M. SAIDU DEPT. OF GEOLOGICAL ENGR. MASTER THESIS MUĞLA 2021

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MUĞLA SITKI KOÇMAN UNIVERSITY

GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

DEPARTMENT OF GEOLOGICAL ENGINEERING

LATE HOLOCENE CLIMATIC CHANGES FROM LAKE SÜLÜNGÜR AND ALAGÖL (SW ANATOLIA) SEDIMENT RECORDS

MASTER OF SCIENCE THESIS

MOHAMMED SAIDU

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THESIS ACCEPTANCE CONFIRMATION

The thesis prepared by **MOHAMMED SAIDU** titled '**LATE HOLOCENE CLIMATIC CHANGES FROM LAKE SÜLÜNGÜR AND ALAGÖL (SW ANATOLIA) SEDIMENT RECORDS**' has been accepted on …04/11/2021...in fulfillment of Master of Science Degree in the Department of Geological Engineering by the jury listed below

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Date of Defense: 04/11/2021

I hereby declare that all information contained in this thesis is obtain and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conducts, I have fully cited and referenced all materials and results that are not original to this work.

Mohammed SAIDU

04 / 11/2021

ÖZET

SÜLÜNGÜR GÖLÜ VE ALAGÖL SEDİMAN KAYITLARINDA GEÇ HOLOSEN İKLİM DEĞİŞİMLERİ

Mohammed SAIDU

Yüksek Lisans Tezi
Fen Bilimleri Enstitüsü
Jeoloji Mühendisliği Anabilim Dalı
Danışman: Doc. Dr. Bedri Kurtulus
Kasım 2021, 54 Sayfa

Dalyan, Türkiye'nin Güneybatı Anadolu'da bulunan bir kıyı lagünüdür. Havza, biyoçeşitlilik açısından zengin olup karasal ve deniz canlıları arasında bir ara geçiş olarak görünmektedir. Gravite yöntemi ile Alagöl ve Sülüngür Gölü'nden farklı noktalarda beş karot alınmıştr. Bu göllerden alınan karotlar iki eşit parçaya ayrılarak litolojik tanımlama yapılmıştır. Çevresel ve iklimsel değişimleri yorumlamak için µXRF, MSCL, duraylı oksijen ve karbon izotop analizleri yapıldı. µXRF sonuçlarından sayımı yüksek olan Ti, Mn, K, Sr, Fe ve Ca elementleri incelenerek yorumlandı. Kırıntılı girdiyi yorumlamak için manyetik duyarlılık analizi kullanılmıştır. Duyarlı oksijen ve karbon izotop analizi sonucuna bakılarak yağışlı/kurak aralıklar belirlenmiştir. Faktör analiz sonuçlardan iki element grubu bulunmuştur. Buna göre birinci grup otojenik karbonat ve ikinci grup ise detrital elementler temsil etmektedir. Sul2015_GO2 ve Sul2015_GO3 karotlarından alınan çamur ve bitki kalıntıları ile ^{14}C yaş analizi yapılmıştır. Sul2015_GO2 karotundan yapılan radiyokarbon yaşlandırma sonuçları uzerine sediman karot yaslarini 1465 ± 30 BP and 2625 ± 30 BP arasinda bulunmustu. Sul2015_GO3 karotundan elde edilen yaşın hatalı olması nedeniyle kullanılmamıştır. Sul2015_GO2 karotuna ait yaşlar ile korelasyon yapılarak diğer karotların yaşları tespit edilmiştir. Çoklu belirteç yöntemleri (MS, µXRF ve duraylı oksijen ve karbon izotop) kullanılarak yağış/kurak iklim değişiklikleri yorumlanmıştır.

Anahtar Kelimeler: Paleoiklim, Geç Holosencene, Sediman Kayıtları, Muğla

ABSTRACT

LATE HOLOCENE CLIMATIC CHANGES FROM LAKE SÜLÜNGÜR AND ALAGÖL (SW ANATOLIA) SEDIMENT RECORDS

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November 2021, 54 Page

Dalyan Basin located at the south-western Anatolia, Turkey. For this study four sediment core were retrieved in different location from both lake Alagöl and Lake Sülüngür using gravity method. Before the analysis, the retrieve samples were firstly divided into halves for lithological description, From the results of µXRF, the element Mn, Sr, Fe, Ca, K and Ti, were chosen for the interpretation of climate changes. For change in detrital input Magnetic susceptibility was used. For the change in precipitation and authigenic carbonate stable isotopes was used. From the result of factor analysis, two group of element were found. The first set was accepted as authigenic carbonate and the second set was accepted as detrital input. The result of radiocarbon dating of Sul2015_GO2 revealed two raw ages, this are, 1465 ± 30 BP and 2625 ± 30 BP. The age of the remaining sediment cores was determined by correlating with Sul2015 GO2. Change in climate were interpreted by using multiproxy result (µXRF, MS and Stable isotope).

Keywords: Sediment Records, Late Holocene, Paleoclimate, Muğla

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SYMBOLS AND ABBREVIATIONS

AD	Anno Domini
BC	Before Christ
B. P	Before Present
BAP	Science Research Project
EMCOL	Eastern Mediterranean Centre for Oceanography and Limnology.
I.T. U	Istanbul Technic University.
L.I. A	Little Ice Age.
M.W. A	Medieval Warm Anomaly
M S	Magnetic Susceptibility.
M.S.K. U	Mugla Sitki Kocman University
M.S.C. L	Multi Sensor Core Log.
S.P.S. S	Statistical Package for the Social science.
X.R. F	Micro-X-Ray Fluorescence.

1. INTRODUCTION

The study of pre-instrumental climate periods allows the recognition of past climate on decadal and centennial time scales that were not visible over time length in instrumental records. The climate variability of the last glacial has received significant attention, but still, little is known about glacial changes during the Holocene (11,500BP) (Mayewski et al., 2004). The mid- to Late-Holocene climate (6,000BP) is similar to today's climate and thus, it can be useful for understanding the present climate changes (Wanner et al., 2008). With human-induced, global warming, the natural climate variability from mid-Late-Holocene present a base line on how anthropogenic effects could be estimated (Matthews and Briffa, 2005). Despite the importance of understanding the mid-late Holocene climate, there are still uncertainties. These uncertainties are assumed to be related to the cyclicity of the mid-late Holocene climate changes, the continuation of the 1,500 year Dansgaard-Oeschger cycles (Bond et al., 2001), or the climate changes could be explained by regional events related to changes in ocean/sea surface temperatures in connection to deep-ocean circulation or tropical volcanic eruptions (Wanner et al., 2008). Some of the notable study era from mid-late Holocene were the Medieval Climate Anomaly (MCA) and the Little Ice Age (LIA). These periods were widely observed in Northern Europe and Turkey by paleo-environmental studies (IB Danladi, S Akçer-Ön 2018, jones et al 2006, Woodbridge and Roberts_2011, Raymond et al., 2003 Hanno et al 2015)

The Medieval Climatic Anomaly (MCA) was a period of warm climate in the North Atlantic region (Raymond et al., 2003). Though this climate change was believed to be due to human high induce of greenhouse gas emissions, which were characterized by fast glacier melting (Le Treut et al., 2007, IB Danladi, S Akçer-Ön 2018). The change in climate during this period resulted in high productivity and development in European cities (Raymond et al., 2003). Although the change had a degree of benefit, evidence showed that it also caused storms and flood. Most of the changes were seen in North-Atlantic and surrounding (Raymond et al., 2003), The Medieval Climatic Anomaly was observed between 950-1250AD. After interruption of mild climate during Medieval Climatic Anomaly (MCA), the Little Ice Age (LIA) was observed and characterized by extremely poor harvest, severe winters, and advance in glaciers between Europe and North America (IB Danladi, S Akçer-Ön 2018). At this period, glacier was moving to the lower latitudes of canals, rivers and lakes in Europe (Tuchman, 1978). While in the Mediterranean mountains, glaciers are several kilometers longer than the present (Hughes. P.D. 2018). The Little Ice Age took place between 1300-1850AD (Akçer Ön et al 2011, Muller and McDonald, 2000,).

Though studies based on multi-proxy indicators are unfortunately rare in Anatolia (England et al. 2008) some of the notable studies from Anatolia are (Ocakoğlu et al., 2016, Tudryn et. al _2013, Ülgen et. al_2012, Woodbridge and Roberts_2011, IB Danladi, S Akçer-Ön 2018, Jones et al., 2006; Kaniewski et al., 2007; Vermoere et al., 2000, Neil Roberts et al 2011, Touchman et al 2007). Some of this research had revealed different estimates of significance between climates and human-induced disturbance. For example, the study from Bereket plain, Gravgaz wetland and Lake Nar records showed a dominant human intervention (Jones et al., 2006; Kaniewski et al., 2007; Vermoere et al., 2000), while some records from northwestern Anatolian showed a direct climatic influence on ecology (Ülgen et al., 2012). Ocakoğlu et al., 2016 study provided a 2800 years' stratigraphic records of landslide-dammed lake at 1030m elevation level by using multi-proxy record (stable isotopes, sedimentology, diatoms, ostracods, major and trace element geochemistry and pollen,). From the study, the Dark Age and the late Byzantine was observed between 670-1070 AD with increase in $\delta^{18}O$ and lake level. The Little Ice Age was observed within 40 years at 1350AD, the Little Ice Age was supported from all the multi-proxies result (Ocakoğlu et al., 2016). Another study from southwestern Anatolia on micro X-ray Fluorescence, stable isotopes ($\delta^{18}O$ and $\delta^{13}C$) magnetic susceptibility and TOC TIC measurement, revealed a high-resolution multi-proxy results that was in connection with water level fluctuation associated with humid and dry spells for 1400 years. From the proxy, it was observed that the higher lake levels are consistent with solar maxima with total solar irradiance and vice versa (IB Danladi, S Akçer-Ön 2018).

However, Lake Salda records showed dry Dark Ages Cold Period (DACP), humid Medieval Climatic Anomaly (MCA), dry Little Ice Age (LIA), and humid Modern Warm Period (MoWP) which are connected to solar forcing, through its influence on atmospheric circulation, which was the main mechanism of climate change during the era in that region (IB Danladi, S Akçer-Ön 2018).

A prudent comprehension of climate change through the usage of geochemical structure of sediments requires the need of utilizing, weathering based rocks by transportation and depositional conditions (Weltje and von Eynatten 2004). Lake sediments are divided into three groups; endogenic, authigenic and allogenic. Endogenic are derived by biological processes or organic from water column, authigenic are derived within the lake by diagenetic processes while allogenic sediment is control by surface stream, erosion, aeolian activity and mass movement (Last 2004 and Ito 2004).

Dalyan Lagoon Basin paleo-climate record is largely dependent on the water dynamics between Mediterranean Sea salinity level and Dalyan Lagoon fresh water. Presented in this study are the results of paleo-climate obtain using multi-proxy (Factor Analysis, XRF and Stable ($\delta^{18}O$ and $\delta^{13}C$ Isotope). By defining and evaluating the chemical, physical, and biological characteristics of Lake Alagöl, Dalyan channel and Lake Sülüngür sedimentation.

The research is mainly on climate variability, and provides the change that occurred during Late Holocene at a decadal to centennial resolution from Dalyan Lagoon basin that is located in the south-western Anatolia. The study further, gives a contribution to the understanding of these changes in the Eastern Mediterranean.

1. The Research Objective

The main objective of this study is to reconstruct past climatic changes from Dalyan Lagoon basin (Alagol Lake, Dalyan channel and Sulungur Lake) by using sediment record and to compare the obtained result with other studies from Southwestern Anatolia.

1.2 The Geographic views of Dalyan Basin.

Dalyan Basin is located at the boundary of Mugla within southwestern Anatolia. From the southwestern Turkey the basin is connected with Mediterranean Sea, for this reason the basin acts as boundary for both terrestrial and marine organisms. Sarigerme is found at Southeast of Dalyan Basin. Taurus Mountain lays at north of the basin, and later extends to the west and create Gölgeli Mountain (Figure 1.1).

The study area the Mediterranean climate features. Mediterranean climate is recognized with a warm-dry summer and cold wet winter. Change in temperature and precipitation in Dalyan basin is in connection with wind direction and surrounding mountains (Gürel, 2000).

