Il Quaternario
Italian Journal of Quaternary Sciences
***12**(1), 1999, 57-62*

THE BURIED TOWN OF HERCULANEUM AND THE LOCAL COASTAL MORPHOLOGY BEFORE THE VESUVIUS ERUPTION OF A.D. 79

Francesco Aprile*, Maurizio Conte* and Giuseppe Rolandi**
* Dipartimento di Scienze della Terra. Università di Napoli " Federico II ". L.go S.Marcellino, 10 - 80138 Napoli . Tel 081/5473313. E-Mail : aprile @unina.it
** Dipartimento di Geofisica e Vulcanologia .Università di Napoli "Federico II " L.go S. Marcellino, 10 - 80138 Napoli. Tel 081/5803316

RIASSUNTO. Dallo studio stratigrafico - vulcanologico di carote provenienti da sondaggi meccanici ubicati nell'ambito del territorio di Ercolano, ivi compresa l'area degli Scavi archeologici , si è individuato il substrato su cui si sono deposti i prodotti piroclastici dell'eruzione del 79 d. C. E' stato quindi possibile ricostruire l'andamento topografico di parte dell'antica Herculaneum prima che venisse sepolta dai materiali da flusso di questa devastante eruzione.
Il modello a cui si è giunti posiziona l'antica città su di un promontorio degradante dolcemente verso il mare e delimitato lateralmente da due valloni. Questa ricostruzione , in completo accordo con le descrizioni degli storici di epoca romana, differisce da quella proposta da Pagano [1996] e da Pagano *et al.*[1997] secondo cui Herculaneum sorgeva su una superficie terrazzata a circa 15-20 metri sul livello del mare.

ABSTRACT. From study of core samples drilled in the present town of Ercolano, which includes the subsurface of the area of the ancient Herculaneum, it has been possible to identify the substrate upon which the pyroclastic deposits of the Vesuvius 79 A.D eruption rest and therefore to reconstruct the local topography prior to the town burial during this devastating eruption.
The restoration here proposed offers an alternative to the interpretation of the topography of the old town suggesting that the original morphology was that of a gentle slope degrading to the sea and flanked by two valleys. This reconstruction is in complete concordance with descriptions given by ancient authors before 79 A.D eruption and contrasts with the recent models of Pagano [1996], Pagano *& al.* [1997] proposing that Herculaneum was situated on a terraced surface 15-20 meters above sea level.

Keywords: Vesuvius eruption, Herculaneum, pyroclastic deposits, morphology
Parole chiave: eruzione del Vesuvio, Ercolano, depositi piroclastici, morfologia

1 - INTRODUCTION

Though there has been a great number of archaeological studies on the ancient site of Herculaneum (Fig. 1), both in the past and in the present times, only very recently these researches have changed direction to include those of a geo-volcanological nature from which it has been possible to reconstruct the topography of the area prior to the Plinian eruption of 79 A.D. In particular with respects to the position of the coast line during this period, Casertano & Pinna [1970], from mechanical soundings performed in the area out side of the archaeological dig (Fig.2), have established that the coast line between Portici and Torre Bassano was approximately three meters lower that the current coast line. This analysis has also been confirmed by Livadie *et. al.* [1990] for the area between Torre Annunziata and Pompei.

With regards to the volcanological aspect Sigurdsson *et. al.* [1982 ;1985] have produced a complete analysis and description of the pyroclastic products from the 79 A.D. eruption. Within the area of Ercolano there has been identified beach deposits in the proximity of the Suburban thermal baths, which correspond to the ancient coast line, at height of approximately four meters below the current coast line.

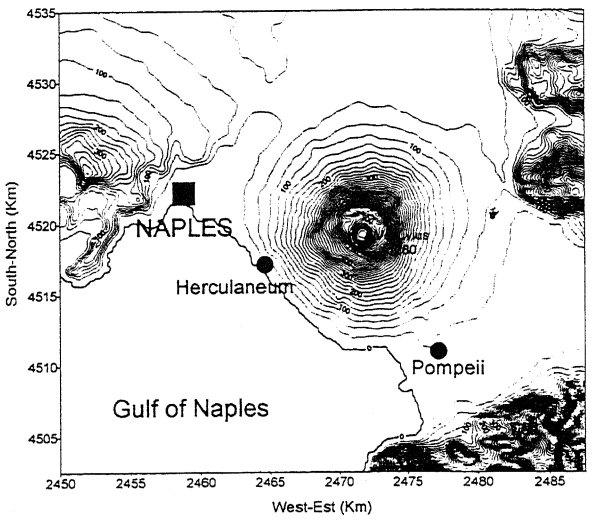

Fig. 1 - Simplified contouring map of Somma -Vesuvius volcano vith location of the Herculaneum site, (Gauss-Boaga UTM coordinates).

