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RESEARCH ARTICLE

A study on the Salt (Urmia) Lake in northwest of Iran focused on sediments lakebed

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INFORMATION

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ABSTRACT

Lake Urmia, as the largest and saltiest permanent lake in Iran, being also known as one of the world's largest and saltiest lakes, has emerged after the last glacial period due to the tectonic activity of compressive faults specially Tabriz and Zarrineh-Rud faults in the northwest of Iran. This relatively young lake has stone foundation being composed of limestone and marlstone without any folding (Qom Formation) in Miocene Epoch on which about 30 meters of soft lake sediments are deposited. More than 80% of these deposits are chemical and evaporative along with mainly aragonite, calcite, and halite minerals with biological origin. The presence of clastic thin layers consisting of quartz, feldspar and kaolinite, especially at the entrance points of the rivers, indicates temporary climate change and lake salinity. The thickness of the evaporitic sediments has remarkably increased with depth decrease in the southern part of the lake along with the increase in evaporation, causing the emergence of more than 56 small and large islands in this part of the lake. Succession of evaporitic sediments in some parts of the lake has deposited sulfate minerals such as gypsum and anhydrite in very fine shapes. In addition, in the swampy areas of the lake, sulfur sediments can also be seen as sedimentary laminates.

1. Introduction

Lake environments are by definition a closed water mass in the continental areas, being formed under the influence of tectonic processes and depending on how water gets to it, they can be permanent or seasonal (Darvishzadeh, 2006). Most of the lakes in temperate climate regions are of permanent type and depending on the amount of salt present in the water are divided into different types, including very saline lakes such as Dead Sea, Great Salt Lake in Utah, and Lake Urmia (Tucker, 2013).

The study of such lakes due to their specific characteristics (high salt content) is done more from the point of view of chemistry, physics and biology and the sedimentology of the lake bed has received little attention due to the complexity of its deposition. Lake Urmia as the world's third Salt Lake is no exception and there is little information on the geology and sedimentology of the lakebed. There are a number of studies mostly geological around Lake Urmia carried out by researchers (Shahrabi, 1981; Shahrabi, 1986; Alipour, 2006; Imanifar and Mohebbi, 2007; Hassanzadeh et al., 2012; WRI, 2006; Tisseuil et al., 2013; Abbaspour and Nazaridoust, 2007; Farzin et al., 2012; Sima and Tajrishy, 2013; Jaafari et al., 2013; Tourian et al., 2014; Soudi et al., 2017; Musapour et al., 2019).

Lake Urmia, one of the largest saltwater lakes on earth and a highly endangered ecosystem, is on the brink of a major environmental disaster similar to the catastrophic death of the Aral Sea. Once with a surface area of approximately half a million hectares, Lake Urmia's shoreline has been receding severely with no sign of recovery, leading to a significant shrinkage in the lake's surface area. Situated ≈1273 m above the sea level, this shallow terminal lake is surrounded by a range of high mountains (UNEP, 2012; Ghaheri et al., 1999; AghaKouchak et al., 2015).

The lake is the world's largest habitat of brine shrimp Artemia (Artemia urmiana), which is a major food source for migratory birds such as flamingos, pelicans, ducks and egrets (Barigozzi et al., 1987; Vahed et al., 2011; Ahmadi et al., 2011). The intensity of bird migration to the area largely depends on the primary production of Lake Urmia, and particularly on availability of salt-adjusted brine shrimp (Karbassi et al., 2010; Eimanifar and Mohebbi, 2007; AghaKouchak et al., 2015).

Lake Urmia is one of the biggest saltwater lakes in the world. This lake basin is one of the few watersheds in the world that 10% of its area is covered by water. Unfortunately, for various reasons the Urmia Lake was much closed to die. It has attracted the world's attention to itself. It is clear that the Urmia Lake Basin Rivers have the most important role on its rescue plan. It is obvious that if all rivers flows reach into the Urmia Lake, it will be saved earlier but it is known that several harvest is done along the rivers and prevent to reach water into the Urmia Lake (Tharme, 2003; Alagoz and Yasi, 2018).

In this study, by collecting the results of previous studies and analyzing them, it is attempted to provide a model for sediment deposition and type of sediment deposits in this lakebed.

2. General Characteristics

Lake Urmia with a variable surface area of 4750-6100 km^2 (Eimanifar and Mohebbi, 2007) and coordinates of 37° 42' N and 45° 19' E is located between the provinces of East Azerbaijan and West Azerbaijan. It is one of the types of permanent evaporative lakes and with maximum temperature of 30°, it has an average annual rainfall of 340 mm. The water of this lake is supplied by the surface flow of rivers, groundwater and direct precipitation to the surface of the lake. The largest share of water comes from surface waters consisting of 13 permanent rivers, 7 seasonal rivers, and 39 flood flows (Shahrabi, 1993).

