PALEO-GEOMORPHOLOGICAL MAP OF ALEXANDRIA SITE, EGYPT BY USING SUBMERGED ARCHAEOLOGICAL AND OTHER EVIDENCES

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Abstract

Several submarine archaeological survey has used to recognize characteristics of Alexandria city remains in the eastern harbor and Abu Qir bay area, by using some technics such as side scane sonar survey (Schwartz, 1980), eco-sound survey, geoaarchaeological settlements dating (Goddio, 1998), remote viewing, remote sensing and sea bottom soil boring during last 50 years. This paper aims to define paleo-geomorphological map and stability of coast line area of Alexandria ancient city and relationship between land and sea as a result of tectonic movements, climatic changes and human activites during last 2000 years ago, depending upon submerged archaeological evidences during Greco-Roman and Ptolemaic periods (http://www.cealex.org). These criteria include: local subsidence or uplifting, relative sea-level rise (RSLR), land topography, width of lagoon barriers, beach-face slope, high-elevated features such as coastal dunes and ridges, eroding and accreting coastlines and ancient protection works.

Keywords: Paleo-Geomorphology, Alexandria, submerged archaeology, Egypt, Mediterranean Sea

1. Introduction

Alexander the Great has constructed Alexandria on the shores of the Mediterranean Sea in 332 B.C. The city was famous in all the world for its huge Royal Library, it is generally have been founded during the reign of Ptolemy II at the beginning of the 3rd century BC, as well as Pharos island lighthouse (one of the Seven Wonders of the Ancient World), it was constructed early in the Ptolemaic period. Most of the royal and civic quarters of Alexandria city sank beneath harbor due to earthquake subsidence, a part of the ancient city of Alexandria lies 6 to 8 meters under seawater as a result of climatic sea level rises in modern times (LA Riche, 1979).

1.1. Objective

This paper aims to reconstruction of paleo-geomorphological map of Alexandria city area before building it by Alexander the great on 331 BC by using submerged archaeological and other evidences.

1.2. Previous work

The submerged archaeological sites of ancient Alexandria city have been studied by: Empereur, 1998; McKenzie, 2003; Ashton, 2004; and Marriner et al., 2008 & Goiran, 2001.

The Alexandria region has been the focus of numerous investigations including: Geography (Goddio et al., 1998); Oceanography of Mediterranean Sea near Alexandria coastline (Inman and Jenkins, 1984); Geology and paleogeography (Warne and Stanley, 1993; Goiran, 2001); Stratigraphical analysis (Goiran et al., 2000); Underwater Archaeological Survey by the Hellenic Institute for the Preservation of Nautical
1.3. Methods
Several submarine archaeological surveys have used to recognize characteristics of Alexandria city remains in the eastern harbor to reconstruction paleo geomorphological map of the study area by using some techniques such as: Interpretation of remote sensing images and historical topographic maps; field surveying; results of side scan sonar survey (Schwartz, 1980; eco-sound survey (Empereur, 1998); Geoarchaeological settlements dating (Goddio, 1998); Sedimentary boring (Goiran, 2001; Stanley et al., 1996 & 2006).

2. Results and discussion:
2.1. Alexandria before Alexander:
The analytic of Alexandria harbor cores sediments have revealed that Alexander the Great did not found the Egyptian city of Alexandria – he just rebranded it. New geochemical data, published by (Véron et al. 2006 and Stanley & Bernasconi, 2006) depending upon geochemical data and C14 dating of seashell fragments found in some cores show that peaks of lead contamination in Alexandria during the Egyptian Old Kingdom between 2686 and 2181 B.C., and again during the Iron Age, from 1000 to 800 B.C. at the end of the prosperous Ramses dynasties, it means that ancient Alexandria was settled 4,500 years ago, more than two millennia before Alexander’s arrival. Rhakotis was the original name of the city of Alexandria.

2.2. Geographical elements of Alexandria’s location:
Alexander Great has chosen this location to construction his city because of the following factors:

2.2.1. He chooses this bay to keep Alexandria harbors from winter storms and marine erosion (Fig.1).

2.2.2. Alexandria location lies between Mediterranean Sea and Mariut lake (Fig.1).

2.2.3. The wind is blowing on Alexandria city most of the year from the N and NW directions; the sea western currents transport the sediments from west to east and inside the eastern harbor (Fig.2 & 3).

2.2.4. The ancient Canopic branch of the Nile Delta was the main source of fresh water in Alexandria (Fig.4).

2.2.5. Pharos Island was joined to the mainland by a mole, constructed by order of Alexander the Great (Fig.5).

2.2.6. Alexandria has been built on limestone coastal ridges with elevation between 5-15 meters, the city constructed on the 1st and the 2nd carbonate ridges, but most of the 1st ridge is eroded by sea waves and appear as some rocky island and sea stacks (Fig.5, 6 &7).

