PROCEEDINGS, Thirty-Second Workshop on Geothermal Reservoir Engineering
Stanford University, Stanford, California, January 22-24, 2007
SGP-TR-183

GEOTHERMAL POTENTIAL SITE SELECTION USING GIS IN IRAN

Hossein Yousefi, Sachio Ehara, Younes Noorollahi

Department of Earth Resources Engineering, Kyushu University
744 Moto-oka, Nishi-ku, Fukuoka, 819-0395, Japan,
Hyousefi2000@yahoo.com

ABSTRACT

In this study, a Geographic Information System (GIS) is used as a decision-making tool to target potential geothermal resources in Iran. The aims of the study are to update and identify promising areas for geothermal exploration, as the base study for the future regional-scale geothermal resources investigations and exploration drilling.
After comprehensive study about available data in the country, and important data layers for site selection of geothermal area, firstly, the available data layers for geothermal resource exploration in national scale are summarized in three datasets; Geological dataset (volcanic rocks, volcanic craters and faults), geochemistry dataset (hot springs and acidic hydrothermal alteration zone) and geophysical dataset (micro seismic epicenters and shallow intrusive bodies). Secondly an integration model in GIS environment was programmed and run and then promising areas were marked as nationwide geothermal potential sites.
In this knowledge-driven based GIS method, the weighted factor maps generated for the evidence layers, and the Boolean integration methods were used for the combination of the factor maps and achieving the site selection process.
ArcMap, consisting of geoprocessing and Model builder tools were used for running the GIS Model for Geothermal Resource Exploration (GM-GRE).
Finally, 18 geothermal potential areas were selected. The geothermal potential areas in Iran are distributed in whole territory of Iran.

INTRODUCTION

Active geothermal areas have various natural manifestations at the ground surface such as hot springs, fumaroles, mud pots and hydrothermal alteration which are natural geothermal indicators. Basically geothermal exploration programs make use of such manifestations and other investigation techniques and measurements to identify prospective geothermal resources in the large scale.
The decision-making process need to combine and analyze the results of a number of different surveys and studies. Thus, human errors are unavoidable during this complex procedure. To minimize human errors, the GIS can be a powerful tool for identifying prospective areas by employing various digital data layers.
In this study ArcGIS was used as an effective tool for the integral interpretation of geoscientific data using computerized approach. This approach has been used to determine prospective areas by combining various digital data layers in Iran.
After comprehensive study about available data in the country, and important data layer for site selection of geothermal area, firstly, the available data layers for geothermal resource exploration in national scale are summarized in three datasets; Geological dataset (volcanic rocks, volcanic craters and faults), geochemistry dataset (hot springs and acidic hydrothermal alteration zone) and geophysical dataset (micro seismic epicenters and shallow intrusive bodies). Secondly an integration model in GIS environment was programmed and run and then promising areas were marked as nationwide geothermal potential sites. The GIS (ArcMap 9.1) is used as a decision support system tool for performing site selection.
The model builder tools in ArcGIS were used as a graphical environment in which to develop a diagram of the multiple steps required to complete complex geoprocessing tasks. When the model is run, the Model builder processes the input data in the specified order and generates output data layers. In the made model for siting geothermal prospected area, the input data layers and related parameters are variable and can be defined by the user when the model is to be applied to other country or regional areas for the detail selection of potential geothermal sites.
To assist the Ministry of Energy and geothermal industry in finding and operating geothermal fields we must develop (1) a more thorough understanding of known geothermal resources and (2) new innovative techniques for finding unexplored or "hidden" geothermal systems. The study took an integrated approach by calling on geological, geochemical, and geophysical techniques and digital data as potential tools for expanding exploration capabilities for Iranian government and geothermal industries.

In the large scales like a country the ability of GIS software allows to successfully site selecting for geothermal promising resources at low cost and with a high success ratio. Thus in this study the potential geothermal areas were selected in the national scale and the most promising areas were marked.

BACKGROUND

In 1998 R.M. Prol-Ledesma, applied GIS in exploration of geothermal recourses in Mexico. In that research GIS was used to determine the spatial association between geophysical and geological evidence and production zones in a well-known Los Azufres geothermal field.

In 2002 Mark F. Coolbaugh used GIS in regional assessment of exploration potential for geothermal systems in the Great Basin geothermal area. In this study the primary goal was to use the GIS to clarify relationships between geothermal systems and geological, geochemical, and geophysical features, and subsidiary goals were to visualize and analyzing the data to find gaps in information and identify potential new research projects.

In 2004 Y. Noorollahi applied GIS for geothermal exploitation in Namafjall high temperature geothermal area in North Iceland. This research focused to find out the best location for drill sites and power plant location in the Bjarnarflag geothermal field in the Namafjall area by using geological, geochemical and geophysical data layer and taking into account the environmental considerations.

METHODOLOGY

GIS is used to carry out a suitability analysis and site selection process because it can handle a large amount of data and information, is a powerful tool to visualize new and existing data, can help produce new maps while avoiding human errors made during decision-making, and allows the effective management of the GIS data (Noorollahi, et, al 2006). Two analytical methods were used for selection queries: the union, and intersecting methods. These methods are described briefly in the following sections.

