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ON THE AGE OF CAMPO IMPERATORE GLACIATIONS, GRAN SASSO MASSIF, CENTRAL ITALY

ABSTRACT: KOTARBA A., HERCMAN H. & DRAMIS F., *On the age of Campo Imperatore glaciations, Gran Sasso Massif, Central Italy.* (IT ISSN 0391-9838, 2001).

Basing on Uranium-Series datings, performed on calcite crystals included within moraine deposits, an ancient glaciation phase which affected the Campo Imperatore depression (Gran Sasso Massif) has been referred to the late-middle Pleistocene (Riss *Auct.*). As testified by the occurrence and distribution of erratics and moraines, this glaciation («Piano Racollo Glaciation») was significantly wider than the Upper Pleistocene (Würm) one («Coppe di Santo Stefano Glaciation»), whose landforms and deposits are much more evident in the area.

KEY WORDS: Glaciation, Middle Pleistocene, Central Apennine, Italy.

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Sulla base dei risultati di datazioni Uranio/Thorio effettuate su cristalli di calcite contenuti all'interno di depositi morenici, viene riferita al Pleistocene medio finale (Riss *Auct.*) una fase glaciale che ha interessato la depressione di Campo Imperatore (Massiccio del Gran Sasso) precedentemente a quella del Pleistocene superiore (Würm). Come dimostrato dalla distribuzione dei massi erratici e dei materiali morenici ad essa attribuibili, l'estensione dela glaciazione antica («Glaciazione di Piano Racollo») è stata notevolmente maggiore di quella più recente («Glaciazione delle Coppe di Santo Stefano»), cui sono legate testimonianze geomorfologiche e sedimentarie molto più vistose.

TERMINI CHIAVE: Glaciazioni, Pleistocene medio, Appennino centrale, Italia.

INTRODUCTION

The Gran Sasso Massif with a maximum elevation of 2,914 m a.s.l. (Mt. Corno Grande) is the highest relief of Central Apennines. The area has been carefully studied by geoscientists for a long time, as it is easily accessible. In the late 70's a 13 km long motorway tunnel was constructed below the area. Thus, the geological structure, including Quaternary deposits, is well documented as compared with other parts of the Apennines. The most extensive studies on the glacial landforms and Quaternary evolution of the area were done by J. Demangeot. His monumental thesis, *Géomorphologie des Abruzzes Adriatiques*, published in 1965, has been used for many years as a background for a large number of researches. This Author formulated the idea that the very fresh and distinct glacial features of the area were formed during the Würm glaciation. This point of view was taken into discussion during the last 10 years. The occurrence of two glaciations has been established (Bisci & *alii*, 1993; Giraudi, 1994; Jaurand, 1998) within the most spectacular portion of the area named Campo Imperatore. Our works have been carried out basing on field geomorphological mapping and air-photo interpretation, as well as Uranium-Series dating.

CAMPO IMPERATORE LANDSCAPE AND GLACIAL LANDFORMS

Campo Imperatore is a NW-SE trending tectonic depression situated south of Corno Grande at elevations ranging between 2,494 (Mt. Aquila) and 1,450 m a.s.l. This depression, ca. 18 km long and 4 km wide in the central portion, generally follows a monocline structure, gently dipping to NE (fig. 1). The outcropping bedrock mainly consists of a Mesozoic-Caenozoic sequence of massive dolomite, limestone, marls and shales (Ghisetti & Vezzani, 1986; Ghisetti & *alii*, 1990).