Mappa semplificata del complesso vulcanico del Somma-Vesuvio con l'ubicazione del sito di Ercolano, (Gauss - Boaga , coordinate UTM).

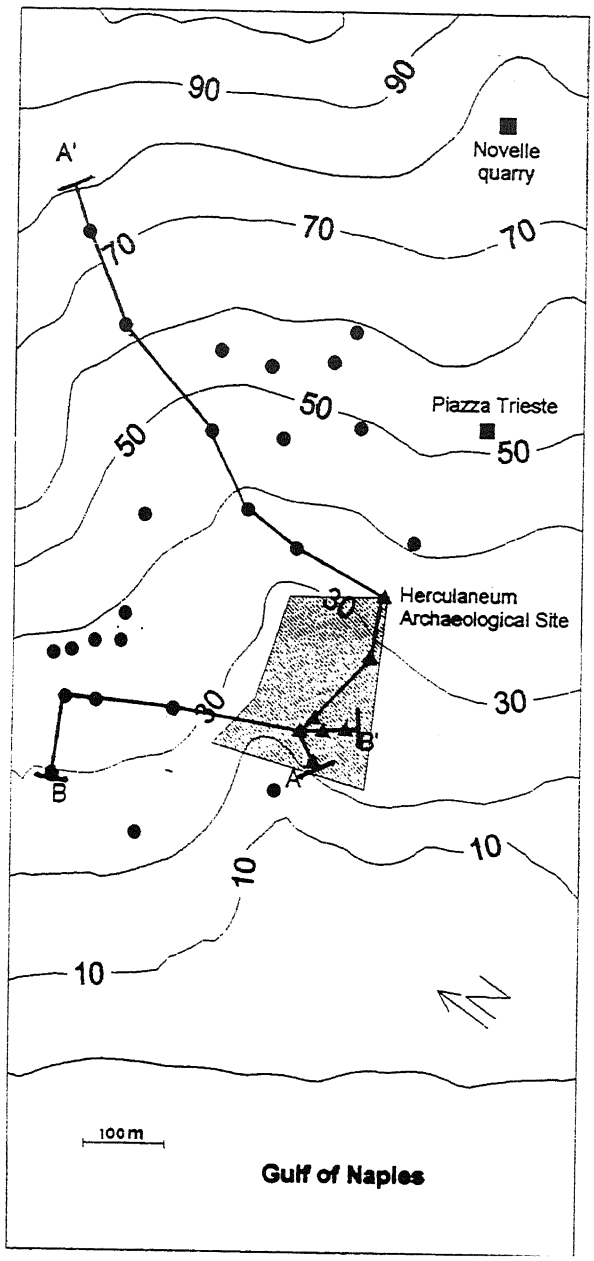

Fig. 2 - Present topography of the area of interest indicating stratigraphic log sites: A-A' ; B-B' = geological cross sections:
● drillholes carried out by Casertano & Pinna in 1970
▲ drillholes carried out recently within Archaeological Site.

Attuale topografia dell'area studiata con la posizione dei sondaggi meccanici: A - A'; B - B' = traccia sezioni geologiche;
● *sondaggi eseguiti da Casertano & Pinna nel 1970*
▲ *sondaggi eseguiti recentemenete negli Scavi Archeologici.*

Golser *et. al.*[1990], within an archaeological marine study of the area around Torre del Greco have established that the ancient coast line is five meters below the current sea level. Pagano [1996] during an archaeological dig, within the Sacred Area, found ancient beach deposits approximately 4.20 meters below the present day sea level.

