Il Quaternario
Italian Journal of Quaternary Sciences
***19**(2), 2006 - 253-260*

SEA LEVEL DURING 4TH – 2ND CENTURY B.P. IN EGNAZIA (ITALY) FROM ARCHAEOLOGICAL AND HYDROGEOLOGICAL DATA

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ABSTRACT: Milella M., Pignatelli C., Donnaloia M. & Mastronuzzi G., *Sea Level During 4th–2nd Century B.P. In Egnazia (Italy) From Archaeological And Hydrogeological Data* (IT ISSN 0394-3356, 2007).
This paper aims to estimate the mean sea level position during the 4th–2nd cent. B.C. along the Adriatic coast of Apulia using archaeological and geomorphological data from the archaeological site of Egnazia. The detailed topographic survey of wells, cisterns and tombs reported from Giornali di Scavo permitted us to reconstruct the probable groundwater piezometric surface in that period. Two different scenarios have been considered. The first one considers the active state of wells: we added the value of 35 cm to the elevation of the well–bottom required in order to take water by means of jars. Furthermore, we subtracted the same value to the elevation of the tomb / cistern–bottom because these structures couldn't come into contact with groundwater. The second one considers the non–activity of wells: the dating of the wells, based on their replenishment, performed on ceramic fragments, indicates the time they were abandoned and the consequent transformation into dump. In this way only the values of well–bottoms for reconstructing the piezometric surface trend are used. The piezometric surface trend corresponding to the two hypothesis was reconstructed with ArcMap 8.3 GIS software through Kriging interpolating method. Sea level during 4th–2nd cent. B.C. stands at least -1,2 m present sea level.

RIASSUNTO: Milella M., Pignatelli C., Donnaloia M. & Mastronuzzi G., Livello del Mare nel IV–II Secolo a.C. da Dati Archeologici e Idrogeologici nell'area di Egnazia (Italia) *(IT ISSN 0394-3356, 2007).*
sec. a.C. lungo la costa adriatica della Puglia nei dintorni della città di Egnazia sulla base della ricostruzione del probabile andamento della superficie piezometrica della falda idrica di quel periodo. Per questo studio sono stati utilizzati: i – rilievo topografico di dettaglio dell'area di Egnazia; ii – la profondità dei pozzi e delle cisterne desunte dai Giornali di Scavo. E' stato ricostruito il possibile andamento della superficie piezometrica della falda idrica dell'epoca in relazione a due differenti ipotesi di lavoro. La prima considera lo stato di esercizio dei pozzi: alle quote dei fondo–pozzi è stato aggiunto il valore di 35 cm, necessario a garantire il prelievo dell'acqua tramite vasi, mentre alle quote del fondo–tombe e cisterne è stato sottratto lo stesso valore di 35 cm, supponendo che tali strutture non dovessero essere a contatto con acque di falda. La seconda ipotesi presuppone l'interruzione dell'esercizio dei pozzi: infatti la datazione dei pozzi basata sul loro riempimento, costituito soprattutto da frammenti ceramici, indica il momento del loro abbandono e la conseguente trasformazione in "discariche". In tal modo, per la ricostruzione dell'andamento della superficie della falda sono stati considerati esclusivamente i valori dei fondo–pozzi. Attraverso il software ArcMap 8.3 GIS è stato ricostruito, mediante il metodo di interpolazione del Kriging, l'andamento delle superfici piezometriche corrispondenti alle due ipotesi. Si è potuto così ipotizzare che la posizione del livello del mare nel IV–II secolo a.C. fosse almeno 1,2 m al di sotto della sua posizione attuale.

Keywords: Sea level, Holocene, Archaeology, Hydrogeology, Puglia, Italy.

Parole chiave: Livello del mare, Olocene, Archeologia, Idrogeologia, Puglia, Italia

INTRODUCTION

In the Mediterranean basin, indications of sea level stands during historical times can be obtained from geomorphological, biological and archaeological sources. Particularly, in microtidal areas geomorphological data provide a valid tool to indicate the biological mean sea level within a few centimetres (Paskoff & Sanlaville, 1983; Dalongeville, 1987; Laborel & Laborel Deguen, 1994; Pirazzoli, 1996) but it is difficult to date them because of the frequent absence of biogenic encrustations useful for radiometric analyses (Auriemma *et al*., 2004).

Archaeological sites are a source of valuable data for reconstructing sea level changes. Here radiometric data can be compared and confirmed by the archaeological chronology (Erol & Pirazzoli, 1992; Stiros & Pirazzoli, 1995; Antonioli & Leoni, 1998; Fleming & Webb, 1986; Mourhange *et al*., 2001, Sivan *et al*., 2001; Auriemma *et al*., 2005).

In the past, along the Apulia coast there was an extensive colonisation due to humans especially in the areas characterised by stability of the landscape and the availability of fresh water. In particular, in the archaeological site of *Egnazia*, located along the Adriatic coast of Apulia (Fig. 1), the more ancient human settlement goes back to Bronze age (16th cent. B.C.). Its coast location, like several Apulian protostoric settlements, made maritime activities easier because the jagged coastal area is suitable for docking and sheltering vessels which carried wares from transadriatic areas (Cremonesi, 1979; Sciarra Bardaro–Andreassi, 1982; Auriemma *et al*., 2005). Recent studies permit us to guess the *Egnazia* settlement originated in the Acropoli: an antropic–made low hill which spreads seaward between two small inlets, reached out into the hinterland occupying the area where the later Roman age houses were found (Dell'Aglio, 1982). The *Egnazia* economy was based mainly on ship commerce between the two sides of the Adriatic Sea: in fact, the town was an important merchant harbour and the wares were transferred by a track road network to the inner centres of Apulia and Lucania by the way of the *Traiana* Road. So *Egnazia* represented an important crossroad and meeting point of the several aged cultures (Donvito, 1988).

