THE EFFECT OF DUMRE DIAPIRS ON THE THERMAL MATURITY OF GEOLOGICAL SECTION IN EAST OF BALLAGATI SYNCLINE, ALBANIA

PRIFTI Irakli, GJIKA Aleksander, PIPERI Arqile, LOÇI Rezeart, MINGA Ervin

Abstract. Syncline of Ballagati is one of the most eastern Adriatic Depression units. It is built by Miocene and Pliocene deposits. In the east, is in discordance with flysch deposits and tectonic contact with the evaporate deposits of diapir. Current thermal regimes express a low thermal regimen. The thermal regime during the history of geological development has been high. In the Ballagati syncline, many wells have been drilled in the search for gas and oil spills. The samples were taken from the cuttings of drilled wells in the geological section of the Ballagati syncline. These samples subjected to the pyrolytic determination (rock-eval analysis). During the process of assessing the petroleum potential in the Neogene section of Ballagati syncline, it was observed that the maturation of the organic matter (expressed by Tmax) is lower than the eastern section contacting the diapir. This fact inspired us to prepare this article, evidencing this phenomenon in the geological units in the west of the Dumrea diapir. The maturation of the sedimentary section in the Ballagati syncline is the result of burial history. There is low maturity, while in the eastern side maturation is higher (in contact with diapir). This is due to the thermal effect of the diapir before it is exposed on the surface. This effect is most evident in the southwest of the diapir (where the wells Gajda-1 and Kosova-2 / s have been drilled).

Keywords: Drilled wells, Tmax, thermal conductivity, calculated vitrinite reflectivity.

Rezumat. Efectul diapirelor din Dumre asupra maturității termice în secțiunea geologică de la estul Sinclinalului Ballagati, Albania. Sinclina din Ballagati este una dintre cele mai estice unități de depresie adriatică. Este construită de depozite Miocene și Pliocene. În est, este în dezacord cu depozitele de flyș și contactul tectonic cu depozitele evaporate ale diapirului. Regimurile termice actuale exprimă un regim termic scăzut. În timp ce regimul termic în istoria dezvoltării geologice a fost ridicat în Sinclinalul Ballagati, multe puțuri au fost forate în căutarea scurgerii de gaze și petrol. Probele au fost prelevate din butașii puțurilor forate în secțiunea geologică a sticlinei Ballagati. Aceste probe au fost supuse determinării pirolitice (analiza rock-eval). În timpul procesului de evaluare a potențialului petrolier în secțiunea neogenă din Sinclinalul Ballagati, s-a observat că maturarea materiei organice (exprimată prin Tmax) este mai mică decât secțiunea estică care intră în contact cu diapirul. Acest fapt ne-a inspirat să pregătim acest articol, evidențiind acest fenomen în unitățile geologice din vestul diapirului Dumărean. Maturarea secțiunii sedimentare din sinclina Ballagati este rezultatul istoriei îngropării. Există maturitate scăzută, în timp ce în partea de est maturarea este mai mare (în contact cu diapirul). Acest lucru se datorează efectului termic al diapirului înainte ca acesta să fie expus pe suprafață. Acest efect este cel mai evident în sud-vestul diapirului (unde s-au forat puțurile Gajda-1 și Kosova-2 / s).

Cuvinte cheie: Fântâni grosiere, Tmax, conductivitate termică, reflexivitate calcinată a vitrinitului.

INTRODUCTION

There is no study of the thermal effect of Dumre's diapir. In general, general considerations are given. In an article quoted as “a memo” in the Kuçova anticline (Ionian zone) is more mature than in other sectors (PRIFTI et al., 2014). Kuçova anticline is located in the southeast of the region under study.

Also, the presence of caprocks on the surface is interpreted as the thermal effect of the diapir during its outbreak.

The drilled wells in the diapir and in the sedimentary section around it have allow thermal regime. This is interpreted for the negative effect of diapir when exposed to the surface (PRIFTI et al., 2017). But the higher temperatures of sedimentary rocks has passed (before the diapir was exposed to the surface) are "fossilized" at the highest maturity level. This is the thermal effect of the diapir, which was evaluated by thermal parameters, such as Tmax, Productivity Index, and Calculated Vitrinite reflectance. Current temperatures measured in drilled wells are low, where it is noticed that drilled wells in diapir have lower temperature gradients.

The eastern side of Ballagati syncline is placed trangressively on the Oligocene flysch deposits (Ionian zone) and affected by hydrocarbon migration. The wells drilled in this direction are included in the Rase-Pekisht oilfield. Also, the wells in the Murrizi region (the eastern side of the Ballagati syncline) have met bituminous sandstones in Messinian deposits. These wells are not included in the study. Only the Pekisht-30 and Pekisht-51 wells were interpreted.

The highest values of maturity indicators at the east of the Ballagati syncline are related to the thermal effect of Dumre diapir.

GEOLOGICAL SETTING

The region we had chosen for the study is built by two geological units: the Ionian Zone and the Adriatic Depression. In the Ionian zone, are included the Dumre diapir, the Murrizi anticline and the syncline of Pekisht, while in the Adriatic Depression there is the syncline of the Ballagat and the Karbunare-Lushnje-Konjat anticline (Fig. 1).

