THE CENTRAL AND SOUTHERN APENNINE (ITALY) DURING OIS 3 AND 2 : THE COLONISATION OF A CHANGING ENVIRONMENT

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INTRODUCTION

Mountain environments are made by a number of ecosystems, some of which are very sensitive to climatic change and may be close to survival limit. With a vertical thermal gradient of 0.6 C° per 100 meters, for instance, a 1C° fall in temperature causes a 170m drop of the tree limit, which will leave vast areas deforested. Soils will soon start to be eroded, and rocks to be disgregated by gelifraction. Once the vegetation and soil cover are lost, plant do not easily recolonise karsified expanses, and short-lived mild oscillations hardly have any effect in such environments. Therefore, a limited climatic change may have dramatic effects, which are registered both in the geological and in the archaeological record.

Our study area is the Central and Southern Apennine, which is the backbone of the Italian peninsula, with elevations up to 2912m (Fig. 1). Vertical gradients are often steep, and different ecosystems may occur on the same slope. Several basins of tectonic origin open in the Central Apennine. The major one is the Fucino basin (latitude 42° N), which lies at an elevation of c. 700m, while the surrounding mountains rise above 2000m asl. During historic times, it was filled by a widely fluctuating lake, extending over some 150 Km^2, which was eventually drained after land reclamation in the Nineteenth Century. Minor and often short-lived lakes also existed at higher elevation (GIRAUDI and FREZZOTTI 1997).

During the LGM, the mean temperature fell by 7°C to 8°C, and on some mountains the equilibrium line altitude (ELA) of the glaciers was between 1900m and 1500m asl. Accordingly, the tree limit dropped by 1200 -1350m, in good accordance with the finding by Jaurand (1994) that the upper limit of the forest was at 700m asl. The areas above 1000m asl, which were close to glaciers, experienced a marked reduction of biological activity and of ecological diversity.

Water availability, too, varied greatly during glacial oscillations. Wherever, as in most of the Central and Southern Apennine, carbonatic rocks are the rule, part of the precipitation ends up in the karstic system. During arid phases, water was scarcely available to plants and animals on the higher slopes, but was found at lower elevations where the springs fed by karstic circulation are located.

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Our study area, however, differs from other mountain ranges because of the widespread deposition of tephra layers, which had originated in volcanic areas of central and southern Italy. During mild oscillations, non-calcareous light soils developed on tephra deposits, which are quite different from soils on carbonatic rocks or on carbonatic slope deposits. This affected plant recolonisation, as many species are sensitive not just to climate, but also to the chemical and physical properties of soils. Tephra layers, furthermore, are good chronological markers as, on a geological scale, they are "instant" events. If properly dated and identified by distinctive chemical components, they allow fine-grained correlation over short as well as long distances.

Starting in the Fifties, archaeological investigation focused on the Fucino basin, where several cave sites have been excavated (RADMILLI 1981). While early research did not always follow modern scientific standards, more caves are currently under excavation, and open-air sites are investigated as well in areas surrounding the basin and at elevations above 1300m (BEVILACQUA 1994; LUBELL *et al.*, in press; MUSSI *et al.*, in press).

CHRONOLOGY AND GENERAL ASSUMPTIONS

Our chronological scale is based on radiometric dates, on archaeological data and on correlation based on the deposition of the following tephra :

- the Neapolitan Yellow Tuff , which originated in the Phlegrean Fields (Campania) and is widely distributed in southern Italy. In central Italy, it has been identified by Frezzotti and Narcisi (1996), and by Sevink and Paris (1989), as well as in cores of the Tyrrhenian and Adriatic Sea, by Paterne *et al.* (1986; 1988). It is currently dated to approximately 12,300 ± 300 bp (ALESSIO *et al.* 1973);