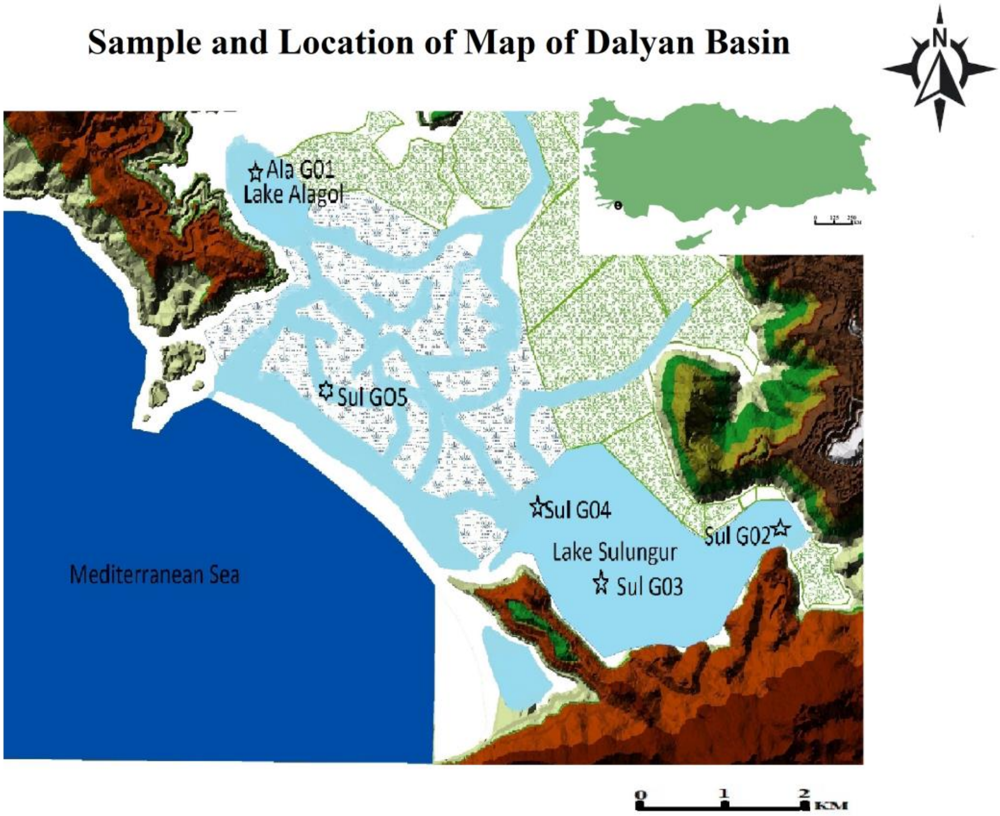

Figure 1.1 Topographic photo describing sample location from Dalyan Lagoon Basin.

1.3 Geological View of Study Area

Dalyan basin is located at the western end of Taurus tectonic belt (Graciansky 1968,1972). The study area dominated by post-orogenic sediments, that are formed during the Plio-Quarternary era. The tectono stratigraphic structures started with autochthonous Beydaglari carbonates that were formed during Cenomanian-Early Miocene age (Graciansky, 1968;1972). The formation is made of lightly-bedded micritic limestone and thickly-bedded calcarenite (Graciansky, 1968;1972). The Miocene flysch, are made of marl, claystone, limestone and sandstone. The south of Lake Sülüngür and southwest of Alagöl Lake are mainly covered with allochtonouse Lycian Nappe that tectonically overly on the autochthonous units (Figure 1.2).

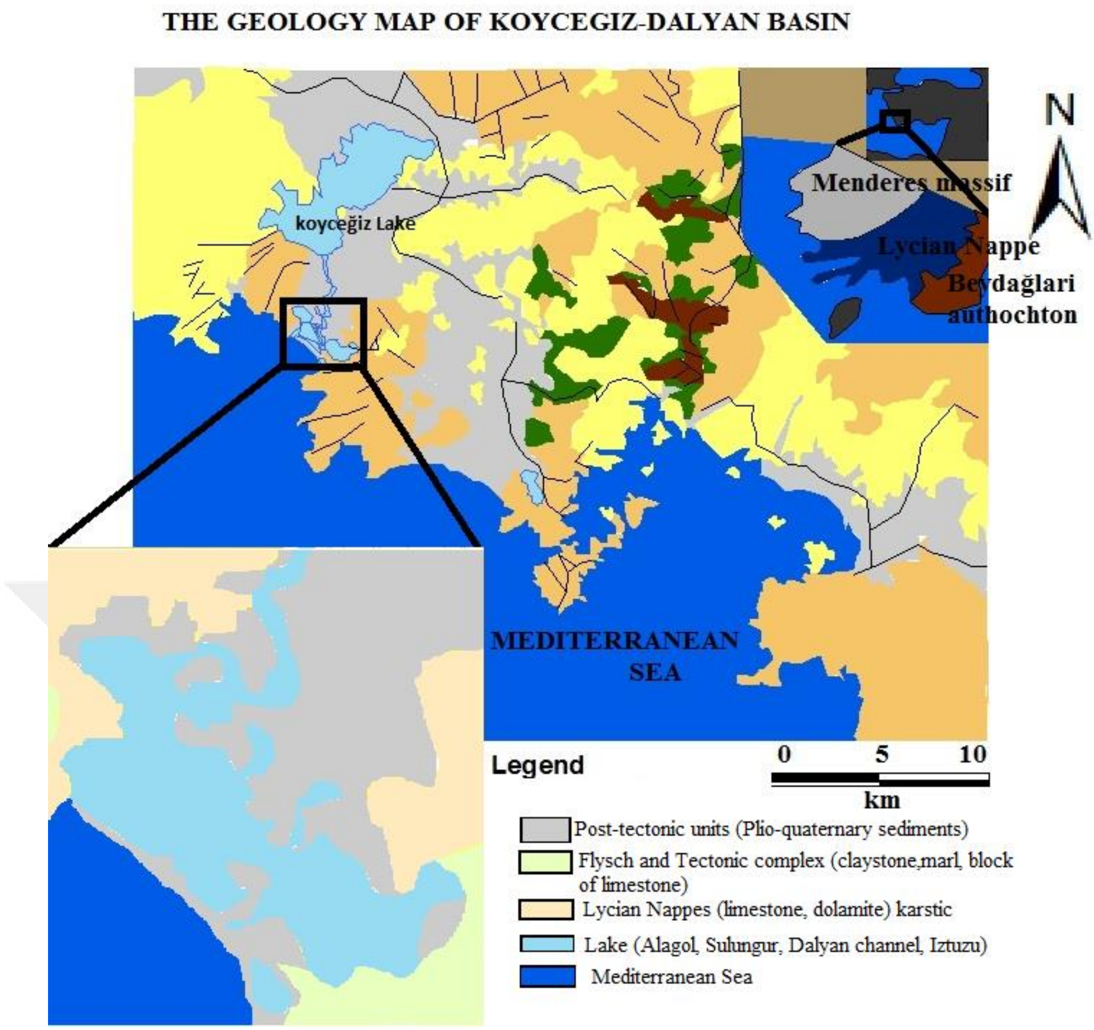

Figure 1.2 Location of Dalyan Basin showing it geological characteristic (Graciansky. 1968; 1972 and Avsar et al 20217).

1.4. The Limnology of Dalyan Basin

The concentration of the later water corresponds with the seasonal climate changes. The Salinity level increases with depth (Gonenc et al, 2004). The salinity level high during summer and in spring it decreases (Gonenc et al, 2002). Dalyan basin is fed by underground water, precipitation and Köyceğiz Lake and discharge to Mediterranean Sea from Dalyan Channel.

2 Materials and Methods

2.1. Method of Core Recovery

The sample that was used for this studies was recovered from Dalyan Basin by using fishing boat on 25/12/2015. This samples were retrieved using a plastic liner (Figure 2.1). This was saved at Muğla Sıtkı Koçman University Geology Lab before the analysis.

Figure 2.1 sample was retrieved on fishing boat by using coring tube.

The sample retrieved coordinate, length and depth are given below in are given below (Table 2.1).

Table 2.1 Sample Length, recovery location and Depth from Dalyan Basin.

Name	Depth.	Length.	X_coordinate. UTM	Y_coordinate UTM
Alagöl2015_G01	3.20_m	33_cm	35,643,464m. E	4,075,802m. N
Sul2015_G02	5_m	49_cm	35,648,237m. E	4,073,135m. N
Sul2015_G03	11_m	39_cm	35,646,070m. E	4,072,349m. N
Sül2015_G05	5.20_m	45_cm	35,644,407m. E	4,073,810m. N

2.2 Method of Core Sampling

This was done in Geology Lab of Mugla Sitki Kocman University. After splitting the samples in half, firstly sediment core photo was obtain from the slice. Change that was observed in level was written down.

2.3. Method of Statistical Analysis.

This was to underline linear relationship in multi-proxy data. This method is known as dimensional reduction method (Principal Component Factor Analysis). PCFA is a correlation-based method, because outliers may easily create pseudo results. For this studies the Fe, Sr, K, Mn Ti and Ca are chosen for the environmental studies. (IB Danladi, S Akçer-Ön 2018). In order to correctly interpret the factor analysis result, firstly elimination of outliers was carried out. For this analysis, ‘’Wilks, 1963’’ statistic method was used and for the significance test ‘’Yang and Lee, 1987’’ method was used in other to detect the outliers (Rencher and Christensen, 2012). The outliers were removed at 95% significance level before usıng the PCFA to identify the factor analysis eigenvalues.

2.4. Multi_Sensor Core Log

This analysis was accomplished on the sediment cores that was split sent to ITU_EMC. This method is used for determining change in detrital input (Thompson et al., 1975, IB Danladi, S Akçer-Ön 2018).

2.5 Method of µXRF Core Scanning.

This analysis was also accomplished on sediment cores sent to ITU-EMCOL lab. For the XRF scanning, 50 kV, 50 mA and an exposure time of 800 ms were used. Fe, Mn, K, Ti, Ca, Sr, intensity expressed as count per seconds (cps) were used. The radiography photos were achieved in ITU_EMCOL lab. The changings observed from radiographic photos were used in making comment base on change in element (Hamblin, 1962; Axelsson, 1983).

2.6 Stable Isotope Analysis

Samples were extracted from sediment cores in accordance with selected intervals. from Alagöl2015-G01, sample was removed with 2_cm interval while from Sul2015-G02, sample was removed at 1_cm intervals. After the extractions, the sample was frozen to dry. This was accomplished in Muğla Sıtkı Koçman University Geology lab. The sample was later washed by using pressurize water. After washing the samples were put to dry in cups. The extraction of microorganism was accomplished later by using optical microscope. Among the organism found, Ammonia tepida was used for this research.

For this analysis 25 samples are selected from Sul2015-G02 while from Alagol2015 G01, 11 samples were selected. The selected samples were later sent to Arizona University, Environmental Isotope Laboratory.

2.7 Radiocarbon Dating

After the extraction of sample that are to be used for stable oxygen and carbon isotope analysis, the remaining organic remain are used for carbon dating. This samples are extracted base on selected intervals from Sul2015-02. The amount of organic remains found in Sul2015-03 was little. For this reasons 100mg plant remains was used for this analysis. (Table. 2.2).

Table 2.2 Radiocarbon sample base on their subtract level that was sent to Poznan Radiocarbon Laboratory

Analysis name.	Test center	Amount of sample
Sul2015_G02_21-22_cm	Poland Poznan lab	14 mg
Sul2015_G02_49-50_cm	Poland Poznan lab	16 mg
Sul2015_G03_36-37_cm	Poland Poznan lab	100mg“Plant remains”

2.8 Calibration

This work was accomplished by using Calib 7.10. the method used for this analysis was Reimer, P J and McCormac, F G, 2002.

2.9 Chronostratigraphy

The age that was obtained after the correction of reservoir effect are later updated base on extracted level before correlation with the remaining three samples that are retrieved from Dalyan basin. This is accomplished using Analyseries.

3 RESULTS

3.1. Result of Lithological Description.

The comment on lithology description was written base on changes that was obtained from the retrieved four sediment core after dividing the sediment core into half.

3.1.1 Alagöl2015_GO1

Some very dark-brown silty granular was observed from all of this sediment core, for this reason, difference in level was hard to differentiate. A bioturbation that was cause by clam shell was noticed. The radiographic photo showed a light-grey level at 30-12cm and from while between 11-4cm, light dark-grey level was noticed and from 3-0cm a light-grey level is seen (Figure 3.1).

