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$^{230}Th/^{238}U$ DATING OF CORALS FROM TYRRHENIAN MARINE DEPOSITS OF VARDA AREA (NORTH-WESTERN PELOPONNESUS), GREECE (+)

Abstract: STAMATOPULOS L., VOLTAGGIO M., KONTOPULOS N., CINQUE A. & LA ROCCA S. - *$^{230}th/^{238}U$ dating of corals from Tyrrhenian marine deposits of Varda area (North-western Peloponnesus), Greece.* (IT ISSN 0084=8948, 1988).

The marine and transitional terrains extensively cropping out nearby Varda (NW Peloponnesus) were studied and preliminarly dated through Th/U measurements on corals collected from three different sections within the area. The dates obtained range between 103 and 209 Kyr B.P. thus indicating a Tyrrhenian age for the entire sequence. From their areal distribution, the studied deposits appear to belong to three distinct transgressive cycles in onlap relations. Their ages substantially correspond on the well known 5.3, 5.5 and 7.1 isotopic sub-stages.

KEY WORDS: Marine terrace, Tyrrhenian, Th/U dating, Peloponnesus (Greece).

Riassunto: STAMATOPULOS L., VOLTAGGIO M., KONTOPULOS N., CINQUE A. & LA ROCCA S. - *Datazione $^{230}Th/^{238}U$ su coralli appartenenti a depositi marini tirreniani dei dintorni di Varda (Peloponneso nord-occidentale), Grecia,* (IT ISSN 0084-8948, 1988).

Sono state studiate le successioni marine e lagunari terazzate affioranti presso Varda (NW del Peloponneso). Le prime datazioni Th/U effettuate sui coralli provenienti da 3 differenti affioramenti indicano età comprese tra 103 e 209 migliaia di anni dal presente ricadenti, quindi nel Tirreniano e corrispondenti abbastanza bene ai substadi isotopici 5.3, 5.5 e 7.1. La distribuzione areale dei terreni datati indica una disposizione in *onlap* dei termini più recenti su quelli più antichi, alla quale si è accompagnata la formazione di un unico vasto terrazzo regolarmente degradante da circa 140 a circa 30 metri di quota.

TERMINI CHIAVE: Terrazzi marini, Tirreniano, Datazioni Th/U, Peloponneso (Grecia).

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INTRODUCTION

Most of the area we have geologically and geomorphologically investigated (see fig. 1) is occupied by a broad marine terrace which continues southwards for other tens of square kilometers. In the study area the terrace has a width of almost 7 km, with the lower rim at about 30 m a.s.l. and the inner boundary at the mountain front of Skolis reliefs- as high as 140 m a.s.l.. Away from the numerous river valleys that cut it with a subparallel pattern, the terraced surface appears even and regularly inclined toward NW. The often fossiliferous marine and transitional deposits forming the entire orographic volume of the terrace are frequently covered by a veneer of reddish sandy and conglomeratic alluvional deposits.

No specific geologic paper on that sequence is present in the literature (KERAUDREN, 1970; 1971) but our terraced deposits seems to correlate with the youngest of the sedimentary cycles recognized by HAGEMAN (1977) during his investigation of Cainozoic deposits near Pirgos, and loosely traced to Pleistocene by the same author. According to TSOFLIAS (1977) the terraced marine sequence belongs to Neogene while its red alluvional cover is Pleistocene in age.

As both the above quoted chronological attributions do not appear supported by conclusive evidence, and since our preliminary geomorphological survey suggested for those deposits a much younger age than those previously suggested, we decided to try some $^{230}Th/^{238}U$ datings on the corals of the sequence. Our initial hypotesis about a younger age of Varda terrace has been recently reinforced by the work of KERAUDREN & SOREL (1987) which pointed out the existence of strong Late Pleistocene uplift in Corinto area by dating between 450,000 and 28,000 yr B.P. a series of 20 marine terraces.

