8 th European Palaeobotany – Palinology Conference
Budapest July 2010

Pleistocene-Holocene Pinus nigra traces on tufa archives in the northern meseta of the Iberian Peninsula

UNIVERSIDAD POLITÉCNICA DE MADRID

Iglesias, R. * [1]; García-Amorena, I. [1]; Pagés, J.L. [2]; Alonso, A. [2]

* contact autor: raulillo15700@hotmail.com
1. Departamento de Silvopascicultura, Escuela Técnica Superior de Ingenieros de Montes, Universidad Politécnica de Madrid
2. Departamento Ciencias del mar y da Terra, Faculta de Ciencias, Universidad A Coruña

UNIVERSIDADE DA CORUÑA

INTRODUCTION

Tubilla del Agua is located in the province of Burgos (Spain). It belongs to the geographic region of La Lora, which is included in a geomorphological wider region of Alto Ebro, placed at the southwestern side of the central sector of the southern front of the Cantabrian Mountains. La Lora is characterized by being a structural platform, formed by upper cretaceous limestones and mainly constitute by the Sargentes-Sedano synclinal (GONZÁLEZ, 1986), with and average high of 900-1000 meters, and cut by fluvio-karstic canons of the Ebro and Rudrón rivers, which can reach up to 300 meters depth. As this limestone platform has been subject of a corrosive action of the water since the last part of the Tertiary and along all the Cuaternary (GONZÁLEZ, 1986), it has developed endo and exo-karstic structures among we can find tufa structures, like the complex of Tubilla, the largest of the area, and where can be found different type of formations, some of them keeping archives of former vegetation.

Due to a set of morphologic, climatic and ecologic conditions, this area take form as a medium height mountain transition space, since put in contact a folded chain with a sedimentary basin, an Atlantic climate with a continental one, and the vegetal communities typical to the atlantic domain with the ones of the Mediterranean one. Actual vegetation of the study area is a set of communities product of an ancient and continuous anthropogenic pressure over the land whit the result of a mixture of pasture lands, transitional bush areas, and forests of *Quercus faginea*, *Quercus ilex*, and *Fagus sylvatica*, along with riparian and rupicola communities (GALÁN, 1990). In its entirety, vegetation characterizes by its heterogeneity and variety as a result of being a transitional biogeogrphycal province (Prov. Aragonesa (3a Sct. Castellano-Cantábrico), halfway between Eurosiberian and Mediterranean biogeographical regions (BERASTEGUI, et al., 1997).

