T. R.
VAN YUZUNCU YIL UNIVERSITY
INSTITUDE OF NATURAL AND APPLIED SCIENCE
DEPARTMENT OF GEOLOGICAL ENGINEERING

QUANTITATIVE ANALYSIS OF PALEOCLIMATE PALEOENVIRONMENT AND PALEOVEGETATION OF LAKE ERÇEK BOTTOM SEDIMENTS

M.Sc. THESIS

PREPARED BY: Renas Ali ROSTM
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CO-SUPERVISOR: Asst. Prof. Dr. Srood Farooq NAQSHABANDI

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ACCEPTANCE and APPROVAL PAGE

This thesis entitled "Quantitative Analysis of Paleoclimate, Paleoenvironment and Paleovegetation of Lake Erçek Bottom Sediments" presented by Renas Ali ROSTM under supervision of Asst.Prof.Dr. Ayşegül Feray MEYDAN in the department of Geological Department has been accepted as a M. Sc. thesis according to Legislations of Graduate Higher Education on 25/12/2018 with unanimity of votes members of jury.

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Member: Asst.Prof.Dr. Ayşegül Feray MEYDAN Signature:

This thesis has been approved by the committee of The Institute of Natural and Applied Science on ..25../..01../.2019.... with decision number ..2019/6-1..

Signature

....

Director of Institute

THESIS STATEMENT

All information existing in this thesis obtained according to the proper comportments and academic rule structure. Not all statement and information belongs to me. In this work prepared in agreement with the rules of these cited to the source of information.

Renas Ali ROSTM

ABSTRACT

QUANTITATIVE ANALYSIS OF PALEOCLIMATE PALEOENVIRONMENT AND PALEOVEGETATION OF LAKE ERÇEK BOTTOM SEDIMENT

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M. Sc. Thesis, Department of Geological Engineering
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December 2018, 87 Page

The aim of this thesis is to reconstruct and correlate high resolution paleoclimatic, paleovegetation and paleoenvironment data obtained from lithological, chronostratigraphical and palynological analysis of the Lake Erçek sediments. For this purpose a sediment core, obtained for a TUBİTAK project no. 114Y825, was chosen.

On the selected short core (^{137}Cs - ^{210}Pb, varve counting), lithological identification, stable isotope analysis ($\delta^{18}O$) and palynological analysis were performed. According to the chronological analysis, the maximum age obtained from the core is about 850 years. Both stable isotope and palynological records support each other along the core.

According to the pollen analysis, four distinct pollen zones, based on the pollen percentages and taxonomical compositions (PZI, PZII, PZIII and PZIV) are defined. In spite of the existence of four dictinct pollen zones, the fact of dominance in steppe-type vegetation *(Artemisia,* Amaranthaceae and Poaceae) can be suggested for the Erçek region.

Keywords: Lake Erçek, Paleoenvironment, Paleovegetation, Paleoclimate, $\delta^{18}O$.

ÖZET

ERÇEK GÖLÜ DİP SEDİMANLARININ PALEO-İKLİM PALEO-ORTAM VE PALEO-BİTKİ ÖRTÜSÜNÜN NİCELİKSEL ANALİZİ

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Aralık 2018, 87 Sayfa

Bu tez çalışmasının amacı, Erçek Gölü dip çökellerinin kronostratigrafik, litolojik ve palinolojik yönden incelenmesi ve elde edilen yüksek çözünürlüklü veriler ile bölgenin paleoiklim, paleovejetasyon ve paleoortam koşullarının yeniden kurgulanmasıdır. Bu amaç doğrultusunda TÜBİTAK 114Y825 numaralı proje kapsamında Erçek Gölü'nden alınan bir adet sediman karot seçilmiştir.

Seçilen kısa karot üzerinde (^{137}Cs - ^{210}Pb, varv sayımı), litolojik tanımlama, duraylı izotop analizi ($\delta^{18}O$) ve palinolojik çalışmalar yapılmıştır. Kronolojik analizlere göre karot boyunca elde edilen yaş son 850 yılı kapsamaktadır. Duraylı izotop analizi ve palinolojik analizler karot boyunca birbirini desteklemiştir.

Polen yüzdesi ve taksonomik kompozisyonuna gore oluşturulan polen diyagramına gore dört ayrı polen zonu tanımlanmıştır (PZI, PZII, PZIII ve PZIV). Bitki örtüsü baskın olarak bozkırdır *(Artemisia,* Amaranthaceae ve Poaceae).

Anahtar kelimeler: Erçek Gölü, Paleo-Ortam, Paleo-Bitki Örtüsü, Paleo-İklim, $\delta^{18}O$.

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2018
Renas Ali ROSTAM

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SYMBOLS AND ABBREVIATIONS

Some symbols and abbreviations used in this study are presented below, along with descriptions.

Symbols	**Description**
Cs	Cesium
H_2SO_4	Sulphuric acid
HCL	Hydrochloric acid
HF	Hydrofluoric acid
KOH	Potassium hydroxide
$(CH_3CO)_2O$	Acetic acid anhydride
$\delta_{18}O$	Oxygen isotope
Pb	Lead

Abbreviations	**Description**
PAZ	Pollen assemblage zone
AP	Arboreal pollen
NAP	Non-arboreal pollen
TRSH	Trees and shrubs
HEGR	Herbs and grasses
CONISS	Constrained incremental sums of squares cluster analysis
ITCZ	Intertropical Convergence Zone
PFJ	Polar Front Jet
STJ	Subtropical Jet
CP	Continental Polar Air Mass
MP	Marine Polar Air Mass
mT	Marine Tropical Air Mass
cT	Continental Tropical Air Mass
SHP	Siberian High Pressure

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1. INTRODUCTION

The climate of the earth is dynamic so it varies from one place to another, periodically (Goossens and Berger, 1985). Despite their statistical nature or physical causes, climatic changes represent all forms of climatic inconsistencies (Mitchell, 1966). The climate change term is explained by discontinuities in climate records. These changes are expressed as abrupt or long-lasting by considering the period of records from one average value to another (Goossens and Berger, 1985). The most important aspect for understanding the past climates is the current climatic conditions since the physical rules and principles causing todays climate records are the base of prediction of past climatological events. Although the climatological records are acted as a funcition of different local and regional variables such as annual/seasonal changes, latitudes, altitudes ect., large-scale climate events (high amplitude) of atmospheric circulation patterns were probably observed in the past (Wigley and Farmer, 1982). Significant changes in these features are mainly controlled by dramatic variations in worldwide boundary conditions.

Among terrestrial archives such as tree rings, loess and peat deposits, the lake sediments are precious archives because they comprise continuous records throughout numerous interglacial/glacial cycles. Additionlly, lake sediments have stratas (laminated layers).This enables us to examine climate records on millennial, centennial and annual time scales. Examination of palynomorphes found in the deposits offers various perspectives in regard to the paleoenvironmental conditions. For vegetation and climatic reconstructions, pollen data are prevalent sources, although they are highly impacted by human activities, particularly for the Late Holocene.

Pollen analysis is soley applied to illustrate paleovegetation and paleoclimate association. This association is established by using the pollen content of current geological deposits and comparing these current results with possible paleoclimate records. Pollen analyses are considered as a qualitative approach, however current progresses in the analytical methods in terms of theory and technology, give way to use them as a quantitative interpretation tool. Since more information is aquired from pollen data, the usage scope of them is wider than the past. The most impotant outcomes of such analyses are flora and vegetation reconstruction studies which are some of the main objectives of this study.

1.1. Aims of the Study

In recent years, usage of pollen data to discuss the climate variability is very popular. One of a key location for such studies is the Near East where the world largest soda lake locates, Lake Van. This lake covers 3574 km^2 area with 607 km^3 volume. The deepest point of the lake is 451m (Degens and Kurtman, 1978). The salinity of the lake water is ‰ 21.4 and pH is 9.81 (Kempe et al., 2001; Reimer et al., 2009). Lake Van is a monomictic lake and has anoxic conditions under 300 m (Kipfer et al., 1994; Peeters et al., 2000). There are lots of studies about Lake Van, because of its crucial location where different climate systems are juxtaposed on the high plateau of Eastern Anatolia. The most recent and impactfull studies were published after PaleoVan Project (Sumita and Schmincke, 2013a; Sumita and Schmincke, 2013b; Cukur et al., 2014; Çağatay et al., 2014; Litt and Anselmetti, 2014; Litt et al., 2014; Stockhecke et al., 2014b; Vigliotti et al., 2014; Stockhecke et al., 2014b; Stockhecke et al., 2016). On the other hand, the first study on the paleo-vegetation of Lake Van was made in 1978 (van Zeist and Woldring, 1978). According to their pollen analysis, the effect of human activities started 1100 years ago and there is nothing left from primary vegetation in the region. Contrary to this study, Wick et al. (2003) argue that the first human effects are determined at 3800 years BP of which last 600 years is the most affected term. In addition, Litt et al. (2009), based on palynological data sets, suggests that a significant increase in humidity is observed with the beginning of the Holocene and a strong human impact is observed in 1250-850 AD time interval Litt et al. (2009). Although there are some regional scale studies conducted on the Lake Van, their resolution in terms of climatologic changes are not high for the Late Holocene period. Also pollen records give information only about human effects on the climate change for the last thousand years. Another important alkaline water body in the region is the Lake Erçek, the main concern of this study. This lake locates at the 30 km east of the Lake Van, however its altitude is 200 m higher than this lake. This altitude difference (i) makes the Lake Erçek cooler than the Lake Van and (ii) creates a micro-climatologic environment for the region around the lake. Even though the lake is a potential area where climatological records can be extracted efficiently, there is no study except a TUBİTAK project named as “Global warming and aridity dynamics in Asia: quantitative reconstruction of annual – decadal climatic variability by geochemistry of lake sediments for the last thousand years” conducted on it.

In this respect, the aim of these thesis is to reconstruct and correlate high resolution paleoclimatic, paleovegetation and paleoenvironment data obtained by lithological, chronostratigraphical and palynological analysis in the sediments of Lake Erçek.

In this thesis;

1- The outcomes of palynological analysis of a short sediman core is presented,
2- The quantitative reconstructions of the last millennium regional vegetation, woody coverage and climate are demonstrated,
3- Regional comparisons are conducted for inferring the paleoenvironmental and paleoclimatic history of this poorly documented region,
4- Undrstanding the relationships between vegetation and pollens of the Erçek Lake and evaluating the productivity of plant taxa pollen are aimed.

1.2. Study Site

Lake Erçek is situated on a high plateau in Eastern Anatolia at 1803m altitude and Lake Van is located at 30km west of it (Figure 1.1). The average depth of the lake is about 18 m with a maximum depth of 40 m (Ipek and Sarı, 1998).

Figure 1.1. Study site (Google Earth).

1.2.1. Geological setting

Lake Erçek is located in Van region, Turkey. It is a shallow terminal lake and an endoreic basin. The region is active in terms of tectonic since it is located in a critical zone close to the Karliova Triple Junction where the North and East Anatolian crustal scale faults are coincides (Kempe, 1977; Ocakoglu et al., 2004; Litt et al., 2014) (Figure 1.2).

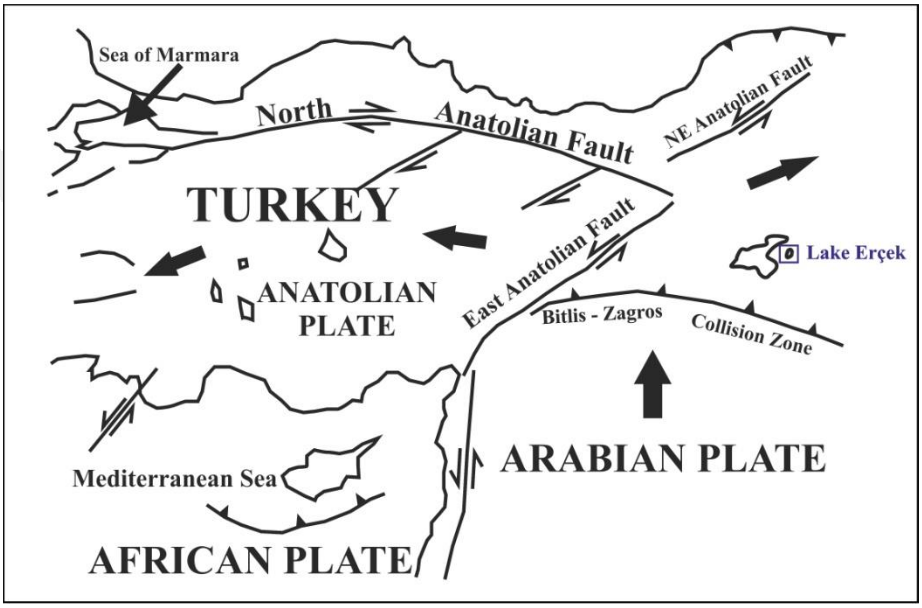

Figure 1.2. Tectonical setting of Turkey (Ocakoglu et al., 2004).

Four geological periods is defined for the geological evolution of the Eastern Anatolia. These periods can be listed;

1. First period covers Paleozoic-lower Mesozoic interval. This period represents the basement rocks (mainly metamorphic rocks, namely Bitlis massif) of the region (Boray, 1976; Perincek, 1980; Perinçek and Özkaya, 1981; Yılmaz et al., 1981; Goncuoglu and Turhan, 1983; Çaglayan et al., 1983).
2. The second period represents the growth of an ophiolitic melange during late-Cretaceous to Paleogene time interval. This melange comprises association of basic, ultrabasic rocks, clatics, and carbonates and it has a tectonic contact with the first period rocks (Demirtaslı and Pisoni, 1965; Ketin, 1977; Yılmaz et al., 1981).

3. Eocene – Lower Miocene marine origin clastics and limestones represent the thirt period.
4. Upper Miocene - recent interval is last period and it is reptesented by cotinental origin deposits and volcanic rocks.

The units mentioned above are exposed around Lake Ercek (Figure 1.3) and gives detritals to the lake.

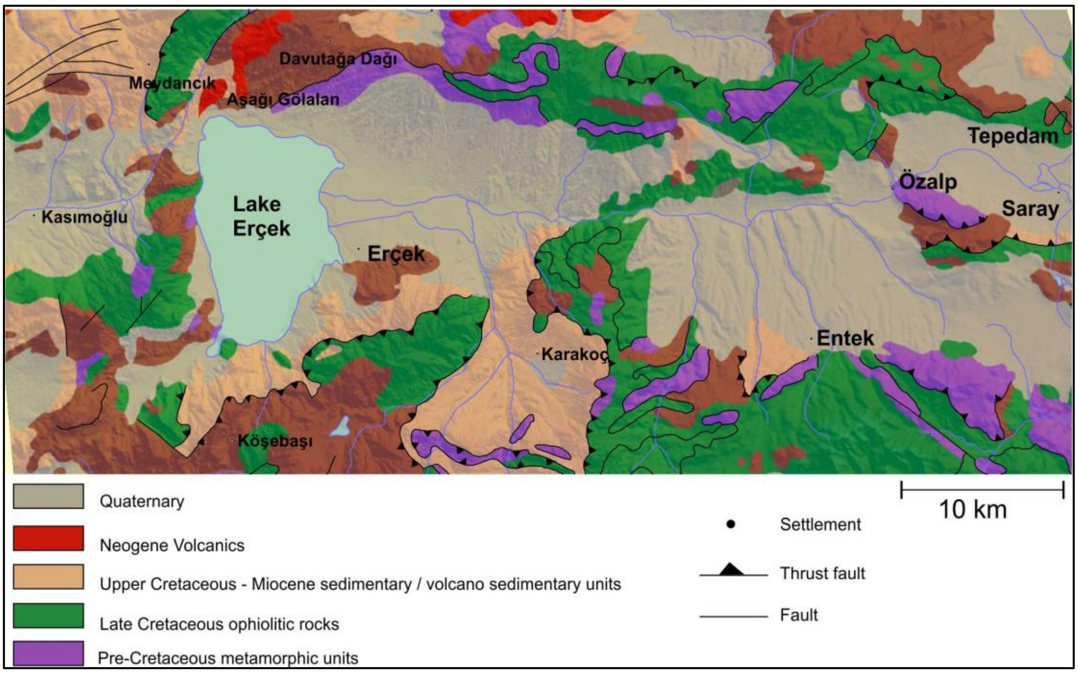

Figure 1.3. Geological map of Lake Erçek drainage basin (modified from Şenel and Ercan, 2002; 1/500000 map).

1.2.2. Morphology of Lake Erçek

According to a geophysical study, eastern part of Lake Van basin is occupied by the Lake Erçek because of the collision occurred between Eurasian and Arabian plates (Toker and Tur, 2018). Commencement of this still active collision is suggested as 13 Ma (Kipfer et al., 1994; Sengor et al., 2003; Keskin, 2003; Arikan et al., 2012). This assertation is supported by geochemistry of magmatic rocks togetger with hydrothermal activity and substantial seismicity, such as the 2011 earthquake in Van. Due to having similar tectonic trends, the Erçek Lake Basin is considered as the eastern structural extension of the Lake Van Basin (Toker and Tur, 2018).

It can be observed form the bottom morphology of the Erçek Lake that the basin of the lake is represented by sub-lacustrine slope (SLs), lacustrine shelf (Ls) and deep Basin (DB) provinces (Figure 1.4). The sublacustrine slope and lacustrine shelf are obviously sharper and have E-margins (Toker and Tur, 2018). In the north and south margins, the sub-lacustrine slope and lacustrine shelf have similar morphological features. The depth of water decreases from the western coast towards east. In contrast to the western parts, the northern, eastern and southern parts of the lake are comparatively shallower (Ipek and Sari, 1998; Duman, 2011). It is stated that the tectonic pattern of the lake is shaped under the control of faulting-related elements (Toker, 2015).

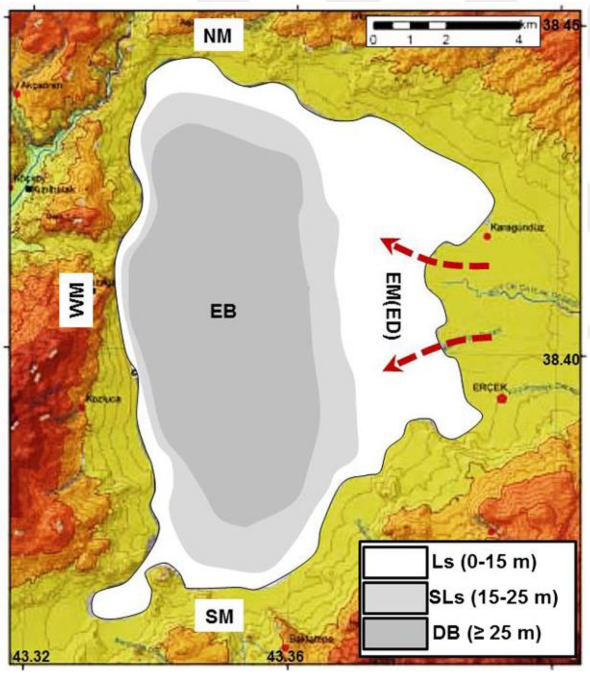

Figure 1.4. Morphology of Lake Erçek (taken from Toker and Tur, 2018).

1.2.3. Hydrology and water chemistry of Lake Erçek

Lake Erçek is a closed lake**.** It is declared that beside the identification of five terraces of a river developed around the lake, the area has an inland river regime (Duman, 2011; Duman and Çiçek, 2012). The pattern of dendritic drainage, braided streams at places and meanders at places are observed as common features in the majority of the rivers. More than 3400 springs are determined by investigation of topographic maps (1:25,000 scale) of the drenaige zone of the Erçek Lake. It is clear that in addition to a secondary river input along the southeast margin, the lake has only one central river input. Typically throughout spring, the river input is activated. Subsequent to snowmelt and rainfalls, the level of lake varies both interannually and seasonally. Up to two meters fluctuations in the level of the lake is reflected by lacustrine palaeo-shorelines. In order to calculate paleo-lake stands, ^{14}C dating was conduted on three core samples taken from 8.5, 11.5 and 14.5m depths by Duman and Çiçek (2011). They proposed that the lake level has been almost stable since Pleistocene. They also suggest that erosion-depositon rates started to decrease by Holocene. Erosion rates are, based on the location of the cores (8.5, 11.5 and 14.5m depths), calculated as 0.8, 1.4 and 0.3 mm/years, respectively. The study exhibits that from the commencement of the Holocene to recent, the erosion and sediment build-up rates have reduced progressively. Moreover, they concluded that complete lake dryness through the Last Glacial maximum (LGM) is not detected.

The Erçek Lake is an highly alkaline (the pH ranges from 9.4 to 10.75) water body. In addition, it is considered as the smallest soda lake on the earth. Erçek Lake covers a space of about 106.2 km^2 and has 65 km^3 volumes. While 18.45 is the average depth, the maximum depth of the lake is around 40 m (Duman, 2011).

The proportion of the dissolved oxygen varies between 2.9 and 6.7 mg/litter. The concentration of magnesium is between 90 and 95 mg/l. Because of carbonate and ultrabasic rocks in the area, the level of Mg is much higher than Lake Van (Ates et al. 2007). Highly alkaline weathering of fine-grained tephra exposed within and at bottom of the lake, the input of alkaline ground water under the volcanoes, and sublacustrine hydrothermal springs are thought as the most important suppliers of the high alkaline content of the lake (Duman, 2011).

1.2.4. Climate

The eastern Anatolia's current environmental condition corresponds sensitively to the northward displacement of the Inter-tropical Convergence Zone (ITCZ). This intensely impacts the sites of the three main circulations of the atmosphere as shown in figure (1.5).

1- The site of the north and north-west atmospheric westerly wind stream.
2- The north branch of the high pressure systems of the subtropic conditions that covers a zone from the Atlantic Ocean through the Sahara.
3- The high elevation of high pressure system of Siberian, with a declining impact of the Mediterranean Sea as a provider of precipitation throughout the winter period.

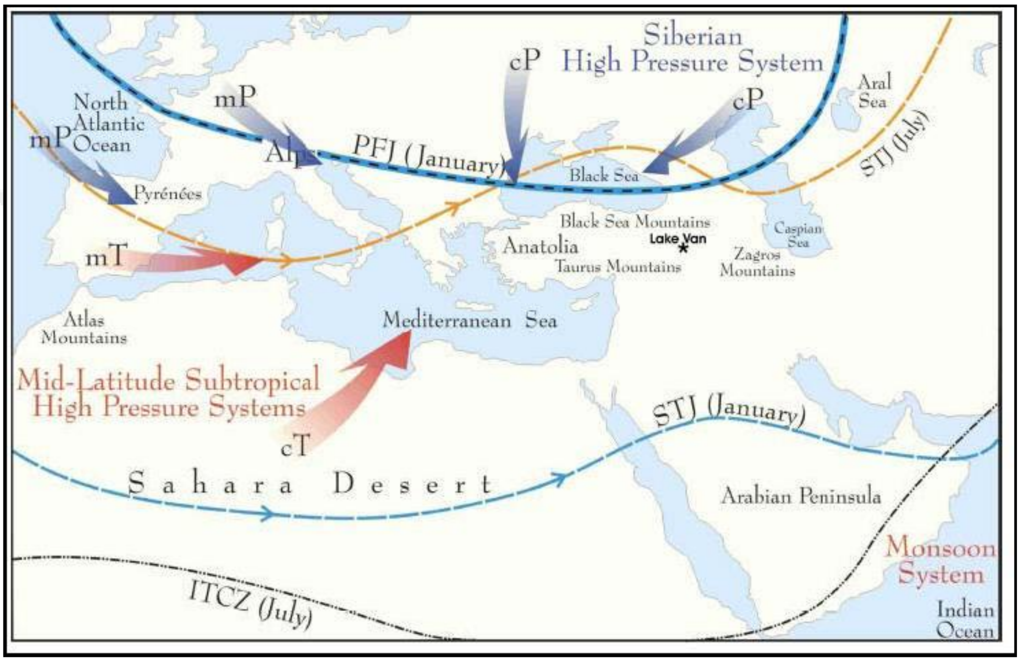

Figure 1.5. Lake Erçek region and its position in atmospheric circulation system: Polar Front Jet (PFJ), Subtropical Jet (STJ) and Intertropical Convergence Zone (ITCZ) in winter and summer in the Mediterranean Region, and High Pressure System that influence the climate of the Eastern Mediterranean Region. cP: Continental Polar Air Mass; mP: Marine Polar Air Mass; mT: Marine Tropical Air Mass; cT: Continental Tropical Air Mass (from Litt et al., 2009; after Akçar and Schlüchter, 2005; modified from Wigley and Farmer, 1982).