- the Biancavilla-Montalto tephra, which was produced by an eruption of Mount Etna (Sicily). In central Italy, it has been identified by Narcisi (1993) and by Calanchi *et al.* (1996), and in cores of the Tyrrhenian and Adriatic Sea by Paterne *et al.* (1986; 1988). It is dated to 14,170 ± 260 bp (DE RITA *et al.* 1991; KIEFFER 1989);

- the Cerchio tephra, of yet undetermined origin, identified in central Italy by Giraudi (1995; 1997). It slightly earlier than 19,100 ± 650 bp;

- the Campanian ignimbrite, which originated in the Phlegrean Fields (Campania) and is the earliest tephra that we have taken into account. It is assumed that it corresponds to one or more tephra layers in the cores of the Tyrrhenian and Adriatic Sea studied by Paterne *et al.* (1986; 1988), which are dated between 38,000 and 33,000 bp. Because of the broad chronological range, this tephra is not a chronological marker in itself. However, it is quite important because it was the parent-material on which soils developed, that are dated to slightly more than 30,000 bp.

The reconstruction of climatic change is based on the following assumptions :

- glacier and permafrost development is indicative of a major drop in temperature;

- fluvioglacial deposits are related both to glacial advance and to glacial retreat, while alluvial fan deposits are related to a reduced plant cover, as well as to morphological instability, during cold and/or dry periods. During glacial phases - as the temperature is low and plant cover scarcely develops – both fluvioglacial and alluvial deposition occur. This is exemplified in our scheme (Fig. 2) by C14 dates which are virtually the same for soils buried under fluvioglacial deposits (19,480±290 bp – CHIARINI *et al.* 1997), and for alluvial deposits (19,470 ± 395 bp – MICHETTi *et al.* , 1997);

- changes in lake levels reflect alternating positive and negative hydrological balances, and accordingly changes in humidity;

- aeolian sedimentation, when non originated by volcanic eruptions, is mostly related to dry phases and/or to a scarce vegetation cover;

- stratified slope deposits are indicative of a lack of plant cover, and of active gelifraction as well;

- solifluction is usually related to a cold and wet climate;

- soil development implies stable and moist conditions, as an extensive plant cover is requested to slow down the erosion which typically affects mountain environments;

- speleothemes form during wet, or mild and wet climatic phases, as they originate from water which is enriched in CO_2 by circulation in well-developed soils. We restricted our observations to caves in which discontinuous speleotheme formation occurred, in order to identify the climatic phases which specifically allowed them to deposit;

- the changing ratio of oxygen isotopes in marine cores reflects changes in temperature.

CLIMATIC CHANGE AND HUMAN ACTIVITY

The overall scheme of climatic change and of human colonisation of the study area during OIS 3 and 2 is reasonably complete (Fig. 2), even if less detailed information is available for the period prior to c. 30,000 bp.

- 44,000 - 40,000 bp : the level of lake Fucino is rising. It is well documented that, over the last 30,000 years, and including historic times, this invariably happened during glacial advances (GIRAUDI 1998). Therefore, we assume that glaciers were also expanding during this early high lake level. We hypothetically correlate with this cool and wet phase the outwash deposits described by Frezzotti and Giraudi (1992), which are not much earlier than the Campanian ignimbrite.

- 40,000 - 32,000 bp : the Campanian ignimbrite is deposited, and deep soils develop on it (FREZZOTTI and GIRAUDI 1992; FREZZOTTI and NARCISI 1996). The lack or very limited evidence of slope deposition points to morphological stability. Speleothemes, studied in caves of Monte Pollino (Calabria), form during the first part of this period, but not later than 37,500 ± 1500 bp. The latter evidence suggests an early phase during which the climate was wetter and/or warmer. Several warm periods are documented in cores of the Tyrrhenian Sea (PATERNE *et al.*, 1986; 1988). Further evidence of a rather mild and wet climate is found in the palynological record, as phases of forest expansion occur before 32,000 bp, both in the Fucino basin and at Canolo Nuovo (945m asl) in the Southern Apennine (FOLLIERI *et al.*, 1986; GRÜGER 1977; SCHNEIDER 1985). In the Central Apennine, north of the Fucino basin, a limited number of undiagnostic lithic implements from Valle Majelama, at c.800m asl, give evidence of human presence prior to the phase of soil formation (FREZZOTTI and GIRAUDI 1992); a few more, possibly including Aurignacian tools, were also discovered near Rieti, at 1000m asl, in a deposit loosely dated between 20 ka and <30 ka. (LORENZONI *et al.*, 1992). Further south, in the area of the Altopiano delle Cinque Miglia, yet undated Aurignacian open-air sites are located between 1300 and 1600m asl (Mussi current research).