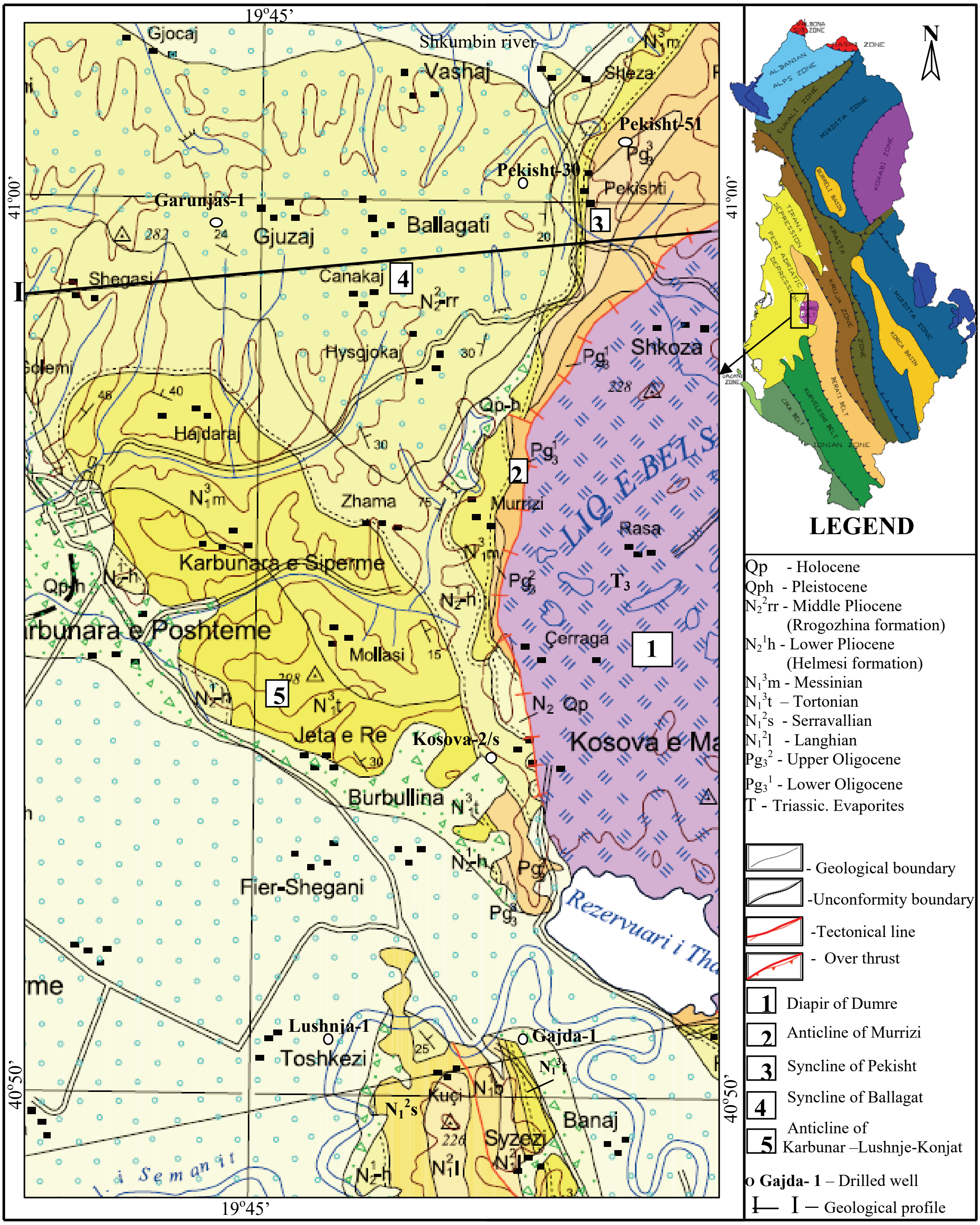


Figure 1. Geological map of Ballagati's syncline (after VRANAJ et al., 2002, modified by Prifti).

The **Dumrea diapir** is considered an important geological link and is represented by the evaporate rocks of the Upper Triassic age. The diapir has the shape of a wedge, has broken the carbonate and flysch rocks. The Dumrea diapir is surrounded by Oligocene flysch deposits, while on the surface it is covered by caprocks. The body of the diapir is represented by anhydrite, gypsum and salts. The lakes and sinkholes are created by the dissolution of salts.

The high thermal conductivity of minerals has contributed to the increase of the sedimentary rock thermal regime (Table 1) which surrounds the diapir until it is exposed to the surface. After this time, the diapir affects the reduction of the thermal regime.

Table 1. Thermal conductivity of some minerals (MIDDTOMME & ROALDSET, 1999).

Minerals	**Thermal conductivity ($Wm^{-1}K^{-1}$)**
Quartz	7.8
Calcite	3.4
Dolomite	**5.1**
Anhydrite	**6.4**
Pyrite	19.2
Siderite	3.0
K-feldspar	2.3
Albite	2.3
Mica	2.3
Halite	**6.5**
Kaolinite	2.8
Illite	1.8
Mixede layer I/S	1.9
Oil	0.21
Gas	0.21

The Murrizi anticline is located in the western part of the diapir contact. It is constructed from the thick layers of sandstones with turbidite layers (Pg_3^1) and onwards with the thin flysch layers. In the western part, it is depicted by the transgressive placement of Messinian deposits (QIRKO, 2008).

The Pekishti syncline is located in the northern part of the flysch belt, which exposes only the eastern side, the western side is disguised by Messinian deposits which are transgressively placed on the flysch deposits. The center of syncline is constructed by a thin layer of flysch deposits (Pg_3^2). The eastern side of this syncline is tectonically complicated by Dumrea diapir. In this unit the Pekisht-51 well was drilled.

These two units represent the eastern extremity of the Ionian Zone.

The Ballagati syncline (Fig. 2) extends the west of the Dumrea diapir. The southern starts somewhere in the Kosova village (Kosova-2/s well is drilled). In this sector, oldest deposits of Langhian-Serravalian are exposed, while the north side continues to the Shkumbini River. The syncline is constructed from the sandstone and claystone sedimentary rock of Miocene-Pliocene.

The newest deposits that fill the center of this syncline are the Pliocene ones. The western side runs to the anticline of Karbunare - Lushnje-Konjat. The eastern side is in contact with flysch and salt deposits of Dumrea diapir. In this regard it meets the oil traps (PRIFTI et al, 2017).

The Karbunar-Lushnje-Konjat anticline stretches to the west of the Ballagati syncline, from Karbunar village to Hajdaraj, north of Lushnja town. It is constructed from the same deposits. In the southern part, Messinian-Pliocene deposits are missing, while in the north they begin to appear gradually. The region is exposed only in the eastern side.

