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THE ROLE OF SARVAK FORMATION IN SUPPLYING POL-E DOKHTAR TOWN (IRAN) WITH DRINKING WATER*

VLOGA GEOLOŠKE FORMACIJE SARVAK ZA OSKRBO MESTA POL-E DOKHTAR (IRAN) S PITNO VODO

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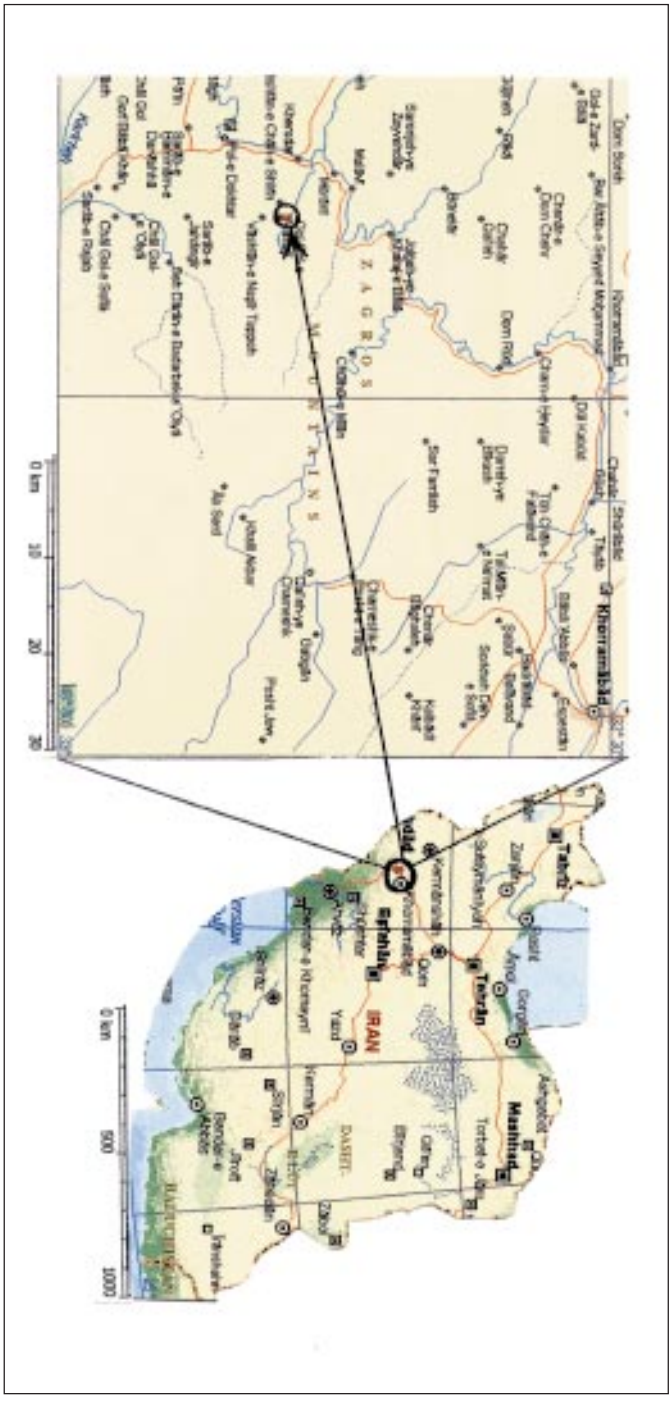
Mohamad Reza Ahmadipour: Vloga geološke formacije Sarvak za oskrbo mesta Pol-e Dokhtar (Iran) s pitno vodo

