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The gypsum karst aquifer in the Ouled Farès area (northern Algeria)

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Abstract

Detailed geological and hydrogeological mapping has been undertaken on about 50 km^2 of the environs of Ouled Farès (northem part of Cheliff valley). In the gypsum karst aquifer, three systems of ground water circulation have been identified :

1. near surface - related to karst cavities and cavems ;
2. shallow - related to fissures and partially to matrix within gypsums and sandstones underlying them ;
3. deep - connected with unrecognized deep basement.

Water samples from 23 springs, 2 from underground stream and 1 from well have been analysed. However chemical composition of ground water is critically influenced by the mineralogy of rocks. All the three circulation systems are dominated by more or less salty waters (2-14 g/1). Increasing mineralization of ground water is accompanied by changes in the chemical composition from SO_4Ca through multi-ion to ClNa.

Résumé

Aux environs d' Ouled Farès (bordure septentrionale de la vallée du Cheliff), on a réalisé la cartographie géologique et hydrogéologique sur une superficie d'environ 50 km². Dans l'aquifère karstique gypseux, on a distingué trois systèmes de circulation des eaux souterraines :

1. *subsuperficiel - associé au réseau karstique ;*
2. *peu profond - associé aux fissures et partiellement au milieu poreux dans des gypses et des grès sous-jacents ;*
3. *profond - associé au socle inconnu.*

Les résultats des analyses chimiques des 26 échantillons d'eaux souterraines (23 sources, 1 puits et 2 provenant d'un torrent souterrain) ont montré que leur qualité dépend strictement de la minéralogie des roches.

Cependant, l'eau souterraine des trois systèmes d'écoulement est plus ou moins salée (2-14 g11). L'augmentation de la minéralisation est accompagnée d'un changement de la composition chimique du type SO_4Ca en passant par un type à ions multiples jusqu'à un type ClNa.

I. INTRODUCTION

The Ouled Farès (1) area is a part of the southern border of the Dahra Mts. This mountain range extends to the north of the Cheliff valley, a deep graben formed in a subduction zone of the Tell Atlas (BIJ -DUVAL & MONTADERT, 1977). The Cheliff valley is an exceptionally active seismic zone in the Mediterranean basin. The Dahra Mts are built of folded Mesozoic and Cenozoic rocks. In the Ouled Farès area, Tertiary and Quaternary sediments form the uppermost part of the sequence and can be observed in outcrops. The highest hill in the area consists of Miocene gypsums underlain by sandstones of the same age. Both rocks form one of the aquifers.

The Dahra Mts have been distinguished by PANTELEEV and GOLOUBEV (1978) as one of the hydrogeological subregions of the Mediterranean coast. According to these authors, titis area is poorly known. Therefore, any results of field studies and any hydrogeological data appear to be valuable.

The present paper summarizes the results of geological and hydrogeological mapping in an area of about 50 square kilometres, with the special attention paid to the gypsum karst aquifer. Moreover, results of chemical analyses of single water samples are presented; the samples were collected from springs, from an underground stream flowing through a gypsum cave and from a well dug in a *wadi.*

