

# Quantification of the northern Italy Pliocene climate from pollen data: evidence for a very peculiar climate pattern

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A climatic reconstruction has been carried out on the Stirone pollen sequence (northern Italy), covering the Pliocene period from the Zanclean to the early Gelasian (~5.1 to ~2.2 Ma). Despite the existence of a number of hiatuses, the section provides a clear picture of the vegetation and climatic evolution during this time interval, which includes the first glacial-interglacial cycles of the Northern Hemisphere. The climate of this period has been quantified using the 'Climatic Amplitude Method' developed for the Neogene, and five climatic parameters have been estimated. The results show that at the beginning of the Pliocene and during the interglacial periods the climate was warm and humid (mean annual temperature from 16 to 20°C, mean annual precipitation from 1100 to 1500–1600 mm), similar to that found elsewhere in the northwestern Mediterranean area. However, during the first glacial periods the reconstructed climate differs from that found at other Mediterranean sites: the mean annual temperature, the temperature of the warmest and coldest months show lower values than those found during the lower Pliocene, but no marked reductions are observed in the annual precipitation, allowing the continuous presence of a forested environment. These results are in agreement with the hypothesis that from at least the Upper Pliocene the Po region has been a special region from the point of view of both vegetation and climate. The difference is particularly marked during the earliest glacial phases in northern Italy.

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It is now well established that during the Pliocene (5.32 to 1.77 Ma) at mid-latitudes there was a progressive transition from a relatively warm climate to the cooler climate of the Pleistocene. This transition includes the first glacial-interglacial cycles of the Northern Hemisphere, which started at around 2.8–2.7 Ma (Leroy *et al.* 1998; St. John & Krissek 2002).

While this period is well documented in pollen records all over Europe, the Mediterranean region *s.l.* is particularly well suited for pollen-based Pliocene vegetation and climate reconstructions, owing to the large number of sites which cover this time period. This is the result of the marine transgression of the earliest Zanclean which terminated the Messinian salinity crisis (e.g. Hsü *et al.* 1973). In addition, most of the Mediterranean sequences covering the Pliocene are chronologically well calibrated using biostratigraphy, magnetostratigraphy and cyclostratigraphy. This is especially true for the Italian Pliocene sequences for which magneto-, cyclo- and biostratigraphic studies have been carried out on land sections in Sicily, Calabria, Northern Apennines (e.g. Channell *et al.* 1988, 1994; Hilgen 1991a, b) and on ODP cores from the Tyrrhenian Sea (e.g. Channell *et al.* 1990; Rio *et al.* 1990a, b).

The climate of the Pliocene has already been reconstructed for 18 Western Mediterranean pollen sequences taken from southern France, Spain (Catalonia, Andalusia), Portugal, North Africa and Italy

(Sicily) (Fauquette *et al.* 1998a, 1999a), but no attempt has yet been made to quantify the climate of this period in northern Italy. Such a reconstruction is of great interest, given the distinct nature of the vegetation of this region, especially during the mid-Pliocene and Pleistocene (Lona 1950, 1962; Lona & Bertoldi 1972; Bertolani-Marchetti *et al.* 1979; Bertini 1994a, b, 2001; Ravazzi & Rossignol-Strick 1995).

In this article, we present the results of a reconstruction of the Pliocene climate of northern Italy using pollen data taken from the Stirone section established by Bertini (1994a, b, 2001). This marine section covers the time interval ~5.1 to ~2.2 Ma and includes the first glacial-interglacial cycles of the Northern Hemisphere. For this study, the 'Climatic Amplitude Method' developed by Fauquette *et al.* (1998a, b) has been used to quantify the climate. This method has previously been applied to 18 pollen sequences of the Western Mediterranean area (Fauquette *et al.* 1998a, 1999a), and the results obtained are consistent with the interpretation of Pliocene pollen diagrams for this period in Europe and the Mediterranean region (Zagwijn 1960; Suc *et al.* 1995a, b), and also in North America (Thompson 1991; Willard 1994).

## The Stirone section

The Stirone section is located in the Northern Apennine