It therefore can be seen that from the results obtained by these authors that there is a general concordance within the position of the ancient level of the coast line during the period prior the 79 A.D. eruption within the area between Ercolano and Torre del Greco, a level which varies between –3 and –5 meters with respects to the current coast line. It should be noted that these results can't be related to the sea level rise within the Mediterranean over the last 2000 years, which is estimated to be approximately +0.5 to +1 m in the Tyrrhenian Sea [Pirazzoli 1976;1977]. The variation of the relative sea level is related to volcanic and tectonic subsidence as hypothesised by Sigurdsson *et. al* [1985] and Cinque [1992]. A hypothetical reconstruction of the topography of the area has been produced by Pagano [1996], and Pagano *et al.*[1997] who based their theory upon the road outline of the ancient town of Ercolano; they suggest that the inhabited centre of Herculaneum was placed upon a morphological high cliff coast line (Fig.3).

2 - GEO - VOLCANOLOGICAL CHARACTERISTICS OF THE PYROCLASTIC DEPOSITS WITHIN THE ERCOLANO AREA

The textural and volcanological characteristics of the pyroclastic flow and surge products on the western side of Vesuvio from the 79 A.D. eruption have been analysed and described by Sigurdsson *et. al.* [1985] who has recognised, from the western wall of the archaeological digs of Herculaneum in the proximity of the Suburban thermal baths, a succession of six pyroclastic flow units. Each unit is over lye a thin surge unit (Fig. 4). The whole succession rests upon the ancient beach of Herculaneum, consisting of a level of dark cross-laminated sand and a layer of rounded cobbles. This layer is approximately 4 meters below the current sea level

This ancient beach deposit rests upon a zeolitic yellowish tuff unit, with pyroclastic flow features, which has been used as a reference horizon within our reconstruction. The chronostratigraphic position of this unit has been established based upon recorded evidence at other outcrops of the same zeolitic tuff deposit, which have the same petrographic features, located within the Novelle quarry and Montedoro valley respectively situated within the modern town of Ercolano and within the suburb of Torre del Greco. In these locations it is possible to see that between the lower lavas from the Somma eruption (17.000 yr B.P.) and the deposits from the 79 A. D. eruption there is a thick tuff layer, with pyroclastic flow features and an approximate thickness of 15 - 20 meters, ascribed by Rolandi [1993; 1997] to the explosive eruption of Somma, called " Avellino " eruption (3550 yr B.P) whose products are widely distributed in the southern and western areas of the volcanic edifice.

From the study of the core samples taken during mechanical soundings, performed within and around the area of the archaeological dig (fig. 2), it has been possible to recognise, below the products of 79 A.D. eruption, a zeolitic yellowish tuff horizon which has the same stratigraphic, petrographic and textural characteristics as the tuffs seen within the Novelle Quarry and Montedoro outcrops.

This clearly indicates that tuff horizon situated below the beach deposits, in the archaeological digs, and the other above mentioned tuffs came from the same eruption, that of "Avellino", and that it is this horizon that

