PRELIMINARY HYDROGEOLOGICAL CHARACTERIZATION OF AN EVAPORITE KARST AREA (PROVINCE OF CORDOBA, SOUTH SPAIN)

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1. INTRODUCTION

The northern sector of the Subbetic Domain in the Betic Cordillera (Fig. 1) is formed by an olistostrome unit known as the Chaotic Subbetic Complex (CSC). This megabreccia is basically made of Triassic (Keuper) clays and evaporites (gypsum, anhidrite and halite) as well as blocks of other lithologies: limestones, dolostones, sandstones, etc. (Vera & Martin Algarra 2004). Despite that low permeability has been traditionally assumed for these materials, water flow and storage through them is likely derived of their aquitard behavior, but also because of the highly permeable conduits generated by dissolution/karstification processes within the evaporite rocks (Calaforra & Pulido Bosch 1999). The geological complexity of the CSC materials determines their hydrogeological heterogeneity, with groundwater flows of different residence time from recharge to discharge areas (Fig. 2).

2. SITE DESCRIPTION

Three saline springs draining the CSC outcrops have been identified around an evaporitic karst plateau located in the province of Cordoba (Spain) (Fig. 1 & 3). The central part of this plateau presents several endorheic areas. Wetlands are often placed at the bottom of these depression (Photo 1.a). However, in some cases, sinkholes are formed and they become active during rainy periods.

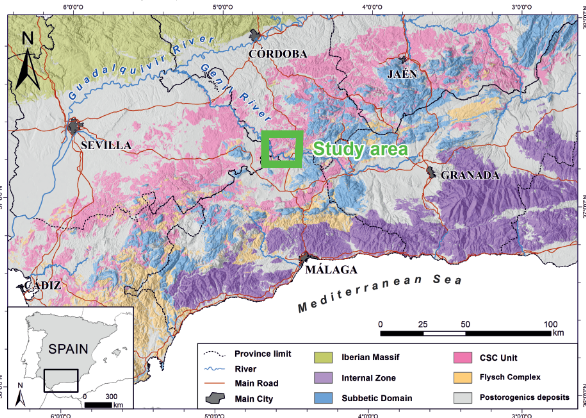

Fig. 1 *Geological framework and geographical location of study area*

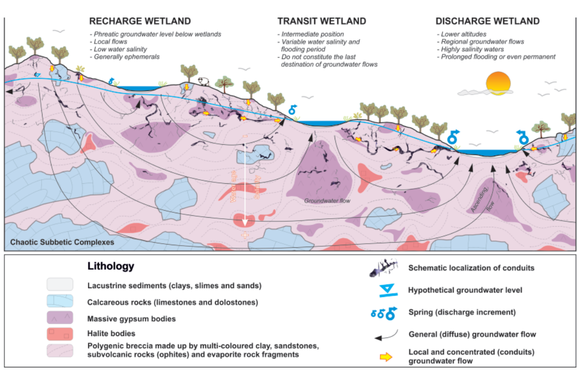

Fig. 2 *Hydrogeological conceptual model of groundwater flow within the CSC. Modified from Andreo et al. (in press)*

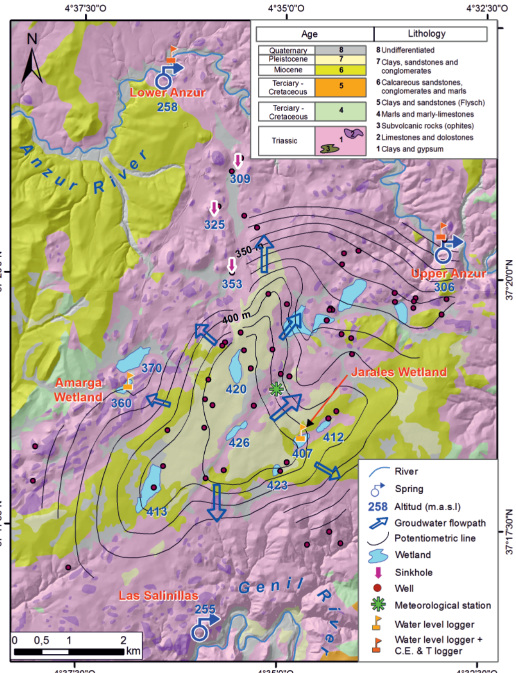

Fig. 3 *Geological and hydrogeological scheme and monitoring network location*

3. MONITORING NETWORK AND METHODS

Hourly records of:

- Water level variations (discharge and wetland water table) → 4 water level data logger (Photo 1.b,c,d; Fig.3) 2 gauging station (Photo 1.c,d)
- Electrical Conductivity
- Water temperature → 2 E.C. and Water temperature data loggers (Photo 1.c,d; Fig.3)
- Precipitation, air temperature and evaporation rate → 1 meteorological station (Photo 1.a; Fig.3)

Additionally:

Fortnightly in situ records of discharge, E.C.and water temperature

Spring, wetland and rain water samples for subsequent chemical and isotopic analysis in the laboratory

4. RESULTS

		Electrical Conductivity (mS/cm)			Temperature (ºC)			Discharge (L/s)			Main Dissolve	
Name	Type	Main	Max	Min	Main	Max	Min	Main	Max	Min	oxygen (mg/L)	Main pH
Upper Anzur	Spring	45	49.7	41.3	20.6	21.2	19.5	1.9	3.5	0.7	1.7	6.9
Lower Anzur	Spring	147.7	157.8	124.9	20.4	21.1	19.4	12.83	87.8	0.76	4.2	7
Salinillas	Spring	77.1	79.9	70.6	21.7	23.1	21.4	0.5	-	-	6.4	7.17
Jarales	Wetland	3.1	5.3	2.6	18.6	27	7.3	-	-	-	7	8.1
Amarga	Wetland	2.9	3.4	2.5	21.7	28.8	14.7	-	-	-	7.3	8
Dulce	Wetland	0.4	0.6	0.3	16.3	22.7	11.1	-	-	-	8.7	8.7