The present paper deals with stratigraphy and sedimentology of outcrops, results of dating and their interpretation. A forthcoming work will deal with geomorphological and geodinamic implications.

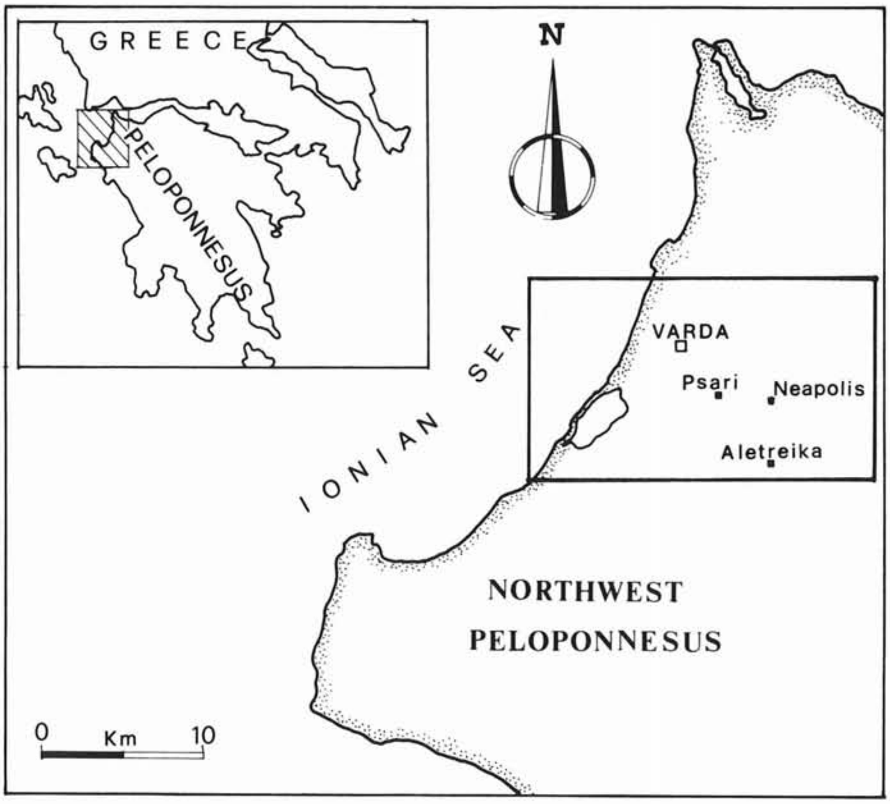

FIG. 1 - Area of geological and geomorphological investigation.

OUTCROPS

The three more interesting and complete sections, out of the several ones we examined along fluvial dissections of the terrace, are herein reported. They are ordered moving from Varda east-southeastward (i.e. from the sea to the interior). Whenever possible the environment of deposition of each interval was determined by taking into account both field characters (composition, texture, fossils, sedimentary structures) and results of sedimentological analises.

PSARI SECTION

A 3.5 m thick sequence is exposed at 45 m a.s.l. along the Varda-Psari-Neapolis-Agios Kostandinos road, about 350 m outside Psari village. From the bottom upwards the following sequence outcrops (fig. 2):

a) 0.50 m thick yellowish sand of lagoonal environment;
b) 1.50 m of sandy silt with abundant *Cladocora* sp., *Ostrea* sp., *Cardium* sp. and other fossils in living position. Low energy and shallow depth environment;
c) 1.50 m thick yellow sand and silt, probably of marine environment. Locally such level is deeply weathered in a reddish soil.

Cladocora coespitosa specimens for dating were sampled from interval b).

