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Communication

An improved time scale for the Holocene history of vegetation and environment on the South Dalmatian Island of Mljet

Malo Jezero and Veliko Jezero are two salt lagoons on the Island of Mljet off the Dalmatian Coast of Croatia (Fig.1). Originally they were fresh water lakes which were later flooded by the Adriatic Sea, Veliko Jezero as a result of a sea transgression and Malo Jezero most probably by the construction of an artificial canal. These two lakes belong to those rare locations in the Mediterranean coastal area where it has been possible to investigate the Holocene vegetation development directly using palynology. A comprehensive study of several cores from Malo Jezero was published by Beug (1961; 1967). It covers the larger part of the Holocene. Four main steps in the vegetation development on the island were revealed. In the oldest period deciduous oak woodland prevailed (Zone A). This zone was divided into an earlier part, rich in pine (Subzone A1) and a later one, with declining *Pinus* values (Subzone A2). This deciduous oak woodland was replaced by evergreen maquis-like vegetation, dominated by *Juniperus* and *Phillyrea*, in Zone B that followed. Later, evergreen *Quercus ilex* woodland spread (Zone C). In this zone the accompanying vegetation changed several times; firstly *Juniperus* still occurred abundantly (Subzone C1), then *Erica* spread (Subzone C2) and finally high frequencies of *Pinus* (Subzone C3) marked the transition to vegetation dominated by pine forests (Zone D).

Beug's study already included 3 radiocarbon dates obtained from bulk samples. Beug concluded from these dates that the change from deciduous oak woodland to evergreen vegetation at the transition from Zone A to Zone B was the result of climatic change to drier conditions around 6000 B.C., whereas the dominance of *Quercus ilex* woodland in Zone C was due to the later immigration of this tree species on the Dalmatian coast. The *Quercus ilex* woodland was considered by Beug to be the natural climax vegetation on the Island of Mljet and the Dalmatian coast. In Subzone C3 the increasing values of *Pinus*, a tree which is not part of the natural vegetation on the Southern Dalmatian coast, coincided with the appearance of *Juglans*, a species which was introduced in the area by man (Bottema 1980). Similarly the spread of *Pinus* was considered to be the result of human impact in historical times, however most of this period was not included in Beug's study.

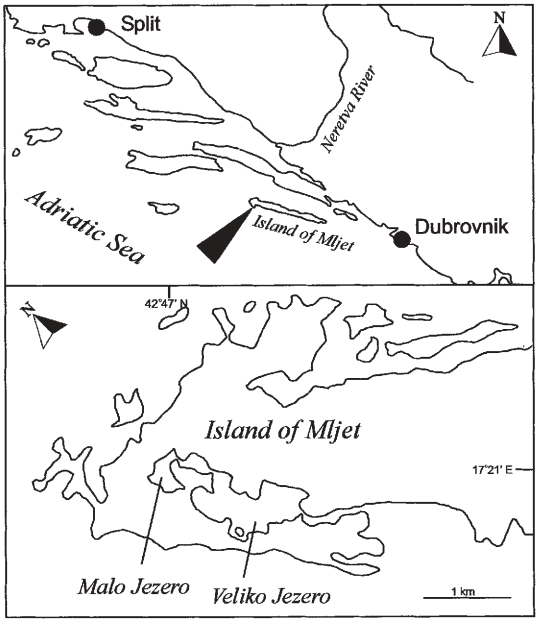

Fig. 1. Location of Malo and Veliko Jezero on the Island of Mljet off the Dalmatian Coast

In a second palynological investigation on sediments from both Malo and Veliko Jezero it was possible to trace the vegetation development up to modern times, and to establish a subdivision of the pine-dominated Zone D into three subzones. The first subzone contained a transitional forest of *Pinus* and *Quercus ilex* (Subzone D1). The next showed a decline in the holm oak and an increase in *Juniperus* (Subzone D2), while the final subzone was dominated by pine forest, fitting well with the picture of the modern vegetation around Malo and Veliko Jezero (Subzone D3). As a result of 11 additional radiocarbon dates a more detailed time scale was established (Jahns 1992) confirming the older one. However, as these dates were also obtained from bulk samples distortion of the ages by old carbonate could not be ruled out, especially as the island of Mljet is mainly formed of limestone. The only reliable date was contributed by the identification of a thick tephra layer in the cores in Subzone A2. This was determined by C. van den Bogaard to have originated from the Mercato-Ottaviano eruption in Italy at 6720 B.C. (Jahns and van den Bogaard 1998).

Although further palynological studies were carried out in the coastal area of the Balkan Peninsula, this sequence of a very early spread of *Juniperus* and *Phillyrea* followed by *Quercus ilex* woodland appeared to be unique to the Island of Mljet. This made the establishment of a reliable time scale for the vegetation development on the South Dalmatian coast especially important.