It is possible to divide the urban space into three bands quite parallel to coastline (Diceglie, 1981a, tav. I–V): the first one, the closest to coastal area, is related to maritime spaces and comprise caves, some messapica tombs and the ancient harbour; the second one, is located between the first and the *Traiana* Road, including the *Acropoli* and public, religious and administrative buildings; the last one, situated to the south of the *Traiana* Road, including all civil buildings. Beyond this third band, about 600 m inward from *Traiana* Road, there is the Western *Necropoli* area, used from the half of 4th cent. B.C. up to 4th cent. A.D. (Fig. 1).

The guidelines at the base of this work was originated by the assumption of the existence of sea level and land indicators (Auriemma *et al*., 2004). Archaeological sea level indicators, such as harbour structures, fishery and so on, permit us to recognise with good approximation past sea level stands (Antonioli & Leoni, 1998). Land indicators such as tombs, cisterns etc. at present below sea level indicate a minimum altitude under which sea level stood. The investigated hypothesis is that wells, cisterns and tombs in the coastal archaeological area of Egnatia are useful to reconstruct the piezometric surface and to put in relation the sea level with the functioning of the wells. Thus, the aims of this paper is to verify the availability of this method along rocky coasts and to define the error limit of the sea level identifications.

REGIONAL SETTINGS

The Apulia region represents the emerged part of the foreland domain of both the Apenninic and Dinaric orogens. The Apulian foreland is slightly deformed and is affected by NW–SE and NE–SW trending faults that subdivided it into five structural domains: Gargano area, Tavoliere basin, Murge upland, Taranto–Brindisi plain and Salento peninsula. The uplift rate of the southernmost Adriatic part of Apulia, based on generic stratigraphic and morphological evidence, ranges between 0,15 and 0,19 mm/yr in the area around Bari and about -0,02 mm/yr along the coastal area near Brindisi (Bordoni & Valensise, 1998; Ferranti *et al*., 2006).

The archaeological area of *Egnazia* is located on the Adriatic coast of Apulia between Monopoli and Fasano. Here, at the feet of the Murge Plateau (locally about 400 m high) the coastal landscape is characterized by a sequence of sub–horizontal surfaces sloping towards sea from an elevation of about 120 m. These surfaces should be produced by marine abrasion phases which occurred since the Middle Pleistocene as a consequence of the superimposition of regional uplift and the glacio–eustatic sea level changes. The monotony of this landscape is broken by a relict drainage network characterized by deep valleys, locally named *gravine* or *lame*, generally parallel to each other and perpendicular to coastline, that were shaped for sapping processes (Mastronuzzi & Sansò, 2002a). The gently sloping rocky coast is marked by the presence of little inlets which guest pocket beaches; the present sea level is shaping a poorly developed wave cut platform locally alternated to a discontinuos notch.

The stratigraphy of the *Egnazia* area is characterized at the base by the presence of the *Calcare di Bari* unit (Cretaceous), recognizable by drilling only, that represents the local basement, marked by karstic pro-