NEAPOLIS SECTION

Along the same road, 400 m northward of Neapolis village, at 60 m a.s.l. the following sequence outcrops, from the bottom upwards (fig. 2):

a) 6.75 m of clay with abundant *Cladocora coespitosa* in growing position. *Pecten* sp., *Glycimeris* sp., *Dentalium* sp., etc. are also present in the lower portion of the interval. Low energy shallow marine environment turning to lagoonal in the uppermost 2 m;
b) 4.20 m thick yellow-grey silt with rare fossils. Low energy marine environment;
c) 0.50 m thick grey silt probably of lagoonal environment;
d) 4.00 m thick pale grey silty clay with mollusc shells in the lower part. Parallel laminations are also present. Low energy coastal marine environment;
e) about 8.00 m of yellowish silty sand with rare fossils and pebbles in the uppermost part. Coastal marine environment.

Three specimens have been sampled from interval a).

ALETREIKA SECTION

Along Cremidi to Borsion road, 500 m before Aletreika village, at about 140 m a.s.l., the following sequence outcrops from the bottom upwards:

a) 2.00 m of grey silty clay with large fragments, very fre-

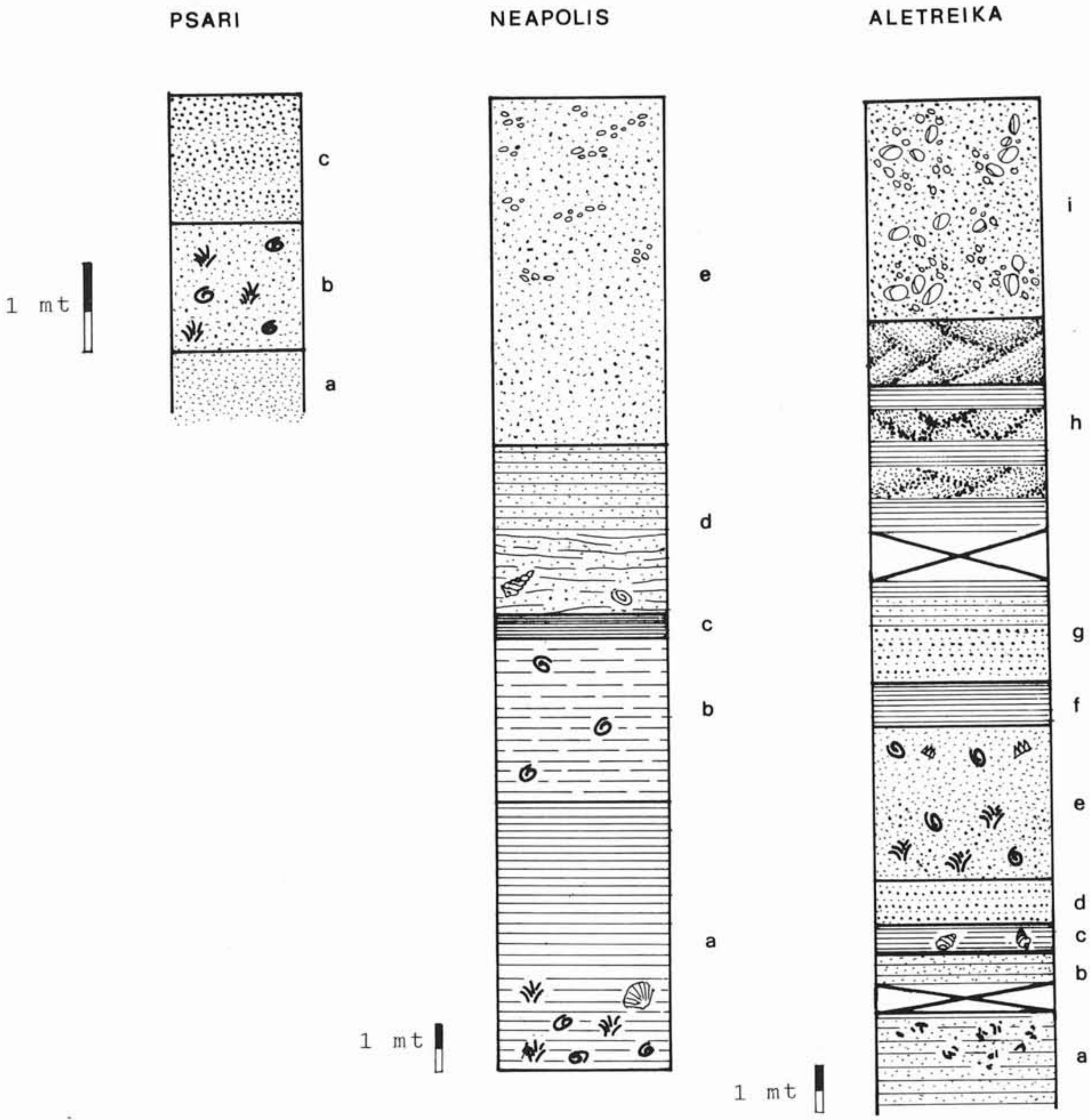

FIG. 2 - Stratigraphic scheme of the outcrops.

quent in the uppermost part, of *Conus* sp. and *Murex* sp. Shallow depth marine facies:

x) unexposed interval of 0.5 m;

b) 0.40 m of yellow silty clay of transitional environment;

c) 0.60 m of grey yellowish clay with some gasteropods, probably of lagoonal environment;

d) 1.50 m of parallel laminated silty sand of low energy marine environment;

e) 1.80 m of grey cemented medium sand passing to silty sand, with abundant *Cladocora coespitosa* in living position, then to fine sand, with *Ostrea* sp., *Pecten* sp., *Balanus* sp., and finally to coarser sand. Marine environment;

f) 0.70 m of dark grey clay passing to silty and sandy clay followed upwards by grey silty clay. Lagoonal environment;

g) 2.00 m of plane-parallel laminated medium sand with intercalations of fine sand. Beach environment;

x) unexposed interval of 1 m;

