated by the wildcat Bu-1s (without scale). The geological profile is from the well file and sketched by the author.

No result has been reported for **Bogaz-1**: 2797-2801m.

In addition, a recrystallized globotruncanid foraminifer, typical of an age not older than Coniacian was found in a thin section resulting from a sample collected in Vuno (Vuno -1, Fig. 6) by Pëllumb Sadushi. Other sample containing pollen (Vuno-1) of genus Callialasporites was prepared, but this microfossil merely informs about the Mesozoic age.

Two samples investigated at the Palynologic Laboratory of the Institute of Mineralogy, Paywanchuang, Beijing, China were selected for reviewing purposes.

Fig. 6: The location of the sample Vuno-1, near the highway West of Vuno.

3. RESULTS

Regarding the palynological content of these two samples, the genera *Dacrydium* prevails (35%), but the flowering plants could be met in one sample only. The other sample consists mostly of unidentified tetrads. Muhameti and Pejo (1974) stated that the absence of flowering plants is a means to address the age of Palasa evaporitic deposits.

Locating the evaporitic deposits outcrops in the Palasa village for new samples was impossible. However, the age of the palynological complexes presented below was determined based on the existing literature.

1) Nr. 15- Sample containing flowering plants.

The microflora is rich and well preserved. In general, the pollen grains of gymnosperms prevail with 72%, followed by the angiosperm pollen with 21%. The following plants were particularly identified:

Pteridophyta

Selaginella-4; Selaginella? -4; Polypodiaceae -1; Dicksonia-1; Unidentified spores-5.

Gymnospermae

Ginkgo -5; Coniferae -4; Podocarpaceae -1; Dacrydium-58; Tsuga -2; Araucariaceae -1; Pinaceae -4; Picea -4; Pinus -8; Cedrus -15

Angyospermae

Liliaceae -1; Betulaceae-1; Quercus -2; Ulmaceae -1; Magnolia -2; Ericaceae -34; Tricolporopollenites -1; Unspecified -6

Sum-165

As it could be clearly noted, the sample presents a poor variety of microflora for all three major groups. *Dacrydium* (*Podocarpaceae*) and *Cedrus* (*Pinaceae*) prevail in the group of gymnosperms, while *Ericaceae* prevails in the group of angiosperms.

The sample Nr. 16 does not contain flowering plants.

Dacrydium 35%; Pinaceae 5%; Cedrus 3%; Picea 1%; Tetrads 53%; Bisaccate indet. 3%

The second sample is characterized by the prevalence of the genus *Dacrydium*, in addition to unidentified tetrads.

In general, it can be said that Palasa evaporitic deposits are characterized by the predominance of *Dacrydium*, *Ericaceae* and *Cedrus,* the presence of the genus *Tsuga* and *Ginkgo* and undetermined *Tetrads*.

4. DISCUSSIONS

Mavrovi (2018) stated that the authors whose work has been a means to address the Geological map of Albania at the scale 1: 200 000 give the evaporites of the Ionian Zone (including Palasa evaporites) a general Permian -Triassic age. Later, they were given the Oligocene age (Gjikopulli and Rama, 1973). They have been considered to be Jurassic-Lower Cetaceous in age since then (Muhameti *et al*., 1982; Diamanti *et al.*, 1999).

Information about the importance of *Tsuga* for the Neogene deposits in SE Europe is given by Traverse A. Given the fact that this microfossil is part of the palynological assemblage of Palasa evaporites, efforts have been made to find the Palasa evaporitic outcrops, but helplessly unfortunately.

An opinion has been given, however, based on the analysis of the samples 15 and 16 (Gjikopulli and Rama, 1973), partly the sample named, *Burimi i Dhikles* (Muhameti and Pejo 1974), and the sample 511, *microfaune,* (Shushkov and Tkaçiev 1960).

Since the main genera for the two analyzed samples are represented by *Dacrydium*, Ericaceae and *Cedrus*, the forthcoming paragraphs emphasize their stratigraphic importance.

Palynostratigraphically, the diagnostic form is *Tsuga* (Photo-7), which in Southeastern Europe appears during the Lower Miocene and disappears during the Pliocene (Traverse, 2007).

Fig. 7: Tsuga, 800 X (Gypsum).

The genus *Dacrydium* (Fig. 8) first appeared in Australia in Santonian, 86 million years ago (Hill, 1994). Flowering plants that have been met mainly appear from the Upper Cretaceous. Nevertheless, the oldest records for Ericaceae, Magnolia, Quercus and *Corsinipollenites* (see below) date since the Eocene.

These palynostratigraphic data represent the other very important argument according to which, the evaporites of Palasa are not Mesozoic in age, but much younger.