This study carried out in the scale of (1:500,000) and 9 important data layers are employed. In every made factor maps the study area was classified into two classless; existence of geothermal resource and non existence of geothermal resource and binary maps were generated. These operations can be represented by the following simple equation:

$$S = (F \cup VR \cup VC \cup VM) \cap (HS \cup AZ) \cap (MiS \cup MaS \cup IB)$$

where the $\cap$ and $\cup$ are “AND” and “OR” operations, S is suitable areas and F, VR, VC, VM, HS, AZ, MiS, MaS, IN are faults, Volcanic Rocks, Volcanic Crater, Volcanic Mud, Hot Spring, Alterations Zone, Micro Seismic, Macro Seismic and Intrusive Bodies respectively. A diagram of the method that was used in the decision-making process to select potential geothermal sites is illustrated in Fig. 1

Union Operation (OR)

The Union Tool in ArcInfo creates a new coverage by overlaying two or more polygon coverages. The output coverage contains the combined polygons and the attributes of both coverages. In using this method, those areas selected as suitable areas by any one of the evidence layers are combined to prevent the loss of any prospective area defined by just a single evidence layer inside of the data sets. The model allows us to put more data layers such as heat flux, heat flow, gravimetry and geophysics into the datasets.

Intersect operation (AND)

The Intersect Tool in ArcInfo calculates the geometric intersection of any number of feature classes and data layers that are indicative of geothermal activity (geology, geochemistry, geophysics). Features that are common to all input data layers were selected using this method (Bonham-Carter, 1994). This implies that the selected area is suitable for the purpose of a study based on all input data layers.

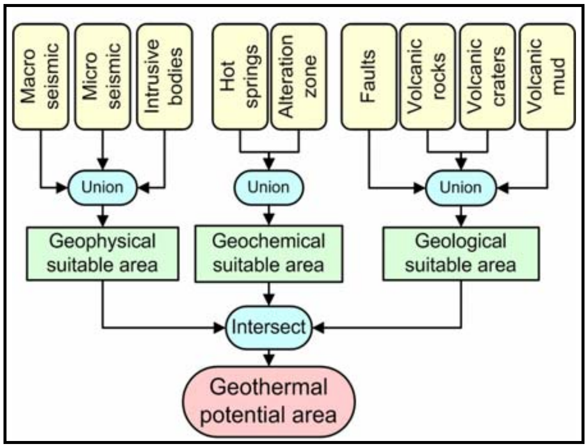

Fig.1.The method of geothermal potential siting

EVIDENCE LAYERS

In this study, the geothermal prospected area in nationwide was identified. The preliminary geothermal resource identification was carried out by using available digital datasets including geology, geochemistry and geophysics. Each data set includes some data layers which mentioned before (Fig.1). These data layers were used to make factor maps and factor maps were applied to the GIS Model for Geothermal Resource Exploration (GM-GRE) that would predict the geothermal resources in the country. The data layers introduced in the model are spatial distribution of volcanic rocks, volcanic craters, mud volcano, faults, hot springs, hydrothermal alteration zones, micro and macro seismic epicenters and intrusive bodies. Figure 2 and 3 show most the evidence layers.

