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Research Article

Archaeology, Physics and Chemistry: Thoughts about a Technique Applied by Mediterranean Sponge Divers throughout the Ages

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Abstract

One of the most difficult professions in history, sponge diving/fishing was widely practiced in the Mediterranean World in 19th and 20th century by Turkish, Greek, Italian and North African divers. Natural sea sponges are the main materials of the profession which extends from here to the North America in mid-20th century. Our earliest data indicate that the sponge, which is well known by many ancient texts used in ancient times, especially in cleaning, medicine, carpentry, mining, chemical industry, and military equipment, was provided by mankind to 4500 BC. The ancient texts are rich in terms of information about the usage of sponges as well as information about sponge-divers. There is a consistent similarity between the centers of the Modern Age and the centers in these ancient texts which convey information about how and where the profession is practiced. The main reason for this situation should be related to the distribution map of the valuable sponge species that human beings can use in their daily life in the Mediterranean World. The information conveyed by the modern age sponge-divers and their families show that these people wandered the Mediterranean along the sponge resources. It shows that these sponge-divers are not only interested in sponges but also supply valuable textile products especially from the Eastern Mediterranean ports and market them in their countries. In this respect, the contribution of the sponge-divers -who can be defined not only as a professional group but also as a merchant- to the acculturation process of the Mediterranean has not been realized except for a few studies. The absolute, compulsory, and continuous supply of sponges needed by the common toilets and bathrooms that serve millions of people, especially in the Greek-Roman Periods, is the most important proof that sponge diving/fishing was an important profession. When we examine the sponge fishing history from the ancient times to the Ottoman Period and almost today for some amateur sponge divers, there is an invariant technique for the sponge divers. When the sponge divers reached to the bottom of the sea, they spout the olive oil from their mouth. According to Oppian and Evliya Çelebi, the sponge divers use this method for the similar purpose, however the explanations of Oppian and Çelebi are too different from each other's. In this study, by considering physical and chemical laws, we analysis these two different examination for the oil-expuition. We determined that the people who lived in ancient ages realized the refraction of waves, and Snell's law before the mathematical equations found.

Keywords: Ancient Diving, Sea Sponges, Sponge Divers, Mediterranean, Snell's Law

Introduction

Mankind, who has discovered, developed on discoveries throughout history and constantly renewed itself in this process, has shifted the production economy to the mechanized industry through new inventions, with the contributions of this new form of industry, natural production objects of the past have left their places to their synthetic and cheap counterparts over time. From ancient times to the process we have mentioned above and defined as the "Industrial Revolution" in general terms, sea sponges, which we can count among the natural products handled by human with their individual labor, are an important item used in many fields, especially cleaning.

Sponges (Porifera), which are included in the group of multicellular invertebrates, have nearly 8000 types known worldwide. It was created by combining the Latin words "porus" and "carry" which means ferre. As a result of close observations made by Aristotle in the 4th century BC, the sponges that he classified as animal (Animalia), however, continued to be defined as a plant by scientists for a long time. As a result of Ellis' extensive examinations in 1765, as observed by Arsitoteles, he was included in the herbal animal group (Zoophyte) due to his proximity to animals (Ellis 1765).

Among the sponge types, those that have a commercial value and are supplied from the Mediterranean Basin from past to present are evaluated in five sub-groups. These; *Spongia Officinalis Mollissima*, *Hippospongia Communis*, Spongia Lamella, Spongia Zimocca, Spongia Officinalis Adriatica (Katağan et. al. 1991; Okus et al., 2004, 2006, 2010; Demir and Okuş, 2007; Ekiz, et al., 2014; Gazioğlu, 2018). It is known that sponges, which have approximately 681 species in the Mediterranean basin, have been hunted and evaluated for many

purposes since ancient times. "Sponge-diver" in Turkish is a term used not only for the provision of this product under the sea, but also for people who trade in a wide geography.

Sponge diving, a risky and difficult profession defined by Oppian with the words “no ordeal is worse than sponge hunters, no effort is harder than theirs” (Opp. H. 5. 601-623), has been one of the main livelihoods of many centers especially in the Mediterranean basin until the 1980s.

