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MORPHOLOGICAL EVOLUTION OF THE NURIGHE CAVE (LOGUDORO, NORTHERN SARDINIA, ITALY) AND THE PRESENCE OF MAN: FIRST RESULTS

ABSTRACT: GINESU S., SIAS S. & CORDY J.M., *Morphological evolution of the Nurighe karst cave (Logudoro, northern Sardinia) and the presence of man: first results.* (IT ISSN 0391-9838, 2003).

From the course of studies in the Logudoro Mejlugu area, where the Nurighe karst system is located, it has been possible to obtain more accurate information on the geomorphologic evolution of this particular cave, and to analyse the samples of sediments from inside the cave. From an analysis of the sediment samples, it has been possible to identify certain evidence of the presence of hominization in remains of fauna, such as traces of mastication; further analysis of the samples revealed human bone remains confirming these early indications. Since the cave is the effect of an inversion of the entrance of the cavity, by locating the original one, which had been closed by lava flow; thanks to the absolute age of the lava flow, it was possible to date the presence of man to a period before 0.1 m.y.BP.

This confirms the hypothesis of the age of first colonisation in the cave, which is certainly referable to about 0.3 m.y.BP the time necessary for the deposit to fossilise and be displaced; moreover the richness in material and its particular recalcification conditions may allow a precise reading of the morphoclimatic phases that occurred in the entire region.

Indications of the presence of man in Sardinia date back to the Lower Paleolithic (Clactonian, as the Auct.) when traces of processing were found on flintstones in Anglona in northern Sardinia, which based on the processing found on the findings, were dated to 0.3-0.5 m.y.BP in the Lower Palaeolithic. The presence of man in the Nurighe cave confirms the discoveries in Anglona based on found items, and for the first time offers absolute dating as well as the possibility of finding abundant remains of the first colonisers of the island.

KEY WORDS: Karst, Paleoanthropology, Upper Pleistocene, Sardinia, Italy.

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RIASSUNTO: GINESU S., SIAS S. & CORDY J.M., *L'evoluzione morfologica della cavità carsica di Nurighe (Logudoro, Sardegna settentrionale) e la presenza dell'uomo: primi risultati.* (IT ISSN 0391-9838, 2003).

I recenti studi nell'area del Logudoro Mejlugu, dove è situato il sistema carsico di Nurighe, hanno permesso di ricostruire con precisione l'evoluzione geomorfologica di questa particolare grotta ed analizzare i campioni di sedimento provenienti dall'interno della stessa cavità. Le analisi hanno consentito di ottenere testimonianze certe della presenza di ominizzazione nei resti faunistici esaminati, quali tracce di masticazione; dalle più recenti analisi sono emersi resti ossei umani confermando queste prime indicazioni. L'evoluzione della grotta è stata determinata da una singolare situazione geomorfologica che ha determinato una inversione dell'ingresso del condotto carsico; l'individuazione di una colata lavica che ha occluso l'originario ingresso della grotta, ha permesso di ottenere una data assoluta che colloca la presenza dell'uomo nella grotta di Nurighe ad un'età anteriore ai 0.1 m.y.BP.

Il dato conferma l'ipotesi che la prima colonizzazione della grotta sia riferibile a circa 0.3 m.y.BP, tempo necessario al periodo di fossilizzazione ed al successivo rimaneggiamento del giacimento; inoltre, dallo studio della cavità emerge la ricchezza e le particolari situazioni di ricalcificazione del materiale con la possibilità di una lettura delle fasi morfoclimatiche riferibili all'intero Logudoro.

La presenza dell'uomo nell'isola era attribuita al Paleolitico Inferiore (Clactoniano, secondo gli Autori), in giacimenti dell'Anglona, ma la datazione era stata ricavata sulla base della cultura nei manufatti rinvenuti con età relative di 0.3-0.5 m.y.BP. La presenza dell'uomo all'interno della cavità di Nurighe conferma le scoperte avvenute nell'Anglona, ma offre, per la prima volta, una datazione radiometrica e la possibilità di ritrovare un importante sito di riferimento per l'evoluzione umana nell'isola.

TERMINI CHIAVE: Carsismo, Paleoantropologia, Pleistocene superiore, Sardegna, Italia.

INTRODUCTION

The Logudoro area is once more proposed as a privileged territory particularly significant in the study of the recent evolution of the landscape and associated fauna.