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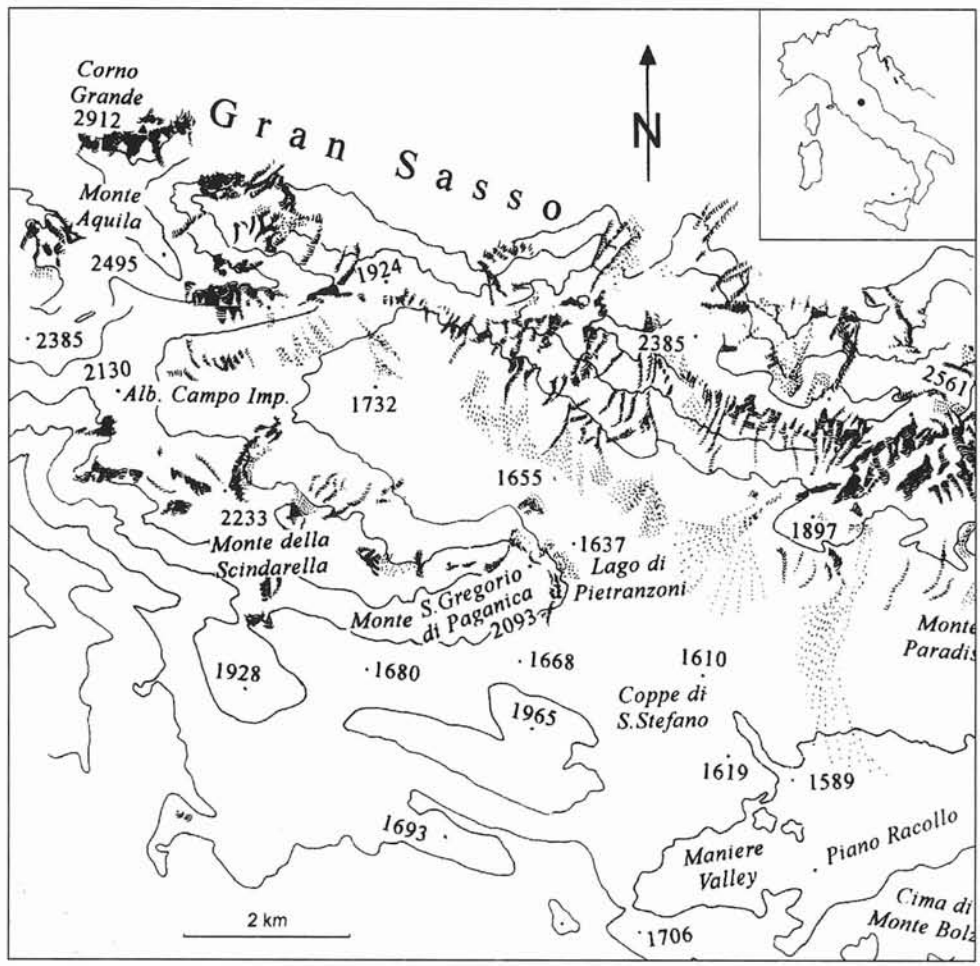

FIG. 1 - Physiography of Campo Imperatore and location of the geomorphological map of fig. 2.

The above terrains are generally disposed according to a faulted monocline, gently dipping to the north-east, even though the overall structure consists of the superimposition of several north-east trending tectonic units which took place during the Upper Miocene-Lower Pliocene (Parotto & Praturlon, 1975; Ghisetti & Vezzani, 1990; Bigi & *alii*, 1991).

During Quaternary times, the area has been affected by extensional tectonics (Carraro & Giardino, 1992; Giraudi, 1994) which produced normal fault systems mostly trending ENE-WSW and bordering to the south the Gran Sasso Massif. This tectonic phase, which has continued up to the present, caused a progressive lowering of the Campo Imperatore depression with respect to the surrounding ridges. Extensional tectonics has been sided by tectonic uplift, whose intensity strongly increased by the end of Lower Pleistocene, causing relief enhancements up to 1,000-1,500 m (Demangeot, 1965; Ambrosetti & *alii*, 1982; Dufaure & *alii*, 1989; Dramis, 1992).

Due to the relatively high elevation, Campo Imperatore was extensively affected by Pleistocene glaciation as testified. by the presence of erosional and depositional landforms, which show evidence of both Alpine steepland morphology on the bordering reliefs and stagnant ice topography typical on the flat-floored bottom. An extensive glacial drift within the depression was related to the Würm I (Demangeot, 1965) or Würm III glacial phase (Federici, 1979).

