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HABITAT AND ENVIRONMENTS OF AL HISHAH DIATOMITE DEPOSITION CENTRAL LIBYA

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ABSTRACT

Diatoms are microscopic algae that occur in both freshwater and marine environments. They have a siliceous shell, or frustule, consisting of two valves, that are generally preserved in sediments. They occur in a variety of habitats; for instance, there are planktonic diatoms, and benthic diatoms that grow on sediments.

Diatoms are particularly useful as environmental indicators because many species have a narrow range of environmental conditions that are optimal for growth and survival, and diatom populations respond rapidly to environmental change.

Diatoms were analyzed from 45 samples collected from the outcrops of Al-Hishah Formation. Estimates of absolute abundance, species types, and centric or pennate shapes were recognized for each sample. Information on the ecology of the diatom species is presented, and changes in diatom modes of life are evaluated.

KEYWORDS*:* Habitat, Al Hishah Formation, Paleo-Environment

INTRODUCTION

Planktonic diatoms are built to remain suspended, and can easily be transported laterally by both bottom and surface currents. This may result in an anomalously high concentration of planktonic forms where non-existed in the local living assemblage, biocoenose.

Diatomite is a sedimentary rock composed mainly of the skeletons of very common type of marine plankton-diatoms. On the other hand, diatoms are tiny plants (algae) that float near the ocean surface, most often recognized by the presence of a siliceous cell wall, the frustule. This structure varies considerably in shape and architecture among species (Figure 1) and virtually all taxonomic diagnosis of taxa is based upon frustule morphology. Since diatom skeletons are highly porous, diatomite is extremely light in weight, and pure in composition. The skeletons of microscopic plants deposited and accumulated on the bottoms of the oceans and lakes forming layer of Diatomaceous earth. Under the microscope the particles of diatomite show up in a variety of forms: symmetrical figures resembling disks, rods, cylindrical and snowflake. It is this shape factor combined with the rigidity of particles that makes diatomite such an excellent evidence for studying paleo-ecological environment.

GEOLOGIC SETTING

In Sirte sedimentary basin of Miocene age, located south of Ajdabia city, central of Libya a thick white and off-white to yellowish diatomite (diatomaceous earth) succession is developed covering an area of more than 40 Km^2. According to the data obtained from the exposed rocks and from excavated locations, the thickness of succession is within an average of 3 meters.

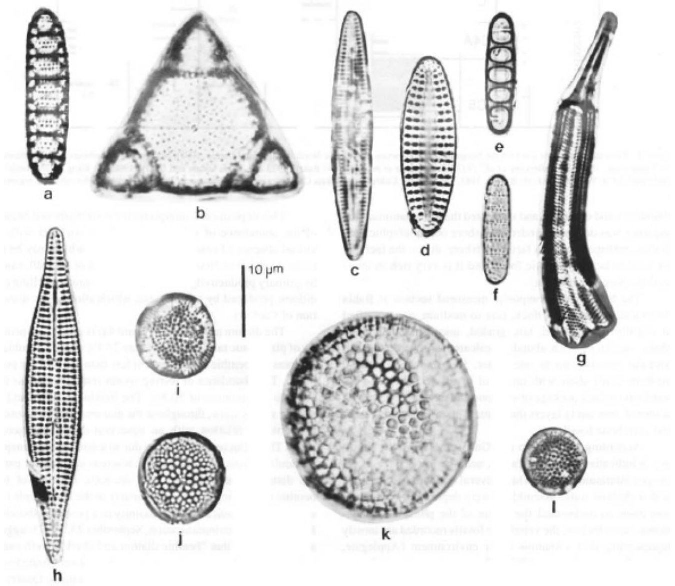


Figure 1: Different Shape and Species of Diatom

The deposit is exposed as two layers existing in the upper part of Al-Hishah Formation (Figure 2). The lower diatomite layer with an average thickness of (2 m) exposed in the western part of the study area, and covered by a sequence of clastic layers in the eastern part. The upper diatomite layer with an average thickness of (3 m) exposed in the eastern part of the study area, which eroded in the western part.

