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LATE GLACIAL AND HOLOCENE BIOCLIMATIC RECONSTRUCTION IN SOUTHERN ITALY: THE TRIFOGLIETTI LAKE

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Abstract – The pollen record from Trifoglietti lake (Calabria region) provides new information about the paleoenvironmental and palaeoclimatic changes occurred during the LateGlacial and Holocene period. The LateGlacial part of the record, for which only preliminary data is available, is a new and original sequence from southern Italy. The Holocene sequence, with 11 AMS radiocarbon dates shows a stable *Fagus* forest for the entire period. Apart from sporadic pastoralism activities and the selective exploitation of *Abies*, only a weak human impact is recognized in the pollen records. Lake level oscillations have been reconstructed and annual precipitations quantified using the Modern Analogue Technique. The reconstruction was effectuated both at millennial and centennial scale: the first shows an increasing of moisture from 11000 to 9400 cal BP and a maximum of humidity from 9400 to 6200 cal BP. Moreover, several climatic oscillations punctuated the Holocene and therefore superimposed the millennial trend.

Keywords: Pollen record, Holocene vegetation, LateGlacial vegetation, lake level, climatic reconstruction

Introduction

The orbitally induced climate change from the last Glacial to the present interglacial (Holocene) are expressed by vegetation changes: since the Late Glacial period or during the early Holocene steppe or tundra steppe were replaced, according to altitude and latitude, by forest successions. The steppe vegetation typical of the last glacial was substituted by forest environment during the Holocene. In comparison with these strong changes, the present interglacial (the Holocene)appears as a stable climate period, even if punctuated by numerous cold events such as Preboreal oscillations (Björck et al., 1997, 2001; Fleitmann et al., 2007; Yu et al., 2010), 8.2 kyr event (Wiersma & Jongma, 2010) and the Neoglacial climate cooling at 6000-5000 cal BP (Magny et al., 2006; Miller et al., 2010). The Mediterranean region has been affected by the human impact at least since the Neolithic (Guilaine, 2003; Mercuri & Sadori, 2013). Howeverin palaeoenvironmental records it is sometimes difficult to distinguish between the climatic and anthropogenic forcing factors (de Beaulieu et al., 2005; Roberts et al., 2011). Palynological study of the Trifoglietti site, located in southern Apennines, is therefore expected to give evidence of vegetation dynamics in a place close to

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glacial refugia, as well as of the possible influences of Holocene climate changes and the Neolithic human expansion on vegetation. Furthermore, it may provide additional data for a better understanding of regional climate variability and possible contrasting changes in seasonality between central and southern Italy (Magny et al., 2011a). Murgia et al. (1984) had already studied Lago Trifoglietti publishing a poor, undated pollen diagram. We carried out new investigations for: i) establishing a new Late Glacial and Holocene vegetation record in an intermediate location between central Italy and Sicily and ii) reconstructing possible palaeohydrological and climatic variations reflected by changes in vegetation.

Materials and Methods

Lago Trifoglietti (39°33'N, 16°01'E; 1048 m a.s.l.) is located in Calabria, in the Catena Costiera Mountains (Fig. 1) and it is included in a protected area by Natura 2000. The present vegetation around the lake is dominated by woods of *Fagus sylvatica* with sparse trees of *Pinus nigra* subsp. *laricio*. Scrub vegetation with *Erica arborea*, *Cistus salvifolius*, *Helichrysum italicum*, *Sarothamnus scoparius* and *Alnus cordata* trees, develops where *Fagus* forest is open. The lake vegetation comprises of a mosaic of different plant communities: the open surface at the center of the lake is discontinuously colonized by communities of *Potamogeton natans*.Most of the lake surface is occupied by *Carex paniculata*. In shallow areas *Carex paniculata* develops with *Osmunda regalis*, *Angelica sylvestris* and *Carex pendula*. The