The area has been studied in other works by present authors (Ginesu 1991; Sias 1994, 1997, 2002; Melis & Sias 1996), that were aimed at interpreting the forms and surface deposits witnessing the complex change in drainage patterns and watershed limits during the entire Pleistocene starting from the upper Pliocene.

Also the Nurighe cave (fig. 1) was the subject of a previous work of intense collaboration with the local speleological group of the town of Thiesi, that pointed out the particular evolution of this cavity (Ginesu & *alii*, 1998). But the progress of the studies, prospection on the land, and the results of samplings and analyses have identified and pointed out for the first time on the island the presence of remains of hominids attributable to the lower Palaeolithic (Cordy & *alii*, 2001).

These results are repropounded as a confirmation of the first phases of human impact on the island identified in the sites of Anglona along the river Altana in the territory of Perfugas, where abundant remains of stone products attributed to lower Palaeolithic cultures have been found (Martini et Pitzalis, 1987-88). However, owing to its characteristics and morphogenesis, the conditions at the Nurighe deposit are very favourable to the preservation of numerous bone remains.



FIG. 1 - Localization of studied area.

FRAMING OF THE AREA

The study area is in southern Logudoro, in a territory particularly characterised by the presence of a volcanic landscape of recent age, which affected the geomorphological evolution of the entire Logudoro and Mejlogu. The studies carried out in this area (Ginesu 1991; Sias 1997) have pointed out the complex scheme of processes that interacted during the Pliocene and Pleistocene to create the landscape of the region, which is not particularly rich in karst morphology. In this context, the Nurighe cave is located in the calcareous outcrops of the municipal territory of Cheremule, a small village at the border between the two subregions of Logudoro and Mejlogu, in the centre-southern part of the province of Sassari, 35 km from the most important town of the northern island.

The entrance to the karst cavity is along an erosional scarp, a little cuesta, about 5 m high in the small valley of the Rio Nurighe. The scarp line of fluvial origin extends into the left slope in an east-west direction for about 500 m drawing a precise outline on the erosional surface of the Sas Animas plateau, where the Nuraghe di Roccamanna and the Funtana di S'Ainalzu are located (fig. 2). The entrance to the cave has been partly modified, as the source that emerges from the cavity is captured and diverted towards Mulino Sanna nearby, where its waters are used as a drinking water supply by the municipality. Access to the cave is easy and well-kept; the locality of Sas Animas is also easy to reach as it is a few km from the highway 131 «Carlo Felice», the main motorway of Sardinia, which links the island's main cities. The cavity is easily visible since as a result of the abundant water that flows out of the rock, it is covered with dense shrub vegetation practically all the year round.

The Sas Animas area is characterised by the presence of detrital calcareous sediments of the marine Miocene and cineritic tuffaceous deposits of the effusive calcalkaline cycle of the Oligo Miocene. The entire surface that makes up the Sas Animas plain is made up of an arenaceous calcareous facies of a thickness assessed at a few tens of metres, since terrains of clear volcanic origin outcrop in the underlying plain of rio Nurighe, which evolved on the tuffaceous arenaceous facies of the oligo miocenic cycle that outcrop extensively a little further westward along the western slopes of Planu Alto, Caput Abbas, and Planu Borgolo.

The contact between the two facies is often sharp and clearly visible. It is often made up of a continuous, slightly inclined horizon, as in the situation highlighted in the study area. In fact, the contact continues with a weak southward inclination, where the arenaceous limestones tend to thicken. As described in a previous work (Ginesu & *alii*, 1998), the direction of the Nurighe cave and its position confirm its lithological contact origin.

The northern part of the Sas Animas plain is made up of outcrops of basaltic rocks of the Pleistocene from the centre of emission of Monte Cuccuruddu, which is located at about 3 km from the area at an altitude of over 600 m on the eastern slope of the basaltic plateau of Nuraghe Coronedda.

FIG. 2 - Aerial view of the entrance of the cave and its surroundings.



The plateau of Nuraghe Coronedda is made up porphyritic trachybasalts generally holocrystalline attributed to an effusive episode of the end of the Pliocene (2.1/2.2 m.y.BP) (Beccaluva & *alii*, 1981).

