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Early Holocene Paleoenvironmental changes in North of Gavkhouni Swamp- East of Isfahan-Iran: a review of evidence from palynology

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Abstract
This study was conducted for palynological investigation of recent deposits from Segzi and Rangideh areas,east of Isfahan in order to reconstruct past environmental conditions of this region. Studying soil profiles consist of dark layers in depth containing organic matter was recovered. Palynological studies were conducted on soil samples taken from five points from different depths. The results of Palynological and Paleontological investigations on Segzi area indicated presence of different aquatic plants species and also gastropod shells. The results showed that this region had received higher level of water during cold and semi-glacial periods of young Dryas than present due to increased effective moisture and has formed a swamp. Palynological studies on buried Rangideh paleosols indicate presence of such microfossils as Dinoflagellate cysts and Micrhystridium which indicated lake and marine environments which shows this area was influenced by further water, compared to Segzi area.

Keywords: *Palynology, Paleoenvironment, Young Dryas, Organic Matter, Gavkhouni Swamp, Isfahan.*

Introduction

Palynological assessments of the periods prior to the Quaternary and especially Paleozoic, in Iran, received the attention of many researchers, but Palynological study of Quaternary are mainly limited to some of the foreign researchers in the country. Palynological studies, in years 1963 and 1966 by Van Zeist on the bores located on Zarivar Lake of Zagros Mountains, West Iran, showed that during the last glacial period, 14,000 to 22,500 years ago, this part of the Zagros had been covered by the steppes of Artemisia, representing dry-cold conditions (Van-Zeist & Wright, 1963; Van Zeist, 1967).

Various researchers around the world, using Palynological assessments and time communicating in particular by the carbon dating method have studied climate conditions, the vegetation, cycles of becoming hot and cold, and periods of becoming dryness and wet of the Quaternary.

Some of the researchers in different parts of the world such as Brazil, Gondwana land, Southern Alberta, California state, Alberta, East Amazon, Urmia, Iran, Irano-Turanian flora, Turkey and Italy have reconstructed the past ecological conditions, using Palynological evidence from lake-and-swamp sediments of late Pleistocene and Holocene eras. (El-Moslimany, 1986. Behling, 1998. Habrl, 1998. Campbell, 1998; Larook *et al*., 1999; Kel *et al*., 2000; Campbell *et al*., 2000; Behling *et al*., 2001; Djamali *et al*., 2008, 2012; Azizi *et al*., 2013; Sharma *et al*., 2014; Davodi *et al*., 2015; Pickarski *et al*., 2015; Ricci *et al.*, 2015)

Geographic situations of the studied area

In the lowlands of the Segzi and Rangideh areas located 30 and 65 km East of Esfahan, the soils are forming thick and dark layers which contain organic matters. Three profiles in Segzi area have been sampled and studied for the genetic relationship between this layer and dark sediments buried in the two profiles were studied in Rangideh. (Figure 1 and 2)

Geomorphology and geology of Isfahan

The studied soils of the region are located in the watershed basin of Zayanderud river. It is one of sub-basins on the central plateau of Iran. The Zayandehrud River originates from the eastern highlands of Zagros with an average flow of 30 cubic meters per second and after traveling about a distance of 300 kilometers and watering the Isfahan plain, reaches the Gavkhouni swamp. The Gavkhouni swamp is a small and perennial lake surrounded by the marshlands and salty and sludge lands (Jafarian, 1986; Aminian & Folladi, 1975). Based on studies by other researchers, the swamp in the past was much greater and has created terraces

far greater distance than its current shores (Ramesht, 1996). The studied soils in Rangideh are located on the old terraces of the Gavkhouni lake, given that the lake's sediments located at the most far end of the river's watershed, it is influenced by the sediments collected from the whole area.