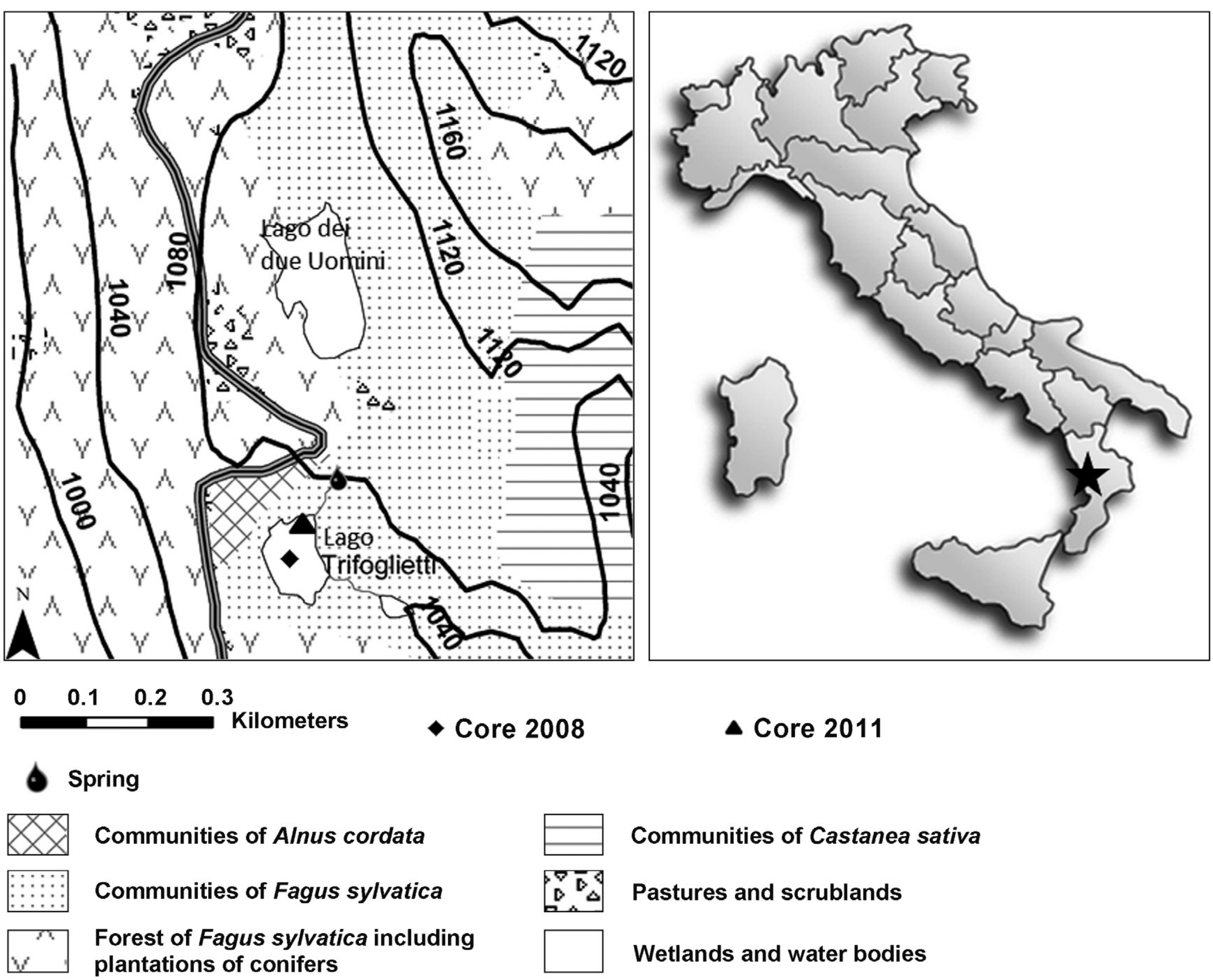

Figure 1. Actual vegetation map, coring sites.

littoral mires are invaded by *Rubus hirtus* and *R. ulmifolius*. For its geographical position, the climate of Trifoglietti area is influenced by warm and humid air masses coming from the Tyrrhenian sea. The annual rainfall can reach 1800 mm/y, the mean annual temperature is 15°, with 24° for August and 7.5° for January.

Two drilling campaigns have been effectuated (2008 and 2011) and the sediments of two cores reaching respectively a depth of 850 cm and of 1595 cm have been the subject of several analyses:the study of the cores includes radiocarbon dating, pollen, tephra, lithological, and magnetic susceptibility analysesas well as the application of the Modern Analogue Technique method to palaeoclimatic reconstruction. More detailed information on location, climate, phytogeography, and treatments can be found in Joannin et al. (2012).

At least 300 terrestrial pollen grains were counted, excluding dominant terrestrial taxa, water and wetland plants, and pteridophytes spores as well. Percentages were calculated based on the total pollen sum excluding aquatic plants, spores, and *Osmunda*. The pollen diagrams were drawn using TILIA 1.12 programme (Grimm, 2004). Local pollen assemblage zones (LPAZ) were defined according to CONISS function of the TILIA 1.12.

Result

Pollen diagrams obtained from the two cores are presented in Figures 2 and 3.The new Late Glacial record of Lago Trifoglietti (Fig. 2) has been divided in 7 zones by CONISS zonation, whereas the Holocene sequence (Joannin et al., 2012) (Fig. 3) has been divided in13zones by CONISS zonation.

