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Introducing the Second Version (2020) of Geothermal Potential Map of Iran

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ABSTRACT

In case of geothermal prospects, Iran has a plenty of geothermal regions which are spread through the country. The first geothermal map of Iran has been generated by the former Renewable Energy Organization of Iran (SUNA) in 1998. Due to the some problems and also implementing of several projects about identification of geothermal resources in the country the second version of geothermal energy map of Iran has been created recently. The new map is much more accurate than its previous one. New map mainly has been generated based on the location of warm springs in the country. Based on the new map it is found that 152 geothermal prospects exist in Iran. Also, it is recognized that Kerman, Hormozgan, East Azarbaijan and West Azarbaijan provinces are the top 4 geothermal rich provinces in Iran. Study on the identified prospects revealed that except a few regions almost all of the Iranian geothermal resources are low to moderate temperature. Hence, they are useful for direct use projects or power generation by binary geothermal power plants.

1. INTRODUCTION

Geothermal activities in Iran dated back to 45 years ago when Mr. McNitt for UN visited the country. He found that Iran has a reasonable geothermal potential. In 1975, ENEL Company started to investigate Iran for geothermal prospects in northern and north-western parts of the country. Consequently, four geothermal regions called Sabalan, Sahand, Maku-Khoy and Damavand have been identified [1].

In 1998, former Renewable Energy Organization of Iran (SUNA) generated the first geothermal map of the country. This map had some problems and might be updated. So, in 2019, Niroo Research Institute (NRI) and Iranian Renewable Energy and Energy Efficiency Organization (SATBA), in a mutual cooperation updated the previous version of geothermal map of Iran. The new map basically is generated based on the location of warm springs.

2. PREVIOUS MAP

The first geothermal map of Iran has been generated in 1998 by former Renewable Energy Organization of Iran (SUNA), Figure 1. It is very old and recent studies showed that there are many geothermal prospects which are not mentioned in this map. Based on this map, 14 geothermal regions have been recognized in the country.

During the past 22 years this map hasn't been updated. Due to the large size of some geothermal regions they are not suitable to recommend for energy investors. As it can be seen in the figure 1, some of the geothermal prospects have more than several thousand square kilometers area which is very large for further exploration activities. Therefore, decreasing the prospect's area was one of the reasons for generation of the new geothermal map.

So, due to the lack of accurate data and also other problems, it was necessary to update previous map. Besides, during the past two decades, many governmental organizations, research institutes and universities have implemented several projects in order to find geothermal prospects in different parts of the country. Therefore, the results of the geothermal projects can be used properly for updating of the previous map.

3. STUDIED PROVINCES

As a part of nationwide geothermal resource assessment in Iran, during the last decade, five provinces in different parts of the country have been studied systematically. They include East Azarbaijan, West Azarbaijan, Ardabil, Qazvin and South Khorasan provinces, Figure 2. These projects were financed by different governmental organizations such as former Renewable Energy Organization of Iran (SUNA) and Vice- Presidency of Science and Technology of the presidency of the Islamic Republic of Iran. These projects had a vital role in developing and promoting the knowledge of the Iranian scientists in the field of geothermal exploration, both in preliminary and detailed exploration methods and techniques. Several universities were involved in the geothermal exploration projects such as Tehran University, Isfahan University of Technology and Shahrud University of Technology. During the past 10 years some MSc students have conducted their thesis about geothermal prospects of Iran. In this study, a lot of data have been extracted from these dissertations.