h) 4.80 m of alternating parallel laminated clay and cross laminated sand passing to cross laminated sandy silt. Marine mollusc shells can be found into the sands.

Repeated environmental changes between coastal bar and lagoon;

i) up to 2.00 m of alluvial sand with sparse pebbles;

Cladocora coespitosa specimens have been sampled from e) interval.

DATING METHOD AND EXPERIMENTAL DATA

The ^{230}Th dating method has been successfully used to date corals belonging to terraced marine deposits aging from 10 to 250 kyr bp. Fossilized corals gives reliable ^{230}Th age probably as a result of «mass» effect (CHERDYNTSEV, 1971) similar to what occur for travertines where continuity and thickness of carbonaceous matter minimizes effects related to migration of radionuclides.

The computed age is a non linear function of $^{230}Th/^{238}U$ and $^{234}U/^{238}U$ ratios, if small non radiogenic ^{230}Th quantities are not taken into account. In fact, ^{230}Th is generally absent in organic and non organic precipitate of calcium carbonate (VECH & BURNETT, 1982). On the contrary specimens contaminated by non carbonaceous matter can release non radiogenic ^{230}Th when chemically attacked. Such anomaly can be corrected following some correction procedures; the simplest and most reliable one is that of KU & LYANG (1984). This method, originally used for travertines, is based on comparison of isotopic U and Th ratios of soluble and non soluble fraction so that to compute ^{230}Th resulting from non carbonatic matter. One of our *Cladocora coespitosa* specimens required such a correction.

About 20 gr of matter for each specimen have been analized after immersion in H_2O_2 and ultrasonic cleaning. Subsequently they have been treated with 1N nitric acid. Separation and analysis procedures consisted in addition of tracing with non activity ratios ($^{230}Th/^{238}U = 1.027$), precipitation of U and Th with 3° analitical group, separation of U and Th isotopes by anionic and cationic resins and estraction of radionuclides by TTA. Full details of procedures are given in GASCOYNE & *alii,* (1978).