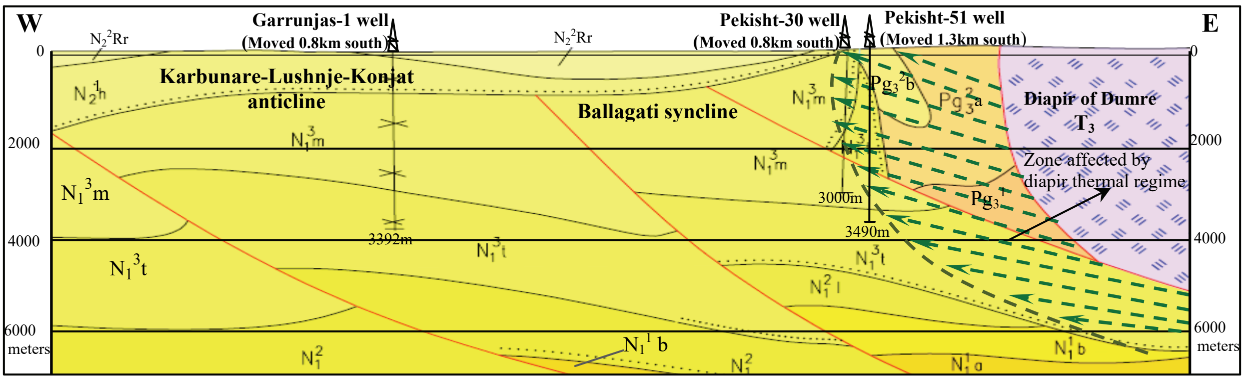


Figure 2. Geological profile in west side of diapir (VRANAJ et al., 2002, modifed by Prifti).

MATERIAL AND METHOD

Current geothermal studies have been conducted by various authors where the most prominent are the studies of prof. Alfred Frasheri (FRASHERI & FRASHERI, 2005). Current geothermal estimations are carried out in drilled wells. The temperature in the wells was recorded at regular intervals. It was measured by means of resistance and hermistor thermometers. The measurements were carried out in a steady-state regime of the wells filled with mud or water (FRASHERI & FRASHERI, 2005).

We have separated 3 wells: the Garunjas-1 well in the Ballagatan Syncline (Miocen-Pliocene section of Adriatic depression); Paper-1 in flysch deposits coverings the diapir (north of diapir body); the Grekan-4 well drilled in the body of diapir (east of the region under study). Their geothermal gradients are different, indicating by diapir and burial history (Figs. 3, 4).

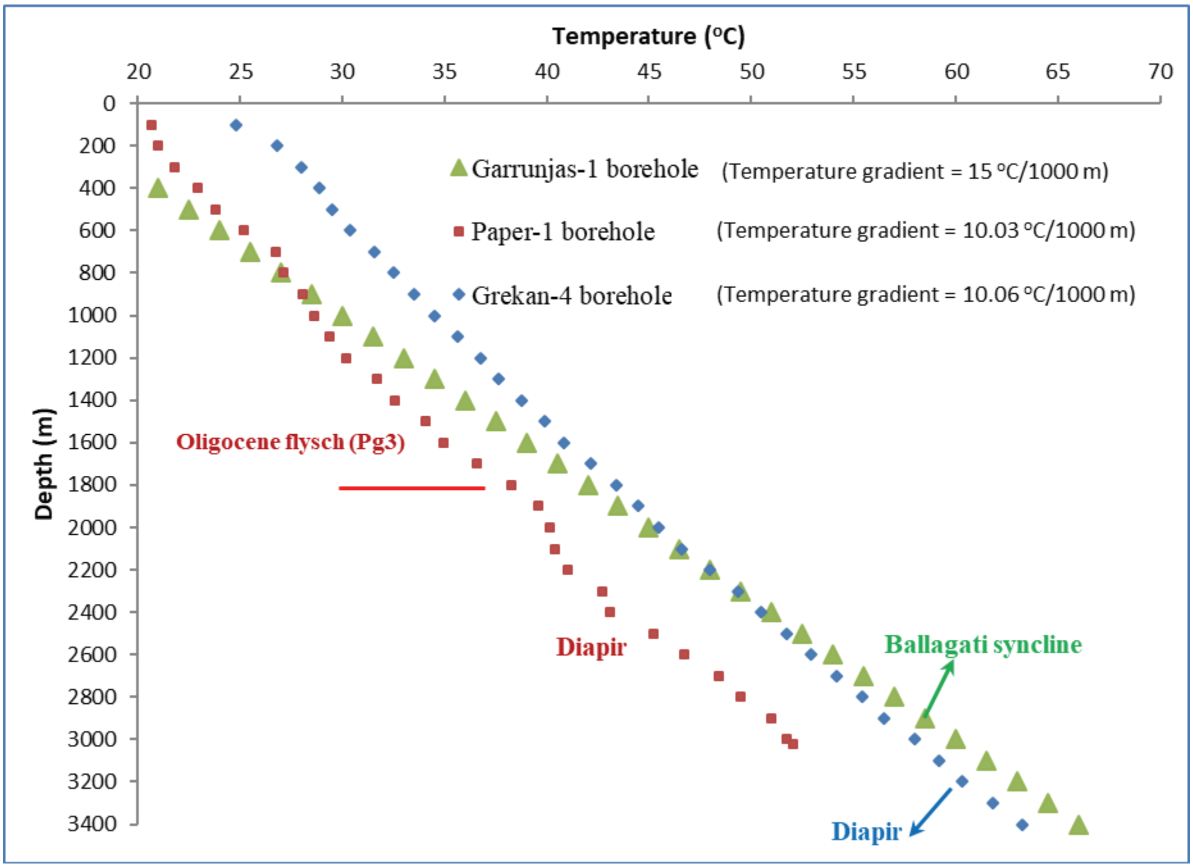


Figure 3. Measured temperatures and geothermal gradient in drilled boreholes in region.

Based on the field observations it was observed that the flysch blocks on the diapir have been reddish, as a result of the thermal influence of the diapir.

The thermal effect of diapir is the result of the high thermal conductivity of minerals, such as dolomite, anhydrite, halite and various salts. This feature has been studied by various authors given in Table 1. Also in the geophysical logs of drilled wells in the diapir, the high content of these minerals are identified (SOTA et al., 2002).