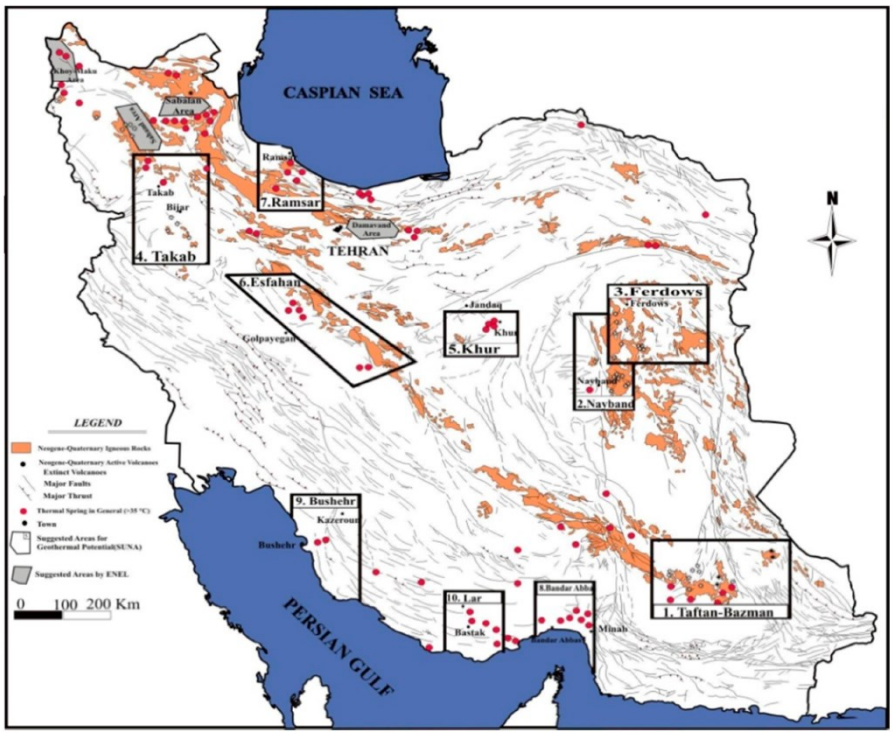

Figure 1. The first version of geothermal map of Iran [6]

Figure 2. Location of geothermally studied provinces in Iran [5,6,7]
(WA: West Azarbaijan, EA: East Azarbaijan, AD: Ardabil, QA: Qazvin, SK: South Khorasan.)

Almost in all of them, similar exploration methods have been applied in order to determine geothermal prospects. These methods were digitizing and analyzing available 100 k geological maps, remote sensing techniques using ASTER satellite images, interpreting of the available aeromagnetic data, sampling and analyzing warm springs, integrated interpretation of the obtained data and finally

recognizing geothermal regions in each province. Also, in some of them gravity surveys have been conducted for achieving better knowledge about the nature of the identified geothermal resources. According to the obtained estimated temperature of the determined geothermal resources, in many cases possible application of geothermal fluid have also been suggested to the Ministry of Energy. Table 1 illustrates some general results of geothermal studies in above – mentioned provinces.

Table 1 – General results of systematic geothermal preliminary exploration in five provinces of Iran [5,6,7]

Provinces Name	Area (km^2)	No of warm springs	Water springs Temperature range (°C)	Number of geothermal prospects
East Azarbaijan	45491	36	25-53	22
Ardabil	17880	31	28-86	6
West Azarbaijan	43000	37	26-57	12
Qazvin	15640	5	30-53	2
South Khorasan	150732	8	31-38	3

Finally, 45 geothermal regions have been identified in the studied provinces. Each region has its own characteristics such as area, geological and geothermal map, estimated geothermal reservoir temperature, first conceptual model and suggested possible future applications and so on.

4. DATA GATHERING

In order to generating the second version of the geothermal map of Iran, all efforts were focused on the collecting of reliable data about surface manifestations of geothermal resources in the country. These manifestations are the first indications or evidences for the existence of a potentially exploitable geothermal resource. The manifestations can be of various types, ranging from active hot springs and fumaroles to hot and steaming grounds and cold but altered grounds indicating extinct geothermal activity on the surface [2]. Among the surface manifestations warm springs are the most common and well-known features. In fact, warm springs are some of the recognizable surface manifestations of thermal fluid circulation at depth, [3]. Hot/warm springs are primary indicators of the presence of geothermal fluids. Sometimes a very small spring or diffuse ascending seepage at the surface indicates an underground geothermal reservoir. Usually such natural drainage is possible through faults, fractures, or joints. The spring yield then directly depends on the size and aperture of the discontinuities allowing the circulation of the fluid (water, steam, or gas), [4].

In Iran, there isn't any active volcano. There are a few high-temperature surface manifestations as well. Hence we focused on the location and some other information about warm springs all over the country. In the past, due to the lack of precise equipments, warm spring's location was not accurate. So, in order to generate new geothermal map, during the several months some scientists have searched every available accurate data about warm springs. Mostly they are found in M.Sc and PhD dissertations, ISI and conference papers, some reports, maps and the data from five pre-studied provinces as well. The later data have been generated by the former Renewable Energy Organization of Iran (SUNA).

We tried to not use any unreliable data in order to increasing the accuracy of the new map. During implementing this search, it is found that plenty of data were gathered which are from unknown sources, so we did not use them. In contrast, a unique technical report was found about warm springs of Kerman province. It was very helpful for us.

5. NEW MAP

At the end of searching data about warm springs of the country, a lot of data were collected from different sources. In the next step, all data had been classified based on the province's names. Finally, we converted all data to shapefiles to use them in Arc GIS software. Definitely, by processing new data we eliminated many enormous geothermal regions in the previous map. According to the available databanks, it is revealed that some provinces have not been studied systematically about their warm springs. Based on our experience, it is recommended that those provinces should be studied in near future to prove their geothermal potential confidentially. In figure 3, number of warm springs and also number of geothermal prospects in geothermal bearing provinces of Iran are shown.