The two pollen diagrams probably partially overlap (zone LPAZ4 with T2) and provide the vegetation history of the region of Lago di Trifoglietti since the Late Glacial.

LPAZ1 (<14700 cal BP) –this zone is characterized by high percentages of Poaceae (40%) with AP (arboreal pollen)at 10%. The site was probably above the timberline LPAZ2 (14700-12400 cal PB) – the pollen of deciduous *Quercus* (20%) and *Abies* (10%) increases whereas NAP (non arboreal pollen) decrease. The site was probably at the edge of the timberline.

LPAZ3 (12400- 11400 cal BP) –a rise of *Artemisia* and *Juniperus*, and a decrease of *Abies* characterize this zone.

T1 (<11400 cal BP) – characterized by *Fagus*, *Quercus robur* tp. and NAP. The pollen data indicate that the site was probably above the timberline during this period surrounded

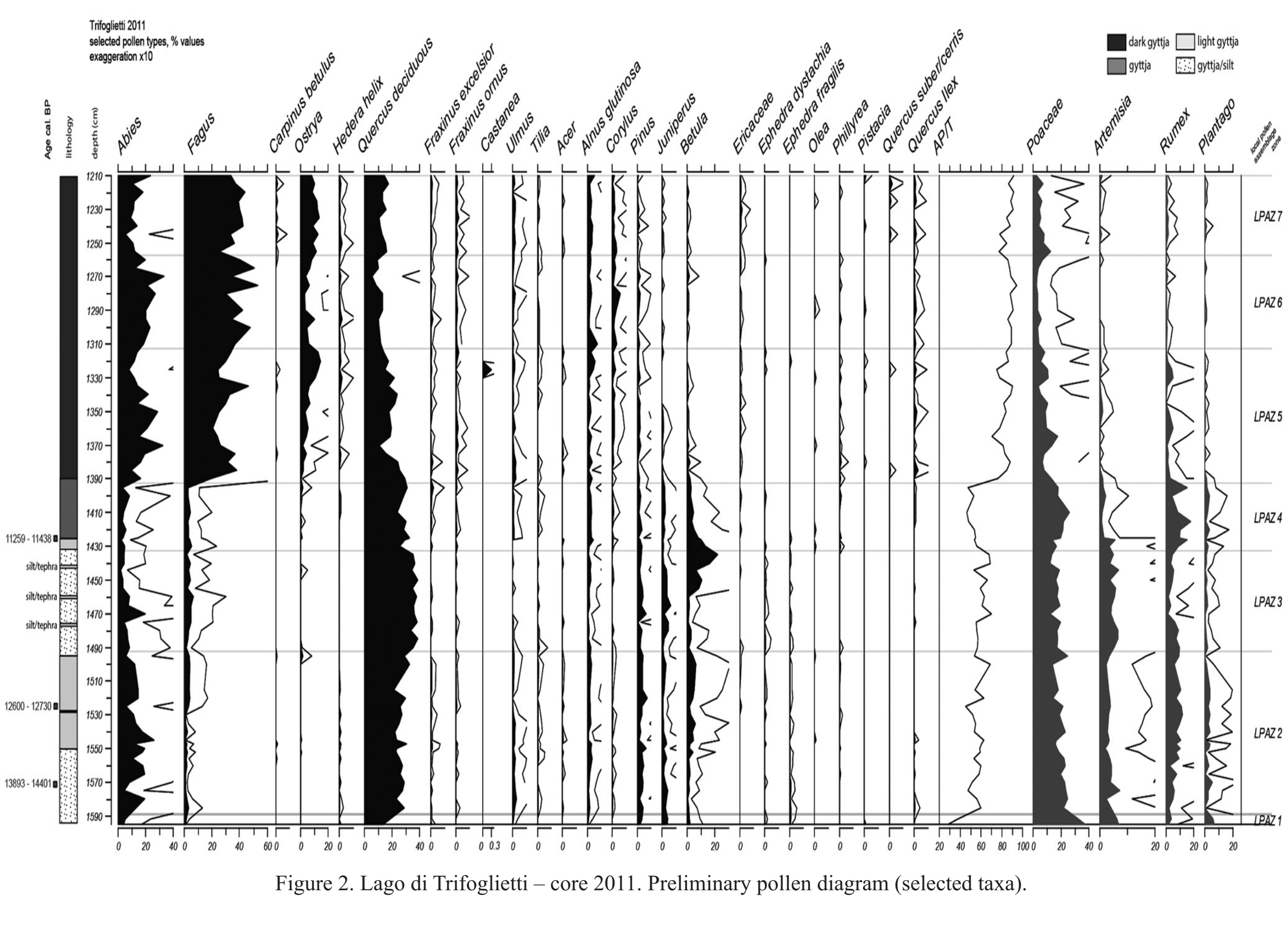

Figure 2. Lago di Trifoglietti – core 2011. Preliminary pollen diagram (selected taxa).