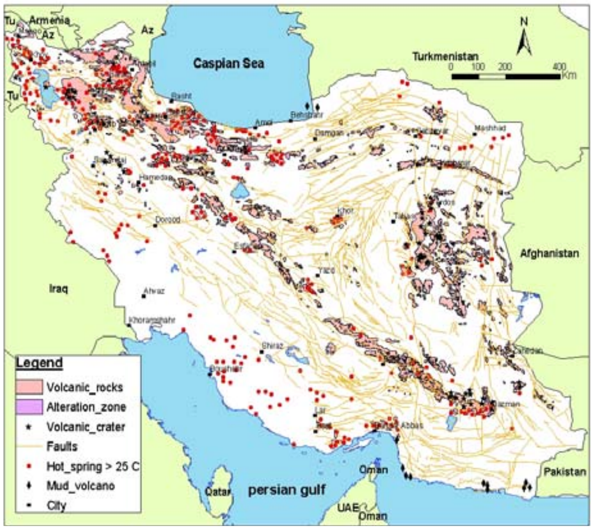

Fig.2. Study area and evidence layers

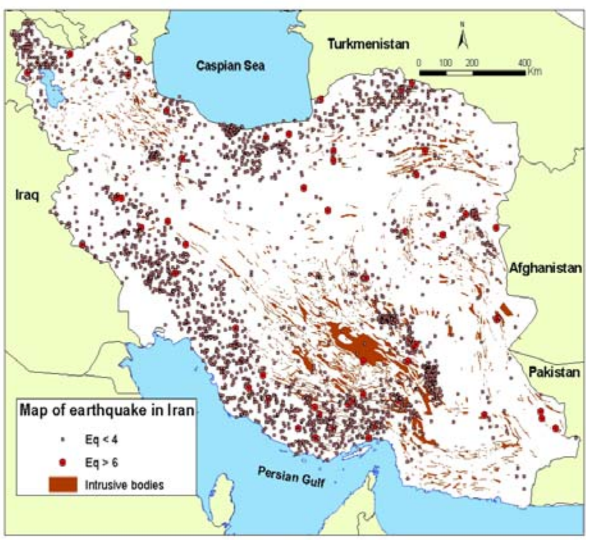

Fig.3. Earthquake epicenters and intrusive bodies

Geological data set

Geological studies play an important role in all stages of geothermal exploration. In the initial stages of siting, a number of geothermal areas are typically studied together, with one being chosen for detailed investigation (Rybach and Muffler, 1981). Geological studies also provide background information for interpreting the data obtained using other exploration methods. Geological information can also be used in the production stage for reservoir development and management. The duration and cost of exploration can be minimized by adopting a well-designed exploration program and efficiently coordinating research (Noorollahi et al, 2006).

Volcanic rocks

The presence of volcanic rocks in an area is evidence for increasing the probability of the existence of the geothermal resources. Investigations in active geothermal areas show, most of the young volcanic racks associated in geothermal fields. On the other word most of the high temperature geothermal area include some volcanic rocks. Therefore, based on this reason the presence of volcanic rocks data layer were used as an evidence to identify geothermal prospect in Iran

Volcanic rocks in Iran lie from NW to SE and northern part of the country in Alborz and Zagros mountains. The area which covered by volcanic rocks is 145973 km^2 (9%). In this study, 3000 m (Noorollahi et al, 2006) buffer size were given around the volcanic rocks polygon data layer to identify promising geothermal resource areas based on the distribution of igneous rocks (Fig. 2).

Volcanic craters

Geothermal energy can be harnessed from the earth's natural heat associated with active volcanoes or geologically young inactive volcanoes still giving off heat at depth. Therefore volcanoes are obvious indicators of underground heat sources. Volcanic craters can constitute one of the evidence in geological exploration for geothermal resources, as the presence of craters leads geologists to assume that the area hosts or hosted a great deal of volcanic activity. Volcanic craters map of Iran were used in this study as an evidence layer for snapshot deciding where have to concentrate for additional geothermal exploration activity in the area. Most of the volcanic craters in this map associated in northwest and east of the country. At present 47 volcanic craters are known in Iran (Fig. 2). To identify suitable areas based on the presence of volcanic craters, a buffer analysis with 5000 m distance (Noorollahi et al, 2006) were given and selected areas were defined as probable geothermal prospects.

Faults

One of the keys to targeting a region of geothermal potential is to understand the role of faults in controlling subsurface fluid flow. Fractures and faults can play an important role in geothermal fields, as fluid mostly flows through fractures in the source rocks. The importance of fractures in geothermal development is well recognized; Hanano (2000) pointed out that faults influence the character of natural convection in geothermal systems.

Blewitt et al. (2003) indicated that at a regional scale, the locations of existing power-producing plants in Great Basin, USA, and the spatial pattern of geothermal wells is strongly correlated with GPSmeasured rates of tectonic transtensional strain. This indicates that in some regions geothermal plumbing systems might be controlled by fault planes that act as conduits that are continuously being extended by tectonic activity.

Distance relationship analysis was conducted by Noorollahi et al in 2006 in Japan to determine the dominant distance association of the geothermal wells to location of active faults presented in map 1:250,000 scale. The results show that 95 % of the wells are located in a zone within 6000 m distance to the active faults. This distance seems too far to have permeability and fluid circulation. However, in this scale only major fault zones are presented and there should be several smaller and associated faults in detailed scales which are not presented here and not accounted in distance relationship calculation.

Therefore, in current study for avoiding to unwanted discarding some prospected area by this layer and using the same scale maps the 6000 m buffer size was applied by using the ArcMap Buffer tool and a certain area is selected as potential geothermal area based on faults and fractures. In this scale there are 12692 thrust, minor and major faults (Fig. 2).

Volcanic mud

A conical accumulation of variable admixtures of sand and rock fragments, the whole resulting from eruption of wet mud and impelled upward by fluid or gas pressure.The mud may form at the time of eruption and flow like lava, or fall from the sky as mud rain. Volcanic muds can constitute one of the evidence in geological exploration for geothermal resources, as the presence of muds leads geologists to assume that the area hosted a great deal of volcanic activity. Volcanic muds map of Iran were used in this study as an evidence layer. At present 12 volcanic muds are known in Iran (Fig. 2). Ten of the volcanic muds located in southeast of the country in the vicinity of Oman Sea and two in Northeast in the vicinity of Caspian Sea. To identify suitable areas based on the presence of volcanic muds, a buffer analysis with 5000 m distance were given and selected areas were defined as probable geothermal prospects.

Geochemical data set

Geochemical methods are widely used in both preliminary prospecting and at every stage of geothermal exploration and development. Geochemical evidence layers were used for siting geothermal resource prospecting which include the distributions of hydrothermal alteration zones and hot springs with temperatures in excess of 25°C.