The sediments which come from plains of Segzi area would be affected by the outputs of sub-basin of the watershed called Murghab in Esfahan province. Therefore, the parent materials of this watershed of the Zayandehrud have overshadowed the sediments. The diverse deposits have been formed through the river, by sedimentary, igneous and metamorphic rocks. A wide range of rocks covers the Zayandehrud's basin, from Per-Cambrian era to those of Paleozoic, Mesozoic and Cenozoic ages.

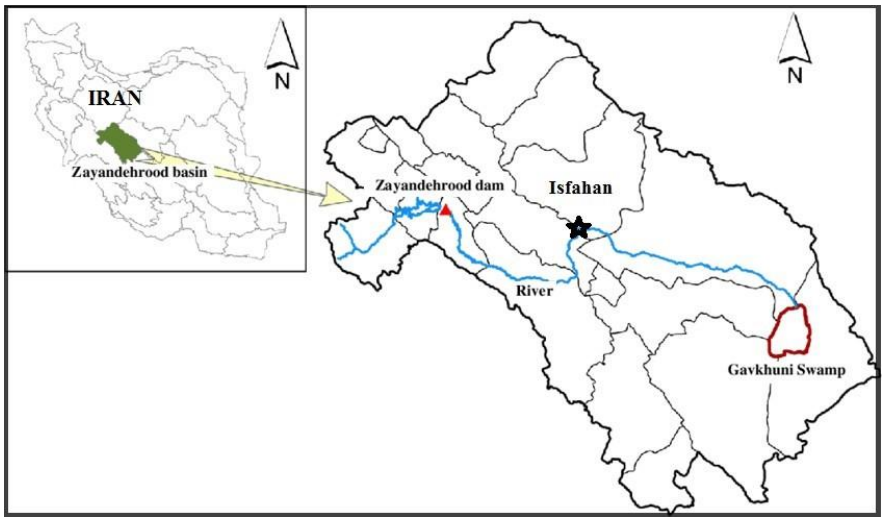

Figure 1. Zayanderud Basin and Gavkhouni swamp location.

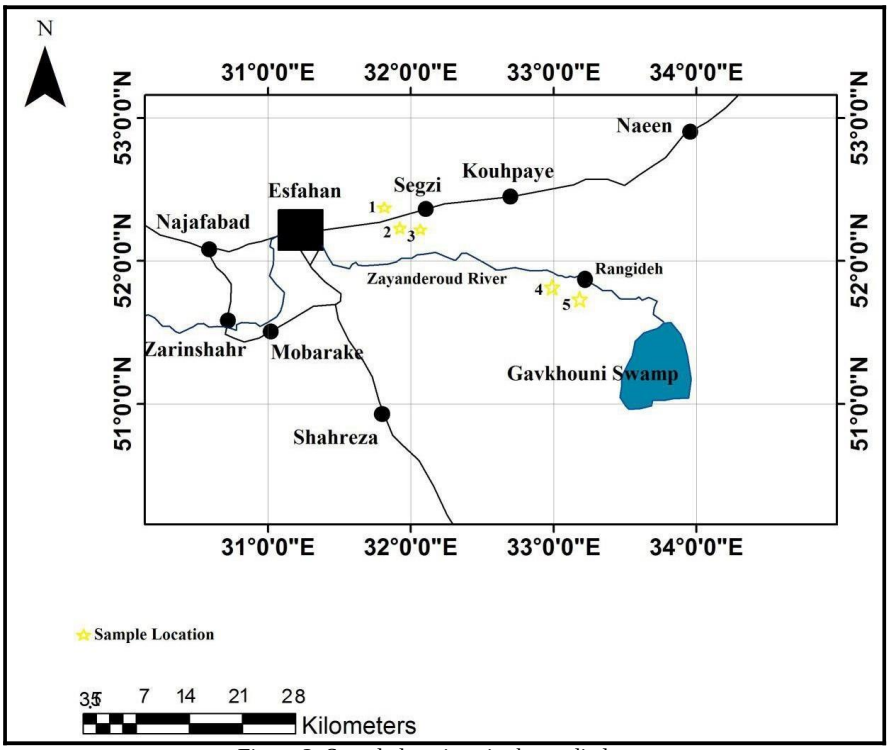

Figure 2. Sample locations in the studied area

Field and laboratory works

By digging deep sections and refreshing of normal levels in Segzi and Rangideh, three samples of dark-colored layers were taken from three different depths from Segzi and two of black layers from Rangideh area for Palynological studies (Figure 3).