According to the records between 1858-1866, it is known that more than 1400 sponge-diver’s boats were used in the Anatolia, Greece, African and Syrian shores, especially Rhodes, during the Ottoman Empire (Çoruh 2009). Sponge fishing, which became stagnant due to wars and some diplomatic problems, regained speed in the 1930s. A disease seen in the Mediterranean sponges in the 1980s caused those who practiced the profession to quit slowly.

Sponge diving, which is a seasonal job, is generally carried out between May and September, and the activity that starts simultaneously in different parts of the Mediterranean is carried out through dives in areas called “sponge fields”. It is known that sponge boats called Tirhandil, Piyade and Korsova were used during the activity carried out in groups of at least 6 and at most 25-30 sailors. Sponge fishing, which was carried out with the naked diving method until the 19th century, has been carried out through a series of technological innovations, especially skafander, since these dates. It is collected through Harpoon-Kamaka, Kakıç, Harpago and special types of cutters. The sponges obtained were transformed into a commercial substance after a series of processes (Erdan 2018).

As a result of pure special techniques and knowledge, the sponges known to be supplied to the sea by diving and gathering have been identified as a result of the recent archaeological studies in Egypt, which date back almost 6500 years (Jones et. al. 2014; Erdan 2018). It is noteworthy that the information in the written sources for the supply and use of sponges by human beings began between 9-8 centuries BC. As a matter of fact, continuous use should be provided with the necessity of supply and the emergence of individuals specialized in this field.

Brief History of Sponge Using in Ancient Mediterranean

There is a lot of information in ancient texts about sponge using and sponge-divers, which we first recognize as a cleaning object in Homer's works in the 8th century BC. In our previous study the data which we evaluated on the subject are includes in terms of different information about the sponge using and sponge-divers from the 8th century BC to the 1st century AD. Similar to the information provided by Homer, it is understood that sponges, which are evaluated as more cleaning products, are frequently used in fields such as medicine, biology nd chemistry, military, carpentry, mining and daily life (Erdan 2018).

Cape Malea, Anthedon, Delos, Rhodes, Lycia and Hellespontos are among the centers where sponge diving was carried out in the early years in the light of the information provided by ancient sources. In these sources, sponge-divers are known as spongotheras, spongokolymnetes and spongeus, and it is known that they were defined as spongotomos, that is, "sponge cutter" during the Roman Empire. However, it is seen that sponge-divers are called urinatores together with all other divers in Latin. In Delos, there are also written records indicating that sponges were offered to the temples of Artemis and Apollo. Here, sponge-diver names such as Apollodoros from Kyzikos and Rodis, son of Didymos are encountered (Erdan 2018).

Information about the Spraying and Pouring Olive Oil Techniques

Although it is primarily a superficially transmitted information by Plutarchos (Plut. De Primo 13), a section in the context of Oppian's extensive content of sponge-divers is essential for our study. As a matter of fact, the section in question provides the first comprehensive information about this technique which was applied by the Mediterranean sponge-divers from the Ancient Period to the Ottoman Period.

Oppian provides detailed information about the activities of the group he called as sponge cutters. His narratives are extensive enough to suggest that he lived with sponge-divers for a certain period to observe them and their profession closely. It is possible to see detailed information about almost all stages of sponge fishing in his narratives. According to Oppian, sponge-divers perform some major rituals before plunging into the sea, the first of which is to appeal to the gods in order to protect them from sea monsters. This is followed by tying ropes to the diver's waist, putting a weight of lead in his hand and taking olive oil into the mouth. Then, the diver, who took olive oil in his mouth at the last stage, observes the waves on the bow for a while, is encouraged by his friends, finally, when he dares into his heart, he leaves himself in the sea and drifts to the bottom of the sea with the help of lead ingot (Opp. H. 5. 650-669).