Hot springs

In the almost all the geothermal potential areas the most important indicators are hot springs with temperatures in excess of 25°C and also cause some more proofs such as alteration zones. Hot springs are evidence of a subsurface heat source and the temperature of springs has correlation with amount of heat flow. Those locations where hot springs rise to the surface are geothermal potential prospected areas because it is assumed that the probability of the occurrence of a geothermal resource is higher than that in the surrounding area.

Analysis of the spatial distribution of hot springs and geothermal wells in Japan shows that 97% of geothermal wells are located within 4000 m of hot springs (Noorollahi et al, 2006) and GIS software allows selecting hot springs with temperatures in excess of 25°C (annual mean temperature). To avoid of loosing potential area, optimistically, 5000 meter buffer distance was used as an evidence distance to select promising geothermal potential areas based on the locations of hot springs. There are 308 hot springs in Iran and most of them are located in North and Northwest of the country (Fig. 2). The hottest one is Geynarjeh in Northwest with 86°C where NW Sabalan geothermal field is located.

Hydrothermal alteration zone

The location and distribution of surface alteration zones can help to identify prospective geothermal areas because the alteration zones may be closely related to the main upflows of the geothermal system at depth. In other words, it is more likely that geothermal resources occur within and around hydrothermal alteration zones than in unaltered areas.

Hydrothermal alteration involves mineralogical changes resulting from the interaction of hydrothermal fluids and rocks. The formation of secondary minerals in geothermal systems is controlled by the chemical/physical conditions of the system. For example, the presence, abundance, and stability of hydrothermal alteration minerals depend on the temperature, pressure, lithology, permeability, and fluid composition of the system (Browne, 1978; Harvey and Browne, 1991). Thus, analysis of the hydrothermal alteration provides information on the occurrence of geothermal resources.

The statistical field analysis shows that more than 90% of existing geothermal wells in Japan are located within 3000 m of the edges of alteration zones (Noorollahi et al, 2006). To define promising areas is based on the locations of hydrothermal alteration zones. To increase the chance and avoid of loosing potential area optimistically, 5000 meter buffer distance was used as an evidence distance to select promising geothermal potential areas. The acidic alteration in Iran mostly locates in northwestern, central and east side of the country. Those area which covered by alterations zone in Iran is 14948 km^2 (about 1% of Iran). The most stretched zone has 208 km^2 areas in north of Iran near to Damavand Volcano Mountain where there are several hot springs (Fig. 2).

Geophysical data set

Geophysical exploration techniques have been used successfully to locate the heat sources of geothermal system and characterized the permeability of the potential reservoir. For geothermal resources siting several geophysical data can be used in national scale but the availability of geophysical data in countrywide scale is restrictive. Gravimetry, Aeromagnetic, Seismic and Thermal methods (thermal gradient and heat flow) which are some of the methods can be used in geothermal resources prospecting in large scale investigations. Based on availability of data in national scale in Iran the micro and macro seismic epicenters and shallow intrusive rocks (detected by aeromagnetic survey analysis) are employed in this study.

At present earthquake mapping is a valuable reconnaissance tool for identifying potential geothermal fields and mapping their structural micro features. Thus in this study micro seismic and macro seismic epicenters were used as evidence layers.

Micro seismic epicenters

Micro seismic occurs in geothermal field more frequently than non geothermal area. The locations of low magnitude seismic epicenters are correlated with the locations to the presence of structures that allow reservoir fluid flow (Simiyu et al., 1998a). Long term experience in geothermal fields shows that micro earthquakes occur around most, but not necessarily all, geothermal fields. Geothermal seismic events tend to occur in swarms of small events with properties that may permit us to distinguish them from normal tectonic seismicity. On the periphery and outside of the field, events are larger and deeper (Simiyu et al., 1998). Earthquake hypocenters allow us to map the fractures that determination of the distribution conducts the hot fluids to or within the reservoir.

The recorded seismic data (< 4 Richter) in Iran was extracted from Geological Survey of Iran's database (Geological Survey of Iran, 2005) and converted to the GIS format. A 5000 m buffer was generated around the points and the generated factor map was used in site selection process. There are 2598 recorded seismic data less than 4 Richter in Iran (Fig.3). About 162,000 km^2 (10%) of Iran were selected by this parameter in the generated factor map.

Macro seismic epicenters

Geothermal systems occur along the tectonic margins where earthquakes are more frequent and crustal thicknesses are greater compared to the relatively a seismic place with thinner crust (D. B. Slemmons, 1975). Therefore based on natural and most of the time destructive earthquakes (in Iran more than 6 Richter) the recordable seismic data layers were used in the current site selection process as an evidence layer. A 40 km buffer (M.F. Coolbaugh et al., 2005b) was generated around the points and the generated factor map was used in site selection process.

There are 68 recorded seismic events more than 6 Richter in Iran from 1909 to 2003 (Fig.3). About 220,000 km^2 (14%) of Iran were selected by this parameter in the generated factor map.