- 32,000 - 29,000 bp : a transitional phase of limited morphological instability is suggested. While in some areas soils are still developing, elsewhere they are being buried by slope and aeolian deposits. At least one warm peak is documented during this period by the isotopic record of the Tyrrhenian Sea (PATERNE *et al.*, 1986; 1988).

- 29,000 - 27,000 bp : slope and aeolian deposition are widespread (FREZZOTTI and GIRAUDI 1990a; FREZZOTI and GIRAUDI 1990b), suggesting morphological instability. The Fucino lake is low (GIRAUDI 1998), and we assume that the climate is not just dry, but rather cool as well.

- 27.000 - 25.000 bp : a wetter climate develops. Slope and alluvial fan deposits, and aeolian deposits as well, are scarce or totally lacking, while speleothemes and soils are being formed.

- 25,000 - 21,000 bp : glaciers advance again, but soils evolve or continue to exist in some upland areas. Lake levels are high, rock glaciers develop, and there is some evidence of permafrost (GIRAUDI 1995; GIRAUDI and FREZZOTTI 1997; GIRAUDI 1998). Accordingly, this period must have been both very cold, and wet. The ELA of glaciers is located between 1900 and 1500m asl, which suggests mean annual temperatures 7.3 to 8.3°C lower than today. Several cold peaks are documented in the cores of the Tyrrhenian Sea (PATERNE *et al.* 1986; 1988). We assume that this is the Last Glacial Maximum.

- 21,000 - 17,500 bp : glacial retreat is under way and lake levels are dropping. Slope and aeolian deposits, however, are ubiquitous, while the ELA of glaciers is still rather low and rock glaciers continue to exist. The climate must have been still very cold, and dry as well. At the end of this period, on the Gran Sasso mountain, the ELA of glaciers is at c. 1950m asl, and mean annual temperatures 5.7-6.7°C lower than today are inferred. The isotopic record of the Tyrrhenian Sea includes an extremely cold peak just during the final phase of this period.

- 17,500 - slightly less than 16,000 bp : soils develop, while glaciers quickly retreat, as it can be seen from extensive outwash deposits. Lake Fucino is low (GIRAUDI 1995; GIRAUDI and FREZZOTTI 1997; GIRAUDI 1998), and mean annual temperatures are assumed to be higher. There is positive evidence of humans settling into Riparo Maurizio and Grotta Tronci, two caves of the Fucino basin (RADMILLI 1981). A substantial amount of equid bones (both *Equus caballus* and *E. hydruntinus*) was found in the archaeological deposit. Assumedly, most of the basin had turned into a grazing flatland because of the reduced lake size.

- 16,000 – 13,000 bp : glaciers are advancing again, aeolian and slope deposition occurs, lake levels are rising (GIRAUDI 1995; GIRAUDI and FREZZOTTI 1997; GIRAUDI 1998). The climate must be at first cold and wet, and later cold and dry. At the beginning of this period, the glaciers ELA is at 2150m asl, and the mean annual temperature, accordingly, is 6°C lower than the present one. The isotopic ratios in the Thyrrenian Sea cores include moderately cold peaks.