Oppian's information about pre-diving is followed by narratives about what happened during the dive. Accordingly, the diver, who left himself in the sea, reaches the bottom of the sea in a short time. The sponge-diver, which reaches the bottom of the sea, sprays the olive oil that it has already taken in his mouth. According to Oppian's narrative, the oil shines in the dark water as a dazzles and brightens the seabed. The oil, which disappeared after a while, mixed with water, fulfilled its function, and the sponge-diver noticed the sponges on the rocks. When he believes that he has cut enough sponges, the sponge diver asks his friends to pull-up himself from the sea.

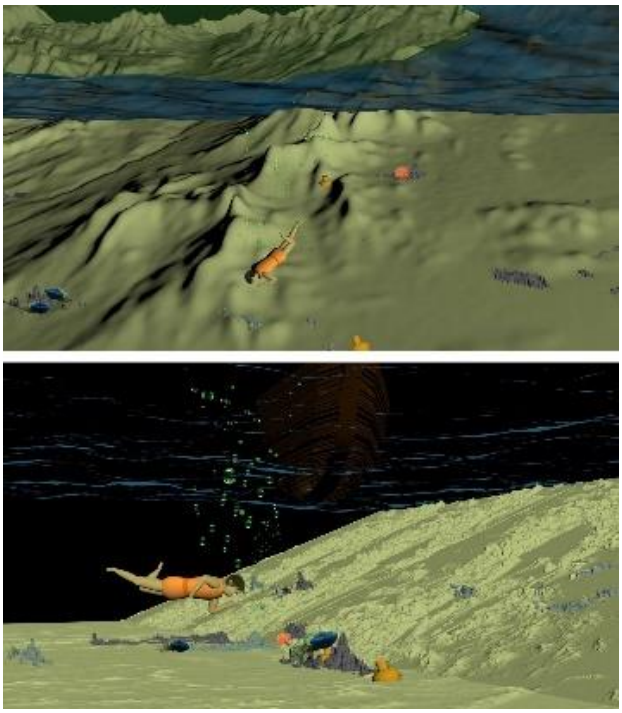

Fig. 1. Illustration of the technique described by Oppian.

Table 1. Information on Sponge Divers and the Use of Sea Sponges Mentioned by Ancient Texts Between 8th Century BC - 2nd Century AD. (Edited from Erdan 2018)

Author	**Intended use of Sponges**
Homer	Cleaning (body-goods)
Aesop	Tale (sponge weight)
Aeschylus	Cleaning (paint removal)
Aristophanes	Medicine (placing the wet sponge on the heart) Cleaning (shoe cleaning)
Plato	Medicine (analogy: lung-sponge)
Pherecrates	Clean (body, "sponge" expression, interruption?)
Hippocrates	Medicine (use of sponges in the treatment of various diseases and drug production)
Demosthenes	Cleaning (seats)
Aeneas	Carpentry (sound insulation)
Aristoteles	Biology (definition of sponge) Military (use of sponge in the helmet)
Theophrastus	Daily Life (drinking water)
Callimachus	Daily Life (drinking water)
Clearchus	Daily Life (sponge between household items)
Antigonus	Daily Life (drinking water)
Erasistratus	Medicine (heat stroke)
Philo	Engineering (sponge use in military vehicles and chemical experiments)
Chrysippus	Chemistry (use of oily sponge in wine-water separation)
Agatharchides	Mining (sponge use in gold separation)
Strabon	Daily Life (covering the mouth of the container with a sponge)
Titus Livius	Military (Sponge use in helmet and armor)
Plinius	Biology (definition of sponge)
Oppian	General (proffesion)

In the process following this detailed and highly informative narrative of Oppian's sponge-divers, which methods and by what threats they face, direct information about sponge diving is not common in ancient texts. It is known that individuals dealing with sponge diving were known as "*urinatores*" together with all the other divers during the Roman Period and they established a union called "*corpus urinatorum*". It was learned that the *urinatores*, who created a treaty text in order to resolve the disputes with fishermen in Ostia in

the 3rd century AD, were now working not only with sponge diving, but also in bridge construction, military activities and other port works (Marzano 2013).