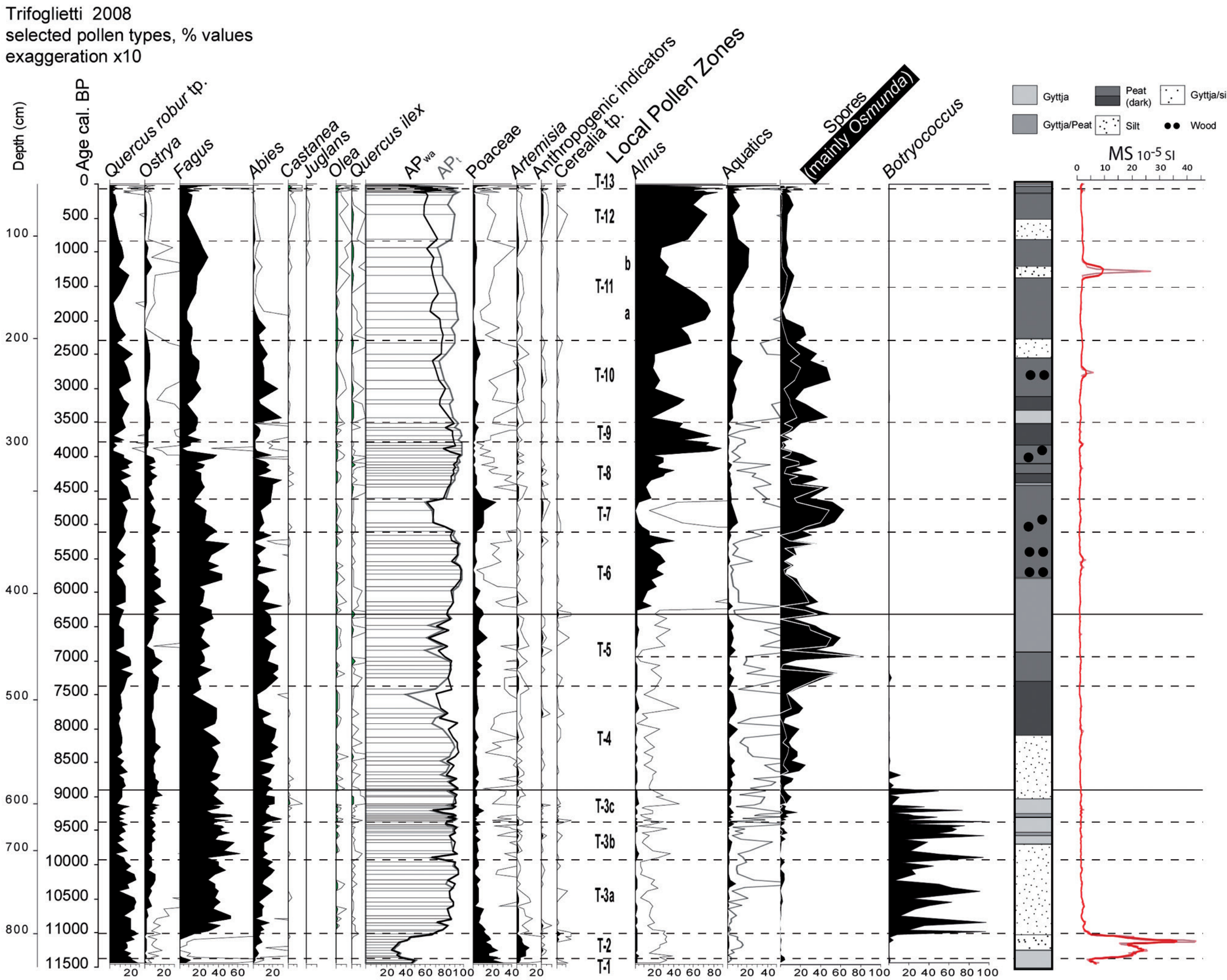

Figure 3. Lago di Trifoglietti – core 2008. Main pollen taxa, lithology and Magnetic Susceptibility (Joannin et al., 2012, modified).

by oro-Mediterranean meadows. It corresponds to the final part of LPAZ3.

