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Pollen Record of the Last 500 Years from the Doniños Coastal Lagoon (NW Iberian Peninsula): Changes in the Pollinic Catchment Size *Versus* Paleoecological Interpretation

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ABSTRACT

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Pollen, diatom, charcoal and sedimentological analyses of a 4.20-m long core collected in the margin of the Doniños coastal lagoon, northwest Iberian Peninsula, provide information about the environmental evolution of this lagoon during the last 530 yr BP. During this time period, local environmental changes, such as changes in the sand-barrier permeability, alluvial sedimentation and/or anthropogenic activity, played a major role in the evolution of this coastal system. This scenario allows us to test the degree the pollinic signal recorded in the sediments of coastal lagoons is reshaped by the influence of local processes.

Diatom and sedimentological data as well as historical archives indicate the development of a lacustrine system at the bottom of the sequence. Therefore, the coring site might be included in the lagoon itself. Pollen data seems to reflect the regional vegetation as a consequence of the large pollinic catchment area. Local *Castanea* cultivation and anthropogenic deforestation are also recorded.

At the top of the sequence, diatom facies suggest increased marine influence at this time as a consequence of the more common events of breaching of a retrograding barrier. This, plus natural silting up by alluvial sedimentation and man-induced drying up of the lagoonal margins, lead to a progressive decrease in the water body extension. The coring point is now outside of the lagoon, implying a reduction in the pollinic catchment area that gave rise to a gradual increase in the local pollinic rainfall of periphytic vegetation.

From the pollen diagram of this coastal deposit signatures of regional vegetation are swamped by local pollen input. The fluctuations in the percentages of the different pollen taxa are related to the complex interaction between basin size, human activities and breaching of the barrier. Caution must therefore be taken with direct paleoclimatic inferences from pollinic studies in coastal lagoons as an alternative where other continental deposits are lacking.

ADDITIONAL INDEX WORDS: *Human impact, late Holocene, vegetation history, NW Iberian Peninsula, coastal lagoon, pollen, diatoms, charcoal.*

INTRODUCTION

The importance of studying paleoclimatic data for the last 2,000 years, known as a stable interglacial period, has recently been emphasized (MASLIN and BERGER, 1997). This time interval covers one of the most important periods of anthropogenic effects on the global environment coincident with the last half-millennium (ROBERTS, 1998). Although analyses of some good continental records in Galicia (NW Iberian Peninsula) which span the Holocene period have contributed to the knowledge of the climatic conditions and vegetation history of that period (*e.g.,* MALDONADO RUIZ, 1994; SANTOS, 1996; SANTOS *et al.,* 2000), detailed studies for the last 2,000 years were lacking until very recently (MARTÍNEZ-CORTIZAS *et al.,* 1999). Besides the very scattered continental records, important deposits in coastal lagoon and salt-marsh environments developed along the Galician coast (VILAS and ROLÁN, 1985) during this time period. Therefore, the sedimentary record of the barrier lagoon systems can constitute an alternative for paleoclimatic studies of the late-Holocene in this region. So far, few paleoenvironmental studies involving micropaleontological and/or geochemical proxies have been undertaken in these systems (SAA OTERO, 1985; SAA OTERO and DÍAZ-FIERROS, 1983, 1985, 1986; SANTOS *et al.,* 1993) and they generally lack a multidisciplinary approach. As a

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consequence, there is a very fragmentary knowledge of the recent evolution of the Galician barrier lagoon environments.

Evolution of coastal lagoons is strongly conditioned by changes in the sea level, sedimentation, storm-surge activity and anthropogenic influence. There is evidence that eustatic and climatic forcing have not been the direct dominant factors in the most recent evolution of the barrier-lagoon type Atlantic coasts but rather local factors such as sediment budget and/or anthropogenic intervention (DEVOY *et al.,* 1996). Without a precise knowledge of the evolution of coastal environments the pollen signal from local and regional sources can be misunderstood. The local signal preserved in the recent sedimentary record of coastal lagoons may interfere with the interpretation of environmental changes taking place at a regional scale and it is therefore necessary to distinguish between the two types of signals. For this, a multidisciplinary approach involving the use of independent micropaleontological and/or geochemical indicators should be addressed. The study of the diatom record can solve a large variety of problems in coastal paleoecology (DENYS and DE WOLF, 1999) and it can be particularly useful tracing changes in the local forcing factors influencing the evolution of coastal lagoons such as hydrochemistry, water depth or rate of accretion at short time-scales (BAO *et al.,* 1999). As a result, they can serve to reconstruct size variations of a particular coastal basin where pollen settles. While the relationship between the basin size and the pollen representation area in continental sites has been largely considered (JACOBSON and BRADSHAW, 1981; PRENTICE, 1985; SUGITA, 1993, 1994; SÁNCHEZ GOÑI and HANNON, 1999), the variation of the pollinic catchment area in coastal lagoons has never been discussed. In this paper we present the multidisciplinary study (pollen, charcoal, diatoms, sediments) of a core collected from the Doniños Lagoon covering the last 500 years to correlate changes in the lagoon size with regional or local pollen representation. This core was collected in the margin of the lagoon in order to detect any changes in the basin size. This work allows us to elucidate reliability of a coastal lagoon pollen record to trace regional environmental changes occurring at a timescale of 10^2 to 10^3 years in a sensitive system strongly affected by local forcing factors.