PALEO-ENVIRONMENT

Diatoms are particularly useful as environmental indicators because many species have a narrow range of environmental conditions that are optimal for growth and survival, and diatom populations respond rapidly to environmental change (Dixit *et al.* 1992). Although, several authors have dealt with various aspects of diatom biology, ecology, and taxonomy, the first edition of this subject was published over a decade ago. In which the summary of many applications and uses of diatoms were considered in paleo-ecological studies. However, this study deals with taxonomy and mode of life of diatoms in constructing the paleo-environment of Al-Hishah Formation.

Al-Hishah Diatomite Species

Samples from the two exposed layers were studied using SEM photos, in order to define the abundant types of diatom frustules. Accordingly the most recognized diatomite species of al-Hishah Formation (Geoindustria, 1985) were: 1. *Fargilaria bungarica Pant,* 2. *Synedra rumpans var. familliaris,* 3. *Nitzschia amphibian Grun.f.,* 4. *Nitzschia amphibian Grun.* 5. *Cyniatoppeura elleptica var. constricta Grun.,* 6. *Melosira granulate (Her.) Ralfs,* 7. *Melosira granulate var. vlida Hust.,* 8. *Melosira granulate (Her.) Ralfs., Melosira granulate var. angustissima MULL.,* 9. *Fargilaria Africana Hust.,* 10. *Stephanodiscus niageriae Ehr.,* 11. *Stephanodiscus Astraea var.minutula (Kutz) Grun* 12. *Stephanodiscus niageriae* Her.*;* (a. *Stephanodiscus caronensis var. minor Grun.,* b. *Coscinodiscus sp. (aff. C.jambori Haj.)* c. *Stephanodiscus Astraea var. minutula (Kutz) Grun.* d. *Stephanodiscus caronensis var. minor Grun*.

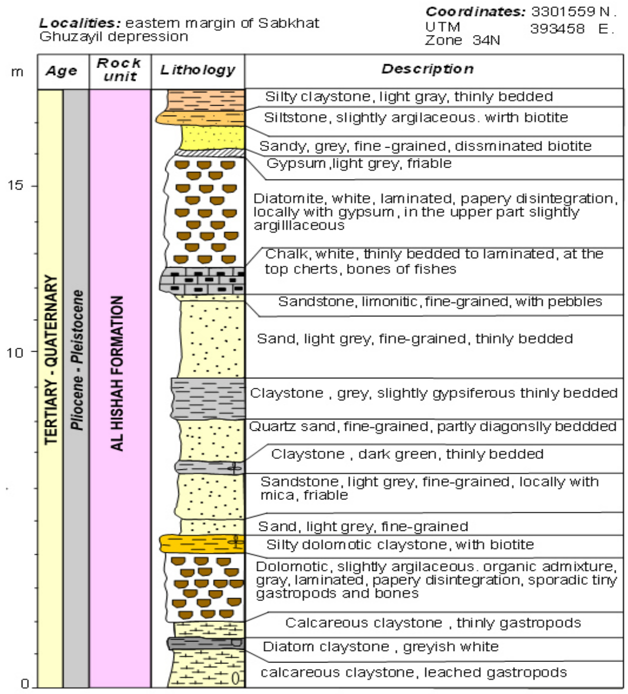


Figure 2: Exposed Sequence of Al-Hishah Formation NE Part

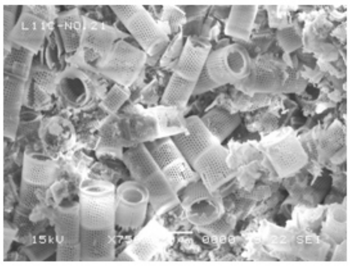
To construct the paleo-environment of Al-Hishah formation using the diatoms, an attempt to use two subjects (taxonomic diagnosis and mode of life), were applied.

TAXONOMIC DIAGNOSES

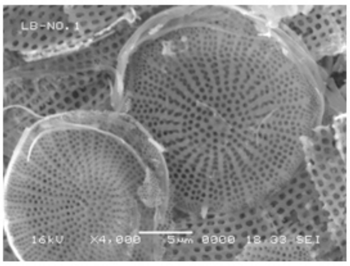
To properly observe diatom frustules for taxonomic identification, sedimentary collections are subjected to various "cleaning" techniques designed to remove all organic materials (e.g. Battarbee *et al.*, 2001; Blanco *et al.*, 2008), allowing unobstructed observation of the frustule in the microscope. This frequent observation of inorganic components of the cell without reference to the organic features allows observers to "forget" that the specimens seen in the microscope represent individual organisms competing in the selective environments driven by biotic and abiotic ecological pressures. The abundance and taxonomic diversity can be attributed to the extraordinary success of diatoms in the competitive ecological arena (Al-Dernawi, *et al*. 2014).