Giraudi & Frezzotti (1997) dated the phases of advance and retreat of the Upper Pleistocene deglaciation pattern. The most extensive and very distinct terminal moraines in the area mark the last maximum advance at an altitude of ca. 1,589 m a.s.l. (Coppe di Santo Stefano, fig. 2). Organic matter within silty-clayey lacustrine sediments taken from a borehole located between the terminal moraine system gave a ^{14}C age of 22,680±630 yr BP. Subsequently the glacier was reduced in size. Several retreat and advance phases are marked by recessional moraines in the upper portion of Campo Imperatore. The last one is correlated with the Younger Dryas. At the beginning of the Holocene glaciers definitely melted at Campo Imperatore (Giraudi & Frezzotti, 1997; Jau-

rand, 1998). Nowadays, a small remnant of glacial ice, the Calderone Glacier, still exists behind Campo Imperatore, at an altitude of 2,700-2,840 m a.s.l., on the north-facing side of Corno Grande (Gran Sasso Massif).

Older glacial sediments were mentioned by Carraro & Giardino (1992) about 3 km downvalley, in the eastern portion of Campo Imperatore (immediately outside the study area). Volcanic ash dated 460,000 yr BP underlies deposits that have been interpreted as glacial drift. The glacial origin of these deposits is highly disputable. Both petrographic features and topographic conditions do not allow to correlate such sediments with