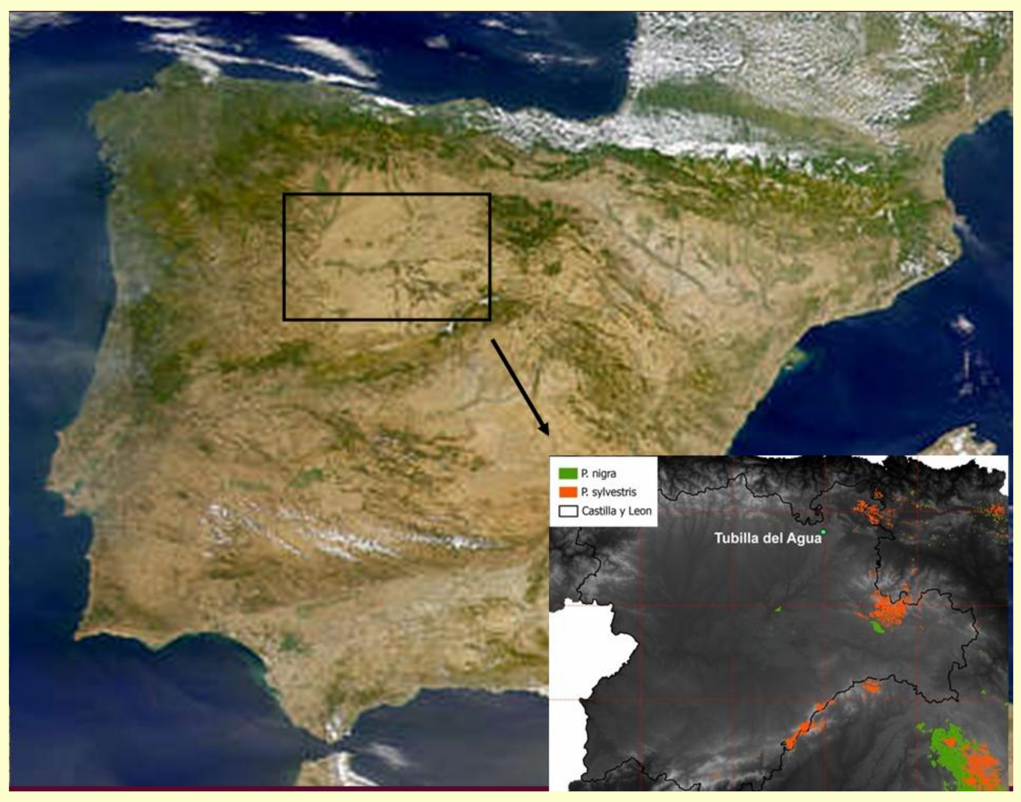

Figure 1: Location of the study area at northern border of the Northern Iberian Meseta. Detailed map also shows the actual distribution of natural populations of *Pinus nigra* and *Pinus sylvestris*.

OBJETIVES

The main goal of the work is to contribute to the knowledge of the roll of Pinus in the vegetation of the Northern Iberian Meseta in the last quaternay from tufa archives of Tubilla del Agua, bringing light over the controversy of its distribution and importance in the ancient forest.

Specific objectives are: 1) searching and identifying remains of Pinus in tufa archives, 2) dating them by stablishing the age of the structures that contain archives and 3) putting them into the palaeoclimatic and palaeofitogeographic context.

Fig. 2: Black pine cone tufa fossil mould. Scale 1cm

Fig. 3: P. nigra pine cone contra-mould (left) and *P. sylvestris* pine cone (right). Scale 1cm

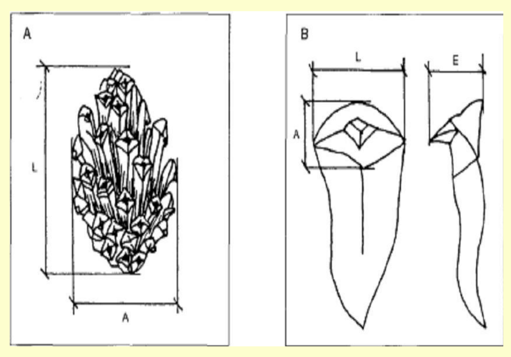

Fig. 5: Pine cone measures A) length (L) and width (A); B) Apofisis width (A), length (L) and thickness (E)

Fig. 5: Macrorremain of a woody pine cone core. Scale 1cm

MATERIALS AND METHODS

Working methodology has consist of a systematic search of Pine evidences in tufa archives, extracting charcoal and woody macrorremains and obtaining a silicone contra-moulds from tufa fossils. Charcoals were prepare for microscopy species identification by key characters (PERAZA, 1964; GARCÍA ESTEBAN & GUINDEO, 1988; SCHWEINGRUBER, 1990), and measures of pine cone contra-mololds parameters were taken in order to define the species by comparing with actual and past populations (GALERA, 1993; ROIG et al., 1997; RUIZ de la TORRE, 2006)

Chronology has been tackle by dating the structures that keep evidences and by revealing the underlying geological model. Dating was carried out by radiometric dating techniques, using uranium-series disequilibrium dating for tufa samples, and radiocarbon dating for tufa and organic material.