The famous Turkish traveler Evliya Çelebi, who lived in the 17th century, provides remarkably interesting information about our study in the second volume of Seyahatname (Book of Travels). The information about Sömbeki / Simi Island sponge-divers in the seventh part of the book is as follows with the description of Çelebi directly; “They don't have shops, but there are guild places in Galata and Kasımpaşa, they are located there. These are mostly Maghrib, Reshad and Alexandria Arabs. However, they are located on Symi Island across Rhodes Island. Divers who dive for pearl in the Hormuz Sea cannot coincide with these. When they take olive oil in their mouths and dive into 70 fat depths and leave the olive oil in their mouths, olive oil spreads to the sea until it blinks, each drop of olive oil becomes a shining sun, because every drop of oil illuminates the bottom of the sea like the stars of Süreyyâ. Divers find a needle, even a dirham. 70 fathoms diving to the ground and standing here, 70 fathoms going out is a miracle job that is not something people can do. They take out the sponge from the sea, take out the goods of the sinking ships” (Evliya Çelebi, Seyahatname, I-2. 503).

As can be seen, in a text written almost 1500 years after the explanation of Oppian, it is understood that individuals who deal with sponge diving are used exactly similar techniques with the ancient Mediterranean sponge divers. However, when both texts are examined carefully, there are differences in olive oil and enlightenment which are included in the narratives of both authors, although the technique is the same. Oppian states that olive oil, which sponges sprayed from their mouths at the bottom of the sea, created a sudden enlightenment. According to him, dazzling oil of the diver in dark water shines brighten the seabed. Evliya Çelebi mentions that the luminous process created by the said application occurs when the oil reaches the surface of the sea.

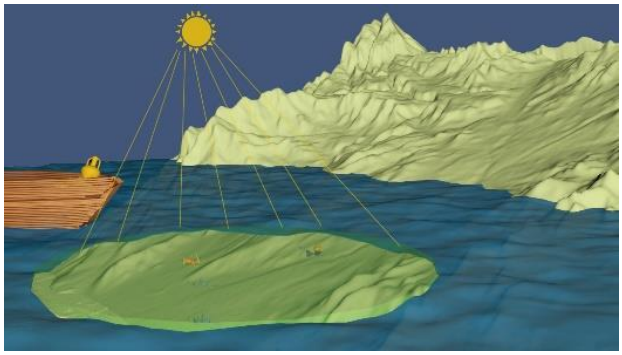

Fig. 2. Illustration of the technique described by Evliya Çelebi

This method, which has been used since ancient times and has been used as a sponge diving technique that lasted for thousands of years, as the two text groups we have shared with the details above show, is the result of more ancient knowledge. Information on the first observations that water and oil varieties do not mix with each other is obtained from the Old Babylonian prophecy texts. In a text dated to the Hammurabi Period of the Akkadian King (18th century BC), it is stated that the prophet identified as "baru" poured oil into a water container in his lap, in order to understand the attitudes of the divine powers towards the country or the individual, and draw the results from the irregular movements of the oil in the water (Oppenheim 1977; Tabor, 1980).

The form of divination, which is continued in a similar way by the Hittites, is transferred to the Ancient Greek world as lecanomancy as a result of the combination of the words lekani = bowl and manteia = divination (Tabor 1980). In addition to this apparently understood to gain continuity over time, Aeschylus's Agamemnon also includes observations and information about the separation and decomposition of both substances (Aesch. Ag. 320).

Today, there are information’s about the use of similar techniques. According to the information conveyed by Kalafatas, sponge divers, which are hunted using harpoons in the West Atlantic today, pour oily sand on the sea, thus smoothing the small wave breaks existing on the sea. At the last stage, they can detect sponges without diving into the sea with the tools they call "sponge glass" or "water telescope". The starting point of this technique used in the West Atlantic should be the Mediterranean. Because “Sea Mirrors” (Fishing Binoculars, Sea Bucket, Yiali), a tool used by Mediterranean sponge divers especially in the last century, are also used with the same function (Kalafatas 2003).

Chemical Overview

Oil-in-water emulsions are conventionally defined as thermodynamically unstable systems which include two immiscible liquids (generally water and oil), in which oil is distributed into the water. Emulsions may be dividing into two phases over time through creaming, coalescence and flocculation. Emulsions are systems consisting of two or more liquid immiscible phases. Emulsions often contain a surface-active agent which has two main functions: (a) to decrease the interfacial tension between phases; thereby enabling easier formation of the emulsion, and (b) to stabilize the dispersed phase against coalescence once it is formed.