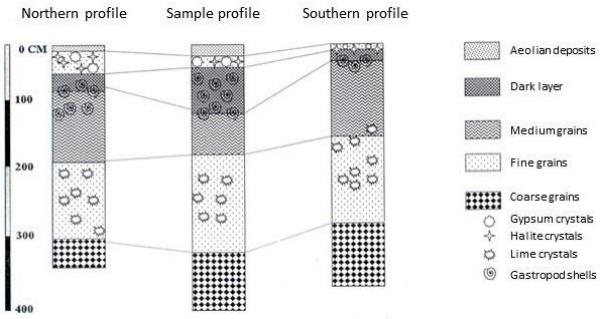

Figure 3. Different formations, texture, thickness of the various layers in the region of Segzi (East Isfahan)

First, the samples containing Palynomorphs were crashed in a small mortar and treated by hydrochloric acid 10% and Fluoric acid 40%, the minerals were removed. Then, in order to isolate heavy minerals, the sample was sunk within the zinc bromide ($ZnBr_2$) solution and palynomorphs were separated from unwanted heavy minerals and organic materials. Then slides prepared by recovered palynomorphs and studied by microscope Olympus BH2.

The absolute age of organic coal-made samples from two different depths in Segzi area were also determined by Accelerator Mass Spectrometry for detecting activity of carbon 14 in those samples.

Palynology

Palynological studies in Segzi and Rangideh were conducted on the samples taken from the profiles drilled. The results of observations and counting of palynomorphs show no significant differences in depth under study in terms of abundance and varieties of species.

The palynomorphs are identified by consulting available literatures up to the family, genus, and sometimes species. The samples under biological appropriate conditions and their origins are divided into the following groups (Figure 4).

A. Hydrophilic plants

Hydrophilic plants found in the layer under study varies from some great hydrophilic plants, some low vascular plants and some algae. The genus, *Nympheacidites* from Nympheaceae family (Plate 1, Fig.1) and *Lilium sp.* from Liliaceae family (Plate 1, Figs.,16) are forms that can grow mainly in watery and echoic conditions. *Illex aquifollium* from Aquifoliaceae family (Plate 1, Figs. 3, 10, 19) belongs to ever green, hydrophilic shrub plants.The genus,Monosulcites and Polypodium from Polypodiaceae family appertain to swamp areas (Tabaei, 1999). Aquatic fern spores "Azolla" were also recorded (Plate 1, Fig.7). Species of *Agrostema githago* (Plate 1, Fig.8) from Caryophylaceae family (Van Zeist, 1967) shows that the land was wet. Trilete spores are belonging to low vascular plants (Petrophytes) and brackens are abundantly observed in the samples under study. Species of genus *Salix* (Plate 1, Fig.5) from the Salicaceae family is a plant that has been mainly reported in the margins of lakes (Van Zeist & Wright, 1963; Van Zeist, 1967).