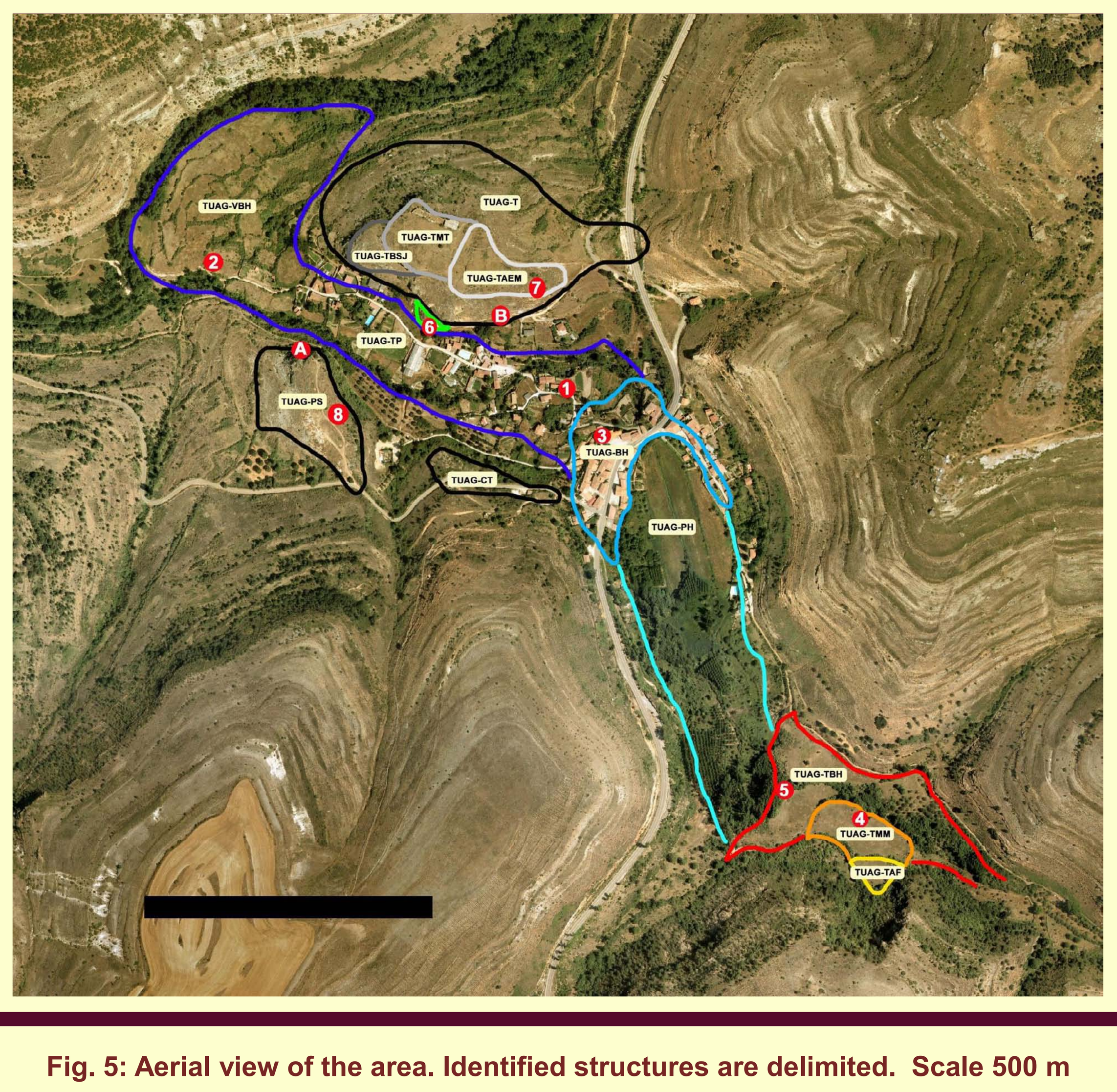

Fig. 5: Aerial view of the area. Identified structures are delimited. Scale 500 m