Mid-latitude Subtropical High pressure system, Monsoon system and North Atlantic and Siberian High-pressure system are the main three factors affecting the environmental condition of the lake Erçek region. This defines a boundary between continental humid and Mediterranean climate (Wick et al., 2003; Akçar and Schlühter, 2005; Litt et al., 2009). It is stated that while the arid summers are associated with continental air masses, the precipitation throughout autumn, winter and spring is caused by the ascendant southwesterly subtropical winds of eastern Mediterranean region.

Siberian High Pressure (SHP) (Siberian Anticyclone)

Due to elevated air at the equator, the (SHP) is generated at latitudes between 20 to 40 degrees from the equator. The hot air cools during ascending and drops its humidity. Then, it is conveyed toward to the pole and decends. This generates a high pressure region. In general, around Baikal Lake, Siberian High Pressure is centered. This results in bringing an enormous mass of cold and dry air to Eurasian terrain. The most powerful semi-stable high in the north hemisphere is Siberian High, and it is responsible for both the biggest pressure (1083.8 mbar) and the lowest temperature (-67.8°C) that happened ever. Generally, the sea level pressure is higher 1040 mbar and temperature is less than -40°C (D'Arrigo et al., 2005).

North Atlantic Oscillation (NAO)

The variation in pressure from Iceland (60°N) to Azores (30°N) is represented as North Atlantic Oscillation (NAO). In winters, the (NAO) transmits cold, warm and wet or dry air to northern Europe. It happens in two stages. In winters, there is a big variation in pressure between Iceland and Azores, and the Positive NAO occurs. This brings stronger storms and high frequency throughout the Atlantic passing in NE direction. Heat from the ocean is brought by these air movements to northwestern Europe resulting in cold and dry winters in Mediterranean region. Nonetheless, when there is a tiny variation in pressure between Iceland and Azores, negative NAO winters are observed. Consequently, weak storms are produced. These kinds of storms generally move more southerly in comparison to positive NAO. It carries cold and dry air to northern Europe and warm and wet air to Mediterranean region (Visbeck et al., 2001).

Mid-Latitude Subtropical High Pressure

In General, it transports warm and moist air with mild winters. Mostly on the western and eastern continental borders, Mid-Latitude Subtropical High Pressure ranges between 30 and 60 degree latitudes. This wind forms commencement of high pressure zone in the direction of poles from west to east, and generates extra-tropical cyclones. While in summer, the westerly wind is the weakest, it is the strongest during winter terms. The Westerly winds are substantial in transporting warm winds and waters from equator to continents' west coasts. Marine tropic and Continental air masses are brought in the direction of Turkey by Mid latitude subtropical high pressure systems.

It is stated that the high pressure system of subtropical conditions regulates the western lies in summer because the Inter-tropical Convergence Zone is located at its north. Dominantly humid westerly winds move northwards during this period. In addition, warm and dry circumstances to the whole Mediterranean area are caused by decending of the subtropical high pressure system's air masses. Thus, arid weather conditions in the interior plateaus' during summer are prevailed because the winds that carry moisture from the Mediterranean do not reach to Eastern Anatolia (Van Zeist and Bottema, 1991; Roberts and Wright, 1993). During winter period, the southern ITCZ allows storm tracks, and comprises masses of cold air from the North Sea and the polar North Atlantic, crossing the Mediterranean Sea (Vannière et al., 2011). Consequently, secondary moisture is saturated with the air masses and cross towards the eastern Anatolian land (Roberts and Wright, 1993; Turkes, 1996; Akçar and Schlüchter, 2005). Lastly, during winter seasons, the atmospheric precipitation falls like snow and upsurges like rain close to the spring terms.

During the winter season, masses of cold air from Asia is regulated by the Siberian high movement which mostly affects the region of Lake Erçek (Akçar and Schlüchter, 2005). Generally, the moisture transport is considered a significant parameter for the distribution of regional precipitation. The lack of mountain barrier at the south of the Alps is a substantial aspect that adds moisture to the Mediterranean Sea and to east (Roberts and Wright, 1993). Furthermore, an effective orographic precipitation obstacling the moisture-bearing winds is the east-west oriented mountain chains. It has impacts on the quantities of entire precipitation, which declines from the costal belts to the interior parts of the Eastern of Anatolia. Additionally, for the Lake Erçek area, the mountain ranges are the main precipitation control parameters. Also it determines the intensity and abundance of precipitation. The area of the Lake Erçek denotes a strong spatial gradient from south-west to north-east because of its location in the rain shadow (Van Zeist and Bottema, 1991; Türkes, 1996; Stevens et al., 2012).

The cold and rainy winters and hot and arid summers are the main character of the Eastern Anatolian climate. This continental character is caused by the seasonal changes of subtropical air masses and maritime subpolar (Cullen and deMenocal, 2000).

The Van Lake is situated in a transitional region between two kinds of vegetation in accordance to the precipitation distribution. The first type of vegetation is related with Kurdo-Zagrosian oak steppe-forest in the south-west and south of the lake. This vegetation type covers an area from east of the central Turkey to south-west Iran. The vegetation of desert steppe and steppe in the north and north-eastern areas is the second vegetation type. *Artemisia fragrans* and sub-Euxinian oak-forest remnants are found in this type (Zohary, 1973a; van Zeist and Woldring, 1978b; van Zeist and Bottema, 1991; Wick et al., 2003; Litt et al., 2009).

It is illustrated that four types of macro-climate are determined in Turkey because of the presence of irregular topography of region (Erinç, 1996). These types of macro-climate are listed below (Figure 1.6).

1) Steppe Climate:
The semi-arid conditions are dominated in this climate type. Precipitation patterns resemble the Mediterranean coasts. The Steppe Climate is separated into two:
a) Climate of Anatolian steppe: this climate characterized by hot summer (20-25°C) and cold winters (0-3°C).
b) The climate of Southeastern Anatolian steppe: in this type, whereas the winters are cold (0-5°C), the summers are substantially hot (>30°C). The annual evaporation is between 1000 and 2000 mm.

2) Climate of Black Sea: it rains throughout seasons. In accordance to temperature and rainfall, this micro-climate is divided in to three types:
a) Climate of Eastern Black Sea: it has temperate winters and high rainfall.
b) Climate of Central Black Sea: rainfall is average.
c) Climate of Western Black Sea: summers and winters have less temperature with less quantity of rainfall.

3) Mediterranean Climate: it has severe summer aridity even though precipitation is high annually. In accordance to temperature, it is separated into two categories:

a) Mediterranean climate: the temperature very high in summer. The amount of snow in the winters is small.
b) The climate of Marmara region: winters are very cold, the evaporation is low.

4) The Climate of Eastern Anatolian: winters are very cold. This microclimate is divided into two types:
a) All seasons with rainfall: characterizes by a continental climate system.
b) Dry summer: in winter and spring the precipitation is high while in summer and autumn the precipitation small and evaporation is high.

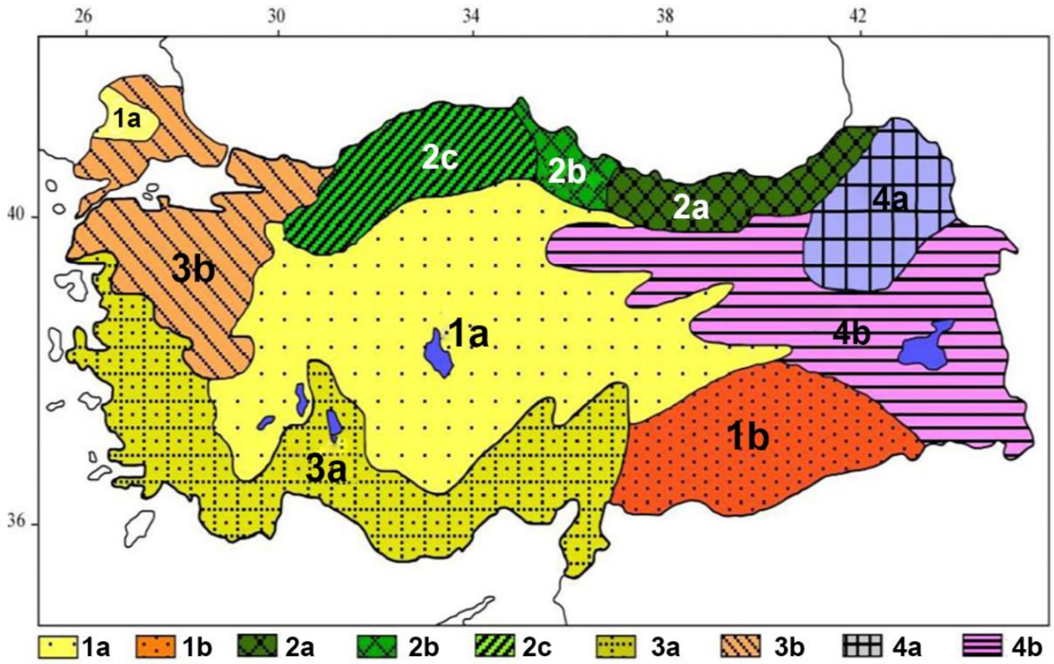

Figure 1.6. Categories of Macroclimate in Turkey (It is modified from Erinç, 1996. 1a represents Anatolian steppe climate; 1b represents Southeastern Anatolian steppe climate; 2b denotes Central Black Sea climate; 2c denotes Western Black Sea climate; 3a represents Mediterranean climate; 3b represents Marmara climate; 4a represents all seasons with precipitation type; 4b represents arid summer type).

2. LITERATURE REVIEW

Wick et al. (2003) assessed the environmental changes and human influence in Eastern Anatolia by using employing charcoal, high-resolution pollen records and isotopic-geochemical data-bases. The samples of this study are come from yearly laminated sediments of Lake Van. The aim of this research is identifying proofs of past human influence and environmental changes in the eastern Anatolian semi-arid area. The reason behind the the growth of steppe vegetation is explained by dominant cold and dry climate during period of late glacial event. The dramatic decrease in lake stand during the Younger Dryas marks semi-desert type of vegetation in the region. The analysis of the isotopic and geochemical records revealed a robust escalation in moisture at the beginning of the Holocene. The pistachio scrub and grass steppe partially are substituted by *Artemisia*-Chenopod steppe. Around 3000 years postponement in the growth of high steppe-fire frequencies and deciduous oak woodlands propose arid climate during spring and summer throughout the beginning of Holocene period. A change occurred in the regional environmental regime at around 8200 year BP that ceased the transfer of more humidity into the interior parts of the Taurus Mountains. This results in a change in the precipitation distribution in each season. Furthermore, at around 6200 years BP, the extension of the steppe-forests reached the its highest level and they were dominated by *Quercus*. According to the whole proxy data, between 6200 and 4000 years BP, weather conditions was ideal, water salinity was low and the level of the lake was high. Subsequent to 4000 years BP, increase in aridity was occurred causing the establishment of the modern climatic condition. The results exhibit that after 3800 years BP human influence in the Van Lake catchment begun. However, throughout the past 600 years human impact got more efficient factor in climate change.

Eastwood et al. (2007) studied weather conditions for Holocene time of the Eastern Mediterranean region. A tiny intra-montane lake, called “Gölhisar Gölü” situated in SW Turkey, was studied. Complementary records of Holocene climate variation were provided by pollen data calculated from the lake. Pollen data infer drier environments compared to the current day condiditons. In several sediment records of east Mediterranean lakes, similar differences between stable isotopes, palaeoclimate and pollen data is suggested. Throughout the beginning to mid Holocene, the isotopic instabilities propose oscillations between humidity and aridity. Even though there are several indications for augmented humidity in accordance with pollen data indicating incerase in human influence and agriculture intensification, particularly throughout the so-called Occupation Phase of Beyşehir lake, higher values of $\delta_{18}O$ and $\delta_{13}C$ prior late the Holocene demonstrate higher aridity conditions than the time interval before ca.5100 cal. years BP. It is revealed that the climate trend similar to the modern aridity begun around 1300 years ago.

Litt et al., (2009) studied the the lake level dynamics under the concept of “PALEOVAN” project. They presented a big data-base comprising noble gas concentration in pore water of the lake's sediment and tephra-stratigraphy of the lake related to the volcanic activities and volcanism history of the region.The partially laminated Lake Van's sedimentary records give information about continuous and long continental series that covers numerous interglacialand glacial cycles.

Biltekin (2010) utilized pollen analysis for identifying NW Anatolia and North Aegean region's climate and vegetation. Because of climatic changes, in the Late Miocene majority of subtropical (mega-mesothermic) and tropical (megatermic) trees reduced. Nevertheless, throughout the Late Pliocene, several mesothermic trees or marsh forests have survived. Simultaneously, although the communities of herbaceous plant (Asteraceae Cichorioideae, Amaranthaceae-Chenopodiaceae, Asteraceae Asteroideae, and Poaceae,) were widespread whereasthe steppe plants (*Artemisia*, *Ephedra, Hippophae rhamnoides*) did not grow a lot. This condition turned back to the presence of dry and cold weather conditions in Late Pliocene. Even though population of mega-mesothermic trees have dropped, with the commencement of glaciation at the Arctic during the commencemet of Pleistocene (2.6 million years), several species, for example Taxodiaceae (perhaps Sapotaceae, *Glyptostrobus, Nyssa* and *Engelhardia*) have survived. Simultaneously, although the mesothermic trees (*such as, Liquidambar, Carpinus, betulus, Alnus, Quercus, Betula, Fagus, Carpinus orientalis, Tilia, Ulmus, Acer, Pterocarya, Zelkova and Carya.)* have nearly extincted, steppe environments intensely growed. After that, in comparison to the mesothermic trees, the Artemisia steppe periods developed for a longer duration According to this, the glacial era (cold and arid weather) took longer time than icebergs period (hot-humid weather). Since the commencement of the Ionian phase (1.8 million years), Artemisia steppes and herbaceous ecosystems such as Amaranthaceae-Chenopodiaceae, Poaceae, Asteraceae Asteroideae, Asteraceae Cichorioideae, etc) have expanded to the current time.

Ülgen et al. (2012) evaluated the environmental climate changes of the Lake Iznik which located in the North West of Turkey. Around 5000 year of climatic records and trends was provided by Geochemistry, palynology, Magnetic susceptibility and mineralogy of Lake Iznik sediments. Reconstructing the differences in dry and humid periods and fluctuations in lake level are constrained by the measured proxies. The sedimentary sequence of the Iznik Lake indicates a fluctuating trend for moist periods interjected by quick environmental change to dry periods. Intense droughts were illustrated by sudden geochemical and lithologic anomalies at 4.2 and 3.3 ka cal BP. This might have resulted in drop in the level of the lake extremely.

Jiménez-Moreno et al. (2015) evaluated the environmental and vegetation change throughout the early and late Pliocene. The investigation covers the south west Anatolia. The research exhibits the changes in vegetation from steppe-like to more woody population same as the recurring oscillations related with interglacial and glacial environmental terms throughout the late Pleistocene. Throughout the cold–dry time, Artemisia was plentiful. This demonstrates that this species was previously prevalent in this region at the beginning of the Pleistocene.

Meydan et al. (2017) utilized a geochemical method for investigating the climate change during the Late Holocene period in the Lake Erçek. As the varved sediment permits examining seasonal variability for understanding the long term environmental patterns, the analyses high-resolution samples of varved sediment taken from the lakes was utilized to explain past climatological events. The prevailed weather in region of the Lake Erçek is continental weather (dry and Warm in summers and cold and wet in winters). The Lake area is impacted by combination of Mid-latitude Subtropical High pressure, Monsoon and North Atlantic and Siberian High-pressure systems. The results of the investigation revealed that the Lake Erçek sediments have local reaction to environmental alterations and it is likely to clarify it with the yearly average air temperature.

Kamar (2017) worked in the Lake Erçek and gave the first result about Lake

Erçek prelimnary palynological results. But the author didn't give any detail about the coring position and core lenghth and also about the age. Author just said that prelimnary findings indicate the steppe vegetation dominant in the area.

Biltekin et al. (2018) demonstrates the Lake Hazar's first pollen record, which located in the east of Turkey. For the period of the late Pleistocene–Holocene, the data of this research offers understanding in to multi-centennial-scale environmental records. Escalation in the mounts of herbaceous plants (like Asteraceae and Poaceae families and the genus *Centaurea*) and decreasing in level of lake to 73m, terrace erosion on the lake margin identifies the commencement of the Younger Dryas. The study stated that the deciduous *Quercus* growth during the initial of Holocene period caused by substantial afforestation. The study expressed that high humidity resulted in this significant afforestation that was apparently appropriate for the oak forest establishment. Furthermore, till the middle Holocene, the upsurge in deciduous *Quercus* was continued. Throughout the late Holocene, the cold and dry climatic conditions caused an upsurge in herbaceous plants, and decrease in lake stand. Furthermore, in Lake Hazar, the suspension in a deciduous *Quercus* was not identified. This indicates that at the commencement of the early Holocene the existence of a humid and warm weather generates advantageous conditions for the expansion of the oaks.

Kılıç et al. (2018) analyzed Lake Aktaş's core sediments in Turkey to evaluate the climate events. Lake Aktas is located in highland in the NE Anatolia. The sediment core of this lake covers the period of the past thousand. For reconstructing past environmental changes, pollen data together with physical and chemical proxies were used. The AMS radiocarbon dating of bulk organic carbon was applied to date of the sediments. Amongst arboreal pollen (AP) the *Picea orientalis*, *Pinus sylvestris*, *Fagus*, *Abies*, *Betula*, and *Quercus* were described as dominant trees for last 900 years. For this time, NAP (non-arboreal pollen) population is calculated as less than AP. Also, they suggest the beginning of the Little Ice Age in the highland in northeast Anatolia.

3. MATERIAL AND METHODS

3.1. Material

One short core was retrieved in Lake Erçek during a Russian-Turkish collaboratin expedition in July 2015. The core was taken in water depths about 38 meters and 1250 mm long. The position of the core Erçek15-03 is displayed (Figure 3.1).

Figure 3.1. Location of Erçek15-03 core.

3.2. Methods

3.2.1. Extraction of the cores

For the extraction of the core, a gravity corer “UWITEC” and a transparent PVC liner with an outer diameter of 63 mm was used (Figure 3.2).

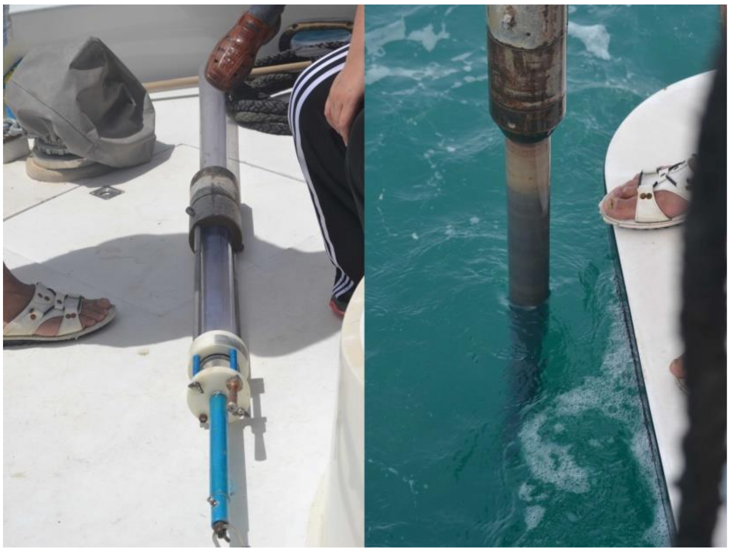

Figure 3.2.Core recovery.

3.2.2. Core opening, photographing and describing the litohology

To split the core, two longitudinal cuts on opposite sides are made into the liner, then two copper plates are pushed through the cut. Then the plates are separated and stripped from the core halves (Figure 3.3). One half of core is stored for the analysis and the other half was prepared to take digital pictures. After the oxidation of the core surface, the describing made and then photographed with a Nikon photographer.

Figure 3.3. Core cutting.

3.2.3. Chronological analysis

In order to obtain the sedimentation rate and the age of the upper part of the Lake Erçek core, we used $_{210}$Pb-$_{137}$Cs radionuclide analysis. Radionuclides were measured with a gamma spectrometry in Siberian Branch of the Russian Academy of Sciences, Institute of Nucleer Physics in Russia. In this thesis, CRS (Constant Rate Supply) model is used for the calculation. From this point, the slope of the linear curve of the graph plotted for the equilibrium Pb yielded the sedimentation rate.

Also to obtain absolute chronology, the annual sediment laminae are counted. The high-resolution pictures of the varved sediments of Lake Erçek allow identifying the bright sediment laminae, which alternate with brown laminae. If the layers are varves, then the graph represents the quasi-linear function sediment accumulation rate (SAR) versus core depth. The following algorithm was used to build such an age model. The core was divided into segments of 10 mm, and each segment was assigned to the SAR from the previous schedule. Then it become a time interval length = 10mm / SAR.

Data on the distribution of ^{137}Cs (marking global fallout 1963 AD) along the depth of the core turned out in good agreement with the obtained age - depth model.

3.2.4. Stable isotope analysis

Stable oxygen isotopic compositions of the bulk carbonate on 18 samples along the core were determined. For this analysis, Kiel III carbonate preparation device attached to a Finnigan-MAT 2545 isotope ratio mass spectrometer was used. The powdered samples were treated with phosphoric acid, and then the isotope ratios were determined. Data are reported the SMOW (Standard Mean Ocean Water) standard and then turned into PDB (Peedee Formation Belemnite). Stable isotope analyses were made at ACME laboratory in Canada.

3.2.5. Pollen analysis

The science of the fossil and current palynomorphs like spores, pollen, acritarchs and dinoflagellate cysts is called Palynology. Pollen grains can be conserved for a long time in the sediments due to their strong wall (exine). Pollen provides high resolution and continuous climate record. Mainly for the assessment of paleoclimate and paleovegetation history, Palynology is a very appropriate instrument. Furthermore, for biostratigraphy, biodiversity and characterization of the past climate changes, palynological examination are utilized.

Sixty-three samples were collected for the new high-resolution pollen examination. The temporal resolution between every single sample of the pollen, taken from the current age-depth model, varied between 1165 and 2015 AD.The palynological analysis standard procedures used for this step (Faegri and Iversen, 1989). The samples were treated with 10% hot hydrochloric acid (HCl; 10 min), 10% hot potassium hydroxide (KOH; 25 min), sieving (250 µm), 40% hot hydrofluoric acid (HF) glacial acetic acid (C2H4O2), hot acetolysis with 1-part sulfuric acid (H2SO4) concentrate and 9-parts concentrated acetic anhydrite (C4H6O3; max. 3 min). Pollen residues mounted in glycerin were analyzed under a light microscope with camera at 400x magnification. Identification of the pollen was performed using a reference pollen collection and pollen atlases (Beug, 2004; Kuprianova and Alyoshina, 1972). Percentages of all taxa were calculated based on setting the total of all pollen taxa equal to 100%. Results of pollen analysis are displayed in the pollen diagram produced with the Tilia/TiliaGraph software (Grimm, 1991, 2004). These diagrams cover the whole arboreal pollen (AP), which includes shrubs and trees; and non-arboreal pollen (NAP), which contains herbs and grasses. In the diagram, CONISS software supports of the pollen zones (PZs) visual definition.

Step 1: Sample preparation

The samples were transferred to test tubes. Then, the details of each samples were recorded immediately after each transfer. In test tubes, the samples were collected with comprehensive labels.

Step 2: Hydrochloric acid treatment (HCL % 10)

In this step, carbonates is removed. The HCL is added step by step and continue until the reaction stops for 20 min. Centrifuge→ decant→ dispose chemical. After the samples were washed twice with distilled water.

Step 3: Potassium hydroxide treatment (KOH% 10)

In this step, sediment was broke up by utilizing a detergent. Also, the humic acids is removed (Figure 3.4). Then, the samples were treated in the water bath for 6 minutes (maximum 8 to 10 minutes). Centrifuge→decant→dispose chemicals. The test tube was filled with 1/3 water, sample is stirred twice.