2.2.7. Lake Mariut is important navigational route to the other parts of Egypt, but the area of the lake was larger than its current area, some ancient harbors found in the paleo shoreline of the lake (Flaux, 2011 and El Assal, 2013) (Fig.8).
Fig. 1: Location of Alexandria as a bay lies between Mariut lake and The Mediterranean Sea

Fig. 2: Seasonal wind directions of Alexandria city

(after: http://climate.umn.edu/wind/kaxn)
Fig. 3: Sea currents directions inside Alexandria eastern harbor (after: Millet & Goiran, 2007)

Fig. 4: The Canopic branch was the main source of the fresh water network of Alexandria (after: Braun and Hogen, 1575)
Fig. 5: Topography of Alexandria site (after Mahmoud-Bey, 1872)

Fig. 6: Relationship between location of Alexandria City and the limestone coastal ridges (after: Stanley & Hamsa, 1992)
Fig. 7: Remains of the first eroded limestone ridge

(after: Captain W.H. Smyth, 1833)

Fig. 8: Relationships between Alexandria city site and limestone coastal ridges and Paleo Mariut lake shorelines (after: Flaux, 2011)
2.3. Estimation of tectonic subsides and erosion rate of the 1st limestone ridge:
Tectonic subsides and erosion rate of the 1st limestone ridge can be estimated during the 20th century by comparison the floor depth of Alexandria eastern and western harbors using historical topographic (Roux, 1764) (Fig.9); (Napier, 1841) (Fig.10), with current bathymetric map (El Geziry et al., 2007) (Fig.11); as well as floor depth maps of the Alexandria eastern harbor. These maps show that the maximum depth in the eastern harbor was 7 meters during 18th and 19th centuries (Fig. 9 &10), but it become 10 meters during 20th century as a result of tectonic subsides and erosion action by waves, and its rate about 3 m/100 years.

Fig.9: Floor bottom depth of Alexandria eastern and western harbors during 18th century (after: Roux,1764)
Fig. 10: Floor bottom depth of Alexandria eastern harbor during 19th century
(after: Napier, 1844)

Fig. 11: Current bathymetric map of Alexandria eastern harbor
(after: El Geziry et al., 2007)
2.4. **Submerged platforms of eastern harbor:**

Location of submerged platforms profiles of east harbor (Fig. 12 & 13), show that the harbor platforms become under the current mean sea level MSL between 5-6.5, although the eustatic sea level during from Roman time less than two meters (Pirazzoli, 1991), it means that the erosion rate plus tectonic subsidence were between 3 - 4.5 meters during last two centuries.

![Fig.12: Location of submerged platforms of east harbor (after: Goddio et al., 1998)](image1)

![Fig.13: Bathymetric profiles on the submerged main pier of the eastern harbor (after Goddio et al., 1998)](image2)
2.5. **Tectonic subsidence:**

The results of underwater excavations and side scan sonar survey (Schwartz, 1980; eco-sound survey (Empereur, 1998); Geoarchaeological settlements dating (Goddio, 1998); Sedimentary boring (Goiran, 2001; Stanley et al., 1996 & 2006) in addition to comparisons with the submerged archaeological ruins in Alexandria east harbor show that Alexandria had been the victim of subsidence. To study this specific phenomenon, a team of geographers and marine biologists began in 1997 to examine both underwater and in the silt deposits on either side of the Heptastadion. Some geomorphic features were recognized from analysis the side scan surviving (Chalari et al., 2009) (Fig.14).

Series of cores have been taken since end of the 20 century to define both eustatic sea level change and tectonic subsidence during this period, which the earth's crust of Alexandria eastern harbor had sunk between 6 - 8 meters.

![Fig. 14: Geomorphic change due to subsidence since 331 BC](image)

(after: Chalari et al., 2009)

2.6. **Submerged shorelines:**

The results of side scan surveying and dating in the Mediterranean Sea bottom in front of Alexandria city Chalari et al., 2009) show that submerged shoreline were found in depths 11-14 meters (5625±40Bp and 5650 ±75Bp) in addition to some submerged scarps and ridges in depth 8 meters below MSL (Fig.15 & 16).
Fig. 15: Dating of archaeological remains near Alexandria east harbor (After Goddio et al., 1998)

Fig. 16: Morphology of sea floor around the eastern harbor for paleo shorelines (After: Chalari et al., 2009)

2.7. Current and Paleo geomorphological maps of Alexandria
2.7.1. The current geomorphological map

2.7.2. **Paleo geomorphological map for Alexandria on 331 BC**

Paleo geomorphological map for Alexandria site before construction the city on 331 BC, can be estimated by using the above results (Fig.18), it shows that there are two submerged shorelines older than the city construction (dated about 5.6 Ka BP); Pharos island and Agami Peninsula were greater than the current time as a part of the 1st limestone ridge; Mariut Lake were bigger than today, some interior harbors were found in its northern beach; Alexandria eastern harbor were submerged under sea level between 5-6.5 meters as a result of sea level change and tectonic subsidence and the city constructed on the second carbonate ridge as separated hills.
3. Conclusion

The unique location of Alexandria site due to several physical and human factors, but they also suffered throughout its long history some risks including earthquakes, tsunamis and tectonic subsidence in addition to sea level rise, which may cause the drowned the city.

4. References

- Braun and Hogen,(1575) Map of Alexandria, British museum.


- Roux, (1764) Map of Alexandria, The Hebrew University & The Jewish National & University library, P.L. 120
- http://www.cealex.org/
- http://climate.umn.edu/wind/kaxn