STUDY SITE

The Doniños coastal lagoon (UTM 29TNJ51, 0 m a.s.l.) (Figure 1) is located in the northwestern Iberian Peninsula, close to the Ría de Ferrol (A Coruña province, Galicia, Spain) occupying a 800 m wide valley over the Ferrol Massif which is made up of Hercinic granitoids (BELLIDO MULAS *et al.,* 1987). The whole back-barrier system has an approximate extension of 150 Ha. Of these, the lagoon extends in a surface area of about 32 Ha.

The lagoon is almost permanently closed by a 1.7 km long sand barrier which extends in a S–N direction and occupies 85,700 Ha (GUITIÁN RIVERA, 1987). A small 2.8 km long river feeds the basin from the east. The average depth of the lagoon is about 11–12 m being reduced when occasional breaching of the barrier occurs during heavy winter storms. Besides this, freshwater can be evacuated to the sea through a narrow point in the northern part of the barrier during episodes of maximum infilling coincident with large rainfall events (VILAS and ROLÁN, 1985; FERNÁNDEZ LÓPEZ, 1998). However, water exchange with the open sea is generally small.

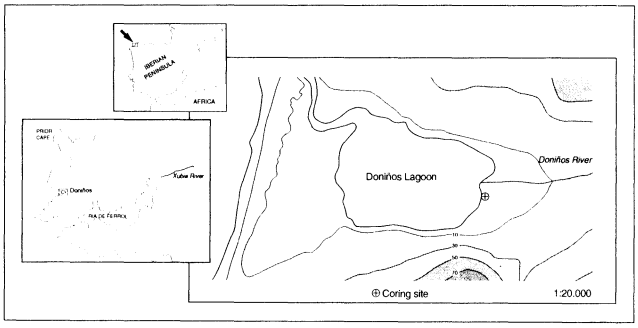

Figure 1. Location of the Doniños coastal lagoon showing the sampling position.

The mean annual precipitation in the area is around 970 mm per year. The mean temperature for January and July are 9.3°C and 17.8°C respectively (CARBALLEIRA *et al.,* 1983).

The lagoon is located inside the Eurosiberian biogeographic region, and the present-day vegetation is dominated by Asteraceae and Poaceae due to human activity taking place in the surrounding area of the lagoon. The aquatic plants living in the Doniños Lagoon are characteristic of the *Scirpo-Phragmitetum* association with *Najas marina* and *Utricularia* sp. *Alnus glutinosa* and *Salix atrocinerea* constitute the residual forest with *Quercus robur* as accompanying taxon (GUITIÁN RIVERA, 1987). A planted 200 years old *Pinus-Eucalyptus* forest occupies the slopes of the adjacent mountains. Although the Holocene vegetation history in the nearby region is unknown, there is some evidence from marine sediments in the Ría de Ferrol that a mixed deciduous forest was the dominant formation at 3,000 years BP (SANTOS *et al.,* unpublished data).

MATERIALS AND METHODS

A 420 cm long core was taken at a marginal position of the lagoon far from the sand barrier and in the alluvial fan of the Doniños river (Figure 1). A manual piston corer of 50 mm of diametre was used.

The core was transferred in the field into plastic gutter pipes, wrapped with plastic foil and stored in the lab at 4°C. Sediments were characterized using the TROELS-SMITH (1955) system. Loss on ignition (LOI) analyses were carried out on 2 cm^3 samples taken at 5 cm intervals to determine the water, organic and carbonate content of the sediment at 105°C, 550°C and 950°C, respectively. Chronology of the sedimentary sequence was controlled by a ^{14}C AMS dating at its bottom carried out by BETA Analytic, USA. The date was calibrated (2σ; 95% probability) according to STUIVER *et al.* (1993), TALMA and VOGEL (1993) and VOGEL *et al.* (1993).

Sampling at different intervals, depending on the nature of the sediments, was conducted for pollen, charcoal and diatom analyses. Pollen extraction followed the method of DE

VERNAL *et al.* (1996) and concentrations of both pollen and microcharcoal particles were determined by addition of exotic *Lycopodium* spores (STOCKMARR, 1971). Pollen grains were counted using a Nikon Labophot II microscope at ×400 and ×1000 (oil immersion) magnifications. Pollen identifications were based on the pollen reference collection at the Department of Earth Sciences of the University of A Coruña as well as on M. Reille's atlas (REILLE, 1992). An average of 300 grains and 20 pollen taxa, excluding aquatic plants and spores, and a minimum of 100 spores of *Lycopodium* were counted in each sample. The pollen percentage for terrestrial taxa is based on the main pollen sum which excludes aquatics and spores. The sum used for the percentage calculation of aquatics and ferns was the total sum, inclusive of aquatics, spores, indeterminables and unknowns. The charcoal particles were identified in pollen slides at ×400 magnification. Charcoal selection was restricted to blacks, completely opaque and angular fragments (SWAIN, 1973). The charcoal surface estimation followed CLARK (1982).

Samples for diatom analysis were treated according to RENBERG (1990) with minor modifications. Diatom valves were counted in strewn slides (Naphrax mountant, r. i. = 1.74) with a Nikon Optiphot II phase-contrast microscope at ×1000. Raw counts were converted to percent abundances. Poor diatom content in many samples made diatom counts to be restricted to 200 valves. Since diatom-based reconstruction of sedimentary environments was based on major trends of percent abundances of ecological groups, this amount has been considered satisfactory (VOS and DE WOLF, 1993).

The Psimpoll computer program (BENNETT, 1992) was used for the diagrams, and the descriptive presentation of both pollen and diatom data is based on the concept of the "assemblage zone" (BIRKS and BIRKS, 1980).