Table 1 summarizes the main experimental data obtained on our *Cladocora coespitosa* samples. U/Th acitivity ratios are given in ppm, age is in kyr +/— 1s. All analyzed samples are very high in aragonite (98%). Neapolis 02L sample shows the highest non soluble residues (4.81%) and lowest $^{230}Th/^{232}Th$ activity ratio. Generally Th isotopic ratios greater then 20 do not need corrections but in marine environment enriched ^{230}Th autigenic component cannot be excluded. In this case correction according KU & LYANG (1984) has been applied. The similarity of U content of the analized specimens with living omologus clearly exclude any post-depositional opening of the sistem.

It is noteworth to observe that specimens form Neapolis section gave similar ^{230}Th age within experimental errors.

DISCUSSION

The results of herein presented datings indicate a Tyrrhenian age for all the sampled layers. In particular, Psari b) interval can be related to 5.3 isotopic sub-stage, Neapolis a) interval to the 5.5 sub-stage and Aletreika e) interval to the 7.1 substage (MARTINSON & *alii,* 1987). As no important stratigraphic discontinuity was seen within the study sections, we believe substantially correct to attribute a Tyrrhenian age to the entire marine-transitional complex forming Varda terrace.

The fact that age of the marine deposits increase with the distance from the coast and with the altitude of the sampling sites, clearly evidenciates that tectonic uplift occurred in the area during Tyrrhenian times. On the other hand, present elevations of the marine deposits proof a post-Tyrrhenian rise of the terraced portion of our study area. The uplift can be enstimated in at least some 50 meters as Psari b) interval was deposited some meters below the sea level of that time, which most likely was very close to present day zero level, if not lower. The average rates of uplift one can compute on the base of the herein presented data are quite high but not surprising at all.

TABLE 1

SAMPLE	INS. RESIDUE	$^{230}Th/^{238}Th$	$^{234}U/^{238}U$	$^{230}Th/^{234}U$	U (ppm)	Th (ppm)	AGE Kyr ± 16
NEAPOLIS 01L	2.90	63.17 ± 7.71	1.035 ± 0.020	0.695 ± 0.032	2.60 + 0.09	0.09 ± 0.04	128 + 12/-12
NEAPOLIS 02L	4.81	33.86 + 0.52	1.066 ± 0.016	0.702 + 0.021	2.80 ± 0.07	0.21 ± 0.01	129 + 8/-7 (NC)
NEAPOLIS 02R		6.01 ± 0.25	1.002 ± 0.035	3.642 ± 0.102	3.82 ± 0.11	7.03 ± 0.27	118 + 15/-13 (C)
ALETREIKA 01L	0.90	> 100	1.047 ± 0.014	0.863 + 0.039	2.82 ± 0.05	< 0.02	209 + 32/-35
PSARI 01L	1.20	> 100	1.028 ± 0.011	0.614 + 0.030	2.56 ± 0.03	< 0.02	103 + 9/-8

L = Leached; R = Residue; C = Corrected; NC = Uncorrected.

In fact, in a similar geological context and not far away from our study area. KERAUDREN & SOREL (1987) found deposits corresponding to 7.1 substage at about 300 m a.s.l.

At the present stage of our study the geometrical and stratigraphical relations among the three dated deposits are not yet completely clarified mainly because lateral discontinuity of exposure. However the time-space distribution of the studied sediments suggests that younger transgressive units partially covered in onlap the older ones when the rate of eustatic sea level rise exceeded the rate of tectonic uplift of the landmass. Progradation of the shore line did probably accompain each relative sea level stand and the subsequent phases of regression when tectonic uplift prevailed again.

The fact that, in spite of the polyciclic nature of the sedimentary history, a single and even marine terrace occurs in the area is probably due partly to the original low gradient of the coastal rim emerging during the regressive phases and partly to the erosional planation occurred at the top of the terrace during and after the younger periods of partial transgression. Said erosional planation, which is testified by the alluvial cover at the top of marine terrains, may have continued till the downslope continuity of the gently inclined terrace went broken by the 30 meters high fault scarp that bounds seawards the terrace itself. That tectonic disruption caused the entrenchement of the network draining the terrace top surface and the erosion of present valleys.

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