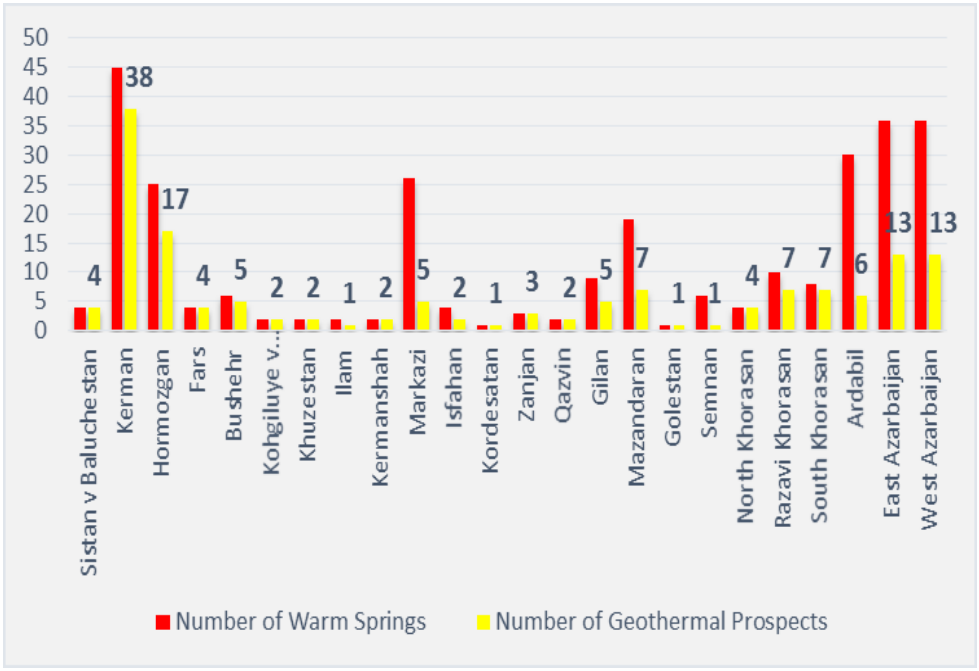

Figure 3. Number of warm springs and geothermal prospects in geothermal bearing provinces of Iran [5-36]

Moreover, we georeferenced available 1:1,000,000 geological maps to extract major faults and also young volcanic rocks in the new map. Those geological maps have been generated by Geological Survey of Iran (GSI). For generating of the map we consider at least 7 Km distance between the warm springs [8].

Regarding the temperature range of warm springs obviously, it is found that a major part of geothermal regions in Iran are low-moderate temperature ones.

6. GEOTHERMAL PROSPECTS IN IRAN

Finally, 152 geothermal prospects were found in 24 provinces in Iran, Figure 3. According to figure 3, Kerman provinces (38 prospects), Hormozgan provinces (17 prospects), East Azarbaijan and West Azarbaijan with seven prospects each are the top four geothermally rich provinces in Iran. After gathering all of these data, second version of geothermal map of Iran, was provided, Figure 4. Based on the available data, it is recognized that hottest warm springs in Iran are located in Ardabil (86 °C), Kerman (73 °C) and Mazandaran (63 °C) provinces. According to the present data it is revealed that among all of the Iranian provinces, 7 provinces haven't any surface manifestations of geothermal energy. They are Tehran, Qom, Lorestan, Yazd, Alborz, Charmahal va Bakhtiari and Hamedan provinces. No doubt, after implementing of exploration projects in these provinces, their geothermal potential would be proven confidentially.

As it is shown in figure 4 geothermal prospects distribution in the country isn't equal. There are two distinctive rich geothermal sections in the northwest and the southeast of Iran. A few prospects are located in the central parts of the country. Also, in the northeastern and southwestern parts some disperse geothermal prospects can be seen. Also, there is a meaningful relation between geothermal prospects and Alborz and Zagros Chain Mountains in Iran. Alborz Mountains are located in the north of Iran and it is elongated from northwest to the northeast of the country. It is formed from the west to the east at the northern part of Iran. Zagros Mountains are formed from northwest to the southeast of the country. These Chain Mountains are the main mountainous regions in the country. Probably, correlation of geothermal prospects and those two chain mountains are due to the presence of large and deep vertical faults and a reasonable rainfalls and snowfalls in the cold seasons in those regions.

There are five volcanoes in Iran which all of them have their own geothermal resources. They are called Sabalân, Sahand in the northwest, Damâvand in the north and Taftân and Bazmân in the southeast of the country.