RESULTS

Lithostratigraphy

Coring reached a depth of 420 cm. Most of the sediments were very sandy ranging from almost pure sands to some organic enriched levels. The lithology of the DON-2 core is summarized in Figure 2, where five major lithological units were distinguished.

A layer of silts and clayey fine sands was observed at the bottom of the sequence between 420–405 cm. Coarse sandy layers were recorded between the 405–380 cm and 380–280 cm intervals but the latter could not be recovered with the corer. These layers were followed by a succession of organic-enriched coarse, medium and fine sands with abundant mica between 280–220 cm. Two layers of coarse to medium sands with abundant quartz crystals were observed in the 220–100 cm interval. The uppermost part of the sequence was very organic with macroscopic plant remains as well as clayey silts with some interbedded sands.

Radiocarbon Chronology

A radiocarbon date of organic-enriched silts at the bottom of the sequence (420 cm) yielded an AMS ^{14}C age of 530±30 yr BP (cal AD 1420–1460) (Beta-118858). Estimated ages were not calculated above this dated level due to the suspected strong differences in the sedimentation rates throughout the core.

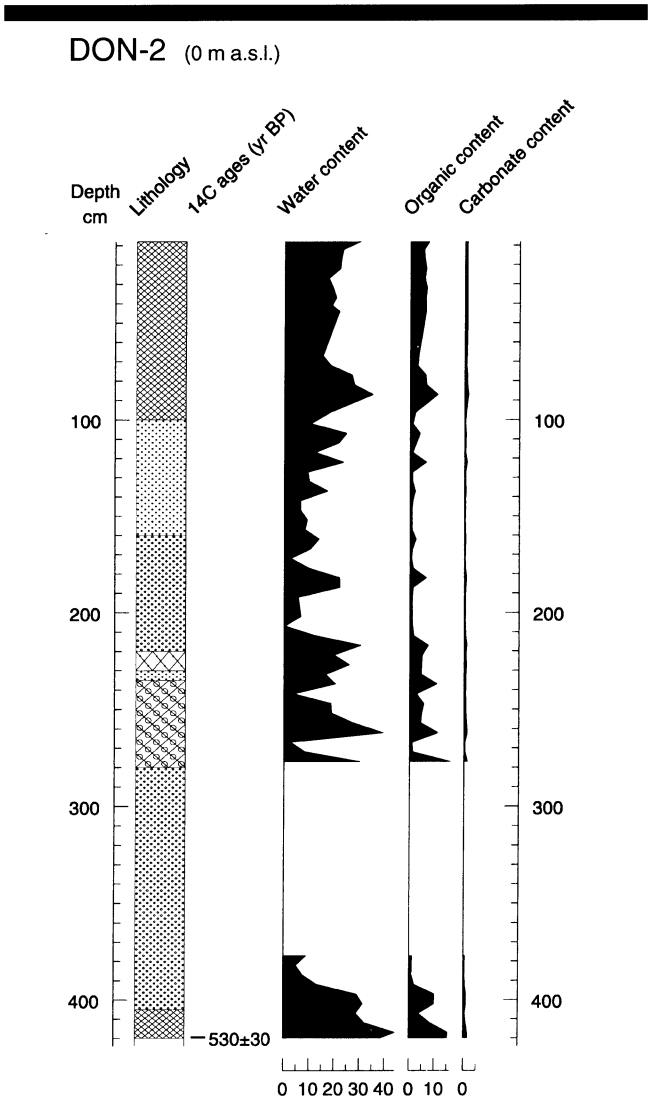

Figure 2. Lithostratigraphy and loss on ignition of the DON-2 core. Lithostratigraphic symbols follow TROELS-SMITH (1955).

Sediment Analysis

The curves of the %water, organic and carbonate content are presented in Figure 2. The organic content was maximum at the bottom of the sequence (around 15%), varying between 1 and 10% for most of the record, showing however a peak at 277 cm (16%) and some other minor peaks at 262, 237 and 87 cm (around 11%). The carbonate content was very low for most of the record with some peaks coinciding in all cases with the peaks in organic content.

Pollen stratigraphy

Pollen analysis was only performed on organic levels, because the sandy layers did not preserve any pollen grains.

