

Magnetostratigraphic dating of an intensification of glacial activity in the southern Italian Alps during Marine Isotope Stage 22

Giovanni Muttoni^{a,*}, Cesare Ravazzi^{b,c}, Marzia Breda^d, Roberta Pini^{b,c}, Carlo Laj^e, Catherine Kissel^e, Alain Mazaud^e, Eduardo Garzanti^c

^a *Dipartimento di Scienze della Terra, Università di Milano, Via Mangiagalli 34, I-20133 Milano, Italy, and ALP-Alpine Laboratory of Paleomagnetism, Via Madonna dei Boschi 76, I-12016 Peveragno (CN), Italy*

^b *CNR-IDPA, Section of Milano, Via Pasubio 5, I-24044 Dalmine (Bergamo), Italy*

^c *Dipartimento di Scienze Geologiche e Geotecnologie, Università di Milano-Bicocca, Piazza della Scienza 4, I-20126 Milano, Italy*

^d *Dipartimento di Geologia, Paleontologia e Geofisica, Università di Padova, Via Giotto 1, I-35137 Padova, Italy*

^e *Laboratoire des Sciences du Climat et de l'Environnement, Unité Mixte CEA-CNRS, Avenue de la Terrasse, F-91198 Gif-sur-Yvette Cedex, France*

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Abstract

We applied magnetostratigraphy and mammal biostratigraphy to date climate-sensitive pollen cycles and lithostratigraphic units of the Pliocene–Pleistocene Leffe sedimentary succession from the Southern Alps, Italy. The Leffe section was correlated to additional sections (Casnigo, Fornaci di Ranica, and Pianengo) to construct a stratigraphic network along a common fluvial system (the Serio River) sourced in the Southern Alps and flowing southward into the Po River Basin. We obtained a coherent scenario of climate variability for the last ~2 Myr. At Leffe, lacustrine deposition commenced during the Olduvai Normal Subchron (1.94–1.78 Ma) and lasted up to a chronologic level compatible with Marine Isotope Stage (MIS) 22 (0.87 Ma). Pollen analysis revealed that climate varied cyclically from warm-temperate to cool during this time interval, but never as cold as during glacial intervals. At around MIS 22, climate cooled globally. Gravels, attributed to high-energy braided river systems fed locally by alluvial fans, prograded from the Serio River catchment area over the Leffe Basin and toward the Po Plain in response to a generalized event of vegetation withdrawal and enhanced physical erosion. At this time, Alpine valley glaciers reached their first maximum southward expansion with glacier fronts located at only ~5 km upstream from Leffe.

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Keywords: Pleistocene; Magnetostratigraphy; Vegetation cycles; Mammal biostratigraphy; Ice ages; Alps; Po Plain

Introduction

Understanding the geological effects of climate change requires the application of robust chronologies to climate-proxy data retrieved from stratigraphically continuous sedimentary successions. We investigated the climatic evolution of a sector of northern Italy across the onset of the so-called mid-Pleistocene Revolution (MPR; Berger et al., 1993), one of the most critical transitions of Pleistocene climate. The onset of the MPR between 0.94 and 0.89 Ma is characterized by an increase of global ice volume that culminated with Marine Isotope Stage (MIS) 22 at 0.87 Ma (Maslin and Ridgwell, 2005). The waxing

and waning of Alpine valley glaciers, known since the early days of the ice age theory, should have followed, at least in principle, global ice volume variations. We would therefore expect to observe evidence of increased glacial activity in the Alps across the MPR, which would result in higher probabilities for valley glaciers to expand symmetrically away from elevated Alpine source regions into nearby less elevated foreland basins, namely those of Central Europe (e.g., northern Switzerland, southern Germany, Austria) and northern Italy (Po River Basin). Glaciogenic and glaciofluvial deposits attributed to such major pulses are indeed known from Central Europe since Penck and Brückner (1909), and from northern Italy since Venzo (1950), but they were rarely accurately dated, leaving open the question whether the MPR represented a turning point in style and intensity of Alpine glacial activity. More generally, it also left

* Corresponding author.