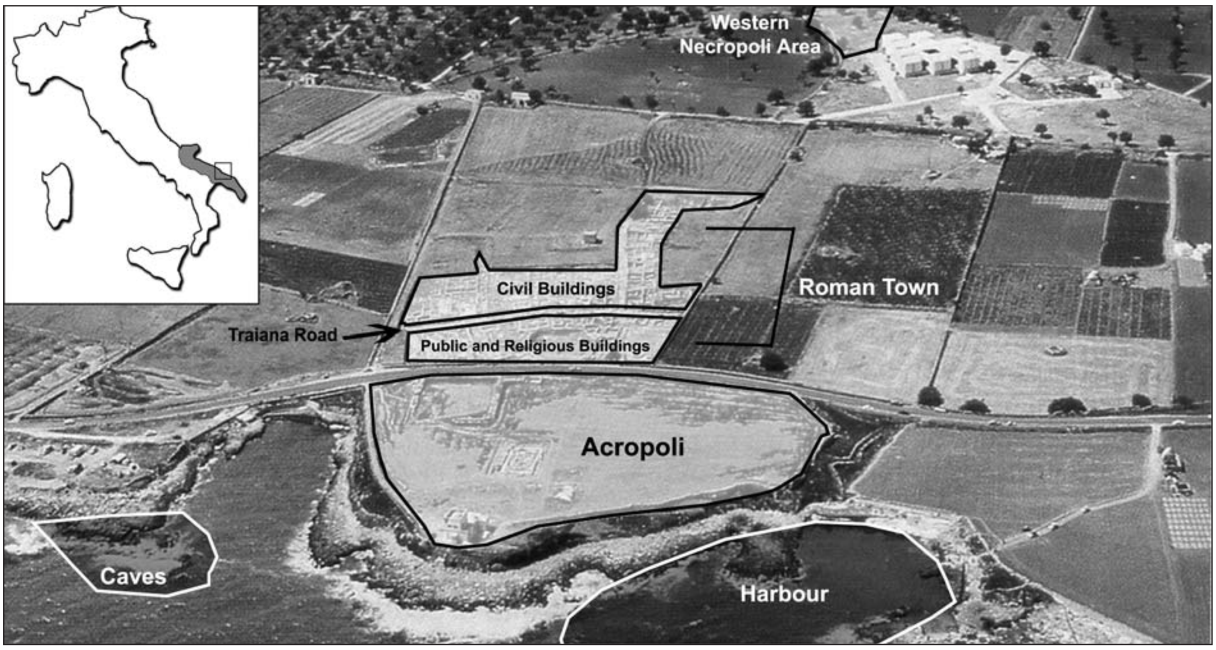

Fig. 1 - Egnazia town: the different urban spaces are evidenced with bold lines (from Cinquepalmi & Cocchiaro, 2000, mod., 4, fig. 3).
Città di Egnazia: in rilievo sono evidenziati i differenti spazi urbani (da Cinquepalmi & Cocchiaro, 2000, modificata, 4, fig.3).

cesses. Biocalcareous sandstone related to the *Calcarenite di Gravina* unit (Lower Pleistocene) (D'Alessandro & Iannone, 1984) overlies in transgression the limestone and outcrops extensively along the cost. Therefore, this lithological sequence is characterized by a high permeability, due to fractures and karst. It causes the lack of a fluvial network due to the rapid rainwater infiltration: this feeds a wide deep aquifer that rests on seawater intruded from the nearby coastal area and its interface follows Ghyben–Herzberg principle. At present, in the inner part of Murge plateau the piezometric surface reaches a maximum altitude of about +200 m m.s.l. sloping about 0,2÷0,8 % towards the coastline (Cotecchia, 1977).

BIBLIOGRAPHIC AND FIELD DATA PROCESSING

To reconstruct the piezometric surface and the probable mean sea level during the 4th–2nd cent. B.C. along the *Egnazia* coastal area the following data were used: **i** – archaeological and hydrogeological bibliographic data; **ii** – new detailed topographic survey of the entire *Egnazia* area and the depth of wells and cisterns (Fig. 2) inferred by Digging Journals (*Giornali di Scavo*).

The piezometric level of the *Egnazia* coastal area was reconstructed by means of bibliographic data (Tanzarella, 1998; Maggiore *et al*., 1999; Maggiore & Pagliarulo, 2004).

In 1997, the piezometric level in the Archaeological Park area was about +0,12 m present b.s.l. whereas it was at +2,5 m present b.s.l. about 5200 m landward (Tanzarella, 1998). Moreover, the bibliographic check allowed us to obtain data on the typology and the depth of the archaeological structures, wells and cisterns, used as indicators for this study. Furthermore, the dating of the same indicators carried out by means of ceramic replenishment were taken on. Wells and cisterns have a good distribution in the entire area of the ancient *Egnazia*, inside the Archaeological Park area and outside, along the coast and inside the western *Necropoli*. A well represents a vertical hole dug by humans (Fig. 3) with a depth of about 30 ÷ 40 cm below piezometric surface useful for collecting water by jars (Sivan et al., 2001). Instead, cisterns were used only to keep rainwater and groundwater withdrawn through wells: so their bottoms did not reach the piezometric surface (Cocchiaro, 1982; Tagliente, 2005).

During archaeological surveys, 70 structures for water supplies were localized (Fig. 4): 52 inside the present Archaeological Park area and 18 along coastal area. Unluckily, only 10 structures out of the first group and 8 structures out of the second one, in particular wells and cisterns to the south of the *Acropoli*, show enough data from Digging Journals about their depth. In particular, wells located inside the Archaeological Park area surrounding *Traiana* Road, have a mean depth of about 3 m; while the ones situated near coastline have a mean depth of about 1,8 m. Among the 10 structures of Archaeological Park 1 dates back to 9th cent. B.C., 4 to 4th cent. B.C., 2 to 3rd cent. B.C., 2 to 2nd cent. B.C. and 1 to 1st cent. A.D.; all the 8 structures of coastal area to the south of Acropoli date back to

Fig. 2 - Detail of a cistern entrance in the Archaeological Park area (Cinquepalmi & Cocchiaro, 2000, 16, fig. 37).

Particolare dell'imboccatura di una cisterna nell'area del Parco Archeologico (da Cinquepalmi & Cocchiaro, 2000, 16, fig. 37).