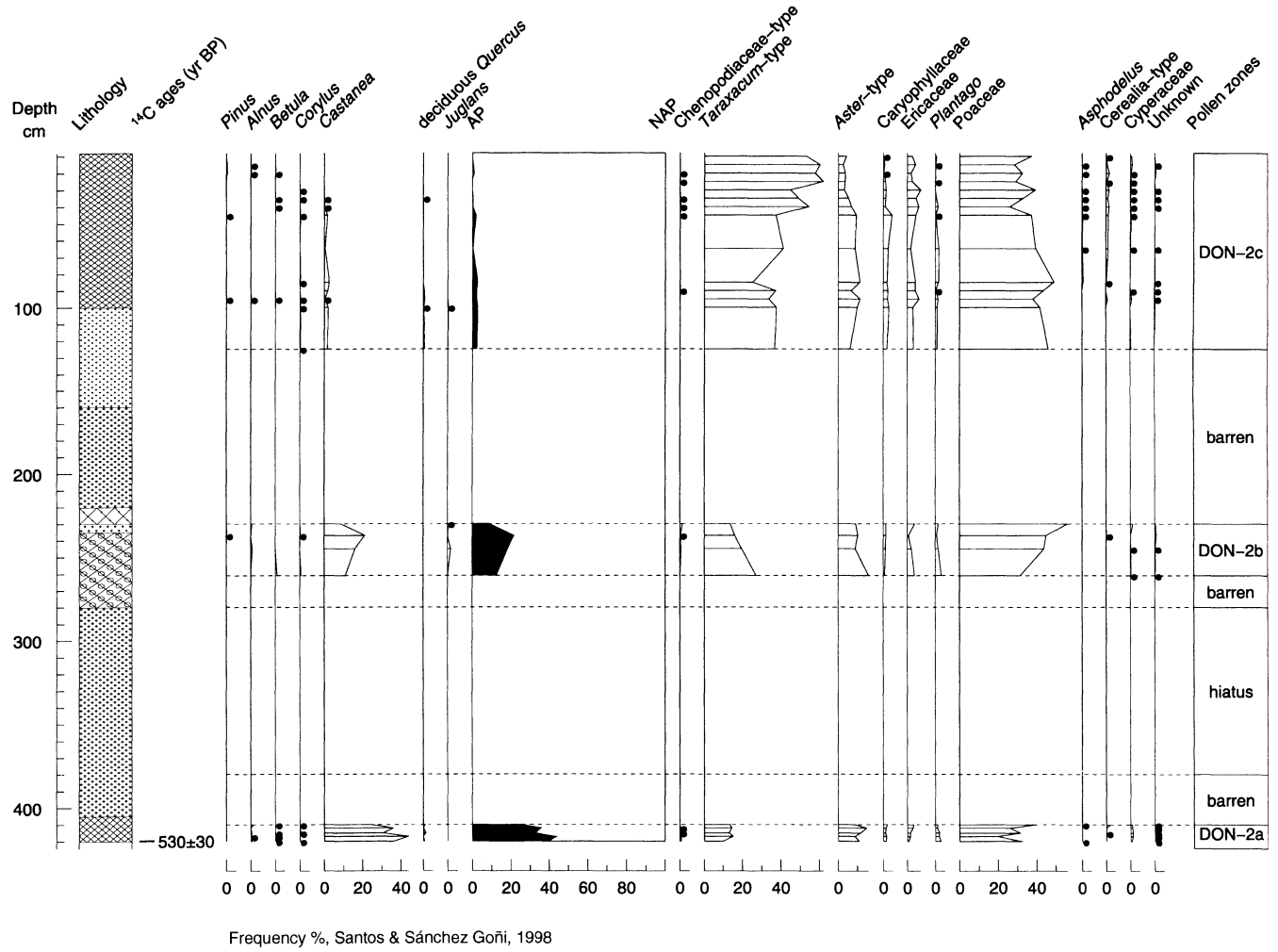

Figure 3. Pollen percentage diagram from DON-2 record (selected taxa). AP: Arboreal Pollen; NAP: Non arboreal pollen. Dots indicate percentages of less than 0.5%. Lithostratigraphic symbols follow TROELS-SMITH (1955).

Forty-five pollen taxa were identified. Two are the most striking features of the palynological diagrams (Figures 3 and 4). The relatively high pollen percentages of *Castanea* and the minor contribution of *Pinus,* which are typical of the recent pollen records of the coastal regions of the northwestern Iberian Peninsula due to modern reforestations (SAA OTERO, 1985).

The pollen percentage and concentration records (Figures 3 and 4) could be divided into three "pollen assemblage zones" (PAZs) numbered upwards from the base of the sediments and referred to using the prefix DON-2.

PAZ DON-2a (420–410 cm; 530 yr BP) corresponds with a layer of maximum organic and carbonate content (Figure 2). This zone is characterized by the maximum percent values of arboreal pollen (44%), mainly represented by *Castanea*, that could be interpreted (HUNTLEY and BIRKS, 1983) as a *Castanea* forest growing in the area during this time period. The low percentages of *Quercus, Betula, Corylus* and *Alnus* pollen recorded in this zone (Figure 3) would indicate isolated specimens of those taxa present nearby or an echo of the regional vegetation.

Relatively high values of Poaceae (30%) and Asteraceae (25%) could reflect the local open vegetation. The presence of other taxa such as Ericaceae, *Plantago* and Caryophyllaceae also characterizes this zone. The presence of Cerealia-type pollen indicates agricultural activities. The pollen concentration curve follows that of the pollen percentages and the area of microcharcoal particles is minimum (Figure 4).

PAZ DON-2b (261–230 cm). The gradual decrease in both arboreal pollen percentages and concentrations and, in particular, of *Castanea* values, may indicate a reduction in the forest cover (Figures 3 and 4). At the same time, deciduous *Quercus* diminish or virtually disappear from the area. The appearance of other cultivated taxa, such as *Juglans,* also

