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Sedimentological Features of the Plio-Quaternary Aquifers of Salento (Puglia)

Aspetti sedimentologici degli acquiferi plio-quaternari del Salento

DELLE ROSE M. (*)

ABSTRACT - Salento, the southern part of the Apulia Carbonate Platform, presents a horst and graben tectonics. The uplifted blocks are made up by Cretaceous rocks, while Pliocene and Pleistocene deposits occupy mainly the lowered blocks. Due to the predominance of calcareous rocks, landforms are characterized by karst morphology.

About 70% of drinking water demand of the Salento is provided by a Cretaceous carbonatic aquifer which contains a huge mass of fresh water floating over salt water intruded by the Ionian and Adriatic Seas. Several shallow aquifers, used only for irrigation, lie in the Pliocene and Pleistocene units.

The current resource management is based on studies connected with groundwater hydrological regimen indicating an overall drawing possibility of about 190 x 10^6 m^3 year, against a recharge volume of 880 x 10^6 m^3 related to the six "wet months" embracing fall and winter. This model does not consider the role of the Pliocene and Pleistocene aquifers in draining a large portion of effective infiltration and pouring out resident water into the Cretaceous aquifer.

A critical situation for the Cretaceous aquifer of Salento has to be stated. Increasing withdrawal induced a strong salinization of the water exploited from wells. Furthermore, several cases of shallow aquifer pollution have been identified. These aquifers are not considered strategic resources and, as a consequence, their management is missing. However, Pliocene and Pleistocene aquifers must be strongly safeguarded especially in presence of karst system, pollutant substances may reach the Cretaceous aquifer within few hours or days.

Three study areas are dealt with. In the Torre dell'Orso coastal area, fresh water is a few meters below the surface and it was drawn since the Bronze Age. Differences in permeability in the local Upper Pliocene deposits create a multilayered aquifer system. A considerable volume of groundwater is discharged into the sea instead of supplying the deep aquifer. In the Burgesi area, karst systems and faulted zones drain waters from the Lower-Middle Pleistocene shallow aquifer into the deep ones strongly increasing groundwater vulnerability. In Contrada Triglio a marly unit act as permeability barrier at the base of the local aquifer which sourced the town of Taranto by means of a Roman-Medioeval aqueduct; this unconfined aquifer is particularly sensitive to climatic changes.

Considering the role of shallow aquifers in recharging the deep ones, as well as the possibility of pollutants spreading, a detailed study of their hydrogeological properties is today necessary. This research provides new evidence of the importance of the sedimentological analysis for a better management of the Salento groundwaters.

KEY WORDS: Aquifers Recharge, Groundwater Management, Pollutant Spreading, Calcareous Rocks, Karst Processes.

RIASSUNTO - Il Salento, parte meridionale della Piattaforma Carbonatica pugliese, ha una struttura ad horst e graben. I primi sono formati da rocce del Cretaceo, mentre le depressioni strutturali sono in parte occupate da depositi del Pliocene e del Pleistocene. A causa della prevalenza di

(*) CNR - Istituto di Ricerca per la Protezione Idrogeologica, Via Amendola 122/i, 70126 Bari. m.dellerose@ba.irpi.cnr.it

rocce carbonatiche, il paesaggio è caratterizzato principalmente da forme carsiche.

Il Salento dipende per oltre il 70% del fabbisogno di acqua potabile dalle proprie riserve idriche sotterranee contenute in un acquifero carbonatico profondo, costituito da depositi di età cretacica diffusamente carsificati, alimentato da acquiferi superficiali formati da depositi plio-quaternari.

L'acquifero di base è soggetto a processi di salsificazione per effetto del miscelamento delle acque di falda con acque di intrusione marina. Il modello di gestione delle risorse idriche sotterranee del Salento prevede prelievi dall'acquifero di base corrispondenti ad una percentuale dell'infiltrazione efficace. Esso però non tiene conto dei tempi e delle modalità imposti alla ricarica dell'acquifero profondo dagli acquiferi superficiali né degli effetti sulla circolazione idrica sotterranea delle barriere di permeabilità costituite da depositi marnosi e argillosi.

Tre aree di studio sono state considerate al fine di evidenziare l'incidenza dell'assetto tettono-stratigrafico e delle caratteristiche sedimentologiche delle unità plio-quaternarie sulla circolazione idrica sotterranea. Nell'area costiera di Torre dell'Orso, si evidenzia come l'alternanza di strati carbonatici a differente permeabilità, ha determinato l'individuazione di un acquifero multistrato che drena verso mare le acque di infiltrazione di un esteso bacino imbrifero. La zona di Burgesi è invece caratterizzata da drenaggio di acque di falda, da un acquifero superficiale all'acquifero profondo di base attraverso sistemi carsici e zone di faglia, che determina elevata vulnerabilità nei confronti della diffusione di sostanze inquinanti. In Contrada Triglio, un'unità marnosa, poco nota in letteratura e non considerata nei correnti schemi idrogeologici, costituisce la barriera di permeabilità alla base di un acquifero superficiale, che ha rifornito per secoli la città di Taranto, le cui caratteristiche permettono di avanzare ipotesi sul legame tra regime idrogeologico e cambiamenti climatici.