Emulsions can be classified into two groups: simple emulsions and multiple emulsions. In the case of simple emulsions, droplets of one liquid phase are dispersed in another immiscible liquid phase. Simple emulsions can be categorized as three types: water-in-oil emulsions (with water droplets as a dispersed phase in the flow of oil as the continuous phase), oil-in-water emulsions (with oil droplets in the flow of water), and more complex configurations of emulsions such as water-in-oil-in-water emulsions. The water-in-oil emulsions consist of water droplets dispersed in a process of oil phase whereas the oil-in-water emulsions have a reverse

arrangement, i.e., oil droplets are dispersed in a process of water phase.

Evaluation under the Physics Rules

As it is known, water molecules and oil molecules are classified as polar and nonpolar (apolar) in terms of chemical bonds. The main difference between these two bonds concerns how electrons are placed on the atoms that make up the molecules. The polar bond is caused by the fact that the electrons are not evenly distributed between the atoms that make up the molecules and causes an electric dipole moment to be formed in the molecule. For example, while the Oxygen atom is partially negatively charged due to the unshared electron pair in the water molecule (H2O), hydrogen atoms are partially positively charged. The electrostatic attraction force between these two different charges causes the water molecules to bond with each other by hydrogen bonding. Oil molecules consisting of hydrogen and carbon and atoms are apolar substances and interact with van der Waals forces, which are quite weak with each other. In apolar molecules, the electron distribution is equal within the molecule, so there is no accumulation of different charges at the ends as in the water molecule. Another important feature of polar and apolar materials is that polar materials interact with polar materials and apolar substances in apolar materials. In summary, the chemical bonds of both molecules differ from each other, preventing oil and water molecules from mixing with each other.

Although this detailed explanation, which we have reached with today's level of knowledge, can provide information about the separation of water and oil, it does not provide information about the effect of the oil to clarify the angle of vision under or above water. At this point, chemistry and physics rules provide some information to explain the situation in question.

The interaction of water and oil molecules with each other has been used for different purposes since ancient times. Some experiments on the subject show that only one spoon of olive oil spread over an area of approximately 100 m2 on the water surface within two minutes (Franklin 1774). The reason for this rapid spread is that, as mentioned above, the chemical bonds between the two molecules are different. The oil molecule has two different ends, one of which is attracted and negatively charged by positively charged hydrogen atoms in the water molecule. All the oil molecules suddenly separate from each other, and the negative ends of the oil molecules rotate to touch the positive ends of the water molecules and are lined up side by side. Thus, a layer of only one oil molecule and a fairly large (proportional to the amount of oil spilled on water) is formed on the water. This super-thin layer remains suspended on water just like a carpet. The amount oil is important for the distribution time, spreading of too much amount of oil on the sea surface will take a long time. However, to make faster distribution of the oil on the sea surface, small amount of oil should use. This can be in a two way, one of them dripping of the olive oil from outside the sea or the divers can take a mouthful of oil before each dive and when the diver reached the bottom of the sea, they can spit out the oil, so the olive oil can reach and distribute on the sea surface rapidly. The ancient times divers were using this second way to gain a more time and remain in the sea more.

Fig. 3. Experiment Photographs which made by Benjamin Franklin in Clapham.

Air and water are in continuous contact with each other, and molecules in the air and water molecules move at different speeds and directions. This causes the air molecules hitting the water surface to create different pressures at different points in the water. These pressure differences cause water molecules to behave differently on the surface and water waves occur. If there is a layer to reduce this interaction between water and air, or if the water surface is completely smooth, wave formation can be prevented. This layer is created with the help of oil molecules. Thus, since the molecules in the air do not interact directly with the water surface, wave formation in the region where the oil layer is located is partially prevented. In addition, this layer on the water made up of oil molecules also plays an important role to extinguish the intensity of the water-waves. Thus, an incident water-wave collide with the oil molecules and a portion of this incident waves damped, some portion of water waves are reflected, and the remaining water waves keep going under this layer. Thus, the area covered with oil molecules get smooth than the remaining water surface (Littlehales 1893). This method also uses in storms at sea to calm the troubled waves (Wyckoff 1886).