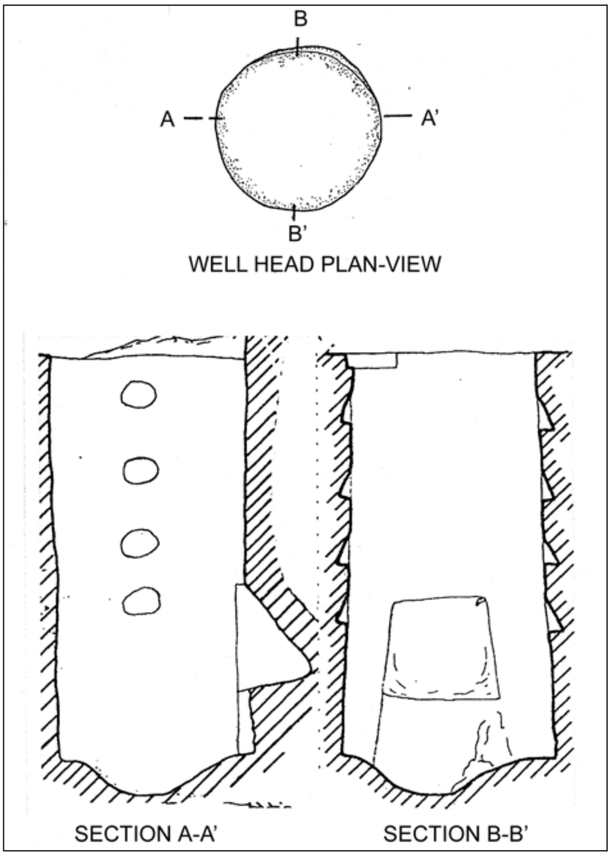

Fig. 3 - Well Scheme: in the vertical sections 4 cavity for each side, named *"pedarole"*, can be distinguished. In the lower part a vertical sub-rectangular cavity opens (from Digging Journals).

Schema di un Pozzo: nelle sezioni verticali si possono distinguere 4 cavità per ciascun lato, chiamate "pedarole". *Nella parte più bassa si apre una cavità subrettangolare (dai Giornali di Scavo).*

2nd cent. B.C. (Tagliente, 2005). Only the structures dating back to 4th–2nd cent. B.C. have been considered for this study.

Detailed topographic survey was carried out by total station (Teodolite “WILD T2” with a Geodimeter “AGA 14A”); it let us get spatial coordinates related to Gauss Boaga system datum ED 50 (X, Y and Z) of all the wells, cisterns and tombs inside *Egnazia* area and depth of all the tombs inside western *Necropoli*. Z–elevations were related to the present biological sea level (= b.s.l.) (Laborel & Laborel Deguen, 1994) thanks to the presence of living concretions of *Lithophyllum lichenoides and Dendropoma sp.* along the coastal inlets near the *Acropoli;* this occurrence allows us to evaluate in +/- 0,10 m the error bar of shown data. So, in the area of the Archaeological Park near *Traiana* Road the mean elevation of well heads is about +4,8 +/- 0,10 m present b.s.l., while along the coastline the mean elevation of well heads does not go over +1,5 +/- 0,10 m present b.s.l..

The spatial coordinates of all the surveyed points (wells, cisterns and tombs) elaborated using software (Surfer 8 and ArcMap 8.3 GIS – Kriging method) permit us to draw a map where topography and the piezometric surface of *Egnazia* area are shown (Figg. 4, 5). The piezometric surface was reconstructed according to two hypothesized scenario.

The **A** scenario considers the active state of wells: we add the value of 35 cm to the elevation of the well–bottom required to take water by means of jars (Sivan *et al.*, 2001); on the contrary, we subtracted the same value to the elevation of the tomb and cistern bottom because these structures could not come into

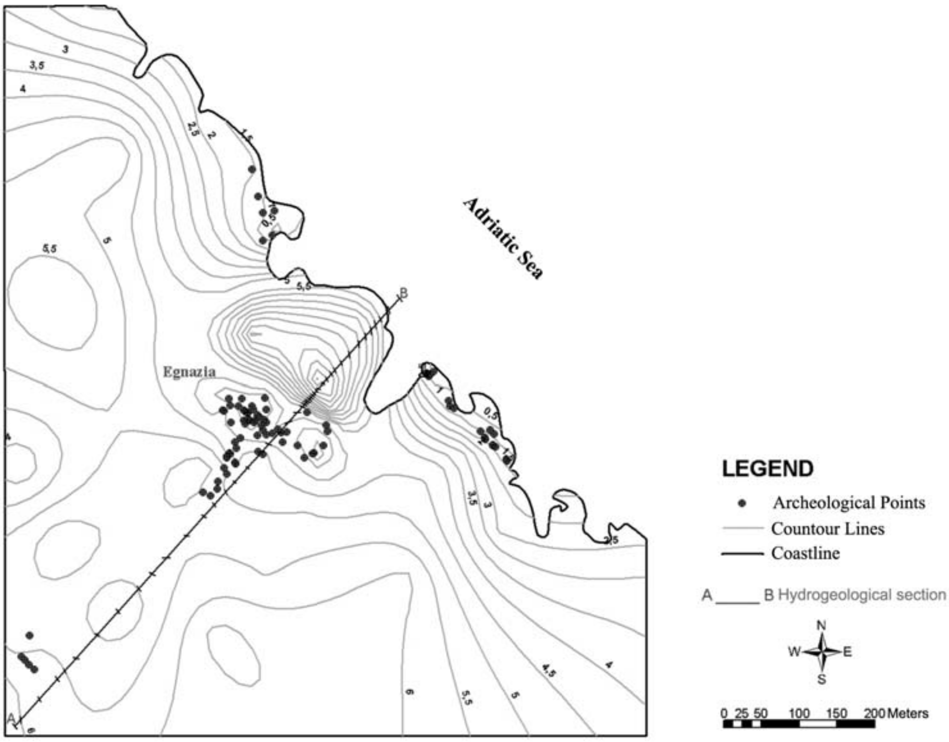

Fig. 4 - Topography restitution of Egnazia town, by means of Surfer 8 software, with contour lines. ⊗: Archaeological Points; __: Contour Lines; _: Coastline; AB: Hydrogeological section track.