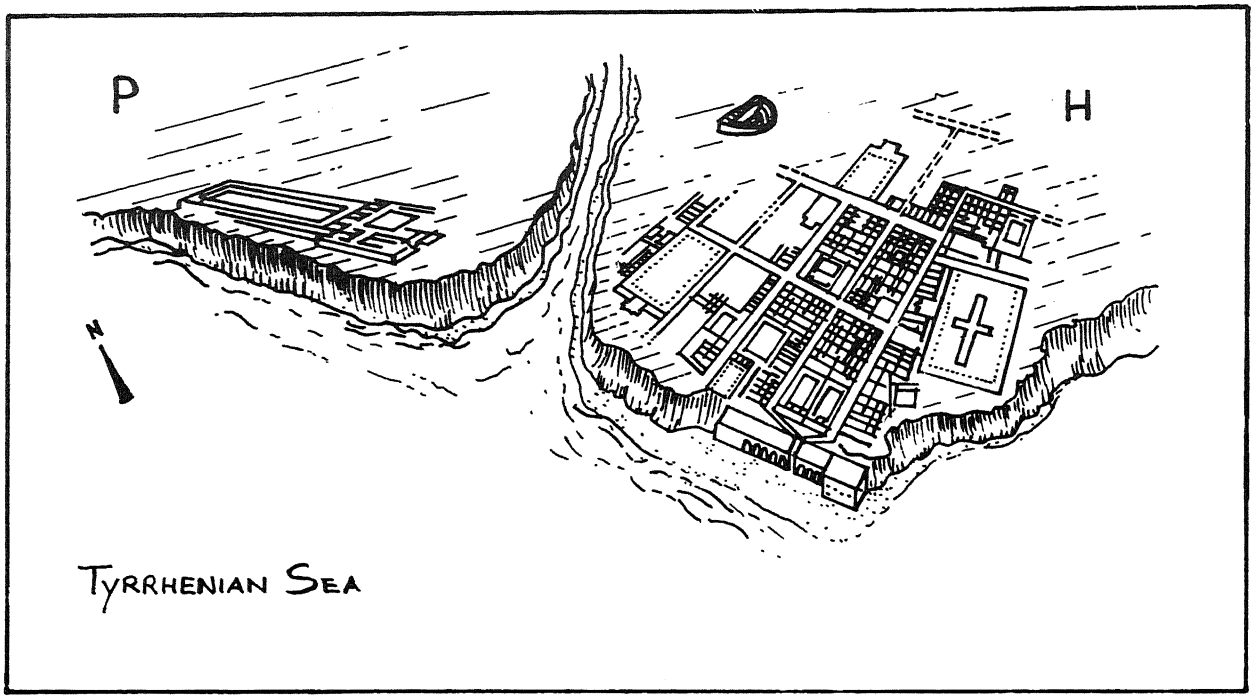

Fig. 3 - Old morphology of Herculaneum area prior to the 79 A.D. eruption in accordance with model proposed by Pagano *et al.*[1997]: H) Herculaneum town ; P) Villa Papiri.

Morfologia del territorio di Ercolano precedentemente all'eruzione del 79 d.C secondo il modello proposto da Pagano et al.[1997]: H) antica Ercolano; P) Villa Papiri.

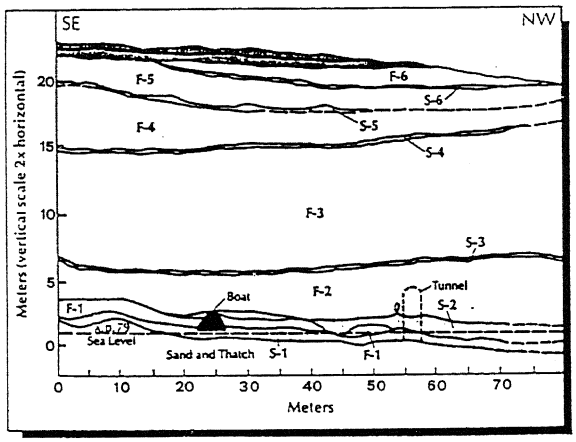

Fig. 4 - Stratigraphy of the 79 A.D. volcanic deposits on the Herculaneum beach. Note that the vertical scale is based on datum that originates five meters below present sea level. F-1 - F-6 = pyroclastic flows ; S-1 - S-6 = surge layers [From Sigurdsson *et al.*1985].

Stratigrafia dei depositi vulcanici del 79 d.C nella zona di spiaggia dell'antica Ercolano. La scala verticale è basata su dati che iniziano da 5 metri sotto il livello marino attuale. F-1 - F-6 = flussi piroclastici; S-1 - S-6= livelli di surge [da Sigurdsson et al.1985].

represents the ancient topographic surface of Herculaneum. Figure 5 shows the stratigraphic column from within the area of the dig archaeological, near the thermal baths, correlated with those, of the recorded outcrops, seen within the Novelle quarry and Montedoro valley. In the succession that occurrs within the archaeological dig area there can also be seen pyroclastic flow deposits from at least two other older eruptive events, assigned to the eruptions of "Ottaviano" and "Novelle" which rest upon ancient tephritic -leucitic products of Somma's effusive eruptive activity [Rolandi *et. al.* 1993, 1997] .

These deposits characterised by reworked products are missing, probably eroded, from within the outcrops of Novelle quarry and Montedoro valley.

Using the reconstructed stratigraphy it has been possible to produce a 'type' sequence for the whole area study (shown in the key of the geological cross sections of Figures 6 and 7) that include all the products which have been emplaced after the effusive eruptive activity of Somma. The sections seen within

the same figures have been constructed using data taken from both inside and outside the area of the archaeological dig.

3 - RECONSTRUCTION OF THE MORPHOLOGICAL ASPECT OF THE AREA AROUND HERCULANEUM PRIOR TO THE ERUPTION OF 79 A.D.