The main characteristic features of the diatomite deposit is its high content of biogenic amorphous silica (opal-A), with the form of disk –shaped (Figure 1 i, j, k and l) and diatom cylindrical diatom frustules (Figure 1 a, b, c, d, e, f, g and h). The presence of detrital quartz and feldspars are minor amounts, whereas, the clay mineralogy includes: a very little amount of smectite group, illite, chlorite and vermiculite. Generally, the mineralogy of Al-Hishah formation is at high standard compared with Danish clay diatomite that has named Moler (Al-Dernawi, *et al*. 2014).

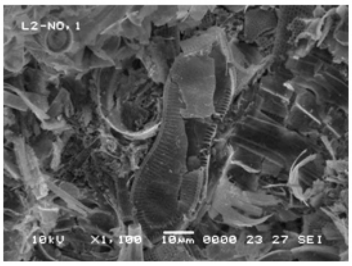
Based on the SEM images recorded for the upper layer (Plate, 1), there are abundant types of diatom frustules (cylindrical/disk shaped) represented by Melosira group in a form of cylindrical shape, and Stephanodiscus group as disk shaped with valve circular, broken by a tangential placation, one side convex, the other side concave. Areolae cover entire valve increasing in size slightly toward margin and then decreasing at the margin. Other disk shaped species have the circular valve flat, Areolae radiate from the central area and are loosely fasciculate. A central nodule is present as broad hyaline ring around the margin. On the other hand, in the pinnate diatoms (Nitzischia, Synedra) the cell wall is distinct with a V-shaped slit, raphe in the Nitschia species families and is composed of silicon dioxide (SiO_2). Therefore, this layer of the study area could be presented as a pure high quality diatomite as a premium expectation with minor contamination that have been noticed at space pores (organic compound). The outlook should be definite by other investigations.



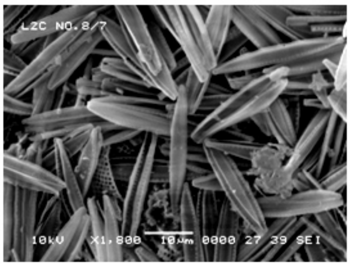
Cylindrical shaped: Melosira granulate Hurst



Disk shaped: Stephanodiscus Niagarae Eut



Nitzschia miocenica Cymatopleura solea



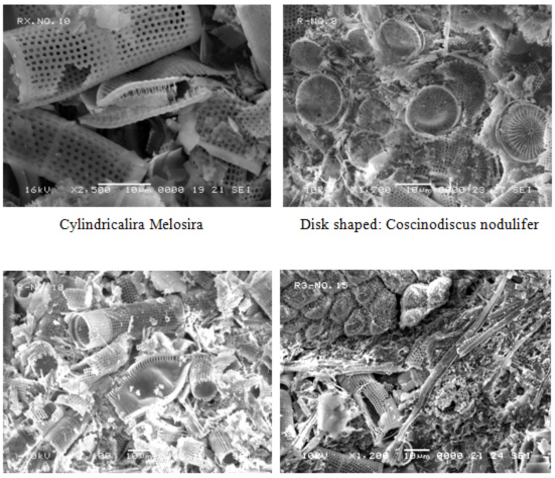
Nitzshia bicapitata Cleve, a pennate form

Plate 1: Upper Layer Diatomite Species

The abundance and diversity of diatom of the lower layer (Plate, 2) grazers directly reflects diatom species abundance and diversity. Diatom species are found in a wide array of nutrient, pH, salinity, and temperature regimes. The many combinations of these chemical and physical parameters provide the diversity of niches required to sustain the thousands of known species. Functionally the diatoms can be described by growth habit, with the understanding that certain strategies likely evolved multiple times in distantly related diatom species. In the lower layer, SEM shows considerable species of disk shaped Coscinodiscus, nodule presents with a small nodule near the centre of the valve. Navicula Cryptocephala as a pennate form, Stephanodiscus minutulus shows both valves and girdle bands comprising the “pill box” architecture are visible with a scale bar equals 10 µm. Most of them recorded hyalite; on the contrary Nitzschia reinh has a valve elliptical with slightly convex margins, costae close together intercostals membrane with rows of small decussate punctae. Rhizosolenia praebarboi straight or gently curved purely hyalite. Consequently, the (lower layer) reported that has a good quality of diatomite (Al-Dernawi, *et al*. 2014).