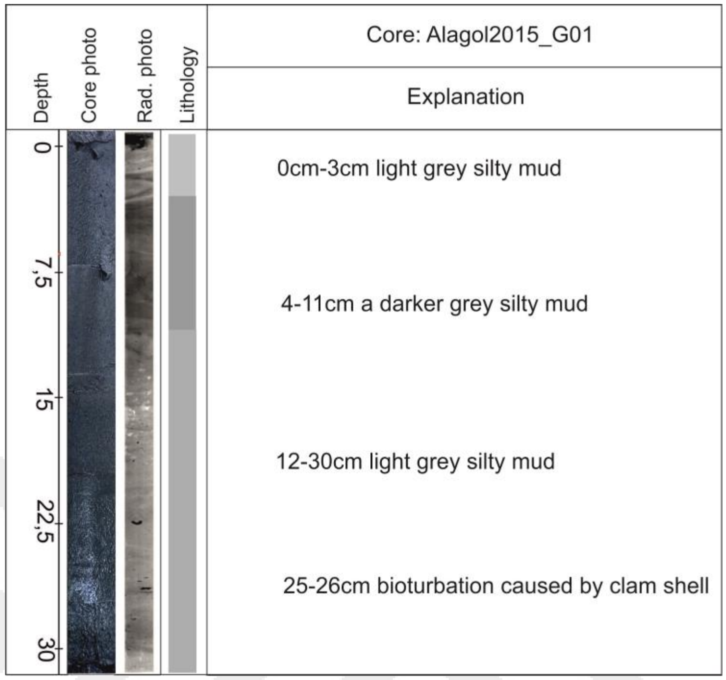

Figure 3.1 Result of lithology description for Alagöl2015_G01

3.1.2 Sul2015_GO2

Between 49cm light olive-and light grey with lamination keeps repeating until. Between 17-23mm light grey silty granular. From 13-17cm dark-grey silty granular was observed. While between 13-14cm olive-grey silty granular with a well laminated level was noticed. From the sediment core between 0-13_cm, dark-grey silty granular was seen (Figure 3.2).

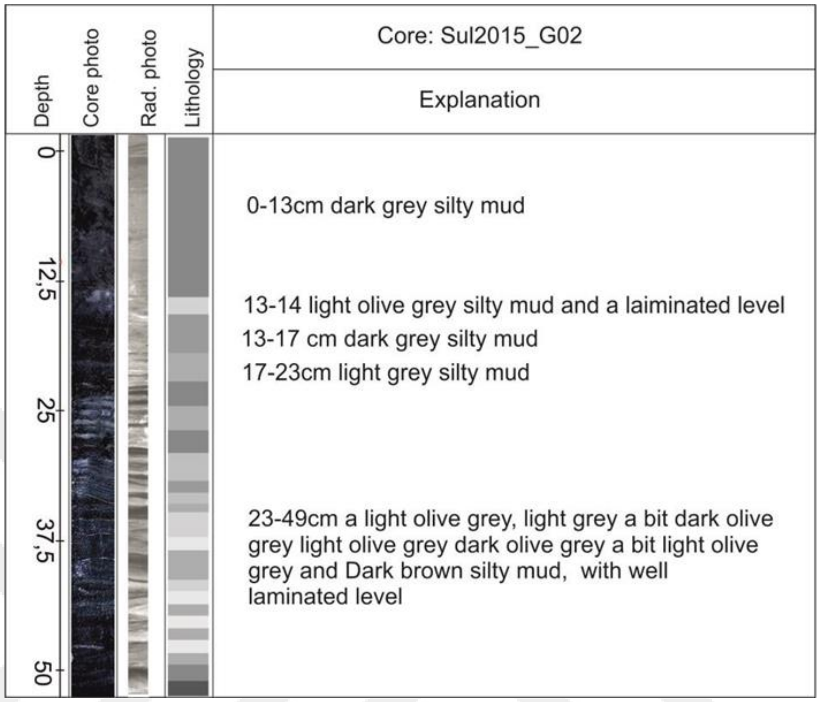

Figure 3. 2 Result of Lithology description for Sul2015_G02

3.1.3 Su2015_GO3

A very dark-grey silty granular was seen between 32-21cm and from 21-17cm, dark-grey silty granular was noticed. Between 22-17cm some light-grey silty granular, from 13-17cm dark-grey silty granular was observed. Light olive-grey silty granular and a laminated level was noticed at 12-13_cm. A bit light-grey and light-beige that is well laminated was seen between 5,7-8,5cm. Between 4-5cm light olive-grey and a laminated level was observed (Figure 3.3).

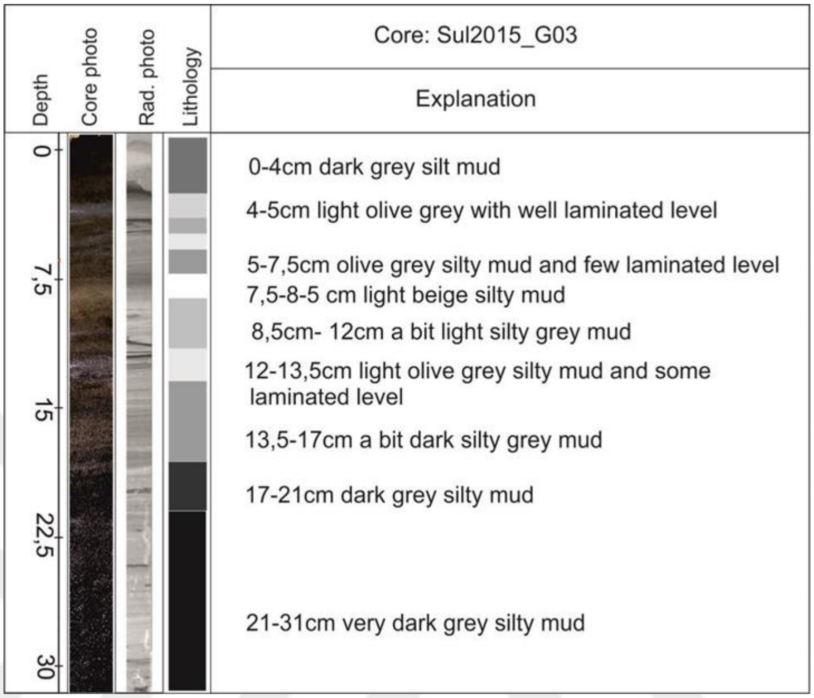

Figure 3.3 Result of Lithology description for Sul2015_G03

3.1.4 Sul2015_GO5

The quantity of silty mud was very high in this sediment core. from 23.6-31cm some dark-brown silty mud was observed and between 23-23.5cm some light-brown silty mud was noticed. some grey granular level was seen between 20.5-21cm while from 19,5-12.5cm, 6.5-7cm a light-grey silty granular and 3.5-5.5cm dark-grey silty granular mud was seen (Figure 3.4).

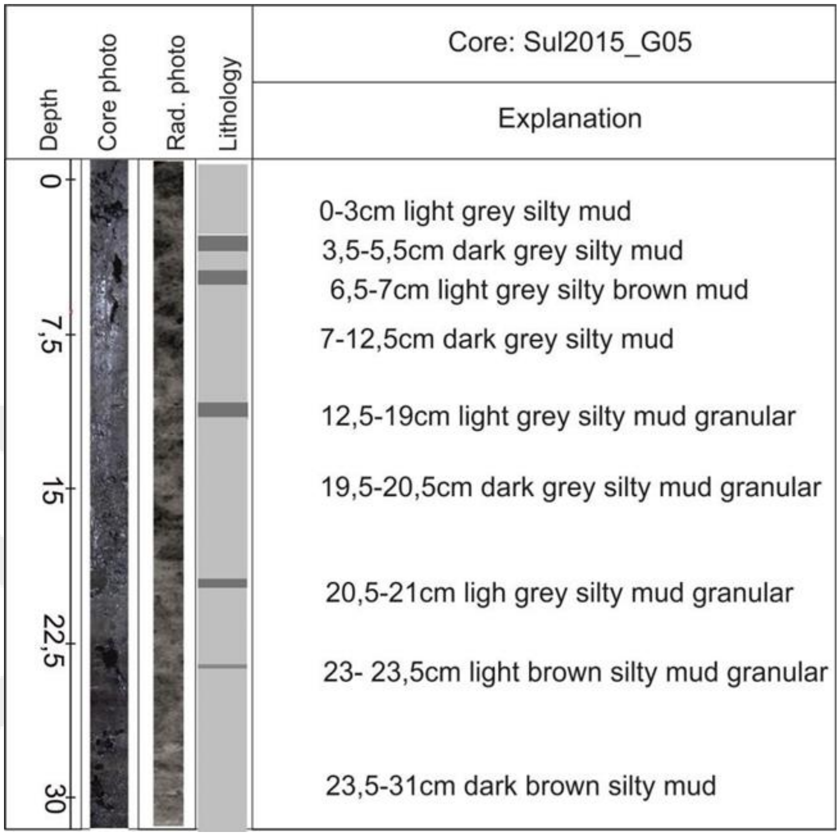

Figure 3.4 Result of Lithology description for Sul2015_G05

3.2 Result of Statistic Analysis.

This method was used in finding existing linear relation between selected element for this studies.

3.2.1 Alagöl2015_GO1

Alagol2015 GO1, lowest value for component one is -0.602. while peak value is 0.947. The second component lowest ratio was -0.198. the peak ratio of the second component was 0.964 (Table 3.1).

Table 3.1 Result of rotational component for Alagöl2015 G01

Rotated Component Matrix[a]		
	Component	
	1	2
K	,892	-,143
Ca	,008	,964
Ti	,847	-,223
Mn	,936	,036
Fe	,947	-,198
Sr	-,602	,674

The result of component plots showing elements base on their rotated space group of element. shows that the first group one consist of Mn, Fe, K, and Ti, while group two include of Ca and Sr (Figure 3.5).

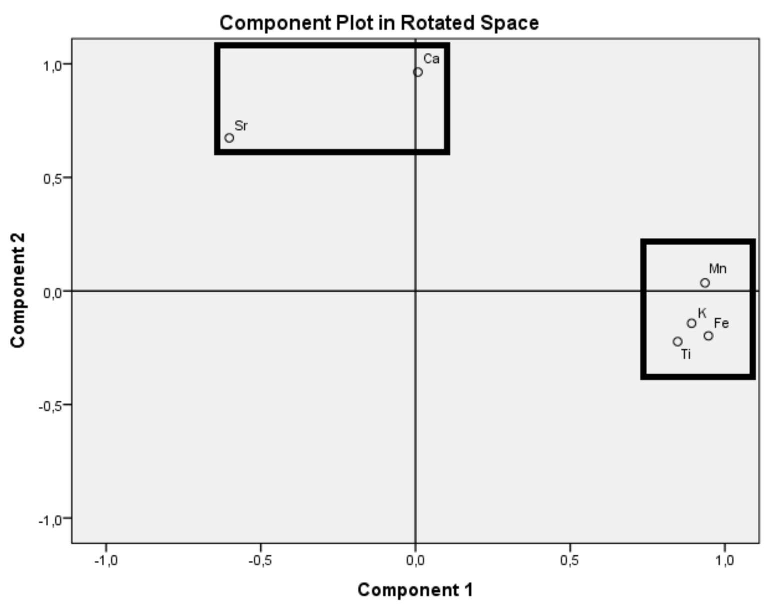

Figure 3.5 Result ofAlagol2015_GO1 by using Factor Analysis.

3.2.2 Sul2015_GO2

Sul2015 GO2, lowest value for component one is-0.648. while peak value is

0.922. The second component lowest ratio was -0.343. the peak ratio of the second component was 0.954 (Table 3.2).

Table 3.2 Result of rotational component for Sul2015 G02

Rotated Component Matrix[a]		
	Component	
	1	2
K	,865	-,343
Ti	,907	-,187
Mn	,787	,008
Fe	,922	-,281
Ca	-,648	,557
Sr	-,103	,954

The result of component plots showing elements base on their rotated space group of element. shows that the first group one consist of Mn, Fe, K, and Ti, while group two include of Ca and Sr (Figure 3.6).

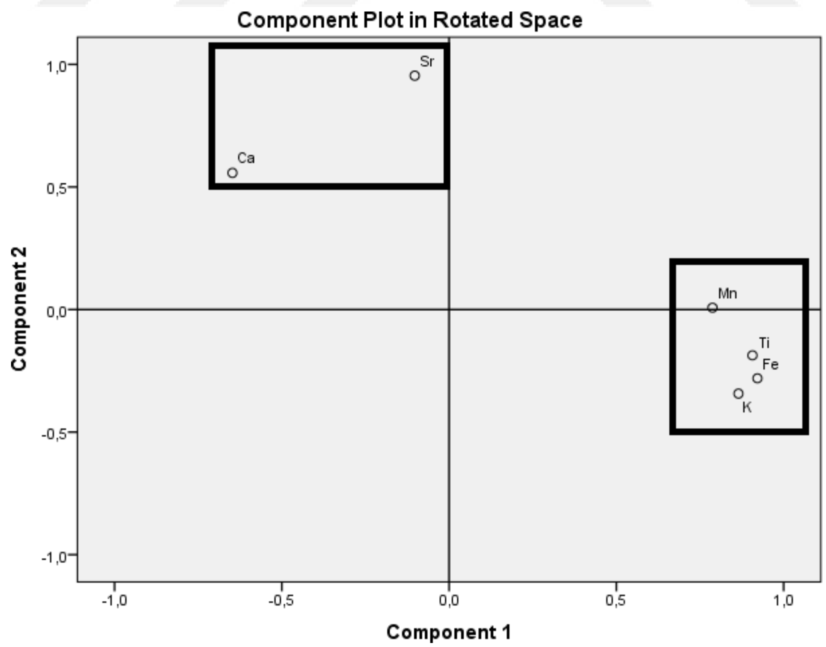

Figure 3.6 Result of Sul2015_GO2 by using Factor Analysis.