Tab. 1 *Summary of results*

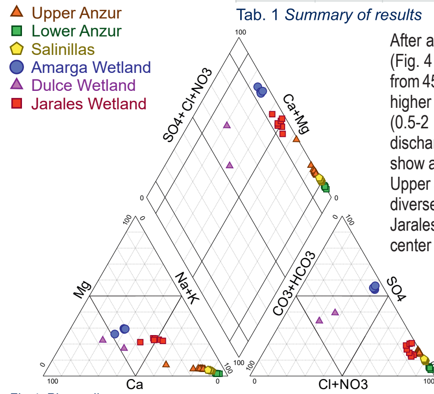

Fig 4. Pipper diagramme

After almost two hydrological years, data reveals significant differences between the springs (Fig. 4 & 5, Tab. 1). They drain water of sodium chloride type, although mineralization varies, from 45 (Upper Anzur) to 148 mS/cm (Lower Anzur), and groundwater temperature is 3.5 to 5 ºC higher than the annual average air temperature (16.8 ºC). Flow rates are low during dry season (0.5-2 L/s). Response to rainfall events is rapid at Lower Anzur spring, with sharp rises of discharge. The other two springs do not have clear variations after rain episodes but rather they show a delayed and smoothed response to recharge periods. The hydrochemical evolution of Upper and Lower Anzur springs is displayed in Fig. 5. Waters from the wetlands are chemically diverse (Fig. 4) and they range from fresh water (Dulce wetland) to brackish water (Amarga and Jarales). Potentiometric measurements indicate the existence of a hydraulic gradient from the center of the plateau towards the edges, where the springs are placed (Fig. 3).

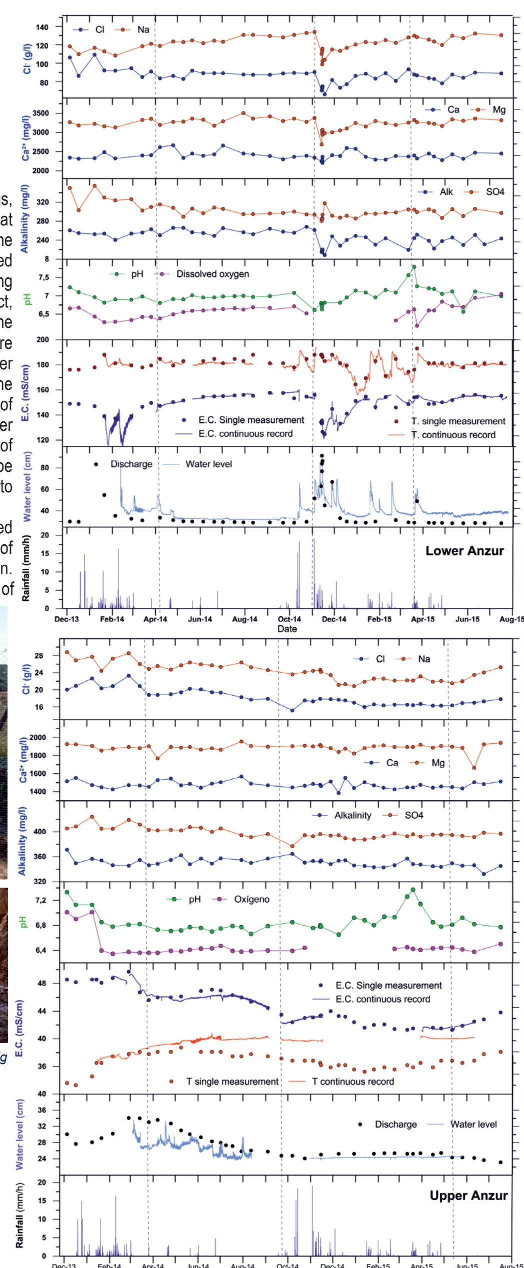

Fig. 5. *Temporal evolution of dishcarge rate, physicochemical parameters and major ions of Lower and Upper Anzur Springs*

5. PRELIMINARY DISCUSSION AND CONCLUSIONS

Groundwater flows from the central part of the area towards the springs, located at the northern border of the system (Fig. 3). Wetlands placed at higher altitudes are recharge elements, whereas the rest are situated in the transit of groundwater flow between them and discharge areas. The studied springs have different behavior. The rapid response of Lower Anzur Spring to recharge events is a strong indication of a markedly karst behavior. In fact, infiltration through swallow holes has been recorded before the rise of the discharge at the spring. The functioning of Upper Anzur Spring is more inertial and its response to precipitation, when observed, it is delayed. Water from the three springs present slight thermal anomaly that, together with the high mineralization values, could be an indicator of the existence of ascending regional groundwater flows. EC increment observed at Lower Anzur Spring during dry periods could be linked to the regional component of discharge. On the other hand, the rise of sulphate after recharge should be related to the abundant presence of gypsum in the media and therefore, to piston flow through the conduits that are formed in it by karstification.
The hydrochemical diversity and the variety of natural responses observed in the study area reflect the heterogeneity of the media, where diffuse flow of large residence time within the aquifer coexist with rapid karst circulation. Additional works are necessary in order to reach a better understanding of the system.

Photo 1. *A: Water level logger at Jarales Wetland. B: Meteorological station. C and D: Weig station equiped with water level sensor at Upper (C) and Lower (D) Anzur Springs.*

6. ACKNOWLEDGMENT

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