3. Morphology

In satellite imagery, as seen in Fig. 1, Lake Urmia has the same shape as Caspian Sea, and in fact it can be thought of as a Caspian Sea shrinking in size. This lake with the approximate length of 140-144 km and width of 61-63 km is in the north-south direction (Shahrabi, 1993; Alipour, 2006). The morphological slope of this lake is to the north, and for this reason, the depth of Lake Urmia measures at most 16 m in the northern part of it and at least 3.5 m in the southern part (Eimanifar and Mohebbi, 2007).

It should be noted that over the past 10 years, due to drought in this area, the Lake's water level has fallen more than 3 meters, resulting in a dramatic decrease in the Lake's depth. Lake Urmia is located at an altitude of about 1250 meters above sea level and is enclosed between high hills (Shahrabi, 1998). The activity of the Alborz fault in the north of the lake has made the northern part of the lake higher and created a water flow to the south (Alipour, 2006).

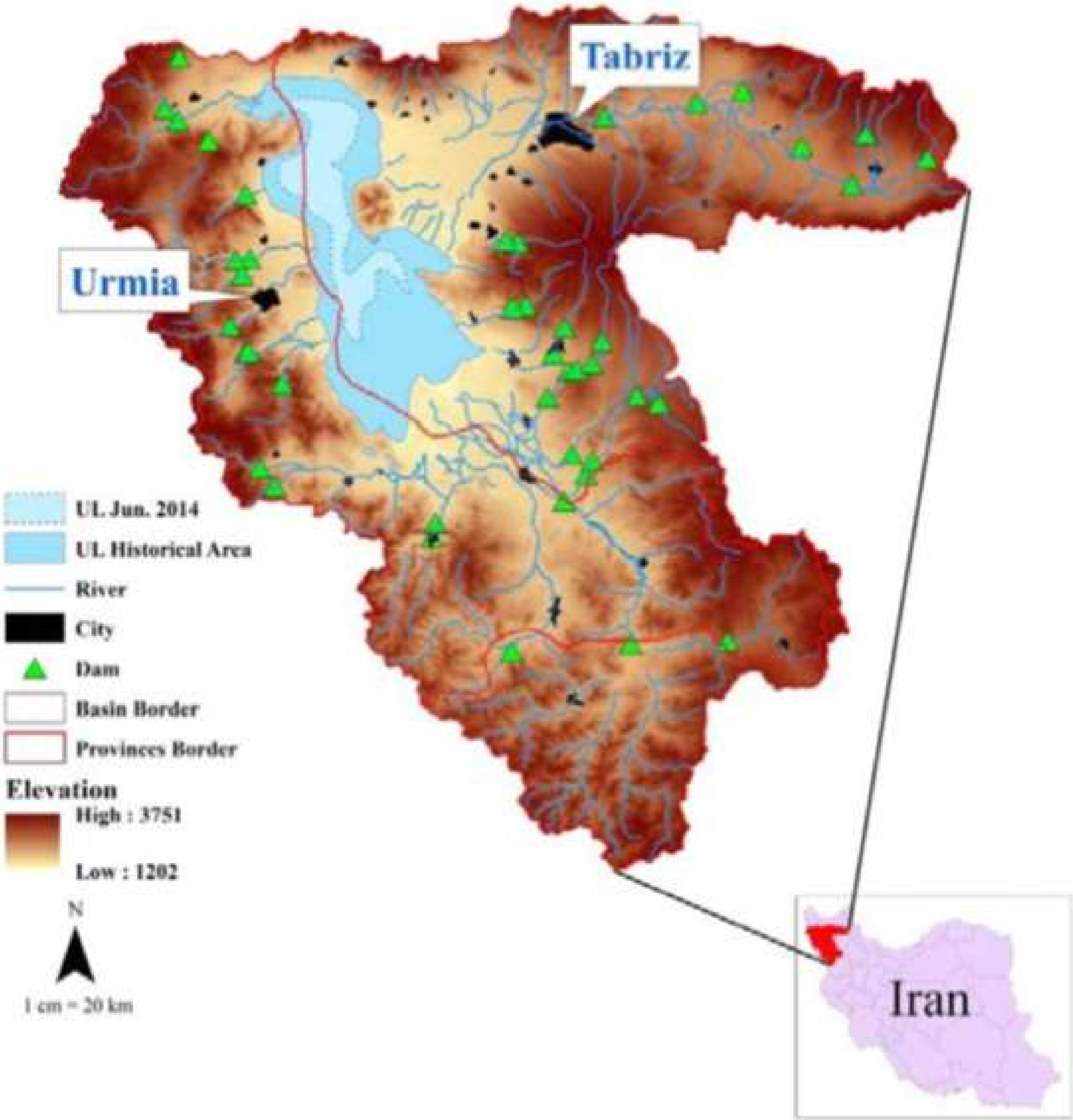

Fig.1. The satellite photo of Lake Urmia

4. Geology

From the plate tectonic point of view, Lake Urmia has a relatively young graben which is located in the split zones between the Arabian and Iranian plates and the micro plates of Iran and Turkey being formed after the last glacial period due to the tectonic activity of compressional faults in the northwest of Iran such as Tabriz fault located (in the north of the lake) and Zarrine-Rud fault (in the south of the lake) (Fig. 2) (Shahrabi, 1998; Darvishzadeh, 2006). The formation time of the lake, according to the information from the sediments of lake gullies, is estimated to be 400-500 thousand years ago, but its present shape is formed 30-40 thousand years ago. Palynological evidence from Lake Urmia indicates a late Pleistocene to early Holocene history (Jamali et al., 2008).

There are a number of volcanic domes exposed within Lake Urmia and its around. Some of them are the Sahand volcanic complex, Eslamy peninsula and Bezudaghi volcanos. The basaltic and andesitic lavas of these volcanoes are attributed to the Arabia-Eurasia collision active in the Quaternary times (Kheirkhah et al., 2009). The Paleozoic metamorphic rocks are exposed in the west of Lake Urmia. The Mesozoic carbonate, sandstone, and quartzite occurrences outcrop in the south and southeast. The coralline limestone aged Early Miocene crops out along the northwestern shores and on many of the islands in the lake. The northern part comprises Eocene to Miocene evaporate-marl sequences and overlying red conglomerate occurrences (Mohajjel and Taghipour, 2014).