3.2.3 Sul2015_GO3

Sul2015 GO3, lowest value for component one is -0.284. while peak value is 0.917. The second component lowest ratio was -0.540. the peak ratio of the second component was 0.957 (Table.3.3).

Table 3.3 Result of rotational component for Sul2015 G03

Rotated Component Matrix[a]

	Component	
	1	2
Ca	-,089	,957
Ti	,917	-,251
Mn	,563	-,472
Fe	,808	-,540
Sr	-,284	,904
K	,948	-,005

The result of component plots showing elements base on their rotated space group of element. shows that the first group one consist of Mn, Fe, K, and Ti, while group two include of Ca and Sr (Figure 3.7).

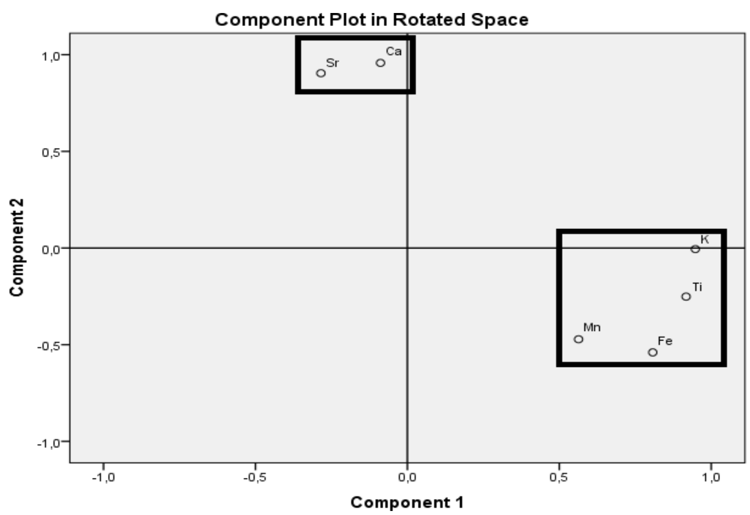

Figure 3.7 Result of Sul2015_GO3 by using Factor Analysis.

3.2.4 Sul2015_GO5

Sul2015 GO5, lowest value for component one is -0.181. while peak value is 0.709. The second component lowest ratio was -0.072. the peak ratio of the second component was 0.836 (Table 3.4).

Table. 3.4 Result of rotational component for Sul2015_G05

Rotated Component Matrix[a]		
	Component	
	1	2
K	,314	,571
Ca	,669	,194
Ti	,468	,296
Mn	,709	-,072
Fe	,694	-,032
Sr	-,181	,836

The result of component plots showing elements base on their rotated space group of element. shows that the first group one consist of Mn, Fe, Ca, K, and Ti, while group two include only Sr (Figure 3.8).

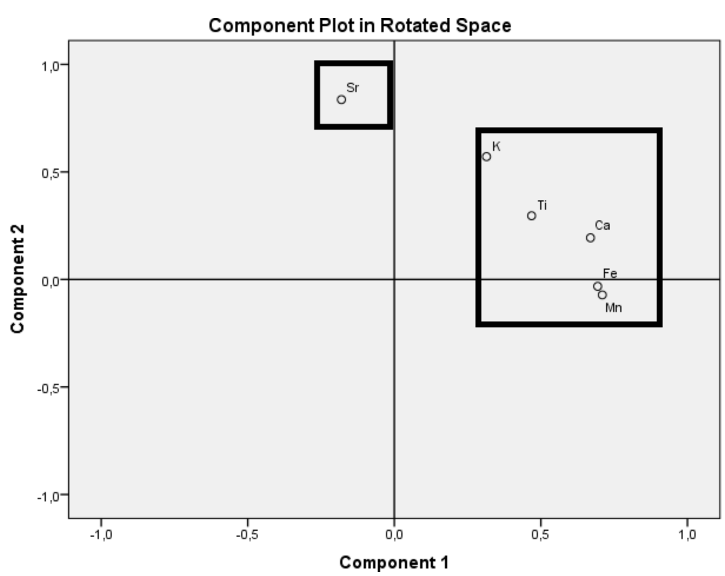

Figure 3.8 Result of Sul2015_GO5 by using Factor Analysis.

3.3. Result of Magnetic Susceptibility and Density.

3.3.1 Alagol2015_GO1

MS and density showed an increase at 280 mm. Density was decreasing in at 255mm, 144 and 76mm respectively when MS was showing an increase in ratio. Lowest ratio of MS was seen at 30mm and Density showed its lowest value at 5mm (Figure 3.9)

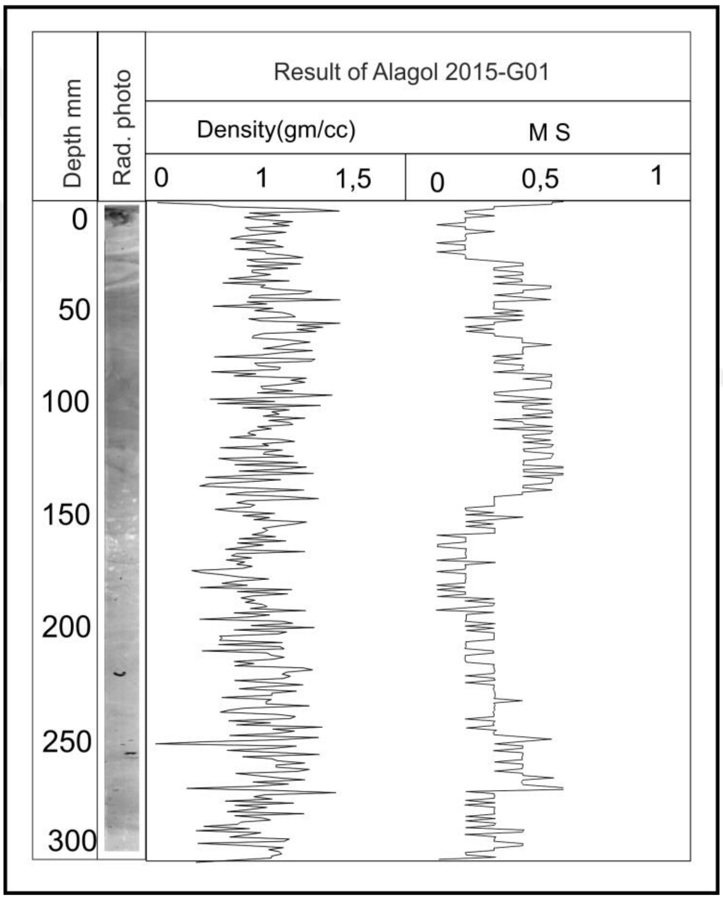

Figure 3.9 Result of Density and Magnetic susceptibility, Alagöl 2015_GO1

3.3.2 Sul2015 GO2

Density and MS gave an increase at 415-405mm, 295-250mm, 200-170mm, 155-140mm, 65-66mm, 36-25mm. The peak of MS was seen at 65mm. Reduction in ratio was seen at 325-305mm, 244-236mm, 125-70 mm. there was a decrease in ratio from between 483-285mm. An increase in ratio from density is seen at 281-243mm, 274-251mm, 127-92mm and 23-5mm (Figure 3.10).

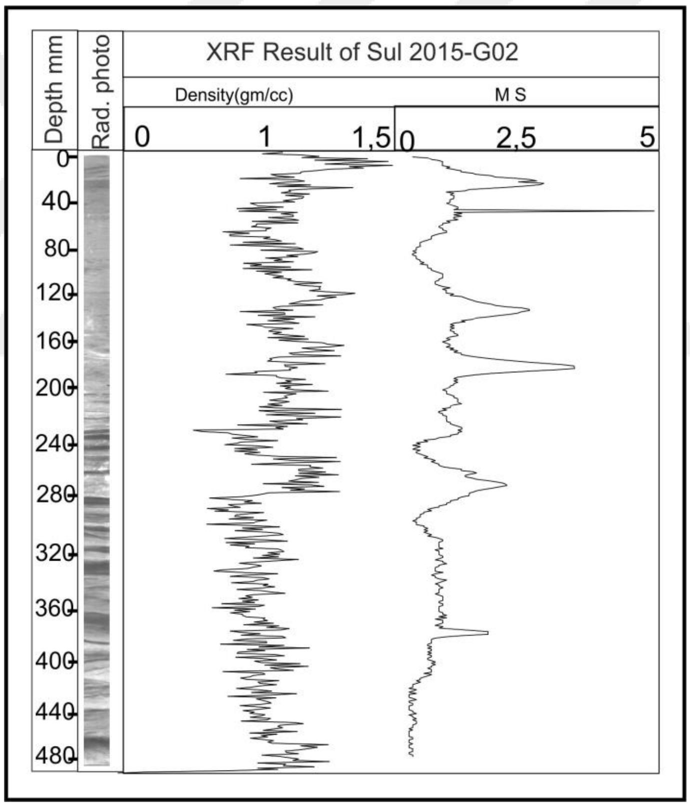

Figure 3.10 Result of Density and Magnetic susceptibility, Sul2015 GO2

3.3.3 Sul2015_GO3

There was an increase in ratio from density and magnetic susceptibility at 362_350mm. an increase in value from density was observed between 325-315_mm. magnetic susceptibility showed a continue increase between 245 to 25_mm. between 225-217 there was an increase density (Figure 3.11).

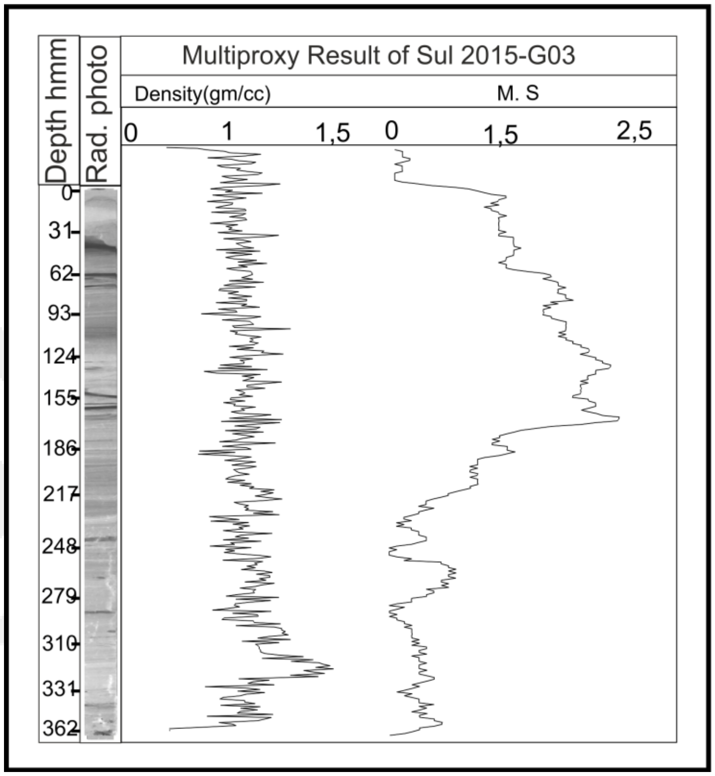

Figure 3.11 Result of Density and Magnetic susceptibility, Sul2015 GO3

3.3.4 Sul2015_GO5

Peak of M S was seen at 300mm. A decrease in ratio was seen from MS at 298_mm. Between MS and density there was a decrease in value at 170_mm. MS showed its lowest ratio at 5mm (Figure 3.12).

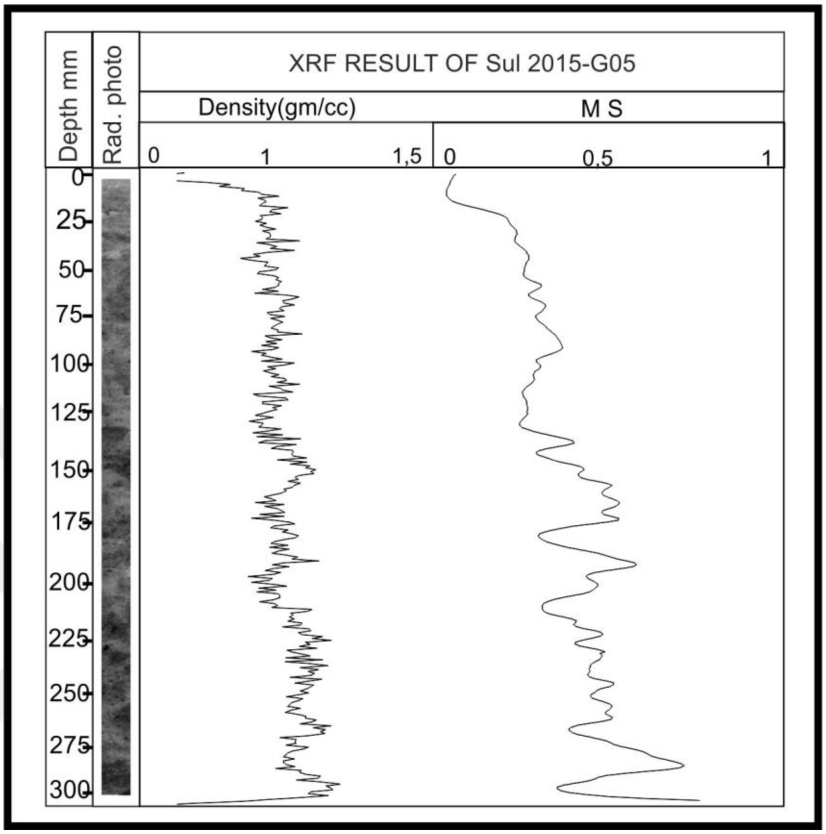

Figure 3.12 Result of Density and Magnetic susceptibility, Sul2015 GO5

3.4. µXRF Scanning Result.