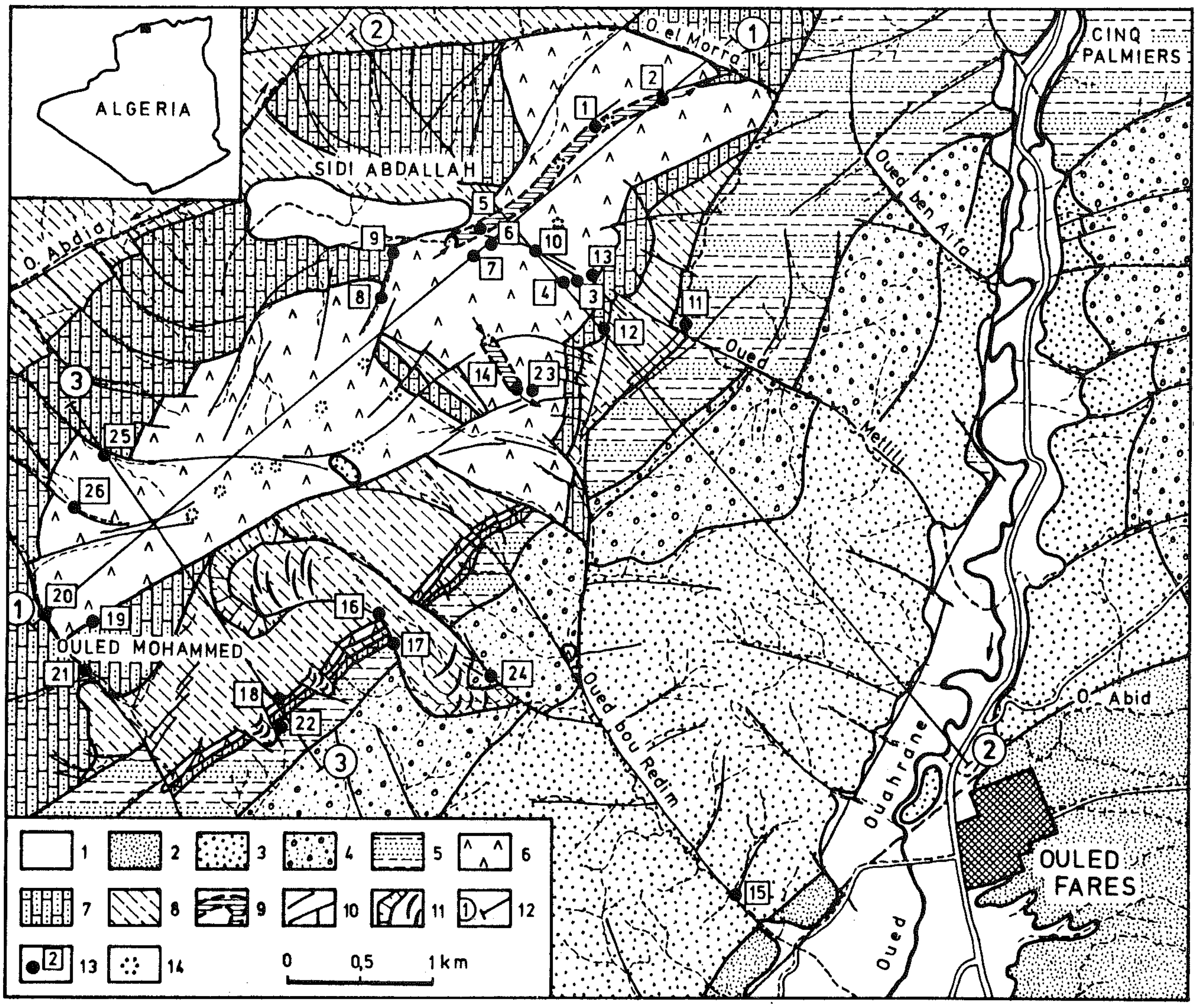

Figure 1 : Geological map of the Ouled Farès area.

1. recent alluvia
2. fossilized Quaternary alluvia
3. Quaternary and Uppermost Pliocene alluvia and sediments
4. Upper Pliocene, continental terrigenous sediments
5. Lower Pliocene, continental-marine terrigenous sediments
6. Upper Miocene, Sarmatian, gypsums
7. Upper Miocene, Sarmatian, sandstones
8. Upper Miocene, Tortonian, clays
9. generalized plan of cave galleries
10. linear discontinuities
11. landslides
12. cross-sections
13. sampling sites
14. sinkholes

II. GEOLOGICAL SETTING

The Ouled Farès area is a part of the northern periphery of the Cheliff graben. The graben is filled with 3000 metres of Tertiary and Quaternary sediments. The oldest rocks reported from outcrops (Fig. 1) are dark clays with thin limestone and dolomite intercalations, all of Upper Tortonian age (Messinian, after MEGHRAOUI, 1982). These are unconformably covered by a slab of Sarmatian sandstones and gypsums (Sahelian, after DALLONI, 1955). The Lower Pliocene sediments in the studied area are alternating marine and continental clays and poorly cemented sandstones with rare, thin limestone interbeds. The Upper Pliocene includes continental, red sediments, mostly poorly cemented sandstones with conglomerate intercalations.

Both the Uppermost Pliocene and the Lower Quaternary strata overlap sediments of varions ages. In the valleys these are light-coloured gravels and sands whereas weathering crusts are developed on slopes and plains. The Upper Quaternary alluvia. composed of brownish-red, sandy silts with