Formacija Sarvak je najbolj zakrasela formacija v skupini Bagestan, SZ od mesta Pol-e Dokhtar. Njeno južno krilo je zakraselo in najpomembnejše za talno vodo. Za oskrbo s pitno vodo mesta Pol-e Dokhtar, so bili izvrtani trije vodnjaki. Opravljen je bil črpalni (72 ur). Analize kisika-18 in devterija kažejo na meteorni izvor vode. Voda iz vodnjaka W_1 ima minimalno, iz W_3 pa maksimalno koncentracijo tricija, kar kaže na različen rezidenčni čas, kemične analize pa, da gre za vode tipa Ca>Mg>Na in HCO_3>SO_4>Cl. Med samim vrtanjem so imeli vzorci vode relativno veliko količino NO_3 (27 mg/l), ki se je, zaradi zavarovanja področja pred kmetijsko dejavnostjo, znižala. Mesto Pol-e Dokhtar, ki je imelo resne težave z oskrbo s pitno vodo še izpred časov islamske republike, teh zdaj nima več, zahvaljujoč predstavljeni raziskavi.
Ključne besede: kraška hidrologija, kemizem kraške vode, pitna voda, Lorestan, Iran.

Abstract UDC: 628.1(55)

Mohamad Reza Ahmadipour: The Role of Sarvak Formation in Supplying Pol-e Dokhtar Town (Iran) with Drinking Water

The Sarvak formation is the most karstified formation of the Bageston group, NW from town Pol-e Dokhtar. Its southern limb is karstified and the most important for the ground water. Three wells were drilled for supplying the drinking water to Pol-e Dokhtar. The pumping test (72 hours) was carried out. Analyses of oxygen-18 and deuterium indicated that the water is of meteoric origin. Water from the well1 has the minimal and from the well3 maximal concentrations of tritium which indicate different residence time. Chemical analyses show that the water is of Ca>Mg>Na and HCO_3>SO_4>Cl type. During the drilling water samples had relatively high NO_3 (27 mg/l), which was reduced due to the protection of the area from agricultural activities. Due to this study, the town of Pol-e Dokhtar, which was facing serious problem of drinking water since before the Islamic Republic of Iran, has been solved.
Key words: karst hydrology, karst water chemistry, drinking water, Lorestan, Iran.



INTRODUCTION

The Sarvak formation is the most karstified formation of the Sultan anticline. The anticline is situated in the village of Gol-Goll which is 14 km to the NW of Pol-e Dokhtar city. The mean annual rainfall is 482 mm and mean temperature is 27°C. The location of the study area is shown in Fig. 1.

REGIONAL GEOLOGY OF THE AREA

The study area is part of the folded Zagros Zone. The general geology of the area includes the quaternary sediments (Q), Gachsaran (GS), Asmari Shahbazan (As-Sb), Kashkan (Kn), Talezang (Tz), Amiran (Am), Gurpi (Gu), Emamhasan (Em), Ham (H), Sarvak (Sv) and Garu (Ga) formations. The last tree formations are classified as the Bangeston group. Geological map of the area is presented in Fig. 2.

Fig. 1: Location of the study area.

