раствор, поднимают бурильный инструмент и проводят комплекс промыслово-геофизических исследований, который начинают и заканчивают γ-каротажом.

Продавливание радонового индикатора в поры и трещины пород. По окончанию бурения перспективного интервала (толщиной 20–300 м) и его промывки в призабойную зону скважины вводят заранее приготовленный активированный раствор концентрацией Rn 3 пг/л. Объём раствора должен быть в 2–3 раза больше объёма скважины в интервале исследования. После введения индикатора проводят ГК и создают в целях продавливания активированной жидкости репрессию на пласт (3–5 мПа), которая должна быть меньше гидродинамического давления при спуске бурильных труб. Необходимый перепад давления обычно создают путём расхаживания бурильного инструмента в течение 1–3 ч. Сразу после расхаживания инструмента проводят повторный ГК. Затем бурильный инструмент спускают до забоя и в процессе промывки скважины трёх-пятикратным объёмом нерадиоактивного раствора вытесняют активированную жидкость из призабойной зоны. По завершении промывки бурильный инструмент поднимают и выполняют комплекс промыслово-геофизических исследований, который начинают и заканчивают гамма-каротажем. В случае регистрации чётких локальных γ-аномалий дополнительно проводят в течение 3–24 ч временные замеры ГК.

Для этого в ёмкостях цементировочных агрегатов приготовляют радоновый индикатор равномерной концентрации (3 мг/л) Rn в объёме в 1,5–2 раза больше объёма скважины в исследуемом интервале. По плотности и реологическим параметрам индикатор не должен отличаться от раствора в скважине. Индикатор продавливают нерадиоактивной жидкостью по бурильным трубам, тщательно контролируя по мерной ёмкости общий объём закачиваемой жидкости, т. к. ГК при этом, как правило, не проводят. По завершении спуска обсадной колонны скважину промывают. В ходе промывки ведут измерения γ-активности и объёмной скорости выходящей из скважины жидкости в целях оценки положения индикатора после спуска колонны.

Гамма-каротаж проводят в исследуемом интервале со скоростью 100 м/ч (не менее 2 раз), а выше него – 300 м/ч.

Во внутриколонное пространство, которое по протяжённости более чем в три раза больше перфорируемого интервала, вводят 3–20 нг растворённого Rn. С помощью ГК контролируют распределение индикатора по стволу скважины. Затем интервал перфорируют и со скоростью 100 м/ч проводят повторный ГК для выявления на высоком фоне локальных γ-аномалий. Исследование завершает индикаторный ГК, который проводят после промывки перфорированного интервала нерадиоактивной жидкостью (трёх-пятикратным объёмом). Если повторным ГК зарегистрированы чёткие аномалии, то дополнительно проводят временные замеры ГК. Такие замеры можно проводить также после промывки скважины или в ходе операции каротаж-испытание каротаж.

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GEOTHERMAL ENERGY IN IRAN

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Introduction. Earth's interiors contain a huge amount of heat generated by different geologic processes. Thermal regime of the crust is formed by the heat entering in its base from the upper mantle and its another part, generated due to decay of long-living radioactive elements. At the most subterranean layers within active tectonic zones the temperature rapidly increases with depth especially in regions of recent volcanism where melting rocks exist at relatively shallow depths not only in the upper mantle, but in a number of instances also in the crust itself. When underground water passes in close vicinity of such rocks, it becomes hot or even turns into water steam. Geothermal resources are not the same everywhere and their highest values mostly exist within areas of young volcanism. Geothermal energy is classified in two directions: The so-called direct use (heating, cooling) and indirect use (electricity production) [1].

Activities in the field of geothermal energy in Iran are focused on scientific and research aspects. The research part is aimed at reduction of financial expenditures required for exploitation of these resources. The second step is to work out research results into scientific dimension and finally to for practical purposes, i.e. both for building-up electric power plants and for direct uses. A distribution map of potential areas for utilization of geothermal resource in Iran have been drawn, it shows 14 suitable regions for geothermal activities. Among these 14 sites, the Sabalan region seems to have the most considerable geothermal resources and the Meshkin shahr field, located also in this region, has a priority for installation here a geothermal power plant (Fig. 1) [1].

Geothermal Resources. The Renewable Energy Organization of Iran (SUNA) as a part of the Ministry of Energy fulfilled a global investigation in the whole area of Iran in 2000–2002. The investigation identified 10 vast areas which have a number of potentially suitable regions for this purpose. Iran has 32 provinces and SUNA, between 2010 up to now, is focused on exploration of geothermal areas in each province according to their standard methods (Chart. 1) shows the layers which were prepared and integrated for determination of geothermal perspectives [1].