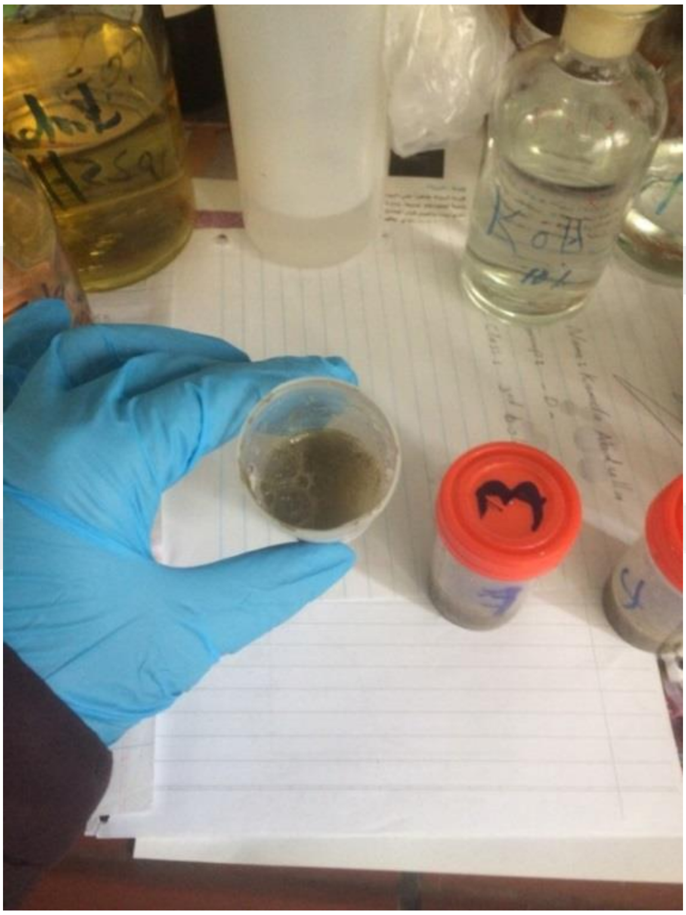

Figure 3.4. The sample in KOH for breaks up sediment and removes humic acids.

Step 4: Screening

The large sand and other particles bigger than 200 µm are removed in this step.

Step 5: Hydrofluoric acid treatment (HF 40%)

In this step, silicates (sand, silt, clay) were removed (Figure 3.5). The sample is placed in the water bath for 20-45 minutes or maximum 2 hours. Stirring the samples thoroughly every 10 minutes then centrifuge samples and decant HF for neutralizing the bottle.

Figure 3.5. The samples in water bath (water bath temp: 90^{0}C before the boiling point).

Step 6: Add HCL 10%

The HCL treatment will be repeated if the color is green→ yellow but maximum 3 times. About 70% of the test tube was filled with 10% HCL and stirred. After that, it was placed in 90^{o}C water bath for 15 minute then centrifuged and decanted. The sample is washed twice with distilled water. And they are ready for the next step (Figure 3.6).

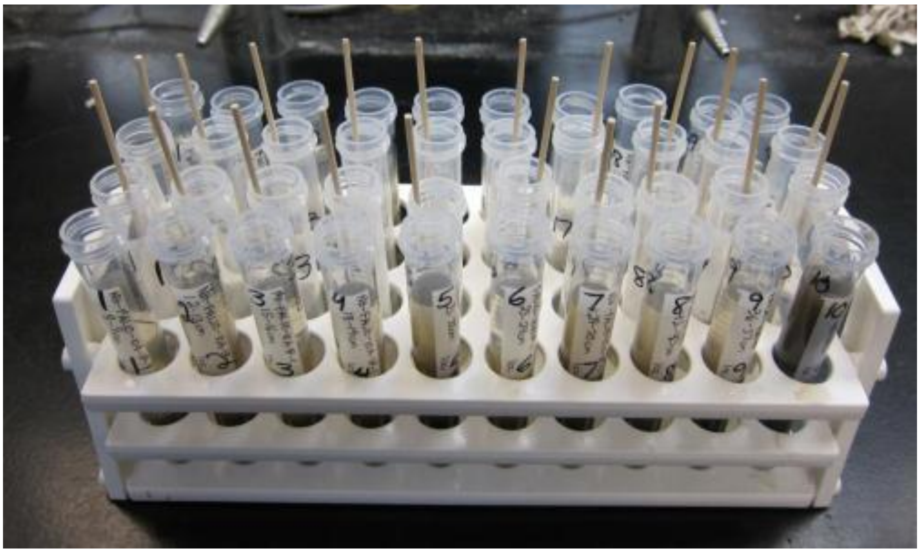

Figure 3.6. Tube rack set up with samples and test tubes holding stir sticks.

Step 7: Glacial acetic acid 100%

The sample is dehydrated. Remove water which does not mix with the silicone oil mounting medium. Always irreversible clumping happens if the water is not removed completely (100%). Half of the test tube is filled with 100% glacial acetic acid. Then, it stirred (cold, no water bath), centrifuged and decanted (Figure 3.7).

Figure 3.7. The samples in the centrifuge (speed: 3000 p.m. for PP test tubes).

Step 8: $(CH_3CO)_2O$+ H_2SO_4 96%-(Acetic acid anhydride + Sulphuric acid)

Nine parts acetic acid anhydride and one parts of sulphuric acid by volume are placed in test tube in the water bath for maximum of 2 minutes.

Step 9: Add Glacial acetic acid100%

Glacial acetic acid100% was added to the the test tube samples. The sample was washed twice with distilled water.

Step 10: KOH 10%

Half of the test tube was filled with 10% KOH. It was stirred and placed in the water bath 5 minutes. After that, it was centrifuged and decanted. Then, it was washed twice with distilled water.

Step 11: - $C_3H_8O_3$-85%-(Glycerine)

Thirty percent of the test tube was filled with Glycerine. Then it was stirred, and another thirty percent was added. After that, the sample was placed in 70ºC water bath for 4 minutes. During this step, the sample was frequently stirred. After that, it was centrifuged for 10 minutes and decanted. The step should be repeated by adding new Glycerine each time, maximum 3 times if the supernatant is dark.

4. RESULTS

4.1. Lithology of Core Erçek15-03

In order to the description of the lithology of the core, macroscopic properties used. These macroscopic properties are; the color of the sediments (gray, green, red), the structure (laminated, banded, massive) and the grain size (clay, silt, sand).

Sediment core which is taken from the study area generally consists of laminae with wide color range. The detailed lithological description of the core is given as follows (Figure 4.1).

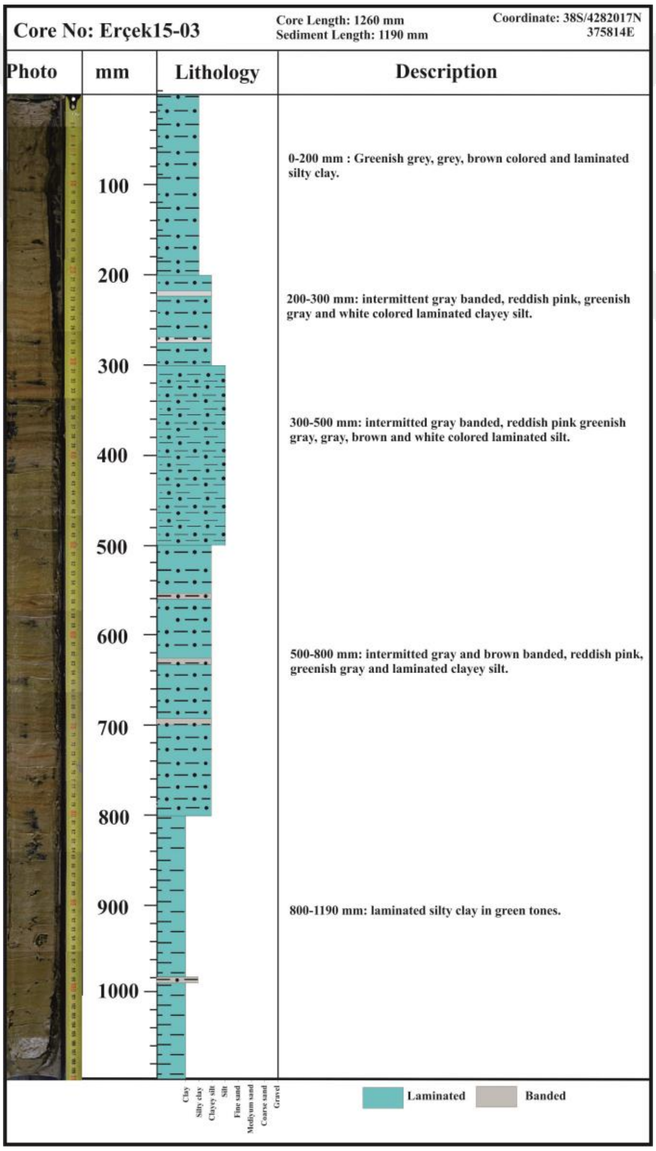

Figure 4.1. Lithology of the core Erçek15-03.

4.2. Age – Depth Model

For the core ^{137}Cs-^{210}Pb analysis result is given below (Meydan et al., unpublished data). Sedimentation rate was calculated from the first 100 mm depth of the core. According to the obtained values, the sedimentation rates was found 1.2 mm/year (Figure 4.2).

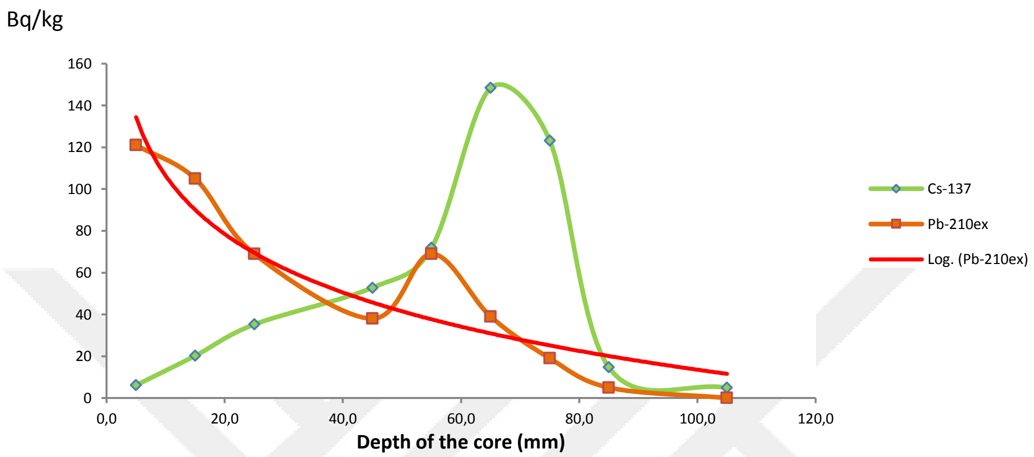

Figure 4.2. ^{137}Cs-^{210}Pb graph.

Varves was counted and different sedimentation rates were obtained throughout the core. The obtained ages and ^{137}Cs peaks were compared and the following depth-age model was obtained (Figure 4.3). Totally 850 years went back with the model, and we backed to MS 1165.

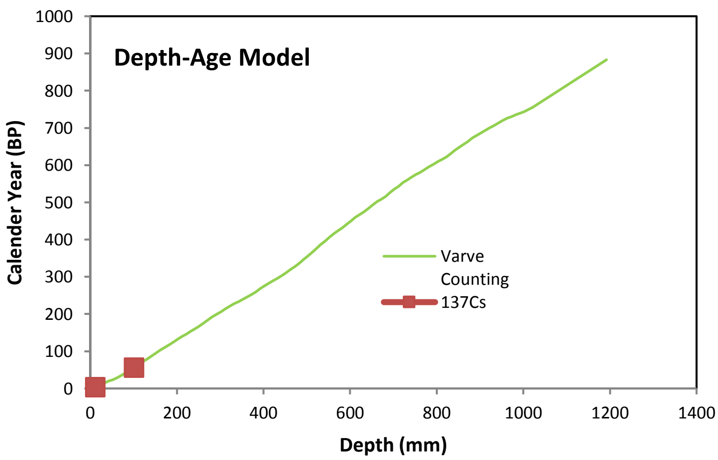

Figure 4.3. Age-depth model for core Erçek15-03.

4.3. Stable Isotope Composition

The δ^{18}O values of bulk carbonate of eigtheen sediment samples from Erçek15-03 core are plotted (Figure 4.4). The δ^{18}O VPDB values were calculated from VSMOW values. Calculated values changing between -2.20 and 0.46 ‰ VPDB.

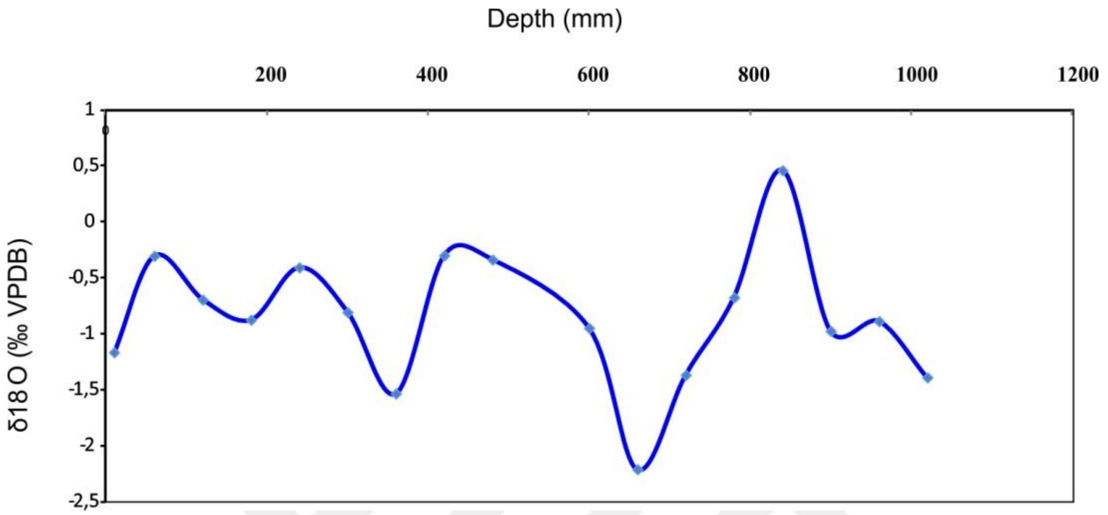

Figure 4.4. ^{18}O isotope graph.

4.4. Pollen Finding in Core Erçek15-03

It has been identified arboreal pollen (AP; trees and shrubs; Table 4.1) total eight taxa; (*Pinus, Quercus, Alnus, Betula, Carpinus, Corylus, Juglans* and *Juniperus).*

Table 4.1. Arboreal pollen names with plates

Pollen	Plate	Plate	Plate
Pinus	plate 1 (1-28)		
Quercus	plate 1 (29-32)	plate 2 (1-32)	plate 3 (1-11)
Alnus	plate 3 (12-23)		
Betula	plate 3 (24-32)		
Carpinus	plate 4 (1-3)		
Corylus	plate 4 (4-7)		
Juglans	plate 4 (8-27)		
Juniperus	plate 4 (28-32)	plate 5 (1-15)	

Also it has been identified non-arboreal pollen (NAP; herbs and grasses; Table 4.2) total 22 taxa (*Artemisia*, Apiaceae, *Helianthemum,* Asteraceae, Rosaceae, Caryophyllaceae, *Plantago*, Brassicaceae, *Ranunculaceae, Rumex*, Poaceae, *Cerealia,* Fabaceae, Lamiaceae, Rubiaceae, *Centaurea solstitiales, Polygonum*, *Sanguisorba,* Cyperaceae , *Sparganium, Thalictrum* and Amaranthaceae).

Table 4.2. Non-arboreal pollen names with plates

Pollen	Plate	Plate
Artemisia	plate 6 (1-32)	plate 7 (1-4)
Apiaceae	plate 7 (5-25)	
Helianthemum	plate 7 (26-32)	plate 3 (1-4)
Asteraceae	plate 8 (5-32)	plate 9 (1-10)
Rosaceae	plate 9 (11-14)	
Caryophyllaceae	plate 9 (15-32)	plate 10 (1)
Plantago	plate 10 (2-23)	
Brassicaceae	plate 10 (24-32)	plate 11 (1-12)
Ranunculaceae	plate 11 (13-20)	
Rumex	plate 11 (21-32)	plate 12 (1-5)
Poaceae	plate 12 (6-31)	plate 13 (1-17)
Cerealia	plate 13 (18-32)	plate 14 (1-12)
Fabaceae	plate 14 (13-17)	
Lamiaceae	plate 14 (18-25)	
Rubiaceae	plate 14 (26-32)	plate 15 (1-22)
Centaurea solstitiales	plate 15 (23-31)	
Polygonum	plate 15 (32)	plate 16 (1-7)
Sanguisorba	plate 16 (8-22)	
Cyperaceae	plate 17 (25-32)	plate 17 (1-16)
Sparganium	plate 17 (17-26)	
Thalictrum	plate 17 (27-32)	plate 18 (1-3)
Amaranthaceae	plate 18 (4-32)	plate 19 (1-5)

4.5. Abundance of Pollens for Erçek15-03

Counting of pollen as defined in lake Erçek core below are given in order of depth (Table 4.3- Table 4.16).

Table 4.3. Number of pollens defined in Erçek15-03 core (10 -100 mm)

Name	**Group**	**10-40**	**50-60**	**70-80**	**90-100**
Pinus	TRSH	6	30	2	6
Qurecus	TRSH	102	123	106	70
Juniperus	TRSH	10	22	32	20
Betula	TRSH	5	1	5	4
Alnus	TRSH				
Corylus	TRSH			1	
Juglans	TRSH	8	10	6	2
Artemisia	HEGR	94	98	118	90
Amaranthaceae	HEGR	50	46	74	64
Cyperaceae	HEGR	1	1		
Poaceae	HEGR	54	64	50	34
Caryophyllaceae	HEGR	4			
Asteraceae	HEGR	32	34	32	18
Brassicaceae	HEGR	4	3	8	4
Rubiaceae	HEGR	2	2	1	
Ranunculaceae	HEGR	12			
Thalictrum	HEGR	5		4	2
Plantago	HEGR	8	10	6	16
Rosaceae	HEGR	2			2
Cerealia	HEGR		3	4	4
sanguisorba	HEGR				2
Fabaceae	HEGR				

Table 4.3. Number of pollens defined in Erçek15-03 core (10 -100 mm)(Continue)

Name	**Group**	**10-40**	**50-60**	**70-80**	**90-100**
Polygonum	HEGR	2	2		
Apiaceae	HEGR	32	18		6
Lamiaceae	HEGR	5			
Sparganium	HEGR				
Centaurea solstitiales	HEGR	1	1		4
Rumex	HEGR	1		1	
Helianthemum	HEGR				
Carpinus	TRSH				

Table 4.4. Number of pollens defined in Erçek15-03 core (110 -180 mm)

Name	**Group**	**110-120**	**130-140**	**150-160**	**170-180**
Pinus	TRSH	4	8	6	12
Qurecus	TRSH	98	60	51	47
Juniperus	TRSH	32	26	37	19
Betula	TRSH	4	5	3	4
Alnus	TRSH				2
Corylus	TRSH				
Juglans	TRSH	6	8	9	3
Artemisia	HEGR	96	120	138	94
Amaranthaceae	HEGR	70	56	60	94
Cyperaceae	HEGR				3
Poaceae	HEGR	26	36	112	120
Caryophyllaceae	HEGR		2		4
Asteraceae	HEGR	18	46	22	21
Brassicaceae	HEGR	14	10	5	2
Rubiaceae	HEGR			3	3
Ranunculaceae	HEGR	4	4	3	5
Thalictrum	HEGR		8		3
Plantago	HEGR	20	10	9	22
Rosaceae	HEGR		2		2
Cerealia	HEGR	8	4	5	3
sanguisorba	HEGR	2	4		
Fabaceae	HEGR				
Polygonum	HEGR	2		7	7
Apiaceae	HEGR	6	24	19	15
Lamiaceae	HEGR				
Sparganium	HEGR				
Centaurea solstitiales	HEGR				
Rumex	HEGR	2	2		
Helianthemum	HEGR	2	2		
Carpinus	TRSH				

Table 4.5. Number of pollens defined in Erçek15-03 core (190 -260 mm)

Name	**Group**	**190-200**	**210-220**	**230-240**	**250-260**
Pinus	TRSH	14	10	17	1
Qurecus	TRSH	54	46	59	45
Juniperus	TRSH	12	22	10	14
Betula	TRSH	1	3	2	2
Alnus	TRSH	2	2		
Corylus	TRSH				

Table 4.5. Number of pollens defined in Erçek15-03 core (190 -260 mm) (Continue)

Name	**Group**	**190-200**	**210-220**	**230-240**	**250-260**
Juglans	TRSH		7	10	1
Artemisia	HEGR	93	86	80	97
Amaranthaceae	HEGR	66	58	56	58
Cyperaceae	HEGR		2		
Poaceae	HEGR	63	58	58	70
Caryophyllaceae	HEGR			2	
Asteraceae	HEGR	16	12	17	34
Brassicaceae	HEGR	2	2	6	2
Rubiaceae	HEGR		2	3	2
Ranunculaceae	HEGR	2		5	6
Thalictrum	HEGR		4	2	6
Plantago	HEGR	4	5	15	
Rosaceae	HEGR				
Cerealia	HEGR	2	2	1	
sanguisorba	HEGR		5	2	
Fabaceae	HEGR	2			
Polygonum	HEGR		1	2	
Apiaceae	HEGR	14	16	9	9
Lamiaceae	HEGR	4	2		
Sparganium	HEGR				
Centaurea solstitiales	HEGR				
Rumex	HEGR				
Helianthemum	HEGR				
Carpinus	TRSH	2			

Table 4.6. Number of pollens defined in Erçek15-03 core (270 -360 mm)

Name	**Group**	**270-300**	**310-320**	**330-340**	**350-360**
Pinus	TRSH	13	6	21	18
Qurecus	TRSH	72	43	87	77
Juniperus	TRSH	10	13	15	23
Betula	TRSH	3	1	1	1
Alnus	TRSH	2			
Corylus	TRSH				
Juglans	TRSH	10	8		6
Artemisia	HEGR	111	76	101	70
Amaranthaceae	HEGR	88	64	82	52
Cyperaceae	HEGR			1	
Poaceae	HEGR	94		80	
Caryophyllaceae	HEGR	2		4	
Asteraceae	HEGR	16	22	20	16
Brassicaceae	HEGR	5	10	2	1
Rubiaceae	HEGR	2		5	
Ranunculaceae	HEGR	2	1	4	2
Thalictrum	HEGR	5	8	4	4
Plantago	HEGR	11	10	12	
Rosaceae	HEGR		1	3	6
Cerealia	HEGR	4	1		1
sanguisorba	HEGR				
Fabaceae	HEGR				
Polygonum	HEGR	8	10	5	
Apiaceae	HEGR	7	10	12	12
Lamiaceae	HEGR	3			
Sparganium	HEGR				1
Centaurea solstitiales	HEGR				

Table 4.6. Number of pollens defined in Erçek15-03 core (270 -360 mm) (Continue)

Name	Group	270-300	310-320	330-340	350-360
Rumex	HEGR	2			1
Helianthemum	HEGR				
Carpinus	TRSH		2		

Table 4.7. Number of pollens defined in Erçek15-03 core (370 -460 mm)

Name	Group	370-380	390-400	410-440	450-460
Pinus	TRSH	20	6	4	6
Qurecus	TRSH	64	66	88	42
Juniperus	TRSH	30	28	20	21
Betula	TRSH	2	5	1	3
Alnus	TRSH	2			
Corylus	TRSH				2
Juglans	TRSH	5	4	8	
Artemisia	HEGR	162	106	126	70
Amaranthaceae	HEGR	103	56	58	30
Cyperaceae	HEGR		2	1	
Poaceae	HEGR	132	134	60	40
Caryophyllaceae	HEGR	2			
Asteraceae	HEGR	17	34	22	35
Brassicaceae	HEGR	2	3	2	4
Rubiaceae	HEGR	6		5	
Ranunculaceae	HEGR		1	10	
Thalictrum	HEGR	3	2	2	1
Plantago	HEGR	22	10	6	6
Rosaceae	HEGR				
Cerealia	HEGR	4		2	
sanguisorba	HEGR				
Fabaceae	HEGR				
Polygonum	HEGR	6	1	2	
Apiaceae	HEGR	4	18	5	8
Lamiaceae	HEGR		1		
Sparganium	HEGR	1			
Centaurea solstitiales	HEGR				1
Rumex	HEGR			2	
Helianthemum	HEGR				
Carpinus	TRSH				

Table 4.8. Number of pollens defined in Erçek15-03 core (470 -540 mm)

Name	Group	470-480	490-500	510-520	530-540
Pinus	TRSH	22	20	25	20
Qurecus	TRSH	88	50	66	58
Juniperus	TRSH	22	8	12	12
Betula	TRSH	5	1	3	6
Alnus	TRSH		2	1	
Corylus	TRSH				
Juglans	TRSH	10		6	2
Artemisia	HEGR	104	68	94	98
Amaranthaceae	HEGR	112	61	66	82
Cyperaceae	HEGR	6	2		4
Poaceae	HEGR	152	60	74	60
Caryophyllaceae	HEGR			2	
Asteraceae	HEGR	26	22	30	28