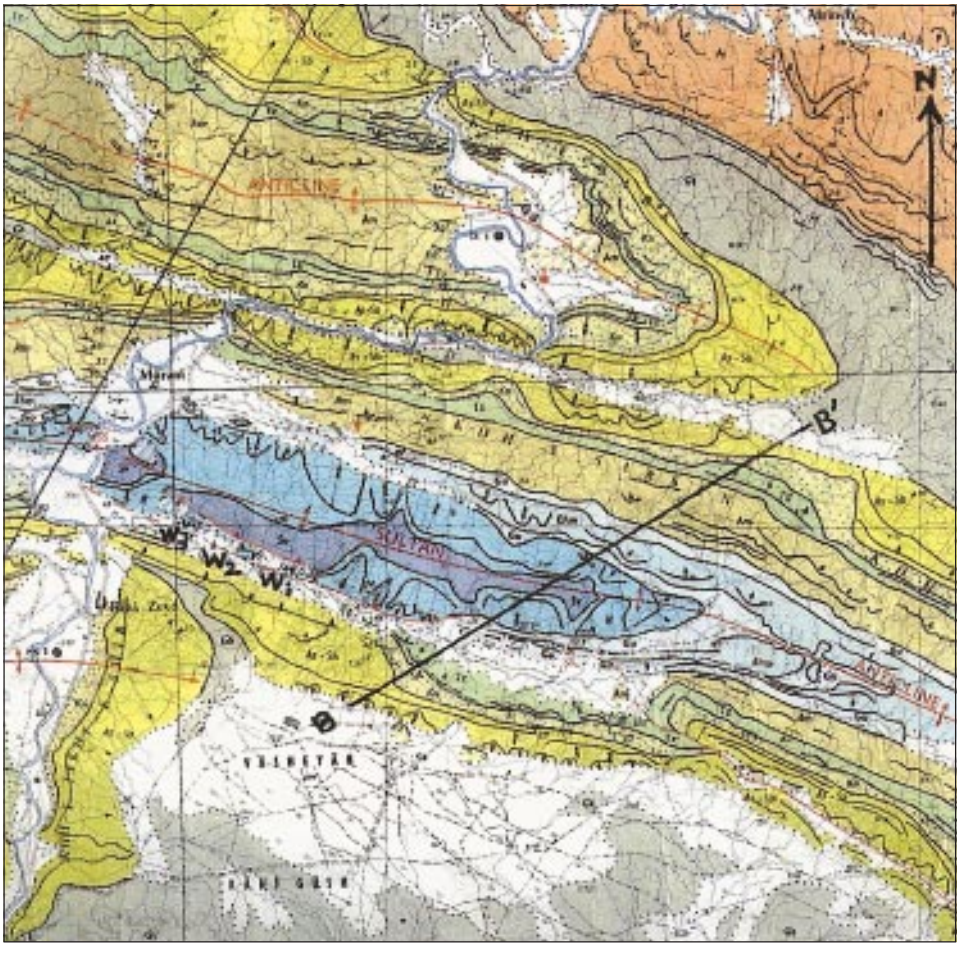


Fig. 2: The geological map of the area.
Legend: Al - Alluvium; Gs - Gachsaran; As-Sb - Asmari-Shahbazan; Kn - Kashkan; Tz - Taleh Zang; Am - Amiran; Gu - Gurpi; Ehm - Emam Hasan Member; Il, Sv - Bangeston Group; Ga - Garu.

THE CARBONATE FORMATION OF SARVAK

The carbonate formation of Sarvak is a part of the Bageston group, which constitutes the Sultan Anticline. The sarvak formation with a thickness of 820 meters at the type section of Lorestan in Sefid Kuh (north-west of Khorram abad) is deposited in the southern margin of the Neotethys Ocean. The age of the formation is Albian-Turonian.

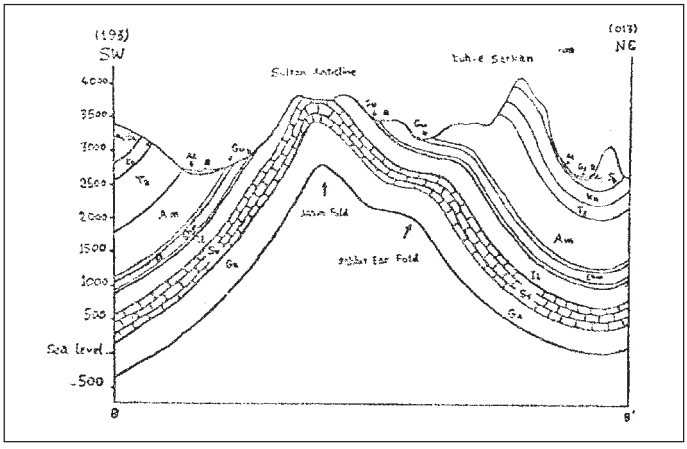


Fig. 3: Cross-Section along BB'.