LPAZ4 = T2 (11400-11000 cal BP) – an increase in percentages of Cichorioideae, Caryophyllaceae and *Artemisia* suggest a strong cooling. The site may have been above the timberline. In T1 and T2 the hygrophilous taxa are represented by sparse aquatics indicating shallow water. The first pollen of *Castanea* appears.

LPAZ5 and 6 = T3 (11000-8900 cal BP) – around 11000 the rapid increase in *Fagus* corresponds to the local establishment of a mountain forest dominated by *Abies* and *Fagus*. The site was below the timberline as evidenced by the presence of *Abies* stomata. The present *Fagus* forest is directly inherited from the remote early Holocene, furnishing a rare example of beech woodstands maintained in the same place for more than 11000 yr. Abundant *Botryococcus*algal colonies are recorded, suggesting the presence of an freshwater lake with deep water (Testa et al., 2001).

LPAZ7 = T4 (8900-7300 cal BP) – the terrestrial vegetation was stable but from 8200 to 7500 cal BP *Abies* and *Fagus* decreased. The lake surface receded to the benefit of a marginal swamp as illustrated by the expansion of marsh plants. The continuous curve of *Osmunda* confirms the infilling of the lake.

T5 (7300-6150 cal BP) – *Abies* becomes more abundant than *Fagus*. The marsh is invaded by *Osmunda* and the Cyperaceae curve shows a slight expansion.

T6 (6150-5100 cal BP) – the regression of *Abies* to the benefit of *Fagus* also suggests a dry period. For the first time *Alnus* invades the pond; its expansion may correspond to a lake infilling tending towards peatland.

T7 (5100-4650 cal BP) – is mainly characterized by a little reduction in *Fagus*. The deeper water extinguished the *Alnus* fen to the benefit of *Osmunda*, Cyperaceae and Poaceae.

T8 (4650-3800 cal BP) – stabilization of *Fagus* and *Abies*. *Alnus* invades the marsh again.

T9 (3800-3500 cal BP) – at ca.4000 cal BP the forest regression began, probably caused by Bronze Age populations though anthropic indicators are almost absent (Sadori et al., 2004; Mercuri et al., 2012). An increase of *Pteridium* spores is observed: this fern takes advantage of forest fire and is an indicator of human disturbance. Optimum of *Alnus*.

T10 (3500-2100 cal BP) – is characterized by a moderate *Fagus/Abies* forest restoration; frequent occurrences of *Rumex*, Chenopodiaceae, Urticaceae, and *Plantago* suggest pastoral activities in the woods.This evidence of pastoralism appears later and is less evident than in central Italy (Mercuri et al., 2013). A new period of deep water is marked by *Alnus* decline to the benefit of aquatic plants and *Osmunda*.

T11 (2100-800 cal BP) – the main event is the quasi-disappearance of *Abies* from the local forest, probably due to timber exploitation beginning in Roman times and/or climate change. In the upper part of T11 *Castanea* and *Juglans* are continuously recorded. Rare but regular *Castanea* pollen grains are identified throughout the Holocene. The lower zone is characterized by a decrease in water depth with a new *Alnus* expansion, the upper zone is characterized by the return to sedges hummocks and deeper water.

T12 (800-33 cal BP) – it is characterized by regional mixed-oak forest reduction and by anthropogenic indicators that are more frequent though not abundant. A new expansion of *Alnus* occurs which may coincide with a final episode of progressive lake infilling.

T13 - the collapse of *Alnus* and the increase of aquatic plants strongly influence pollen assemblages and prevent a reasonable reading of vegetation changes. The infilling of the lake is abruptly stopped by artificial damming of the lake in order to maintain the hygrophilous ecosystem.

Discussion

Lago Trifoglietti is a unique example of a well-dated pollen sequence from the mountain belt of southern Italy recording both Late Glacial and Holocene periods. Given the relatively late and weak human impact observed in the Trifoglietti pollen record, changes in the vegetation as well as in the water-depth and annual precipitation may help to recognize long term climate variations which have affected southern Italy since the Late Glacial. The Late Glacial at Lago di Monticchio (Allen et al., 2002) is characterized by a *Quercus* deciduous wood, and this is in accordance with the hill trees vegetation at Lago Trifoglietti. But at Trifoglietti the treeline was composed, probably, by *Abies* during LPAZ2.