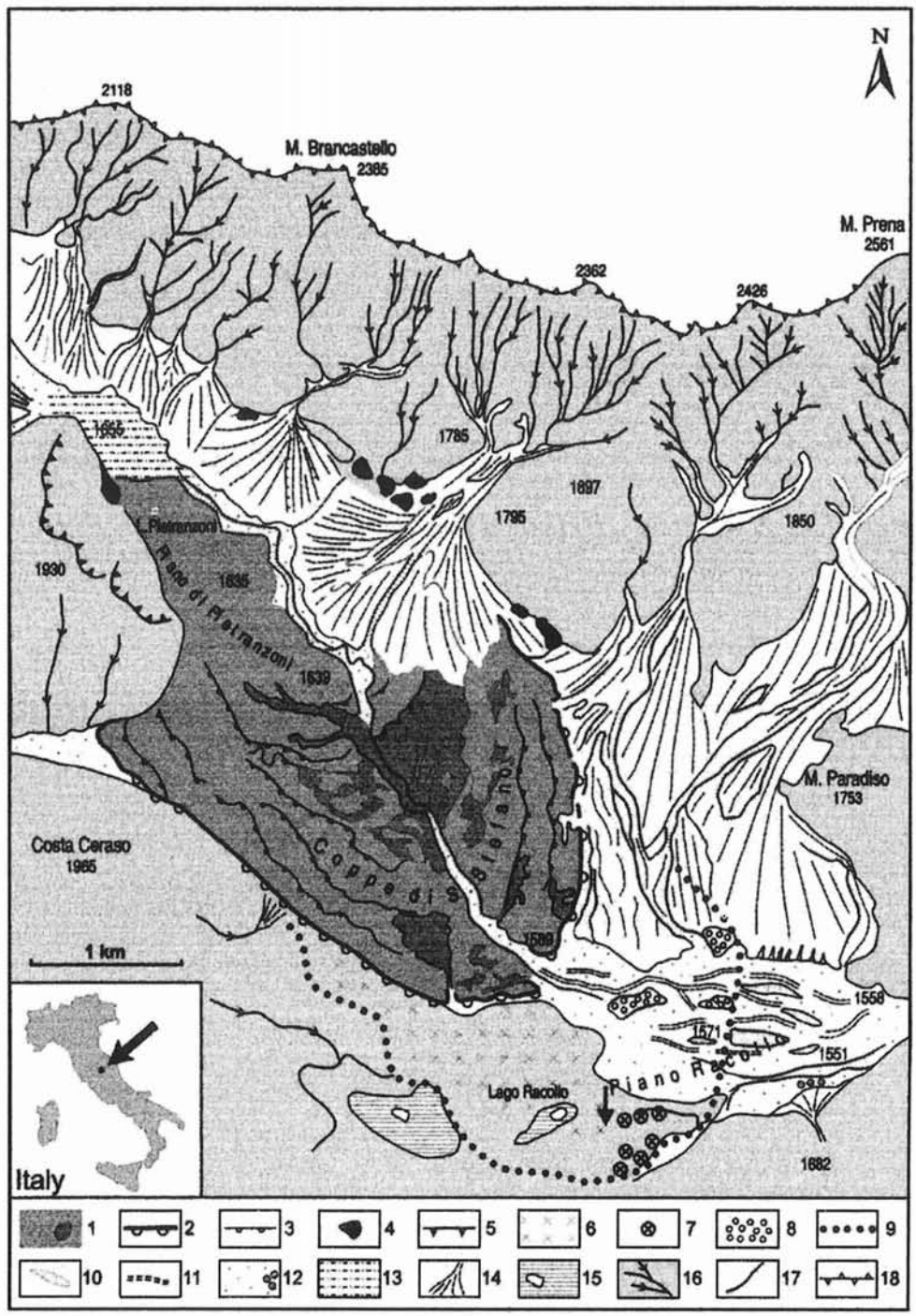

FIG. 2 - Simplified geomorphological map of the frontal portion of the Campo Imperatore glaciations. The Coppe di Santo Stefano Glaciation (1-5): 1 - Hummocky morainic system, partly filled with glacifluvial sediments; 2 - Distinct front of maximum extent; 3 - Extent of recessional stages; 4 - Lateral moraine remnant hills; 5 - Break in slope marking glacial cirque limit. Piano Racollo Glaciation; (6-9): 6 - Glacially scoured bedrock covered by thin erratic sheet; 7 - Single erratic boulders; 8 - Moraine hills, erosional remnants; 9 - Reconstructed drift limit of the Piano Racollo Glaciation. Glacifluvial landforms; (10-12): 10 - Glacifluvial hill, erosional remnant of an old outwash plain; 11 - Proglacial paleochannels within outwash plain; 12 - Glacifluvial terrace/plain locally with dead-ice hollows. Other landforms; 13 - Fluviolacustrine plain (Coppe di Santo Stefano Glaciation); 14 - Alluvial/colluvial fans, different generations, Pleistocene and Holocene in age; 15 - Proglacial/lacustrine plain in front of Piano Racollo Glaciation; 16 - Rocky slopes fragmented by chutes, bedrock topography; 17 - Erosional scarp; 18 - Narrow rocky ridge. of sampling material for Uranium-Series dating of calcite crystals.

the glacial features of the western portion of Campo Imperatore.