Gli acquiferi pliocenici e pleistocenici del Salento, ritenuti risorse non strategiche, sono inquinati già da alcuni decenni. In realtà essi andrebbero tutelati e gestiti in modo più appropriato in relazione alla funzione di ricarica dell'acquifero profondo e al rischio di rapida propagazione di sostanze inquinanti.

PAROLE CHIAVE: Ricarica degli acquiferi, Gestione risorse idriche, Propagazione inquinanti, Rocce calcaree, Carsismo.

1. - INTRODUCTION

Due to the predominance of calcareous rocks, the morphology of Salento (south Puglia) is characterized by karst features and is nearly lacking of surface water. Such environmental situation has always restricted the growth of human activities. On the other hand, it has impelled the autochton peoples to investigate on the groundwater circulation. As a matter of fact, the presence of shallow aquifers has determined the human settlement of the territory since the prehistory (DE GIORGI, 1922).

The hydrogeological setting of Salento was outlined at the end of the 19th century on the basis of both empirical observations and physics general principles (DE GIORGI, 1906; DELLE ROSE, 2005), however it was better defined later by means of a number of deep borings (COTECCHIA, 1958).

Presently, about 70% of drinking water demand of the Salento is provided by a deep Cretaceous carbonatic aquifer which contains a huge mass of groundwater floating over salt water intruded from the Ionian and Adriatic Sea. A number of shallow aquifers, used only for irrigation, lie in Pliocene and Pleistocene rocks and are locally connected with the Cretaceous aquifer. They are not considered strategic resources and, as a consequence, their safeguard is really missing while spreading of pollutants interest several zone of Salento (CALÒ *et alii*, 1990).

As a whole, deep and shallow aquifer forms the Salento Hydrogeological Unit which is conventionally separated from the Murge Hydrogeologial Unit by a limit without any real hydrogeological significance (fig. 1), conventionally drawn within the current water management model of the regional authority (REGIONE PUGLIA, 1984).

The management is based on studies of the groundwater hydrological regimen indicating an overall drawing possibility of about 190 x 10^6 m^3 year, against a recharge volume of 880 x 10^6 m^3 related to the six months embracing fall and winter. This model does not consider the role of the Pliocene and Pleistocene aquifers which drain a large portion of the recharge volume and supply a number of coastal and marine springs.

The model roughly uses the effective infiltration, which is a fraction of the annual rain water, as a measure of the deep aquifer recharge. Furthermore, the water management neglects the discrete nature of the Cretaceous aquifer, and do not consider the role played by karst systems, fault discontinuities and variations in permeability of the Plio-Quaternary deposits (DELLE ROSE *et alii*, 2000, 2003).

Actually, the need of water for domestic use is 90 x 10^6 m^3 year; there is no official value of the water demand for irrigation and industrial use, but it can be estimated in the same order of the domestic one. A critical situation for the deep aquifer has therefore to be stated. The increasing withdrawal induced a moderate to strong salt pollution of the water exploited from wells and groundwater with low saline content (less than 0.5 g/l) is barely found in Salento (TULIPANO, 1988, 2001). As a consequence, a substantial revision of the water resources management model of the regional authority appear to be strongly opportune.

2. - GEOLOGICAL SETTING AND WATER RESOURCES

Salento is the southern emerged part of the Apulian Carbonate Platform and is formed by Jurassic-Cretaceous limestones and dolomitic limestones covered by Tertiary and Quaternary clastic carbonates, sands and clays. During the Upper Cretaceous - Early Pleistocene, Salento developed a horst and graben structure due to the dynamics of the microplates involved in the convergence of the Apenninic and Dinaric chains (FUNICIELLO *et alii*, 1991).

Starting from the Burdigalian, Salento grabens were infilled by mostly neritic skeletal deposits, while the central sector of the Puglia region, the present Murge plateau, was submerged only in the upper Pliocene (RICCHETTI, 1967; LARGAIOLLI *et alii*, 1969; BOSELLINI *et alii*, 1999).

Within the horst and graben tectonic setting of Salento, the uplifted blocks are made up by Cretaceous rocks, while Pliocene and Pleistocene deposits occupy mainly the lowered blocks. The blocks are dissected by normal or strike-slip faults showing NW-SE and NNW-SSE direction with local evidence of tectonic inversion (DELLE ROSE, 2001a); other NE-SW trending faults can be hardly identified in the field, being usually covered by Quaternary deposits (LARGAIOLLI *et alii*, 1969; FUNICIELLO *et alii*, 1991).