The diapir thermal effect is sensitive to the sedimentary rock surrounding the diapir. This effect is "fossilized" at the maturity level of the organic matter of sedimentary rocks. Exposure to the surface of the diapir ends up the thermal effect, or otherwise affects the cooling of the geological section.

Salts of diapir have been modeled as having a large effect on the thermal maturity of surrounding sediments as a result of the high thermal conductivity contrast between halite and other lithologies (DOWNS, 2012).

The study did not take into account the wells drilled in the Rase-Pekisht oilfield. The pyrolytic indicators are masked by the presence of oil and lead to wrong conclusions. For this reason, 6 wells were studied. Four wells were drilled in the eastern side of the Ballagati syncline (Pekisht-30, Pekisht-51, Kosova-2/s and Gajda-1), while Garunjas-1 was drilled on the western side. The Lushnja-1 well was drilled to the west of the Gajda-1 well. Samples of wells (which are stored) were subjected to pyrolytic determination by means of the "Oil Show Analyzer". The samples were taken only in the clay faction in the Messinian-Tortonian deposits. In the Middle Miocene deposits, the samples were taken from the claystone and marlstone fractions (MILE, 2017).

Geochemical estimation was performed on sedimentary section penetrated by wells. We will not interpret all the "rockeval" indicators, but only those who evaluate the maturity of the organic matter as Tmax (Table 2).

Table 2. Geochemical parameters of Tmax, PI and calculated vitrinite reflectivity.

Wells	Depth (m)	Tmax (°C)	RoCalc (%)	PI	Wells	Depth (m)	Tmax (°C)	RoCalc. (%)	PI
Garunjas-1	3000	415	0,31	0	Garunjas-1	3265	422	0,436	0
Garunjas-1	3003	416	0,328	0	Garunjas-1	3266	426	0,508	0
Garunjas-1	3006	419	0,382	0	Garunjas-1	3270	417	0,346	0
Garunjas-1	3009	417	0,346	0	Garunjas-1	3273	421	0,418	0
Garunjas-1	3010	421	0,418	0	Garunjas-1	3277	418	0,364	0
Garunjas-1	3012	416	0,328	0	Garunjas-1	3280	421	0,418	0
Garunjas-1	3018	420	0,4	0	Garunjas-1	3283	422	0,436	0
Garunjas-1	3021	419	0,382	0	Garunjas-1	3286	419	0,382	0
Garunjas-1	3024	416	0,328	0	Garunjas-1	3288	416	0,328	0
Garunjas-1	3027	420	0,4	0	Garunjas-1	3293	418	0,364	0
Garunjas-1	3034	418	0,364	0	Garunjas-1	3296	413	0,274	0
Garunjas-1	3036	413	0,274	0	Garunjas-1	3299	419	0,382	0
Garunjas-1	3042	413	0,274	0	Garunjas-1	3302	426	0,508	0
Garunjas-1	3045	416	0,328	0	Garunjas-1	3305	422	0,436	0
Garunjas-1	3047	425	0,49	0	Garunjas-1	3308	425	0,49	0
Garunjas-1	3051	413	0,274	0	Garunjas-1	3311	420	0,4	0
Garunjas-1	3059	417	0,346	0	Garunjas-1	3314	421	0,418	0
Garunjas-1	3061	416	0,328	0	Garunjas-1	3318	421	0,418	0
Garunjas-1	3064	416	0,328	0	Garunjas-1	3321	423	0,454	0
Garunjas-1	3069	416	0,328	0	Garunjas-1	3327	425	0,49	0
Garunjas-1	3072	414	0,292	0	Garunjas-1	3330	427	0,526	0
Garunjas-1	3075	414	0,292	0	Garunjas-1	3333	417	0,346	0
Garunjas-1	3101	414	0,292	0	Garunjas-1	3336	423	0,454	0
Garunjas-1	3105	418	0,364	0	Garunjas-1	3339	420	0,4	0
Garunjas-1	3107	418	0,364	0	Garunjas-1	3342	421	0,418	0
Garunjas-1	3110	413	0,274	0,03	Garunjas-1	3342	428	0,544	0
Garunjas-1	3112	418	0,364	0	Garunjas-1	3345	414	0,292	0
Garunjas-1	3114	418	0,364	0	Garunjas-1	3349	419	0,382	0
Garunjas-1	3119	415	0,31	0	Garunjas-1	3352	419	0,382	0
Garunjas-1	3122	422	0,436	0	Garunjas-1	3355	427	0,526	0
Garunjas-1	3125	420	0,4	0	Gajda-1	1279	425	0,49	0
Garunjas-1	3128	414	0,292	0	Gajda-1	1353	429	0,562	0
Garunjas-1	3131	415	0,31	0	Gajda-1	1512	428	0,544	0
Garunjas-1	3134	423	0,454	0	Gajda-1	1640	430	0,58	0
Garunjas-1	3137	423	0,454	0	Gajda-1	1723	429	0,562	0
Garunjas-1	3144	419	0,382	0	Gajda-1	1802	429	0,562	0
Garunjas-1	3149	417	0,346	0	Gajda-1	1876	425	0,49	0
Garunjas-1	3166	413	0,274	0	Gajda-1	1971	430	0,58	0
Garunjas-1	3169	416	0,328	0	Gajda-1	1997	431	0,598	0,063
Garunjas-1	3172	420	0,4	0	Gajda-1	2090	427	0,526	0
Garunjas-1	3175	423	0,454	0	Gajda-1	2225	428	0,544	0,026
Garunjas-1	3178	424	0,472	0	Gajda-1	2268	424	0,472	0,045
Garunjas-1	3181	422	0,436	0	Gajda-1	2268	428	0,544	0,063
Garunjas-1	3184	416	0,328	0	Kosova-2/s	648	428	0,544	0
Garunjas-1	3187	415	0,31	0	Kosova-2/s	803	424	0,472	0
Garunjas-1	3190	417	0,346	0	Kosova-2/s	955	429	0,562	0
Garunjas-1	3195	414	0,292	0	Kosova-2/s	1006	430	0,58	0
Garunjas-1	3198	417	0,346	0	Kosova-2/s	1796	427	0,526	0
Garunjas-1	3201	417	0,346	0	Kosova-2/s	1996	432	0,616	0
Garunjas-1	3205	422	0,436	0	Kosova-2/s	2247	435	0,67	0,049
Garunjas-1	3208	419	0,382	0	Kosova-2/s	2383	431	0,598	0
Garunjas-1	3211	417	0,346	0,07	Kosova-2/s	2745	426	0,508	0
Garunjas-1	3216	419	0,382	0	Lushnja-1	1020	430	0,58	0
Garunjas-1	3220	424	0,472	0	Lushnja-1	1143	428	0,544	0,036
Garunjas-1	3224	422	0,436	0	Lushnja-1	1260	424	0,472	0,053
Garunjas-1	3228	419	0,382	0	Lushnja-1	1669	430	0,58	0,166
Garunjas-1	3229	420	0,4	0,56	Pekisht-30	2005	427	0,526	0,375
Garunjas-1	3232	422	0,436	0	Pekisht-30	2629	414	0,292	0,1
Garunjas-1	3235	423	0,454	0	Pekisht-30	2921	412	0,256	0,333
Garunjas-1	3240	417	0,346	0	Pekisht-51	3439	426	0,508	0,47
Garunjas-1	3250	415	0,31	0	Pekisht-51	346	429	0,562	0,118
Garunjas-1	3255	416	0,328	0	Pekisht-51	3473	418	0,364	0,04
Garunjas-1	3263	418	0,364	0	Pekisht-51	3473	424	0,472	0,063