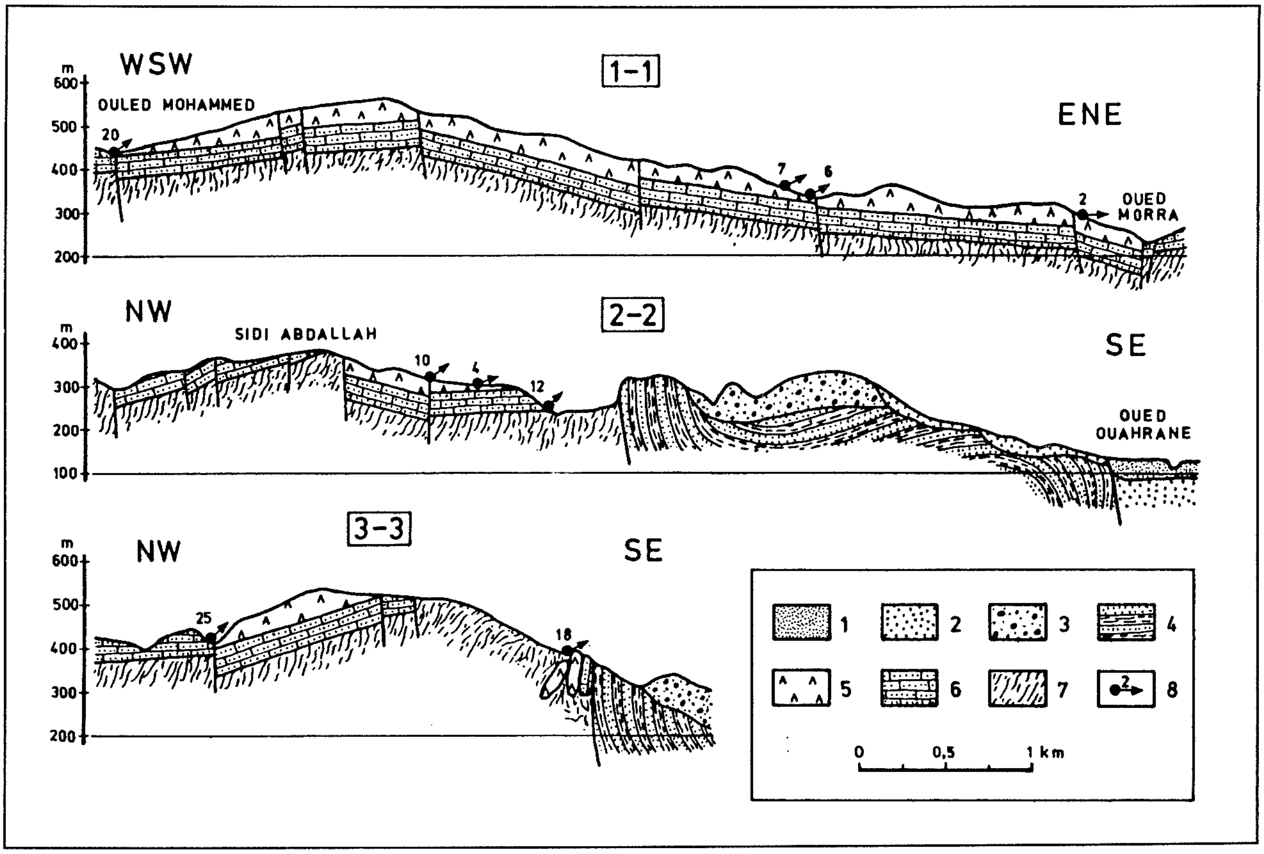

Figure 2 : cross-sections

1. Recent alluvia
2. Quatemary-Pliocene alluvia
3. Upper Pliocene, continental sediments
4. Lower Pliocene, continental-marine sediments
5. Upper Miocene, Sarmatian, gypsums
6. Upper Miocene, Sarmatian, sandstones
7. Upper Miocene, Tortonian, clays
8. Springs

intercalations of sands and gravels fill a wide morphological depression which partly belongs to the south-western part of the studied area.

Two principal tectonic units can be distinguished in the Ouled Farès area (Fig. 1, 2) :

1. system of Pliocene Quaternary folds and faults ;
2. system of Miocene folds and faults.

With regard to the faults, typical are SW-NE striées which reflect general direction of frame dislocations of the Cheliff graben. One of the most important tectonic structures is the Ouled Farès fault. To the north of Ouled Farès village, the Wadi Quahrane is developed along this fault (Fig. 1, 2). The Ouled Farès fault is still active and lias an average annual horizontal displacement of about 0.12 mm (EL-FOU L, 1984). Accompanying NW-SE striking, an echelon fault system controls the development of local valleys (e.g. Wadi bou Redim, Wadi Metlili, Wadi ben Aïfa).

III. CONDITIONS OF GROUND WATER CIRCULATION

The studied area belongs to the Dahra Mts which have been classified by PANTELEEV and GOLOUBEV (1978) as one of the hydrogeological regions of the Mediterranean coast. The Cheliff valley has a continental climate. Summers are dry, with a high number of days of a temperature close to or above 40°C.

Winters are chilly and humid. The average annual précipitation ranges between 300 and 400 mm.