Clayey sands and marls coeval to the Trubi Formation, widespread in southern Italy (BOSELLINI *et alii*, 1999), mark the base of the Salento Pliocene series and disconformably overlie clastics dismantled during the Messinian lowstand (DELLE ROSE, 2001a). Upper Pliocene - Lower Pleistocene calcarenites and calcilutites overlie the previous deposits and underlie Lower-

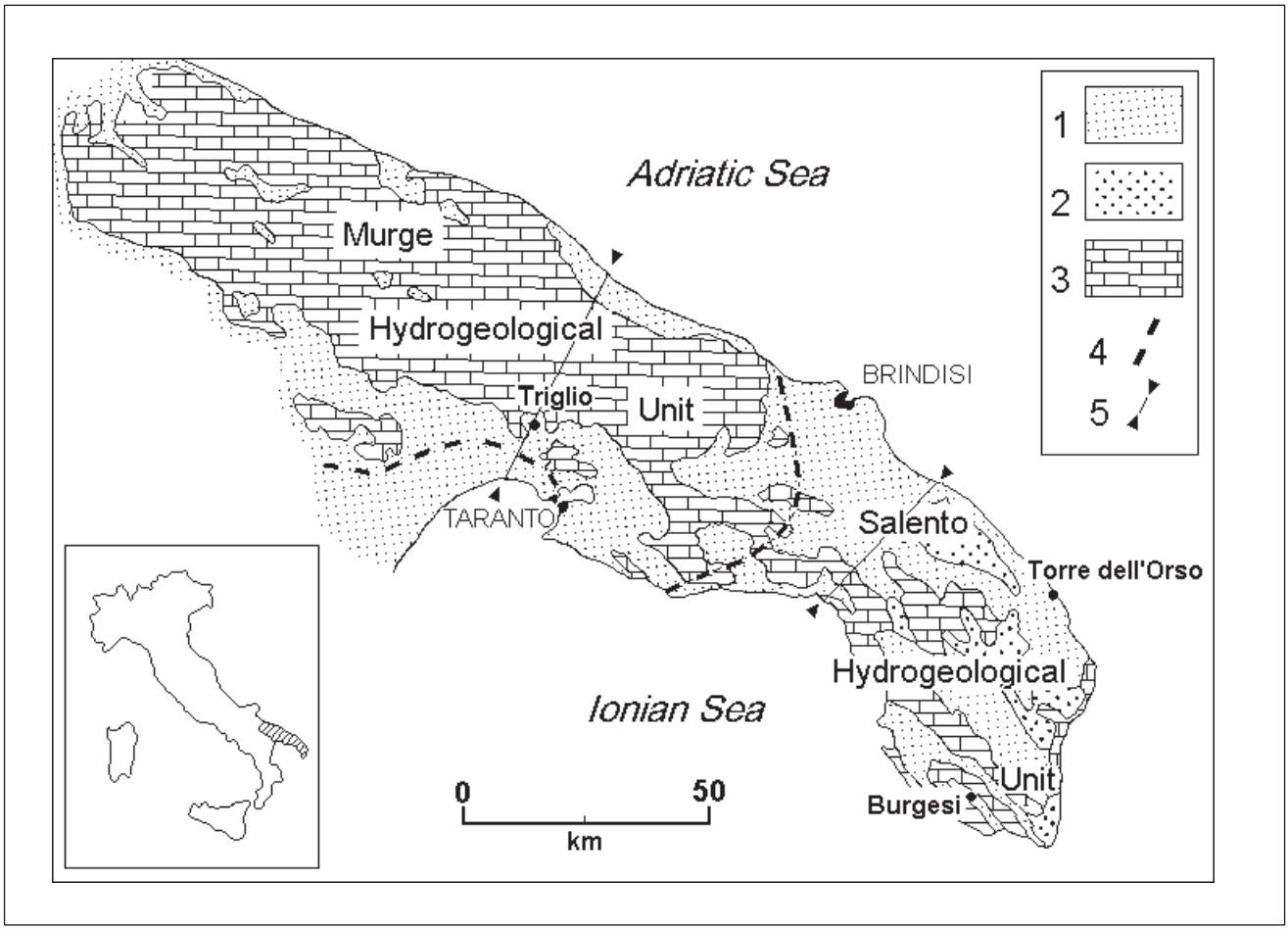

Fig. 1 - Geological setting of central southern Puglia and main hydrogeological units. 1. carbonatic, marly and clayey units (Pliocene and Pleistocene); 2. mainly carbonatic units (Oligocene and Miocene); 3. limestones and dolomitic limestones (Cretaceous and Eocene); 4. hydrogeological boundary of the groundwater management model of REGIONE PUGLIA (1984); 5. hydrogeological boundary according to COTECCHIA (1958).

- Assetto geologico della Puglia centro meridionale e principali unità idrogeologiche. 1. unità carbonatiche, marnose ed argillose del Pliocene e del Pleistocene; 2. unità prevalentemente carbonatiche dell'Oligocene e del Miocene; 3. calcari e calcari dolomitici del Cretaceo e dell'Eocene; 4. limite delle unità idrogeologiche del modello di gestione della REGIONE PUGLIA (1984); 5. limiti dei bacini idrogeologici di COTECCHIA (1958).

Middle Pleistocene mixed carbonate-siliciclastic sediments (BOSSIO *et alii*, 1985; D'ALESSANDRO & MASSARI, 1997). The former can be related to the Calcareniti di Gravina Formation and the latter to the Argille Subappennine Formation and the Terraced Marine Deposits (RICCHETTI, 1967; LARGAIOLLI *et alii*, 1969).

The hydrogeological setting of the Pliocene and Pleistocene deposits is controlled by their litostratigraphic features. Clayey sands and marls related to the Trubi Formation and marly levels of the aforementioned mixed carbonate-siliciclastic sediments forms the main permeability barriers. However, due to the lack of stratigraphical and sedimentological data, the other hydrogeological boundaries of the shallow aquifers cannot be detailed (BRUNO & TADOLINI, 1989; CALÒ *et alii*, 1990).