Ricostruzione, ottenuta con il software Surfer 8, dell’andamento plano–altimetrico dell’area di Egnazia mediante curve di livello.
⊗ : Punti Archeologici; __: Curve di Livello; _: Linea di Costa; AB: Traccia della Sezione Idrogeologica.

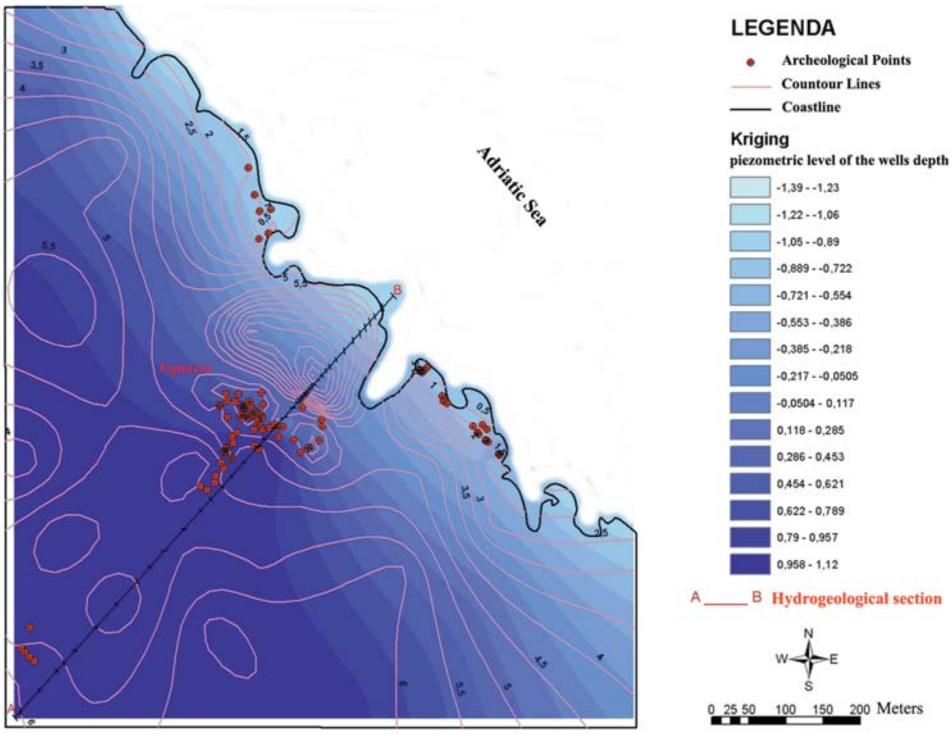

Fig. 5 - Piezometric surface restitution of Egnazia town, by means of ArcMap 8.3 GIS software, for **B** scenario.
⊗: Archaeological Points; __: Contour Lines; _: Coastline; AB: Hydrogeological section track.

*Ricostruzione, ottenuta con il software ArcMap 8.3 GIS, dell’andamento della superficie piezometrica nell’area di Egnazia nel caso dello scenario **B**.*
⊗ : Punti Archeologici; __: Curve di Livello; _: Linea di Costa; AB: Traccia della Sezione Idrogeologica.

contact with groundwater. The use of this value allows us to obtain the best extrapolation of the piezometric surface trend so that its slope is coherent with the one of the uptodate groundwater.

The **B** scenario considers the non–active state of wells: the dating of wells based on their replenishment, obtained by means of ceramic fragments, indicates the time they were abandoned and consequent transformation into dump. In this way only the values of well bottoms for reconstructing the piezometric surface trend were used (Fig. 5).

According to these hypothesis, either real hydrogeological sections or theoretical best–fitted on 2° degree equations extrapolations, were obtained (Figg. 6a,b).

DISCUSSION

Auriemma *et al.* (2004; 2005) reconstructed a curve of relative sea level changes in ancient time using geomorphological, archaeological and radiometric data. In particular, in the inlet north to the *Acropoli* submerged piers in *opus caementicium* of the Roman age are present. These structures and the building techniques indicate that sea level stands at about -2,5 m present b.s.l. during the 1st cent. B.C..

Hydrogeological section, "A–B", made up for both the work scenario reaches out about 800 m from the south limit of western *Necropoli* to the present coastline in front of *Acropoli* (Fig. 4). Some uncertainties derive from the historical and bibliographical sources: depth of wells and cisterns, taken from Digging Journals, have not been ascertained because of their replenishment and / or covering protection following the archaeological digging surveys.