3.4.1 Alagöl2015_ GO1

Between 300-200mm, Iron, titanium, potassium and manganese where at their lowest level while calcium and strontium where high and from 200-50mm strontium showed a decrease while Iron, titanium, potassium and manganese level where increasing. Iron showed it peak at 130mm. between 75-25mm there was an increase iron concentration. (Figure 3.13).

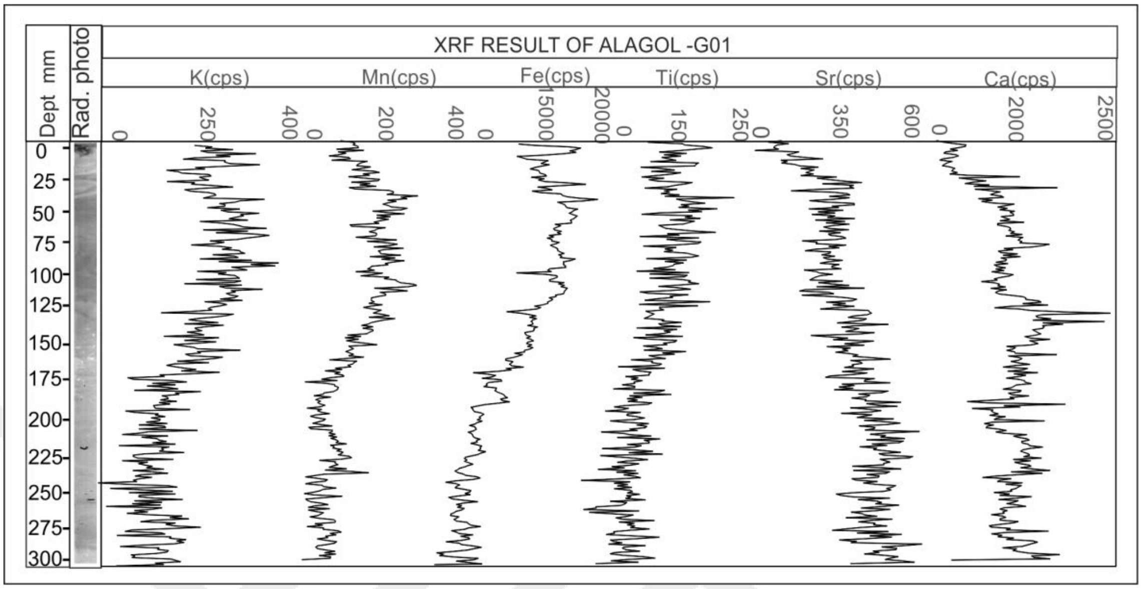

Figure 3.13 Result of count per second of Alagol2015_G01 sediment core record.

3.4.2 Sul2015_GO2

Fe, Ti, K and Mn was decreasing from bottom to 280mm while at this level Ca and Sr were gradually dropping from its peak level. At 270-225mm iron, titanium, potassium and manganese showed an increase while calcium and strontium showed a decrease. Between 225-200mm calcium and strontium showed an increase while at this level, Iron, titanium, potassium and manganese where deflating. The peak of Iron, titanium, potassium and manganese where observed between 195-100mm while at this level the concentration of calcium and strontium where at their minimum. (Figure 3.14).

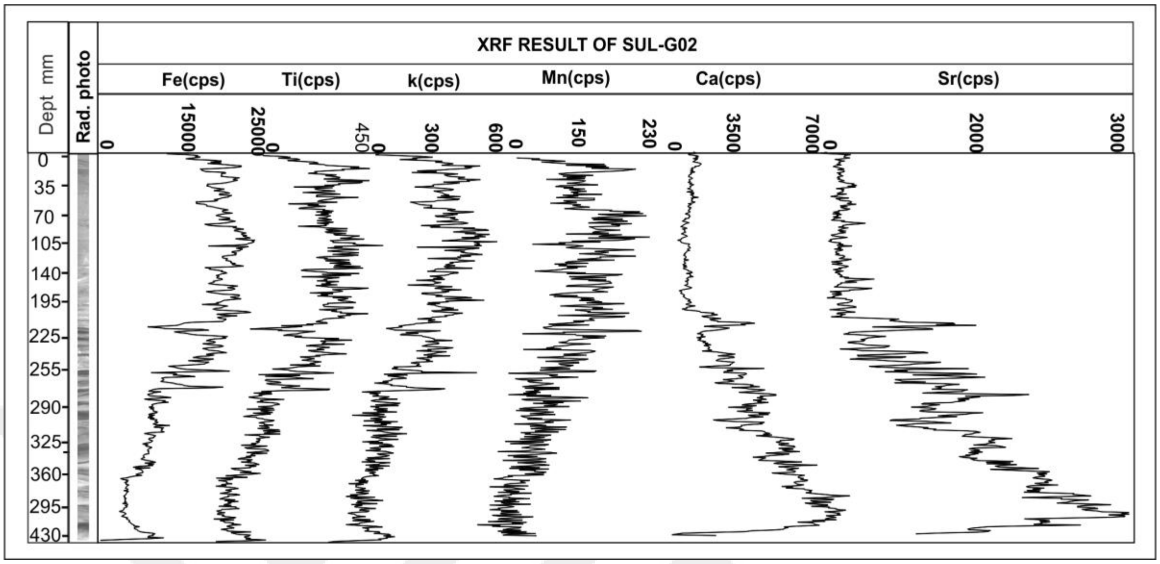

Figure 3.14 Result of count per second of Sul2015_G02 sediment core record.

3.4.3 Sul2015_GO3

K, Mn, Ti and Fe value was increasing at 355-315mm when Sr and Ca concentrations was decreasing. Between 315-25mm Sr and Ca was increasing when K, Mn, Ti and Fe where decreasing. At 255-235mm K, Mn, Ti, and Fe, an increase in value was observed when Sr and Ca showed a decrease. While between 225mm, Sr and Ca there was an increase in value that later started decreasing until 66mm when K, Mn, Ti and Fe are showing increase (Figure 3.15).

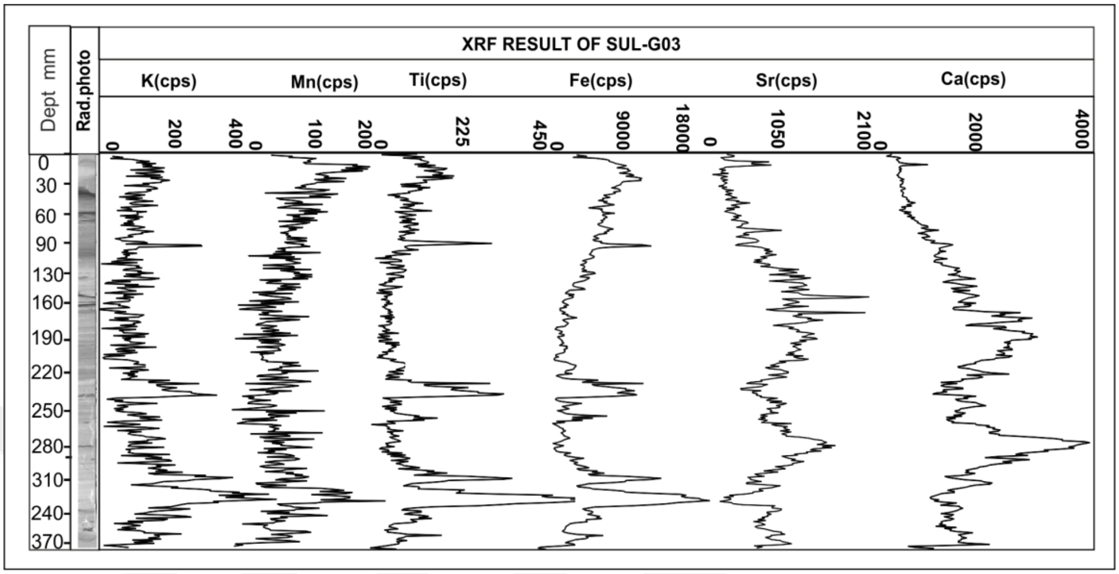

Figure 3.15 Result of count per second of Sul2015_G03 sediment core record.

3.4.4 Result of Sul2015_GO5

Mn,Fe and K were increasing at 305mm. Peak of Sr was observed at 280mm. Peak of Ca, Ti and Fe was observed at 165mm. a decrease was observed from Mn at 150- 50mm. the lowest ratio of Ca, Fe, and Ti was seen at 125mm and K gave its lowest value at 70mm (Figure 3.16).

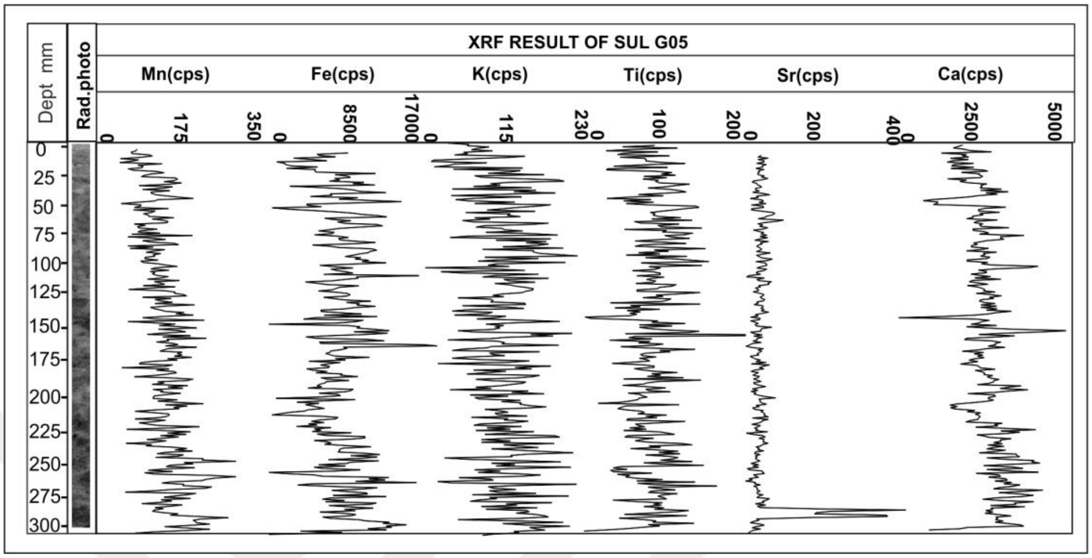

Figure 3.16 Result of count per second of Sul2015_G05 sediment core record.

3.5 Stable (oxygen, carbon) Isotope Analysis

Results obtain from stable (oxygen carbon) isotopes are giving as (Appendix. A, Appendix. B).

3.5.1 Alagöl2015_GO1

An increase was observed between $\delta^{13}C$ and $\delta^{18}O$ at 305-230mm (Figure 5.1). A decrease in value was observed between $\delta^{18}O$ and $\delta^{13}C$ at 225-150mm. The highest value of $\delta^{18}O$ was seen at 80mm. The peak of $\delta^{13}C$ was seen at 80mm. the lowest value of $\delta^{13}C$ and $\delta^{18}O$ was seen at 45mm (Figure 3.17).