Sarvak is a thick and coarse-grained carbonate formation of the Sultan Anticline. The geological cross-section along the BB' of the geological map is shown in Fig. 3.

It is overlain and underlain by the thin fine-grained Ilam and the bituminous shaly formation of Garu formations respectively. Due to the tectonic activities, the rocks of the Bageston group have been folded and faulted. The effect of tectonism is highty developed in the southern limb of Sarvak, which has been thrust over the Ilam formation. The shattering of the rocks (at the contact of Sarvak and Ilam) and the Z type folding on the southern limb of Ilam are indications of the intensity of tectonism (Figs. 4 and 5).

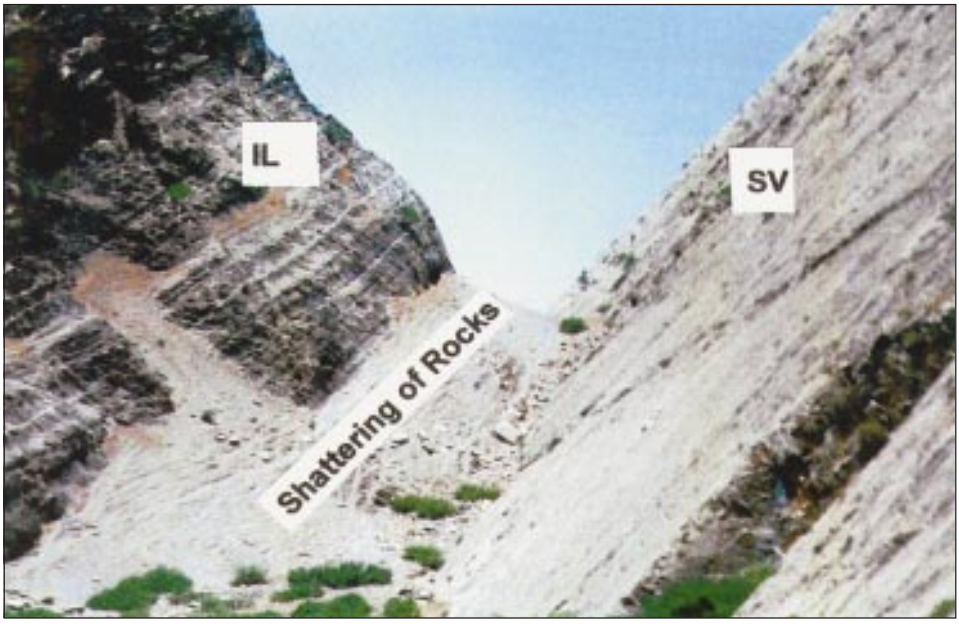


Fig. 4: Scattering of the rocks at the contact of Sarvak and Ilam.