Power Generation. The Sabalan geothermal prospect area lies on the north-western western slopes of Mt. Sabalan. Fig. 2 shows the position of this field. It is located about 20 km to south of the city of Meshgin shahr within the Moil Valley in the Province of Ardebil, northwestern Iran in between 38° 12' 52" and 38° 20' 00" N and 47° 40' 30" and 47° 49' 10" E.

Present Iranian conventional strategy for power generation has been largely established on the utilization of inexpensive local fossil fuels and to a lesser extent on hydroelectric resources as shown in Table1 [2].

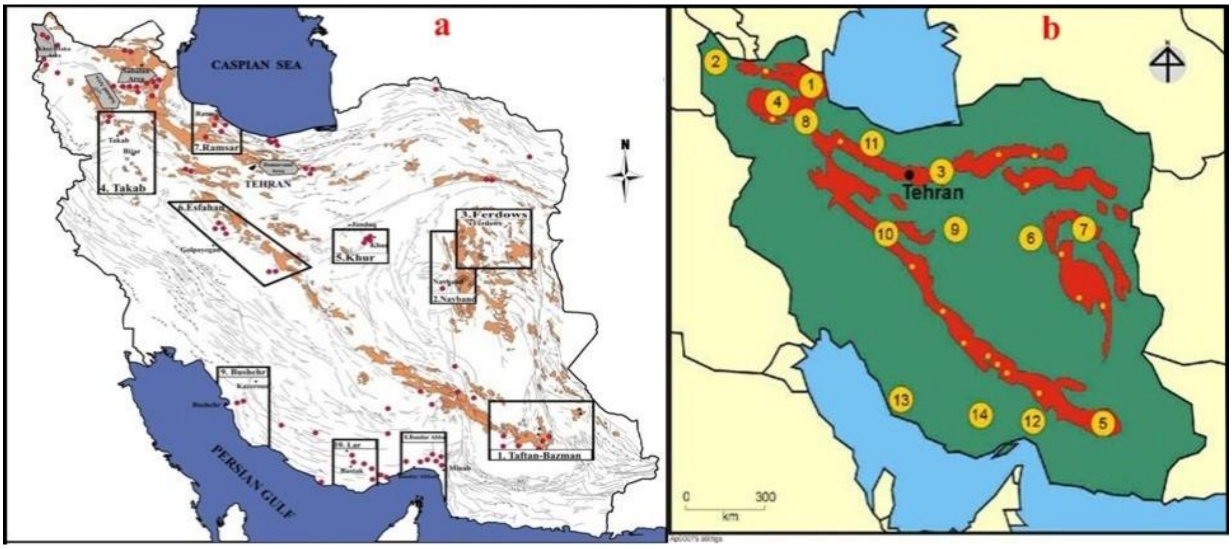

Figure 1 – a) Distribution Maps of Potential Areas (rectangle squares) perspective for Geothermal Resources in Iran according to Renewable energy organization of Iran (SUNA), (1998), [1]. b) Geothermal fields: 1 – Sabalan, 2 – Kuoy Maku, 3 – Damavand, 4 – Sahand, 5 – Taftan, 6 – Tabas, 7 – Ferdos, 8 – Takab, 9 – Khour Biabanak, 10 – Mahalat, 11 – Ramsar, 12- – Minab, 13 – Kazeroon, 14 –Lar-Bastak.

In order to better understand the reservoir characteristics, geothermal professionals from Iran initiated the geo-related investigations. Later a number of scientists from New Zealand have contracted in frames of the running investigations. As a result of geological, geochemical and geophysical surveys, locations for three exploratory wells were determined; each with a target depth of 3000 m. The main characteristics of these exploration wells are shown in the Table 2. Their drilling was started in late 2002 and they were completed in 2004. According to joint information of the companies SUNA, Iran and the Sinclair Knight Merz Ltd, New Zealand the downhole temperature was approximately 240 °C, it was recorded in two wells at the final depth of about 3200 m. Completion test and discharge evaluations of these wells were conducted successfully. Numerical modelling of the reservoir was accomplished and the capacity of the field was approved to install a 55 MW geothermal power plant. Drilling of seventeen more production and injection wells are proposed to supply the required steam for this power plant [2].