By means stratigraphic correlation and tracing of numerous geological sections (outcrops, digs and drilling sites) it has been possible to reconstruct the topographical surface of the area prior to the 79 A.D eruption. It was assumed that said palaeo-topography coincides with the eroded top of the zeolitic yellowish tuff correlated to the pyroclastic flow of the Avellino eruption. The present absolute heights obtained for the top of the yellow tuff have been uplifted by 4 meters taking note of the subsidence, of volcanic and tectonic origin,

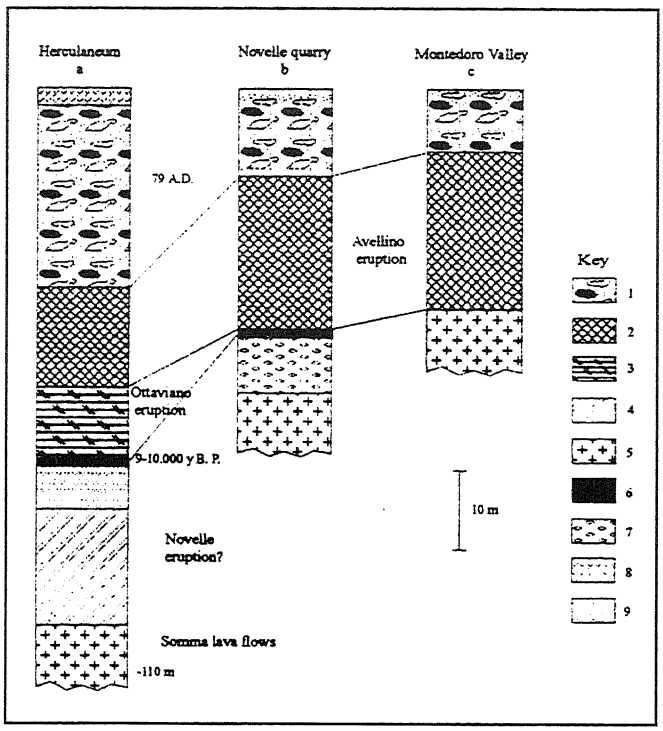

Fig. 5 - Stratigraphic correlation of buried and outcropping volcanic deposits at Herculaneum Archaeological site (a), Novelle quarry (b) and at Montedoro valley (c): 1) products from 79 A.D. eruption; 2) yellow tuff from the "Avellino" eruption; 3) products from "Ottaviano" eruption; 4) products from "Novelle " eruption; 5) Somma lava flows; 6) paleosoil; 7) white and grey pumice fall deposits; 8) reworked pyroclastic deposits; 9) volcanic ashes deposits.[By Rolandi *et al.*1997, modified].

Correlazione stratigrafica tra i depositi vulcanici negli Scavi Archeologici (a) e quelli affioranti in località cava Novelle (b) e in località Montedoro (c): 1) prodotti dell'eruzione del 79 d.C; 2) tufo giallo dell'eruzione di " Avellino"; 3) prodotti dell'eruzione di "Ottaviano"; 4) prodotti dell'eruzione di "Novelle"; 5) lave del Somma; 6) paleosuolo; 7) pomici bianche e grigie di depositi da caduta; 8) depositi piroclastici rimaneggiati; 9) ceneri vulcaniche .[da Rolandi et al.1997,modificata].