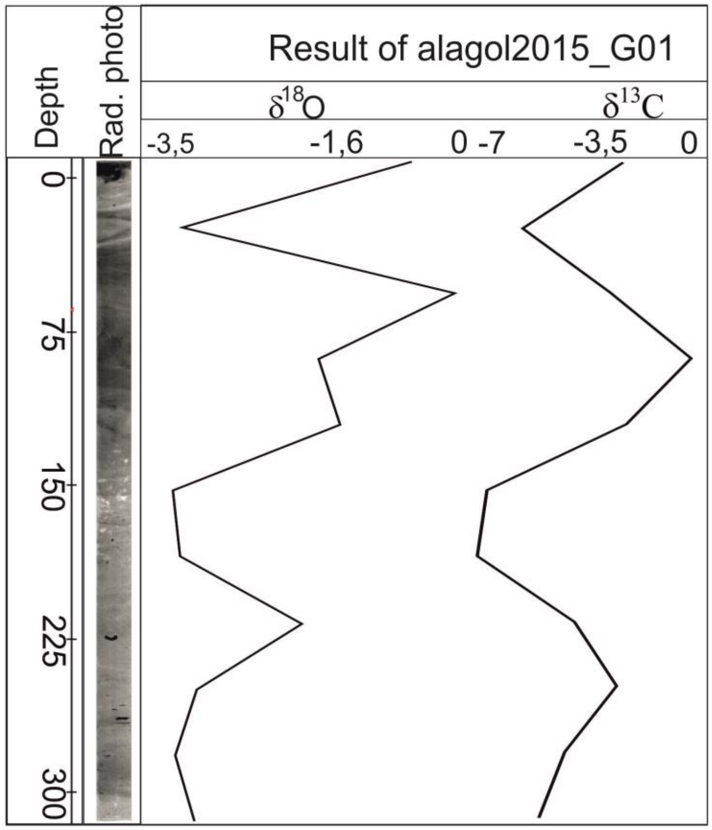

Figure 3.17 Stable (oxygen, carbon) isotope analysis result obtain from Alagol2015 GO1 sediment core.

3.5.2 Sul2015_GO2

Between 485-465mm, 470-440mm, 430-220mm there was an increase between $\delta^{18}O$ and $\delta^{13}C$. Fall in value was seen in $\delta^{18}O$ at 235mm. At 230mm $\delta^{13}C$ and $\delta^{18}O$ increase in value up to l55mm. the peak of $\delta^{13}C$ and $\delta^{18}O$ seen at 55mm (Figure 3.18).

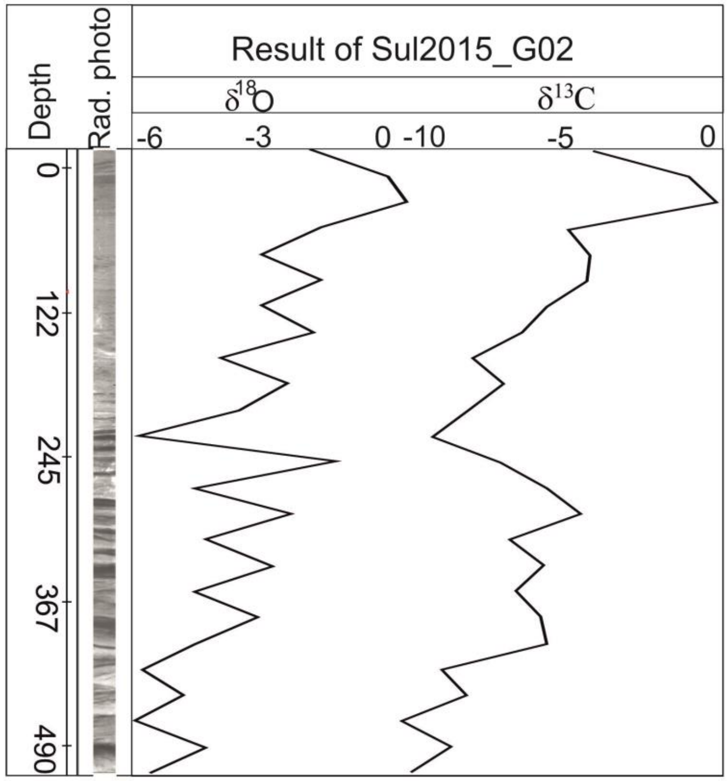

Figure 3.18 Stable (oxygen, carbon) isotope analysis result obtain from Sul2015_GO2 sediment core.

3.6. Radiocarbon Age modeling.

For the reservoir effect, Reimer, PJ and McCormac, FG, (2002) method was used. Delta R was 40 while the uncertainty of delta R was 40. this was performed on analysis result that was obtain from Poznan laboratory. The result of this analysis are giving below. For Sul2015 GO3, the result of the corrected reservoir effect was below 100BP. For this reason, we accepted this analysis result could be corrupt.

Table 3.5 Result of Radiocarbon dating after reservour effect correction for Sul2015 GO2 and Sul2015 GO3

Samples name.	Laboratory number.	Age. δ ^{14}C	Remark.	Calibrated Age
Sul2015 G02 21 to 22cm	Poz 94611	1465±30 Bp		975±30 Bp
Sul2015 G02 49 to 50cm	Poz 94613	2625±30 Bp		2255±30 Bp
Sul2015 G03 36 to 37	Poz 95255	105.26±0.33 pMC	Modern.	

The remaining sediment core that are retrieved from Dalyan Basin where later correlated by using Analyseris. For this correlation, some random element that was selected for this studies were used.

3.6.1 Alagol2015_GO1

The age correlation between Alagol2015 G01 and Sul2015G 02 provided a 2231Bp. The rate of sedimentation the age and depth is given (Figure 3.19)

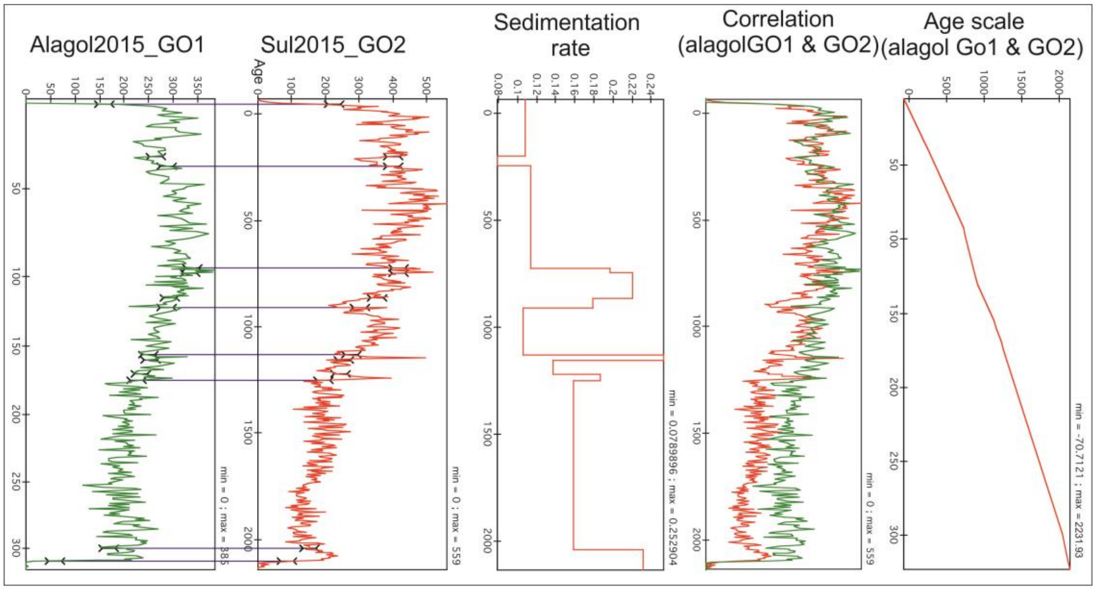

Figure 3.19 correlation of Alagol2015 GO1 with Sul2015 GO2 by using Ti

3.6.2 Sul2015_GO3

The result of correlation between Sul2015 GO3 and Sul2015 GO2 provided an age of 2243BP. The result of this correlation is given below. The rate of sedimentation the age and depth is given (Figure 3.20).

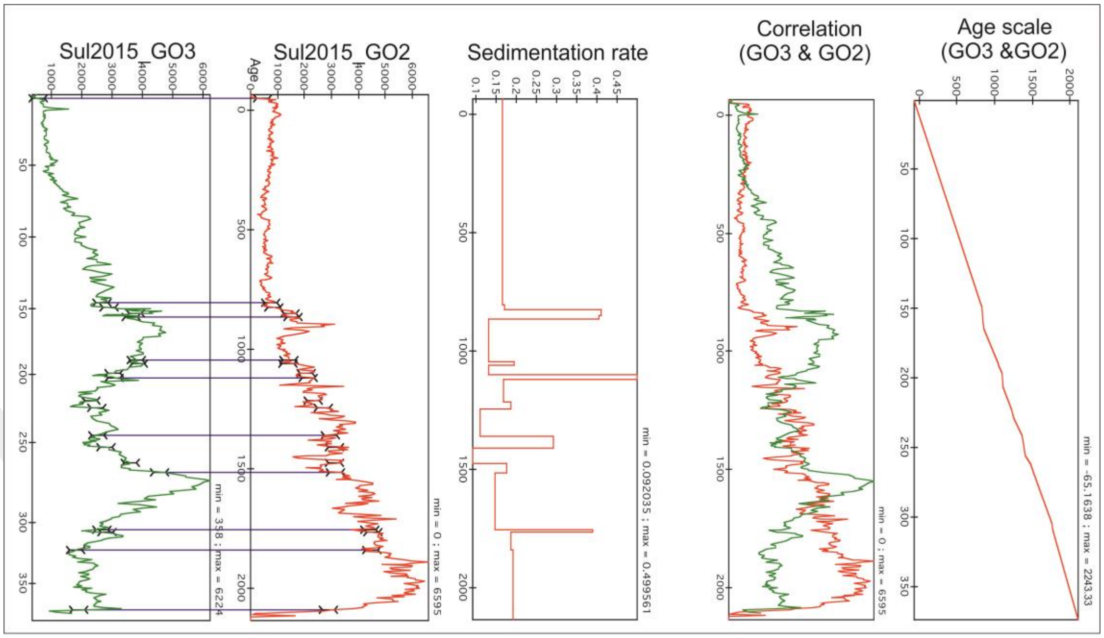

Figure 3.20 Correlation of Sul2015 GO3 with Sul2015 GO2 by using Ca

3.6.3 Sul2015_GO5

The sediment core of Sul2015 GO5 was correlated with Sul2015 GO2 the result an interval of 2208Bp. The result of this correlation is given below. The rate of sedimentation the age and depth is given (Figure 3.21).

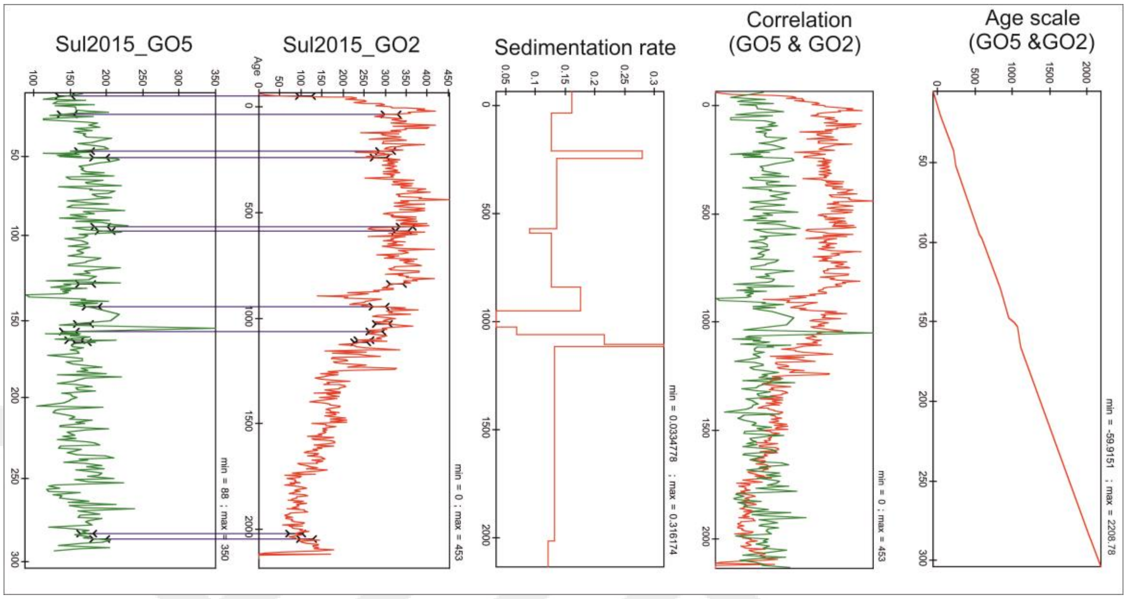

Figure 3.21 correlation of Sul2015 GO5 with Sul2015 GO2 by using Ti

4 DISCUSSIONS.

4. 1. The Statistical Analysis.

Two groups of element were represented from factor analysis, from the first set, Sr this first set of element are in connection with carbonates ration, which are accepted they exist in the lake (Akçer Ön. 2017), the second Set Fe, K, Ti, and Mn, are classified as detrital element coming from the catchment (Akçer Ön 2017). Counts of Fe and Ca are having high values base on all the element used in the studies, Because of this, Fe and Ca were used in representing the component. The sediment core Sul2015 GO5, Ca was observed as the only endogenous carbonate in the study area and Sr was observed as detrital components. This sediment core Sul2015 GO5 was collected close to the Mediterranean Sea and at this location, the Basin interruption with the Mediterranean Sea is high. And observation of microorganism in Sul2015 GO5, there was no ostracod shell, but the amount of foraminifera was high and Foraminifera endure brackish environment.

