

3.19 Description of the South Dobrogea aquifers case study, Romania

Title of Case Study	Dating of Sarmatian and Upper Jurassic – Lower Cretaceous aquifers from South Dobrogea and the Implications on Groundwater Management in Romania, South-Eastern Europe.
Location (region, Country)	South-Eastern Europe, Romania
Other information	

Description of Case Study (background information on the region)

Romanian territory is located in the eastern part of the Black Sea Basin, and the case study area is situated near the Black Sea coast, at the border with Bulgaria. The Sarmatian aquifer and the Upper Jurassic – Lower Cretaceous aquifer are cross-border aquifers, and they are important water reservoirs for the South Dobrogea region. These two aquifers provide water supply for two Municipalities, Constanța and Mangalia, and for 58 communes of the Constanța County, as well as for several resorts situated on the seashore of the Black Sea.

The upper aquifer, which is the Sarmatian (Middle Miocene - Volhynian, Bessarabian, Kersonian) aquifer, has a surface of 2192 km², and is an unconfined aquifer hosted in limestones and covered by Pleistocene loess. The lower aquifer (having a surface of almost 4000 km²) which is the Upper Jurassic - Lower Cretaceous Aquifer is a confined aquifer on almost 60% of the surface of the South Dobrogea.

Description of problem (why is this location chosen for a Cases Study)

For the last 25 years, for Dobrogea de Sud region, isotopic monitoring (³H, ¹⁴C, ¹³C, D, ¹⁸O) has been performed by integrated research of all-natural types of waters in order to improve the knowledge of the hydrogeological parameters and of the regional flow pattern. The origin and the age of groundwater have been determined, for both aquifers. The major objectives that have been constantly considered are:

- delimiting the recharge areas of the Sarmatian and the Barremian-Jurassic aquifers;
- determining certain regional hydrodynamics parameters of the two aquifers;
- assessing the changes over time in regional isotopic distribution as a consequence of interaction with surface waters.

Together with the conclusions for the regional studies of the two main aquifers, the acquired isotopic data have also been used to emphasize some local aspects, such as the interrelations between the surface waters (Lake Siutghiol) and the groundwater extractions, by using tritium based isotopic method for the quantitative assessment of the water mixture.

Methods to be used in the Case Study (analytical and isotope techniques, modelling)

A study conducted in 1986 (Tenu et al., 1986) was mainly based on the determination of environmental isotopes (³H, ¹⁴C, ¹³C, D, ¹⁸O) along with thermal and physic-chemical parameters which were determined both in situ and in the laboratory. This association of parameters was very useful in certain interpretations and also in correcting radiocarbon ages. Except for the ¹⁴C and ¹³C analyses, which were carried out at a single stage, starting from 1983, all determinations were resumed annually using the samples taken in May from a network of water points maintained unchanged. Based on this network, a synthesis study has been conducted in 1986 by Tenu et al. This database has been updated and new assessments have



been published in 1993, 1994, 1995, 2004, and 2014 by Tenu et al. Radiocarbon and tritium measurements were carried out using liquid scintillation counting. Deuterium and oxygen-18 isotopic composition was determined by mass spectrometry. Research by means of artificial tracers has been conducted since 1971 (Găstescu & Hîncu, 1971; Gaspar & Orășeanu, 1987). The software that has been mainly used is FeFlow.