Thus, *Dacrydium* begins to spread northwards, arriving in India 50 million years ago, i. e. in the Lower Eocene (Morley 2010). In addition, the author states after covering all the countries of Southeast Asia, *Dacrydium* arrived in Japan 16 million years ago, during the Middle Miocene. Taking a look at the Eurasian map and considering India as a point of reference, it is probable that *Dacrydium* has arrived in Albania more or less at the same time as in Japan.

No information has been reported about the occurrence of *Dacrydium* in Pakistan. In Eocene arrived in Georgia (Shatilova et al., 2014). Data report about Turkey emphasize Oligocene age as the time when *Dacrydium* was distributed in Europe (http://file.flora.cn>fastdfs>group 1 pdf). The absence of normal geologic section makes it impossible for an accurate definition of the moment when this microfossil first appeared in the Miocene deposits in Albania. Nevertheless, it has appeared after the first appearance of Tsuga and before the evaporitic thickness of Upper Miocene. Therefore, this moment does not improve the situation of the age of Palasa evaporitic tectonic blocks imposed by the presence of Tsuga — the Neogene age.

Fig. 8: Dacrydium, 800X, (Gypsum).

There are many authors who reject the existence of *Dacrydium* in the Miocene deposits of Italy and Greece, (Bertolani-Marchetti 1962 a,b; Bertolani-Marchetti 1973; Benda *et al*., 1974; Guernet *et al*., 1970; Guernet *et al*., 1976; Jarrige *et al*., 1983; Jimenez-Moreno *et al*., 2007; Kovar- Eder 2003; Orgetta *et al*., 1976; Sauvage 1979; Mettos *et al*., 1988;), but Lona (1973), Follieri (1977), Sauvage (1975), Sauvage 1977a), Sauvage (1979), Sauvage (1980), Guerrera *et al*., (1985), Bertoldi *et al*., (1994) inform about the occurrence of *Dacrydium* in Pliocene deposits. Bertoldi *et al*., (1994) and Sauvage (1977a) stated that *Dacrydium* dates from Late Neogene to Pliocene or Pleistocene, affirming the appearance of *Dacrydium* in the Upper Miocene. Consequently, Palasa evaporites might belong to the uppermost part of Upper Miocene.

Table 1 reports on the local distribution of some palynomorphs in Italy, Greece, and Europe (for *Tsuga* and *Ginkgo*), arranged by time of appearance as considered by the author, based on the data from (Traverse 2007) about 1-SE Europe; (Lona *et al*., 1971; Lona *et al*., 1973; Follieri 1977; Guerrera *et al*., 1985; Bertoldi 1988; Bertoldi *et al*., 1994) about 2- Italy; from (Guernet et al., 1970, 1976; Sauvage 1977a; 1977b; 1979; Mettos et al., 1988) about 3-Greece and https://ucmp.berkeley.edu/seedplants/ginkgoales/ginkgofr.html about 4-Europe.

Table 1. Table of local distribution of some palynomorphs in Italy, Greece, and Europe (for *Tsuga* and *Ginkgo*).

Palinoforma	Mioc 1	Mioc 2	Mioc 3	Pliocen	Pleistocen	Holocen	
Ulliaceae	....	....	....	....	....	3	
				2			
Quercus	....	....	....	....	2		
	....	....	....	3			
Tsuga	....	....	....	1			
Cedrus			....	....	3		
			....	....	2		
Dacrydium			....	....	2		
			.....	....	3		
Ericaceae			....	....	2		
			.....	....	3		
Ginkgo	....	....	....	4			

As there is no a clear palynological boundary of the evaporites in Palasa region, it could be accepted as Neogene in age. The author says that the evaporites are in the Peri-Adriatik Depression of Upper Miocene (Messinian) age. There are no normal sections of evaporites here, but tectonic blocks only.

Information about the extinction of *Ginkgo* in Europe could be found in (https://ucmp.berkeley.edu/seedplants/ginkgoales/ginkgofr.html) by stating that *Ginkgo adiantoides* was particularly abundant in Europe at the beginnings of Pliocene, it was gone from that region by about 2.5 million years ago. This extinction more or less coincides with the extinction and migration of *Tsuga* from Europe. The extinction of these two microfossils would define the upper palynological boundary of the age of Palasa evaporite deposits. On the other hand, its lower boundary is determined by the appearance (in a hypothetical section) of *Dacrydium* and *Tsuga*. The complex is characterized by the presence of *Dacrydium, Ericaceae* (or undetermined *Tetrads*) and *Cedrus* at a considerable rate — altogether making up 65% of the complex. *Ginkgo* and *Tsuga* are typical of the complex.