Detailed geomorphological mapping of Campo Imperatore made it possible to distinguish another older glacial generation in the frontal portion of Coppe di Santo Stefano (fig. 2). Using local names this older glaciation has been named «Piano Racollo Glaciation» (Bisci & *alii*, 1993). It was suggested that the Piano Racollo glacial deposits could be correlated with the last cold stages of the Middle Pleistocene (Riss *Auct.*). Such chronological reference is consistent with the pre-Würm glacial landforms and sediments known in other parts of the Central and Northern Apennines (Demangeot, 1965; Pfeiffer, 1967; Federici, 1977; Dramis & *alii*, 1980; Cassoli & *alii*, 1986). Remnants of two different glaciations at Campo Imperatore were found also by Giraudi (1994) and Jaurand (1998, 1999). On the foreland of the Coppe di Santo Stefano terminal moraines an extensive outwash plain exists. Within this outwash plain small hills are protruding. They have been interpreted as the remnants of a more extensive moraine system created during the older glaciation. They are strongly eroded, smoothed and reduced in size. The south-western maximum lateral extension of the Piano Racollo Glaciation has been reconstructed basing on the distribution of erratics deposited on glacially polished limestone/dolomite hills on the right side of Coppe di Santo Stefano. The boulders are made up of well-cemented conglomerate (breccia) or red limestone whose source area is located in the upper part of Campo Imperatore, at an altitude of 1,900 m a.s.l. Within this bedrock topography, a road cut section showed a 0,5-1 m deep and ca. 5 m long pocket in limestone filled with pebbles and cobbles cemented with calcite. This sediments were interpreted as glacial drift remnants related to older glaciation of unknown age, as evidenced by the residual moraine hills at the frontal portion of Coppe di Santo Stefano, and the erratic boulders (Aringoli & *alii*, 1997; Bisci & *alii*, 1999). Samples of calcified material infilling the pocket were collected for Uranium-Series dating.

URANIUM SERIES DATING

Two independent datings were done: the first in the Bergen Uranium-Series Laboratory, the second in the Warsaw Uranium-Series Laboratory. The standard radiometric dating procedures of $^{230}Th/^{14}U$ method were used (Ivanovich & Harmon, 1982). Two samples of 40 g (Bergen) and 13.5 g (Warsaw) were dissolved in c.a. 6 mm of nitric acid. Uranium and Thorium fractions were separated by chromatography method. The activities of ^{234}U, ^{238}U, ^{230}Th and ^{232}Th were measured by using isotope dilution with $^{228}Th/^{232}U$ spike. All measurements ware done with alfa spectrometry using *OCTET PC* (*EG&G ORTEC*). The ages were calculated by a standard algorithm (Ivanovich & Harmon, 1982) using the «Uran Age» program (Hercman, 1996). Correction for detrital Thorium was performed using the initial $^{230}Th/^{232}Th$ ratio = 1.5±0.5. Reported errors are 1 sigma.

The results of the two independent datings are presented in table 1. They are consistent each other in the 1 sigma error range. Basing on the reported results we can estimate the age of the calcite samples as a weighted mean of these Uranium-Series ages.

CONCLUSION

Geomorphological mapping of glacial, glacifluvial and lacustrine features on the direct foreland of the Coppe di Santo Stefano terminal moraine amphitheatre makes it possible to recognize traces older than Würm glaciation. The age of these landforms and sediments at Piano Racollo was supposed to be Middle Pleistocene (Bisci & *alii*, 1993, Giraudi & Frezzotti, 1997). Two independent Uranium-Series dating allow to conclude that both erratic blocks, nowadays deposited directly on the bedrock, without preserved accompanying glacial sediments, and small remnants of dated drift deposits are in the same geomorphological position and thus, could be connected with the same timespan, *i.e.* «Late Riss *Auct.*». During this last cold period the glacial ice body was larger and longer ca. 1.5 km than the Würm one. This is documented by the erratic blocks. The red limestone fragments in the breccia boulders rich in red limestone were mostly derived from the Campo Imperatore source area, close to the western end of the main watershed of Mt. Aquila. The last statement fits well with the opinion of Federici (1980) on the «Riss» glaciation of the Apennines who mentioned that «the snowline during Riss appears to have been lower than that of Würm».

TABLE 1 - Uranium-Series dating of calcite crystals

Laboratory	Lab. No.	U Conc. (ppm)	$^{234}U/^{238}U$	$^{230}Th/^{233}U$	$^{230}Th/^{232}Th$	Age (ka)	Correct Age* (ka) *BO = 1.5±0.5
Warsaw	W 6	0.187±0.008	1.112±0.061	0.711±0.026	12.5	131±7	121 (+13/–12)
Bergen	1447	0.028±0.001	1.341±0.070	0.762±0.022	17.9	142±6	135 (+10/–9.7)
Mean age:							131 ka (+12/–11)

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