Based on the conducted studies, it is estimated that the organic matter in the Miocene-Pliocene deposits is of the third type.

Another indicator for the maturity assessment is the productivity index, which is calculated from the equation, $PI = S_1 / (S_1 + S_2)$ ratio, where S_1 is the presence of free rock oil, S_2 the presence of oil, which is generated during the increase of temperature.

By means of Tmax, the reflectance of the vitrinite for the values of Tmax <430°C was calculated, by equation:

$Ro(\%) = (0.018 \times Tmax) - 7.16$ where Tmax is reported in °C (JARVIE, 2001).

The values of the used indicators (Tmax, PI) and the calculated reflectance are given in Table 2.

The relationship between vitrinite reflectance and time-temperature history of the sedimentary rocks (GURI et al., 2002; LOPATIN, 1976; PRIFTI, 1995; 2011) was applied to calculate the paleotemperatures. This method utilizes a modified Lopatin method, which presents the relationship between Vitrinite Reflectance and the time-temperature history of the sedimentary rocks (LOPATIN, 1976; PRIFTI, 1995; PRIFTI & PRENJASI 2011), as follows:

$Ro^a = R^a_{init} + bt \exp(cT)$, where:
Ro = vitrinite reflectance
R_{init} = initial reflectance of vitrinites (0.20 or 0.15%),
a = 5.5, b= 2.8 $*10^6$, c = 0.065,
t = time (Ma), T = temperature (°C).

The paleotemperatures are about 18°C higher than current temperatures, while the paleogeothermal gradient is 20.6ºC/1000m for Miocene-Pliocene deposits. Actual geothermal gradient is 15ºC/1000m. While in diapir, actual geothermal gradient is 10ºC/1000m.

RESULTS AND DISCUSSION

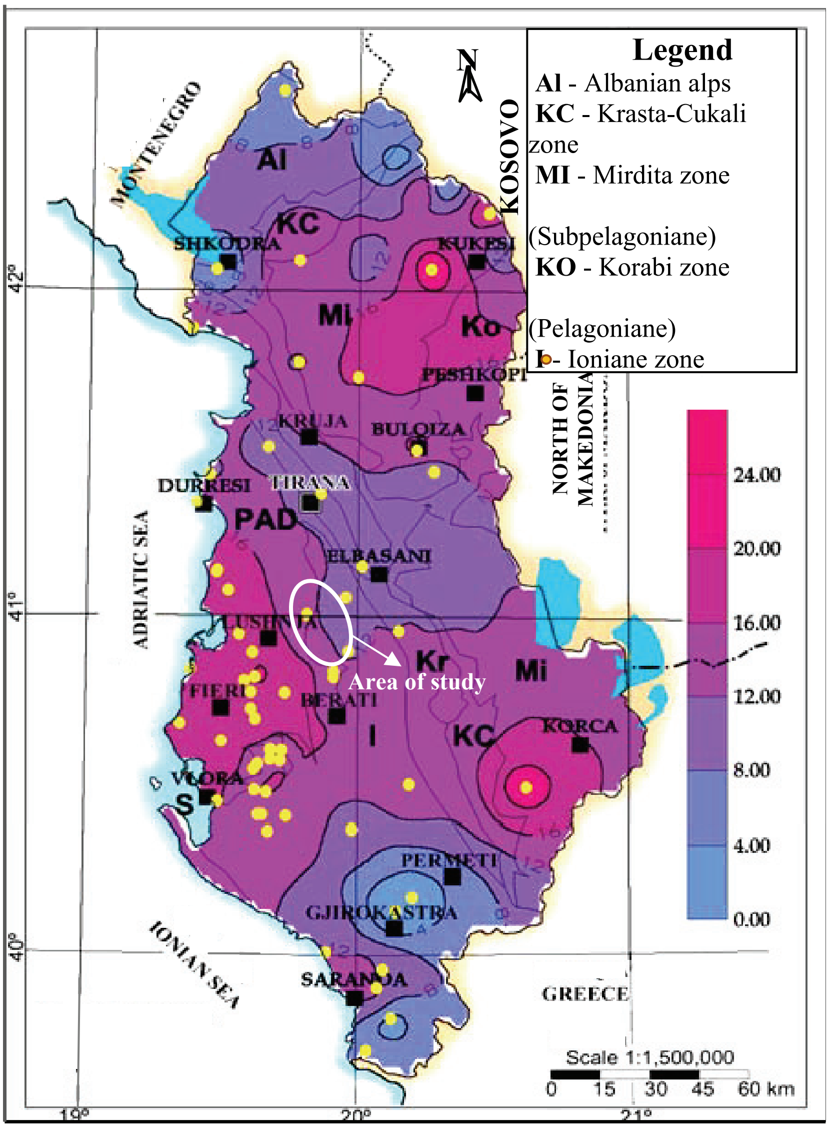


Figure 4. Geothermal gradient map of Albania (based on FRASHERI & FRASHERI, 2005, modified by Prifti and Gjika).