- 13,000-11,000 bp : glaciers are retreating again, soils are being formed, lake Fucino is low, aeolian and slope deposits are scarce (GIRAUDI 1995; GIRAUDI and FREZZOTTI 1997; GIRAUDI 1998). We suggest a period of morphological stability and of higher temperatures. A warm peak can be seen in the isotopic record of the Thyrrenian Sea (PATERNE *et al.* 1986; 1988). Quite clearly, this is the lateglacial interstadial (Bölling- Alleröd). A steppe-like vegetation cover with *Artemisia* develops at c.1000m asl in the Southern Apennine (Canolo Nuovo), and as high as 1400m asl in the Central Apennine (Aremogna plateau) (FREZZOTTI and GIRAUDI 1990a; FREZZOTTI and GIRAUDI 1990b; GRÜGER 1977; SCHNEIDER 1985). In the Fucino basin, Riparo di Venere, Grotta di Ortucchio, Grotta La Punta, and possibly Gr. Maritza, all give evidence of intermittent human settlement.

- 11,000-10,500 bp : there is evidence of a short-lived glacial advance, of aeolian sedimentation, of marked lowering of lake levels – some of them actually disappear – , of stratified slope deposits, of a new generation of rock glaciers (DRAMIS and KOTARBA 1994; FREZZOTTI and GIRAUDI 1989; GIRAUDI 1996; GIRAUDI and FREZZOTTI 1995). Accordingly, the climate is dry and very cold. The ELA is at 2300m asl, and the mean annual temperature must have been 5.6-6.6°C below the present one. The isotopic ratio of the Thyrrenian Sea drillings includes a cold peak (PATERNE *et al.* 1986; 1988). We correlate this phase with the Younger Dryas.

- 10,500 bp and later : soils start again to develop, glaciers disappear, aeolian deposition comes to an end, the climate is more and more wet, as it can be expected under typical Holocene conditions (GIRAUDI 1995; GIRAUDI and FREZZOTTI 1997; GIRAUDI 1998). Around 10,500, there is a number of well-dated archaeological layers in the Fucino basin at Grotta Maritza, Grotta La Punta and Grotta Continenza. Fish remains (trout) are extremely abundant at the first site, and must be related to a rising lake level.

CONCLUSIONS

In the study areas, geomorphological features and other indicators suggest a series of climatic fluctuations which encompass OIS 3 and 2. At cave sites of the Fucino basin, deposits started to accumulate after the LGM, and Epigravettian industries are the rule. Epigravettian, as well as Aurignacian open-air sites are also known. They were discovered at higher elevation and above 1300m asl, close to flint outcrops which provided the raw material used in the Fucino caves (LUBELL *et al.*, in press; MUSSI *et al.*, in press).There is no evidence so far of any Gravettian industry.

The archaeological record points to a strong correlation between mild oscillations and human presence at cave sites, at which radiocarbon and other dates are available. In the open, lithic typology and technology, as well as altitude, also suggest a similar chronology and a link with warmer episodes.

After our reconstruction of cold phases with low ELA, rock glacier formation and permafrost development, depopulation of mountain areas would have been the outcome of a general biological crisis and of an impoverished environment. The pattern of cyclic colonisation and abandonment is both earlier and more complex than what has been hypothesised for northern Europe by Housley *et al.* (1997), and for north-eastern Italy by Broglio (1994; 1995). However, as our record is still incomplete and possibly biased, including early excavations with poor chronological resolution, we believe that more research is needed to assess if, in the Apennine of central Italy, during Younger Dryas and earlier cold oscillations, human groups really abandoned the basins at low elevation as well as the mountains.

ACKNOWLEDGEMENTS

The study of the archaeological evidence by M. Mussi was funded by a grant of MURST (Ricerca scientifica 60%), awarded by the Università di Roma "La Sapienza" (Progetto di Ateneo).