Intrusive bodies

Shallow intrusive bodies are a type of volcanic rocks which have been formed and cooled slowly under the surface. In some of the geothermal fields, young intrusive bodies play an important role as a heat source to supply some of the geothermal energy. Thus, the location and presence of the shallow intrusive rocks are important in primary geothermal exploration process. In the current study, it was assumed that the probability of the geothermal resource occurrence in the areas with intrusive racks is higher than other areas. The Geological Survey of Iran (2004) published a distribution map of the magnetic shallow bodies' intrusion which is generated by processing and interpreting of total magnetic intensity map as well as available geological data. This map is digitized and 5000 m buffer (Noorollahi, et al., 2006) was applied.

The most of bodies' intrusion in Iran located in northwest and center of Iran (Fig.3). The area which occupied by this racks are around 100 000 km^2 (6%).

DATA INTEGRATION METHOD

In applying data integration models to exploration of natural resources i.e. geothermal exploration, skill is important in the selection of the maps that will provide predictor keys of the resource to be studied, and if possible to avoid the cost of gathering redundant information (Prol-Ledesma, 2000).

Boolean integration modeling which is used in current study involves the logical combination of binary maps resulting from the application of conditional "OR" (Union) and "AND" (Intersect) operators. For performing Boolean logic model the study area based on each evidence layer was classified into two different areas. The area which assumed that the geothermal resource is exists assigned the value of 1 and the others value of 0. Figure 1 shows the conceptual model of the Boolean integration method which was applied for data integration in the site selection process.

Geological suitability was determined by integrating the selected areas (Buffer) based on volcanic rocks, volcanic craters, volcanic muds and faults factor maps. This four evidence layers were overlain by Boolean "OR" operator and the selected areas were combined (union) to identify geologically suitable areas. A suitability map based on geological investigations in Iran is shown in Fig. 4.

Geochemical suitability was identified by integrating selected areas on the base of alteration zones and hot springs factor maps. These two layers were overlain and the selected areas were combined (union) to identify the geochemical suitable area. A suitability map based on geochemical investigations in Iran is presented in Fig. 5.

Geophysical suitable area was determined by overlapping of the micro and macro seismic and shallow intrusive bodies factor maps by using the Boolean "OR" method. The selected areas were merged to identify the geophysical suitable area for geothermal prospected. A suitability map based on geophysical investigations is shown in Fig. 6. Table 1 shows the employed evidence layers and relative buffer distance which was used in geothermal site selection process.

Tab.1.Integration of evidence layers with buffer size

Data sets	Evidence layers	Relative distance (m)
Geology	Volcanic Rocks	3000
	Volcanic craters	5000
	Volcanic Mud	5000
	Faults	6000
Geochemistry	Hot springs	4000
	Alteration Zone	5000
Geophysics	Micro Seismic	5000
	Macro seismic	40000
	intrusive bodies	5000

Finally the Geological, geochemical and geophysical suitable area overlain and intersected using Boolean "AND" operator to identify the geothermal prospected areas. Fig.7. shows the location and extend of **18** prospected geothermal areas in countrywide which were selected and defined.

CONCLUSION

In the current study the geothermal potential area in Iran were investigated and identified by using available geological data including presence of volcanic rocks, volcanic craters, volcanic muds and faults, geochemical data such as hydrothermal alteration zones and hot springs and geophysical data consisting micro-seismic epicenters, macro seismic epicenters and shallow depth intrusive bodies. All of the involved digital maps provided in the scale of 1: 500,000.

Boolean integration method by using "OR" (Union) and "AND" (Intersect) operators were applied to combine the evidence layers in GIS environment. Finally 18 geothermal prospective areas were identified.

Totally **8.8** % of Iran has defined as a geothermal energy potential sites. Further detailed filed investigations are recommended in every potential site and finally prioritizing of the sites. Table 2 shows geothermal potential prospected area in Iran.

The designed model in GIS environment is a dynamic model and can be improve by adding new data layers.

Tab.2. Characteristics of geothermal areas in Iran

Geothermal Area	**Providence**	**Area (Km^2)**
Sabalan	Ardebil	13037
Damavand	Tehran	4648
Khoy_Maku	Azerbaijan garbi	3257
Sahand	Azerbijan shargi	3174
Bazman	Systan va baloochestan	8356
Taftan	Systan va baloochestan	4310
Tabas_Ferdoos	Khorasan Jonoobi	46628
Khor	Esfahan	2334
Tekab_Hashtrood	Azerbaijan garbi	4639
Mahallat_Esfahan	Esfahan_Markazi	13648
Zanja	Zanja	3285
Avaj	Hamadan	4283
Kashmar	Khorasan Markaz	7107
Ramsar	Gilan	5532
Amol	Mazandaran	1697
Baft	Kerman	11525
Minab_Bandar abbas	Hormozgan	3191
Lar_Bastak	Hormozgan	4191

REFERENCES

Blewitt, G., Coolbaugh, M., Holt, W., Kreemer, C., Davis, J., Bennett, R., (2003), "Targeting potential geothermal resources in the Great Basin from regional- to basin-scale relationships between geodetic strain and geological structures". *Geothermal Resources Council Transactions* 27, 3–7.

Browne, P.R.L., (1978). "Hydrothermal alteration in active geothermal fields", *Annual Review of Earth and Planetary Science* 6, 229–250.