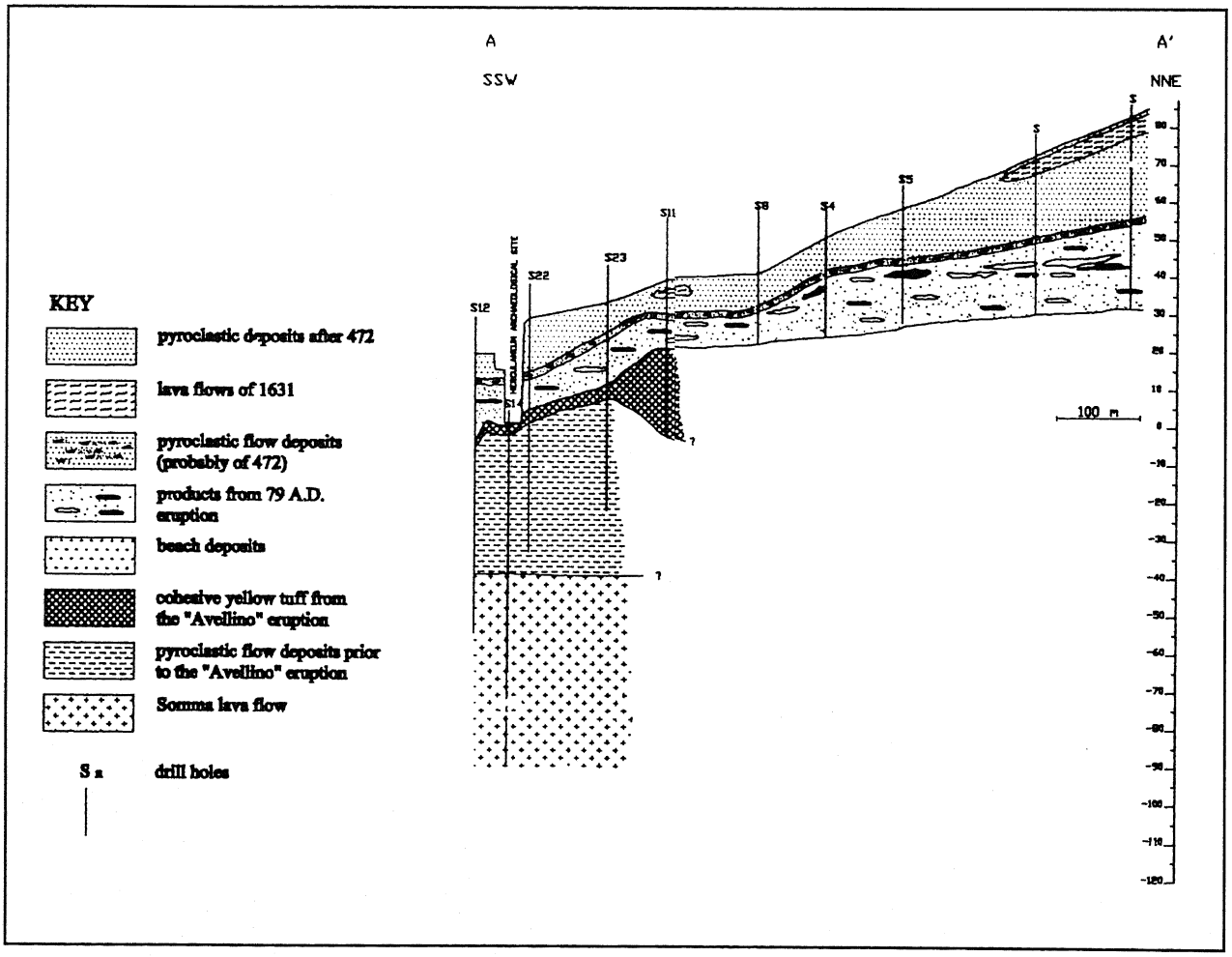

Fig. 6 - Schematic Geological cross section A - A' of the area of Ercolano, as obtained from subsoil data.

Sezione geologica schematica, A - A', del territorio di Ercolano, desunta dai dati del sottosuolo.