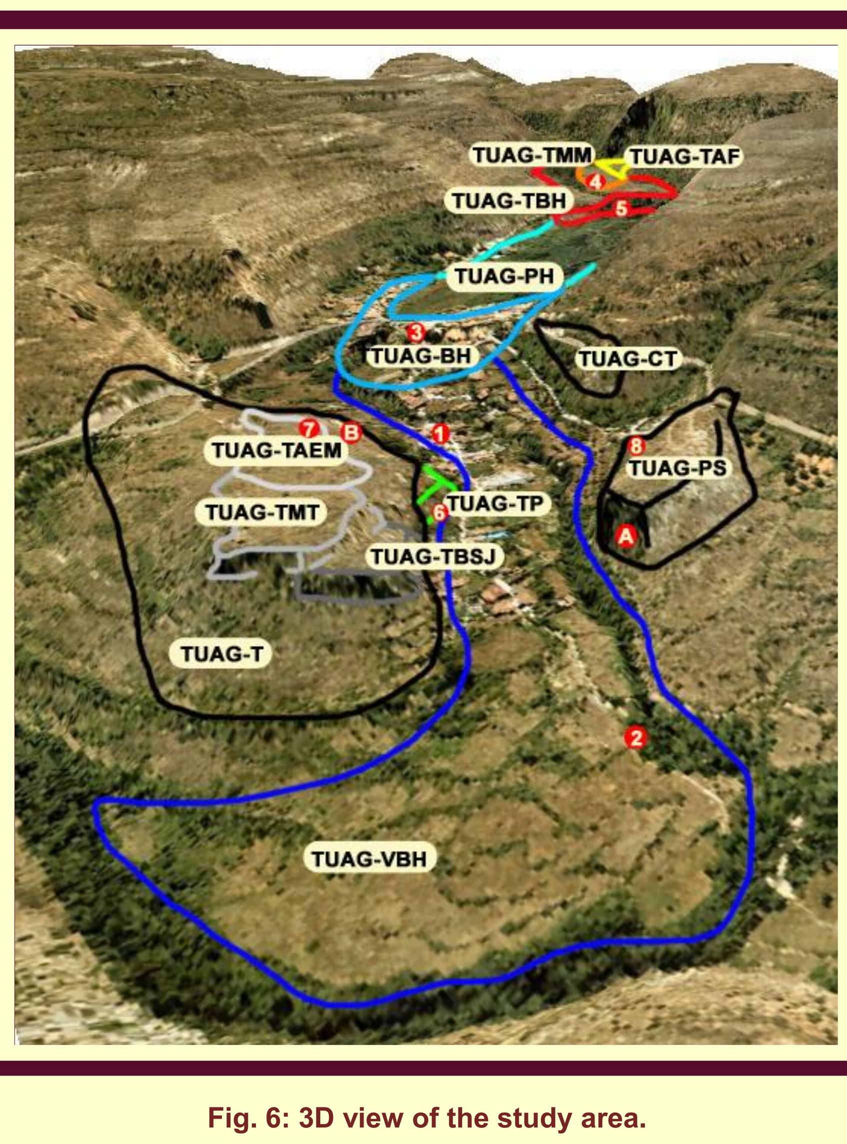

Fig. 6: 3D view of the study area.

RESULTS

Samples for determining the evolution of the tufa complex were taken in key places of the 13 different identified tufa structures, at the places represented by the numbers 1 to 8 in figures 6 and 7. Results show, as is represented in tables 1 and 2, that the complex covers at least the last 300000, years in a series of deposition and destruction phases.

The first accretion phase is reveal by the remains of a barrage system (TUAG-PS, TUAG-T and TUAG-CT) which probably kept a paludal or lacustrine area behind the dam. Samples from the top of TUAG-PS and from an upper terrace TUAG-TAEM, in which the barrage was arrange, have shown a large deposition phase, or series of phases, that began much before the most ancient sample, dating over 300000 years BP, and taken 30 meters above the settling of the structure. This phase lasted as least till the formation of TUAG-TAEM, placed 10 meters over TUAG-PS, and dating 245261 +47470 / -33755 years BP. A subsequent destruction phase broke down the barrage, leaving two remains of the dam (TUAG-T, TUAG-PS), and drained the system, since the terrace TUAG-TP, dating 95970 +6673 / -6318 years BP, deposited upstream and at a lower level. The small structure of TUAG-TP stay as a proof of this new accretion phase, since the erosion empty the basin again, deepened into base rock.

In the transition between Pleistocene to Holocene a new barrage arise upstream (TUAG-BH), that structure a system where downstream the dam developed a paludal deposits arranged in terraces that covered the bottom of the valley (TUAG-VBH), and upstream, the dam contain a lacustrine and paludal environments (TUAG-PH). This system stand active till historical epoch, when lake was drained to take advantage of the created agricultural lands (CIDAD, 1988). Upstream the palaeolake, a separate system of terrace appear, being made up by a three level of terrace (TUAG-TBH, TUAG-TMM, TUAG-TAF), having been dating at Würm glacial stage.

Sample	Estructure	X Coordinate UTM-30N ED50	Y Coordinate UTM-30N ED50	Altitude meters	Material	13C/12C	Conventional Radiocarbon Age	Calendar Calibrated Age
A	TUAG-PS	433888	4729175	752	Wood	-21.0 o/oo	1570 +/- 40 BP	Cal BP 1540 - 1370
B	TUAG-T	434189	4729220	764	Charcoal	-23.2 o/oo	37870 +/- 370 BP	The result is outside of calibration range
1	TUAG-VBH	434286	4729110	757	Carbonate	-9,6 o/oo	2650 +/-40 BP	Cal BP 2840-2820 and Cal BP 2800-2740

Table 1: Dating results of radiocarbon method.

Sample	Estructure	X Coordinate UTM-30N ED50	Y Coordinate UTM-30N ED50	Altitude meters	U-238 ppm	Th-232 ppm	U-234/U-238	Th-230/Th-232	Th-230/U-234	Nominal Age (years BP)
2	TUAG-VBH	433720	4729301	721	0.09	0.01	1.27 +/- 0.06	2.298 +/- 0.322	0.09 +/- 0.01	10241 +929 / -922
3	TUAG-BH	434333	4729027	776	0.12	1.72	1.27 +/- 0.05	1.723 +/- 0.169	0.11 +/- 0.01	12331 +910 / -903
4	TUAG-TMM	434753	4728448	798	0.08	0.05	1.42 +/- 0.07	1.328 +/- 0.114	0.18 +/- 0.01	20891 +1607 / -1586
5	TUAG-TBH	434614	4728467	785	0.12	0.22	1.22 +/- 0.04	0.917 +/- 0.044	0.43 +/- 0.02	59270 +3863 / -3738
6	TUAG-TP	434060	4729217	750	0.14	0.02	1.30 +/- 0.05	20.246 +/- 1.976	0.60 +/- 0.03	95970 +6673 / -6318
7	TUAG-TAEM	434271	4729273	780	0.12	0.2	1.18 +/- 0.04	2.058 +/- 0.108	0.93 +/- 0.04	245261 +47470 / -33755
8	TUAG-PS	433902	4729143	776	0.16	0.29	1.17 +/- 0.05	2.557 +/- 0.083	1.25 +/- 0.05	> 300,000