Table 4.8. Number of pollens defined in Erçek15-03 core (470 -540 mm) (Continue)

Name	Group	470-480	490-500	510-520	530-540
Brassicaceae	HEGR				12
Rubiaceae	HEGR	5		4	8
Ranunculaceae	HEGR	4		8	12
Thalictrum	HEGR		4	5	8
Plantago	HEGR	16	6	10	14
Rosaceae	HEGR			3	1
Cerealia	HEGR	1	4	8	8
sanguisorba	HEGR				
Fabaceae	HEGR				
Polygonum	HEGR			2	
Apiaceae	HEGR	20	6	12	16
Lamiaceae	HEGR	1			
Sparganium	HEGR				
Centaurea solstitiales	HEGR				
Rumex	HEGR		2	1	4
Helianthemum	HEGR				
Carpinus	TRSH	1			

Table 4.9. Number of pollens defined in Erçek15-03 core (550 -620 mm)

Name	Group	550-560	570-580	590-600	610-620
Pinus	TRSH	26	22	14	12
Qurecus	TRSH	64	40	77	60
Juniperus	TRSH	30	14	10	5
Betula	TRSH		2	2	1
Alnus	TRSH		1	1	
Corylus	TRSH			1	
Juglans	TRSH	6	7	8	
Artemisia	HEGR	148	86	91	100
Amaranthaceae	HEGR	82	30	61	60
Cyperaceae	HEGR		6	4	6
Poaceae	HEGR	126	88	100	84
Caryophyllaceae	HEGR		6		5
Asteraceae	HEGR	34	18	25	20
Brassicaceae	HEGR	4	4	7	1
Rubiaceae	HEGR	4		4	2
Ranunculaceae	HEGR	14	12	3	1
Thalictrum	HEGR	4	4	2	2
Plantago	HEGR	20	14	7	10
Rosaceae	HEGR		1		
Cerealia	HEGR	2	6	7	5
sanguisorba	HEGR				2
Fabaceae	HEGR				
Polygonum	HEGR	2		2	3
Apiaceae	HEGR	22	22	20	14
Lamiaceae	HEGR	1			1
Sparganium	HEGR				
Centaurea solstitiales	HEGR				
Rumex	HEGR	3	1	3	2
Helianthemum	HEGR		1	1	
Carpinus	TRSH		1	2	

Table 4.10. Number of pollens defined in Erçek15-03 core (630 -760 mm)

Name	Group	630-640	650-680	690-720	730-760
Pinus	TRSH	8	14	2	8
Qurecus	TRSH	30	38	30	52
Juniperus	TRSH	8	4		4
Betula	TRSH		3	4	2
Alnus	TRSH		1		
Corylus	TRSH		1		
Juglans	TRSH	2	12	1	
Artemisia	HEGR	94	130	99	136
Amaranthaceae	HEGR	78	76	118	136
Cyperaceae	HEGR		14	2	1
Poaceae	HEGR	66	78	64	123
Caryophyllaceae	HEGR			2	4
Asteraceae	HEGR	30	14	18	13
Brassicaceae	HEGR	1	2		6
Rubiaceae	HEGR	1	1		2
Ranunculaceae	HEGR		2	5	
Thalictrum	HEGR	4	10	8	9
Plantago	HEGR	1	4	4	22
Rosaceae	HEGR				
Cerealia	HEGR	1	10	7	2
sanguisorba	HEGR				5
Fabaceae	HEGR				
Polygonum	HEGR	2	1	1	3
Apiaceae	HEGR	12	6	3	5
Lamiaceae	HEGR				
Sparganium	HEGR				
Centaurea solstitiales	HEGR		1		
Rumex	HEGR			1	
Helianthemum	HEGR				
Carpinus	TRSH	1			

Table 4.11. Number of pollens defined in Erçek15-03 core (770 -840 mm)

Name	Group	770-780	790-800	810-820	830-840
Pinus	TRSH	12	2	2	1
Qurecus	TRSH	39	80	51	72
Juniperus	TRSH	3	6	3	4
Betula	TRSH	2	4	2	3
Alnus	TRSH	1	1	2	
Corylus	TRSH			2	
Juglans	TRSH	10	8	5	5
Artemisia	HEGR	84	123	134	89
Amaranthaceae	HEGR	110	121	96	56
Cyperaceae	HEGR	8	1	3	2
Poaceae	HEGR	108	106	73	93
Caryophyllaceae	HEGR	2	2	4	2
Asteraceae	HEGR	24	28	18	20
Brassicaceae	HEGR	10	1	6	7
Rubiaceae	HEGR	2	1	4	4
Ranunculaceae	HEGR	2	4	1	
Thalictrum	HEGR	4	5	6	5
Plantago	HEGR	10	21	4	12
Rosaceae	HEGR				
Cerealia	HEGR	10	9	5	4
sanguisorba	HEGR	2	3	2	

Table 4.11. Number of pollens defined in Erçek15-03 core (770-840 mm) (Conrtinue)

Name	Group	770-780	790-800	810-820	830-840
Fabaceae	HEGR				
Polygonum	HEGR	6	3	1	1
Apiaceae	HEGR	6	20	16	15
Lamiaceae	HEGR				1
Sparganium	HEGR				1
Centaurea solstitiales	HEGR				
Rumex	HEGR	4			
Helianthemum	HEGR				1
Carpinus	TRSH				

Table 4.12. Number of pollens defined in Erçek15-03 core (850 -920 mm)

Name	Group	850-860	870-880	890-900	910-920
Pinus	TRSH	7	1	4	6
Qurecus	TRSH	64	54	79	75
Juniperus	TRSH	4	4	8	11
Betula	TRSH	3	2	4	3
Alnus	TRSH			1	
Corylus	TRSH			1	
Juglans	TRSH	6	1	2	2
Artemisia	HEGR	61	98	97	82
Amaranthaceae	HEGR	69	79	67	54
Cyperaceae	HEGR	2	5	4	5
Poaceae	HEGR	90	95	86	85
Caryophyllaceae	HEGR	2		2	2
Asteraceae	HEGR	17	1	16	21
Brassicaceae	HEGR	1	9	1	2
Rubiaceae	HEGR			1	2
Ranunculaceae	HEGR	3	4	10	3
Thalictrum	HEGR	2	1	1	2
Plantago	HEGR	5	11	20	11
Rosaceae	HEGR		1		
Cerealia	HEGR	1	2	1	13
sanguisorba	HEGR			2	
Fabaceae	HEGR	1			
Polygonum	HEGR			2	3
Apiaceae	HEGR	6	11	5	6
Lamiaceae	HEGR				
Sparganium	HEGR	1			
Centaurea solstitiales	HEGR				1
Rumex	HEGR	1	1		2
Helianthemum	HEGR			1	
Carpinus	TRSH				

Table 4.13. Number of pollens defined in Erçek15-03 core (930-1000 mm)

Name	Group	930-940	950-960	970-980	990-1000
Pinus	TRSH	2	6	5	31
Qurecus	TRSH	70	85	51	77
Juniperus	TRSH	9	8	20	9
Betula	TRSH	2	2	2	5
Alnus	TRSH	1			
Corylus	TRSH				

Table 4.13. Number of pollens defined in Erçek15-03 core (930-1000 mm) (Continue)

Name	Group	930-940	950-960	970-980	990-1000
Juglans	TRSH	2	4	3	10
Artemisia	HEGR	101	90	140	180
Amaranthaceae	HEGR	66	72	85	110
Cyperaceae	HEGR	6	7	11	12
Poaceae	HEGR	69	64	106	148
Caryophyllaceae	HEGR	1	3	1	1
Asteraceae	HEGR	22	19	22	21
Brassicaceae	HEGR	5	1	4	4
Rubiaceae	HEGR		2		1
Ranunculaceae	HEGR	2	6	2	5
Thalictrum	HEGR	4		4	1
Plantago	HEGR	12	3	16	17
Rosaceae	HEGR				
Cerealia	HEGR	4	3	4	2
sanguisorba	HEGR		1		1
Fabaceae	HEGR				
Polygonum	HEGR		5	1	1
Apiaceae	HEGR	3	10	3	6
Lamiaceae	HEGR				1
Sparganium	HEGR				
Centaurea solstitiales	HEGR				
Rumex	HEGR	3	3		9
Helianthemum	HEGR		1	1	1
Carpinus	TRSH			1	

Table 4.14. Number of pollens defined in Erçek15-03 core (1010 -1080 mm)

Name	Group	1010-1020	1030-1040	1050-1060	1070-1080
Pinus	TRSH	5	5	16	8
Qurecus	TRSH	36	43	78	94
Juniperus	TRSH	7	17	8	1
Betula	TRSH	1	2		3
Alnus	TRSH			1	
Corylus	TRSH			1	
Juglans	TRSH	3	3	5	10
Artemisia	HEGR	67	107	125	168
Amaranthaceae	HEGR	40	70	107	124
Cyperaceae	HEGR	8	3	6	4
Poaceae	HEGR	59	61	124	96
Caryophyllaceae	HEGR	2	3	1	
Asteraceae	HEGR	10	20	15	18
Brassicaceae	HEGR	3	4	2	3
Rubiaceae	HEGR	1			1
Ranunculaceae	HEGR	3	2	5	3
Thalictrum	HEGR	4	4	4	2
Plantago	HEGR	9	5	10	10
Rosaceae	HEGR				
Cerealia	HEGR	1			
sanguisorba	HEGR	1		1	1
Fabaceae	HEGR	1			1
Polygonum	HEGR	1		1	
Apiaceae	HEGR	6	1	6	8
Lamiaceae	HEGR				

Table 4.14. Number of pollens defined in Erçek15-03 core (1010 -1080 mm) (Continue)

Name	Group	1010-1020	1030-1040	1050-1060	1070-1080
Sparganium	HEGR				
Centaurea solstitiales	HEGR				
Rumex	HEGR		1	10	
Helianthemum	HEGR	1			
Carpinus	TRSH				

Table 4.15. Number of pollens defined in Erçek15-03 core (1090 -1160 mm)

Name	Group	1090-1100	1110-1120	1130-1140	1150-1160
Pinus	TRSH	19	28	23	11
Qurecus	TRSH	99	139	125	115
Juniperus	TRSH	7	22	12	22
Betula	TRSH	3	4	1	6
Alnus	TRSH	2	1	1	
Corylus	TRSH	1	3	1	5
Juglans	TRSH	11	10	7	3
Artemisia	HEGR	168	208	188	196
Amaranthaceae	HEGR	107	120	123	85
Cyperaceae	HEGR	4	9	7	13
Poaceae	HEGR	94	135	145	93
Caryophyllaceae	HEGR			1	
Asteraceae	HEGR	20	37	23	26
Brassicaceae	HEGR	6	9	6	2
Rubiaceae	HEGR	1			
Ranunculaceae	HEGR	5	5	1	14
Thalictrum	HEGR		3	1	3
Plantago	HEGR	6	3	8	10
Rosaceae	HEGR				
Cerealia	HEGR	3	3		5
Sanguisorba	HEGR				2
Fabaceae	HEGR				
Polygonum	HEGR		1		4
Apiaceae	HEGR	8	13	18	15
Lamiaceae	HEGR				
Sparganium	HEGR			1	
Centaurea solstitiales	HEGR				
Rumex	HEGR	1			1
Helianthemum	HEGR		1		
Carpinus	TRSH	1			

Table 4.16. Number of pollens defined in Erçek15-03 core (1170 -1240 mm)

Name	Group	1170-1180	1190-1200	1210-1220	1230-1240
Pinus	TRSH	15	22	18	1
Qurecus	TRSH	137	147	52	37
Juniperus	TRSH	16	11	5	1
Betula	TRSH	1	7	2	
Alnus	TRSH	1	2		1
Corylus	TRSH		2		1
Juglans	TRSH	8	13	5	3
Artemisia	HEGR	139	166	92	114
Amaranthaceae	HEGR	77	59	50	76
Cyperaceae	HEGR	5	7	4	6

Table 4.16. Number of pollens defined in Erçek15-03 core (1170 -1240 mm) (Cnt)

Name	Group	1170-1180	1190-1200	1210-1220	1230-1240
Poaceae	HEGR	98	105	73	71
Caryophyllaceae	HEGR	1	7	4	1
Asteraceae	HEGR	13	18	20	9
Brassicaceae	HEGR	1	2	5	1
Rubiaceae	HEGR	2	4	5	4
Ranunculaceae	HEGR	1	3	4	2
Thalictrum	HEGR	2			1
Plantago	HEGR	7	5	5	7
Rosaceae	HEGR				1
Cerealia	HEGR	2	7	5	2
sanguisorba	HEGR	1	4		
Fabaceae	HEGR				
Polygonum	HEGR	1		6	1
Apiaceae	HEGR	12	10	7	11
Lamiaceae	HEGR				
Sparganium	HEGR				
Centaurea solstitiales	HEGR				
Rumex	HEGR	2	6		2
Helianthemum	HEGR				
Carpinus	TRSH				

4.6. Pollen Assemblage Zones

The pollen diagram is subdivided into four pollen zones (PZ), based on the pollen percentages and taxonomical compositions (Figure 4.5).

PZ I (1250 - 800 mm) (1165-1405 AD): is characterized by the dominance of *Artemisia* pollen; the percentages of Amaranthaceae are also high. The percentages of Poaceae decrease and the percentages of *Quercus* increase, *Juniperus* and *Pinus* pollen abundances are low in this zone. Other pollen identified at almost every level along the zone include Asteraceae and *Pinus*. Cyperaceae, *Alnus*, *Corylus*, *Juglans*, *Carpinus*, *Betula*, Caryophyllaceae, Brassicaceae, Rubiaceae, *Ranunculaceae*, *Thalictrum*, *Sanguisorba*, Fabaceae, *Sparganium*, *Plantago*, Rosaceae, *Cerealia, Polygonum,* Apiaceae, *Rumex*, *Helianthemum* such as pollen are defined at some levels.

PZ II (800 - 600 mm) (1405 – 1565 AD): is characterized by high amounts of *Artemisia*, the percentages of Amaranthaceae pollen are also high and increase. The percentages of *Quercus* decreases; *Juniperus* and *Pinus* pollen decrease and almost disappear, the ratio of NAP/AP is higher than other zones, Decrease of AP probably reflects the climate cooling during Little Ice Age.

PZ III (600 - 100 mm) (1565 - 1958 AD): is characterized by high amount of *Artemisia* pollen about (35 %) and is similar to PZI, slightly decrease of Amaranthaceae pollen comparing to PZ II, Poaceae pollen is not stable changing from very low to high percentage range, The percentages of *Quercus* slightly increases. *Juniperus* and *Pinus* pollen increase, Asteraceae pollen increases in this zone.

PZ IV (100 - 0 mm) (1958 - 2015 AD): is distinct by increase of *Quercus*, the percentages of Amaranthaceae and Poaceae are also low comparing to PZIII, the percentages of *Artemisia* about 30% and decrease toward top of the zone, *Juniperus* pollen slightly decreases at the top of zone.

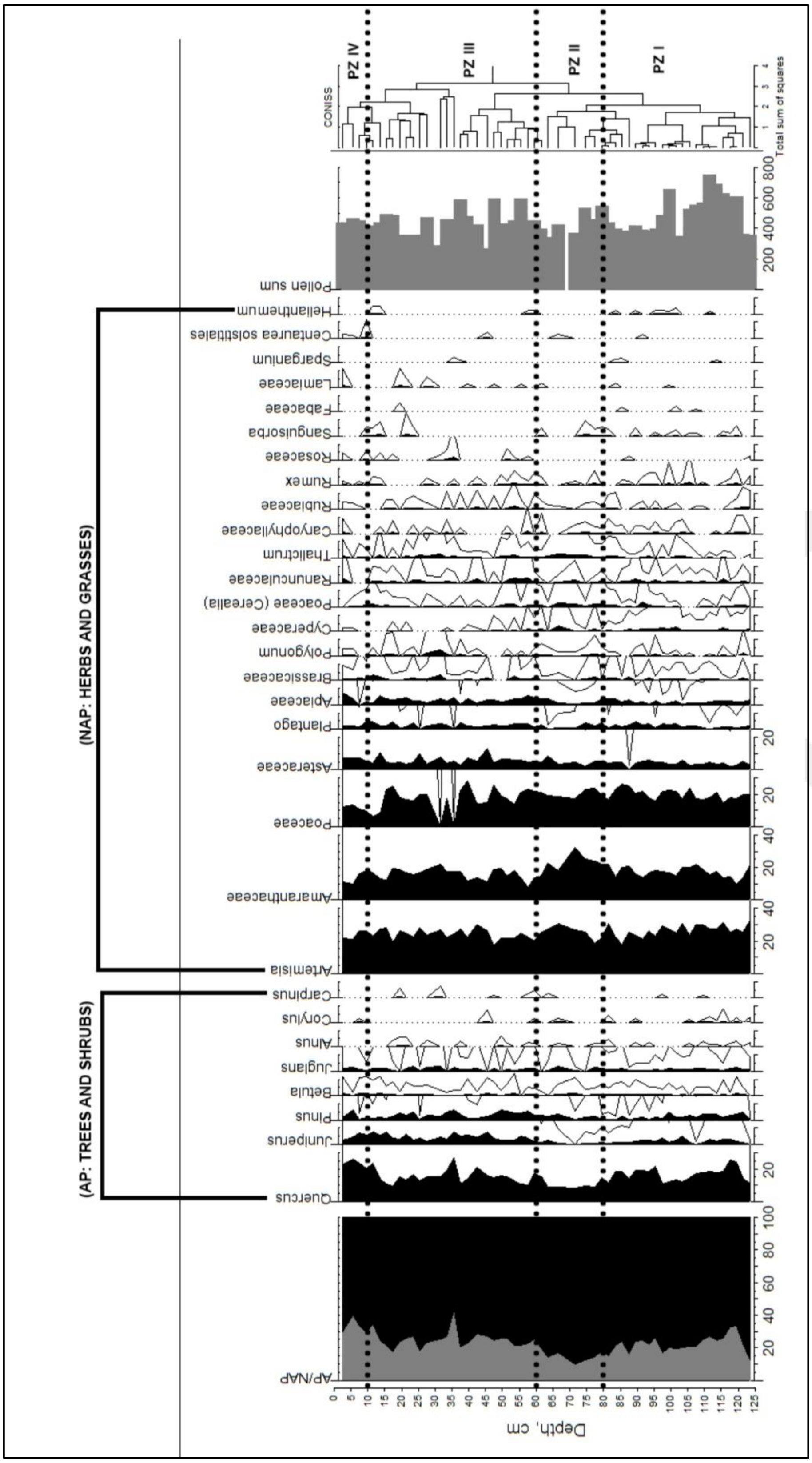

Figure 4.5. Pollen diagram of Lake Erçek.

5. DISCUSSION AND CONCLUSION

5.1. Vegetation

The vegetation of eastern Anatolia has been examined (Louis, 1939; Walter, 1956; Zohary 1973a,1973b ; van Zeist and Woldring, 1978b; Frey and Kürschner, 1989; van Zeist and Bottema, 1991). In addition, the vegetation as a part of Flora of Turkey has been studied (Davis, 1965). It is stated that the Turkish vegetation is divided into three imperative ecological and phytogeographic areas (the Euro-Siberian-, Irano-Turanian, from north to south and the Mediterranean floristic area) (Zohary, 1973a; Kaya and Raynal, 2001). It has been explained that each floristic area can be recognized by their different vegetational element according to the current weather conditions, reflecting various weather conditions (Davis, 1965; Kaya and Raynal, 2001). The steppe and *Quercus*-dominated forests are the main characters of eastern Anatolia vegetation. Forests and woodlands spread and also displaced infrequently the fluctuation in climate caused steppe which was previously existed in Central Anatoliathrough the time (Aytuğ and Görecelioğlu, 1996; Cordova, 2005). It is declared that climate change is the most significant cause of the vegetation change. Thus, changing of vegetation is highly influenced by human impact (Bottema, 1993). It has been expressed that the settlement of the pre-steppe developments in eastern Anatolia gradually resulted from the devastation of these forests by human activity (Akman, 1974). Also, it also caused the transformation of the *Quercus* dominated forests into small shrubs.

In Turkey and all over the world, one of the most vital ecosystems is the steppe, comprising unique plant and animal species. Throughout the last three decades, because of deforestation, overgrazing, and intensive agricultural activities in Central Anatolia, the steppe composition has altered significantly (Akman et al., 2014). Heavy grazing, and intensive agricultural activities deforestation mainly in the past three decades have caused degradation in the majority of the steppe and steppe forest region in eastern Anatolia. The erosion of soil and destruction of the natural vegetation and loss of plant variety have resulted from overgrazing. This is normally also caused remain ecosystems degradation (Koç, 2000; Yunusbaev et al., 2003; Kürschner and Parolly, 2012).

Moreover, deforestation, viticulture and agricultural activities on semi-arid lands, settlements and urban development strongly impact this type of vegetation. Ecologically, the steppe and forest - steppe, which are one of the most sensitive ecosystems, have great importance. Within semi-arid environments, the steppe and forest - steppe can satisfy the requirements for maintainable utilization of the natural resources. Therefore, to preserve and regenerate the natural vegetation in this type of ecosystems, heavy human impact has to be evaded. Some authors revealed that human-induced deterioration of the woodland and by agricultural activity highly influence the vegetation in eastern Anatolia (Wick et al., 2003; Huguet et al., 2012).

Lake Erçek pollen diagram in PZ IV (100-0 mm, 1958 - 2015 AD) is characterized by *Quercus*-dominated forest communities in central Anatolia. The increase of *Quercus*, Amaranthaceae and Poaceae decreases and decrease of *Artemisia* about 30%. In this stage, $_{18}$O isotopes rate is about ‰ -0.5 and -1 (VPDB).

The oak forest steppe expanded during this phase (PZ III (60 – 10 mm, from 1565 to 1958 AD). Initially, the pioneer trees like *Betula* colonized the open habitats then followed by *Juniperus, Quercus and Pinus*. This designates comparatively mild winters and the occurrence of summer dryness because of an evaporation and higher temperature regime at the Holocene in the eastern Mediterranean area (Wick et al., 2003; Litt et al., 2009, 2014; Pickarski et al., 2015a). Same as the commencement of interglacials, the postponement from the beginning of environmental amelioration and the formation of deciduous oak steppe-forest as the possible natural interglacial vegetation in the East of Anatolia might be caused by spring and summer dryness in the early interglacial. An alteration from oak steppe forest to the prevalence of dry-tolerant and/or cold adapted conifer taxa (for example *Juniperus* and *Pinus*) indicates ecological succession of this phase PZ III. The *Pinus* proportion proposes a cooling and/or drying trend that happened throughout low seasonal differences. According to some researchers as a significant arboreal constituent of the "Xero-Euxinian steppe-forest", *Pinus* occurs mostly in the center and west of Anatolia and in the rain shadow of the mountain range of coastal Pontic (Zohary, 1973a; van Zeist and Bottema, 1991). Oxygen isotopes is compatible with pollen diagram in this stage (Figure 5.1).

PZ II (80-60 mm) (1405 – 1565 AD) (the amounts of *Artemisia is* high, the percentages of Amaranthaceae pollen increase, *Quercus* decreases) is dominated by more open steppe vegetation. In general, this period (cold phase) was characterized by widespread steppe vegetation as tree development was inhibited either by low atmospheric CO2 or cold and dry conditions (Litt et al., 2014; Pickarski et al 2015b) Substantial deterioration in the climate was suggested by the cold phase and augmented dryness. More negative isotopic values indicated a wetter climate.

In PZ I (125-80 mm and 1165-1405 AD) is dominated by expansion of forest steppe vegetation in wich *Quercus* increases, Poaceae decreases and the percentages of Amaranthaceae and *Artemisia* are high. Oxygen isotope in this stage indicated warmer period.