4.2. The Result of Multi-Proxy Result

The multiproxy that was used to define past climate by using sediment record are Factor Analysis, Ca/Fe, inc/coh, Ca, stable (oxygen, carbon) isotope and MS (magnetic susceptibility). For the in hydrologic cycle, the ratio of $\delta^{18}O$ was used (Akçer Ön Sena., 2017). The ratio of $\delta^{13}C$ was used in giving information on change in biological properties and dissolved inorganic carbon (Akçer Ön.Sena, 2017 and Sören Hakansson 1985). Usually, the ratio of $\delta^{18}O$ and $\delta^{13}C$ isotopes values increase and decrease at same level in a close Lake (Akçer Ön., 2017). Sr and Ca, are inversely related to clastic element (Ti, Fe, and K), reduction value at dry/cold periods and rise in value at wet/warm periods. Though Sr and Can mostly reveal endogenous properties, at some level, they are also effected with detrital materials. Ca/Fe represent autogenic deposition (Cohen, 2003, Burnett et al 2011, Thompson & Oldfield 1986, Mueller et al 2009, Akcer On, 2017,). The change in İnc/Coh ratio is use for making comment on organic material (Akçer Ön., 2017 and Rodriguez-Germade et al., 2014). Change in value from magnetic sensitivity is dependent from the amount of ferromagnetic minerals that are found in the mud.

4.2.1 Alagol2015_GO1

The of this sediment core is 2231BP years. Between 2000-1650, 1410-910BP and 250-50BP, a warm/wet period was seen. The mud in this sediment core is very soft and dark and this makes it hard to different change in content. from 1650-1410BP and 910-250BP, showed some dry/cold period (Figure 4.1)

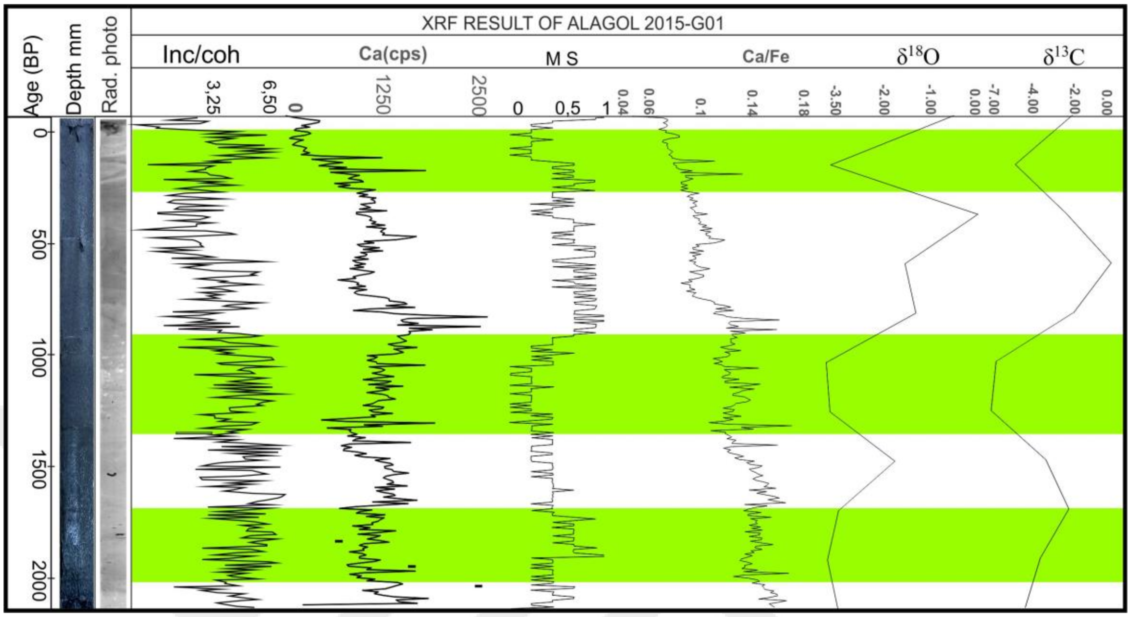

Figure 4.1 Multi-Proxy of Sul2015-G05 sediments core. green reperesent wet/warm period.

4.2.2 Sul2015_GO2

There was high amount of microorganism in this sediment core, because this core sample is located close to aquaculture environment. The age of this sediment core is 2255BP years. Between 2100-1650BP, 1460-1250BP, 1040-700BP, 450-50BP wet/worm period was observed. Cold/dry period where observed from 1650-1460BP, 1250-1040BP and 700-450BP. From the record of well-laminated levels that was seen on lithological description was observed with increase in inc/coh at 1210-1060BP, 610-510BP and 340-290BP (Figure 4.2).

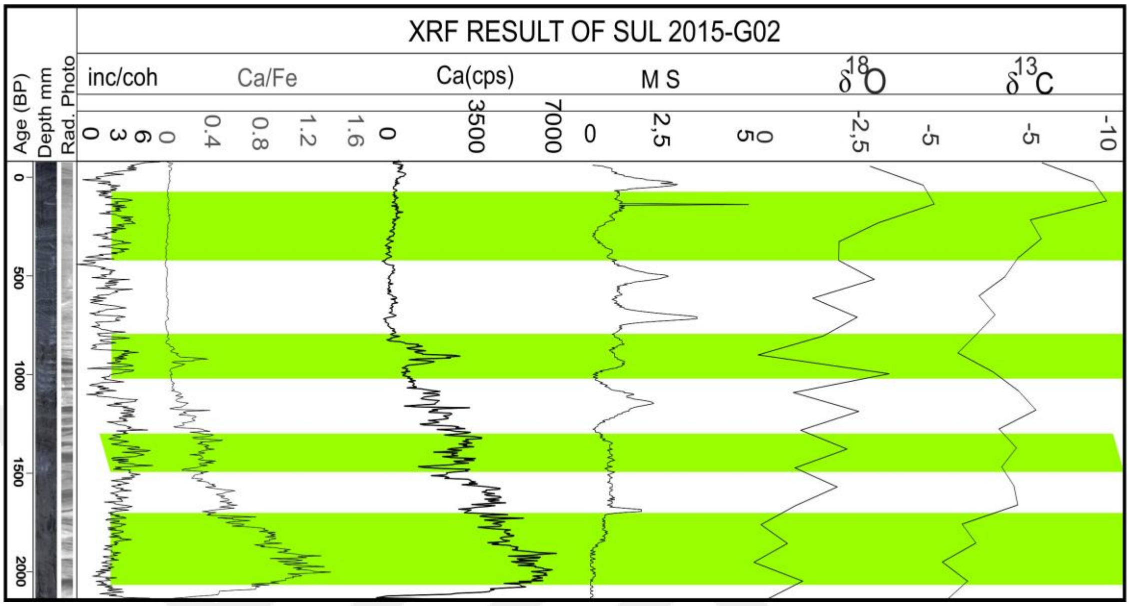

Figure 4.2 Multi-proxy of Sul2015-G02 sediments core. green reperesent wet/warm period.

4.2.3 Sul2015_GO3

The correlated age is 2249BP years. Between 2200-2000BP, 1900-1800BP, 1550-1200BP, 1050-950BP, 600-550BP and 450-50BP a wet period was observed. The lamination that where observed are mostly seen at inc/coh increase. While between 2000-1900BP, 2000-1900BP, 1200-1050BP, 950-600BP and 550-450BP a decrease in inc/coh was observed. This was translated as dry period (Figure 4.3).

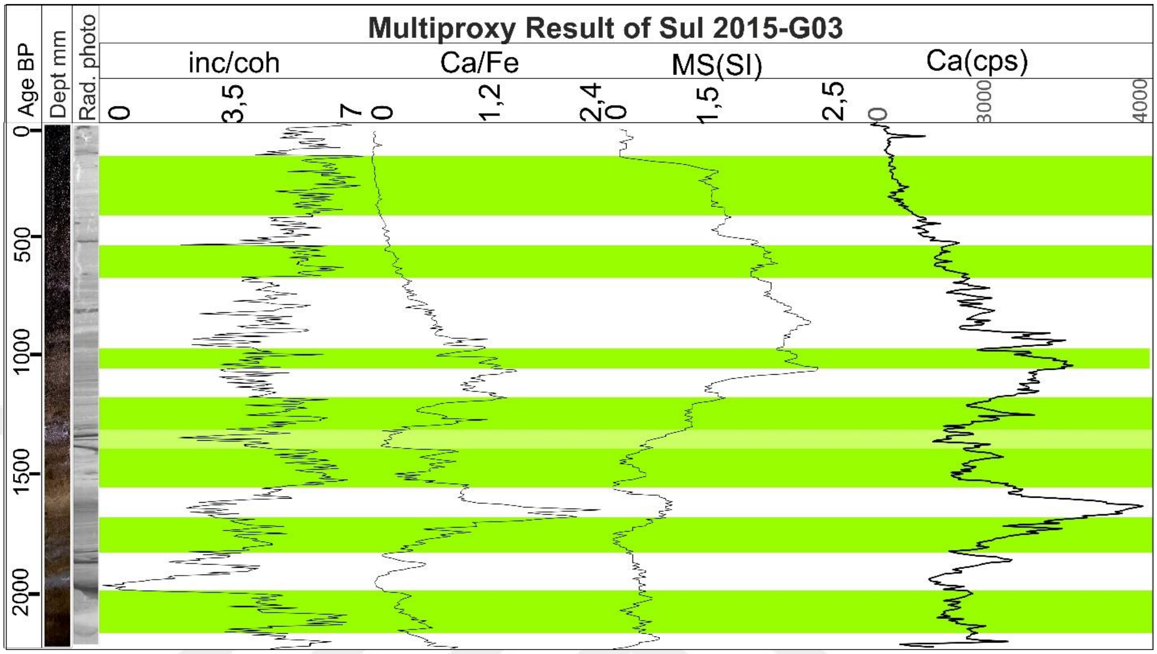

Figure 4.3 Multi-proxy of Sul2015-G03 sediments core. green reperesent wet/warm period.

4.2.4 Sul2015_GO5.

This was retrieved close to Dalyan channel. Because of this, the amount of microorganisms in the sample were mainly foraminifera. The correlated age is 2208BP years. between 2000-1720BP, 1550-1400BP, 1250-1010BP, 950-650BP and 400-50BP a warm/wet period was observed from sediment core. Between 1720-1550BP, 1400-1250BP and 650 and 400BP a cold/dry period was observed. Between 1720-1550BP and 650-400BP, dark gri silty sludge which correspond with cold/dry period is seen (Figure 4.4).

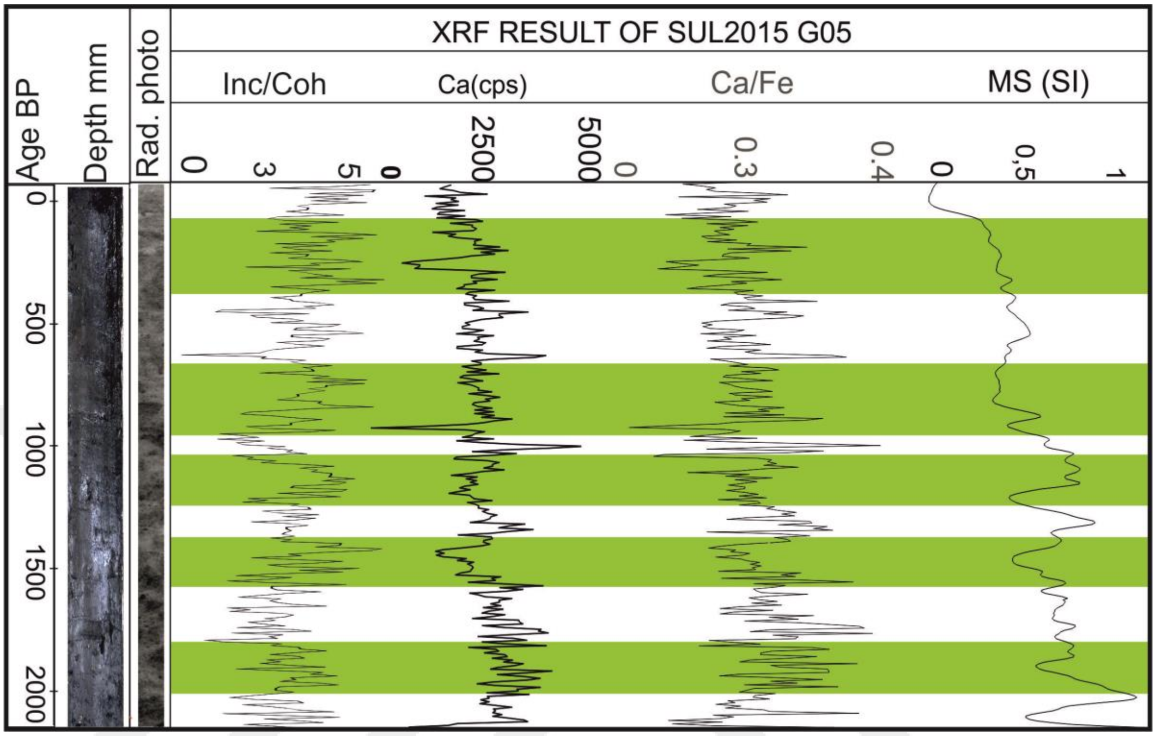

Figure 4. 4 Multi-proxy of Sul2015-G05 sediments core. green reperesent wet/warm period.