Snell's law is the name given to the equation that allows us to calculate at what angle light or other waves will travel when a refractive index arrives on a surface that separates two different environments (Kwan et. al. 2002; Hecht 1974). The refractive index of water (1.333) is greater than the refractive index (1.0) of air, so light from air to water is refracted approaching normal and moves along a line. If the nerve surface that separates the environments with two different refractive indices is smooth, the incoming rays travel parallel to each other.

It is believed that the naked divers are immersed in a depth of 15 m to 30 m and are submerged for a maximum of 5-7 minutes. Experiments have shown that the rate of spread of oil molecules on the water increases by leaving the oil in drops rather than pouring water from the outside of the water. As we mentioned above, the oil layer formed on the water will make the water surface smoother. Thus, the rays coming to the surface of the water will be broken at approximately similar angles and will reach the sea bottom parallel to each other. This means that the area where the diver is located

at the bottom will be exposed to more than normal light and therefore will be brighter. Thus, the method of spraying oil in the mouth applied by the divers will enable the oil molecules to spread faster on the surface of the water and allow the divers to stay in water for a longer period. At the same time, since it will create a relatively smooth surface on the water, it will make the seabed more clearly by using additional materials from the outside.

Conclusion

Olive oil and sponge have an important place especially in the daily life of Mediterranean people since ancient times. Although natural sea sponges have been replaced by their chemical counterparts over time and have lost their former importance, it is known that their widespread use continued especially until the mid-20th century. After these dates, both the diseases affecting the sea sponges and the risks in the sponge diving that provided the product in question did not make this ancient profession attractive anymore, and this caused the profession to disappear over time.

The combination of sponge, sponge divers and olive oil is not limited to the hunting techniques we evaluate within the scope of our study. Sharing their observations about individuals performing the profession at different dates, scientists report that sponge divers were rubbed with olive oil three times a day and half an hour each time between diving tours. Although it is not causally related to sponge divers, other applications are known in ancient texts where sponges are used together with olive oil for medical purposes. It is explained in detail in the scope of ancient surgical operations transmitted by Hippocrates, that the sponge was immersed in olive oil and applied to the wounds (Voultsiadou 2007).

Interesting information about sponge divers' use of olive oil is told by British scientist Robert Morey. Submitting a letter to the Royal Society of London, Morey introduces diving observations in detail and the instruments used by individuals dealing with the diving profession at the center he examines. He states that the divers he observed obsessed their ears with a sponge soaked in oil in order to remove the pressure difference. However, olive oil is known to have a special place in daily food consumption within the scope of sponge diving activities that last for months.

Olive oil has different usage purposes in the ancient shipping activities. Based on this point, the main question we should focus on is the function of olive oil amphora detected in the wrecks. Could the olive oils carried on ancient ships not only be commercial but also related to the diving and similar uses we consider in our study? For now, although we are far from answering this question, a practice that has been going on for thousands of years suggest that olive oil is not only a commercial object for seafarers.

Although it is not evaluated much, the fact that the sponge should be a mandatory requirement in baths and toilets, especially in the Greek and Roman periods, makes us think that the profession of sponge diving was an important business in antiquity. It is quite reasonable to think that individuals who are involved in shipping are saving a significant part of the olive oil we know that they use when they spend on and under the sea.

At the end, by considering the physical and chemical laws, we evaluated that the sailors and sponge-divers has been found by their observations that olive oil can spread on the sea surface in a very short time and can extinguish the amplitude of the incident waves. Although, there are two different discourses about the olive oil effect in the sea, we believe that sponge-divers were using olive oil technique to obtain smooth sea surface to see the bottom of the sea clearer by tools like sea mirrors.

Fig. 4. Illustration of a sponge-diver while using olive oil technique to obtain smooth sea surface to see the bottom of the sea clearer by tools like yiali/sea mirror.

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