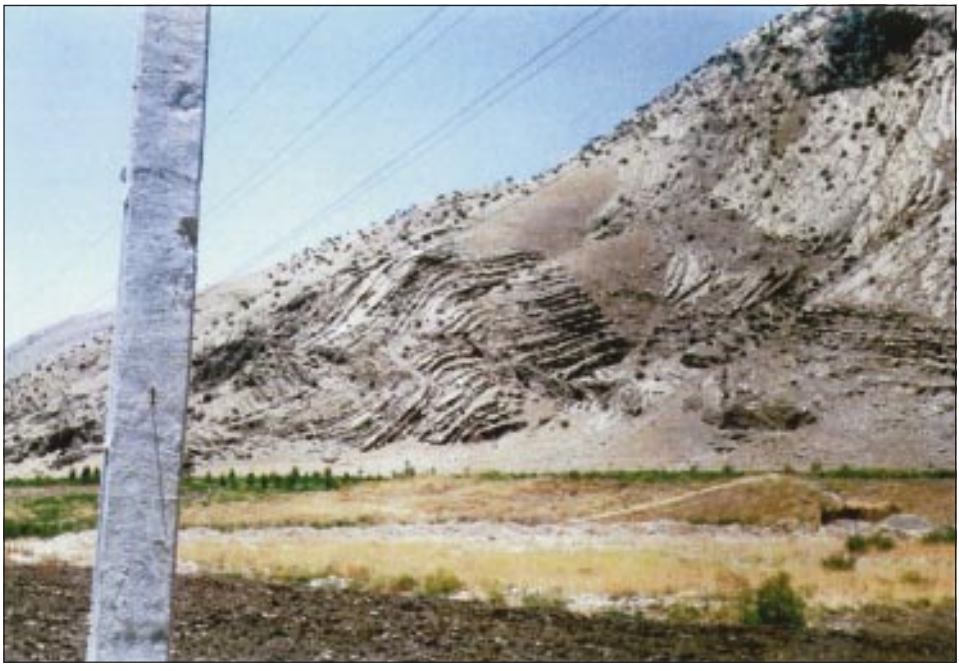


Fig. 5: The development of Z type folding along the southern limb of Ilam.

DEVELOPMENT OF FRACTURES

In general the fractures related to the Sarvak formation are of shear and tensile type (Fig. 6), which has been developed on the southern limb of Sarvak. The tensile fracturing has an important role in karstification.

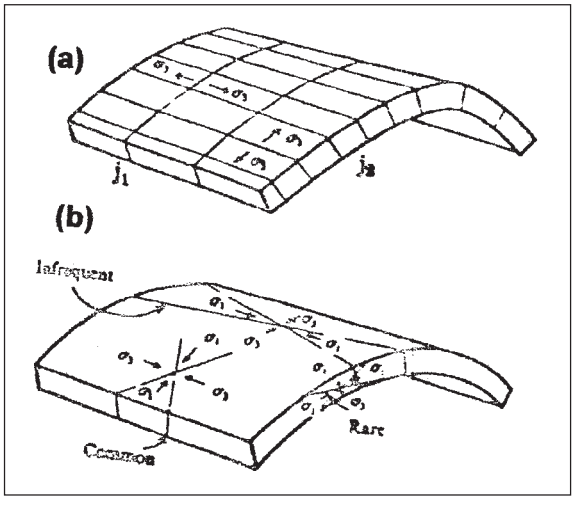


Fig. 6: Types of fracturing: (a) shear, (b) tensile.

Fig. 7: Development of karrens.

KARSTIC FEATURES

Due to the high intensity of tectonism and the action of dissolution, in the southern limb of sarvak karstic features such as karrens, dolines have been developed. The area is a typical karst in that surface drainage is lacking. Dolines and caves of the larger forms occur at the axes of the anticline. The dolines at the valley floor are circular in shape with different diameters. The karstic features are the main avenues for transmitting and storage of groundwater (Fig. 7).

WELLS

Based on the karstic features and the fractures (especially the tensile factures) in the southern limb of the Sarvak formation, three wells wit the total depth of 525 meters were drilled in order to supply the drinking water of the city of Pol-e Dokhtar with a population of more than 20,000 persons. The wells were drilled at a distance about 1 kilometer from each other. The situation of the wells is shown in the geological map of the area. Fig. 8 shows thle discharge of well (W_1).

The wells were pumped at a constant rate of 40 lit/s for 72 hours by the author. During the pumping test the wells did not show draw down. The calculated transmissivity for the first well (W_1) was 27417 m/day. The high transmissivity indicates the well-developed secondary fractures. At present the wells are being pumped to the city of Pol-e Dokhtar through a pipeline of 400 mm.

Fig. 8: Discharge of the well (W_1).

HYDROCHEMISTRY

In order to study the rock-water interaction, water samples from the wells were analyzed. The result of the chemical analyses of the samples during the pumping test is shown in the Table 1.

Table 1: Chemical analyses of the wells during drilling (mg/l).