Table 2: Dating results of Uranium series method

Twenty-two pine cones moulds were found in the emerging tufa rock from structures TUAG-PS (14), TUAG-TMM (2), TUAG-TP (5) and TUAG-BH (1). Despite it is not possible to conclude wich species we are dealing with from quantitative analysis, the qualitative study of the obtained silicone contra-mould, allow us to state that all of them are Pinus nigra estrobily, since they present rounded end of the external margin of the apophysis and the hook-like mucron eccentrically located in the umbo, that define the species (ROIG et al., 1997; RUIZ de la TORRE, 2006)

Charcoal is assigned to the P. sylvestris / P. nigra group, due to the absence of thick epithelial cells in the resiniferous channels, the window-like crossfield pits, and the sharp dentitions on the walls of the radial tracheids (PERAZA, 1964; GARCÍA ESTEBAN & GUINDEO, 1988; SCHWEINGRUBER, 1990). However there are not enought features to identify the pine cone core.

DISCUSSION

The present results show that *P. nigra Arnold* was present since Middle Pleistocene to final Holocene in the studied site, where currently there are no natural masses of this taxon. This statement is made based on pine cone fossil mould and macrorremains contained in the emerging tufa rock structures.

Dynamics of the tufa complex seems to be drive by climatic factors, in such a way that there is a correlation between the frequency of this kind of formations in Mediterranean Basin, whit interglacial periods (HENNING et al., 1983; MAIRE, 1990), which match whit odd numbered Marine Isotope Stages (MIS), specially to MIS 1, 5 and 7 (Figure 7). Main accretion episodes took place in Tubilla as well, at MIS 7-8 (TUAG-T, TUAG-CT and TUAG-PS), MIS 5 (TUAG-TP) and MIS 1 (TUAG-VBH and TUAG-BH), what fit to the main tufa formation periods in Spain (Figure 7). However an upper system developed at colder stages (TUAG-TBH) (MIS 3) and even at the Last Maximum Glacial (TUAG-TMM) (MIS 2). Proofs of the presence of Black Pine has been found through out those mentioned period, making up an archive that support the broad ecological range or *P. nigra* (CLIMENT et al., 2009; RIVAS-MARTINEZ et al., 2002; REGATO, 1989).

Cites of Pinus nigra in the Northern Iberia in Pleistocene are very scarce, limited to Beceite in Teruel (MARTINEZ et al., 1983) and San Juan de Mozarrifar in Zaragoza (POSTIGO, 2003). Nonetheless, palynological prospections suggest a wider distribution, as P. sylvestris/P. nigra group are represented in antracological records since Middle Pleistocene (GARCÍA, 1992) to the Late Pleistocene (ROUCOUX, 2005). There are as well palynological sites that proof the importance of pinus forest along the Holocene (MENÉNCEZ, 1975; GARCÍA et al., 1995; MUÑOZ et al, 1996; PEÑALBA, 1997; FRANCO MUGICA et al, 2001; FRANCO MUGICA et al, 2005) with remains, of Black Pine in some sites (ROIG et al., 1997; AICALDE et al., 2001).

Taking all the references together, it has been draw an scenario of greater importance of microthermal pines in northern Iberian along Last Pleistocene and Holocene that just became reduce at coolest times of glaciations, when it refuge at at best places (GARCÍA et al., 2002). The tufas of the palaeobotanical site of Tubilla del Agua have preserved the proofs of such a glacial refuge. Sunny slopes of the deep Ebro and Rudron Cannons of the calcareous platform of La Lora seems to be a suitable place for waiting for better days. Furthermore, Tubilla keeps evidence of the recent anthropogenic regression of pinus, verificate all over Iberia (PEÑALBA et al., 1996; RAMIL-REGO et al., 1998; FRANCO MÚGICA et al., 2001; IRIARTE, 2003; ZILHÃO, 1993)