Fortunately it became possible, within the framework of the Circum-Mediterranean Biomes Initiative (CiMBIO) of the Max-Planck-Institute for Biogeochemistry, Jena, to obtain five AMS dates from pollen concentrates of material remaining from the second study on Malo Jezero (core MJ1) and Veliko Jezero (core VJKA). The samples were prepared after Brown (1994) and Regnéll and Everitt (1996). Since the sediment was very rich in pollen and there were hardly any pollen grains from aquatic taxa, conditions were excellent for obtaining undistorted ages. These results are presented in Table 1.

Based on these new data it is now possible to fix a precise age for most of the steps in vegetation development referred to above (Fig. 2). As the two coring sites MJ1 and VJKA are only ca. 500 m apart, it is possible to transfer the dates obtained from one core to the other. Together with the date of the deposition of the Mercato-Ottaviano tephra, the new dates reveal a very constant sedimentation rate of 0.2-0.5 mm/a from 6720-820 B.C. in both lakes. From this it is possible to calculate the ages of the flooding of Veliko Jezero by a sea transgression (3900 B.C.) and the construction of the canal between Malo and Veliko Jezero (850 B.C.); this latter event must now be attributed to pre-Roman inhabitants of Mljet. *Juglans* was introduced to the island in ca. 900 B.C., not by the Romans as previously assumed, but probably by Phoenician or Greek traders or settlers, who are reported to have been on the Dalmatian coast at that time. From ca. 820-660 B.C., when human impact starts to be shown clearly by the pollen record, the sedimentation rate increases markedly in both lakes, most probably as a result of land-use. A comparison with the older bulk samples shows a reservoir effect of ca. 300 years for the older dates.

With the help of the new radiocarbon dates and the dating of the Mercato-Ottaviano tephra, it is possible to date the major part of the Holocene vegetation development on the Island of Mljet precisely. This is crucial for the interpretation of plant migration, climatic change and human impact on the vegetation. However, as regards the most recent part of the pollen record which is the most important in view of human impact in historical times, all the material has been used in the palynological study. Therefore precise dating of this section is still required. For this there is the option of using annual sediment layers and several tephra layers from Malo Jezero, which have already been described by Jahns and van den Bogaard (1998).

Table 1. Radiocarbon dates (calibrated after Stuiver et al. 1998)

Lab. Nr.	Core	Pollen zones	^{14}C dates from new pollen samples	Bulk samples (Jahns 1992)
J 498	VJKA	C3/D	2500 ± 40 B.P. 761; 680; 668; 613; 593; 564 B.C.	
J 494	VJKA	C2/C3	2670 ± 40 B.P. 821 B.C.	ca. 1100 B.C.
J 495	MJ1	C1/C2	4370 ± 45 B.P. 3005; 3002; 2923 B.C.	ca. 3300 B.C.
J 496	MJ1	B/C1	5300 ± 50 B.P. 4218; 4200; 4157; 4151; 4127; 4049 B.C.	ca. 4400 B.C.
J 497	MJ1	A/B	6730 ± 70 B.P. 5636 B.C.	ca. 6000 B.C.

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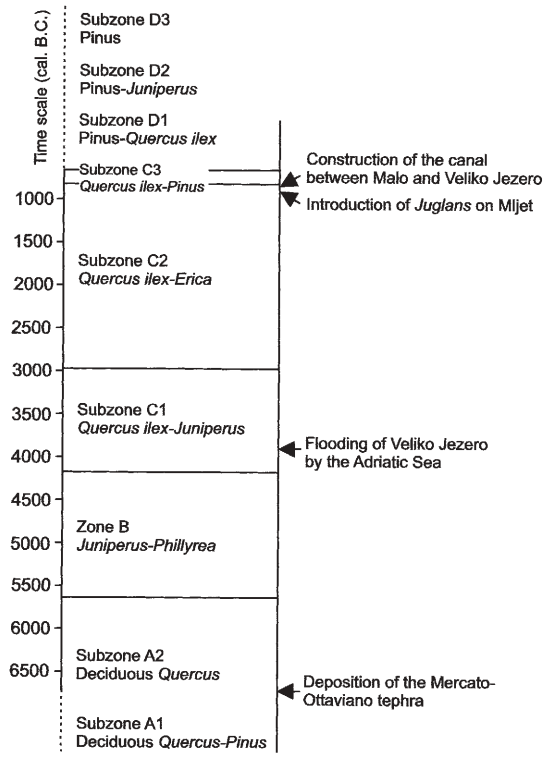

Fig. 2. The development of the vegetation and environment on Mljet showing the new time scale

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