The lava flow from Monte Cuccuruddu, a small mountain range on the western slope of the small plateau made up of the scoriae of the effusive centre, was attributed by the same authors to a volcanic activity of the same geotectonic characteristics effused 0.2 m.y.BP (Beccaluva & *alii*, 1981) by K/Ar dating, the new data from an Ar/Ar analysis gave two different data and have permitted to describe two lava flows in the same paleovalley from the same central vent. The first data is about 0.1 and confirm the first datation, the second give a data less than 0.1 and confirm the others results from paleontological and geomorphological observations (Sias & *alii*, 2002).

The shape and size of the flow suggest a clear pre-existing morphology characterised by incisions in the slope that became deeper and more deeply set under the existing *cuestas*, as described in previous studies (Sias, 1997), similarly to a few parallel incisions still active today. The lava flow levelled out this morphology filling the entire incision where it had flowed in its entire width and depth and expanding over the entire surface of the underlying morphological plain located at an altitude of about 420 metres; the activity of the renewed system of surface washing during this time caused a partial inversion of the mountain range along the northern contact of the lava flow, where colluvial deposits are present along the moderate incision of the rio that gave rise to the small asymmetrical valley of Su Tippiri, which is still narrow and steep today.

THE CAVE

As mentioned earlier, the Nurighe karst cavity develops along the contact between the Miocene calcareous arenaceous sediments widely spread over the entire territory, and the underlying lower Miocene levels represented by green-grey tuffaceous-cineritic deposits and continental marly conglomeratic levels. These outcrops are evidence of the early transgressive phases of the sea along the rift structure that crossed the island from north to south, from the Gulf of Asinara to the Gulf of Cagliari. In the area between the towns of Thiesi and Cheremule, these sediments make up a sub-horizontal surface, located at an altitude of 400-450 m, which corresponds to a few erosion surfaces in the territory referred to the middle Pleistocene. This dating is also confirmed by the presence of basalt flows attributed by K/Ar analysis to effusive episodes between 600 thousand and 400 thousand years before the present (Beccaluva & *alii*, 1981; Sias, 1997; Ginesu, 1991).

The entire cave develops with a prevalent north-south trend on the entire erosional surface, which is incised by the rio Nurighe to the south and by basalt flow from Monte Cuccuruddu. The total length of the explored cave is of about 700 metres, but at least another 50 m referring to the northern part of the cave, where the original entrance used to be, are still to be explored (Ginesu & *alii*, 1998). This part of the cave is blocked by a debris wall of very large blocks caused by the basalt flow entering in the initial part of the cave.

Exploration of the cave, which was very difficult, was made possible thanks to the effort of the speleological group of town of Thiesi. The cave itself is not very large,

though its horizontal development is quite extended, often becoming a narrow muddy passage (fig. 3). The karstification process shown by these types of rocks is modest but concordant with the general karst morphology of the Miocene of Sardinia and in its northern part in particular; in fact speleothem depositions and hypogean morphologies inside the cave are rare and with small thickness.

The surface of the plateau shows clear signs of epigeal karstification, but the process is limited by the composition of the rock rich in sand and clay, and forms of dissolution, highlighting the structural aspects of the Miocene formation, such as stratification joints and fracture directions are especially observed. Moreover, the particular rock structure favoured the development of a number of small quarries in historic times, while evidence of an archaeological value is also present. In fact the etymology of the place name for the area, Sas Animas, recalls an ancient frequentation of the place; this is confirmed by the *domus de janas*, particular funerary megalithic monuments excavated in the rock and referable to about 3800 years before Present; these remains are located along the scarp of the cuesta on the eastern boundary of the plateau.

Two points in particular could be proper swallow holes in direct connection with the Nurighe cavity; they are found near the country road leading to Mulino Sanna near the entrance to the cave. One of these is a few metres large and could correspond to the point where the exploration of the karst cavity showed presence of a possible collapse, marked on the map with the letter G (fig. 4) where the vault of the cave opens upwards.

The cavity of the Nurighe cave develops along the contact joint between the two formations and shows a weak southward inclination concordant with this passage (Ginesu & alii, 1998) without negative gradients inside the cave, but its depth from the surface is of a few metres. This can be deduced from the entrance to the cave and from the contact with the basalt flow that obstructed the old entrance. Moreover, the western cuesta of the plateau confirms the existence of a calcareous arenaceous level of the same thickness and dip.