Name	Ca	Mg	Na	K	SO_4	HCO_3	Cl	NO_3	NO_2	EC μScm^{-1}	TDS	TH	°C	PH
W_1	26.8	26.5	18.6	1.95	90.8	195.7	8.5	23	0.019	576	296	174.5	22	7.6
W_2	27.8	27.9	26.6	1.95	142	159.2	8.1	27	0.013	660	350	184.5	22	7.5
W_3	28.5	31	30.1	2.34	143	170	7.8	28	0.019	716	434	199.5	21	7.8

From the table it can be seen that the concentration of ions increases from W_1 to W_3. The type of water is Ca>Mg>Na, HCO_3>SO_4>Cl. The relatively high concentration of SO_4 in the water samples can be due to the effect of the Gachsaran formation. The high concentration of NO_3 in the

sample was known to be due to the agricultural activities, animal waste and human waste around wells. The concentration of NO_3 due to the protection steps from the agricultural activities and the continuous pumping was considerably reduced (Table 2).

Table 2: Chemical analyses of the water samples after protection and continuous pumping (mg/l)

Name	Ca	Mg	Na	K	SO_4	HCO_3	Cl	NO_3	NO_2	EC µs/Cm	TDS	TH	Ph
W_1	73.6	20.64	12.2	1.53	36.5	214	32.153	6.202	0.0066	496	400	270	7.53
W_2	75.2	22.56	26	1.8	1.8	210	38.72	9.303	0.0066	544	420	294	7.63
W_3	68	32.16	29	2.24	2.24	222	38.91	16.61	0.0099	608	480	330	7.15

The concentration of NO_2 in water samples during pumping test and after protection and continuous pumping is shown in Fig. 9.

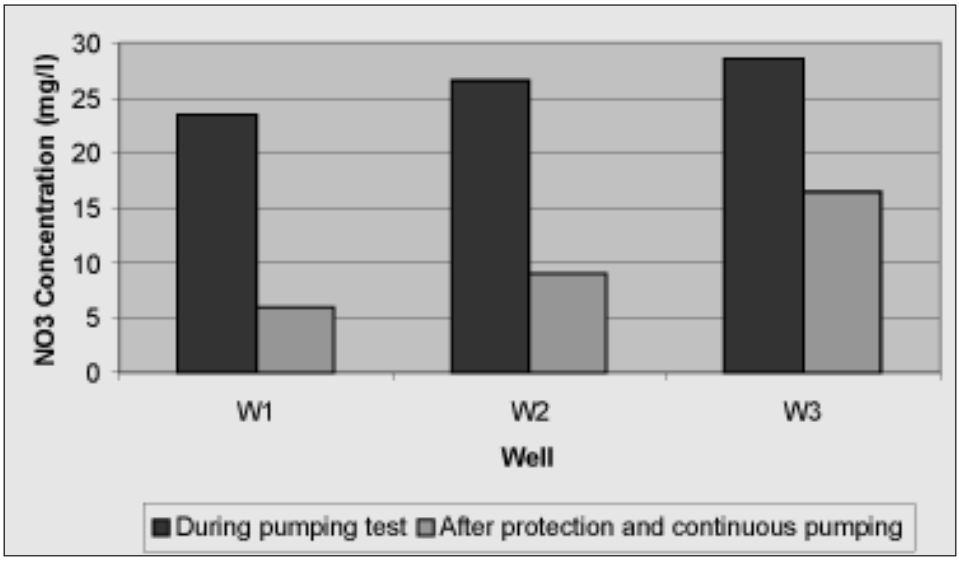


Fig. 9: The concentration of NO_2 in water samples during pumping test and after protection and continuous pumping.

ENVIRONMENTAL ISOTOPES

Sampling of the water samples for analyzing the environmental isotopes (oxygen-18 Deuterium and Tritium) were taken according to the standard of the International Atomic Energy Agency (IAEA) on 12/10/2000. The water samples were analyzed for oxygen-18 and Deuterium at the

facuhy of Earth Sciences, Liverpool University, England during my sabbatical leave. The Tritium analysis was done in Austria. The result of the data is shown in the Table 3.