One of the Tertiary aquifers is formol by Miocene gypsums and underlying sandstones. Three systems of water circulation can be distinguished : near surface, shallow and deep. The near surface circulation is rapid and proceeds through large karst cavities and caves cut in gypsum beds, close to the surface. Two caves have been recognized. One is about 500 metres long and has an entrance in a large sinkhole located some tens of metres upslope from the cave entrance (Photo 1). During raie season the sinkhole becomes a ponor which drains surrounding terrain. A seasonal spring (N°. 14, Fig. 1), which flows from this cave, disappears several days, up to a dozen, after a rainfall.

Photo 1 : Sinkhole with ponor - upper part of a system of karst cavities and fissures terminated with a cavern and intermittent stream (N° 14 spring, Fig. 1)

The second, much longer and complicated cave has been encountered in a northern part of the gypsum slab (Fig. 1). The main passage is about 2 km long. The cave is supplied by a small stream (about 600 metres long) which comes up from the Sarmatian sandstones and, after a long underground flow, discharges as N° 2 spring (Fig. 1). In some places the roof of the cave collapsed, which gave rise to shafts of various diameters (e.g. Photo 2).

In several places, the gypsum slab is truncated by sinkholes (Photo 3), typical of this type of rock (comp. e.g. PULIDO-BOSCH, 1986). Due to the seismic activity in the Cheliff valley, gypsum beds are strongly jointed (Photo 1). Dissolution which proceeds along some joints produces narrow shafts which enable recharge of both the near surface and shallow circulation systems. The shallow circulation system includes the pore spaces of clastic rocks as well as fissures and karst cavities located at greater depths (e.g. N° 3 spring, Fig. 1, Photo 4).

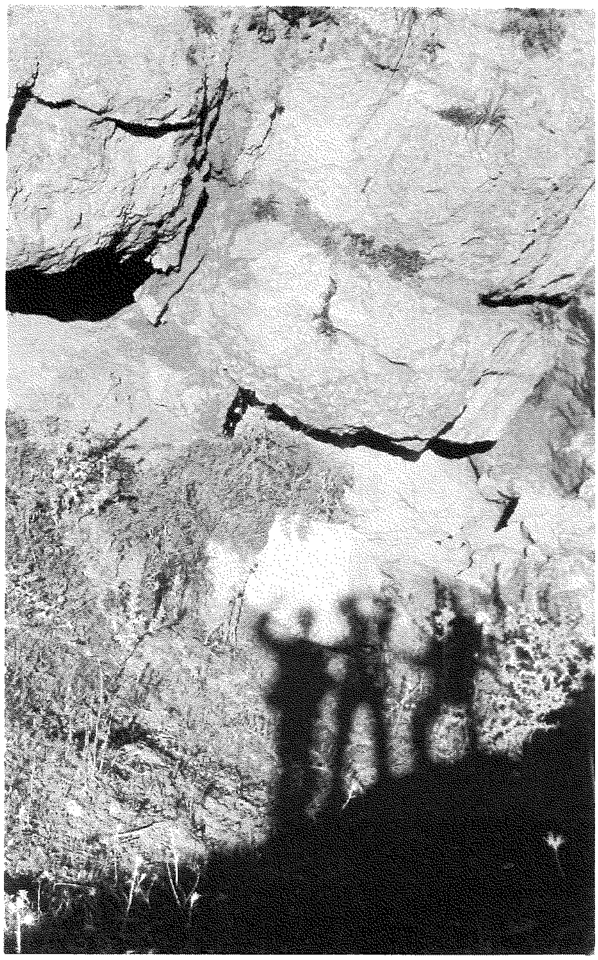

Photo 2 : sinkhole in gypsum beds - a collapsed fragment of a cave from the north-eastern part of the studied area

The deep circulation system is related to an unrecognized Miocene/Pliocene basement. Its recharge areas are located presumably far north from the studied area, in the higher parts of the Dahra Mts. Some ascending springs which accompany fault zones probably belong to this system (e.g. N° 10 spring, Fig. 1). Typical features of such springs are: small but stable discharge and detectable salty taste. Additionally, hydrogen sulphide was found to release from N° 10 spring.

Photo 3 : karst shaft in gypsum beds

Photo 4 : N° 3 spring - the shallow system of the circulation.

Discharges of springs in the studied area, measured during field studies (February, March 1986), were generally low. Most of the values vary between 0.03 and 1.0 1/s. Only a few flows and springs revealed higher values: N° 1 (cave flow) and N° 2 spring - 8 1/s; N° 5 spring (cave flow) - 6 1/s; and N° 4 flow - 3 1/s.