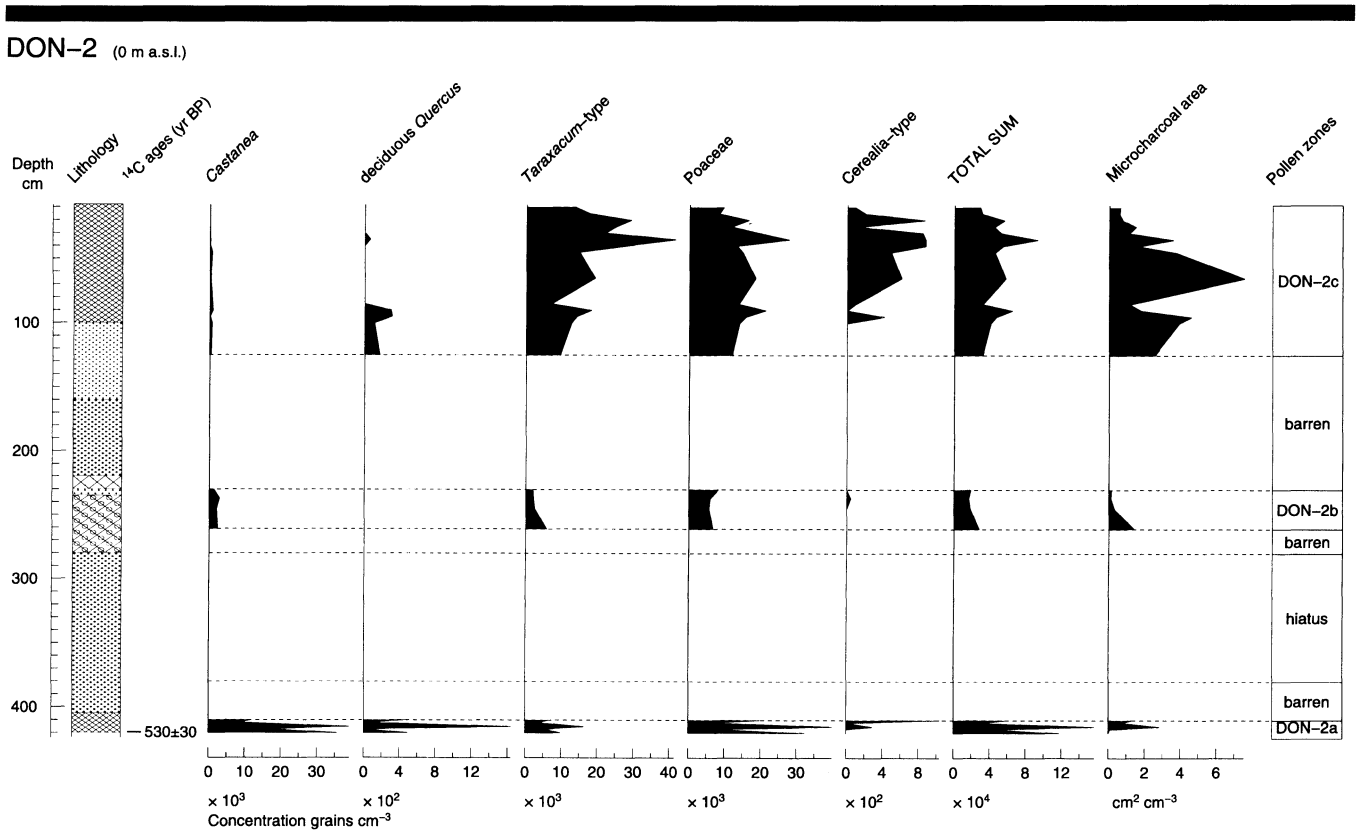

Figure 4. Pollen concentration diagram from DON-2 record (selected taxa). Lithostratigraphic symbols follow TROELS-SMITH (1955).

characterizes this zone. All this, combined with the gradual development of Poaceae, suggests that a reduced forest cover, possibly of anthropogenic origin, may have been present locally. The mentioned development of Poaceae combined with the slight increase in Chenopodiaceae and *Plantago* may indicate the growth of salt-marsh habitats nearby. *Pinus* pollen appear for the first time in this zone. Because of their increasing expansion in the last 200 years (DÍAZ-FIERROS *et al.*, 1982), they can be used as a chronological indicator for recent sediments.

PAZ DON-2c (125–0 cm). The decrease in the arborean pollen values involves all the trees with the exception of *Pinus* which slightly increases at the top of the sequence (Figure 3), probably due to modern reforestations. The reduced forest cover combined with the elevated frequencies of Poaceae, Asteraceae and Ericaeae, suggests an open environment. The distinction between both terrestrial and aquatic Poaceae is difficult. For this reason the increase in Poaceae that we observed can also be due to the development of aquatic grasses in the lagoon. The decrease of *Plantago* and Chenopodiaceae coinciding with a rise in Cyperaceae pollen may reflect the removal of marine influence at the site. Cerealia pollen also expands in this zone.

A considerably higher content of microcharcoal particles in this zone in comparison with the previous zones (Figure 4) indicates a possible increase in the occurrence of fires (SWAIN, 1973). In fact, a decrease in both *Castanea* and total arboreal pollen percentages at 60 cm coincides with a maximum in the occurrence of microcharcoal particles. This is accompanied by a slight increase in Asteraceae and Poaceae pollen concentrations and the development of the well known pyrophyte *Asphodelus*.

Diatom stratigraphy

Diatom preservation was very variable throughout the core. Sampled levels between 155 and 175 cm contained few diatoms making reliable quantitative analysis not possible. The top 105 cm were barren of diatoms.

Eighty-four species were identified in the core. Relative abundances of those reaching 5% in at least one sample are shown in Figure 5. Both this diagram and that which groups diatoms according to the criteria of VOS and DE WOLF (1993) (Figure 6) allowed the distinction of three diatom assemblage zones (DAZs). These zones, however, were not coincident with the pollen assemblage zones (PAZs).