Bonham-Carter, G.F., (1994). "Geographical Information Systems for Geoscientists: modeling with GIS". *Computer Methods in the Geosciences 13*, Pergamon, New York, 398 pp.

Coolbaugh, M., Zehner, R., Kreemer, C., Blackwell, D., Oppliger, G., Sawatzky, D., Blewitt, G., Pancha, A., Richards, M., Helm-Clark, C., Shevenell, L., Raines, G., Johnson, G., Minor, T., and Boyd, T., (2005a), "Geothermal potential map of the Great Basin", *western United States: Nevada Bureau of Mines and Geology Map 151*.

Coolbaugh, M.F., Zehner, R.E., Raines, G.L., Oppliger, G.L., and Kreemer, C., (2005b), "Regional Prediction of Geothermal Systems in the Great Basin, USA using Weights of Evidence and Logistic Regression in a Geographic Information System (GIS), *in* Cheng, Q. and Bonham-Carter, G., eds., GIS and Spatial Analysis", *International Association of Mathematical Geology Annual Conference Proceedings, Toronto, Canada*, Aug. 21-26, 2005, p. 505-510.

D.B.Slemmons, (1975), "Fault activity and seismicity near the Los Alamos Scientific Laboratory Geothermal Test Site", *Jemez Mountains, New Mexico, Los Alamos Scientific Laboratory*, Report LA-5911-MS.

Hanano, M., (2000). "Two different roles of fractures in geothermal development". *Proceedings of World Geothermal Congress 2000*, Kyushu–Tohoku, Japan, May 28–June 10, 2000, 2597–2602.

Geological Survey of Iran,.(2004), Distribution map of magnetic shallow bodies intrusion; based on airborne magnetic data, in scale of 1: 6,5000,0000, geological survey of Iran.

Geological Survey of Iran,. (2002), Distribution map of Acidic hydrothermal alteration zones of Iran.

Noorollahi. Y, Itoi. R, Fujii. H and Toshiaki. T., (2006), "GIS model for geothermal resource exploration in Akita and Iwate prefectures, Northern Japan", *Journal of Computer & Geosciences*, November 2006, (accepted)

Noorollahi, Y., (2005). "Application of GIS and remote sensing in exploration and environmental management of Namafjall geothermal area, N-Iceland". *M.Sc. Dissertation*, Univ. of Iceland, Reykjavik, Iceland, 193 pp.

Prol-Ledesma, R.M., (2000). "Evaluation of the reconnaissance results in geothermal exploration using GIS". *Geothermics 29*, 83–103.

Rybach, L., Muffler, I.J.P., (1981). "Geothermal Systems; Principles and Case Histories". John Wiley & Sons Ltd, New York, 359 pp.

Simiyu, S.M., Oduong, E.O., and Mboya, T.K., (1998) "Seismic wave parameter analysis at Olkaria,Kenya". *KenGen, internal report*, 38 pp.