The speleologists that explored the cavity also carried out a few elementary percussion tests between the cave and the surface to determine the distance; and the result was that the teams at the surface and those inside the cave could «communicate».

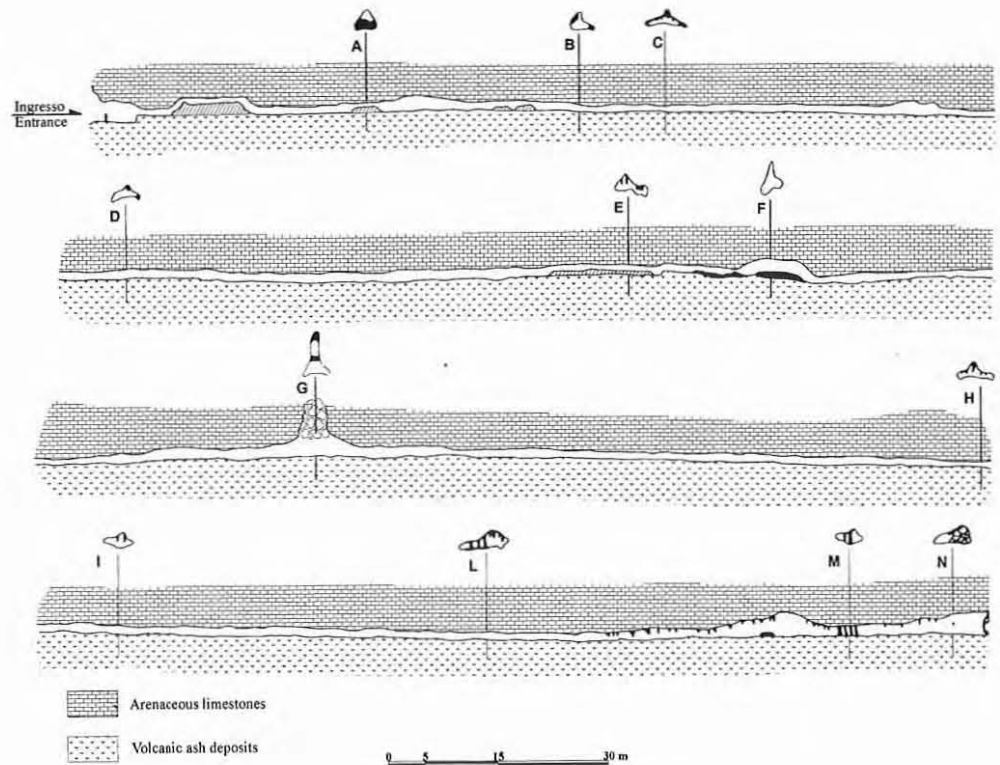
Based on previously processed data (Ginesu & alii, 1998) a simplified geomorphological sketch was elaborated (fig. 5), in which is evident that the terminal point of the cavity, marked with the letter N, «the collapse» (fig. 4), is near the contact with the basalt flow of Monte Cucuruddu.

In order to define the distance between the surface of the plateau and the karst cavity more precisely, a geophysical survey was carried out with the electric tomography method. Wenner's quadripolar device with a variable electrode opening for the study of progressively deeper portions was adopted as a measurement device. Nevertheless, it was not possible to extend the geoelectric study to the entire area but only to the terminal part, in an attempt to locate the point of the original entrance precisely.



FIG. 3 - The final part of the narrow conduit shows a very rich deposit of fossils; in the foreground, a complete skull of *Megaceros cazioti*.

FIG. 4 - The progressive sections of the Nurighe cave. The «N» point is near the contact with the basaltic lava flow.



The results of the geoelectric survey are still satisfactory and agree with the measurements and data obtained with the land survey. In fact, between december 1999 and january 2000, eight tomographic sections were laid orthogonal to the axis of the estimated trend of the cave and parallel to each other at a constant distance of 8 metres. Due to the irregular perimeter of the area and because access to the neighbouring areas is impossible, the length of the sections varied from a minimum of 22 metres to a maximum of 32 metres. Each section was subsequently identified with a letter of the alphabet starting from the southernmost, while electrode n. 1 was always to the east.

A remarkable change in resistivity was therefore pointed out with large increases in values that could be indicative of the presence of caves, and in a few cases, the decrease in resistivity could be attributed to the partial filling of some of them. On observing some of these sections (fig. 6), such as section C, we can particularly note the presence of «cavities» at a few metres below the surface and a sharp change in resistivity on passing over an underlying horizon, which is certainly due to the impervious tertiary substrate underlying the Nurighe karst cavity.