The recharge area of the major shallow aquifer lies in Pliocene deposits, the "Fontanelle hydrogeological basin" (REINA, 1969), extends about 200 km^2, that is 1/15 of the areal extension of the Salento Hydrogeological Unit. Minor aquifers lie in Pleistocene deposits overlying basal permeability barriers formed by Miocene or Pliocene marine sediments or residual clay deposits. In spite of the low specific capacity of the wells bored into shallow aquifers, they can store relevant volume of water. They can also supply the Cretaceous aquifer through faults dissecting the horst and graben structure (TADOLINI *et alii*, 1985; BRUNO & TADOLINI, 1989), although some faults may act as permeability barriers (TULIPANO, 1988). Nevertheless, a considerable pouring out of shallow aquifers resident waters into the Cretaceous ones, along semipermeable sedimentary boundaries, has been recognized by measuring water temperature inversion using thermal log methods (TULIPANO, 1988).

Some shallow aquifer lie in calcarenite and sand deposits overlying the clayey deposits of the Argille Subappennine Formation. Groundwater flow is mainly directed toward the coastal zones (CALÒ *et alii*, 1990) and, as a consequence, this portion of infiltrated rain water cannot recharge the deep aquifer.

3. - STUDY AREAS

Some examples of the relevance of the tectonic-stratigraphic setting and sedimentological features of Plio-Quaternary deposits on groundwater circulation are provided in the following. The geological and hydrogeological surveys were performed in three different settings of the southern Apulia Carbonate Platform in the years 2000-2004.

3.1. - TORRE DELL'ORSO AREA

Torre dell'Orso lies along the coastal cliff of the "Fontanelle hydrogeological basin" (REINA, 1969). At Rocavecchia (fig. 2), groundwater was drawn starting from the Bronze Age, although the major part of the ancient wells were bored during the Archaic Age (PAGLIARA, 2001).

The outcropping substratum of this area is made by a 30 m thick succession of laminated calcilutites and fine calcarenites alternated to coarser macro-fossiliferous and bioturbated calcarenites. Its beds exhibit a thickness ranging from few decimetres to about 2 metres. The tectonic structure is characterized by folds with axes oriented NNW-SSE. In particular, the coastline between Rocavecchia and Torre dell'Orso constitutes the eastern flank of an anticline. According to BOSSIO *et alii* (1985), the local succession belongs to the Middle-Upper Pliocene, although it must be attributed to the Gelasian as defined by the GSSP (RIO *et alii*, 1998) and according to the PATACCA & SCANDONE (2004) chronological scheme.

The rhythmical alternation of coarser and finer calcareous beds has led the formation of a multilayered aquifer system with a top unconfined aquifer (fig. 2). Besides, due to the role of permeability barriers (aquiclude), the calcilutites form also the karst base levels of speleological systems.

A number of coastal springs are present along the coastline, in some places within karst caves such as in the Grotte dell'Acqua Dolce (fig. 2). Along tracts of the cliff, the groundwater constitute linear fronts of outflow. Inland, especially along fluvial gullies, border and depression spring are present.

The reconstructed hydraulic heads of the local shallow aquifer refer to the highest water level. In some places, sharp hydraulic head lowerings are observed which could be due to karst conduits drainage developed along sub-vertical fractures.

Karst cave systems favour the marine intrusion and, as a consequence, the salinization of groundwater. This phenomenon can also be present where the coarser calcarenites crop out at sea level as indicated by a preliminary set of salinity analyses. On the contrary, the fine-grained calcilutites constitute barriers against marine intrusion.

Taking into account the extension of the whole "Fontanelle hydrogeological basin", it can be stated that a considerable volume of groundwater is discharged into the Adriatic Sea and, as a consequence, the effective infiltration of a large territory of the east Salento is not supplying the deep aquifer.