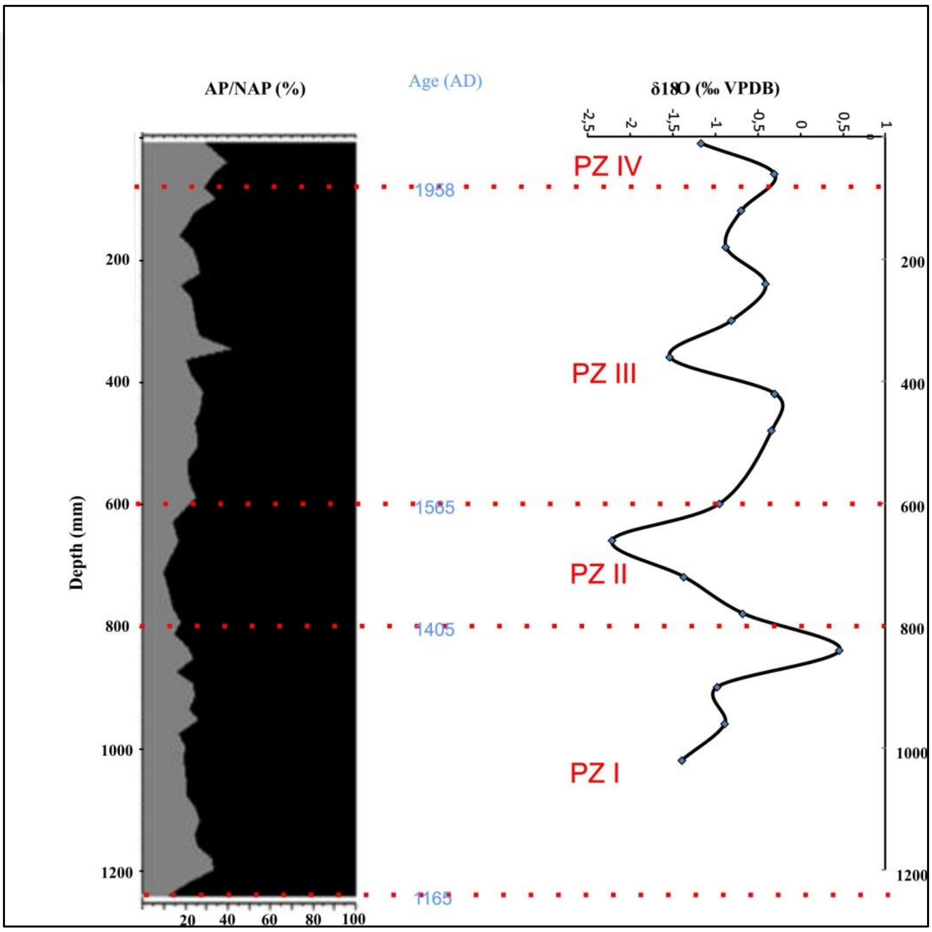

Figure 5.1. Correlation pollen zones and stable isotope data.

5.2. Climate Changes

Numerous palynological records on the long sediment sequences picked from the Ahlat area, and the Tatvan basin of Van Lake have been conducted (Van Zeist and Woldring, 1978; Wick et al., 2003; Litt et al., 2009; Kaplan and Heumann, 2010). Throughout the last millennium, according to palynological examination, the steppe plants dominated the vegetation in the northern basin of Lake Van. *Artemisia*, Amaranthaceae and Poaceae were the predominant the herbaceous pollen. Also, the arboreal pollen percentage was comparatively low. It is stated that the most significant arboreal pollen proportion was *Quercus* (Kaplan and Heumann, 2010). The other arboreal pollens are *Pinus, Alnus, Betula, Fraxinus, Pistacia, Olea a*nd *Salix* correspondingly. The impact of human activity on the steppe vegetation is proved through the existence of *Cerealia* pollen in Lake Van for the Late Holocene (Kaplan, 2012). The examination of palynology in the east of Anatolia has mostly concentrated on Lake Van. However, for the Lake Erçek area, there have not been any multi-proxy analyses yet. Thus, this investigation aims to fill this gap and focus on the palaeo-climatic implications of the Lake Erçek and examines the connection between the vegetation and past weather condition.

The profusion of shrubs and herbs (regularly inadequately denoted in pollen spectra, as displayed by Favre et al., (2008) as well as the tree taxa deficiency in the pollen measurement from eastern of Turkey indicate that the weather in this region was mostly dry throughout Holocene. This complies with earlier pollen and climate examination that expressed that Anatolian climate was dry since the Miocene (Popescu, 2006; Jiménez-Moreno et al., 2007). Nevertheless, the occurrence of hygrophilous and temperate tree species indicates comparatively more wet climate in the surrounding the mountains or nearby the lake. The incidence of Mediterranean adjusted classes like evergreen *Quercus* also demonstrates that weather may have been periodic at that time, with noticeable summer drought. On the other hand, the changes of *Artemisia* steppe indicate arid and cold periods. Moreover, more forested and grassy (Poaceae) vegetation exhibit wetter and warmer climate.

Demonstrates “aridity pollen index” (ratio of *Artemisia* plus Amaranthaceae to Poaceae) at which *Artemisia* (represents steppe), total *Quercus* (represents forest). The alterations can be observed. The aridity pollen index ratio was measured according to research which proposed this ratio for distinguishing moist meadow steppe and forest-steppe vegetation from dry steppe in north-central Mongolia (Fowell et al., 2003). It was supposed that while Poaceae are more plentiful in relatively more moist conditions, Amaranthaceae and *Artemisia* characterize dry climate. Some researchers who created a same index depending upon modern pollen data in contrast to Asteraceae and Poaceae that are utilized as “aridity vs. humidity” proxy have proven the validity of this ratio (Cour and Duzer, 1978; Bachiri Taoufiq et al., 2008). The steppe-like landscape is dominated by Grasses (Poaceae) and other shrubs and herbs (for example Amaranthaceae and *Artemisia*). In the Mediterranean region and Europe, the *Artemisia*, which is an herbaceous shrub and plant that regularly raises in dry or semiarid environments, is widespread presently. It has proven that the first establishment of *Artemisia* was in the central Anatolian plateau (Biltekin, 2010; Işık and Toprak, 2010). In addition, it is stated that *Artemisia* probably originates from an arid or semiarid area in Central Asia such as Tibetan Plateau (Yunfa et al., 2011). Moreover, it is expressed that throughout the Pliocene and early Pleistocene, *Artemisia* became prevalent and covered the entire Mediterranean region (Traverse, 1982; Suc and Popescu, 2005; Popescu, 2006; Biltekin, 2010). The period of the prevalence of *Artemisia* in Anatolia and after that in Europe makes sense complies with the time of the commencement of the glaciations, general aridification and origin of periodic Mediterranean weather in the Mediterranean region, in accordance to some research (Suc, 1984; Biltekin, 2010; Yunfa et al., 2011; Jiménez-Moreno et al., 2013; Biltekin et al., 2015). It is revealed that the existence of *Artemisia* pollen in the immediate east and throughout the eastern Mediterranean has a main precaution for the glacial period (Bottema, 1995). In accordance to the pollen profile in Lake Van sediments (Tatvan Basin) in the period of 20,000 and 11,580 years, Chenopodiaceae and *Artemisia* dominate steppe vegetation (Wick et al., 2003, Litt et al., 2009). Thirty percent of the steppe vegetation was Poaceae pollen (Litt et al. 2009). Tree bush growth in the pollen reaches from 5% to 50% (Wick et al., 2003; Litt et al., 2009). Percentage of *Quercus* pollen among tree pollen is present Starting from 8200 years ago, we have started to show a continuous development line (Wick et al., 2003) and up to 40%, 6,000 years ago today (Litt et al., 2009). *Quercus* curve 6000 years daily (Wick et al., 2003; Litt et al., 2009). The percentage of *Artemisia* and Chenopodiaceae pollen decrease (about 10 to 15%) with the commencement of the Holocene about 11,500 years ago (Litt et al., 2009). Within the scope of this research, the changes in samples of Lake Erçek woody-bush and herbaceous pollen proportion are stable throughout the entire diagram. The maximum escalation in the *Quercus* curve is only up to 25%. The fractions of *Artemisia*, Chenopodiaceae and Poaceae pollen are 10-35% in abundance. The development of vegetation in the last millennium period is reflected by the observation of *Artemisia* and Chenopodiaceae in pollen fractions and woody pollen. The *Quercus* and *Pinus* were dominant in the tree assemblage. Possibly, these taxa raised locally in more humid environments at higher elevation surrounding the mountains. Directly around the lake, Riparian tree species grew (*Alnus*). The most plentiful was Cyperaceae. It is clear that the most abundantly recognized in the pollen diagram of the Lake Erçek are pollen Poaceae, Amaranthaceae, *Artemisia* and Asteraceae. These family members are capable of surviving in various climatic conditions (Seçmen et al., 2004). Furthermore, the majority of the identified pollen are in the genus and family ranks which makes it problematic to interpret a climatic condition based on the diagram. Taking *Pinus* as an instance, East *Pinus* sylvestris grew in cold humid and semi-humid environmental conditions around Kars in Anatolia. Nonetheless, *Pinus,* is widespread in the Mediterranean and Aegean region, is frequently develop in rainy and very rainy Mediterranean environment (Tatlı, 2004.)

Thus it can be stated that these two diverse *Pinus* species live and grow in various areas and climates and reflect different climatic conditions. In general, because of prolific production of *Pinus* and having transportation ability in water and air, they are overrepresented. Amaranthaceae, Poaceae and Asteraceae family develop nearly everywhere in Turkey (Seçmen et al., 2004). Thus, interpreting the climatic condition is complex unless it is defined.

The improved anthropogenic impact in the area is indicated by the presence of *Rumex*, *Plantago*, *Juniperus* and *Quercus*. Clearly, the existence of *Sanguisorba minor*-type (is recognized as small burnet as well) and Caryophyllaceae a good indication for the presence of animal husbandry and farming throughout the late Holocene.

5.3. Comparison to Anatolian Terrestrial Records

Numerous investigations are available in Eastern Anatolia for comparing with our results. However, the majority of them focused on Lake Van (van Zeist and Woldring, 1978; van Zeist and Bottema, 1991; Wick et al., 2003; Litt et al., 2009;

Kaplan and Heumann, 2010; Kaplan, 2012). According to these researches, steppe plants such as Poaceae, Amaranthaceae and *Artemisia* mostly dominated the vegetation in the last 1000 years. Three pollen zones are distinguished in the diagram of Lake Van Northern Basin (Kaplan and Örçen, 2011). They interpreted them as steppe and anthropogenic steppe throughout the past 4000 years. A study revealed that non-arboreal more abundant compare to arboreal pollen in the last 1000 years in Lake Van (Wick et al., 2003; Litt et al., 2009). While *Pinus* and *Quercus* were dominant among the arboreal pollen, Amaranthaceae, *Artemisia* and Poaceae have prevailed among the non-arboreal pollen. Lake Aktaş distinguished pollen trends correspond to the pollen diagrams of Lake Van for the last 1000 years. Results of the proxy element analysis also support the AP/NAP ratio in Lake Aktaş (Kılıç et al., 2018).

The results of this thesis revealed more abundant non-arboreal than arboreal pollen, the vegetation dominated mostly by steppe plants comprising Poaceae, Chenopodiaceae and *Artemisia*, An increase in herbaceous plants, and lower lake levels occurred during the last millennium as a result of cold and dry climatic conditions in the the last 1000 years in Lake Erçek. In the pollen diagram of this study, arboreal pollen decreased, and non-arboreal increased around (1405- 1565 AD) in PZ II.

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EXTENDET TURKISH SUMMARY
(GENİŞLETİLMİŞ TÜRKÇE ÖZET)

ERÇEK GÖLÜ DİP SEDİMANLARININ PALEO-İKLİM PALEO-ORTAM VE PALEO-BİTKİ ÖRTÜSÜNÜN NİCELİKSEL ANALİZİ

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1. GİRİŞ

Son yıllarda, geçmiş iklim değişikliklerinin açıklanmasında polen verilerinin kullanılması artış göstermiştir. Yakın Doğu'da geçmiş iklim değişikliklerinin kurgulanması üzerine bir çok çalışma yapılmaktadır. Van Gölü 451 m maksimum derinliğe sahiptir ve hacmi bakımından dünyanın en büyük soda gölüdür (607 km^3). Alansal açıdan (3574km^2) en büyük dördüncü gölüdür (Degens ve Kurtman, 1978). Bulunduğu konum itibarı ile Van Gölü üzerinde birçok paleolimnolojik çalışma gerçekleşmiştir. En önemli çalışmalar 2010 yılında gerçekleşen PaleoVan Projesinin ardından yayınlamıştır (Sumita and Schmincke, 2013a; Sumita and Schmincke, 2013b; Cukur et al., 2014; Çağatay et al., 2014; Litt and Anselmetti, 2014; Litt et al., 2014; Stockhecke et al., 2014b; Vigliotti et al., 2014; Stockhecke et al., 2014b; Stockhecke et al., 2016). Bu çalışmaların içersinde aynı zamanda palinolojik verileride kapsayan çalışmalar yer almaktadır (Litt ve ark., 2014). 1978 yılında başlayan ve hala devam eden Van Gölü'nü palinolojik açıdan konu edinen çalışmalar Geç Holosen periyodunda yüksek çözünürlüklü değildir. Aynı zamanda bu çalışmalar Geç Holosen süresince özellikle insan etkisinin araştırılmasını amaçlamaktadır. Bu çalışmanın konusu olan Erçek Gölü, Van Gölü'nün 30 km doğusunda yer almaktadır. Van Gölü'nden 200 m daha yüksekte yer alan göl ve çevresinin iklimi kot farkı nedeni ile daha soğuktur. Atmosferik konumu nedeniyle iklimsel çalışmalar için bir anahtar görevi gören gölün dip sedimanlarını konu edinen ve basılmış bir yayın mevcut değildir. Bu çalışma Rusya-Türkiye arasında 2018 yılında sonuçlandırılmış "Asya'da Küresel Isınma ve Kuraklık Dinamikleri: Son Bin Yıllık Göl Sedimanlarının Jeokimyası ile Yıllık-On Yıllık İklimsel Değişkenliğin Nicel Olarak Yeniden Kurgulanması" isimli Tübitak projesi kapsamında değerlendirilen göllerden olan Erçek Gölü dip çökellerinin litolojik, kronostratigrafik ve palinolojik analizleri ile gölün paleo-iklim, paleo-ortam ve paleo-bitki örtüsü'nün açıklanmasını amaçlamıştır.

Çalışma alanı Türkiye'nin doğusunda Anadolu yüksek platosunda yer alan Van Gölü'nün 30 km doğusunda yer alan Erçek Gölü oluşturmaktadır (Bkz. Şekil 1.1). Göl deniz seviyesinden 1803 m yüksekte konumlanmaktadır. Gölün ortalama derinliği 18 m ve maksimum derinliği 40 metredir (İpek ve Sarı, 1998). Gölün tektonik açıdan aktif bir noktada bulunması, Kuzey Anadolu Fayı (KAF) ve Doğu Anadolu Fayı (DAF) nın kesişme noktası olan Karlıova eklemine yakın noktada bulunmasına bağlanmaktadır (Kempe, 1977; Lit ve ark., 2014; Bkz. Şekil 1.2). Erçek Gölü'nün içinde yer aldığı Doğu Anadolu'nun jeolojik evrimine ait dört yapısal dönem tanımlanmaktadır (Bkz. Şekil 1.3). Bunlar;

1. Bölgenin en eski kayaçlarını oluşturan metamorfik kayaçlardan oluşur ve Paleozoyik – Alt Mezozoyik yaşlı oldukları düşünülmektedir (Boray, 1976; Perincek, 1980; Perinçek ve Özkaya, 1981; Yılmaz ve ark., 1981; Goncuoglu ve Turhan, 1983; Çaglayan ve ark., 1983).
2. Üst Kretase'de bir önceki dönem kayaları üzerine tektonik dokanakla yerleşmiş ofiyolitik melanj. Bu topluluk bazik- ultrabazik kayaçlar, kumtaşı, kireçtaşı ve tüf bloklarından oluşmuştur (Demirtaslı ve Pisoni, 1965; Ketin, 1977; Yılmaz ve ark.,1981).
3. 3.Bir önceki dönemi uyumsuz olarak örten Eosen-Alt Miyosen yaşlı çökel istif. Bu dönem kırıntılı çökeller ile kireçtaşlarından oluşur ve üste doğru sığlaşan deniz ortamına işaret eder.
4. Üst Miyosende başlayıp günümüze kadar devam eden dönemde karsal ortamlarda gelişmiş silis kırıntılı ve karbonatlı çökeller ile volkanik kayaçlardan oluşan bir istif gözlenmektedir (Yılmaz ve ark., 1985).

Erçek Gölü'nün taban morfolojisi sismik yansıma profillerinden elde edilen veriler ile haritalanmıştır (Toker ve Tur, 2018). Araştımacılar gölü, gölsel şelf (Ls), gölsel yamaç (SLs) ve derin havza (DB) olmak üzere 3 fizyografik bölgeye ayırmışlardır (Bkz. Şekil 1.4).

Erçek Gölü'nün suyu yüksek miktarda alkalin özellik sunar ve pH'ı 9.4 ile 10.75 arasında değişmektedir (Yıldız, 1997). Magnezyum konsantrasyonu 90-95 mg/l arasında değişmektedir. Bu durum gölün drenaj havzasında yer alan karbonat ve ultrabazik kayaçlara bağlanmıştır (Ateş ve ark., 2007).

Erçek Gölü iklimsel açıdan üç iklim sisteminin kesiştiği noktada yer almaktadır. Bunlar Sibirya Yüksek Basınç Sistemi, Orta enlem subtropik yüksek basınç sistemi ve muson sistemidir (Bkz. Şekil 1.5). Türkiye'de yer alan düzensiz topoğrafya nedeni ile dört makroiklim tipi tanımlanmıştır (Erinç, 1996). Bunlar Bozkır İklimi, Karadeniz İklimi, Akdeniz İklimi, Doğu Anadolu İklimi olarak adlandırılırlar (Bkz. Şekil 1.6). Yukarıda sözü edilen makroiklim tipleri aynı zamanda kendi içerisinde mikroiklim tiplerine ayrılırlar.

2. MATERYAL VE YÖNTEM

Tez çalışması kapsamında 2015 yılında Rusya-Türkiye işbirliği çerçevesinde Tübitak Projesi kapsamında Erçek Gölü'nün 38 m derinliğinden 1250 mm uzunluğunda bir sediman karot alınmıştır. Alınan karotun lokasyonu harita üzerinde verilmiştir (Bkz. Şekil 3.1).

Karot alınırken "UWİTEC" marka bir gravite karotiyer ve dış çapı 63 mm olan transparan plastik tüpler kullanılmıştır (Bkz. Şekil 3.2). Karot açılırken boylamasına olara enine ikiye ayrılmış ve iki adet bakır levha yardımı ile iki kısma ayrılmıştır. Bakır levhalar karot üzerinden kaydırılarak ayrılmıştır (Bkz. Şekil 3.3). Karot yüzeyi oksitlendikten sonra litolojik tanımlaması ve fotoğraflaması yapılmıştır.

Erçek13-03 karotunun en üst seviyesinin sedimantasyon oranının eldesi için ^{210}Pb-^{137}Cs analizi yapılmıştır. Bu analiz Siberian Branch of the Russian Academy of Science, Nükleer Fizik Enstitüsü / Rusya'da yapılmıştır. Aynı zamanda Erçek Gölü varvlı birimlerden oluştuğu için varv sayımı yapılmış ve ^{137}Cs yaşları ile kıyaslanmıştır. Tüm bu verilerden yola çıkılarak karot için yaş-derinlik modeli elde edilmiştir.

Duraylı oksijen izotop analizleri, karbonat örneklerinin $\delta^{18}O$ and $\delta^{13}C$ Finnigan MAT 252 kütle spektrometresi ve buna bağlanmış KIEL-III marka otomasyonlu karbonat hazırlama cihazı kullanılarak yapılmıştır. Toz numuneler susuz fosforik asit ile işlem gördükten sonra, izotop oranları tesbit edilmiştir. İşlemler Acme Laboratuarlarında Kanada'da yaptırılmıştır.

Palinolojik açıdan örnekler Erbil / Irak'ta bulunan Salahaddin Üniversitesi, Jeoloji Mühendisliği Bölümü Palinoloji Araştırma Laboratuarında çalışılmıştır. Polen analizlerinde uluslararası anlamda standardize edilen bir yöntem kullanılmıştır (Faegri ve İversen, 1989). Bu yöntemin adı asetoliz yöntemi olarak bilinmektedir. Yönteme göre örnekler analize sırasıyla aşağıdaki gibi hazırlanmaktadır.

1- Örneklere ilk aşamada polen konsantrasyonunu hesaplamak amacıyla lycopodium tablet eklenmiştir.
2- Daha sonra örneklere %10'luk HCL (hidroklorik asit) eklenerek sıcak su banyosu yaptırılmıştır (süre 10 dk), bu işlemden sonra örneklerden karbonat uzaklaştırılmıştır ve örnekler damıtık su ile yıkanarak ve geri kalan malzeme santrifüj ile çöktürülmüştür.
3- Geriye kalan örneğin üzerine %10'luk KOH (potasyum hidroksit) eklenerek sıcak su banyosu yaptırılmıştır (süre 25 dk). Bu işlem ile birlikte hümik asit ve organik madde örneklerden uzaklaştırılmıştır.
4- Kalan örnek 200 µm polyester elekten geçirilmiştir.
5- Elekten üzerinde kalan kaba taneli malzeme üzerine %40'lık HF (hidroflorik asit) eklenmiştir. Bu aşamada silikatlar (kum, silt, kil) uzaklaştırılmıştır. Numune su banyosuna 20-45 dk veya en fazla 2 saat süreyle yerleştirilmiştir. Numuneleri her 10 dakikada bir iyice karıştırdıktan sonra örnekleri santrifüj edilmiş ve şişeyi nötralize etmek için HF boşaltılmıştır. Bu işlemden sonra örnekler tekrar damıtılmış su ile yıkanmışve tekrar çöktürülmüştür.
6- 6-Elde edilenörnekler üzerine %10'luk HCL (hidroklorik asit) eklenerek sıcak su banyosu yaptırılmıştır. Santrifüj edilen ve asitten uzaklaştırılan örneklere %95'lik CH_3COOH (asetik asit) sıvısı eklenmiştir.
7- Elde edilcek karışıma asetoliz sıvısı eklenmiş ve ortalama 3 dakika sıcak su banyosu yaptırılmıştır. Bu sıvı 9 birim %99'luk $C_4H_6O_3$ (asetik asit anhidrit) ve 1 birim %96'lık H_2SO_4 (sülfürik asit) den meydana gelmektedir. Sıcak su banyosundan sonra örnekler santrifüj ile çöktürülmüş ve asetoliz sıvısı uzaklaştırılmıştır.
8- Geriye kalacak örneklere yine %95'lik asetik asit eklenerek yıkama işlemi yapılmıştır.
9- Elde edilecek örnekler 10 µm polyester elekten gerçirilmiştir.

Bu işlemlerden elde edilen polenlerin tanımlamaları yapılmış ve mikroskopta görüntülenmeleri sağlanmış ve levhalar hazırlanmıştır. Elde edilen sonuçlar Tillia / Tillia Graph programına aktarılmış ve bolluklarına göre polen zonlarına ayrılmıştır (Grimm, 1991; 2004).

3. BULGULAR

Erçek15-03 numaralı karot yer yer bantlı ama baskın olarak geniş renk aralığına sahip laminalı birimlerden oluşmaktadır (Bkz. Şekil 3.8).

Karotun sedimantasyon oranı 1.2 mm/yıl olarak hesaplanmıştır (Bkz. 3.9). Aynı zamanda karot boyunca varv sayımı yapılmış ve toplam 850 yıl geriye gidilerek en alt seviyede 1165 yılı elde edilmiştir. ^{137}Cs pikleri varv sayımı ile uyumlu çıkmış olup derinlik-yaş modeli çizilmiştir (Bkz. 3.10).

^{18}O izotopları analizi sonuçları şekilde gösterilmiştir (Bkz. Şekil 3.11). VSMOW olarak elde edilen veriler, VPDB verilerine dönüştürülmüştür. Buna göre elde edilen veriler -2.20 ile 0. 46 ‰ VPDB arasında değişmektedir.

Polen analizlerine göre ağaçsıl polenlerden toplam 8 taxa ve otsul polenlerden 22 taxa tanımlanmıştır (Bkz. Çizelge 4.1 – Çizelge 4.2). Tanımlanan polenler karotun derinliklerine göre bolluk oranları açısından gösterilmiştir (Bkz. Çizelge 4.3-Çizelge 4.6). Elde edilen bu sonuçlar Tilia programına aktarılmış ve polen diyagramı çizilmiştir (Bkz. Şekil 4.5). Polen diyagramıAP/NAP oranına göre 4 polen zonuna ayrılmıştır (PZI-PZIV). Buna göre;

<u>PZI (1250-800 mm ve MS 1165-1405):</u> *Artemisia* poleni bu zonda baskındır. Amaranthaceae oranı ayrıca yüksektir. Poaceae oranı düşer, *Quercus* artmıştır. *Juniperus* ve *Pinus* polen oranı düşüktür. Asteraceae ve *Pinus* poleni bu zon boyunca neredeyse her seviyede tanımlanmıştır.