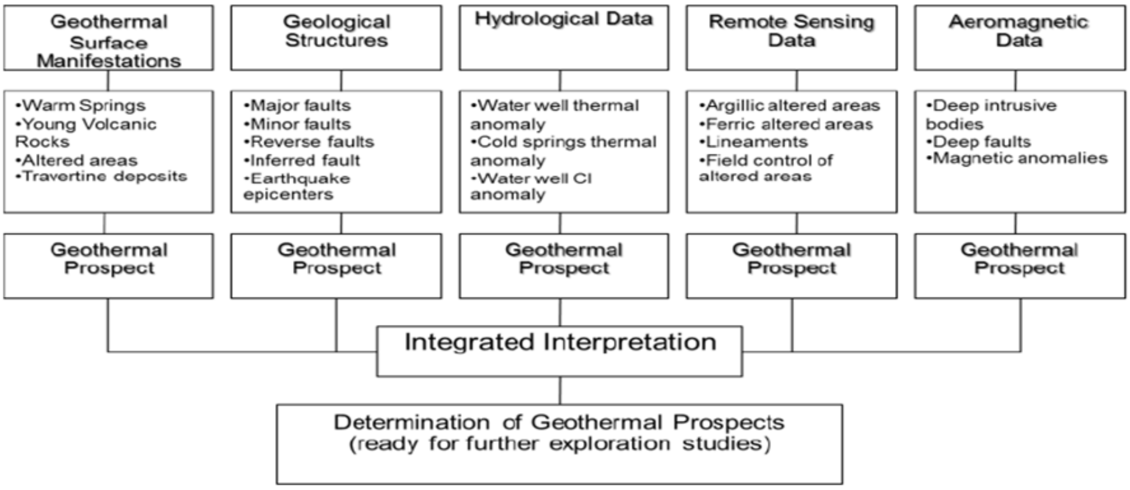

Chart 1 – Layers developed and integrated for determination of geothermal prospects [1]

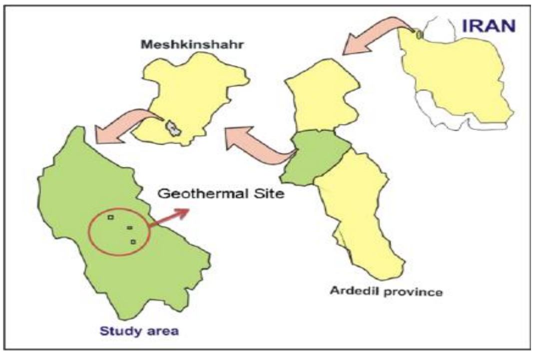

Figure 2 – Location of Sabalan field in Iran [1]

Table 1 – Present and planned production of electricity in Iran [2, modified]

Production of electricity in Iran	Geothermal		Fossil fuels		Hydro small and large		Other renewables (wind, solar, biomass)		Total	
	Capacity (MW)	Gross. Prod., GWh/yr	Capacity (MW)	Gross. Prod., GWh/yr	Capacity (MW)	Gross. Prod., GWh/yr	Capacity (MW)	Gross. Prod., GWh/yr	Capacity (MW)	Gross. Prod., GWh/yr
In operation	Under testing	?	39 568	182 000	3 037	8 085	11,9	31,65	43 714	190 116
Under construction	55	375	10 000	46 000	4 746	12 635	59,6	158.54	15 861	–
Funds committed, but not under construction	55	375	–	–	7 816	20 808	148,4	394,74	28 019	–
Total projected use by 2010	100	674,5	45 568	209 612	11 296	30 072	637,75	1 696,41	58 602	–

Table 2 – Specifications of three exploration wells [2]

Well		NWS1	NWS3	NWS4
Location (UTM)		739108E 4238580N	737028E 4240784N	738712E 4239833N
Elevation (m a.s.l.)		2 632	2 277	2 487
Well depth (m)		3 197	3 177	2 266
Casing depth, m	Conductor 30□	27	24	26
	Surface 20□	110	113	105
	Anchor 13–3/8□	380	357	541
	Production 9–5/8□	1 587	1 599	1 195
	Liner 7□	3 197	3 170	2 265
Well permeable zones (m a.s.l.)		1 800–1 400	No permeable zone	1 050–9 00
		200–0		880–890
		–200– –350		
Maximum T (ºC)		240	148	229

Conclusions. Regarding to the growing urban population and also to new policies of the government for replacement of traditional resources as well as the domestic energy consumption, Iran is aimed to utilize available renewable energy resources in near future to partly compensate the energy demand and also to save crude oil as fuels for export, because majority of our incomes comes from its export. On the other hand environmental agreements force all the countries to use clean energy production and to prevent the environmental pollution by modifying the old technologies for new environmental sound ones. So, there is a lot of despite to use other suitable resources, for instance the geothermal energy.

Initial stage of investigations, a lack of basic data and also national qualified experts, specialist and organizations, as well as the lack of high-tech equipment production in Iran didn't yet allow to wide-scale production of energy from these resources. Furthermore, Iranian government has shown in last years a strong interest to attract foreign investments. Regarding to good trade relationship between Iran and Japan there are many opportunities for Japanese companies to invest in geothermal energy development and transfer the related technology. Anyway, due to economic, environmental and new policies reasons it seems that energy production from Iranian geothermal fields in near future is inevitable. So it is hoped that exploration drilling at Mt. Sabalan over the next months will lead directly to a commitment to develop further the first geothermal power plant in Iran during forthcoming years (Fig. 3) [4].

Figure 3 – Iran's first geothermal power plant located near the city of Meshkin Shahr, northwestern Iran [3]

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