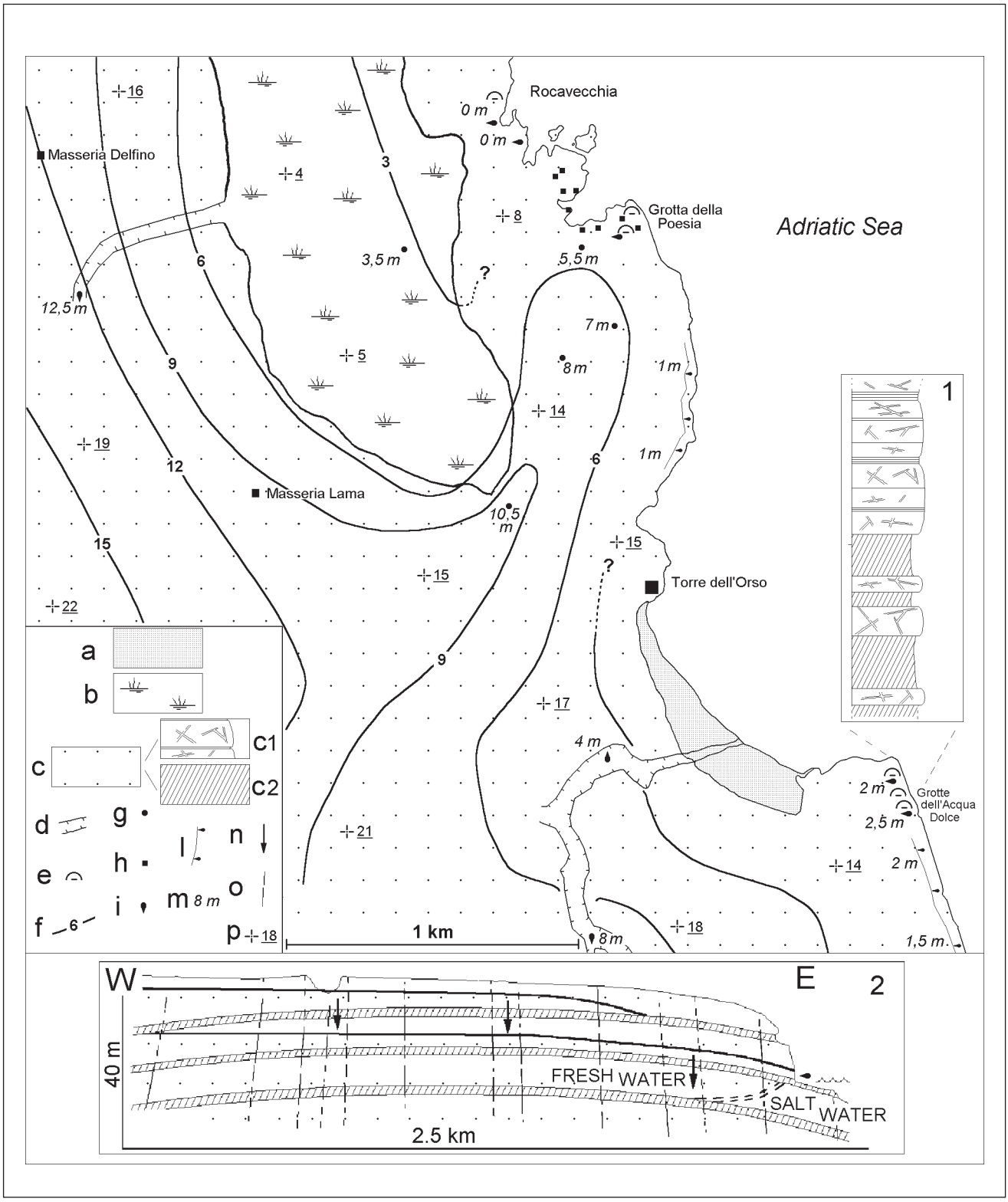

Fig. 2 - Hydrogeological map of Torre dell'Orso area.
a) sand; b) clay and sand (Holocene); c) calcareous-marly units (Upper Pliocene), c1) calcarenites, c2) calcilutites (permeability barrier); d) gully; e) karstic cave; f) contoured hydraulic heads of shallow aquifer; g) working well; h) ancient well; i) spring; l) linear groundwater outflow; m) hydraulic heads; n) water flow; o) tectonic fracture; p) elevation (m a.s.l.). Stratigraphic section (inset 1, from Bossio *et alii*, 1985, modified) and hydrostratigraphic section (insert 2) of the Grotte dell'Acqua Dolce coastal zone.

- Carta idrogeologica della zona di Torre dell'Orso.

a) sabbie recenti; b) argille e sabbie (Olocene); c) unità calcareo-marnosa (Pliocene superiore), c1) depositi calcarenitici, c2) depositi calcilutitici (barriera di permeabilità); d) incisione fluviale ; e) cavità carsica; f) isofreatica dell'acquifero superficiale; g) pozzo attualmente in uso; h) pozzo antico; i) sorgente; l) fronte di deflusso della falda; m) livello piezometrico; n) deflusso idrico; o) frattura tettonica; p) quota topografica (m s.l.m.). Inserto 1, colonna stratigrafica (da Bossio et alii, 1985, modificato) e inserto 2, schema idrostratigrafico del settore costiero di Grotte dell'Acqua Dolce.