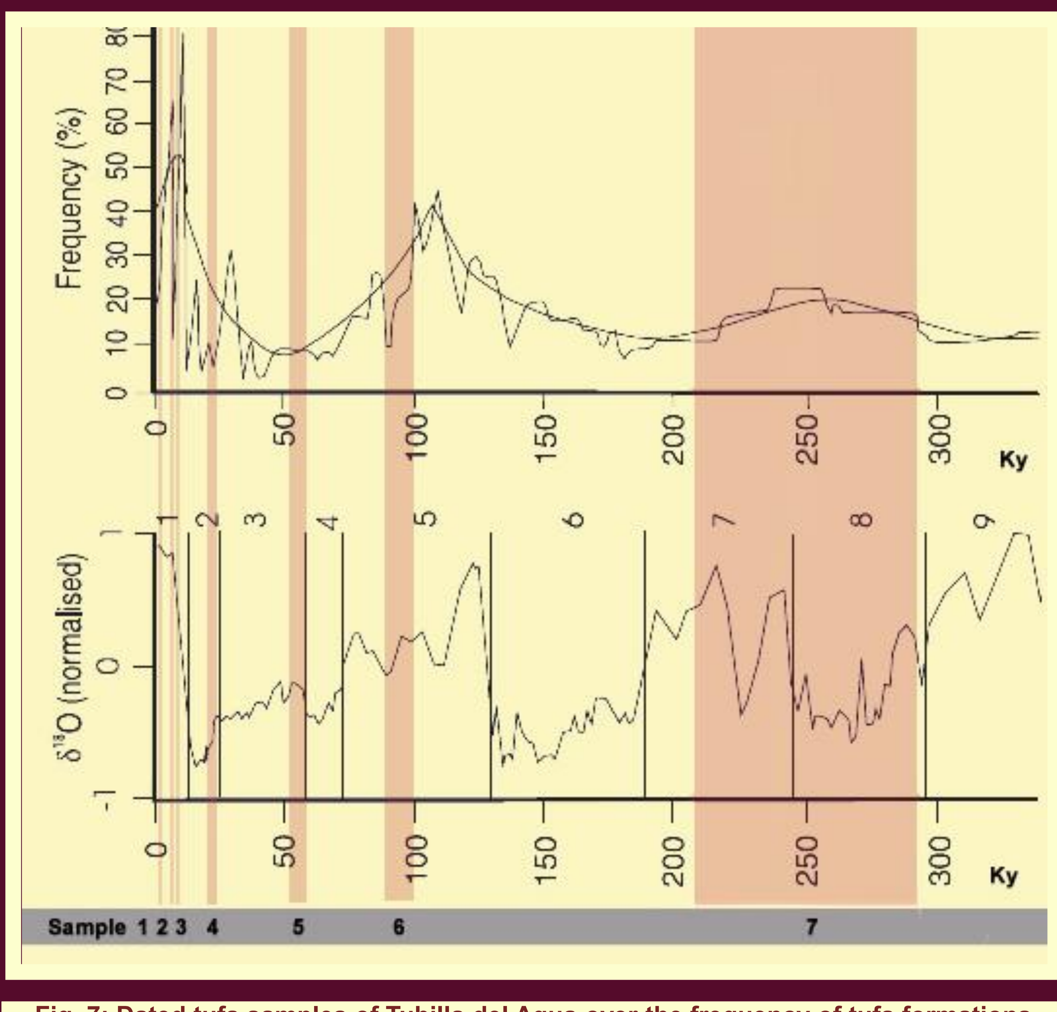

Fig. 7: Dated tufa samples of Tubilla del Agua over the frequency of tufa formations dated in Spain (DURAN el al.,1988) and δ^{18} temperature proxi for the last 300 ky (SHACLETON & OPDYKE 1973) with the delimitation of MIS.

CITED BIBLIOGRAPHY

ALCALDE, C., GARCÍA-AMORENA, I., GÓMEZ, F., MALDONADO, J., MORLA, C., y POSTIGO, J.; 2000. Estudio de los macrorrestos vegetales del yacimiento de Lomilla (Aguilar de Campoo, Palencia, España), Anales del Jardín Botánico de Madrid, 59, 101-112.

BERASTEGUI, S., DARQUISTADE, F.& GARCÍA MIJANGOS, I ; 1997. Biogeografía de la España centro-septentrional. Itinera geobotánica,

CIDAD, J.; 1988. Tubilla del Agua; Apuntes históricos sobre el municipio. Diputación de Burgos.