The genus *Taxodium sp.* from Taxodiaceae family (Plate 1,Figs. 6,14) is a kind of shrubs entitled swamp cypress (Mozaffarian,1996) or pond tree are special to swamp and water-full areas. A prominent feature of the pollens from this family would be highly sensitive relative to humidity of the air. Once placed in dry condition, the outer cell wall gets cracked. The cracks viewed on the images results from this process. The genus Lecaniella is of freshwater algae and is reported by other researchers (Yi, 1997) in Quaternary marine sediments. It is also emphasizing on the watery conditions, presenting different species of algae containing *Lecaniella triplidiscus* and *Lecaniella multigonata* (Plate 1, Fig. 23). Acritarch of genus Michrystridium (Plate 1, Fig. 22) was observed in the samples from Rangideh. This grows and propagates over lake and marine environments of high-level water (Ghavidel – Seyoki, 1992). From dinoflagellates phylum family, the genus *Fromea sp.* is a prominent sample (Plate, Fig. 18), which is typical for marine areas and in some cases has been reported in continental freshwater (Jansonious, 1989).

(B) Xerophilous plants

Xerophilous species observed in the study layers include the plants which have mainly been growing in the mountainous and dry areas. Examples of Graminae family are among them. The Artemisia genus (Plate 1, Fig.13) is from the Composite family and has been attributed to the cold periods in Zagros regions by Van Zeist and Wright (Van Zeist & Wright, 1963).

Plate 1: Images of the plants remain (hydrophilic, xerophilouses, fungi and reworked), 1-*Nympheacidites* sp., 2,16- *Lilium* sp., 3,10,19-*Illex aquifollium*,4- *potamogetonacidites* sp., 5- *Salix* sp., 6,14- *Taxodium* sp.,7-*Azolla* sp., 8- *Agrostemna githago*,9- *Arauacaria sp.* , 11- *Ephedra* sp., 12, 27- *Cycas* sp., 13- *Artemisia* sp., 15- *Brachysporiporites sp*., 17- *Petrocarya* sp., 18- *Fromea* sp., 20- Fungal Remain, 22- *Michrystridium* sp., 23- *Lecaniella multigonata*, 24- *Hypoxylonites* sp., 25- *Ginkgoretectina vastus* (Reworked), 26-*Palmidites* sp. (Reworked), 28- *Cheilanthoidspora enigmata*, 29- *Potamogetonacidites* sp., 30- Trilete Spore.

Another important genus called *Araucaria sp.* from Araucariaceae family (Plate 1, Fig. 9) have a significant abundance in samples from this period, taking up mainly cold and dry regions to the highlands as a habitat (Sah, 1967) and generally consists of perennial plants and shrubs. The genus, *Ephedra sp.* from Ephedraceae family (Plate 1, Fig. 11) is also of Xerophilous species that has grown in wide range of temperate deserts to the mild and mountains regions (Mozaffarian, 1996). Among the species of *Triticum* sp. from Graminea family, genus *Alisporites* sp. from gymnosperms and *Petrocarya* sp. (Plate 1, Fig.17) and Carya from Juglandaceae family, based on the palynomorphs observed in Rangideh indicating drought conditions can be noted (Mozaffarian, 1996).

C: Fungi

The fungi are mainly associated with hot and humid conditions, but sometimes have high prevalence in mild and wet conditions (Glass *et al*., 1986; Ediger *et al*., 1989; Kumar, 1990). Totally, for the fungi, the humidity is more important than temperature, although cold temperatures, severely limit their activities (Ediger *et al*., 1989). Fungal spores observed in these samples include different genera and different arrangements. The genus *Neothyrites sp.* and Brachysporiporites would be the examples of these fungi. The remainders of fungal masses would be seen in form of tetrads and fourfold and various solitaire mass. In Rangideh region, genus Hypoxylonites (Plate 1, Fig. 24) was introduced as prominent example with cold and temperate conditions (Elsik, 1990). In addition, the genus Spirotremesporites (Plate 1, Fig. 31) along with remainders of other fungal species were found in the samples.