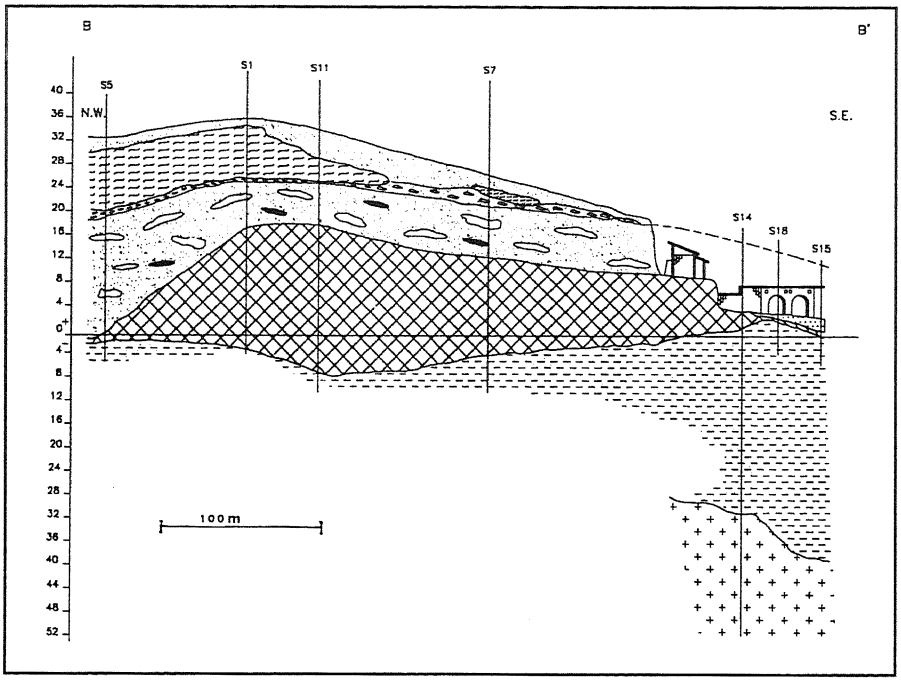

Fig. 7 - Schematic geological cross section B - B' of the area of Ercolano, as obtained from subsoil data.(For key symbols see Fig. 6).

Sezione geologica schematica, B - B', del territorio di Ercolano, desunta dai dati del sottosuolo.(Per la legenda vd. Fig. 6).

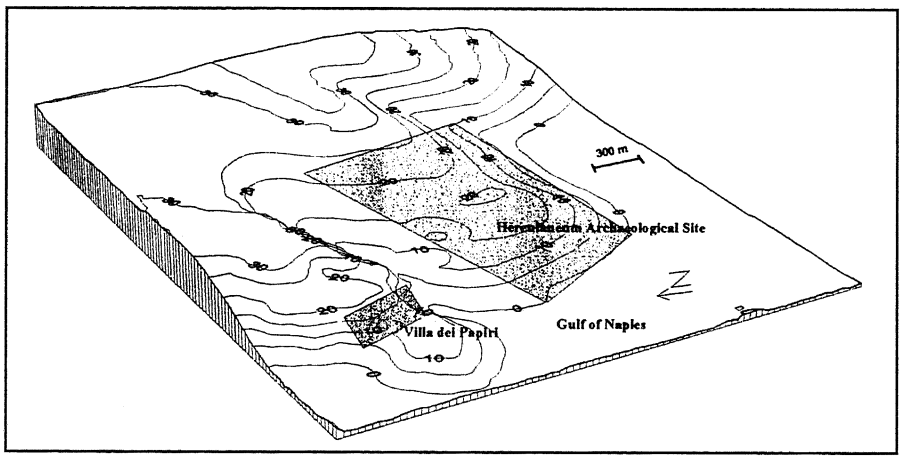

Fig. 8 - New 3D interpretation of the topography and morphology of the area of Herculaneum town prior the 79 A.D. eruption.

Nuova Interpretazione in 3D della topografia e morfologia dell'antica Ercolano prima dell'eruzione del 79 d.C.

over the past 2000 years. The final analysis has resulted in the 3D topographic map (Fig. 8) showing the ancient morphological surface of Ercolano and the surrounding area prior to the 79 A.D. eruption. It clearly shows that the Roman town of Herculaneum was constructed upon a hill which gently slopped down to the Tyrrhenian sea, confined to the NW and SW by two incisions that allowed water to flow from the volcanic edifice to the sea.

Having established the ancient morphological aspect of the area it can now be noted that the Villa Papiri assumes a specific topographic position. In fact it has been noted that the pavement of the Villa, which is currently situated at + 11 meters above sea level, was at the time of the 79 A.D. eruption four meters higher, at + 15 meters a.s.l as showed in Fig. 8.

The morphological aspects of the ancient town of Ercolano proposed by this study, based upon volcanological and stratigraphic data, is in complete agreement with the description given by the Roman historian Sisenna who described the town of Herculaneum as *"oppidum tumulo in excelso loco propiter mare, parvis moenibus inter duas fluvias infra vesuvium collocatum".*

4 - CONCLUSIONS

Close scrutiny of the outcropping volcanics and core logs from within and around Ercolano, coupled with volcano-stratigraphic restoration, has enabled us to produce a precise reconstruction of the area prior to the devastating eruption of 79 A.D and to define the lithological characteristics of the substrate upon which the products from the said eruption lay (zeolitic yellowish tuff unit from the 3550 yr B.P. "Avellino" eruption).