Libyan diatomite was classified accordingly in order to determine the characteristics of the basin plaeo-environment. Table (1) showed the distribution of the pennate (represented by Fragileria species) and centric (represented by Melosira, desko species) in the study area. The distribution indicates that both species types exist in different parts of the deposits, which reflect temporal and spatial variations in water depth and eutrophy. The same phenomena interpreted by Barrow, K. T (1983) as the existence of alternating Melosira and Fragilera rich beds, infer seasonal changes in eutrophy.

Barrow, K. T (1983) mentioned that diatom activity was influenced by water temperature, pH, chemistry, and nutrients and all of these parameters influenced by a wide variety of processes.



Cylindricalira Melosira Disk shaped: Coscinodiscus nodulifer

Nitzschia, cylindricle Melosira Rhizosolenia praebarboi straight or gently curved

Plate 2: Lower Layer (western part) Diatomite Species

The influence of tectonic activity on diatomite deposits was stated by Nash (1996). He cleared that the development of thick and pure sequence of diatom deposits requires periods of tectonic stability to minimize input of clastic detritus. He also explained that preservation of delicate diatom frustules requires quiet – water deposition and minimal digenesis (heat, burial and cementation).

Scanning electron microscope examination confirms, that the presence of the diatomaceous frustules. Plates (1 and 2) show a group of different main types of frustules, the cylindrical, pennate and the centric.

Many frustules were found clear and clean which proof high quality of the diatomite deposits (upper layer). However, others were preserved, filled, surrounded with clay, broken and reworked. This would support the mineralogical evidence of clastic supply as a nutrition source, whereas the presence of some broken, laminated friable shells in the (lower layer) put forward the Subkhat Ghuzyail diatomite deposited in a relatively non-quiet sedimentary environment.

Diatoms have adapted to various marine and continental aquatic conditions, predominantly to planktonic or benthic environments. Marine environments favor planktonic diatoms because diatoms flourish in the widespread photic zone, less than 100 to 200 m deep (Barron, 1987).

Previous geological studies of Al-Hishah formation indicated that two environments characterized the sequence of rocks formed Al-Hishah. These are marine and lacustrine environment (Figure 3). The different species of diatoms recognized by this study confirm the conclusion reached by the geologists related to the prevailing ecological conditions at Tertiary to Recent times. On the other hand this would reflect channel shifts and closure within the delta usually distribute the water elsewhere in the system.

A classification of Al-Hishah diatomite species were carried out depending on the form of life (planktonic or benthic). Table (1) indicates the relative abundance of each species as planktonic or benthic in both diatomite layers. Planktonic type represents more than 77% of the population species in all samples, while the benthic represents 7 to 8%. Both planktonic and benthic species were found in the upper and lower diatomite layers (Table 1).

This result confirmed with that showed by classifying Alhishah diatomite species according to their shape form (centric and pennate).

Table 1: Classification of Libyan Diatomite Species in the Lower and Upper Layers (Al-Dernawi, et al. 2014)

Frequency of Occurrence of Diatom in the Lower Layer Samples (Western Area)			
Sample No.	**Centric Meloseria**	**Disko**	**Pennate Frgilira**
L11cNo21	***		
L2No.2	*		*
LB No.1	***	*****	
LBLNo.2	***	***	**
LB No.3			**
L No.9	**		*
R No.2	**		*
R No.3	***		
R No.5\6	***		
R No.8	*	**	***
Rx_1 No.10	***		**
R3 No.15	*		**
R3 No.16	**	*	
R_4 No.18	*		

Table 1: (Continued)

Frequency of Occurrence of Diatom in the Upper Layer Samples (Eastern Area)			
Sample No.	**Centric Meloseria**	**Disko**	**Pennate Frgilira**
L1cNo.4	*	***	*****
L2cNo.7/8	**	****	*
L5cNo.12	*		
L7cNo.14	**	*	**
L9cNo.18	**	**	**
LB No.10	**		*
LB No.8	***		
L4c No.11	****		***