D: Reworked Palynomrphs

From the most important species and genera found in this group, species of T*odisporites* sp. and *Cheilanthoidspora enigmata* (Plate 1, Fig.28) and genus *Drosera sp*. were originated from old sediments. The Dictyophyllidites from Matoniaceae family is originated from Tertiary sediments from the ayandehroud basin. Trilet spore of the genus *Palmidites sp.* (Plate 1, Fig. 26) and genus *Lepidolepidites sp.* from Palmaceae family were also originated from the Tertiary sediments. The species of *Ginkgoretectina vastus* would be one of the prominent palynomorphs of Mesozoic being moved to this location in detrital (Plate 1, Fig.25).

The marine microfossils, which are known as micro-plankton, were identified in this period. These pertain just to the marine environments and are related to older depositional environments than Quaternary transferred by erosion to the new environment.

Conclusion

The results of palynologically qualitative and quantitative studies have shown that pollen and spores and other microfossils distributed similarly in different soil layers of Segzi. Based on studies of carbon dating by Ayuobi (Ayuobi, 2002), it was obtained that layer ‘s age is from 10200 to 10800 years old, at the highest and the lowest point, respectively, and during this period of several hundred years, environmental and ecological conditions prevailing in the region has been uniform. These conditions include humidity, temperature and amount of water entering the area that finally has controlled the vegetation.

The dominant vegetation in the study samples of different depths include mainly plants which are hydrophilic and grow in wet areas. The simultaneous presence of pollen and spores of the hydrophilic grasses along with hydrophilic trees such as Salix and Taxodium indicate water conditions to be of the swamp type. According to the Palynological results, the studied lands would be accounted for an old swamp. The hydrophilic plants growth, especially trees in an area that is now quite dry and is often the target of the sand deposits over many years corroborates the fact that at the time of the formation of these deposits (about 11-10 thousand years ago), due to higher rainfall and lower temperatures compared with currently the regional catchment area, more moisture had been transferred to the location and the swamp conditions have been created. Those conditions were much more moderate than today's, because it was not observed any trace of grass and dry and desert plants such as Chenopodiaceae family in all cases. As Zeist and Wright (1963), when studying Lake Zarivar in the Zagros, showed that the abundance of the genus Artemisia of Palynologic samples indicate the colder periods in the watershed. Therefore, it can be concluded that in 10-11 thousand years ago in the watershed over looked on the region the climate was colder than today's. The cooler climate caused increased effective moisture and decreased evapo-transpiration. Of course, the weather was not cold

enough to prevent the propagation and growth of fungi in the lowlands of the watershed, because a large variety of fungi were found in the samples. Since the growth and activity of fungi is often limited in low temperatures the temperature could be too low. This conclusion reinforces the theory that the colder the weather becomes, the wetter the climate is. On the basis of the samples' age, the strati-form row under study in terms of time is coordinating with time-climate periods of younger Drays with age of about 10-11 thousand years ago. During this period, in transition range between the last glacial period and the beginning of the last interglacial period, it was reported several cold and wet periods in the US, Europe and Asia (Uoe *et al.*, 2001, Uoe 2000). Coincidently occurring these cold time periods of the higher latitudes, the relevant Cyclones could also overshadow the lower latitudes such as Iran.

Among the most important environmental indicators of Rangideh, would be the presence of two different types of Palyonomorphs that make this region distinguished seriously from Segzi. As mentioned in section of the result from Segzi region, the area has been like a swamp; but, the present palyonomorph of Fromea and Micrhystridium associated different conditions. Microfossils Fromea belongs to Dinoflagellate class and lived only in the environmental conditions filled with fresh waters and sometimes in continental lakes of freshwater (Jansonious, 1989). Also the presence of the acritarch Micrhystridium confirms lake conditions and the depth of water to be relatively high. Therefore, due to the presence of these indices, it can be acknowledged this would be one surface of the oldest terraces of the Gavkhouni lake that experienced a greater volume of water than the Segzi region to hold the mentioned species within.

The presence of such fungi as Hypoxylonites that grows at low to moderate temperatures could lead us to conclude that during the time when developing Gavkhouni Lake up to the study level the climate had been colder and wetter than today to be able to have the bulk of the water.

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