7. CONCLUSIONS AND RECOMMENDATIONS

The second version of Iranian geothermal map have been generated mostly based on the location of the warm springs in the country. According to the new map it is revealed that there are 152 geothermal prospects in the country. Mainly, they are low to moderate temperature prospects. Kerman, Hormozgan, East Azarbaijan and West Azarbaijan provinces are the top four provinces which have the highest geothermal potential in Iran. Most of the determined prospects are applicable for direct use purposes and also useful for binary cycle geothermal power plants. By conducting of this study it is found that based on the available information, 7 provinces including Tehran, Qom, Lorestan, Yazd, Alborz, Charmahal va Bakhtiari and Hamedan provinces have no geothermal potential at the moment. It is strongly recommended to study the potential of geothermal energy in a nation- wide scale or at least individually for each province. Besides, in order to collect more data about the potential of geothermal energy in Iran, it is highly recommended to update the present map in 5 or 10 years later.

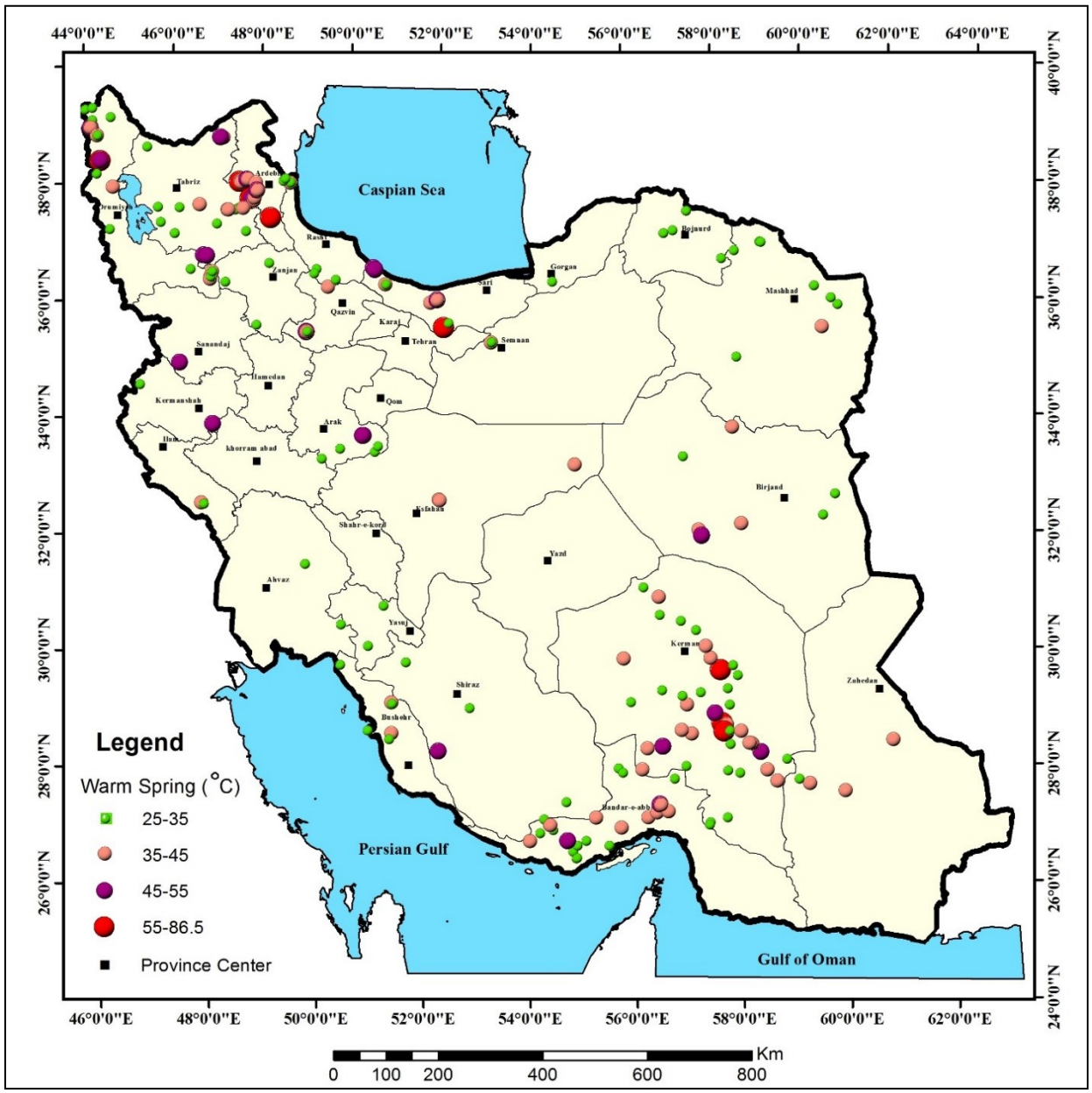

Figure 4: The second version of geothermal Map of Iran [5-36]

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