Current geothermal gradient estimates. As noted above, we will discuss the trend of thermal gradients in the three wells: Garrunjas-1; Papri-1 (in the northeast of the region) Grekan-4 (in the east of the region, on top of diapir body). Temperature measurements are obtained from wells files. By comparing the geothermal gradients, these changes are observed:

a. The current geothermal gradient in the Garrunjas-1 well is 15^{o}C / 1000m.

b. The geothermal gradient in the Grekan-4 well, is 10.06^{o}C1000m. It has higher values of temperatures, but low geothermal gradients. These phenomena are related to the high thermal permeability of evaporate rocks.

c. Papri-1borehole presents an interesting curve of the geothermal gradient. After the flysch block (in contact with the diapir) there is a very low temperature rise. We think it should be related to the presence of "cuprock". After the 2100m depth the same tendency of the geothermal gradient of diapir continues. The geothermal gradient is 10.03^{o}C1000m (Figs. 3, 4).

Evaluation of the Maturity of Garunjas-1well. Garunjas-1well is the most studied well. This is also related to the search for biogenic gas traps in the Messinian-Tortonian section. The maximum temperature (Tmax) as described above fluctuates in the range of 410 ^{o}C ÷ 425 ^{o}C in the Messinian deposits (Fig. 5). These values show a low level of maturity of organic matter (is immatured).

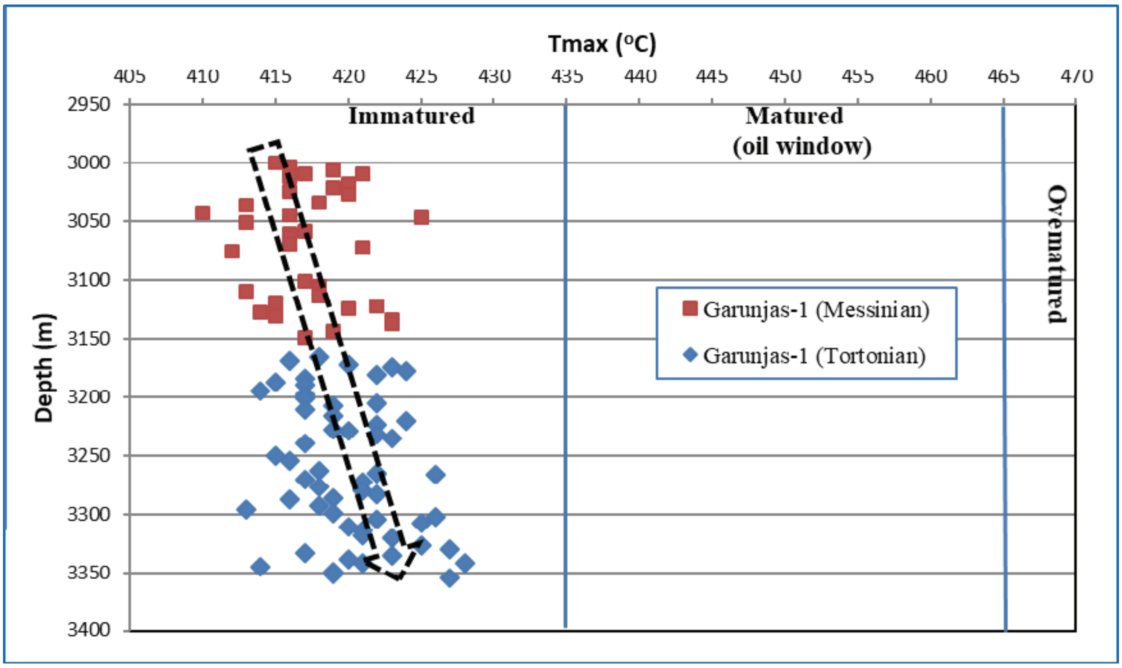


Figure 5. Maturation of organic matter (Tmax) in the geological section of the Garunjas-1 well.

Interpretation of this indicator is given in Fig. 5, where up to 435^{o}C is the immatured stage, 435^{o}C ÷ 465^{o}C organic matter is matured and is included in the “oil window”, whereas when exceeded the value of 465^{o}C is included in the overmatured stage.

The maximum temperature (Tmax) varies in the range of 413 ^{o}C ÷428 ^{o}C in the Tortonian deposits; therefore it is more mature than those of Messinian. In Fig. 5 it is noticed that maturation of organic matter increases with the depth as a result of the burial history of the Ballagati’s syncline.

The same tendency is observed with the calculated reflectance of vitrinitite (Fig. 5). This indicator fluctuates in the range of 0.22%÷0.49% for the deposits of Messinian and 0.274%÷0.544% for the Tortonian deposits.

Evaluation of the Maturity of others wells (Pekisht-30, Pekisht-51, Kosova-2/s, Gajda-1, Lushnja-1). The maximum temperature (Tmax) fluctuates in the range of 424 ^{o}C ÷ 435 ^{o}C in the upper block of Messinian deposits (Fig. 6). These values show a maturity level somewhat higher than of Garunjas-1 well. This phenomenon is the result of Diapir's thermal impact.

Current geothermal studies show low values of geothermal gradients (Figs. 3; 4). The current geothermal gradients of geological section rise from the diapir to the geological section surrounding the diapir.

Calculated values of the vitrinite reflection in the Messinian-Tortonian section of Garunjas-1 well (Fig. 7), were faced with the measured values of vitrinite reflection in drilled wells (PRIFTI, 2007) in the Adriatic Depression. It is noted that they are almost the same values that express the maturation of sedimentary section as a result of the burial history of the Adriatic Depression.