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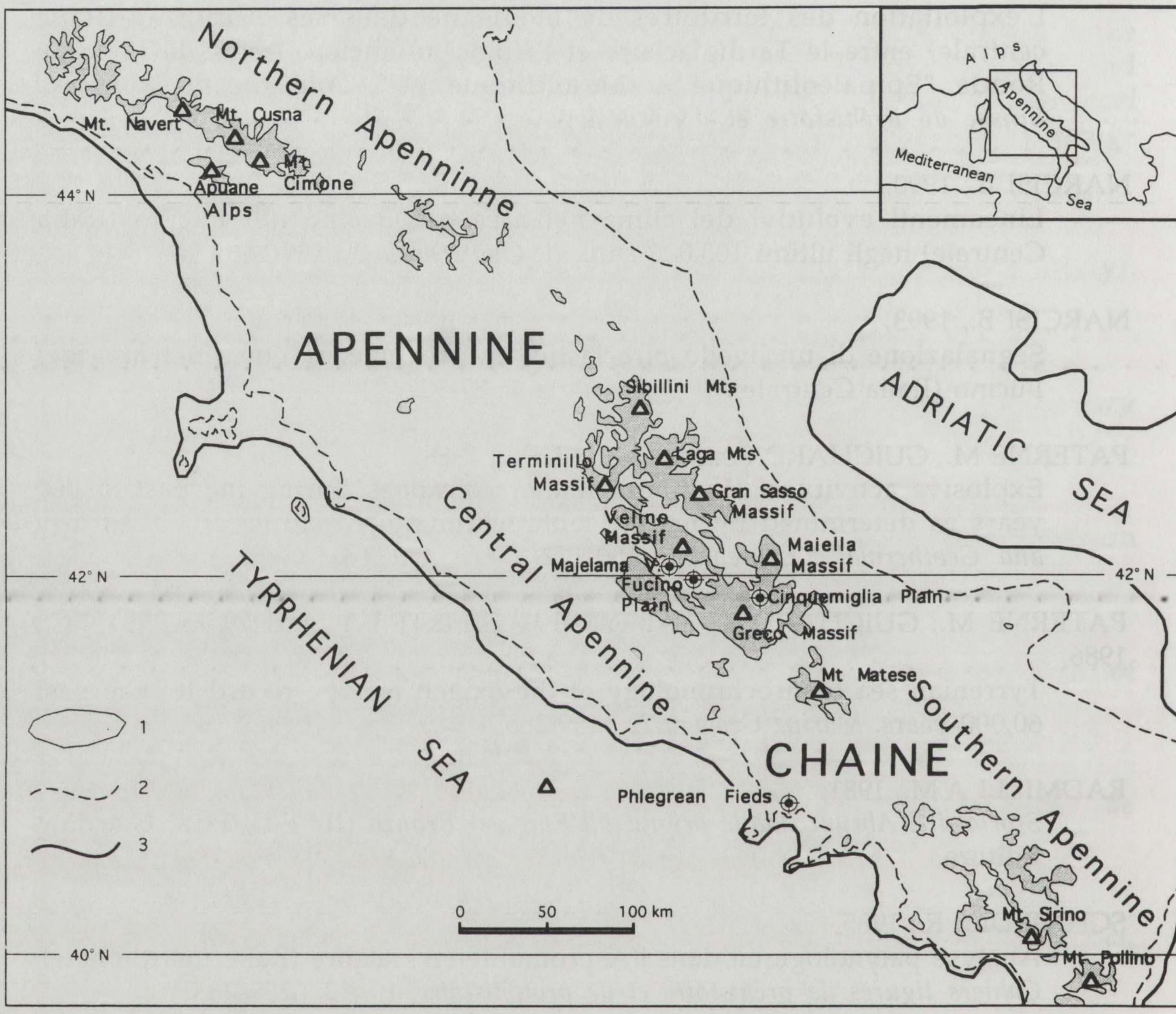

Fig. 1.- La Laouza (Sanilhac, Sagriès, Gard) : analyse pollinique (J. Renault-Miskovsky, 1981).