In particular, in the Archaeological Park, differences of depth have been recognized:
- the bottom of one cistern is about 0,5 m deeper than the bottom of very close coeval wells;
- bottoms of wells of coeval age, up to 30 m close,

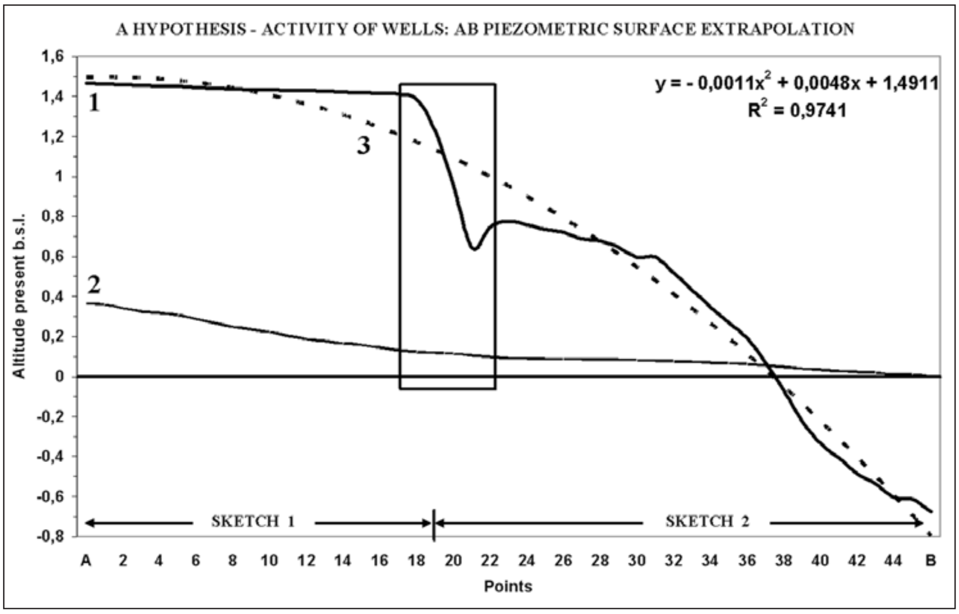

Fig. 6a - Real hydrogeological section and theoretical best – fitted on 2° degree equation extrapolation for **A** scenario. The rectangle represents the present Archaeological Park area. 1 = Past Piezometric Level; 2 = Present Piezometric Level; 3 = Past Extrapolation Level based on "Y" 2° degree equation.

*Sezione idrogeologica reale e relativa estrapolazione teorica ottenuta mediante equazione di 2° grado, nel caso dello scenario **A**. Il rettangolo corrisponde all'area del Parco Archeologico. 1 = Livello Piezometrico passato; 2 = Livello Piezometrico presente; 3 = Estrapolazione del Livello Piezometrico passato sulla base dell'equazione di 2° grado "Y".*

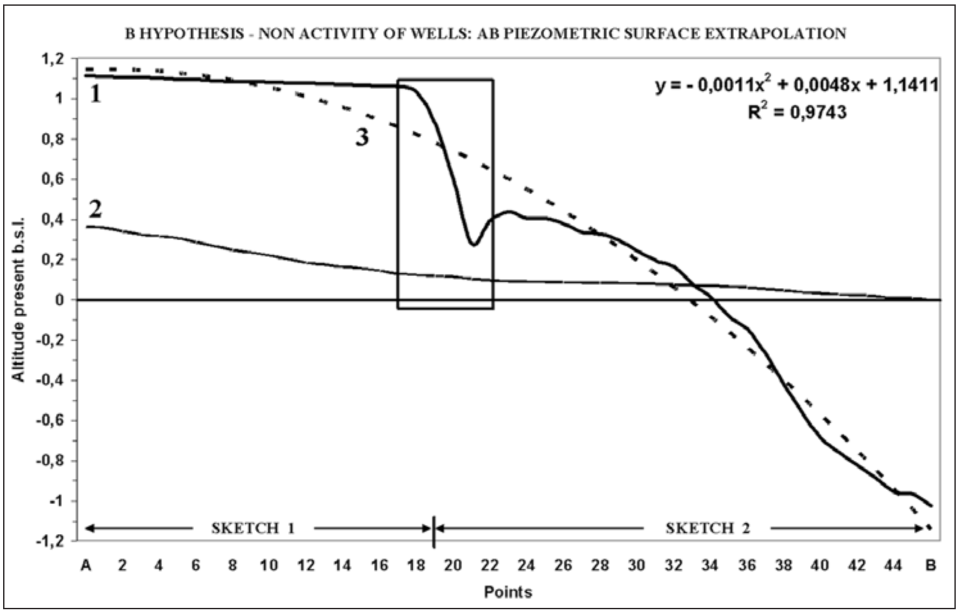

Fig. 6b - Real hydrogeological section and theoretical best – fitted on 2° degree equation extrapolation for **B** scenario. The rectangle represents the present Archaeological Park area. 1 = Past Piezometric Level; 2 = Present Piezometric Level; 3 = Past Extrapolation Level based on "Y" 2° degree equation.

*Sezione idrogeologica reale e relativa estrapolazione teorica ottenuta mediante equazione di 2° grado, nel caso dello scenario **B**. Il rettangolo corrisponde all'area del Parco Archeologico. 1 = Livello Piezometrico passato; 2 = Livello Piezometrico presente; 3 = Estrapolazione del Livello Piezometrico passato sulla base dell'equazione di 2° grado "Y".*

show differences of depth of about 0,8÷1,0 m.

To overcome this discrepancy the extrapolated piezometric level, for both scenarios, has been considered (curve 3 in Figg. 6a,b). The scenario **A** (active state of wells) suggest a piezometric level between about +1,15 m present b.s.l. along *Traiana* Road and about -0,8 m present b.s.l. on coastline. The scenario **B** (non–active state of wells) indicate a piezometric level between +0,75 m present b.s.l. in the Archaeological Park and -1,2 m present b.s.l. along the coast (Tab. 1).