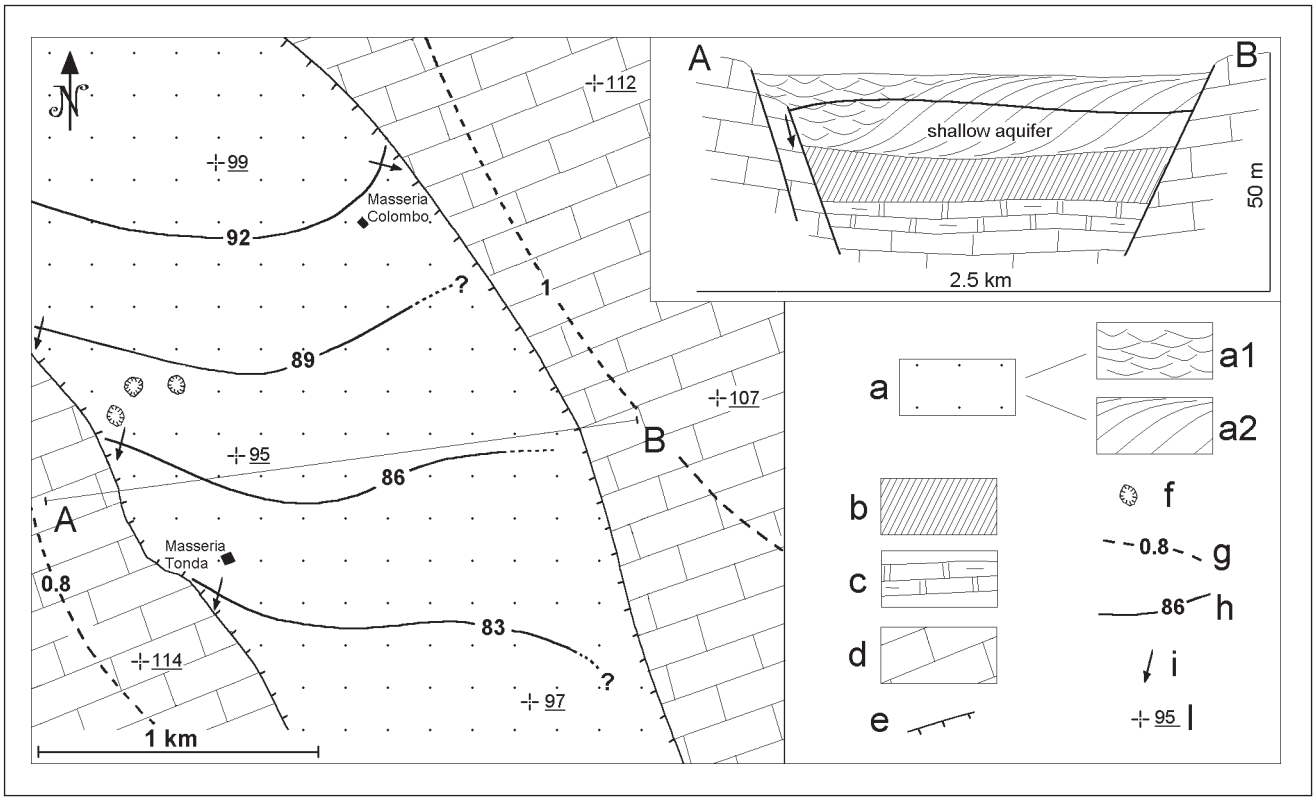

Fig. 3 - Hydrogeological map of the Burgesi area. a) upper calcarenitic unit (Middle Pleistocene?), a1) festoon cross-beds, a2) large-scale inclined beds; b) Argille Subappennine Fm. (permeability barrier, Lower Pleistocene); c) lower calcarenitic unit (Lower Pleistocene); d) limestones and dolomitic limestones (Cretaceous); e) fault; f) sinkhole; g) contoured hydraulic heads of deep aquifer (from REGIONE PUGLIA, 1984, modified); h) contoured hydraulic heads of shallow aquifer; i) pouring out of waters within shallow aquifer into deep aquifer; l) elevation (m a.s.l.). Inset: geological section (from D'ALESSANDRO & MASSARI, 1997, modified) indicating the watertable.

- Carta idrogeologica della zona di Burgesi. a) unità calcarenitica di tetto (Pleistocene medio?), a1) depositi a stratificazione incrociata, a2) depositi clinostratificati; b) Argille Subappennine (barriera di permeabilità, Pliocene inferiore); c) unità calcarenitica di base (Pleistocene inferiore); d) calcari e calcari dolomitici (Cretaceo); e) faglia; f) dolina; g) isofreatica dell'acquifero profondo (da REGIONE PUGLIA*, 1984, modificato); h) isofreatica dell'acquifero superficiale; i) deflusso dalla falda superficiale a quella profonda; l) quota topografica (m s.l.m.). Inserto: sezione geologica (da D'ALESSANDRO & MASSARI, 1997, modificato) con riportata la superficie freatica.*

3.2. - BURGESI AREA

Burgesi is part of a narrow graben located in the southern Salento (fig. 1). Lower-Middle Pleistocene deposits (D'ALESSANDRO & MASSARI, 1997) occupy the graben and form a shallow aquifer, used for irrigation, which bottom permeability barrier is made up by the Argille Subappennine Fm.

The deposits overlying the permeability barrier consist of two calcarenitic units, respectively characterized by clinoforms and festoon-cross bedding (fig. 3). The first unit is a south-eastward dipping progradational body with a large-scale sigmoidal shape. Its beds show a coarse laminated structure in the lower part and fine bioturbated structure in the upper part (D'ALESSANDRO & MASSARI, 1997). The cross bedded unit is made up by coarse calcarenites and calcirudites. It forms a narrow belt parallel to the fault which is the SW boundary of the Burgesi graben.

The piezometric surface, contoured by means of several well measures, indicates the pattern of groundwater circulation. The faulted zones between lowered and uplifted blocks constitute transfer zones from the shallow to the deep aquifer. Also some depositional features appear to influence the pattern of groundwater flow. The general attitude of the the coarse/fine calcarenite bed couplets of the progradational body and the difference of permeability between the finer clinoforms unit and the coarser cross beds unit, direct south-westward the percolation within the vadose zone as well as the principal axis of groundwater flow (fig. 3).