Table 3: The water samples analyses for oxygen-18, deuterium and tritium.

T (°C)	Altitude (m)	δ D (SMOW) (0/00)	δO_{18} (0/00)	Tritium (TU)	Sample
22	770	-14.9	-3.89	8.7	W_3
22	740	-18.2	-3.18	10.3	W_3

From the table it can be seen that the water samples with higher concentration of oxygen-18 (lower negative values) are recharged from lower altitude and vice versa.

Water samples show different values of Tritium (TU) in which the well (W_1) with 8.7 TU has the lowest and the well (W_3) with 10.3 TU has the highest concentrations. In general the wells with higher values of Tritium have a lower residence time than those with lower concentrations.

CONCLUSIONS

The karstic features such as karrens and dolines are the main avenues for transmitting and storage of groundwater in the southern limb of Sarvak formation. Due to the protection of the area around the wells, the concentration of nitrate was reduced.

Analyses of the stable isotopes show that the water samples have different recharge area (altitude effect). The W_1 with lower concentration of tritium has higher residence time than the W_3.

SUGGESTIONS

Since the wells are the only source of fresh-water drinking of the city therefore the following points are recommended:

1 - The wells must be protected from any source of pollution
2 - Piezometric wells must be drilled around the wells in order to have a continuous record of water level.
3 - Isotopic analyses must be carried out for a longer time in order to have a better understanding of recharge and residence time of the wells.

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VLOGA GEOLOŠKE FORMACIJE SARVAK ZA OSKRBO MESTA POL-E DOKHTAR (IRAN) S PITNO VODO

Povzetek

Formacija Sarvak je najbolj zakrasela formacija v skupini Bagestan pri vasi Gol-Gol, okoli 14 km severozahodno od mesta Pol-e Dokhtar. Zaradi tektonske aktivnosti in raztapljanja, so v južnem krilu formacije Sarvak razvite kraške oblike, kot npr. škraplje in vrtače. Zakraselo podzemlje je najpomembnejše tako za pretakanje kot tudi za hranjenje talne vode. Za oskrbo s pitno vodo mesta Pol-e Dokhtar, ki šteje preko 20.000 prebivalcev, so bili v južnego krilo Sarvak formacije izvrtani trije vodnjaki. Avtor je opravil črpalni preizkus v trajanju 72 ur. V vodnjakih se ni pokazal pomembnejši upad gladine. Da bi ugotovili izvor vode in njen čas zadrževanja v podzemlju, so bile na vzorcih vode opravljene analize okoljskih izotopov. Analize kisika 18 in devterija so naredili na Fakulteti za znanosti o Zemlji univerze v Liverpoolu (Anglija). Vsi vzorci vode so bili v okviru meteorne vode, kar kaže tudi na tak izvor vode. Analize tricija so bile opravljene v Avstriji. Voda iz vodnjaka W_1 ima minimalno, iz W_3 pa maksimalno koncentracijo tricija, kar kaže, da ima voda v vodnjaku W_1 daljši rezidenčni čas, kot v vodnjaku W_3. Kemične analize vzorcev vode kažejo, da gre za vode tipa Ca>Mg>Na in HCO_3>SO_4>Cl. Med samim vrtanjem so imeli vzorci vode relativno veliko količino NO_3 (27 mg/l). Zaradi črpalnega preizkusa in zaradi zavarovanja področja pred kmetijsko dejavnostjo, se je koncentracija NO_3 znižala na 7,1 mg/l. Mesto Pol-e Dokhtar, ki je imelo resne težave z oskrbo s pitno vodo še izpred časov islamske republike, teh zdaj nima več, zahvaljujoč predstavljeni raziskavi.