4. 3 Comparison of Result with studies in Turkey

From Dalyan Basin the period between 2250-50Bc a dry/cold period was seen in Alagol2015-G01, Sul2015 G05 and Sul2015 G03. But at this time interval, Sul2015-G02 showed a wet period that correspond with Lake Tecer and Lake Cubuk. In Lake Çubuk, this record was characterized by a rise in lake level (Figure 4.5).

Between 20BC-170AD a wet period was observed from Dalyan Lagoon and Lake Cubuk, while Lake Iznik provided a wet period that started from 190AD until 700AD and Lake Tecer, provides chemical evidence indicating a drier condition until AD 500.

The time interval AD 950–1180 showed a wet period in Dalyan Lagoon. This wet period extended upto 1300AD in Lake Çubuk and Lake Iznik climate record. From this period

Lake Salda provided a dry period that extended to 1700AD, this dry period coincides with Alagol2015-G01 climate record (Figure 4.5).

From 1700-1890AD a wet period that was observed in Dalyan Lagoon with a peak from $\delta^{18}O$ record. This wet period was also observed from Lake Cubuk, Lake Tecer, and Lake Salda (Figure 4.5).

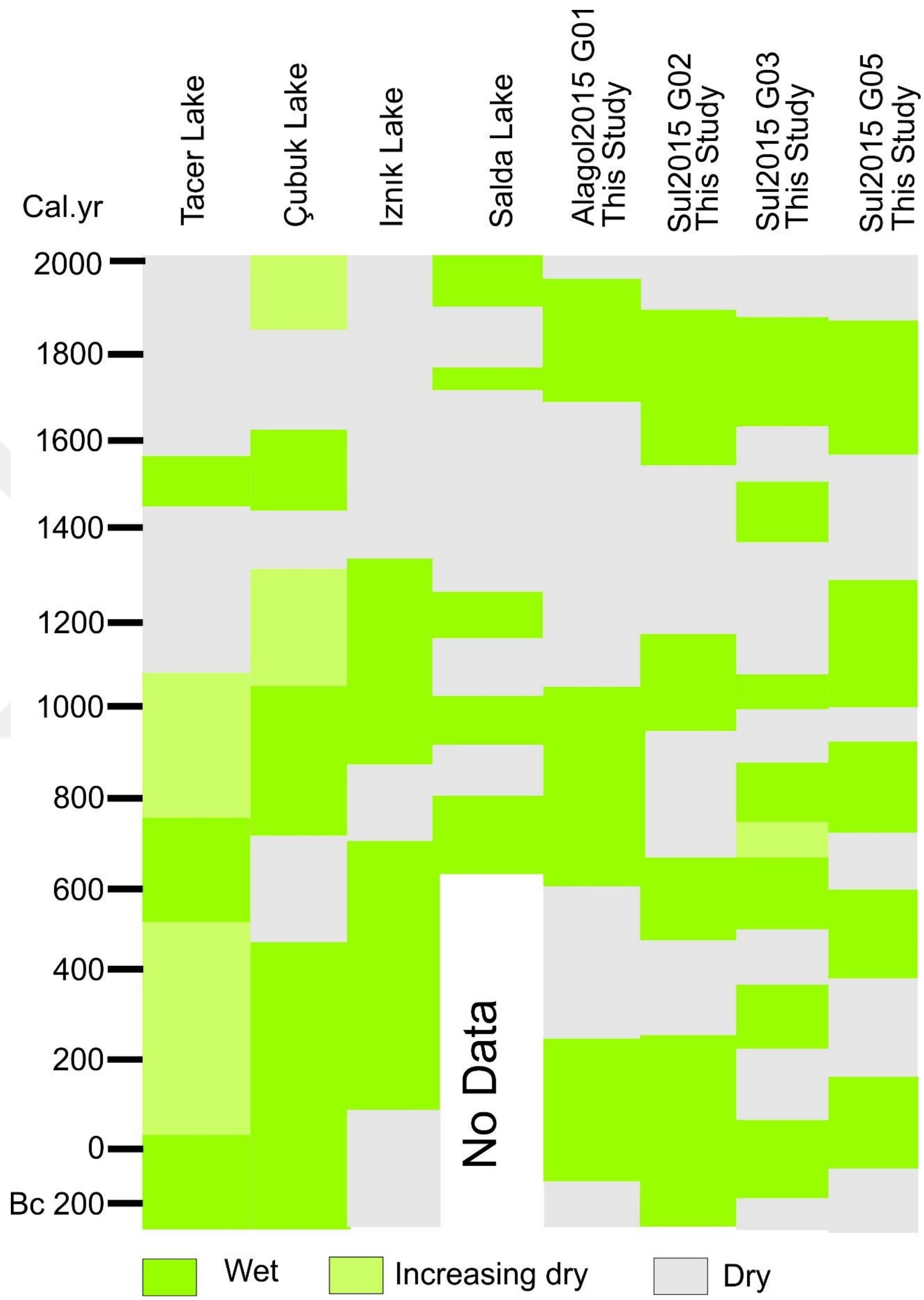

Figure 4.5 Correlation of Dalyan Bsin climate variability with, Cubuk Lake (Ocakoğlu et al 2016), Lake Tecer (Kuzucuoğlu. Et. al., 2011), Lake İznik (Ülgen. et al., 2012), Lake Salda (I.B Danladi. and Akçer. Ön. 2017.)

5 CONCLUSIONS

After correlating Alago2015_G01 with Sul2015-G02 a 2231BP age was provided. From the result of multyproxy provided a 2000-1650, 1410-910BP and 250-50BP, a warm/wet period Between 1650-1410BP and 910-250BP, a dry/cold period was observed

The result of Sul2015_G02 gave an age of 2255. From the multyproxy result between 2100-1650BP, 1460-1250BP, 1040-700BP, 450-50BP wet/worm was observed from result while between 1650-1460BP, 1250-1040BP and 700-450BP a dry/cold period was observed from multyproxy result.

The multyproxy result of Sul2015-G03 was colorated with radiocarbon result of Sul2015-G03. The multyproxy age was 2249BP. Between 2200-2000BP, 1900-1800BP,1550-1200BP,1050-950BP, 600-550BP and 450-50BP a wet period was observed. While between 2000-1900BP, 2000-1900BP, 1200-1050BP, 950-600BP and 550-450BP a decrease in inc/coh was observed. This was translated as dry period.

Sul2015-G05 sample Age was 2208 BP. Between 2000-1720BP, 1550-1400BP, 1250-1010BP, 950-650BP and 400-50BP a warm/wet period was observed. Between 1720-1550BP, 1400-1250BP and 650 and 400BP a cold/dry period was observed

The Medieval Warm climate was seen around 980 and 1100AD. While Little Ice age was seen after 1100AD from Dalyan Lagoon Basin

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Appendix A Stable Carbon and Oxygen Isotope Result of Alagol2015_G01.

SAMPLE ID	13 VPDB	d18O VPDB	C measurement. Std. dev.	O measurement. Std. dev.	Voltage.
analytical precision (1 sigma)	± 0.08	± 0.10			
Alagol2015_GO1_0cm	-5,25116	-1,34398	0,.026752	0,.05175	1,.543153
Alagol2015_GO1_3cm	-6,2197	-2,84563	0,.052019	0,.066182	1,.514637
Alagol2015_GO1_6cm	-5,3507	-1,05432	0,.020821	0,.02817	2,.097972
Alagol2015_GO1_9cm	-4,58999	-1,93952	0,.039462	0,.026507	2,.05027
Alagol2015_GO1_12cm	-5,22087	-1,80719	0,.008974	0,.008937	2,.448299
Alagol2015_GO1_15cm	-6,54422	-2,89748	0,.00852	0,.01849	2,.514973
Alagol2015_GO1_18cm	-6,63141	-2,85282	0,025732	0,.05227	1,.220929
Alagol2015_GO1_21cm	-5,70217	-2,06224	0,.037333	0,.040373	2,.513634
Alagol2015_GO1_24cm	-5,30831	-2,74811	0,.041602	0,.054457	2,.177616
Alagol2015_GO1_27cm	-5,79593	-2,88223	0,.01136	0,.036818	1,.959265
Alagol2015_GO1_31cm.	-6,05093.	-2,75466.	0,008371.	.0,029943	.2,755982

Appendix B Stable Carbon and Oxygen Isotope Result of Sul2015_G02.

SAMPLE ID.	d13C. VPDB.	d18O. VPDB.	C. measurement. Std. dev.	O. measurement. Std. dev.	Voltage.
analytical precision (1 sigma)	± 0.08	± 0.10			
Sul2015_GO2_0cm.	-6,77561	-3,50502	.0,029768	.0,080715	.1,723616
Sul2015_GO2_2cm.	-5,38007	-2,93352	.0,027433	.0,034986	.2,56972
Sul2015_GO2_4cm.	-5,00411	-2,81174	.0,025701	.0,048493	.2,410454
Sul2015_GO2_6cm.	-7,10578	-3,41903	.0,017443	0.,052083	.1,286891
Sul2015_GO2_8cm.	-6,80386	-3,84439	.0,010981	.0,078045	.1,449632
Sul2015_GO2_012cm.	-7,43868	-3,84827	.0,005787	.0,058462	.2,001808
Sul2015_GO2_14cm.	-7,80309	-3,46279	0,030358	0,082621	1,160282
Sul2015_GO2_16cm.	-8,50974	-4,13079	0,045345	0,052674	1,891843
Sul2015_GO2_18cm.	-8,0704	-3,64837	0,008207	0,057762	2,352284
Sul2015_GO2_20cm.	-8,56943	-4,01853	0,026423	0,027356	2,483983
Sul2015_GO2_22cm.	-9,08869	-4,72306	0,058282	0,045038	1,45476
Sul2015_GO2_24cm.	-8,12181	-3,30198	0,030009	0,017817	2,68849
Sul2015_GO2_26cm.	-7,42799	-4,33992	0,039886	0,018551	2,180806
Sul2015_GO2_28cm.	-6,94952	-3,63075	0,013028	0,033797	1,556886
Sul2015_GO2_30cm.	-7,96493	-4,26017	0,034889	0,021245	1,805547
Sul2015_GO2_32cm.	-7,48279	-3,75796	0,030377	0,033438	2,095839
Sul2015_GO2_34cm.	-7,88623	-4,3233	0,014328	0,008669	2,28214
Sul2015_GO2_36cm.	-7,54941	-3,86455	0,029061	0,049943	2,21758
Sul2015_GO2_38cm.	-7,44515	-4,31975	0,026455	0,016382	2,590886
Sul2015_GO2_40cm.	-8,97718	-4,69173	0,019121	0,023397	1,83801
Sul2015_GO2_42cm.	-8,59882	-4,40529	0,011594	0,019896	2,151513
Sul2015_GO2_44cm.	-9,51727	-4,7688	0,008883	0,055497	2,740212

Sul2015_GO2_46cm.	-8,82289	-4,23951	0,011199	0,028127	2,715152
Sul2015_GO2_48cm.	-9,39951	-4,63964	0,012247	0,039347	2,579911

CURRICULUM VITAE

Individual Data

M******D S ******U

N******a

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g******1@gmail.com

Credentials Acquired	**Education level**	**Year**
Secondary school	PSS Niger State Nijerya	2006
Turkce kursu	Gazi Univesitesi	2010
First University	Sakarya Unibersite, Turkiye	2014
Masters	Sitki Kocman University, Mugla, Turkey	2021

Linguistic

Linguistic (inglizce)	**Basic**	**Middle**	**Brilliant**
Writing		x	
Speaking		x	
Understanding		x	
Reading		x	
Linguistic (Hausaca)	**Basic**	**Middle**	**Brilliant**
Writing		x	
Speaking		x	
Understanding		x	
Reading		x	
Linguistic (Turkce)	**Basic**	**Middle**	**Brilliant**
Write level			x
Speak level			x
Understand level			x
Read level			x

Hobby

Trekking

Reading of Novels