The hypogean morphology of the cave shows a few modest signs of the karst process that affected it for about 400 thousand years. The main cause of this modest activity is related to the lithotype supporting the cave, that is arenaceous marly sediments of Miocene, which, even in places where they are more carbonaceous, offer modest

hypogean scenarios often characterised by a large quantity of clayey sandy deposits, a clear sign of the high residue content of these rocks.

Nevertheless, towards the terminal part of the cavity, where the cave becomes larger, even the frequency of deposits and speleothems is richer. Here, the stalactite and subordinately, stalagmite deposits are more frequent and also include material from the bottom of the cave, including fossil remains that were transported a few hundred metres towards the new entrance from the deposit *in situ*. In fact the fossiliferous deposit is along a tract of the cave confined to the terminal part, which the speleologists themselves named «the ossuary». The fossils on the bottom of the cave were investigated in a previous work (Ginesu & *alii*, 1998), in which it was possible to identify a terminal biozone not limited only to the Upper Pleistocene.

The considered fossil remains come from a sampling made during an exploring survey to analyze the cave mud deposit. Nevertheless, a sample of clayey material from this area was neglected for some time and only later studied more carefully in order to look for some further traces of anthropization observed in the bone remains.

The analysis of the speleothem incorporating the fossil remains could provide useful dating elements to identify more recent concretion episodes probably attributable to the passage between the Upper Pleistocene and the Holocene, a poorly known period in the geological literature on Sardinia.

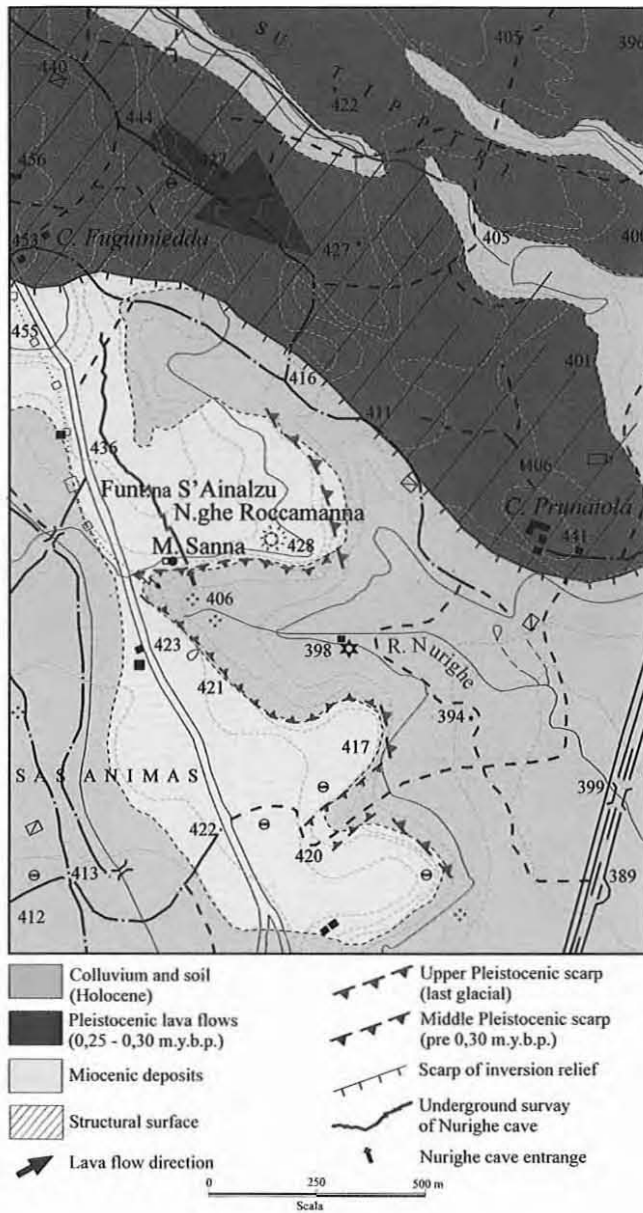


FIG. 5 - The geomorphological sketch of the Nurighe-Sas Animas region.