Assuming the position of sea-level stand at -0,8 or at –1,2 m during 4th–2nd cent. B.C. in both scenario the piezometric level of +1,95 m past b.s.l. along *Traiana* Road results. This value is too high and incongruous for the topographic and hydrogeologic features of *Egnazia* area (Tab.1). In fact the Archaeological Park is located only 250 m landward and in the last 30 years the piezometric level went down about 15% due to human activity (POLEMICO & DRAGONE, 1999). Since the climatic state during 4th–2nd cent. B.C., it was not very different in comparison with the present time (MASTRONUZZI & SANSÒ, 2002b) the past piezometric level could not be much different in comparison with the present trend too.

The present piezometric surface in the *Egnazia* area has a mean slope of 0,048%: it is quite steady up to 5200 m landward. In the curve 3 of figg. 6a,b it is possible to detect two sketches characterized by different slope. Sketch 1, from western *Necropoli* to *Traiana* Road, has a mean slope of about 0,076% and 0,073%, respectively for **A** and **B** scenario. Sketch 2, from *Traiana* Road to coastline, has a mean slope of about 0,77% and 0,76%, respectively for **A** and **B** scenario. Only the values obtained for the Sketch 1 can be compared with the present piezometric mean slope. Using the mean slope of Sketch 1 the values of +0,19 m and +0,18 m, respectively for **A** and **B** scenario, result: these values should be the piezometric level in the Archaeological Park referred to every stand of past sea level. The piezometric levels calculated and the present one of +0,12 m b.s.l. (TANZARELLA, 1998) can be brought into comparison. Thereby, the piezometric surface during 4th–2nd cent. B.C. along *Traiana* Road had to stand necessarily about 1,6 m below the wells–bottom (Tab. 2).

The Archaeological Park is only 250 m far from the coastline: according to the present hydrogeological features the piezometric surface near *Traiana* Road did not have to overcome the elevation of about +0,2 m past sea level. Mean elevation of the wells–bottom is about 1,6 m above this piezometric surface. Consequently, the wells of this area could not operate during 4th–2nd cent. B.C., according to the **B** scenario. Thus, the reconstruction of the piezometric surface allowed us to estimate that sea level during 4th–2nd cent. B.C. had to stand at least -1,2 m present b.s.l. (Fig. 7).

In any case, the available data and the results of

Tab. 1 - Comparison among extracted levels for past and recent piezometric surface along different areas of *Egnazia* town.
Confronto tra i livelli ricavati per le superfici piezometriche passata e attuale in differenti zone della città di Egnazia*.*

		Archaeological Park area				Coastline
	Past Piezometric Level related to	**Past Piezometric Surface**			**Present Piezometric Surface related to Present b.s.l.**	**Past Piezometric Surface related to Present b.s.l. = Past Sea Level Position (+/- 0,10 m)**
	Wells Bottom	Cisterns / Tombs Bottom	**Related to Past Sea Level**	**Related to Present b.s.l.**		
A Hypothesis: Activity	+0,35 m	-0,35 m	+1,95 m	+1,15 m	+0,12 m	-0,8 m
B Hypothesis: Non – Activity	0 m	-0,35 m	+1,95 m	+0,75 m	+0,12 m	**-1,2 m**

Tab. 2. Comparison among extracted slopes and relative levels for present and past piezometric surface along different sketches of AB section in *Egnazia* area.
Confronto tra i valori delle pendenze medie e dei relativi livelli ricavati per le superfici piezometriche presente e passata in corrisponde-za di differenti tratti della sezione AB nell'area di Egnazia*.*

		Sketch 1: A – 19	**Sketch 2: 19 – B**	**Archaeological Park area**	
	Present Piezometric Surface mean Slope along AB Section	**Past Piezometric Surface mean Slope from Necropoli to@ Traiana Road**	**Past Piezometric Surface mean Slope from Traiana Road to coastline**	**Present Piezometric Level**	**Past Piezometric Level calculated by Sketch 1 Slope**
A Hypothesis: Activity	0,048%	0,076%	0,77%	+0,12 m	+0,19 m
B Hypothesis: Non – Activity	0,048%	0,073%	0,76%	+0,12 m	+0,18 m