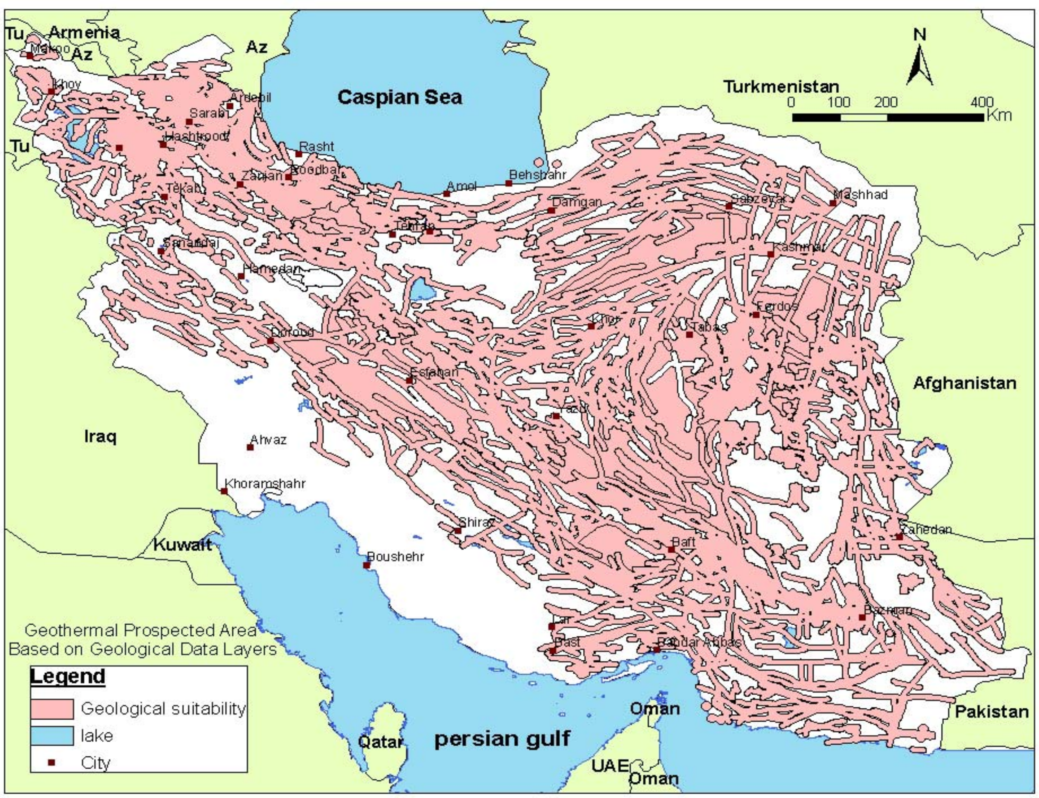

Fig. 4. Geothermal prospected area base on the geological evidences

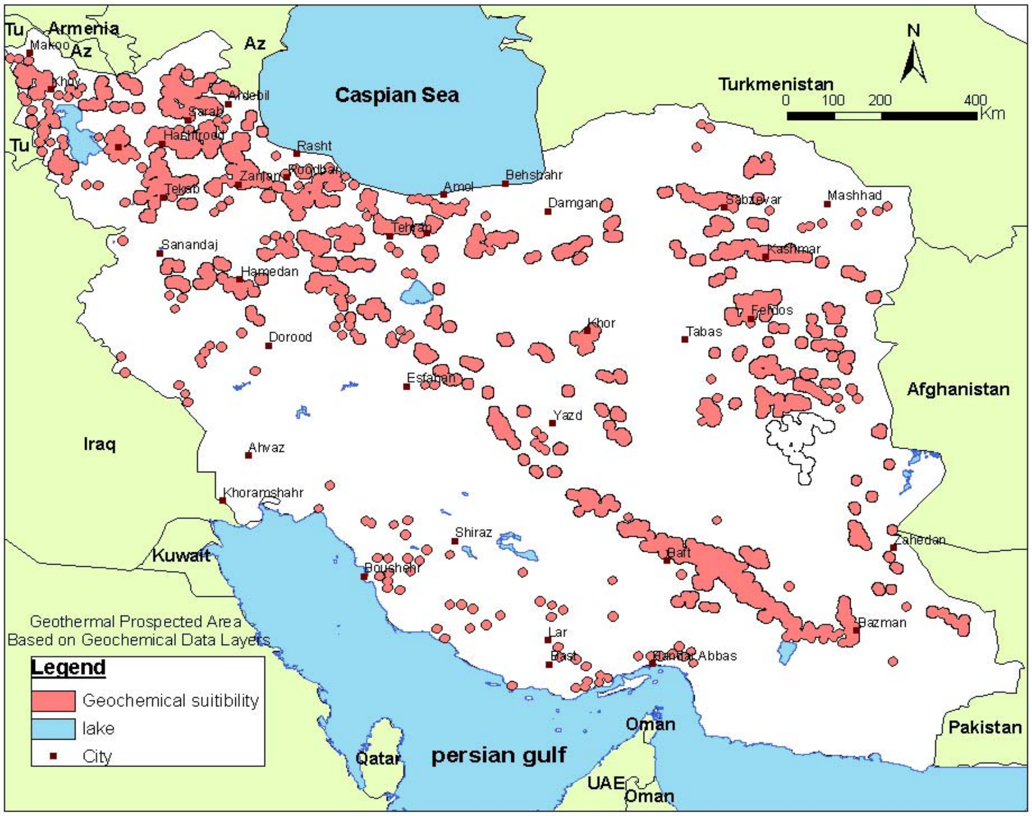

Fig. 5. Geothermal prospected area base on the geochemical evidences