<u>PZII (800-600mm ve MS 1405-1565):</u> *Artemisia* poleni bu zonda baskındır. Amaranthaceae ayrıca yüksek olmakla birlikte artış göstermektedir. *Quercus* oranı azalmaktadır. *Juniperus* ve *Pinus* poleni azalmakta ve neredeyse ortadan kaybolmaktadır. AP/NAP oranı diğer zonlardan daha yüksektir.

<u>PZIII (600-100 mm ve MS 1565-1958):</u> PZI'e benzer şekilde *Artemisia* polen yüzdesi yüksektir (%35). Amaranthaceae poleni PZII'ye oranla az miktarda azalma

göstermektedir. Poaceae polen yüzdesi bu zonda farklı seviyelerde kararlı değildir ve salınım gösterir. *Quercus* az miktarda artış gösterir. *Juniperus*, *Pinus* ve Asteraceae polen miktarı artış göstermektedir.

PZIV (100 – 0 mm ve MS 1958-2015): *Quercus* poleninin artışı belirgindir. Amaranthaceae ve Poaceae polen miktarı PZIII zonuna oranla azdır. *Artemisia* poleni 30% oranında ve bu zonun üst kısmına göre azalma göstermektedir. *Juniperus* poleni yukarı doğru az miktarda düşüş göstermiştir.

4. TARTIŞMA VE SONUÇ

Erçek Gölü'nden elde edilen polen diyagramına göre MS 1958-2015 yılları arasında bölge *Quercus* baskın orman toplulukları ile karakterize edilmektedir. Oksijen izotop değerleri ‰ -0.5 ve -1 (VPDB) aralığında ve polen verilerini doğrular niteliktedir (Bkz. Şekil 4)

MS 1565-1958 yılları arasında elde edilen verilere göre bölgede meşe ormanlarının genişlediği söylenebilir. Başlangıçta *Betula* gibi öncü ağaçlar bölgede kolonize olmuş ve ardından Juniperus, *Quercus* ve *Pinuz* bunu izlemiştir. Bu durum, Doğu Akdeniz bölgesinde Holosen'de buharlaşma ve daha yüksek sıcaklık rejiminden dolayı nisbeten ılıman kışları ve yazın kuraklığı ortaya koymaktadır (Wick et al., 2003; Litt et al., 2009, 2014; Pickarski et al., 2015a).

MS 1405-1565 aralığında elde edilen verilerden bölgede daha açık bozkır tipi bitki örtüsünün baskın olduğu söylenebilir. Genel olarak bu dönem (soğuk dönem), ağaç gelişiminin düşük atmosferik CO2 veya soğuk ve kurak şartlar ile engellendiği için yaygın bozkır bitki örtüsü ile karakterize edilmiştir (Litt et al., 2014; Pickarski et al 2015b). Bu aralıkta elde edilen negatif izotopik değerler daha soğuk iklim koşullarına işaret eder.

1165-1405 yılları arasında bölgede orman bozkır bitki örtüsünün genişlediği dönem olarak tanımlanabilir. Bu aralıktaki oksijen izotop değerleri daha sıcak iklim tipine işaret etmektedir.

Bu tez çalışmasın sonucunda;

1.Erçek15-03 karotunun palinolojik bulguları sunulmuş,

2.Geçmiş milenyum süresince bölgesel bitki örtüsünün nicel analizi, odunsuların yayılım alanı ve iklimi tanıtılmış,

3. Önceden üzerinde bu kadar detaylı çalışmalar yapılmamış olan gölden elde edilen sonuçlar bölgesel anlamda diğer veriler ile kıyaslanmış,

4. Erçek Gölü yakın çevresindeki bitki örtüsü ve polen arasındaki ilişki kurulmuştur.

APPENDIX

APPENDIX I: Plate Descriptions and Plates

Plates	Figures	Trees and shrubs
PLATE 1	1-28	*Pinus*
	29-32	*Quercus*
PLATE 2	1-32	*Quercus*
PLATE 3	1-11	*Quercus*
	12-23	*Alnus*
	24-32	*Betula*
PLATE 4	1-3	*Carpinus*
	4-7	*Corylus*
	8-27	*Juglans*
	28-32	*Juniperus*
PLATE 5	1-15	*Juniperus*

Plates	Figure	Herbs and grasses
PLATE 6	1-32	*Artemisia*
PLATE 7	1-4	*Artemisia*
	5-25	Apiaceae
	26-32	*Helianthemum*
PLATE 8	1-4	*Helianthemum*
	5-32	Asteraceae
PLATE 9	1-10	Asteraceae
	11-14	Rosaceae
	15-32	Caryophyllaceae
PLATE 10	1	Caryophyllaceae
	2-23	*Plantago*
	24-32	Brassicaceae
PLATE 11	1-12	Brassicaceae
	13-20	*Ranunculaceae*
	21-32	*Rumex*
PLATE 12	1-5	*Rumex*
	6-31	Poaceae
PLATE 13	1-17	Poaceae
	18-32	*Cerealia*
PLATE 14	1-12	*Cerealia*

Plates	Figure	Herbs and grasses
PLATE 14	13-17	Fabaceae
	18-25	Lamiaceae
	26-32	Rubiaceae
PLATE 15	1-22	Rubiaceae
	23-31	*Centaurea solstitiales*
	32	*Polygonum*
PLATE 16	1-7	*Polygonum*
	8-22	*Sanguisorba*
	25-32	Cyperaceae
PLATE 17	1-16	Cyperaceae
	17-26	*Sparganium*
	27-32	*Thalictrum*
PLATE 18	1-3	*Thalictrum*
	4-32	Amaranthaceae
PLATE 19	1-5	Amaranthaceae

PLATE 1

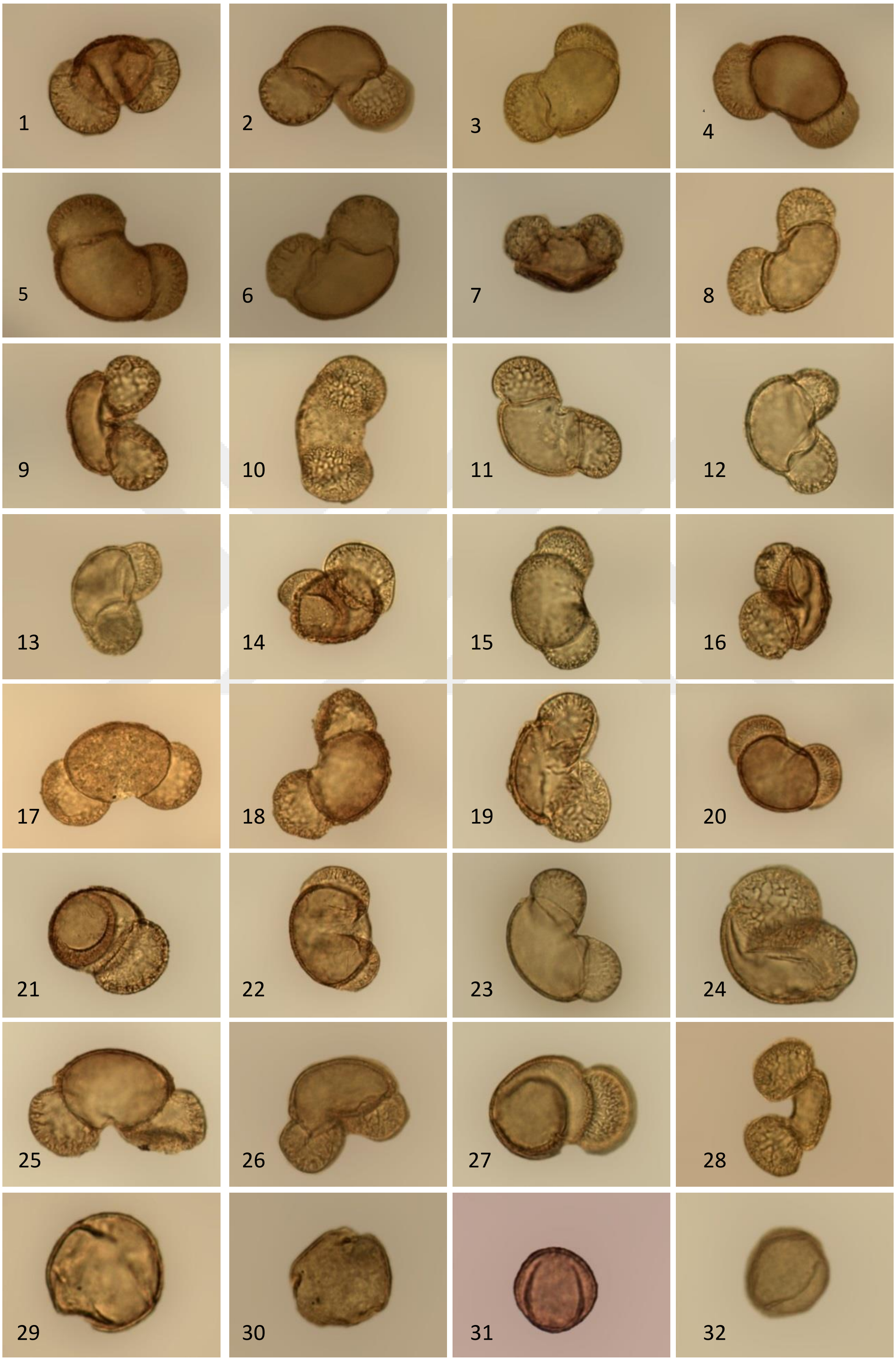
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PLATE 2

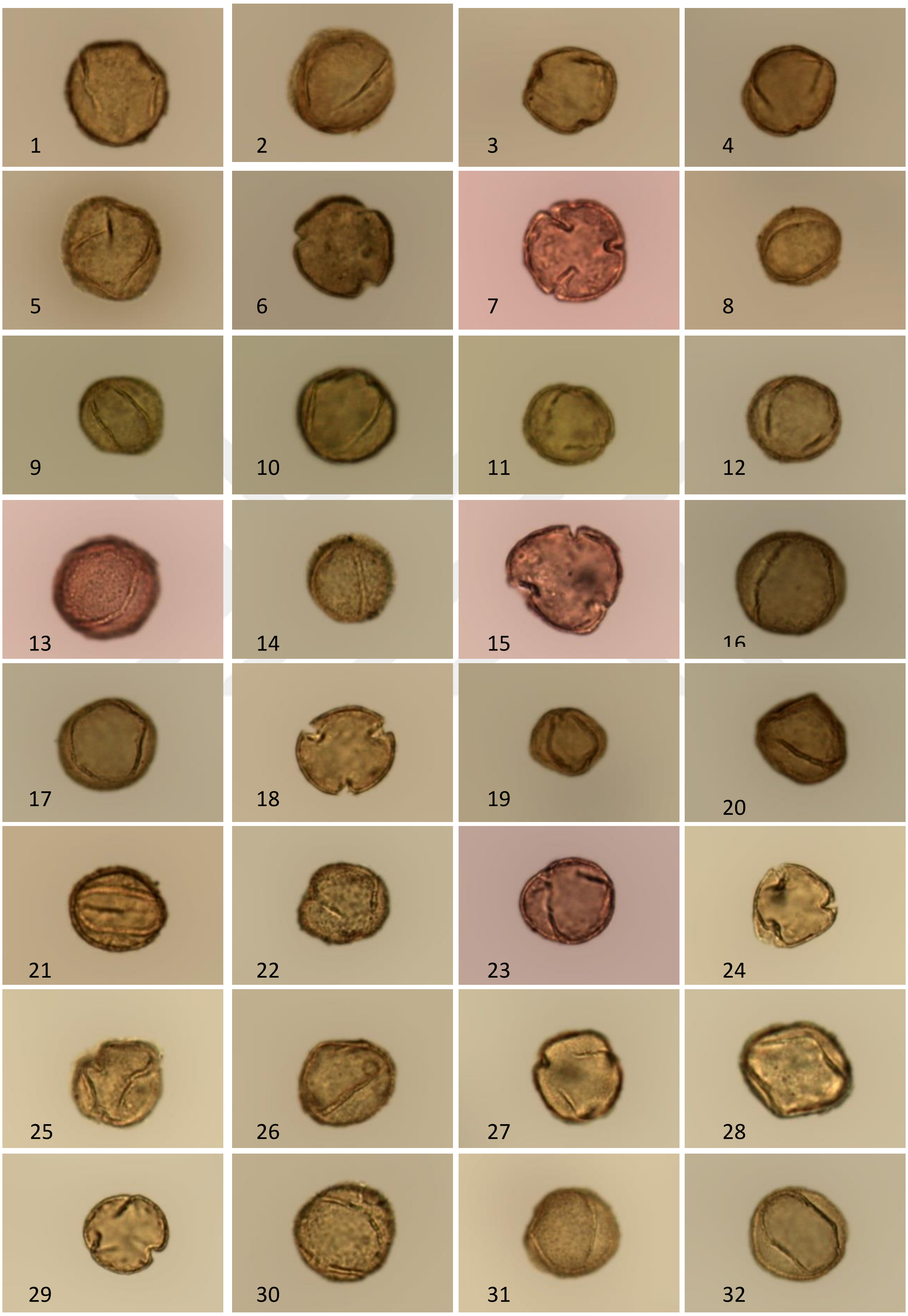
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PLATE 3

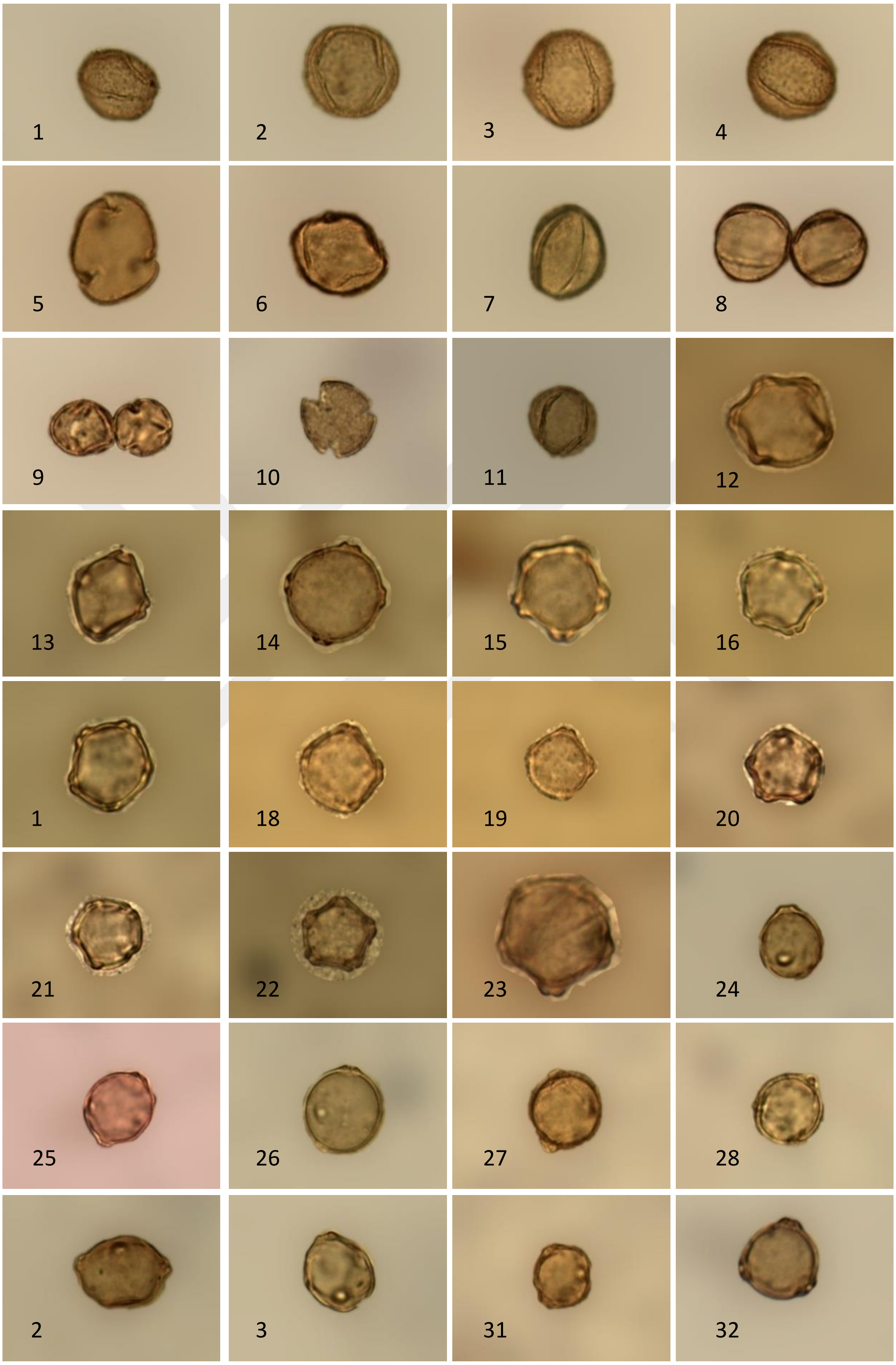
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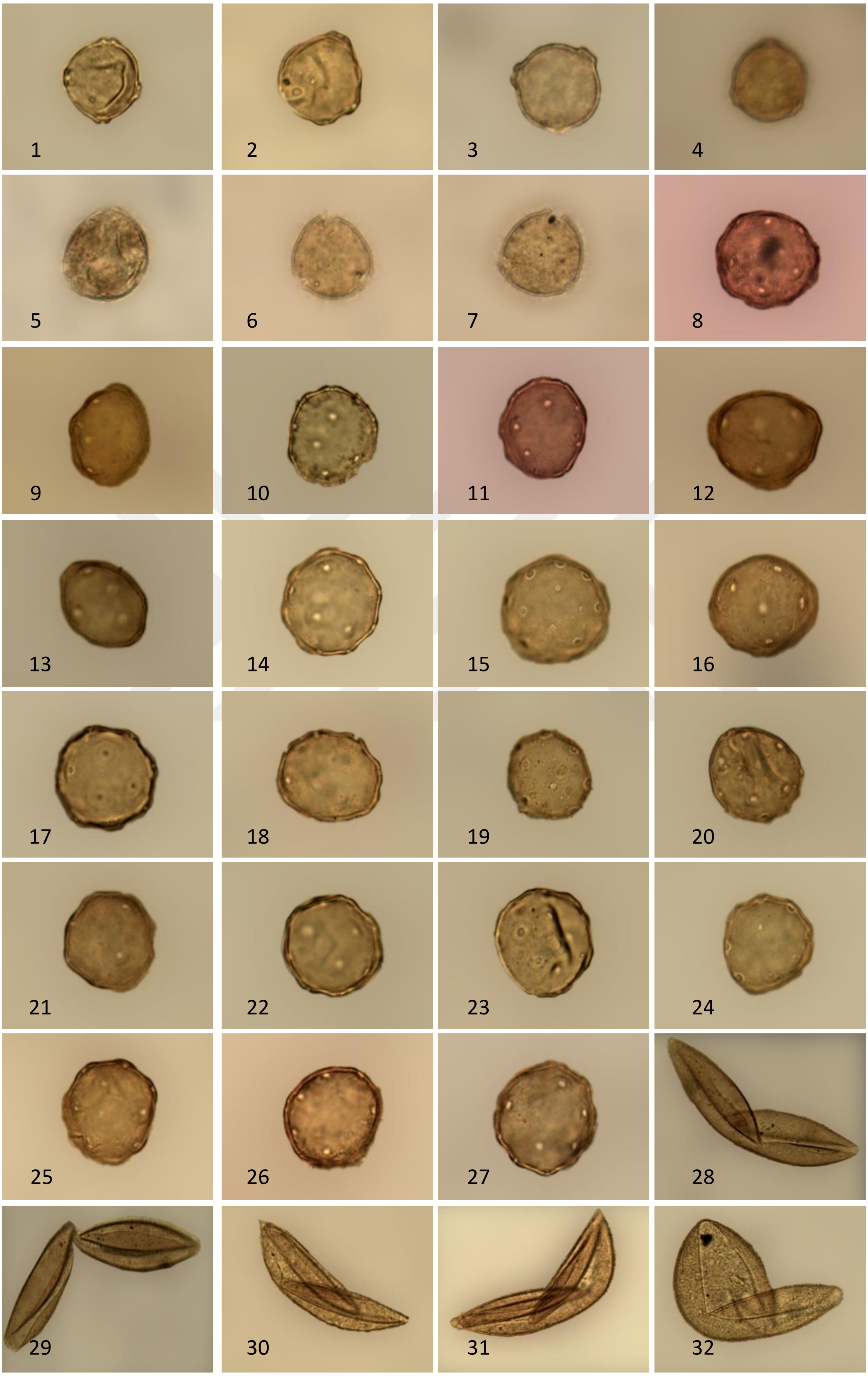
PLATE 4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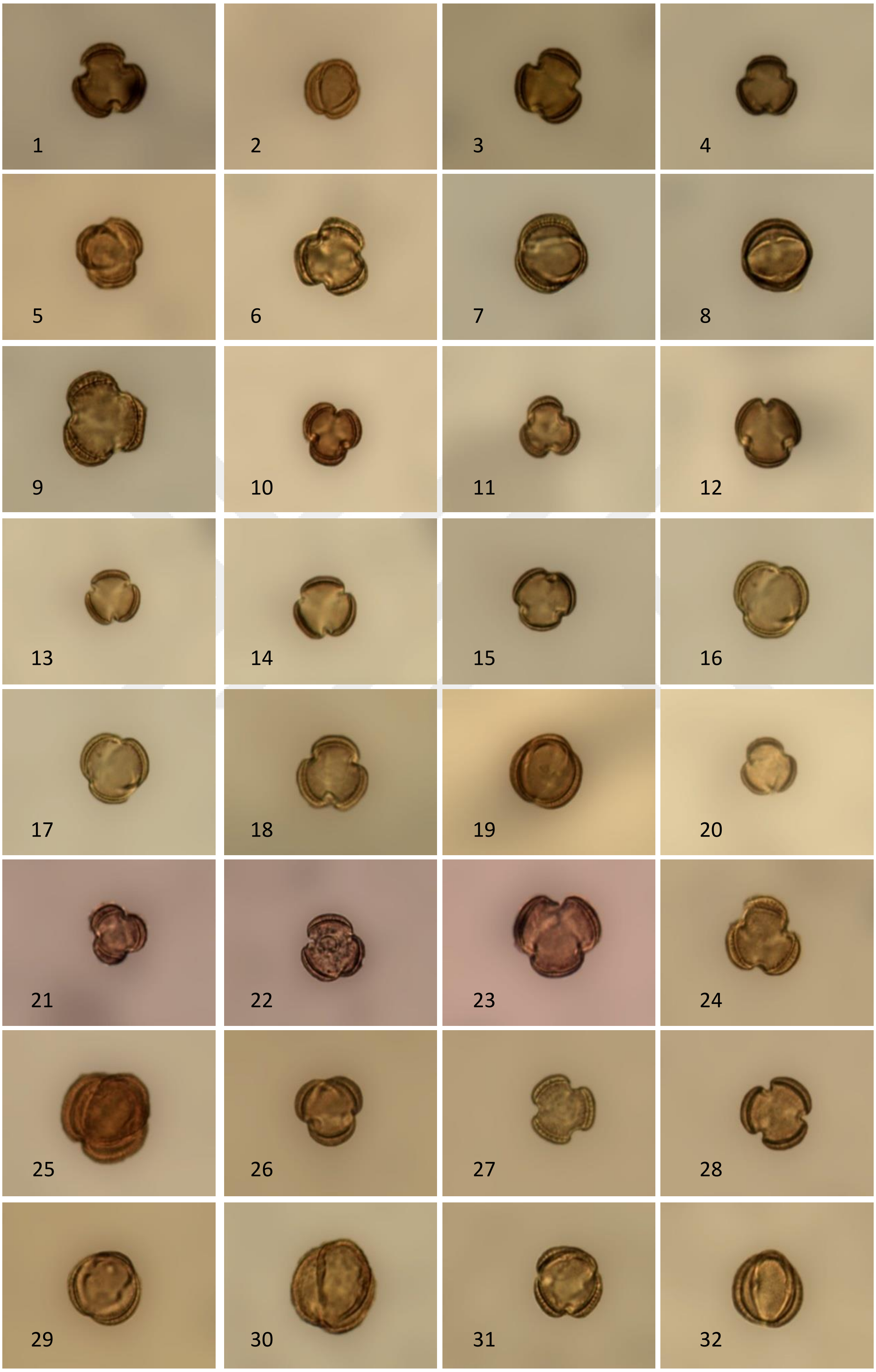
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PLATE 7