DAZ DON-2a (420–230 cm). This zone shows the codominance of freshwater epiphytes (mainly *Achnanthes minutissima*) and freshwater plankton (mainly *Aulacoseira ambigua* and *Cyclotella pseudostelligera*). There is an upward decrease in the freshwater plankton essentially due to the diminution in *Cyclotella pseudostelligera*. Percent abundances of the most prominent diatom groups reflect the establishment of a typical freshwater coastal lagoon subjected to no tidal influence

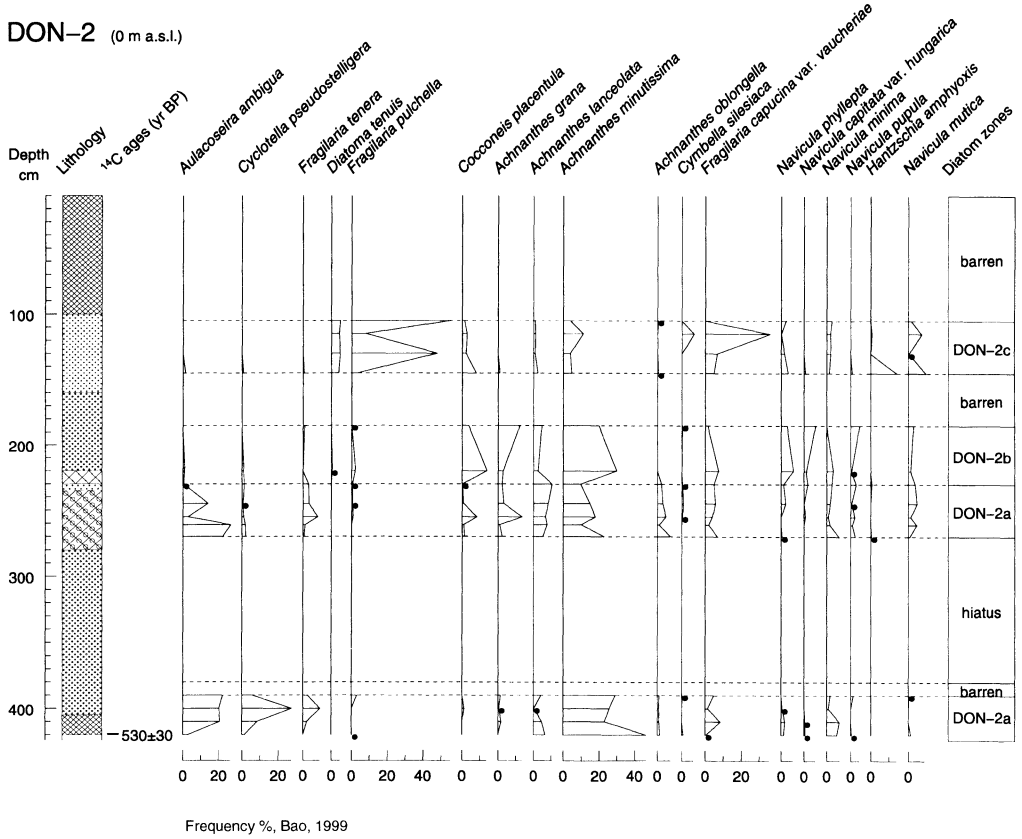

Figure 5. Diatom diagram (percentage abundance) for selected taxa of DON-2. Lithostratigraphic symbols follow TROELS-SMITH (1955).

(VOS and DE WOLF, 1993) with a salinity almost never above 0.5‰. The high percent value of the planktonic diatoms reflects moderate depth conditions with the development of ample extensions of open waters.

DAZ DON-2b (230–185 cm). Freshwater epiphytes, basically *Achnanthes minutissima*, predominate in this diatom zone, while planktonic and tychoplanktonic diatoms almost disappear. These data support the idea of the development of a denser macrophytic cover in the lagoon. The high abundance of *Achnanthes minutissima* might also be indicative of a higher accretion rate (EARLE and DUTHIE, 1986). Increased relative abundance of brackish/freshwater diatoms compared to the previous zone might indicate a slight increase in salinity.

DAZ DON-2c (145–105 cm). A peak in brackish/freshwater aerophilous diatoms (mainly *Hantzschia amphyoxis* and *Navicula mutica*) characterizes the commencement of this zone. However, the main feature for this diatom zone is the existence of alternative episodes of dominance of the freshwater and marine/brackish epiphytes. The former are represented by *Fragilaria capucina* var. *vaucheriae* while the latter mainly correspond to *Fragilaria pulchella,* which can reach 55% of the total diatom assemblage in this zone. Although high values of marine/brackish epiphytes are also characteristic of coastal lagoons (VOS and DE WOLF, 1993), they clearly point to a stronger tidal influence in the system. Episodes with dominance of *Fragilaria pulchella* might indicate that salinity could reach as high as 30‰. The data point to a notable contrast in salinity conditions for this zone when compared to the rest of the core.

PALEOENVIRONMENTAL INTERPRETATION AND DISCUSSION

Pollen, charcoal, diatom and sedimentological analyses allow a tentative reconstruction of the environmental changes taking place in the Doniños coastal lagoon and surrounding area for the last 500 years which can be contrasted with the available documentary data.

The base of the sequence (AMS ^{14}C 530±30 yr BP; cal AD 1420–1460) is characterized by high abundances of freshwater planktonic diatoms (DAZ DON-2a) suggesting the establishment of moderately deep water conditions which contrast with the present-day development of a soil environment at the site where the core was taken. According to diatom data, this site therefore developed an inner lagoonal facies typical of a freshwater coastal lagoon situation. Diatom assemblages indicate that salinity conditions probably never surpassed 0.5‰, suggesting the existence of a quasi-permanently closed inlet which prevented marine influence and provoked freshwater retention giving rise to moderate water depth conditions at this time. Sedimentological data confirm the devel-