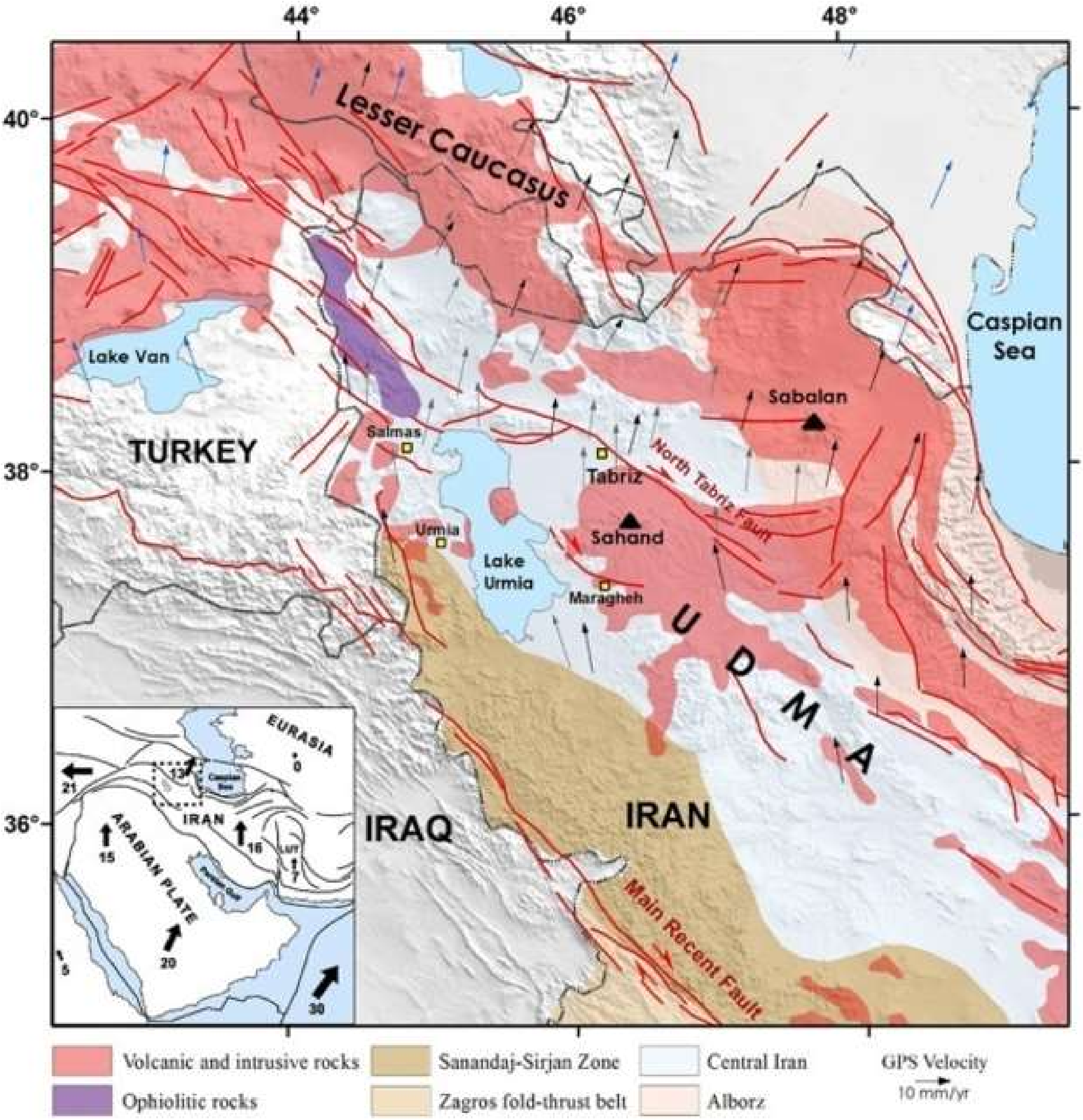

Fig.2. Location of the faults around and the bed of Lake Urmia

5. Sedimentology

The stratigraphic studies of the sediments of Lake Urmia bed show that the basement of this lake is composed of thick layers of limestone with green marls and shales of the Miocene Qom Formation and it is covered with about 30-45 m of soft sediments with solid storage of more than 5 billion tons of deposit (Darvishzadeh, 2006). These sediments are divided into clastic and chemical sediments according to climatic conditions, water chemistry and water intake scheme of the area (Moussavi-Harami, 1988).

Clastic sediments transported by rivers into the lake environment, being affected by the type of sediments around the lake, contain quartz, feldspar, especially plagioclase, calcite and kaolinite minerals, and are deposited as thin layers on the estuary of most of the rivers and specially sides of the lake and mostly in the northern part of it (Eimanifar and Mohebbi, 2007). In the central and western part of the lake, these types of sediments are formed like lenses.

Chemical sediments, especially evaporitic rocks, are the major deposits of Lake Urmia which are influenced by the evaporation and geochemistry of the lake water and also by the amount of incoming solute by the rivers, producing various types of evaporitic minerals in different areas of the lake. The origin of these sediments is chemical and biochemical, which is caused by the concentration of ions in the lake water or the dissolution of calcareous organs of the lake's living creatures including green algae like Oundella and crustaceans such as Artemia Salina and bacteria. In addition to providing the ions needed to form sediments in Lake Urmia, these organisms play an important role in the survival of the lake and preventing its destruction (IWRM, 2019).

Mineralogically, aragonite is the major constituent of evaporitic sediments which accounts for more than 80% of evaporitic ores. This mineral in the form of regular and irregular thin blades has created beautiful landscapes in evaporitic sediments on the western side of the lake and north of the Golmankhaneh. The calcite mineral, which is mostly of biochemical origin, is the second evaporitic mineral in the sediments of the Lake Urmia bed. Dolomite, in shape of fine crystals (less than 10 microns) within the studied sediments, is formed secondarily and alternatively.

