FINAL REPORT PROGRAM LEFE

Two pages to be written in English

Program LEFE/ action(s)	Project Title **FUcino Tephrochronology Unites Quaternary Records**	Years 2018 – 2020

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General context: early 2018 a 98 m long double cores (F4/F5) were recovered in the sedimentary infilling of the Fucino lake. Located east of the main volcanic sources this lake is perfect for building a reference tephrochronology as well as independently dated paleoclimatic and paleoenvironmental records covering the last five interglacials.

Objectives / scientific questions: the « FUTURE «LEFFE project is the corner stone of the multidisciplinary study of this F4/F5 cores by providing a precise and independent chronological framework based on the direct 40Ar/39Ar dating of tephra layers, combined with a full chemical fingerprinting study. The goal was to provide a reference tephrostratigraphy (more than 110 tephras) that can be used as a synchronization tool for paleoclimatic archives as well to reconstruct the temporal distribution of the explosive activity of the peri-Tyrrhenian potassic volcanism, a major interest for volcanic hazards assessment.

Main results :

2018/2019: The field work (late 2018) on the Vulsini and Vico stratovolcanoes and around Roma Tiber's terraces allowed to collect the main MIS 7 to MIS 11 proximal explosive deposits that cover the time span in the Fucino sedimentary successions. The first tephrostratigraphic, palaeomagnetic, and multiproxy data including a 40Ar/39Ar date from a ~98 m deep tephra was summarized in a first article. Palaeoenvironmental proxy data show a cyclical variability related to interglacial-glacial cycles since the Marine Isotope Stage (MIS) 12-MIS 11 transition. More than 130 tephra layers are macroscopically visible, 11 of them were first analyzed (glass-WDS) and successfully correlated to known eruptions and/or other equivalent tephra (Giaccio et al., 2019) including the Tufo Giallo di Sacrofano, Sabatini (288.0 ± 2.0 ka); Villa Senni, Colli Albani (367.5 ± 1.6 ka); Pozzolane Nere and its precursor, Colli Albani (405.0 ± 2.0 ka, and 407.1 ± 4.2 ka). The direct 40Ar/39Ar dating of the lowermost tephra layer gave an age of 424.3 ± 3.2 ka.

2020: Data obtained on the reference tephrostratigraphic sections of the Roman volcanic provinces including the Vico, Mt Sabatini and Colli Albani spanning the MIS 11 to MIS 10 stages have led through a systematic integrated approach, which combined lithostratigraphic, geochronological and geochemical analyses of tephra from near-source sections of the peri-Tyrrhenian volcanoes and mid to distal settings to the improvement of the tephrochronological framework from ~425-395 ka in the Central Mediterranean area. These new data allow a critical reappraisal of the previously claimed identifications of Vico tephra from mid-distal to ultra-distal successions (i.e., Vico-Sabatini volcanic districts, Roman San Paolo Formation and Castel di Guido archaeological site, Sulmona Basin, Valdarno and Lake Ohrid), which were unavoidably biased by the poor and incomplete geochemical and geochronological reference datasets previously available (Pereira et al., 2020). By the end of 2020 the chemical fingerprinting as well as 40Ar/39Ar dating of tephra layers on the core from the 200-300ka as well as 365 to 425 ka was achieved.

2021: We are obtaining the last 40Ar/39Ar dates and geochemical data between 200 and 425 ka which represent a total of 100 tephras geochemically characterized and fourteen 40Ar/39Ar dates obtained directly on the tephras from the core. Monaco et al., (2021) publication is about Mediterranean tephrostratigraphy and peri-Tyrrhenian

explosive activity between 430-365 ka (Fig. 1). This review reveals a highly time resolved chronicle of explosive activity from the Vulsini, Vico, Sabatini, Colli Albani and Roccamonfina volcanic complexes. It is now a benchmark and valuable geochemical and geochronological dataset that can be used as a reference. Giaccio et al., (2021, Figure 2) using the 40Ar/39Ar dates obtained in the Tiber river terraces as well as the reference tephrostratigraphy sections around Roma gave precise information concerning the timing and nature of sea-level change prior to and during glacial termination V. In particular the San Paolo formation document the occurrence of two phases of relatively rapid sea-level rise, is reaction to meltwater pulse (MWP) events. The earlier MWP occurred between ~450 and ~445 ka and matches a relatively minor episode of the sea-level rise documented in an existing RSL record, while the younger MWP at ~430 ka corresponds to the high amplitude sea-level rise that marks T-V. Both MWPs coincide chronologically within uncertainties with known episodes of ice-rafted debris deposition in the North Atlantic (Heinrich-like events) and with attendant Southern Hemisphere warming, plausibly associated with the bipolar seesaw (Figure 2). Three other publications in preparation will be submitted early 2022 and will focus on the sub millennial tephrostratigraphy of MIS 6/7; MIS 7/8 and MIS 9/10 respectively. Overall at the end of project FUTUR 100 tephra layers will be chemically characterized, thirty of them being 40Ar/39Ar dated. This represents an unseen improvement for this time period of the italian explosive volcanism and a benchmark dataset for any future development and application of the tephrostratigraphic methods across the central Mediterranean paleoclimatic records between 200 and 450 ka.