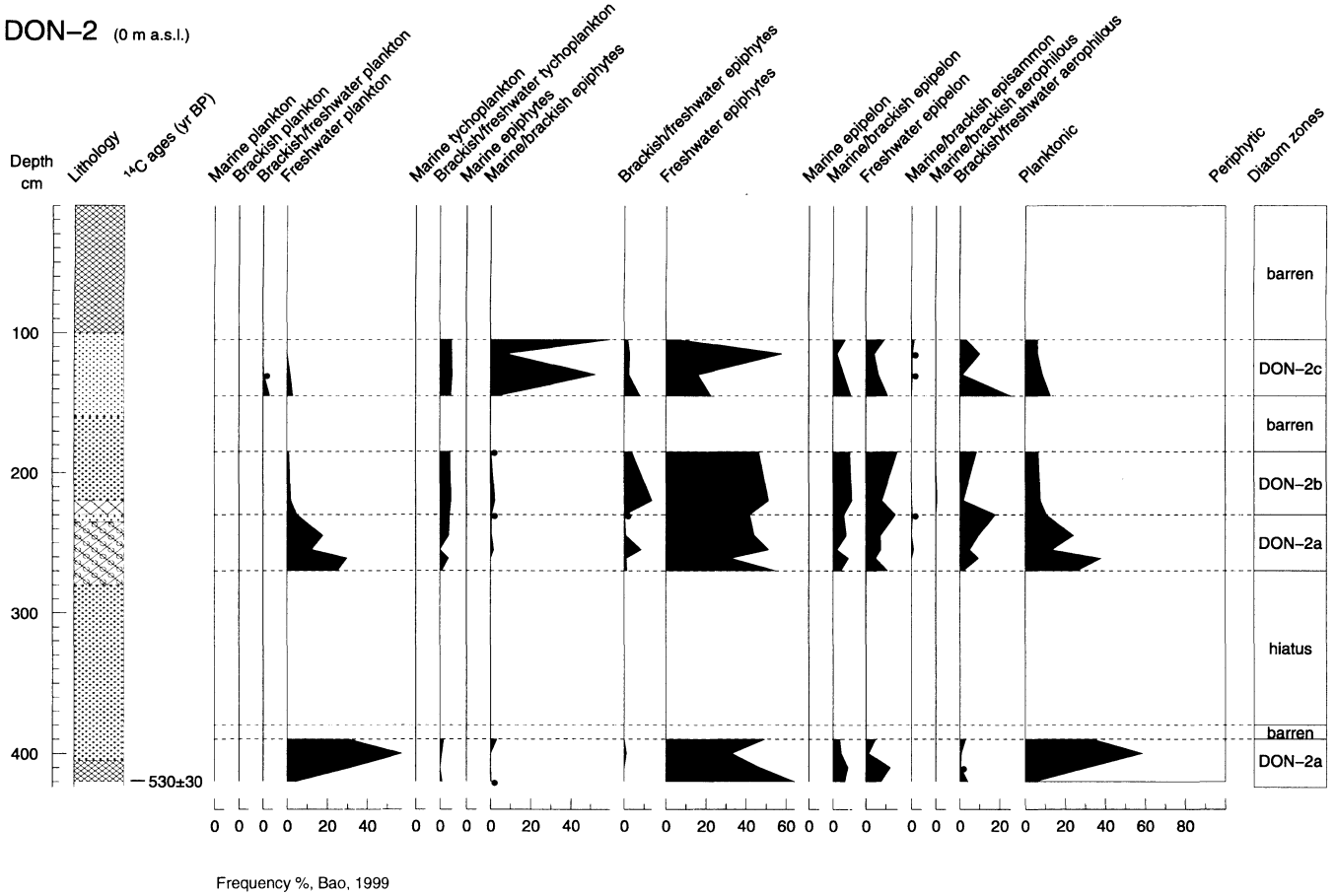

Figure 6. Diagram of diatom ecological groups (Vos and De Wolf, 1993) of DON-2. Lithostratigraphic symbols follow Troels-Smith (1955).

opment of a non-alluvial but lacustrine dominated type of sedimentation at the bottom of the sequence.

Written sources confirm the paleoecological data. They document that the Doniños Lagoon occupied an extension at least twice the size of present-day times, 150 years ago (Madoz, 1847; Montero Aróstegui, 1858 in Fernández López, 1998). According mainly to the diatom and sedimentological data, the coring site might be included in the lagoon itself at the beginning of our record.

On the basis of previous works (Jacobson and Bradshaw, 1981; Prentice, 1985; Sugita, 1993, 1994) this large basin would recruit in its lacustrine sedimentation period, pollen from the regional vegetation. Pollen data during this episode (PAZ DON-2a and PAZ DON-2b) show, however, high abundances of *Castanea* pollen percentages (20–45%) which indicate a *Castanea* forest in the Doniños basin. We believe the pollen representation of this forest has masked the regional deciduous *Quercus-Corylus* forest signature recorded by the pollen analysis of a core from the Ría de Ferrol (Santos *et al.*, unpublished data, indicate a dominance of this forest since 3,000 yr BP). In our record of Doniños deciduous forest taxa are only represented by low percentages of pollen grains of deciduous *Quercus, Corylus* and *Betula* trees. Under natural conditions, *Castanea* would probably not be dominant but only a component of the regional mixed forest. The dominant *Castanea*-woodland could be related to its cultivation as attested by the historical archives (Carballo, 1991).

This result contrasts with the typical reflection of local vegetation dominated by *Pinus* in most of the Galician late-Holocene coastal sequences (Saa Otero, 1985; Saa Otero and Díaz-Fierros, 1983, 1985, 1986). *Castanea* woodland and a regional deciduous forest were coeval with patches of herbaceous plants indicating to some extent that deforestation existed at this time. Evidence of anthropogenic deforestation exists from at least the XVI century when there was an important demand of wood for the closeby shipyard of Ferrol and for exportation (Saavedra, 1991). The preservation of *Castanea* woods as opposed to deforestation could be due to the traditional use of chestnuts for food in the region which was abandoned around the XVII century (Carballo, 1991).