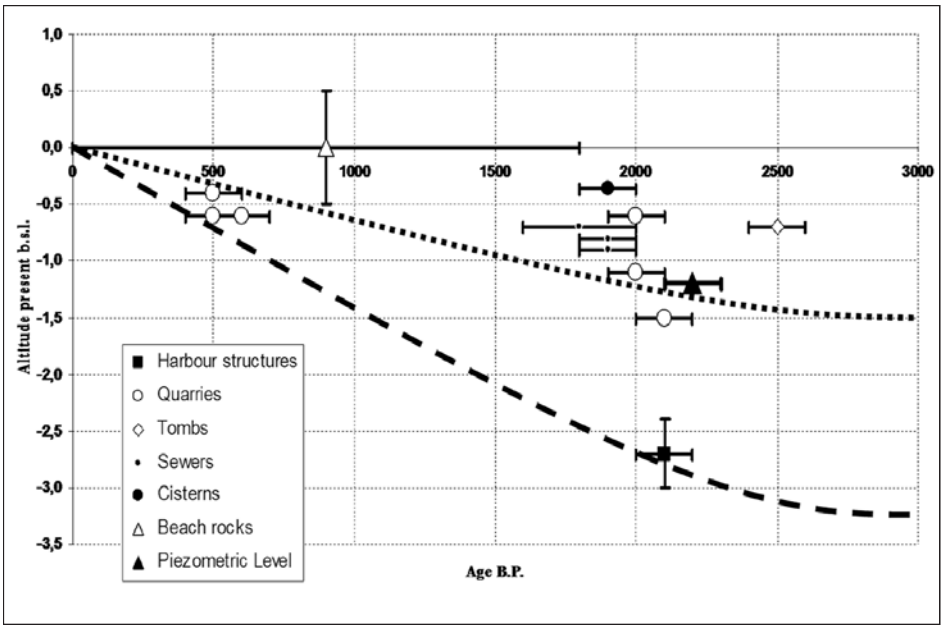

Fig. 7. - - - : Curve of sea level change during the last 3000 years in Southern Apulia reconstructed from Auriemma et al. (2004) data; ... : Curve of sea level change during the last 3000 years according to the past piezometric surface in *Egnazia* area. ▲ : Sea level during 4th - 2nd cent. B.P. deducted by Piezometric Level in Archaeological Elements (Wells, Cisterns and Tombs).

Curva della variazione del livello del mare durante gli ultimi 3000 anni lungo la Puglia meridionale ricostruita in base agli indicatori di Auriemma et al. (2004); ... : Curva della variazione del livello del mare durante gli ultimi 3000 anni secondo la ricostruzione della superficie piezometrica del passato nell'area di Egnazia. *▲ : Livello del mare durate il VI - II sec. a.C. dedotto dalla Superficie Piezometrica ricavata dagli Elementi Archeologici (Pozzi, Cisterne e Tombe).*

elaboration indicate a relative sea level change lower than supposed by AURIEMMA *et al*. (2004; 2005). Unluckily, they do not permit us to recognize the eustatic and/or tectonic contribution although the entire area where *Egnazia* is located, is considered by some Authors in slow downlift (MASTRONUZZI & SANSÒ, 2002a; LAMBECK *et al*., 2004). Moreover, this reconstruction fits in well with some recent surveys that, in coastal areas, individuate the bottom of Messapic tombs up to -1,1 m present b.s.l.. Therefore taking into account that some eastern *Necropoli* coastal tombs and *Egnazia* Roman harbour structures stay currently below the present b.s.l. (AURIEMMA *et al*., 2004) it is unlikely that Messapic people used to bury dead people at the seaside, where storms and spray could reach the tombs.

CONCLUSION

The aim of this work was to estimate the relative position of the sea level during 4th–2nd cent. B.C. by means of archaeological data from *Egnazia*. News and bibliographic data permit us to imagine the trend of the piezometric surface related to 4th–2nd cent. B.C.; two hydrogeological sections respectively based on two different scenarios have been implemented. According to the suggestions derived by Sivan et al. (2004), the first one considers the active state of wells adding the value of 35 cm to the elevation of the well–bottom and subtracting the same value to the elevation of the tomb / cistern–bottom. The second one considers the state of abandoning of wells.

Data and discussion shown in these pages indicate that wells, cisterns and tombs dug in coastal areas could be used in the reconstruction of piezometric surface and related sea level with prudence. In fact, pottery remains inside do not indicate necessarily the age of their use but more probably their use as a dump. Moreover, when using bibliographic data, their accuracy needs to be verified, in particular in the evaluation of deep values. As a consequence the error limit of this method on rocky coast should be bigger than the 0,10 m supposed in previous pages or the 0,10÷0,20 m supposed by Sivan et al. (2001) for sandy coasts.

In summary, the shown data and the reconstructions obtained indicate that: **i** – the wells were dug in times before the 4th–2nd cent. B.C.; **ii** – the wells were abandoned and filled at least at the beginning of the 4th century; **iii** – the piezometric level during the 4th–2nd cent. B.C. ran at about 1,6 m below the wells-bottom; iv – the sea level during the 4th–2nd cent. B.C. was at least -1.2 m present one.

The discrepancy between this last data and that indicated by the presence of the submerged harbour structure is only apparent; in fact, the value -1,2 m is a limit lower than the sea could stand and it is heavily conditioned by the approximation of data registered and derived by Digging Journals.

ACKNOWLEDGEMENTS

We would like to thank anonymous reviewers for constructive criticism and useful suggestions, Dott. Rossella Pagliarulo from CNR – Bari and Dott. Vittoria Tagliente for the helpful discussions.

This work was financially supported by National Project ARCHEOMAR by Ministero dei Beni e delle Attività Culturali (Project Leaders: Dott. L. Fozzati; Dott. C. Mocchegiani Carparo; Leader of Puglia Unit: G. Mastronuzzi).

This is an Italian contribution to the IGCP Project n.495 – International Geological Correlation Programme "Quaternary Land-Ocean Interactions: Driving Mechanisms and Coastal Responses " dell'UNESCO – IUGS (Project Leader: Dr. Anthony Long, University of Durham, UK).

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Ms. ricevuto il 20 febbraio 2006
Testo definitivo ricevuto il 31 ottobre 2006

Ms. received: February 20, 2006
Final text received: October 31, 2006