The Burgesi area is also characterized by karst systems mainly developed along both the base of the calcarenitic units and the faulted zones; these systems increase the potential vulnerability of groundwater being able to drain pollutants into the deep aquifer in a very short time (DELLE ROSE, 2001b). Actually, several episodes of uncontrolled and illegal waste disposal were registered in the area, the most dangerous of which consisted in the heaping of drums containing phenols, polychlorinated biphenyls, and polyaromatic hydrocarbons.

3.3. - Contrada Triglio Area

A shallow aquifer located at Contrada Triglio (fig. 1) supplied the town of Taranto by means of a 15 km long Roman and Mediaoval aqueduct (Becchetti, 1897). The hydraulic construction was dismantled during the '70 due to water pollution (Gentile & Mauro, 1999).

A marly unit, nearly unknown in literature and probably Upper Pliocene in age (Verri & De Angelis D'Ossat, 1899; Ricchetti, 1967; Zorzi & Reina, 1962; Martinis & Robba, 1971), acts as permeability barrier at the base of the aquifer. The marls, rich in molluscan shells, underlie the Calcareniti di Gravina Fm and crop out along a narrow strip with a thickness of about 5 m (fig. 4). This deposits is not documented on the "Carta Geologica d'Italia in scala 1:100.000 - Foglio n. 202 Taranto" (Servizio Geologico d'Italia, 1969) and has been mapped in this study. At the base of the marls a residual deposit drapes the lower contact with the limestones and dolimitic limestones of Cretaceous age.

Marly and calcarenitic deposits exhibit thickness varying according to the tectonic deformation of the Cretaceous substrate (fig. 4). The marly unit appears less clayey and thinner southward. The overlying *Calcareniti di Gravina* beds, locally with bioturbation traces, are from few decimetres to about 2 metres thick.

Presently the Contrada Triglio shallow aquifer has no springs along the fluvial incisions. Nevertheless, during past wet climatic periods the effective infiltration was probably greater and the phreatic