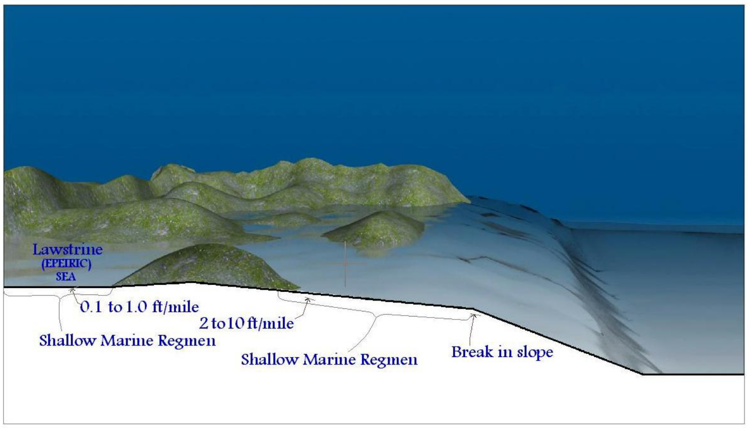


Figure 3: Schematic Model Showing Marine and Continental Environment Deposits (Al-Dernawi, et al. 2014)

The environmental conditions observed from both classifications were supported by the conclusion reached by Sverdrup and others (1970) saying that "most marine forms are stenosaline – that is, they tolerate only a narrow range of salinity". Another agreement coincides with what Baron (1987) and Bradbury and Kerbs (1995) said. They concluded that non-marine diatoms have the same nutrient (phosphate, nitrate, and silica) and light requirement as marine organisms (Al-Dernawi, et al. 2014).

Geological studies showed that Al-Hishah Formation was deposited under marine to continental environment (Figure 3). Both environments produced diatoms of its origin. Recent studies of diatomite used the ratio of pennate diatoms to centric diatoms to show the degree of eutriphication in each environment. Kerbs and Bradbury (1984) indicated that pennate diatoms represented by Fragilera species reflect shallow basin and eutrophic, whereas centric diatoms represented by Melosira species reflect locally deeper and/or less eutrophic environment.

SUMMARY AND FUTURE PLANS

In coastal areas, the tide is the most important factor for the classification of different sedimentary environments. Although the classification of the ecological groups is not based on the tidal range, an indirect relation between the different ecological groups and the various sedimentary environments exists. Based on this assumption the paleo-environment of Al-Hishah diatomite studied on this work was summarized according to the following points with a view to future plans.

- 21 species and varieties of diatoms were identified in 45 samples. Many of the dominant species show large changes in percent abundance. The existence of different species of the diatomite in different mode of environment (marine and lacustrine) lead to the conclusion that these species tolerating the change in pH, chemistry and eutrophy of the environment.
- The distribution of the Fragilera species (pennate shape) and Melosira species (centric shape) in the study area, indicates that both species types exist in different parts of the deposits, which reflect temporal and spatial variations in water depth and eutrophy.
- Depending on the mode of life of Al-Hishah diatomite species (planktonic or benthic) indicates the relative abundance of each species as planktonic or benthic in both diatomite layers. Planktonic type represents more than 77% of the population species in all samples, while the benthic represents 7 to 8%. Both planktonic and benthic species were found in the upper and lower diatomite layers. This result confirmed with that showed by classifying Al-Hishah diatomite species according to their shape form (centric and pennate).
- The environmental conditions observed from both taxonomy and mode of life approaches were supported by the conclusion reached by Sverdrup and others (1970) saying that "most marine forms are stenosaline – i.e, they tolerate only a narrow range of salinity". Another agreement coincides with a conclusion suggested that non-marine diatoms have the same nutrient (phosphate, nitrate, and silica) and light requirement as marine organisms.
- The goal of the Industrial Minerals in different environments is to study the processes of formation in more details. Several critical regional and local factors have received little or no research attention, and more information on some or all of these factors would provide a better understanding of diatomite deposits in the region. Basin- and deposit-specific factors include duration and age of diatomite formation; paleoecology,

paleogeography, and chemistry of the lakes; sources and amounts of silica and nutrients; diatom speciation and related flora and fauna; structural environment during and after diatomite formation; sedimentologic controls, including types and sources of clastic materials; causes of lake formation and termination; and post-depositional alteration. Using a combination of past and ongoing research in related fields and new work for this project, we expect to gain a better understanding of the processes that formed and preserved diatomite deposits.

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