CILIMENT, J., COSTA E SILVA, F., CHMBEL, M.R., PARDOS, M., ALMEIRA, M.H.; 2009. Freezing injury in primary and secondary needles of Mediterranean pine species of contrasting ecological niches. Ann. For. Sci., 66(4), 407-407.

DURÁN, J.J, GRÚN, R. y SORIA, J.M.; 1988. Aportación del estudio geocronológico de espeleotemas y travertinos al conocimiento paleoclimático del Cuaternario de la Peninsula y Baleares. Actas II Congreso Geológico de España, 1, 383-386. Sociedad Geológica de España. Granada.

FRANCO MÚGICA, F., GARCÍA-ANTÓN, M., MALDONADO-RUIZ, J., MORLA-JUARISTI, C., y SAINZ-OLLERO, H.: Ancient pine forest on inland dunes in the Spanish northern meseta, Quaternary Research, 63, 1-14, 2005.

FRANCO MÚGICA, F., GARCÍA, M., MALDONADO, J., MORLA, C., y SAINZ, H.: The Holocene history of Pinus forests in the Spanish nothern meseta, The Holocene, 11, 343-358, 2001.

GALÁN CELA, P. -1990- Contribución al estudio florístico de las comarcas de la Lora y Páramo de Masa (Burgos). Fontqueria 30: 1-167.

GALERA PERAL, R. M.; 1993. Thesis. Type, Universidad Politécnica de Madrid.

GARCÍA ANTÓN, M.; 1992. Paleovegetación del Pleistoceno Medio de Atpuerca a través del análissi polínico. Actas, Evolución humana en Europa y los yacimientos de la Sierra de Atapuerca, vol.1, p. 147-165. Valladolid, Junta de Castilla y León.

GARCÍA ANTÓN, M., FRANCO, F., MALDONADO, J., MORLA, C., y SAINZ, H.; 1995. Una secuencia polínica en Quintana Redonda (Soria). Evolución holocena del tapiz vegetal en el Sistema Ibérico septentrional, Anales del Jardín Botánico de Madrid, 52, 187-195,.

GARCÍA ANTÓN, M., MALDONADO, J., C, M., y SAINZ OLLERO, H.; 2002. Fitogeografía histórica de la península Ibérica, in: La Diversidad Biológica de España, editado por: Pineda, F., De Miguel, J., y Casado, M., Prentice Hall, Madrid [...], 45-63,.

GARCÍA, L.GUIDEO, A.; 1988. Anatomía e identificación de las maderas de coníferas españolas, AITIM, Madrid.

GONZÁLEZ, R.; 1986. Dinámica de un espacio natural: Los cañones calcáreos del Ebro (Burgos). ERIA 5 – 86.

HENNING, G.J., GRÚN, R. y BRUNNACKER, K. 1983. Speleotems, Travertines and Paleoclimates. Quaternay Research, 20, 1-29.

IRIARTE, M.J., 2003. Man made landscape during the Holocene in the Basque country, In:Ruiz Zapata, M.B., Dorado, M., Valdeolmillos, A., Gil García, M.J., Bardají, T., Bustamante, I., Martínez, I. (Eds.), Quaternary climatic changes and environmentalcrises in the Mediterranean Region. Universidad de Alcalá-MCYT-INQUA, Alcalá deHenares, pp. 23-33.

MAIRE, R. 1990. La haute montagne calcaire. Karstología Mémoires, 3, 73 Pp.

MARTÍNEZ TUDELA, A., ROBLES CUENCA, F., SANTISTEBAN, C. de, GRÚN, R. y HENTZSH, B. 1986. Los travertinos del río Matarraña, Beceite (Teruel), como indicadores paleoclimáticos del Cuaternario. In: Quatenzay Climate in Western Mediterranean. 307-324.

MENÉNDEZ AMOR, J.; 1975. Análisis palinológico de los sedimentos turbosos de Calatañazor (Soria), Estudios Geológicos, 31, 795–797.

MUÑOZ-SOBRINO, C., RAMIL-REGO, P., DELIBES DE CASTRO, G., y ROJO GUERRA, M.; 1996. Datos paleobotánicos sobre la turbera de la Piedra (Páramo de Tozo, Burgos), in: Biogeografía Pleistocena-Holocena de la Península Ibérica, editado por: Ramil- Rego, P., Fernández Rodríguez, C., y Rodríguez Guitián, M., Consellería de Cultura de Santiago de Compostela, Santiago de Compostela, 149-162.

PERAZA, C.; 1964. Estudio de las maderas de coníferas españolas y de la zona norte de Marruecos Instituto Forestal de Investigaciones y Experiencias, Madrid.