During the early Holocene Trifoglietti was above the timberline and the comparison with Prato Spilla, and Padule (Lowe & Watson, 1993; Watson, 1996) in the northern Apennines, Lago Grande di Monticchio (Watts et al. 1996; Allen et al., 2002) in Basilicata, Lago di Pergusa (Sadori & Narcisi, 2001; Sadori et al., 2011), Lago di Preola and Gorgo Basso (Tinner at al., 2009; Magny et al., 2011b; Calò et al., 2012) and Biviere di Gela (Noti et al., 2009) in Sicily, suggests an increasing delay in reafforestationfrom northern to southern Italy. Here in fact arid conditions persisted during a large part of the early Holocene (Magny et al., 2011b). These relatively dry conditions in the early Holocene may also have affected Calabria and may explain both a low-altitude timberline and the late expansion of *Fagus* at Trifoglietti. The Preboreal oscillation (T2) identified by Joannin et al. (2012) appears to be confirmed in this new diagram (LPAZ4). From 10500 the progressive rising of the annual precipitations favored the growth of *Ostrya/Carpinus orientalis* wood.The annual precipitation reconstructed at Trifoglietti (Joannin et al., 2012) is high from 9500 to 6000 cal BP and attain its maximum at 8700 cal BP. This humid phase is reported in different studies in the central Mediterranean area (Ariztegui et al., 2000;Sadori and Narcisi, 2001; Drescher-Schneider et al., 2007; Colonese et al., 2010). From the Mid to the Late Holocene, water depth as well as annual precipitation show a general decrease at Trifoglietti. This is in accordance with a fall in lake level observed in Sicily (Magny at al., 2011b), while a contrasting palaeohydrological pattern has been reconstructed for central Italy (Magny et al., 2007). The water-depth recorded at Trifoglietti supports the hypothesis by Magny et al. (2011a) of contrasting patterns in precipitation seasonality north and south of latitude 40°N in the central Mediterranean in response to orbitally-induced climate change. Since 6000 cal BP Trifoglietti has become a peatland with shallow water probably due to the persisting and joint effects of drier climate and lake infilling.

The pollen record of Trifogliettialso shows centennial-scale climate and environmental fluctuations (Joannin et al., 2012) which have punctuated the entire Holocene: a cold dry event is recorded around 11300 cal BP, two cold and drier Boreal oscillations at 9800 and 9200 cal BP. The 8.2 ka event corresponded atTrifoglietti to the onset of cooler and drier climatic conditions which persisted until 7500 cal BP. The second half of the Holocene was characterized by dry phases at 6100-5200, 4400-3500 and 2500-1800 cal BP, alternating with more humid phases at 5200-4400 and 3500-2500 cal BP. The anthropogenic indicators are absent or very scarse. Probably the local mountain forests may have filtered the pollen rain or the agricultural surface was too small because the slopes were unfavorable to settlement. Since 4000 cal BP progressively AP decreases probably related to the combined effects of climate drying and increasing human impact. During the middle Bronze age the use of fire to clear land for agricultural or pastoralism is shown by the development of *Pteridium* spores. During Roman times mainly *Abies* and*Quercus* deciduous were cutfor use in shipbuilding (Allevato et al., 2009). *Castanea* is present at 10200 cal BP and this contributes to confirm its early presence in forest vegetation, as shown in Lago Albano and Lago di Nemi (Mercuri et al., 2013) strengthening the hypothesis of indigenous chestnut populations in this area.

CONCLUSIONS

The research carried out at LagoTrifoglietti provides the evidence of new palaeoecological changes during Late Glacial and Holocene period:

- first considerationson the history of the Late Glacial vegetation (work still in progress) clearly show that *Abies* trees werenearbythe lake (some epidermal cells with stomata have been detected in the pollen slides) since 14400 cal BP and that *Quercus* deciduous trees formed the lower hillbelt.
- the history of Holocene vegetation shows an important stable forest directly inherited from the Late Glacial for *Abies* and inherited from early Holocene for *Fagus*.
- the pollen analysis supports a southward delay in the forest expansion dated to ca.13500 cal BP at Monticchio, to ca 11000 cal BP at Trifoglietti, even if in the area around Trifoglietti the *Quercus* deciduous trees was present during Late Glacial, and finally to ca 9800 cal BP at Pergusa. Persistence of arid conditions is expected to explain the increasing delay from northern to southern Italy.
- the pollen record of Trifoglietti shows poor imprints of agricultural activities and only evidence of pastoral activities. Probably the strongest human impact is the selective exploitation of *Abies* for shipbuilding. A major analysis about human impact will be necessary to explain the use of the area.
- a ratio between hygrophilous and terrestrial taxa and the Modern Analogue Techniquewas used to reconstruct the changes in lake depth and annual precipitation (Joannin et al., 2012).