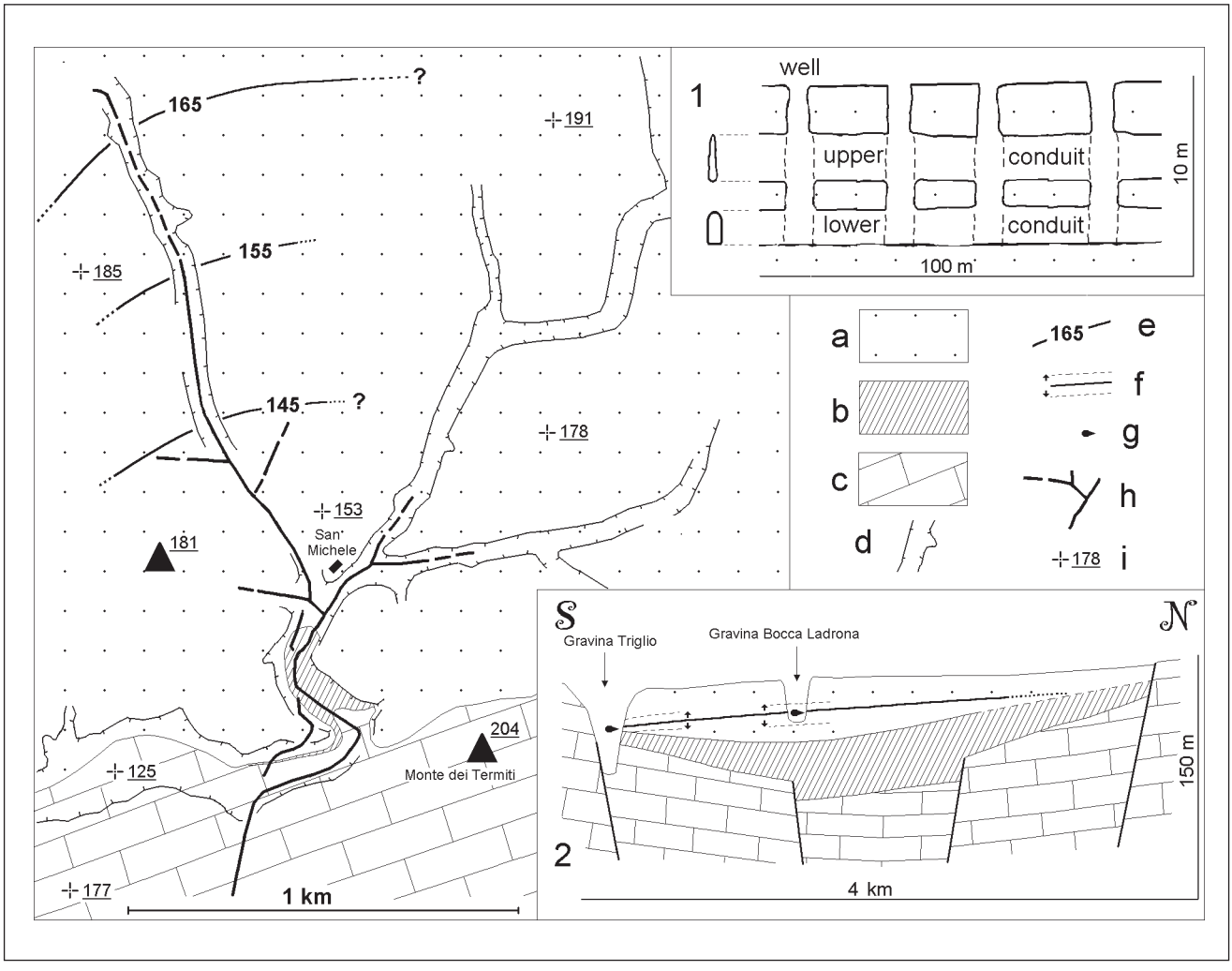

Fig. 4 - Hydrogeological map of Contrada Triglio. a) calcarenitic unit (Lower Pleistocene); b) marly unit (permeability barrier, Upper Pliocene-Lower Pleistocene); c) limestones and dolomitic limestones (Cretaceous); d) fluvial incision; e) contoured hydraulic heads of shallow aquifer; f) watertable fluctuations; g) spring; h) aqueduct trace; i) elevation (m a.s.l.). Inset 1: section of the aqueduct west of S. Michele; Inset 2: hydrogeological section.

- Carta idrogeologica di Contrada Triglio. a) unità calcarenitica (Pleistocene inferiore); b) unità marnosa (barriera di permeabilità, Pliocene superiore?-Pleistocene inferiore); c) calcari e calcari dolomitici (Cretaceo); d) forra; e) isofreatica dell'acquifero superficiale; f) oscillazioni del livello della falda; g) sorgente; h) tracciato dell'acquedotto; i) quota topografica (m s.l.m.). Inserto 1: sezione di un tratto dell'acquedotto ad ovest di San Michele; Inserto 2: schema idrogeologico.

surface higher than today (DELLE ROSE *et alii*, 2004); such environmental condition could have determined border and depression springs (fig. 4). During warm and dry phases, the lowering of the watertable could cause the interruption of water supply to the aqueduct pipes; this hypothesis is confirmed by the discovery of two levels of drainage conduits, the upper one, probably the older, being partially faced with impermeable mortar.

Considering the extension of the Triglio catchment area, which is of some tens of km^2, the infiltrating waters recharging the shallow aquifer are relevant and a part of them can probably supply the Cretaceous aquifer trough karstified faulted zones.

4. - DISCUSSION AND CONCLUSION

The role of tectono-stratigraphic setting as well as the sedimentologial features of the Plio-Quaternary units on groundwater circulation can be inferred from the surveys performed at the three study areas.

Plio-Quaternary rocks form a number of shallow aquifers which drain a large amount of the effective infiltration. On the basis of the catchment basins characteristics (CARROZZO *et alii*, 2003) and of the evaluated infiltration rate (TROISI *et alii*, 1988), about 2/3 of the effective infiltration must supply the shallow aquifers (BRUNO & TADOLINI, 1989; CALÒ *et alii*, 1990).

In principle the infiltrated water can be subdivided into increased storage, coastal and marine springs outflow, groundwater withdrawal and pouring out of waters into deep aquifer by means of karstfied faulted zones or increased conductivity at stratigraphic contacts. In practice however, the amount of groundwater withdrawal during the last decades indicates that the shallow aquifers storage has worryingly decreased.

Unlike the direct infiltration in the Cretaceous rocks, the pouring of water from shallow aquifers to deep aquifer occurs also during the six "dry months" embracing spring and summer. This supply of the Cretaceous aquifer reduces the water deficit during the dry seasons. However, the karstified faulted zone connecting shallow and deep aquifer can favour a fast movement of pollutants and deteriorate the quality of the groundwater resources of Salento.

Concerning the current groundwater management, the critical situation stated for the deep aquifer (TULIPANO, 1988, 2001) makes it necessary to revise the regional model, starting from the boundary between Murge and Salento Hydrogeological Units. The relationships between the Cretaceous aquifer and the Plio-Quaternary ones could be the best criterion to trace the boundary, being the Murge plateau nearly lacking in shallow aquifers. The Contrada Triglio area considered in this paper occupies part of the ramp between Murge and Salento, but it belongs to the Murge Hydrogeological Unit according to the regional model (REGIONE PUGLIA, 1984). Nevertheless, a previous subdivision (COTECCHIA, 1958) contemplated a hydrological unit interposed between Murge and Salento including also the Contrada Triglio area, providing a better model of groundwater circulation.

The vast archaeological remains of Puglia are precious tools for detailed research. In the coastal aquifer of the Torre dell'Orso area, the ancient wells bored at Rocavecchia could be used to reconstruct the relationships between sea level and phreatic level fluctuations since Bronze Age. The two levels of drainage conduits recognized in the Roman-Medioeval aqueduct of Contrada Triglio and the facing with impermeable mortar of the upper pipeline could be related to climatic changes. The waterproofing of the upper conduit could have been realized to contrast a lowering of the watertable. The lower conduit could have been successively excavated to intercept the further lowered watertable. These interventions could coincide with the climate deterioration culminated with the arid phase at the beginning of the first millennium (ALLOCCA *et alii*, 2000).

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