PEÑALBA, M., ARNOLD, M., GUIOT, J., DUPLESSY, J-C, y DE BEAULIEU, J.; 1997. Termination of the Last Glaciation in the Iberian peninsula inferred from the pollen sequence of Quintanar de la Sierra, Quaternary Research, 48, 205-214.

POSTIGO, J. M.; 2003. Contribución al conocimiento de la vegetación pleistocena de laPenínsula Ibéricaestudio paleobotánico de macrorrestos vegetales fósiles Universidad Autónoma de Madrid. Departamento de Biología., Madrid, 265 pp.,

REGATO, P., Y ESCUDERO, A.; 1989. Caracterización fitoecológica de las comunidades de Pinus nigra subsp. salzmannii en los afloramientos rocosos del Sistema Ibérico Meridional, Botanica complutensis, 149-161.

RIVAS-MARTÍNEZ, S., DÍAZ, T., FERNÁNDEZ-GONZÁLEZ, F., IZCO, J., LOIDI, J., LOUSÄ, M., PENAS, A., 2002. Vascular plant communities of Spain and Portugal. Addenda to the syntaxonomical checklist of 2001. Vascular plant communities of Spain and Portugal. Addenda to the syntaxonomical checklist of 2001, 15(1), 5-432

ROIG, S.; GÓMEZ, F.; MASEDO, F.; MORLA, C. DÁNCHEZ, L.; 1997. Estudio paleobotánico de estróbilos y maderas subfósiles holocenas en el yacimiento de Cevico Navero (Palencia, España). Anales del Jardín Botánico de Madrid 55: 111-123.

ROUCOUX, K. H., ABREU, L., SHACKLETON, N. J., y TZEDAKIS, C.; 2005. The response of NW Iberian vegetation to North Atlantic climate oscillations during the last 65 kyr, Quaternary Science Reviews 24, 1637-1653.

Ruiz de la Torre, J.: 2006. Flora mayor. Organismo Autonomo de Parques Nacionales. Dirección General para la Biodiversidad, Madrid

Shackleton, N.J. y Opdyke, N.D. 1973. Oxygen isotope a.nd paleoclimatic streatigraphy of Equatoriál Pacific Core V 28 - 238: Oxygen isotope temperatures and ice volumes on a ¡Q5 year and 106 year scale. Quaternay Research, 3, 39-55

SCHWEINGRUBER, F.; 1990. Anatomy of European woods, WSL/FNP, Paul Haupt Berne & Stuttgart Publishers, Stuttgart.

Zilhão, J., 1993. The spread of agro-pastoral economies across Mediterranean Europe: A view from the far west. J. Mediter. Archaeol., 6(1), 5-63.

Pleistocene-Holocene P. nigra traces on tufa archives in the northern meseta of the Iberian Peninsula

García-Amorena, I[1], Iglesias, R*[1]; Pagés, J.L.[2]; Alonso, A. [2]
* contact autor: raulillo15700@hotmail.com
[1]. Departamento de Silvopascicultura, Escuela Técnica Superior de Ingenieros de Montes, Universidad Politécnica de Madrid
[2]. Departamento Ciencias del mar y da Terra, Faculta de Ciencias, Universidad A Coruña

Molds preserved on travertines constitute exceptional species-informative material to reconstruct past vegetation. These are common on the High Ebro region. Here, the fluvial system erosion and karstification of the Mesozoic limestone since the Late Tertiary, origins extensive travertine complexes like the one studied in Tubilla del Agua (Burgos). In this site, three different travertine complexes are observed. The older one is represented by two disconnected edifices incised by the Valoria river. The age of this structure is established between > 300,000 and 240,000 yr BP, as from the U/Th dating on its base and top. The subsequent incision lasted until at least 90,000 yr BP, when another edifice erected upstream on the older one. The second travertine group comprises three platforms aged 60,000 yr BP the lower one, and 18,000 yr BP the middle one. The third travertine group is a lake-barrier complex 12,000 yr BP old, on which Tubilla del Agua was built, and a stratified travertine body that covers the valley bottom 10,000 to 2700 cal yr BP old. Some of the ages of the oldest travertines, and the most modern ones, coincide with the principal travertine formation cycles described by Durán (1996) for Spain.

The matrix of precipitated calcium carbonate of all these complexes are rich in plant remain molds (mosses, stems, leaves, cones) of the surrounding flora. *Pinus nigra* Arnold cone molds have been localized and identified by comparative morphology studies. These remains are of high valuable information about the Pleistocene and Holocene presence of this taxon, in a site where no natural presence can be found today.
This work was funded by project CGL2008-06005.