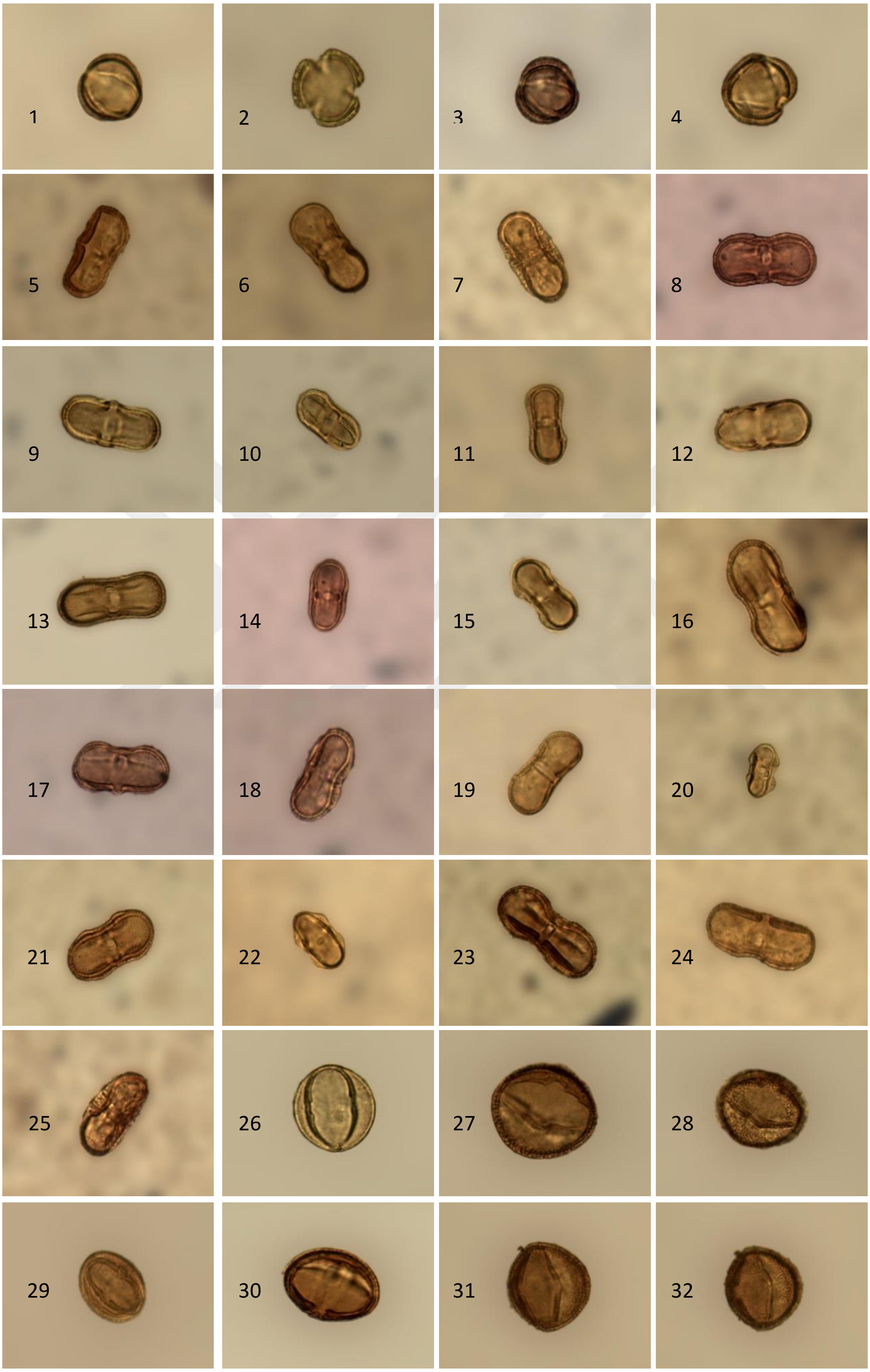
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PLATE 8

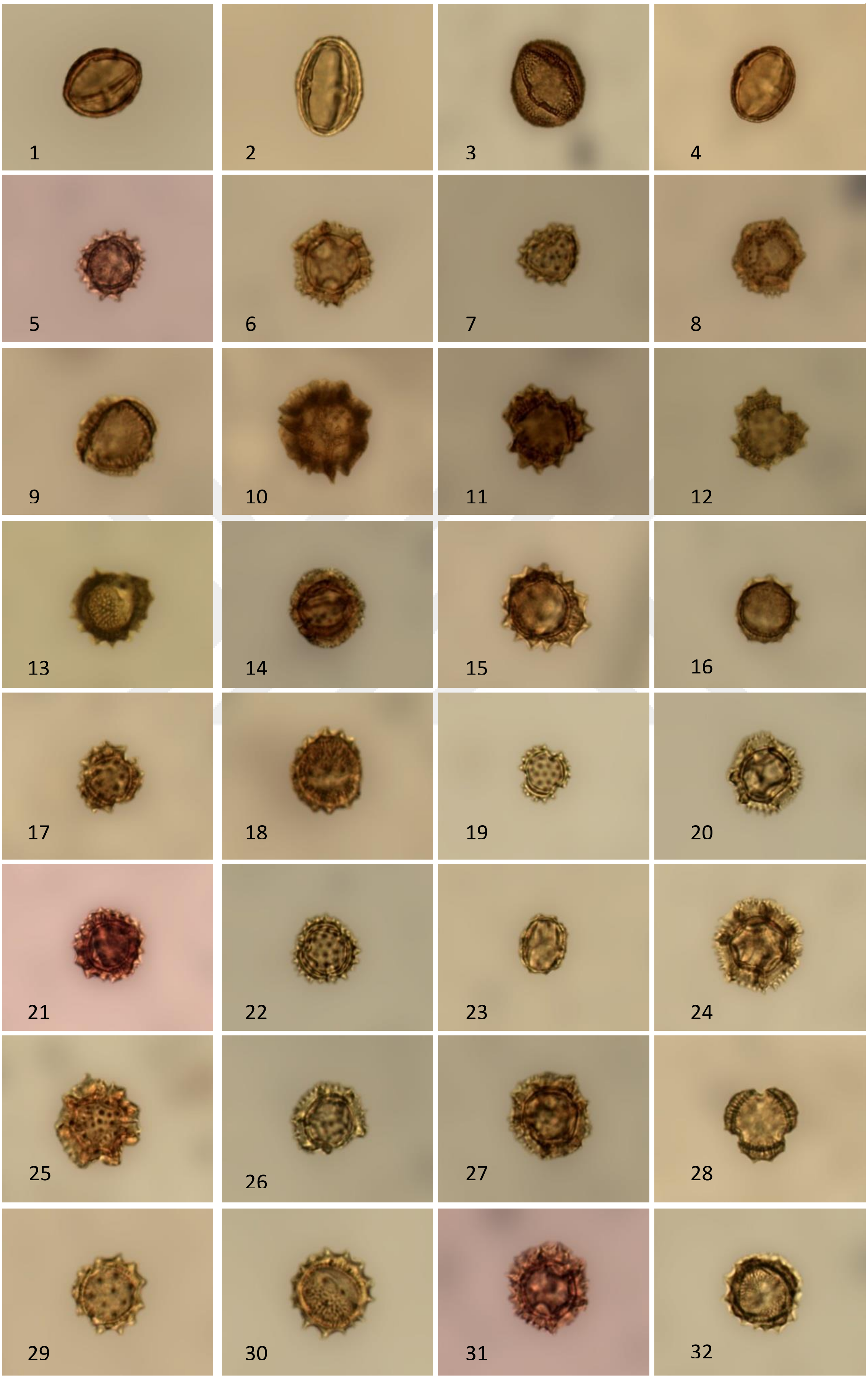
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PLATE 9

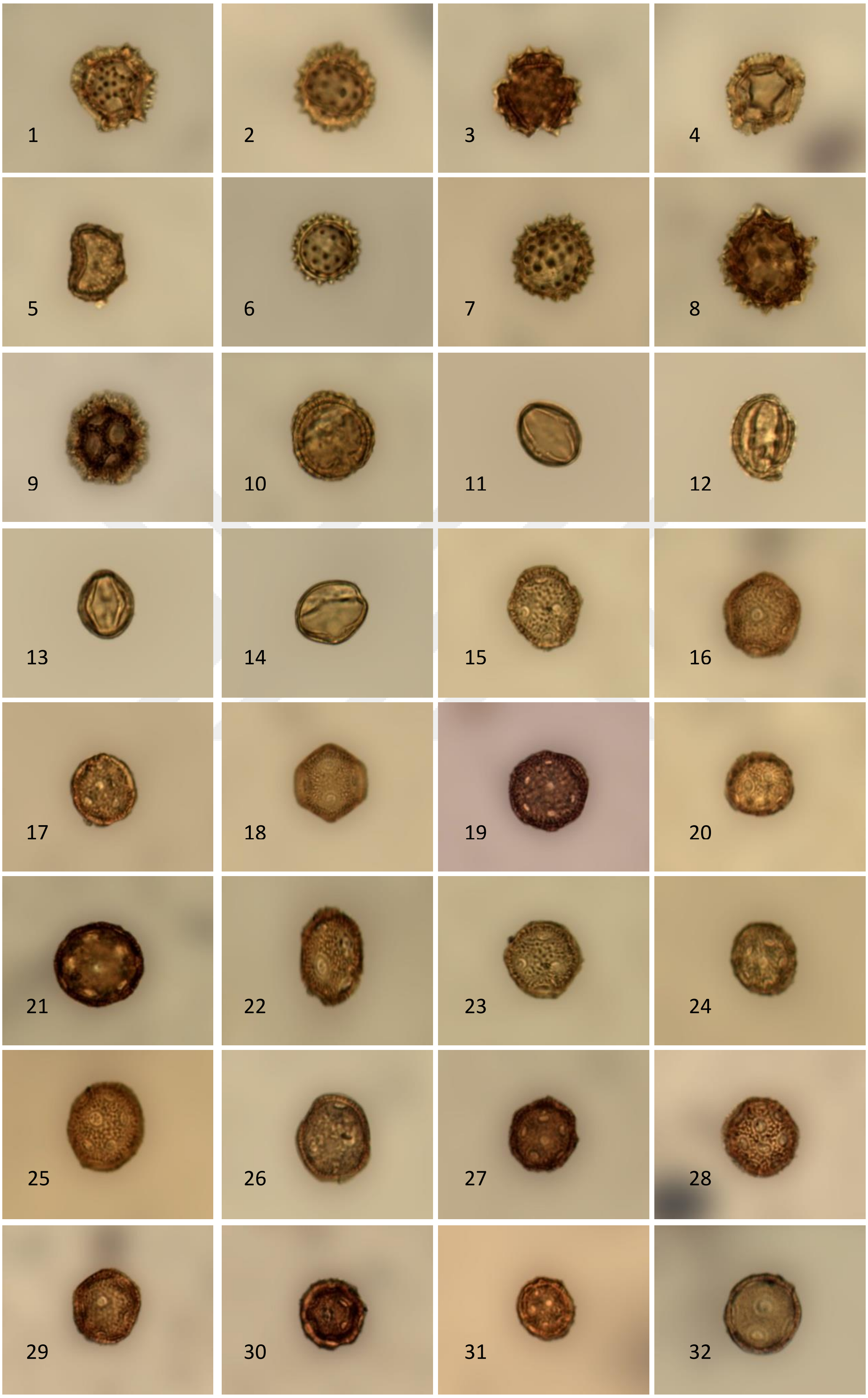
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PLATE 10

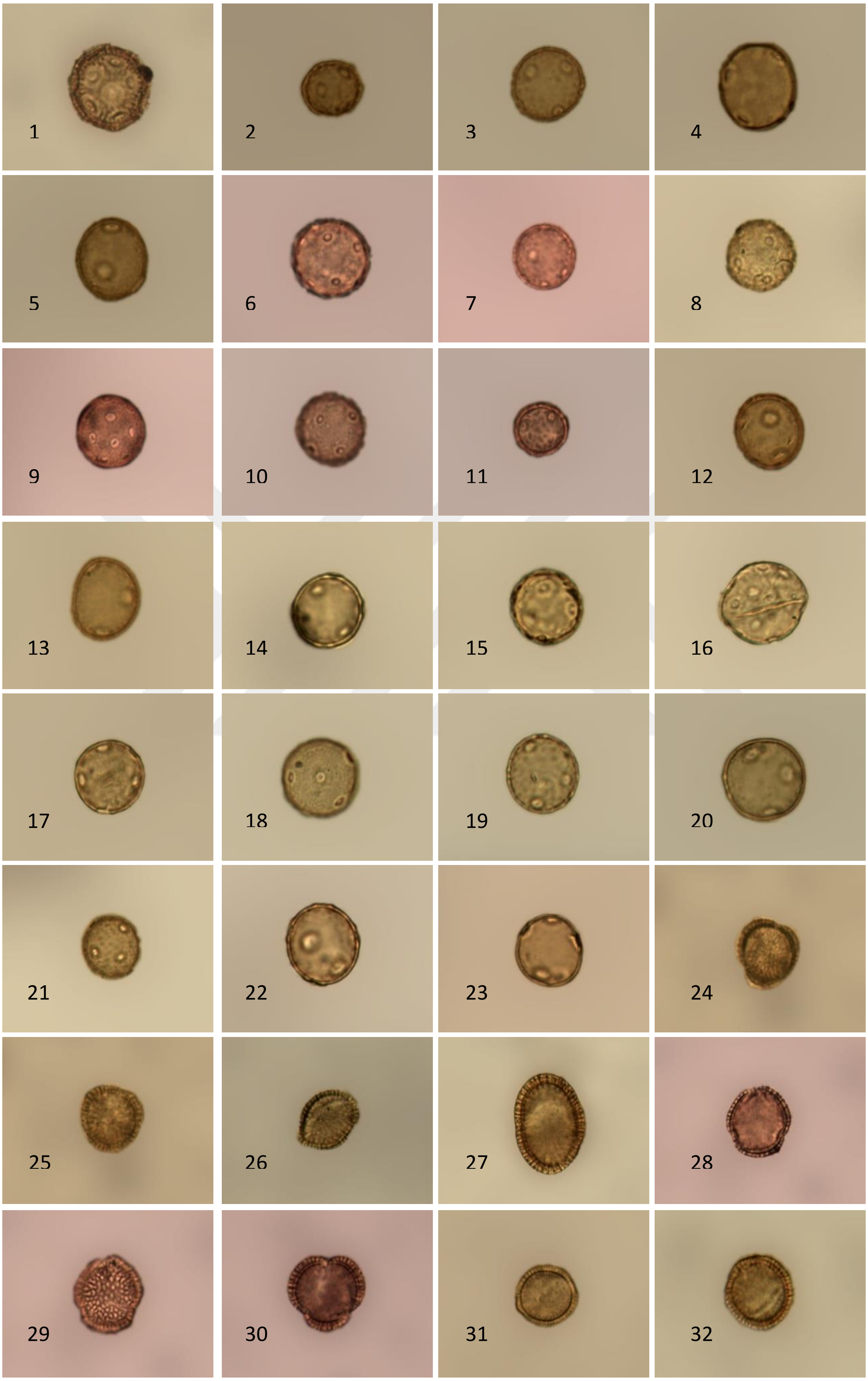
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PLATE 11

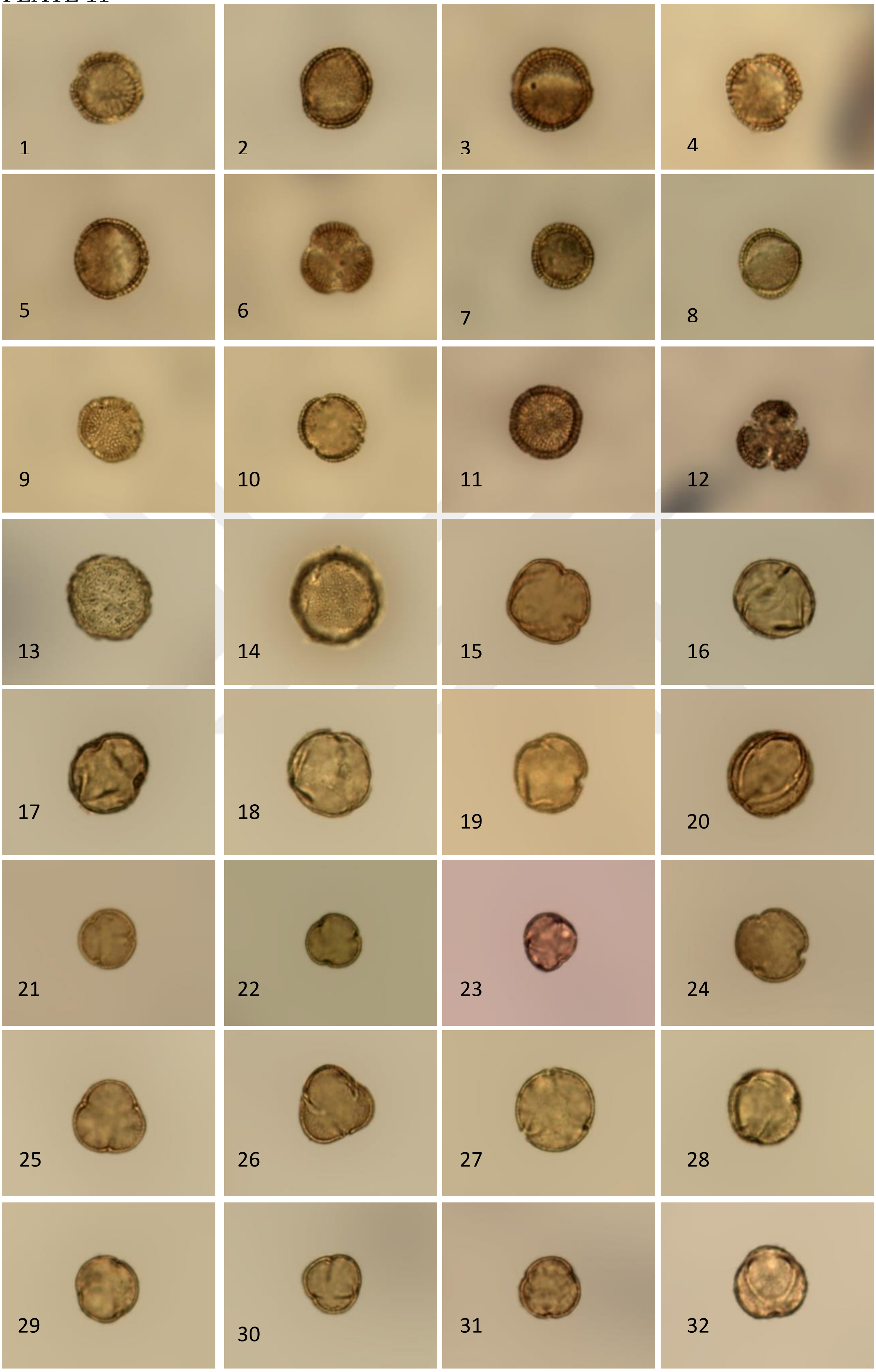
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PLATE 12

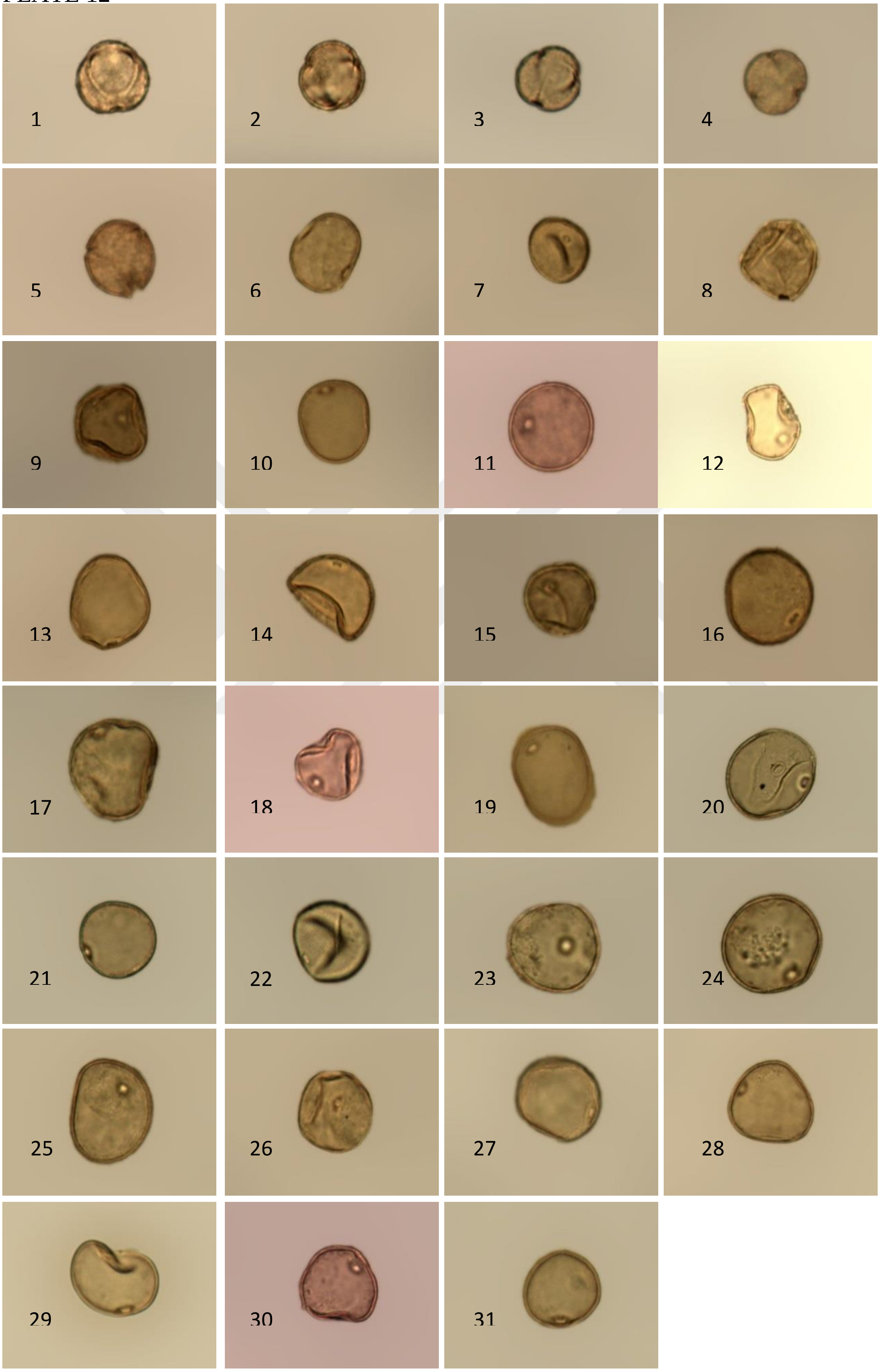
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PLATE 13