Maturity is also valued with the productivity index. There are few calculated PI values as there is no free oil on the sedimentary rocks (organic matter is of the third type that does not generate oil). Based on this indicator the section did not enter the “oil window” and its tendency to increase with depth is noticed (Table 2).

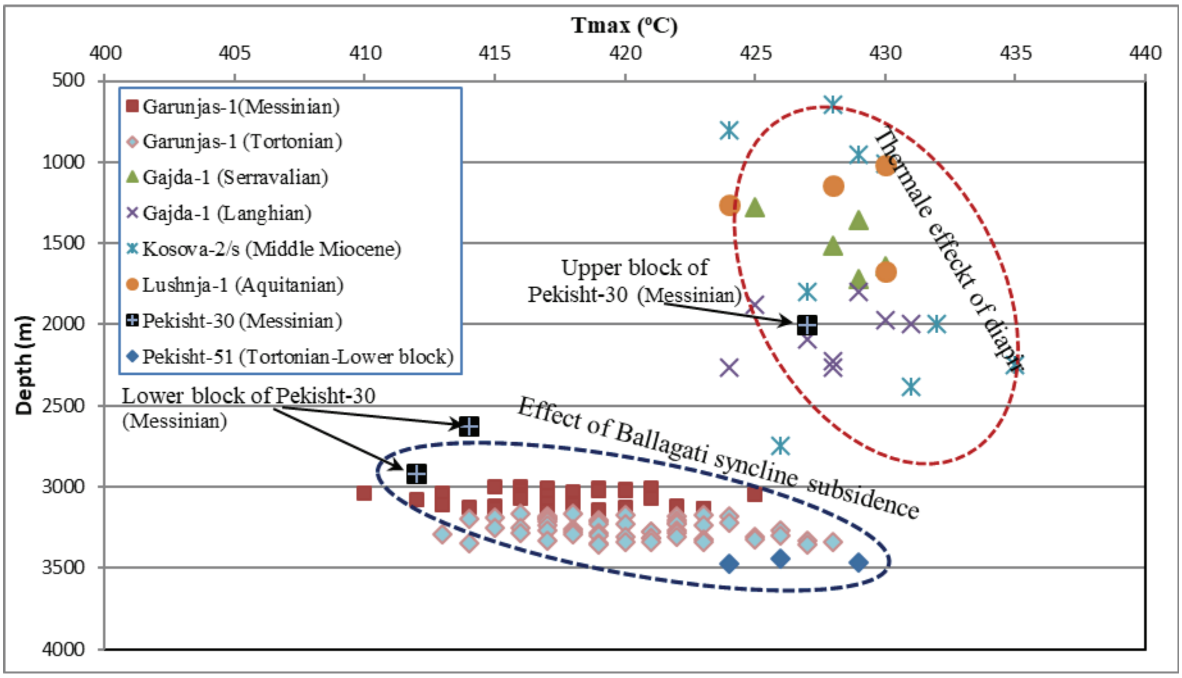


Figure 6. Maturity of Organic matter (Tmax) in geological section of wells drilled in the Ballagati region.

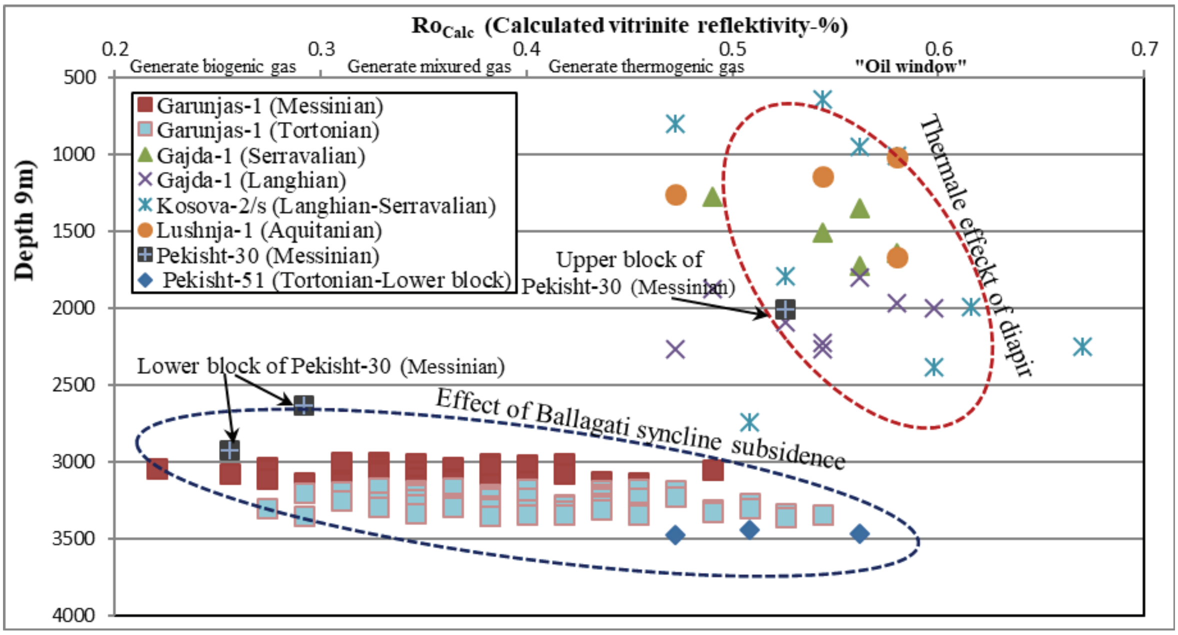


Figure 7. Maturity of Organic matter by Calculated vitrinite reflection (Ro_{calc}) in geological of drilled wells in the Ballagati region.