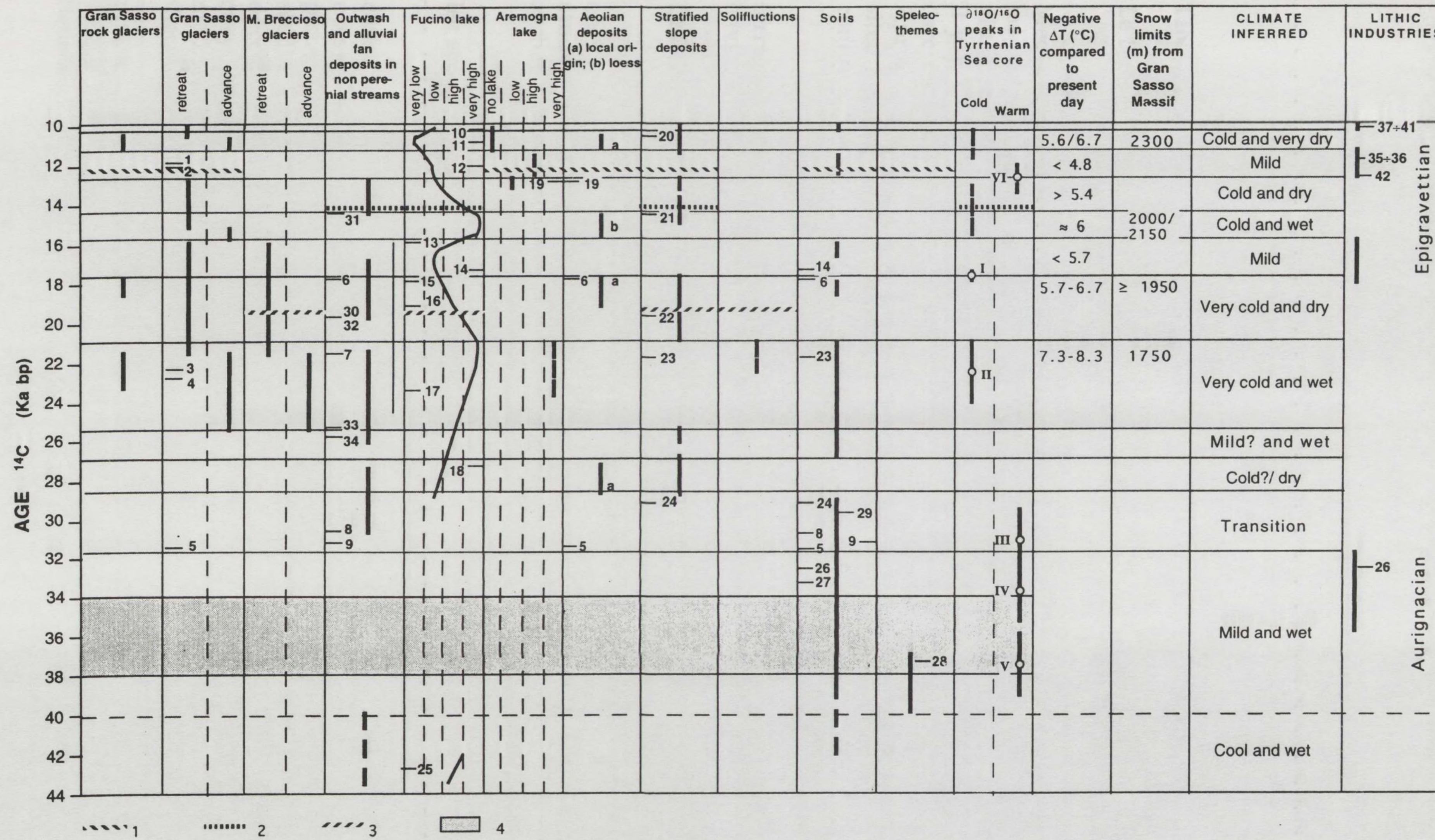

Fig. 2.- L'Esquicho-Grapaou (Saint-Anastasie, Gard) : analyse pollinique (S. Farbos, 1984).