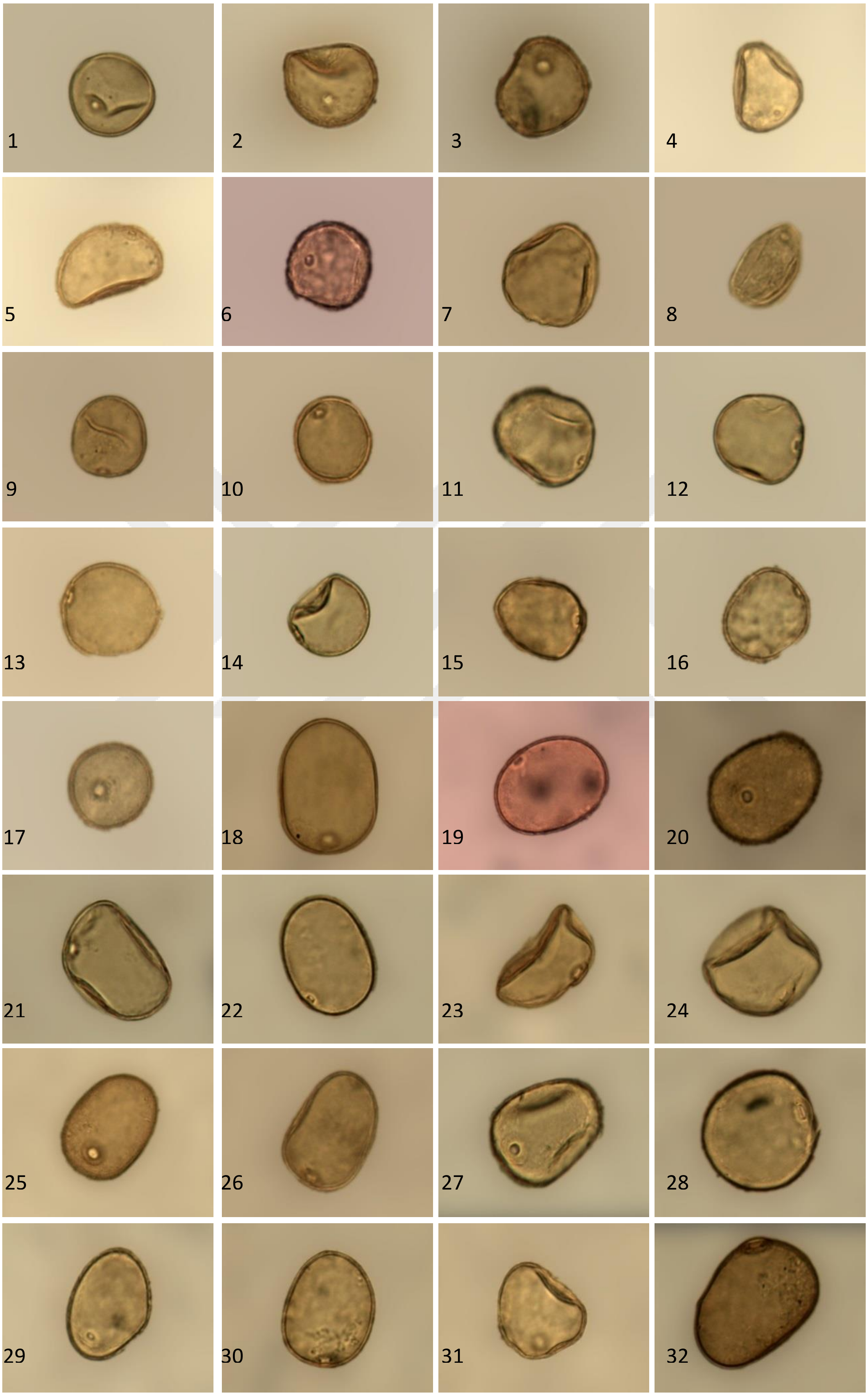
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PLATE 14

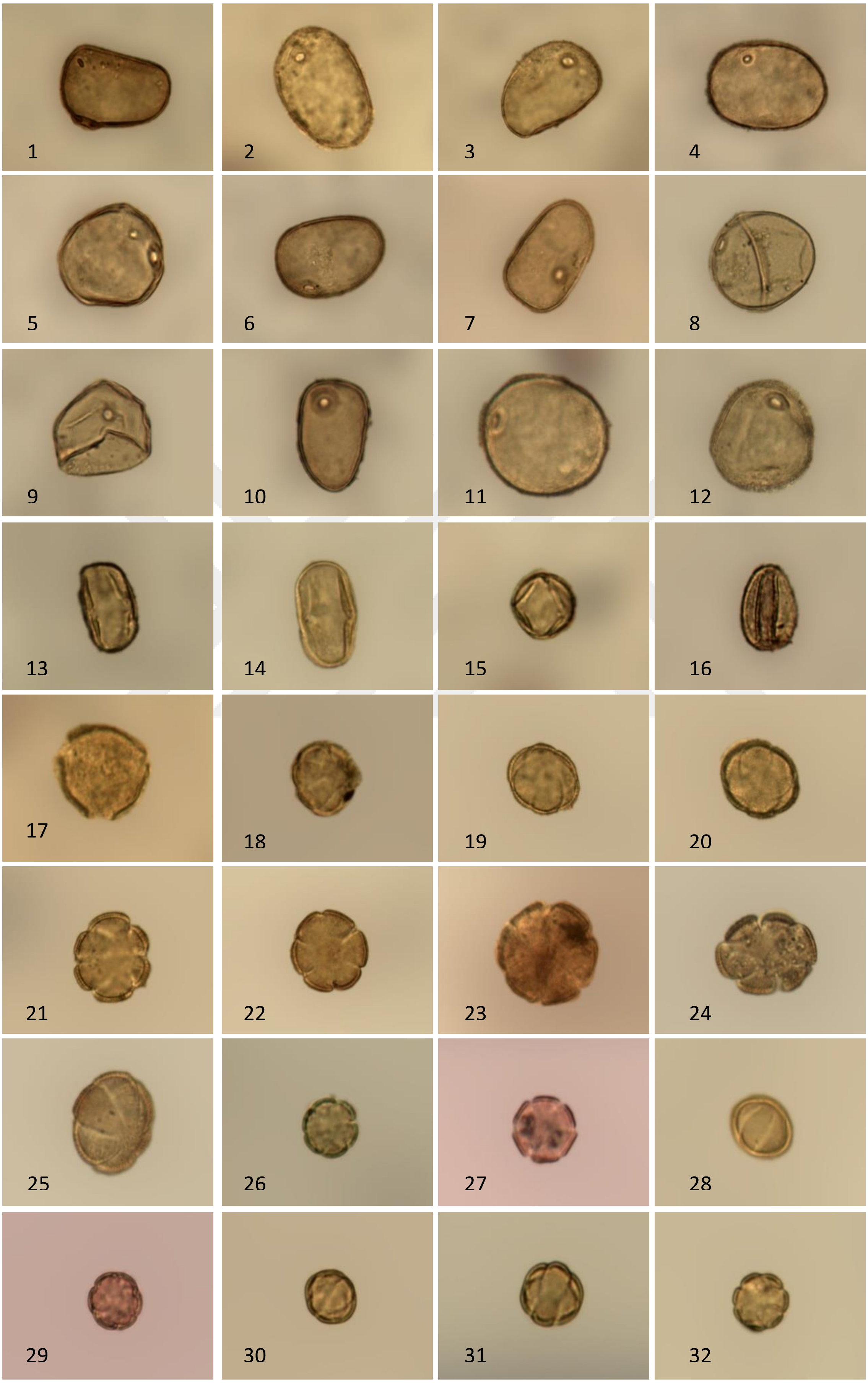
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PLATE 15

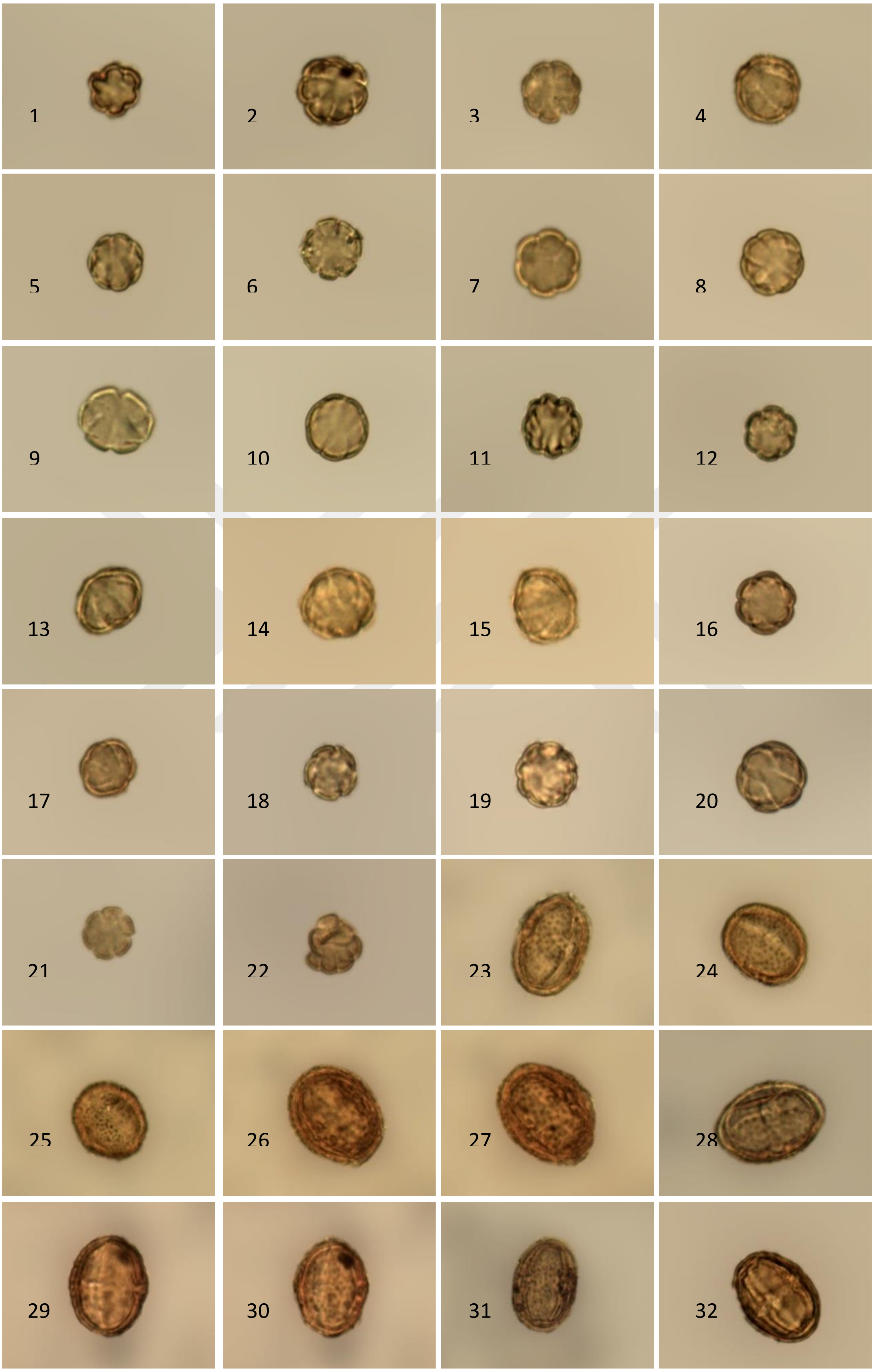
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PLATE 16

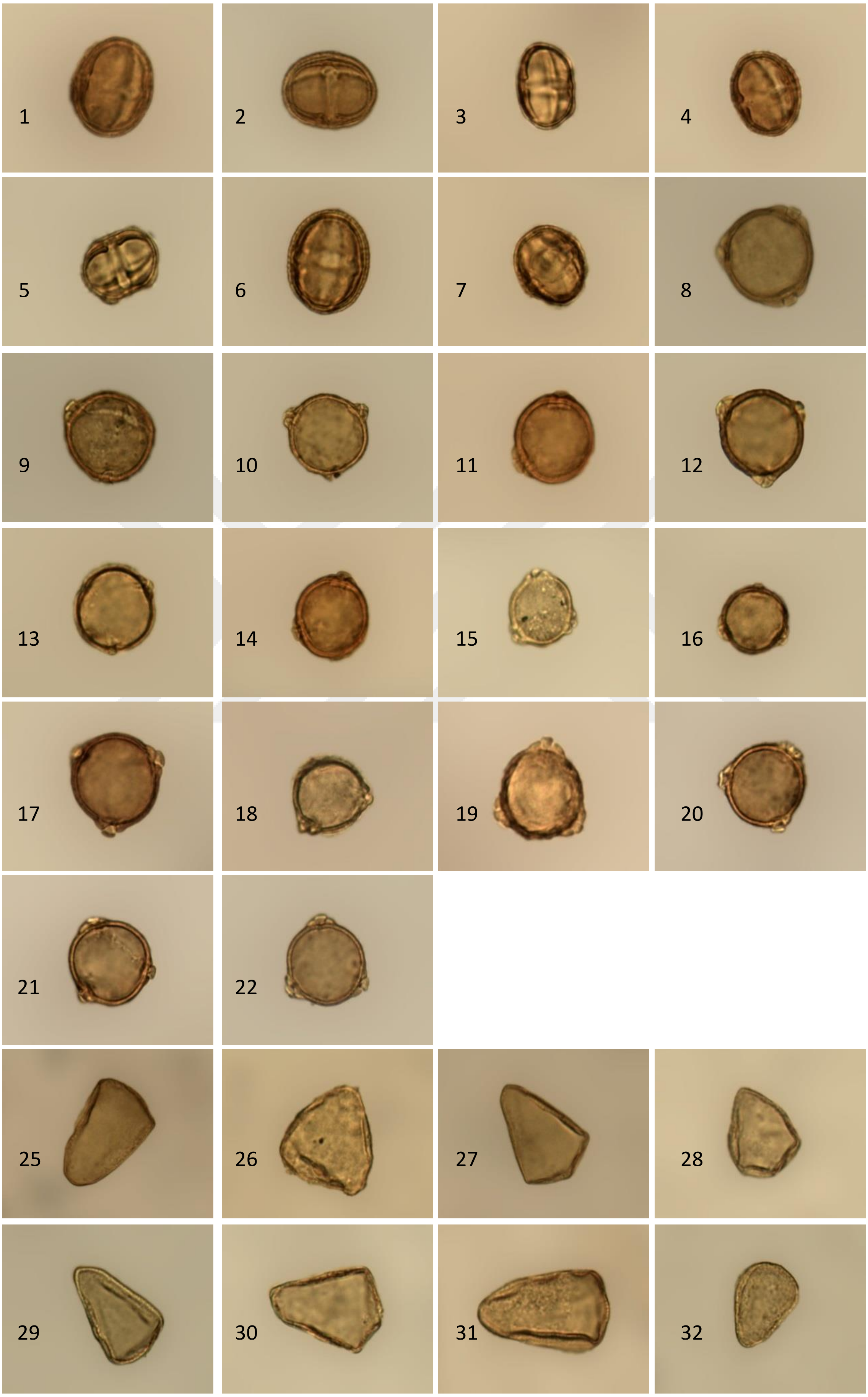
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PLATE 17

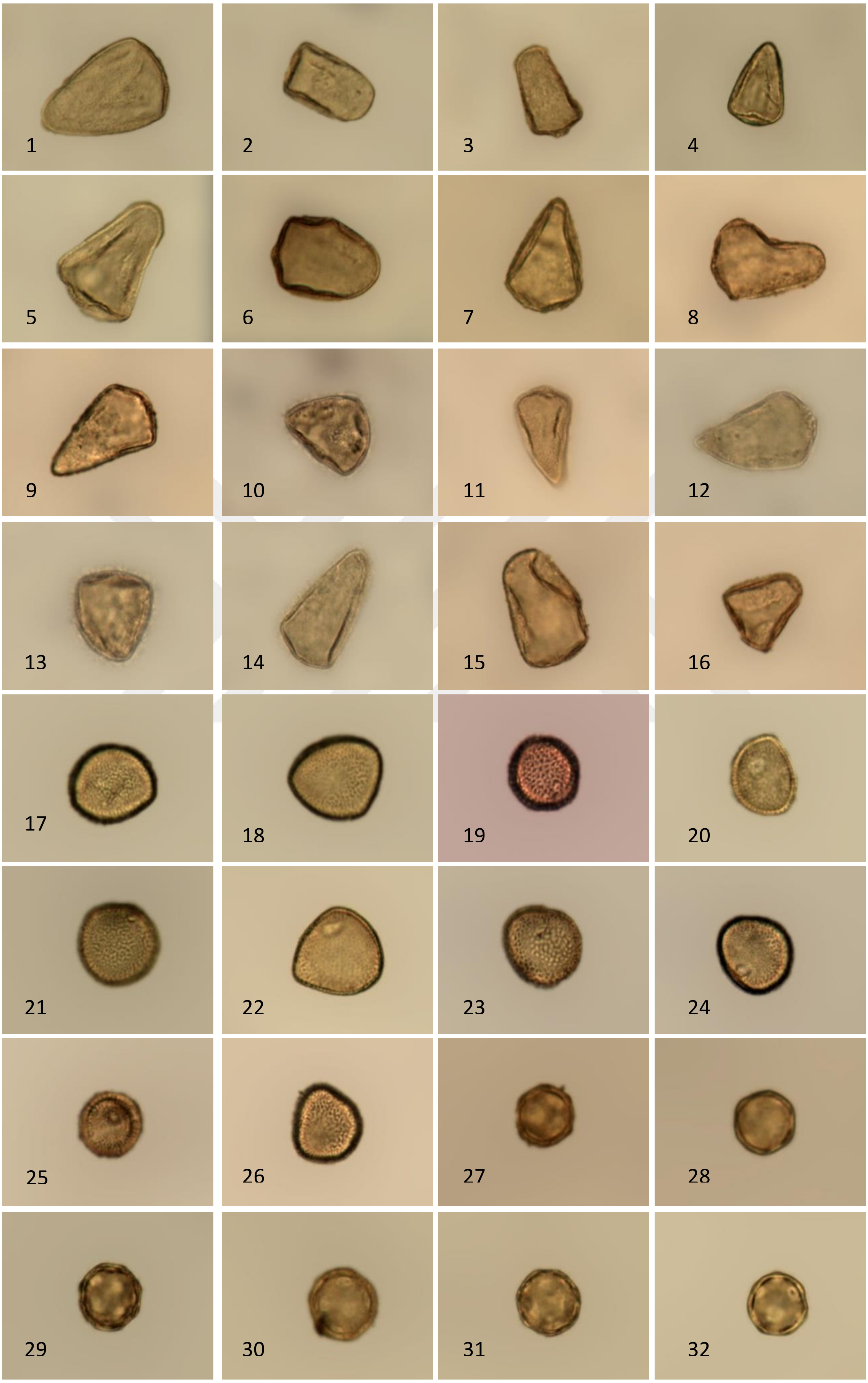
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PLATE 18

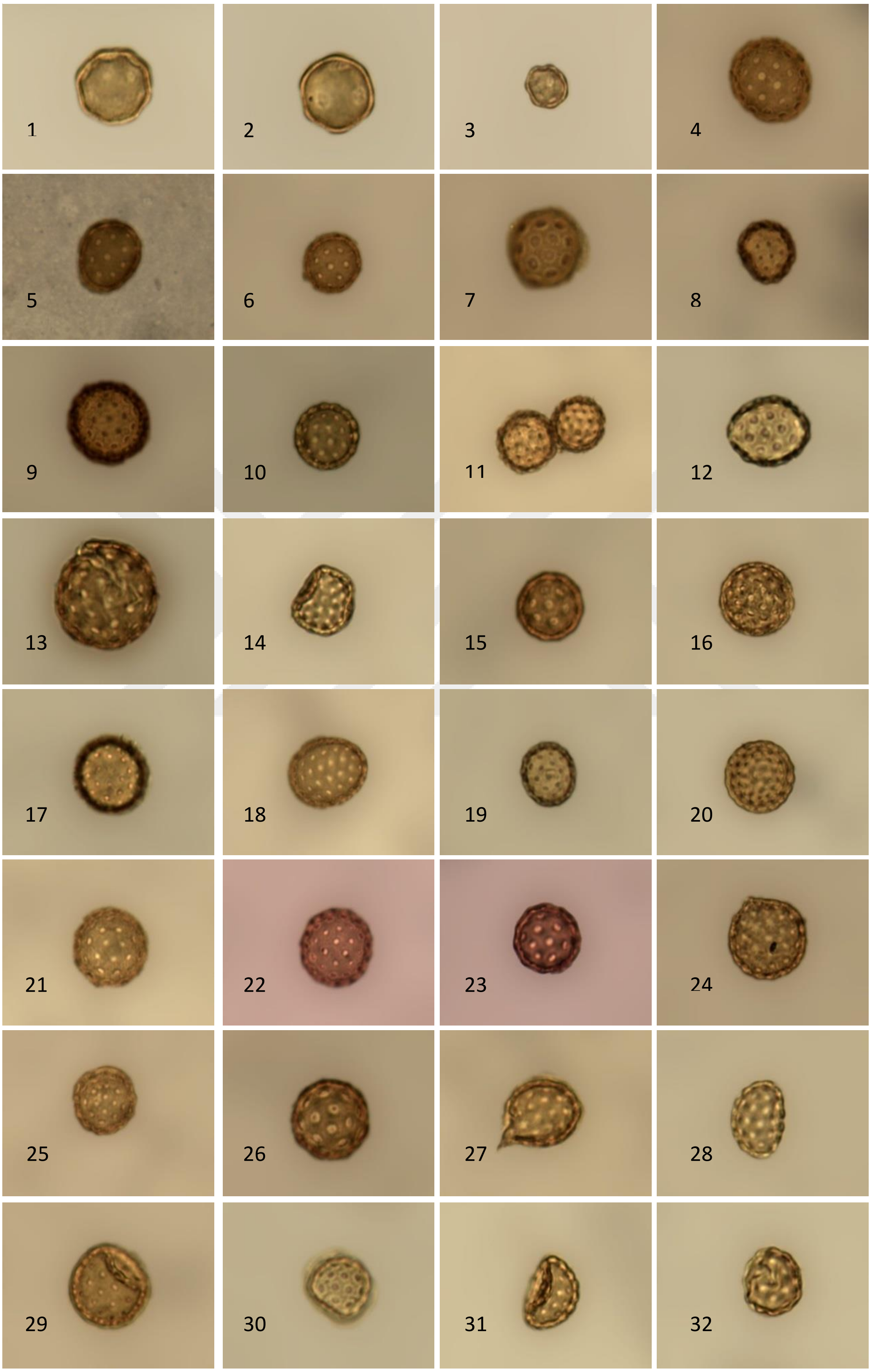
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PLATE 19

CURRICULUM VITAE

Personal information

Name	: Renas Ali ROSTM
Surname	: ROSTM
Nationality	:Iraq
Date and place of birth	:1.12.1987/Iraq- Sulaymaniyah
Phone number	: +964(0) 750 4526604
E-mail	: renasali13@gmail.com

Education

Degree	: B.Sc
Department	: Geological Sciences Department
University	: Salahaddin University Erbil, IRAQ (2011)

Other Skills and Competences

- Computer skills: Windows ,Word, Excel and PowerPoint
- Worked in World Vision International, for 3 years .
- Languages: Kurdish: Native,. English: Very good,. Arabic: Very good.

T.C
VAN YÜZÜNCÜ YIL ÜNİVERSİTESİ
FEN BİLİMLERİ ENSTİTÜSÜ
LİSANSÜSTÜ TEZ ORİJİNALLİK RAPORU

Tarih: 24/01/2019

Tez Başlığı / Konusu: Erçek Gölü Dip Çökellerinin Paleolimnolojisi

Yukarıda başlığı/konusu belirlenen tez çalışmamın Kapak sayfası, Giriş, Ana bölümler ve Sonuç bölümlerinden oluşan toplam 87 sayfalık kısmına ilişkin, 24/01/2019 tarihinde şahsım/tez danışmanım tarafından Turnitin intihal tespit programından aşağıda belirtilen filtreleme uygulanarak alınmış olan orijinallik raporuna göre, tezimin benzerlik oranı % 10 (On) dur.

Uygulanan filtreler aşağıda verilmiştir:

- Kabul ve onay sayfası hariç,
- Teşekkür hariç,
- İçindekiler hariç,
- Simge ve kısaltmalar hariç,
- Gereç ve yöntemler hariç,
- Kaynakça hariç,
- Alıntılar hariç,
- Tezden çıkan yayınlar hariç,
- 7 kelimeden daha az örtüşme içeren metin kısımları hariç (Limit inatch size to 7 words)

Van Yüzüncü Yıl Üniversitesi Lisansüstü Tez Orijinallik Raporu Alınması ve Kullanılmasına İlişkin Yönergeyi inceledim ve bu yönergede belirtilen azami benzerlik oranlarına göre tez çalışmamın herhangi bir intihal içermediğini; aksinin tespit edileceği muhtemel durumda doğabilecek her türlü hukuki sorumluluğu kabul ettiğimi ve yukarıda vermiş olduğum bilgilerin doğru olduğunu beyan ederim.

Gereğini bilgilerinize arz ederim.

Renas Ali ROSTM
24/01/2019

Adı Soyadı: Renas Ali ROSTM

Öğrenci No:149101266

Anabilim Dalı: Jeoloji Mühendisliği ABD

Programı: Jeoloji Mühendisliği

Statüsü: Y. Lisans ☑ Doktora ☐

DANIŞMAN ONAYI
UYGUNDUR

Dr. Öğr. Üyesi Ayşegül Feray MEYDAN

ENSTİTÜ ONAYI
UYGUNDUR

Prof.Dr.Suat ŞENSOY
Enstitü Müdürü