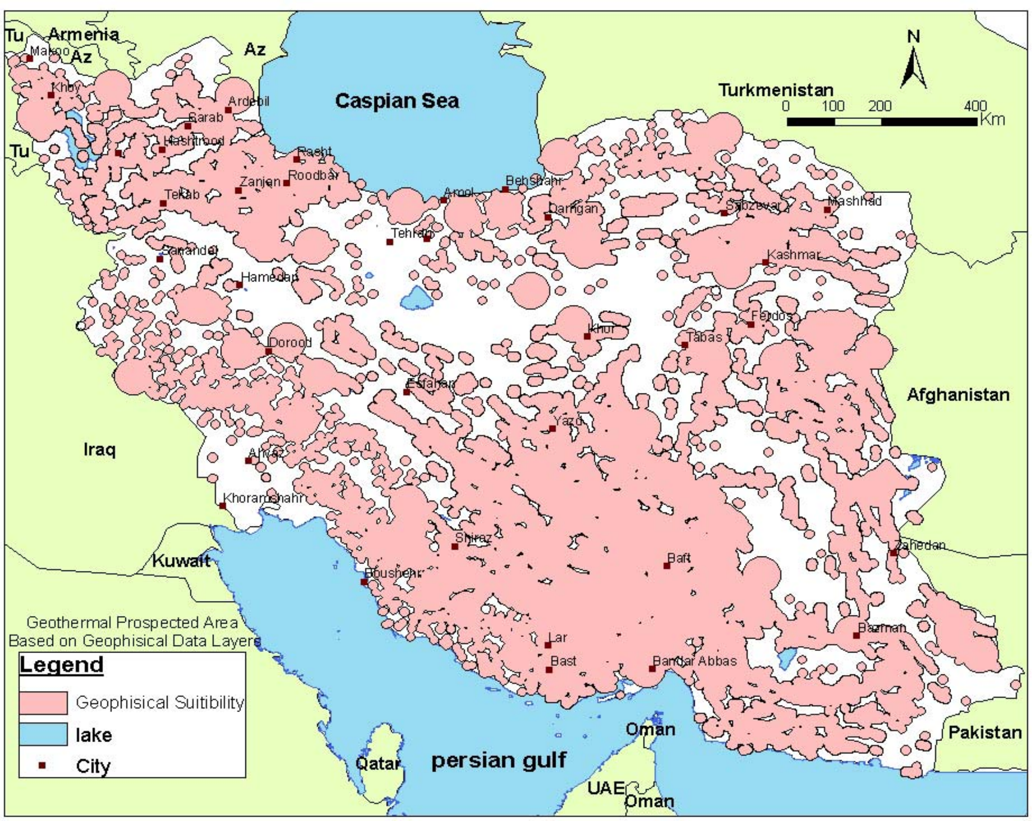

Fig. 6. Geothermal prospected area base on the geophysical evidences

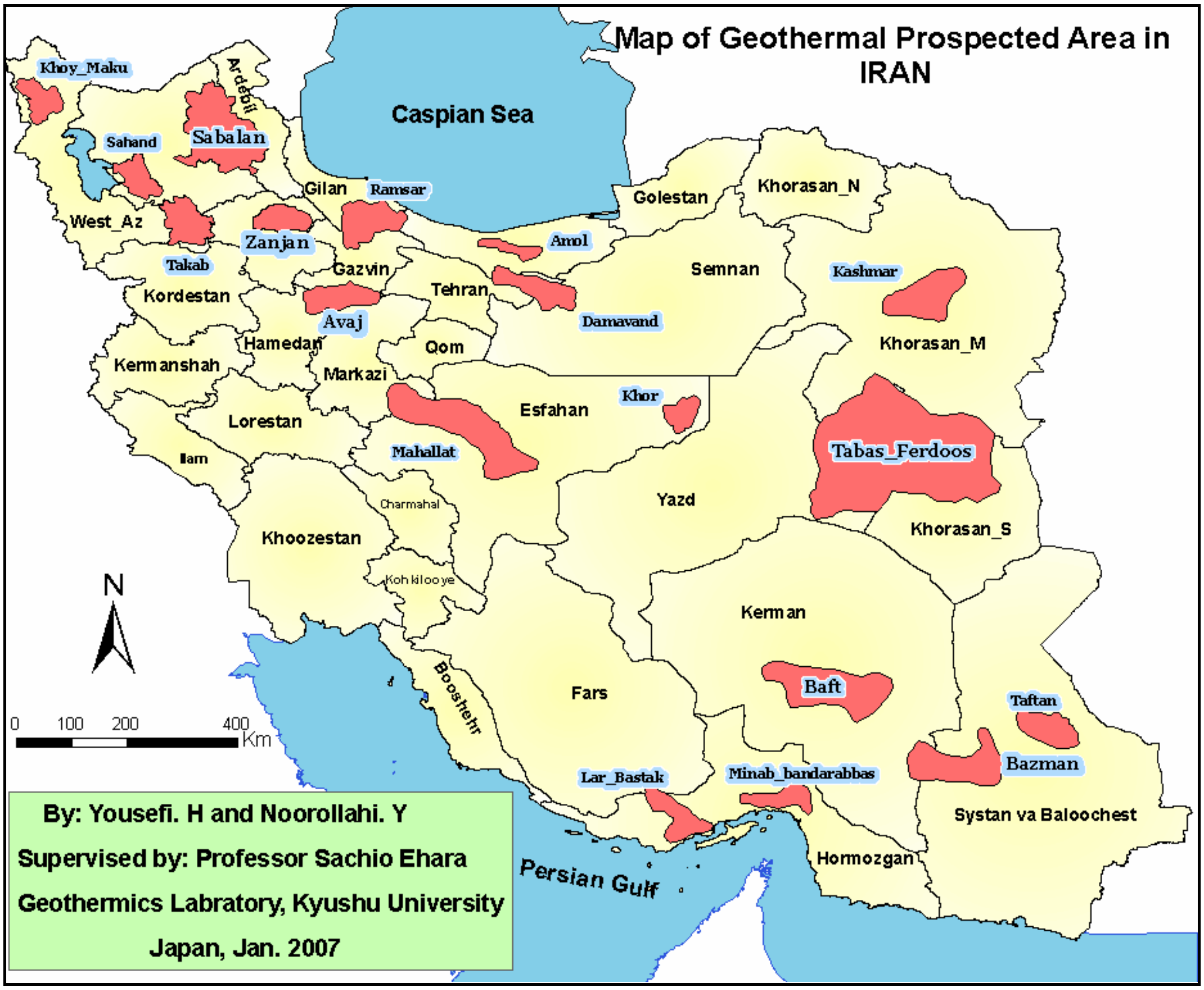

Fig. 7. Geothermal potential areas in Iran