Results from this Case Study

By means of isotopic research correlated with other methods, a conceptual model of the aquifers of South Dobrogea has been realized by Tenu et al in 1986 and reassessed in 2004. Thus, regarding aquifer types, there have delineated: 1. the shallow groundwater (^{14}C = 20 to 50 pMC, ^3H = 0.8 to 14.3 TU); 2. the partial confined aquifer (local covered by the Lower Cretaceous aquitard: ^{14}C = 5.0 to 10 pMC, ^3H = < 0,8 to 1,1 TU); 3. the confined aquifer covered by the intermediate complex aquitard: ^{14}C = 1.0 to 10 pMC, ^3H = < 0.8 TU). The recharge area is located mainly in the Pre-Balkan Platform (Bulgaria); the main groundwater flow direction is east-northeast, towards the Siutghiol Lake, and the flow velocities, at the regional scale, vary from 100 m/year on a secondary groundwater flow and 500-1,800 m/year on the main mentioned one. The adventive recharge (by surface water) area is located in the northern area of the region. Regarding drainage: there is a natural drainage area (Np below + 17 m) near Lake Siutghiol, and a major (natural and anthropic conditioned) discharge area (Np below + 2m). Regarding hydraulic of groundwater: there is a flow direction of groundwater, confirmed by isotopic means and the value of hydraulic gradient is between 0.0001 to 0.0024, and there is a flow direction of groundwater, suggested by underground hydraulic information but non-confirmed by radiocarbon, having the direction from SV to NE. Also, there is a zero line of the area having the piezometric head with up to 15 m above the upper aquifer. Based on ^{14}C and ^{13}C analyses the age of the upper aquifer (Sarmatian) is estimated for between 1 (in the western area) to 12.3 thousand years (in the eastern part of the region). The values of ^{14}C isochrones for the lower aquifer vary from 5.7 to 21 thousand years.

Impact - how this Case Study contributes to the overall project aims

The isotopic research brings an essential contribution to creating a detailed groundwater flow model that leads to a proper management of the aquifers from South Dobrogea. Thus, based on this model, it was possible to dimension the water supply systems, delimit the areas of vulnerability of the aquifers and take the necessary measures to protect them.

Name of pilot area / aquifers / type: South Dobrogea / Sarmatian, Upper Jurassic – Lower Cretaceous/ limestone aquifers / karst		Country: Romania Region: South – East Romania		
Study level	Transboundary : ☐ Regional: X Local: ☐ Single well(s): ☐			
Type of observations <i>(choose one of the options, create separate template if needed for each type if each type need specific information)</i>	☐ Short screened observation wells (not pumped) ☒ Long screened observation wells (not pumped) ☐ Pumped wells, long screens in one aquifer ☐ Pumped wells, long screens over multiple aquifers ☐ Springs ☐ Other (eg. research wells; indicate type and information on pumping):			
Approximate location of pilot:				
Geological cross section / conceptual model of the pilot area:	<i>Reproduced after Popa et al, 2019. A unit is Sarmatian aquifer; C unit is Barremian – Jurassic aquifer.</i>			
Name of Shape- / Geopackage file defining the area: Eesti_wgs84.shp		Projection to be used: WGS84 (Epsg4326)		
Hydrological parameters:	Mean annual precipitation (mm or range in mm)	Mean annual groundwater recharge (mm or range in mm)	Mean annual groundwater recharge temperature (°C)	Thickness of unsaturated zone (range in m)
	500 - 550	unknown	unknown	0-60

Pumped wells only		Typical pump discharge of sampled individual well (m ³ /day):		Typical pump discharge of complete well field (m ³ /day): <i>If relevant</i>
List of aquifers and aquitards in pilot area		No. of confined or semiconfined aquifers in pilot area: 1		No. of unconfined aquifers in pilot area: 1
Aquifer no. (aqf): 2 Aquitard no. (aqt): 1 Aquiclude no. (aqc): 1	Aquifer/aquitard type and/or name	Lithology (Resource WP6 terminology)	Depth range (m)	GW age range (yr)
Aqf-1: Sarmatian	Sarmatian	Limestones	Mainly 0 – 60 (locally up to 100 m)	1000 - 12500
Porosity type	Porous: ☐	Fissured: ☐	Karst: ☐	Fissured and porous / dual porosity: X
Aqf-2: Upper Jurassic – Lower Cretaceous	Upper Jurassic – Lower Cretaceous	Limestones and dolomites	60 – 800	5000 - 25000
Porosity type	Porous: ☐	Fissured: ☐	Karst: X	Fissured and porous / dual porosity:
Aqt-1: Senonian	Senonian	Chalk		
Porosity type	Porous: ☐	Fissured: ☐	Fissured and porous / dual porosity: ☐	No hydraulically active porosity: X
Aqc-1: Devonian	Devonian	Clay shales, quartz sandstone	800 - 1500	
Porosity type	Porous: ☐	Fissured: ☐	Fissured and porous / dual porosity: ☐	No hydraulically active porosity: X
Applied tracer age indicators (³ H, ³ H/ ³ He, ⁸⁵ Kr, ³⁹ Ar, ¹⁴ C, ³⁶ Cl, ⁸¹ Kr, ⁴ He, CFCs, SF ₆ , etc.) Applied recharge temperature indicators (¹⁸ O, D, noble gases)		Aquifer-1 ¹⁴ C, ¹³ C, ¹⁸ O, D, ³ H		
		Aquifer-2 ¹⁴ C, ¹³ C, ¹⁸ O, D, ³ H		
Number of sites (wells/springs) with age indicators		Aquifer-1 1-5: ☐ 5-10: X 10-25: ☐ >25: ☐		
		Aquifer-2 1-5: ☐ 5-10: ☐ 10-25: X >25: ☐		
GW age range (GAR) GAR-1: Modern (< 60 yr) GAR-2: Old (> 60 yr and 10 kyr)		Aquifer-1 GAR-1: 1-10%: ☐ 10-25%: ☐ 25-50%: ☐ >50%: ☐ GAR-2: 1-10%: ☐ 10-25%: ☐ 25-50%: ☐ >50%: X		