THE DEPOSIT AND THE HUMAN PRESENCE

This preliminary study on the fauna is based on the finding of bones collected by speleologists from a deposit of filling sediments inside the cave and from two small samples of material collected in superficial strata. These two samples were washed, screened, and separated carefully in order to collect micromammals. Moreover besides pleistocenic fauna, the sediment also contains remains of bivalves and echinoderms from the dissolution of the miocenic limestones.

From a taxonomical point of view, it should be pointed out that the bones are well preserved though a little decal-

cified, and do not show signs of significant fluvial erosion. Moreover they are blackened at the surface by a layer of manganese salts.

Among the large mammals, fragments of a cervid of the size of a present fallow deer, referable to the insular species *Megaloceros cazioti* have been recognised, of which a tibia and a few horn fragments indicating a medium sized animal are well preserved.

Next to this cervid are two bones (and a coxal bone) testifying the presence of the insular canid, *Cynotherium sardus*.

Among the microfauna, a large number of *Prolagus sardus* bones and teeth were found, and among the rodents, remains of *Tirrenicola benseli* and *Rbagamys orthodon* with a prevalence of the former. The teeth size clearly indicates that they are evolved forms of two insular lines.

Besides fauna and mammals, remains of birds and a Batricide, both of which undetermined, were also found. Undoubtedly this fauna belongs to the terminal biozone of the paleontological history of Sardinia (*Megaloceros cazioti*, *Tirrenicola benseli*, and *Rbagamys orthodon* biozone). As a recall this biozone probably started in the middle-recent Pleistocene and ended with the transition between the Pleistocene and the Holocene.

Dating of the obstruction of the cave by a basalt flow (2 samples, 57.3 ± 33.2 and 55.5 ± 23.9 thousand years ago by Ag/Ag dating method in 2001; Sias & alii, 2002) is concordant and confirms the idea of a long terminal biozone that is not only limited to the Upper Pleistocene.

Jointed with this middle-recent pleistocenic fauna, a human remain was unconsciously taken in the sample of the cave sediment and was found during the sorting of the same sample. It's the first phalanx of the finger 1 (thumb?) of an adult (fig. 7).

This important discovery confirms definitively the hypothesis of a very ancient settlement of Sardinia by prehistoric man as advanced from the discovery of the arcaic allure industry in the Anglona region (Martini & Pitzalis, 87-88), a place not far from Nurighe (30 kms). In this way, it's reconsidered the classical theory about the late colonization of the mediterranean islands at the end of Mesolithic as a result of the navigation development.

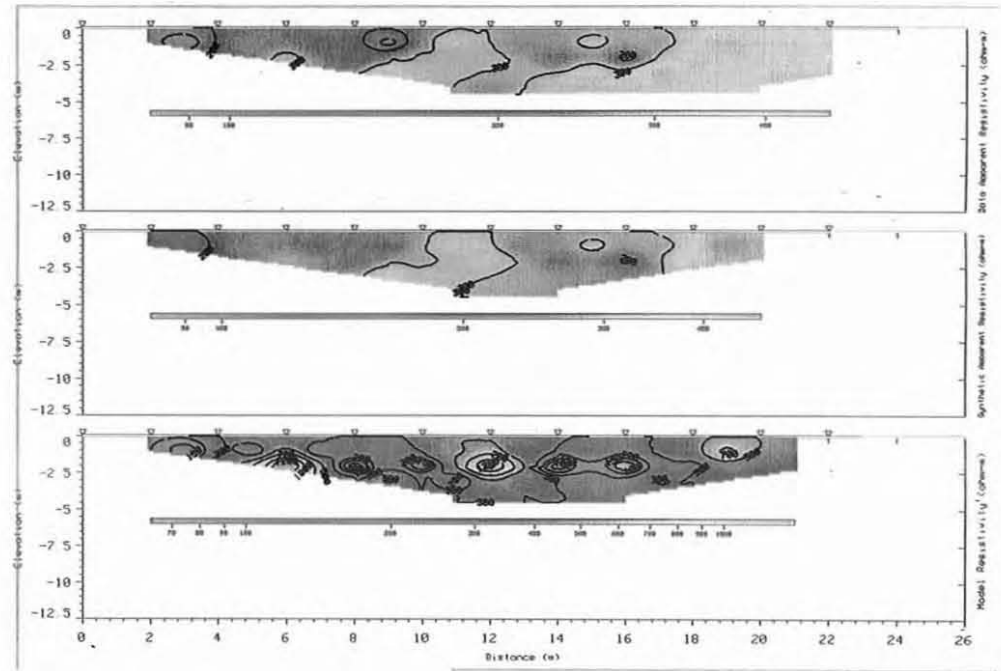
Although a phalanx is not enough to establish a specific determination, for comparison with human evolution in the continental Europe we can concretely consider that the Nurighe fossil correspond to an evolved *Homo erectus* at the change to the individualization of an arcaic *Homo sapiens*.