At this level of maturity that has the geological section penetrated by Garunjas-1 well. The lower block penetrated by the Pekisht-30 and Pekisht-51 wells is at the same level of maturity. This block represents one of the deeper sectors of the Ballagati's syncline. This maturity level is not influenced by the thermal effect of the diapir but by the burial history of the Ballagati syncline. Thus, the Tmax in the Tortonian deposits in the Pekisht-51 well fluctuates in the range of 424 °C to 429°C, which represents the most mature level of Ballagati syncline.

Evaluation of the maturity of wells in the eastern part of Ballagati syncline. Drilled wells near the western periphery of the diapir are: Pekisht-30 (upper block); Pekisht-51 (upper block); Kosovo-1/s; Gajda-1 and Lushnja-1.

The maximum temperature (Tmax) fluctuates at 424°C÷ 435°C, therefore it is higher than that in the Ballagati's syncline (mostly Garunjas-1). This change appears clearly in the two blocks penetrated by the Pekisht-30 well, where the upper block (Messinian deposits) has Tmax higher than the lower block (Messinian deposits).This result is interpreted only with the diapir thermal effect.

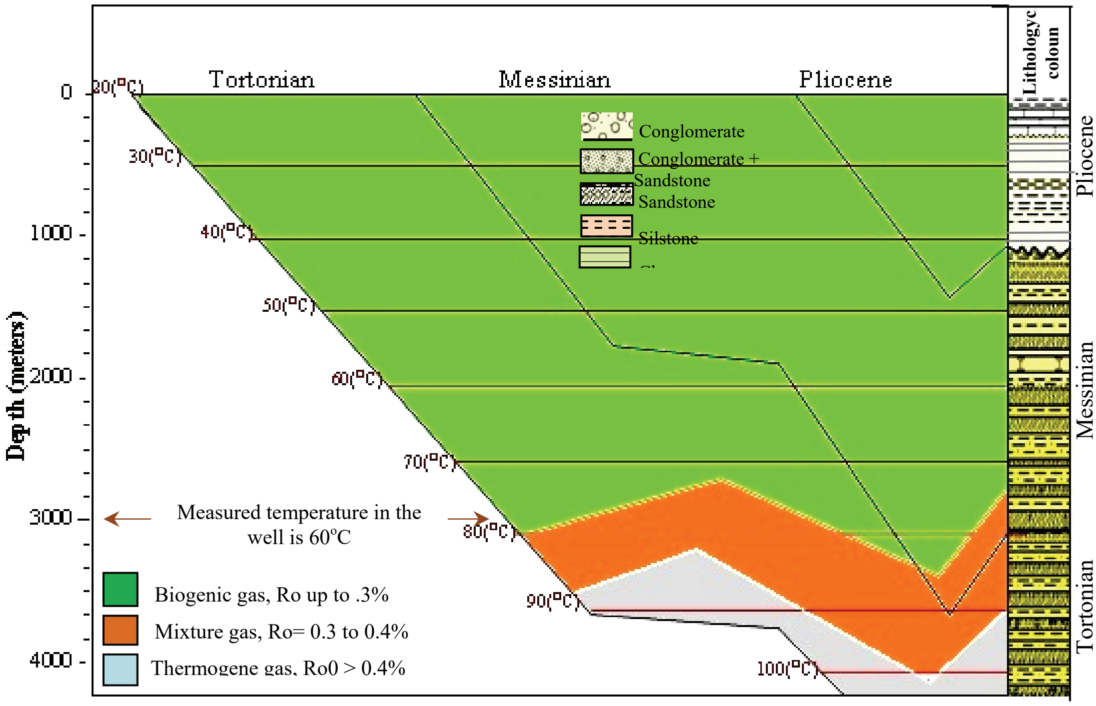
The highest values of Tmax are most clearly reflected in the geological section of the Gajda-1 and Kosovo2 / s wells (wells near the diapir).

The high values of Tmax reflect the thermal effect of the Dumrea diapir in increasing the maturation of the sedimentary rocks surrounding the diapir.

The same tendency to increase maturity is also represented by the values of calculated reflectance vitrinite and productivity index.

Burial history of Ballagati syncline. Preparation of the burial history requires several conditions: recognition of the real thickness of the geological section (Pliocene and Miocene); there should be no tectonic breakdown and geothermal gradient estimation. These conditions are met by the geological section of the Garrunjas-1 well Proper paleotemperatures and paleogradients data help determine burial history (PRIFTI & PRRENJASI, 2011) of the Ballagati syncline (Fig. 8).

Geothermal paleogradient is estimated 20°C/1000m (in position of Garrunjas-1 borehole).



Burial history can't be prepared on the eastern side of the Ballagati syncline. In this side, the thickness of Miocene-Pliocene deposits is reduced. This sector has an active tectonic as a result of tectonic activity of the diapir. This phenomenon is clearly expressed in the geological section of Kosovo-2 / s well.

Based on the interpretations in Figs. 7 and 8, Pliocene section has generated biogenic gas. Messinian section has generated mixed hydrocarbon gas (generated by early biochemical and thermal factor) and early thermal gas. Tortonian section has entered the "oil window" and has generated thermal hydrocarbon gas.

The geological section of Kosovo-2 / s well has entered the "oil window" and has generated hydrocarbon thermo-gas. The highest level of maturity is influenced by the diapir's thermal effect.

CONCLUSIONS

The current geothermal gradient decreases in the direction of the diapir towards the west from 10°C/1000m to 16 °C / 1000m.

Geothermal paleogradients have been higher than the current one and go up to 20°C/1000m.

The region has undergone two thermal regimens:

The thermal regime as a result of the burial history of the Ballagati syncline. ;

The thermal regime influenced by the Dumrea diapir in sedimentary rock surrounding the diapir.

The level of maturity at Ballagat's syncline goes up to the entrance of the “oil window”.

The level of maturity on the eastern side of the Ballagatan syncline is included in the “oil window”.

The region where the diapir's thermal effect is most evident extends to the Kosovo-1 / s and Gajda-1 wells. This should be the result of the southwest direction of the explosion of the Dumrea diapir.

The sedimentary section that has been on the cup’s diapir (before it is exposed to the surface) should be more mature than the other large distance of diapir.

The thermally influenced section by the diapir is tectonised.

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