It is therefore possible, based upon the position of the top surface of this horizon, to outline the ancient topography of the area not only within the archaeological dig

but also in the surroundings. In the resulting 3D reconstruction of the topography of Ercolano area prior to the 79A.D. eruption, the general morphology was one of a gentle slope running down to the sea, dissected by two valleys as seen in Fig. 8. It is therefore denied the existence of the surface terraced proposed by Pagano [1996] and Pagano *et al.* [1997] .The pyroclastic products of the 79A.D. eruption changed the landscape in two fundamental ways: the general slope profile become less inclined and the coast line moved 0.3 km to the west not-withstanding a subsidence of approximately 4 meters which occurred after the eruption.

Acknowledgements.

The authors wish to thank Prof. B. D'Argenio for his reading of the work and for his recommended alterations, Dr. John G. Taylor for the time spent translating the work.

REFERENCES

1) Casertano L.& Pinna E., 1970 - *Variazione del litorale vesuviano e fenomeni bradisismici* . Atti Accademia Pontaniana - Napoli -**19**, 1-32
2) Cinque A., 1992- *La trasgressione Versiliana nella Piana del Sarno.*Geografia Fisica e Dinamica Quaternaria - vol. **14** (1) 1991, pp. 63-71
3) Golser C., Pagano M. & Russo F., 1990 - *Evidenze archeologiche sommerse a Torre del Greco e loro implicazione sull'andamento della linea di costa vesuviana del 79 d.C.* Volcanologie et Archeologie, Pact **25**, Strasbourg pp. 183 - 195
4) Livadie A., Barra D., Bonaduce G., Brancaccio L., Cinque A., Ortolani F., Pagliuca S. & Russo F., 1990 - *Evoluzione geomorfologica, neotettonica e vulcanica della piana costiera del fiume Sarno (Campania) in relazione agli insediamenti anteriori all'eruzione del 79 d.C.* Volcanologie et Archeologie, Pact **25**, Strasbourg, pp. 237 - 256
5) Pagano M., 1996 - *Considerazioni sulle variazioni del livello del mare lungo il litorale vesuviano.* Boll. Archeologia subacquea del Ministero per i Beni Culturali ed Ambientali **I**, pp. 241 - 251
6) Pagano M., Pescatore T.& Rippa F., 1997 - *The coast in the area of the Herculaneum excavations at the time of the romans. International symposium of Geotechnical Engineering for the preservation of Monuments and Historic sites*, pp.459 - 466. Napoli ottobre 1996. AA. Balchema - Rotterdam
7) Pirazzoli P.A., 1976 - *Sea level variations in the Northwest Mediterranean during Roman Times.* Science **194**, pp. 519 - 521
8) Pirazzoli P.A., 1977 - *Sea level relative variations in the World during the last 2000 years.*Zeit.Geomorph. N.F., **21**, 3 pp. 284 296
9) Rolandi G.,Maraffi F., Petrosino p. & Lirer L., 1993 - *The Ottaviano eruption of Somma-Vesuvio (8000 ys B.P): on magmatic alterating fall and flow-forming eruption.* Journal Volc.and Geotherm.Res. **58**, pp. 43-65
10) Rolandi g., Mastrolorenzo g., Barrella a.m. & Borrelli A., 1993 - *The Avellino Plinian eruption of Somma-Vesuvio (3760 ys B.P): The progressive evolution from magmatic to Hydromagmatic style.* J. of Volc. and Geotherm. Res. **58**, pp. 67-88
11) ROLANDI, G.,1997-*The eruptive hystory of Somma-Vesuvius.* Volcanism.and Archeology in Mediterranean Area. Research Signpost - India.
12) Sigurdsson H., Cashdollar S., & Sparks R.S.I., 1982 - *The eruption of Ve suvius evidence in A.D. 79: Reconstruction from historical and volcanological evidence.* Am. Journal of Archeology, **86** pp. 39-51
13) Sigurdsson H., Carey s., Cornell w.,& Pescatore T., 1985 -*The eruption of Vesuvius in A.D. 79.* National Geographic Research, **1**, pp. 332-387

Ms. ricevuto il 29 marzo 1999
Testo definitivo ricevuto il 5 luglio 1999

Ms. riceived: March 29, 1999
Final text received: July 5, 1999