Swallowtail gypsum with quartz and mica are found (Alipour, 2006) in sediments of the lake's volcanic shores, reflecting climate change in the region. Halite (NaCl) and sodium feldspars are seen only as minor minerals along with other evaporitic minerals, and contrary to the assumption that a high percentage of halite mineral should be formed due to the high concentration of sodium and chlorine ions in the lake water, this mineral does not form in any part of Lake Urmia separately indicating that Lake Urmia water has never dried completely. Another type of chemical sediment that is found in the marshy areas of the lake is sulfur sediments which are visible as sedimentary laminates.

6. Conclusion

Submarine lavas of Heiran area has been formed above a convergent zone with an extension in late Cretaceous and early Tertiary. Results of geothermometery, geobarometery and Mg# of clinopyroxenes show high temperature and low pressure during the formation of rocks, which confirm the extensional environment. Some geochemical features in these rocks such as enrichment with LREE and LILE and depletion from HFSE indicate the effect of subduction parameters and consequently the formation of these lavas in correspondence with the subduction zone in the back arc basin. This is quite similar to the formation of ophiolites corresponding to suprasubduction environments. These lavas have probably originated in lithospheric mantle as a result of the effect of fluids emanating from subducted plate and have been contaminated with crust during the rising procedure. The transitional alkaline lavas in the marginal ocean along the southern Caspian Sea, which are likely to be Sevan-Akera-Qaradagh back arc basin, have formed submarine structure in late Cretaceous-Eocene and have probably been overthrusted in late Paleocene on the northern Alborz as a result of the complete closure of this ocean.

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