IV. CHEMICAL COMPOSITION OF UNDERGROUND WATERS

In order to characterize the chemistry of underground waters in Ouled Farès area, 26 samples were collected in February-April, 1986. From these samples, 23 originated from springs, two from sinkholes (e.g. Photo 3) truncating the 2-kilometres-long gypsum cave (Fig. 1) and one from a well in Wadi Metlili. Both conductivity and pH were measured at the laboratory. All the samples have been analysed for Ça+2, Mg+2, HCO^-_3, SO_4
Metlili well, for which only sulphate ion has been analysed. Results of chemical analyses are listed in Table 1.

Conductivity of the samples measured at 25° C varies from 600 (N° 11 well) to 21000 pS/cm (N° 10 spring). Specifically, 22 samples (84 %) showed a conductivity below 6400 pS/cm and the remaining four gave over 10500 pS/cm. Total dissolved solids (TDS) measured as a sum of ions contents, were found to change from 2.0 to 14.1 g/1 (Tab.1). The pH for most of the analysed samples fans into the range 6.9 - 8.4 i.e.; most of the studied waters are weakly basic. Although samples were collected chiefly from ground waters coming from or flowing through the gypsum beds (20 samples), only 5 of them revealed SO_4Ca composition (N° 3, 4, 20, 23 and 26 springs). Commonly, these two ions were accompanied by Mg or Na or both. In samples of below 5 g/1 TDS, increased contents of Cl^- were detected. Concentrations of chlorine ion were found to augment with the increasing TDS; and above 14 g/1

N° of point	Aquifer	Cations (mval/l)			Anions (mval/l)			TDS (g/l)
		Ca	Mg	Na	Cl	SO_4	HCO_3	
1	G	31.4	9.8	4.2	8.5	34.2	2.8	2.95
2	G	3.1	8.9	10.6	8.2	40.6	2.0	3.34
3	G	29.9	2.5	0.97	3.9	27.2	2.2	2.23
4	G	30.4	0.01	4.1	4.1	27.8	1.8	2.28
5	G	32.3	3.0	2.1	8.5	26.8	2.1	2.45
6	G	30.4	4.9	3.5	11.9	24.9	2.0	2.49
7	G	27.4	2.0	18.9	13.1	33.2	2.0	3.19
8	G	31.4	2.9	8.9	2.9	37.5	2.7	2.94
9	G-S	30.4	1.0	9.8	17.1	22.1	2.0	2.64
10	UB	3.4	14.3	218.6	215.0	8.9	12.3	14.07
11						1.35		
12	G-S	25.5	10.8	30.6	8.2	56.5	2.1	4.48
13	G	24.0	11.3	2.8	4.0	31.8	2.2	2.49
14	G	26.5	7.9	14.5	3.3	43.7	1.7	3.28
15	S-UQ	9.8	19.7	39.2	52.8	12.1	3.8	4.02
16	G	6.9	27.5	43.2	7.9	67.0	2.6	5.12
17	S	28.4	12.8	20.5	21.1	38.7	1.9	3.92
18	G-S	25.5	48.0	71.5	59.5	82.1	3.4	9.00
19	G	22.5	48.0	77.7	70.1	74.3	3.9	9.11
20	G-S	24.5	5.9	0.31	5.4	23.6	1.7	2.00
21	S	18.6	13.7	38.3	33.6	34.2	2.8	4.43
22	G-S	34.3	7.9	15.5	14.7	40.1	2.8	3.76
23	G	30.4	6.9	5.9	4.5	37.1	1.6	2.87
24	S-C	33.3	47.1	57.4	95.1	39.4	3.3	8.03
25	G-S	26.4	43.1	1.7	23.8	41.7	5.8	4.29
26	G	31.4	5.9	1.6	2.8	33.9	2.1	2.59

Table 1 : Ionic contents of groundwater
G gypsum G-S gypsum-sandstone UB unrecognized basement
S-UQ sandy silt, sand (Upper Quaternary)
S-C sandstone, conglomerate (Upper Pliocene)

water type was observed to change into ClNa (N° 10 spring, Tab. 1). It should be emphasized that both the TDS and the chemical composition of ground waters from gypsum beds of the Ouled Farès area differ from those coming from gypsum beds in Sorbas (Almeria, Spain), an area which has the same climate as Ouled Farès (PULIDO-BOSCH, 1982, 1986). Ground waters from Spain represent mostly the SO_4Ca type, although that author also found increased concentrations of Mg, Na and Cl ions. Their origin has been related to the influx of brines from rocks adjacent to the gypsum slab.

V. NOTE

(1) All the local names are used in French transcription.

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