The Oligocene deposits of Aranitas section have been previously studied, and this microfossil *Dacrydium* has never been met (Pejo and Muhameti 1973). It has neither been met in the sections later investigated (Jançe† L., Personal Communication, 2019), nor in the Tortonian-Messinian deposits. (Gjani 1989; Muhameti 1992).

Fergusson (1967) states that *Dacrydium* is little known in Europe. No information about it could be found in (Kovar- Eder 2003; Jimenez-Moreno *et al*., 2007). Jimenez-Moreno *et al.*, (2007) provide information about the Miocene and Pliocene deposits in all Balkan countries (except Albania), including those from Crete Island, the southern coast of Turkey and northwestern Syria.

The microfauna identified from the clays beneath an evaporite lens (No. 511), (Shushkov and Tkaçiev 1960), consists of these planktonic foraminifera species: *Acarinina miocenicus* Putrja; *Globigerina trilocularis* Ran.; *Orbulina universa* d'Orbigny, *Globorotalia albanensis* Mjatluk; *Cibicides helveticus* Mjatluk.

Age: Middle Miocene

The survey geologists, Shushkov and Tkaçiev (1960) accepted the Lower Helvetian age. Simon Prillo, accepts the Upper Langhian-Lower Serravallian age for the aforementioned microfauna based on the current stratigraphic nomenclature (personal communication, 2021). The age of the microfauna does not automatically define the age of Palasa's evaporites, but rather its importance lies in the confirmation of the Miocene age as was initially suggested by the presence of *Tsuga*.

The author states that only two evaporite horizons exist from the Upper Triassic to Upper Miocene, within the Ionian zone and the Peri-Adriatic Depression; the Upper Triassic (Carnian) horizon and the Messinian horizon. The palynological content of Palasa evaporites is not similar to Kavaja and Ndroqi sections, which include the Serravallian (partly) -Tortonian-Messinian in the Peri-Adriatic Depression. The predominance of *Dacrydium*, *Ericaceae* (this is substituted by undetermined *Tetrads* in sample 16) and *Cedrus* is not signaled in the aforementioned sections. This evident difference may be explained by washing during the Pliocene transgression. Another less credible hypothesis may be the existence of an unknown phytogeographic province.

In the Butrinti wildcat-1s (3020-3021,5m) which is situated in the West of Çika Belt (in the South of Palasa), the microfossil *Corsinipollenites* (Fig. 9), an herbaceous from the family *Onagraceae* which dates from Early Tertiary to Pleistocene (Song, Wang, Huang 2004), could be met. This fossil, although very rare, testifies that the age of Butrinti evaporites may be also a young one (probably Upper Miocene).

Fig. 9: ***Corsinipollenites spp.*** -59.76-microns, (without scale), **Butrinti-1s** (3020-3022,1m)., (black salt rock).

It could be preliminarily argued that the identification of Neogene evaporite deposits in both Palasa and Butrint might represent a regional phenomenon. In this context, it would be interesting to analyze the palynological content of evaporites from the village of Çiflik, south of Butrint.

5. CONCLUSIONS

The age evolution of Palasa evaporites is as following:

Before the application of paleopalynology: Permian-Triassic or Triassic.

1971: without any definition;

1973: Oligocene;

1974-1999: Jurassic-Lower Cretaceous.

Both *Tsuga* and *Dacrydium* are a means to address the Neogene age of the evaporites in Palasë. Consequently, the evaporites of Palasa are not part of Ionian Tectonic Zone.

The data about the microfauna prove the Miocene (Middle Miocene: Upper Langhian-Lower Serravallian) age. An evaporite lens with continental Neogene microflora overlays the microfauna clays. Between *Orbulina universa* clays and *Dacrydium-Ericaceae-Cedrus* evaporites, deposits of the Upper Serravallian-Tortonian-Messinian ages might be missing.

In this context, the scarce data about the Butrint-1s well require review of the age of the respective evaporitic deposits. Consequently, further investigation is needed to obtaine additional microfossil material, all the more so, if we recall that this diapiric structure has been attacked by deep wildcat to prepare it as a perspective structure for hydrocarbon exploration.

Dacrydium entered Albania probably during the Upper Miocene, and along with Ericaceae, *Cedrus* and undetermined *Tetrads* constitute a particular case in Europe.

No phytoplankton was found in the evaporites of Palasa, which proves that the environments where the evaporites were formed had a very limited connection with the sea.

Terrestrial vegetation has been represented by moist and evergreen forests both in the lowlands and in the mountains, mainly *Dacrydium* and *Cedrus*. The shrub belt is represented by *Ericaceae*, proving the existence of acidic infertile soils.

Warm-temperate climate; the region has been mainly mountainous with low coastal areas, and salty lagoons.

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