The transition from DAZ DON-2a to DAZ DON-2b at 230 cm coincides with an increase in organogenic sedimentation as reflected by the LOI values (Figure 2). Shallowing of the lagoon is confirmed by the almost exclusive dominance of benthic diatoms during DAZ DON-2b. The epiphytic character of the dominant species, *Achnanthes minutissima*, sug-

gests an important increase in macrophytic development and a higher sediment supply (EARLE and DUTHIE, 1986). All this indicate a reduction in the size of Doniños Lagoon. Unfortunately, between 230 and 125 cm no pollen was recorded in the sequence.

The diatom record shows a sharp change taking place in the lagoon at DAZ DON-2c. A peak in brackish/freshwater aerophilous diatoms (*Hantzschia amphyoxis* and *Navicula mutica*) indicates increased silting up taking place in the lagoon at this time. Dominance of marine/brackish diatoms at 130 and 105 cm implies two important past salinization episodes that could raise salinity to a maximum of 30‰. The two episodes were interrupted by a peak in freshwater epiphytes mainly represented by *Fragilaria capucina* var. *vaucheriae.* The data suggest that important episodes of opening of the barrier occurred at this time. The dominance of *Fragilaria* species in this zone would be an indication of high environmental instability (DENYS, 1990) probably associated to episodes of breaching and closure of the barrier. The oligohalobous indifferent *Fragilaria capucina* var. *vaucheriae* would act as a pioneering form during closure episodes and the mesohalobous *Fragilaria pulchella* as an indicator of periods of breaching of the barrier. There is no historical documentation on important human intervention in the barrier in the period studied nor in present-day times. Establishment of a connection with the open sea was most likely a natural process that is related to the retrogradation of the sand barrier in the last 2,000 years. Analysis of a long core taken at the sand barrier records a 1,795 ± 75 years BP lacustrine episode under 20 m of sands (SANTOS *et al.,* 1999) suggesting that sand infilling has also been a decisive forcing factor. The lagoonal water body is at the same level than present-day low-tide facilitating marine water and dune sediment inputs into the lagoon during storm activity.

The pollen diagram (Figure 3) shows a barren zone corresponding to the sandy level between 230–125 cm. Following this a soil horizon, without diatoms, characterizes the top of the sequence (PAZ DON-2c: 125-0 cm). We estimate that this horizon was formed over the last two hundred years, approximately. This would be a reflection of anthropogenic drying up of the lagoonal margins conducted to obtain broader meadow extensions as documented by some historical sources (MADOZ, 1847; MONTERO ARÓSTEGUI, 1858 in FERNÁNDEZ LÓPEZ, 1998). The coring point is now outside of the lagoon implying a reduction in the pollinic catchment area that gave rise to a gradual increase in the local pollinic rainfall of periphytic vegetation. This is manifested in the important decrease in both arboreal pollen percentages and concentrations (PAZ DON-2c) and the paralell increase in herbaceous taxa such as Poaceae, Asteraceae and Ericaceae. The decrease in the percentages of the arboreal pollen and, in particular, that of *Castanea* is also probably due to the abandonment of traditional *Castanea* woodland exploitation and the transition to more intensive agricultural activities. It is well known that the introduction of potato crops started at around the XVII century replacing the *Castanea* cultivation (CARBALLO, 1991). This would indicate that the surroundings of the lagoon were mainly colonized by herbaceous plants as at present. Agriculture is documented by the increase of Cerealia pollen which shows a continuous curve from 100 cm to the top of the core. Although *Pinus,* mixed with *Eucalyptus* trees in the most recent times, is the dominating taxa in the surrounding forests since approximately the last 200 years, this core interval does not record a significant increase of *Pinus* nor the presence of *Eucalyptus,* confirming the very local pollen input at this time. The present-day regional deciduous forest is only represented by isolated pollen grains of *Quercus, Corylus* and *Betula* trees. Moreover, the concentrations of *Castanea* and *Quercus* significantly decrease although the total pollen concentration increases.

The highest content of microcharcoal particles in PAZ DON-2c (Figure 4) indicates an increase in the occurrence of fires, probably man-made, as is the case in present agricultural activities. The local vegetation, as represented by pollen assemblages, shows a clear response to this increase of fire frequency in the surroundings of the lagoon during the last few years. Deforestation probably lead to an accentuation of basin infilling due to stronger alluvial activity at the coring site.

CONCLUSIONS

The recent evolution of the Doniños Lagoon is strongly conditioned by a progressive infilling which is forced not only by anthropogenic activity but by the natural two-fold effect of alluvial sedimentation and the accumulation of big thicknesses of sand from a retrograding sand barrier. Closening of the lagoon has important effects on the interpretation of the pollen signal which changes from a mirroring of regional to local vegetation from base to top of the sequence as the lagoon fills up. From the pollen diagram of this coastal deposit is, therefore, difficult to infer changes in the regional vegetation for the last 500 years. The variations in the pollen percentage curves seem to be related to the complex interaction between basin size, human practices and breaching of the barrier. The use of the pollen records in lagoon systems to directly infer regional climatic changes could be problematic due to local noise in those systems affected by strong natural or anthropogenic siltation. A careful selection of the coring sites for any pollinic study trying paleoclimatic reconstructions is compelling in order to avoid any misinterpretation of the results.

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