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REFERENCES

Allen J.R.M., Watts W.A., McGee E., Huntley B., 2002. Holocene environmental variability-the record from Lago Grande di Monticchio, Italy. Quaternary International 88, 69-80.

Allevato E., Russo Ermolli E., Di Pasquale G., 2009. Woodland exploitation and Roman shipbuilding. Méditerranée 112, 33-42.

Ariztegui D., Asioli A., Lowe J.J., TrincardiF.,Vigliotti L., Tamburini F., Chondrogianni C., Accorsi C.A., Bandini Mazzanti M., Mercuri A.M., van derKaars S., McKenzie J.A., Oldfield F., 2000. Palaeoclimatic and the formation of sapropel S1: inferences from Late Quaternary lacustrine and marine sequences in the central Mediterranean region. Palaeogeography Palaeoclimatology 158, 215-240.

Björck S., Rundgren M., Ingölfsson O., Funder S., 1997. The Preboreal oscillation around the Nordic Seas: terrestrial and lacustrine responses. Journal of Quaternary Science 12, 455-465.

Björck S., Muscheler R., Kromer B., Andresen C.S., Heinemeier J., Johnsen S.J., Conley D., Koç N., Spurk M., Veski S., 2001. High-resolution analyses of an early Holocene climate trigger, imply decreased solar forcing as an important climate trigger. Geology 29, 1107-1110.

Calò C., Henne P.D., Curry B., Magny M., Vescovi E., La Mantia T., Pasta S.,Vannière B.,Tinner W., 2012. Spatio-temporal patterns of Holocene environmental change in southern Sicily.Palaeogeography, Palaeoclimatology, Palaeoecology 323-325, 110-122.

Colonese A.C., Zanchetta G.,DotsikaE., Drysdale R.N., Fallick A.E., Grifoni Cremonesi R., Manganelli G., 2010. Early-middle Holocene land snail shell stable isotope record from Grotta di Latronico 3 (southern Italy). Journal of Quaternary Sciences 25, 1347-1359.

De Beaulieu J.-L., Miras Y., Andrieu-Ponel V., Guitier F., 2005. Vegetation dynamics in north-western Mediterranean region: Instability of the Mediterranean bioclimate. Plant Biosystems 139, 114-126.

Drescher-Schneider R., de Beaulieu J.-L., Magny M., Walter-

Simonnet A., Bousset G., Millet L., Brugiapaglia E., Drescher A., 2007. Vegetation history, climate and human impact over the last 15,000 years at Lago dell'Accesa (Tuscany, Central Italy). Vegetation History and Archaeobotany 16, 279-299.

Fleitmann D., Burns S.J., Mangini A., Mudelsee M., Kramers J., Villa I., Neff U., Al-Subbary A.A., Buettner A., Hippler D., Matter A., 2007. Holocene ITCZ and Indian monsoon dynamics recorded in stalagmites from Oman and Yemen (Socotra). Quaternary Science Review 26, 170-188.

Grimm E.C., 2004. TGView Version 2.0.2. Illinois State Museum, Springfield.

GuilaineJ., 2003. De la vague à la tombe. La conquête néolithique de la Méditerranée, Seuil, Paris.

Joannin S., Brugiapaglia E., de Beaulieu J.-L., Bernardo L., Magny M., Peyron O., Goring S., Vannière B., 2012. Pollen-based reconstruction of Holocene vegetation and climate in southern Italy: the case of Lago Trifoglietti. Climate of the Past 8, 1973-1996.

Lowe J.J., Watson C., 1993. Lateglacial and early Holocene pollen stratigraphy of the Northern Apennines, Italy. Quaternary Science Review 12, 727-738.

Magny M., Leuzinger U., Bortenschlager S., Haas J., 2006.Tripartite climate reversal in Central Europe 5600-5300 years ago.Quaternary Research 65, 3-19.

Magny M., de Beaulieu J.L., Drescher-Schneider R., Vannière B., Walter-Simonnet A., Miras Y., Milleta L., Bossueta G., Peyron O., Brugiapaglia E., Leroux A., 2007. Holocene climate changes in the central Mediterranean as recorded by lake-level fluctuations at Lake Accesa (Tuscany, Italy). Quaternary Science Review 26, 1736-1758.

Magny M., Peyron O., Sadori L., Ortu E., Zanchetta G., Vannière B., Tinner W., 2011a. Contrasting patterns of precipitation seasonality during the Holocene in the south- and north- central Mediterranean. Journal of Quaternary Science 27, 290-296.