The presence of *Homo* in Sardinia before 0.1 m.y.BP is another evidence of the important role that the island had in the human diffusion between Africa and Europe (Tobias, 2001).

CONCLUSION

This work accompanies a communication by the same authors containing prevalent paleontological references in the conviction of having to supply the circumstances that

FIG. 6 - The geoelectric data show the presence of the cave near the surface. Section C (a above, b middle, c low).



led to the finding of remains attributable to the «homo» species for the first time in Sardinia. Besides the significance of the paleontological discovery itself, the Nurighe cave, with its particular evolution and morpho-evolutionary dynamics characterising this area and the entire Logudoro, offers an excellent opportunity to date events that involved the entire territory of the northern Sardinia.

The deposit containing hominids confirms the existence of an entrance in the opposite side compared to the present entrance, thus defining a geomorphological inversion in the evolution of the cave; the blockage of the old entrance by the Cuccuruddu basalt flow favoured the flow of the waters

of the old paleostream inside the cave thus stressing the progressive lowering of the cave towards south.

Drainage of the waters from the exterior is still supplied by a contact layer between the basalt flow and the pre-existing palaeomorphology, a part of these waters is channelled along the cave crossing it lengthwise and emerging at the mouth of the present entrance where it is now used for drinking by the population of the near village of Cheremule. This flow caused the fossiliferous material to be washed away, and also allowed continuous transport of the material from the north to the south, distributing it over about 150 metres inside the karst cavity starting



FIG. 7 - The human falanx of the finger I.

from the end part. It follows from this that the primary deposit, which is probably still under the material that caused the «collapse» closing the original entrance, had been partially eroded and remobilised inside the cavity before the final collapse of the entrance due to volcanic activity. These fossils may be attributable to the same presence of the homo that used the inner part of the original entrance of the cave like a litter for remnants of food. In a place in the cave is possible to see a deer skull (*Megaceros cazioti*) still in primary position.

This would confirm that the deposit in situ was old enough to have been displaced by the dynamic conditions of the original cave; it is presumable therefore that, also from a geomorphological point of view, the primary deposit may be about 100 thousand years older than the basalt flow.

The recent process of karstification (Holocenic) in the cave is modest and limited to continuous washing away of altered material and to residual clays produced; the speleothems, which also incorporated fossiliferous material, is attributable to the Riss-Wurm passage, when conditions of karstification resumed definitely. However, future samplings of these materials will provide a precise dating of this event.

Thanks to recent effusive activity, which favoured the reconstruction of the morphologies and of the sequence of morphogenetic processes of the whole centre-northern sector, it is possible to formulate a precise reconstruction of the palaeoenvironment and of the morphological situation that favoured the first human colonizations of the island not too far removed from acquired knowledge. In fact, in the morphology that existed before the basalt flow, the ancient small valley of Sas Animas presented a slope rich in ravines, rocky shelters, and small cavities along the front of the cuesta that is buried under lava today. This morphological condition is still present along the cuesta scarps of the whole Logudoro and Mejlugu, which could be explored in search for other possible signs of human presence following the cuestas referable to the middle Pleistocene.

Thanks to the morphogenetic reconstruction of the area of Sas Animas-Nurighe, it has been possible to attribute a precise age to the small valley of the present rio Nurighe where the entrance to the cave is located. In fact, this valley was formed after the effusion of the Cuccuruddu basalt and only after a period of evolution of the cave itself, which «re-emerged» only after the formation of the pla-

teau of Sas Animas as a result of the fast renewal of erosive activity.

Undoubtedly this period can be identified in the last climatic passage of the Würm, which caused a faster erosion accentuated by the imposing marine regression, which multiplied the energy of the mountain range in the inner territory where the watershed limit between the rio Mannu of Porto Torres and the rio Coghinas rivers that pass near the studied site.

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