E-mail address: giovanni.muttoni@unimi.it (G. Muttoni).

unresolved the age of onset of the oldest major glaciations in the Alps. For example, evidence of glacial activity as old as late Pliocene was reported from the foreland basins of northern

Switzerland (Ellwanger et al., 1994; Bolliger et al., 1996) and northern Italy (Uggeri et al., 1997). However, according to classical chronostratigraphic schemes recently updated with

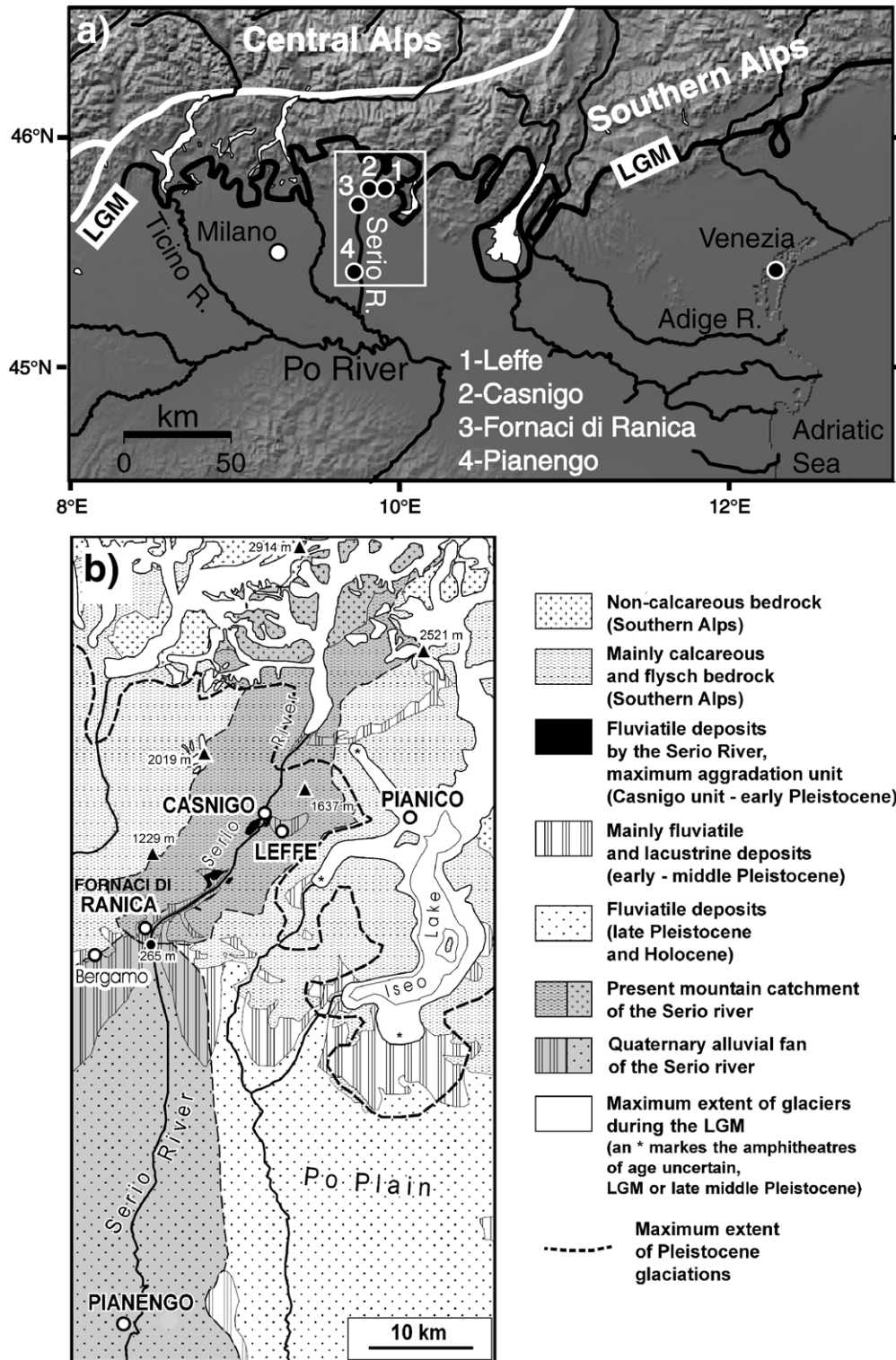


Figure 1. (a) Global elevation model of the Alpine region and (b) simplified lithologic map of the studied region with indication of the stratigraphic sections discussed in the text (white dots); the actual extension of the Leffe Basin is indicated by the outcrop area of the “mainly fluvial and lacustrine deposits” around the white dot assigned to Leffe in panel (b); the coordinates of the center of the Leffe Basin are 45°49'N, 9°51'E. All sections discussed in the text lie south of the last glacial maximum (LGM; solid line in a) and the maximum extent of any Pleistocene glaciations (dashed line in b) along a common longitudinal fluvial system sourced in the Southern Alps (i.e., the Serio River system).

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