Magny M., Vannière B., Calò C., Millet L., Leroux A., Peyron O., Zanchetta G., La Mantia T., Tinner W., 2011b. Holocene hydrological changes in south-western Mediterranean as recorded by lake-level fluctuations at Lago Preola, a coastal lake in southern Sicily, Italy. Quaternary Science Review 30, 2459-2475.

Mercuri A.M., Bandini Mazzanti M., Torri P., Vigliotti L., Bosi G., Florenzano A., Olmi L., Massamba N'siala I., 2012. A marine/terrestrial integration for mid-late Holocene vegetation history and the development of the cultural landscape in the Po valley as a result of human impact and climate change. Vegetation History and Archaeobotany 21, 353-372.

Mercuri A.M., Sadori L., 2013. Mediterranean culture and climatic change: past patterns and future trends. In: S. Goffredo, Z. Dubinsky (Eds.) The Mediterranean Sea: Its History and Present Challenges, Springer, Dordrecht.

Mercuri A.M., Bandini Mazzanti M.,Florenzano A., Montecchi M.C., RattighieriE., 2013. *Olea*, *Juglans* and *Castanea*: The OJC group as pollen evidence of the development of human-induced environments in the Italian peninsula. Quaternary International, in press, http://dx.doi.org/10.1016/j.quaint.2013.01.005.

Miller G.H., Brigham-Grette J., Alley R.B., Anderson L., Bauch H.A. Douglas M.S.V., Edwards M.E., Elias S.A., Finney B.P., Fitzpatrick J.J., Funder S.V., Herbert T.D., Hinzman L.D., Kaufman D.S., MacDonald G.M., Polyak L., Robock A., Serreze M.C., Smol J.P., Spielhagen R., White J.W.C., Wolfe A.P., Wolff E.W., 2010.Temperature and precipitation history of the Artic. Quaternary Science Review 29, 1679-1715.

Murgia M., Puntillo D., Cesca G., Sassi N., 1984. Aspetti vegetazionali e palinologici del Lago Trifoglietti nella Catena Costiera (Calabria). Biogegraphia Nuova Serie X, 101-108.

Noti R., van Leewen J.F.N., Colombaroli D., Vescovi E., Pasta S. La Mantia T., Tinner W., 2009. Mid- and late-Holocene vegetation and fire history at Biviere di Gela, a coastal lake in southern Sicily, Italy. Vegetation History and Archeobotany 18, 371-387.

Roberts N., Eastwood W.J., Kuzucuoglu C., Fiorentino G., Caracuta V., 2011. Climatic, vegetation and cultural changes in the eastern Mediterranean during the mid-Holocene environmental transition. The Holocene 21, 147-162.

Sadori L., Narcisi B., 2001. The Postglacial record of environmental history from Lago di Pergusa, Sicily. The Holocene 11, 655-671.

Sadori L., Giraudi C., Petitti P., Ramrath A., 2004.Human impact at Lago di Mezzano (central Italy) during the Bronze Age: a multidisciplinary approach. Quaternary International 113, 5-17.

Sadori L., Jahns S., Peyron O., 2011. Mid-Holocene vegetation history of the central Mediterranean. The Holocene 21, 117-129.

Testa M., Gerbaudo S., Andri E., 2001. Data report: *Botryococcus* colonies in Miocene sediments in the western Woodlark Basin, southern Pacific. In: Proceeding ODP, Huchon P., Taylor B, Klaus A. (Eds), pp. 1-6.

Tinner W., van Leeuwen J.F., Colombaroli D., Vescovi E., van der Knaap W.O., Henne P.D., Pasta S., D'Angelo S., La Mantia T., 2009. Holocene environmental and climatic changes at Gorgo Basso, a coastal lake in southern Sicily, Italy. Quaternary Science Review 28, 1498-1510.

Watson C.S., 1996. The vegetational history of the northern Apennines, Italy: information from three new sequence and a review of Regional vegetational change. Journal of Biogeography 23, 805-841.

Watts W.A., Allen J.R.M., Huntley B., Fritz S.C., 1996. Vegetation history and climate of the last 15,000 years at laghi di Monticchio, southern Italy. Quaternary Science Review 15, 113-132.

Wiersma A.P., Jongma J.I., 2010.A role for icebergs in the 8.2 ka climate event. Climate Dynamic 35, 535-549.

Yu S., Colman S.M., Lowell T.V., Milne G.A., Fisher T.G., Breckenridge A., Boyd M., Teller J.T., 2010. Freshwater Outburst from Lake Superior as a Trigger for the Cold Event 9300 Years Ago. Science 328, 1262-1266.