GAR-3: Paleowaters (> 10 kyr)		GAR-3: 1-10%: ☐ 10-25%: ☐ 25-50%: ☒ >50%: ☐			
		Aquifer-2 GAR-1: 1-10%: ☐ 10-25%: ☐ 25-50%: ☐ >50%: ☐ GAR-2: 1-10%: ☐ 10-25%: ☐ 25-50%: ☒ >50%: ☐ GAR-3: 1-10%: ☐ 10-25%: ☐ 25-50%: ☐ >50%: ☒			
Groundwater age ranges (GAR) estimated by:		Tracer based estimates ☐ Flow and age model simulations ☒ Combination of model and tracer estimates ☐ Expert judgement: ☐			
Objective of age dating studies:					
Basic research or General groundwater management	Assessment of pollutant history		Assessment of the efficiency of remediation and mitigation measures		Indication of vulnerability of aquifers and water supply wells
X					
Water Usage <i>(not relevant for observation wells)</i>	Water supply		Irrigation	Industry	Other
	X		X	X	
Geoenery related activities <i>(not relevant for observation wells)</i>	Shallow Geo-T	Deep Geo-T	Hydrocarbons		Nuclear waste disp.
Mining activities <i>(not relevant for observation wells)</i>	Construction materials		Minerals / metals	Coal	Other
	X				
REFERENCES					
OPEN Access reports and papers (PDF versions made available in EGDI repository making them downloadable via maps and keyword / free text searches): (Romania) by Environmental Isotopes, International conference on isotopes in environmental studies - Aquatic Forum 2004. Book of extended synopses https://inis.iaea.org/search/search.aspx?orig_q=RN:36043436 Mircea, I., 2012, Stabilirea zonelor de protecție ale principalelor captări care exploatează acviferul cantonat în calcarele sarmațiene din Dobrogea de Sud, Rezumat teza de doctorat, http://gg.unibuc.ro/wp-content/uploads/2018/05/ION-Rozica-Irina-MIRCEA.pdf ;			Reports and papers with restricted access: Blaga, L., Blaga, L.M., 1975, Concentratia deuteriului in apele din zona Dobrogei, report, I.I.S. Cluj Napoca. Blaga, L., Blaga, L.M., Ciobotaru, T., Feurdean, V., 1979, "Studii pe baza de izotopi stabili ale originii si modificarii regimului apelor din Dobrogea de Sud ca urmare a realizarii canalului Dunare – Marea-Neagra", raport la contract de cercetare ITIM Cluj-Napoca nr.957/1979. Tenu, A., Davidescu, F., D., Slavescu, A., 1986, Isotopic investigation on the evolution of groundwater dynamics in the principal aquifers of Dobrogea, I.A.E.A. Report R - 3621-F. Tenu, A., Davidescu, F., D., Slavescu, A., 1987, Recherches isotopique sur les eau souterraines des formations calcaires dans la Dobroudja Meridionale (Roumanie). Isotope techniques in water resources development, I.A.E.A., Vienna, pp. 439-453, https://inis.iaea.org/search/search.aspx?orig_q=RN:19054635		



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Remarks / other relevant information:	