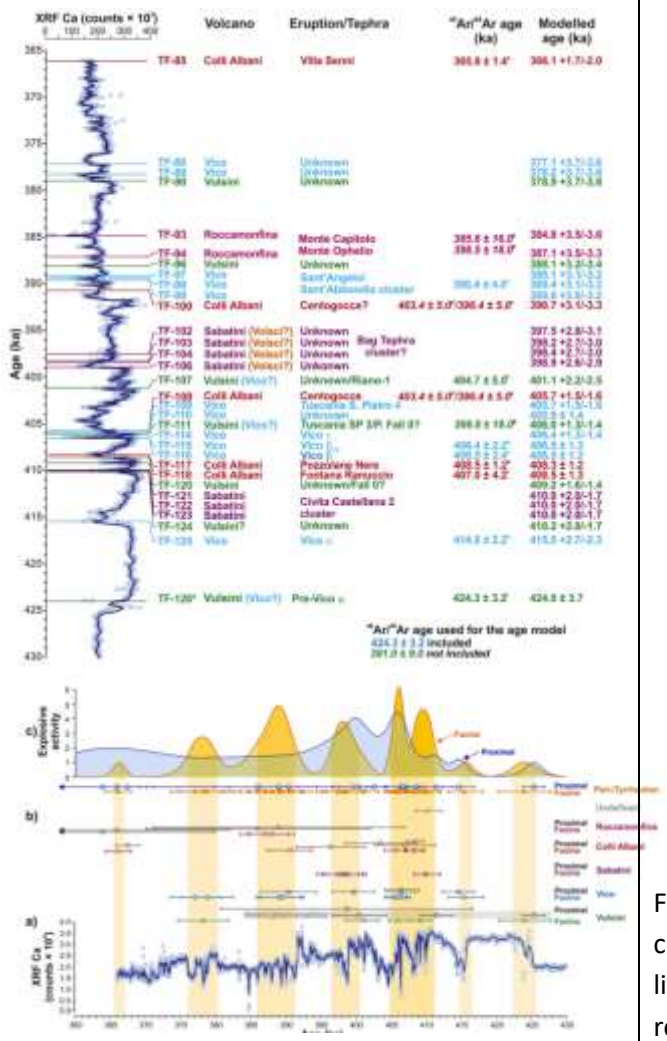

Figure 1 : Summary of the volcanic sources, individual correlation and chronology between 430 and 365 ka in Fucino F4-F5 core as well as temporal distribution of the explosive activity of the peri-Tyrrhenian potassic volcanism (from Monaco et al., 2021).

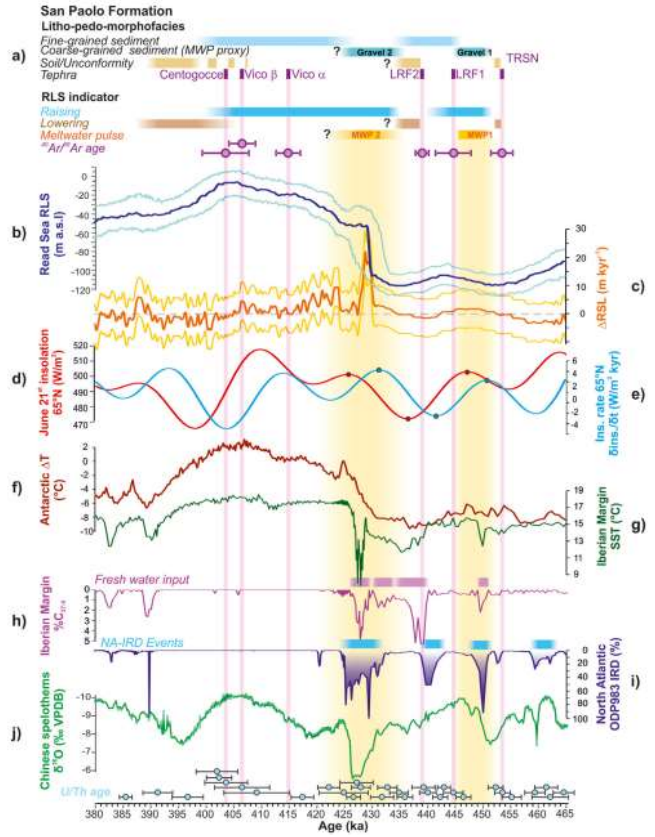

Figure 2 : Evidence of insolation, sea-level, and climate changes during the MIS 12 to MIS 11 transition. a) Main litho-pedo-stratigraphic and morphological features with related Relative Sea Level (RSL) indicators and 40Ar/39Ar geochronology of the San Paolo Formation aggradational succession (from Giaccio et al., 2021).

Future of the project :

1) Numerous studies have been initiated following the finalization early 2021 of the fully independent chronological frameworks for the Fucino F4/F5 cores including high-resolution stable isotopes sampling as well as pollens studies in key periods (i.e. MIS 6-5 and MIS 11-MIS10).

2) The discovery in the Fucino core of numerous unknown massive eruptions that can be used as tie-points/correlation points in various paleoclimatic archives between 200 and 350 ka have led to new investigations on the Roccamonfina stratovolcano in particular in order to improve our knowledge concerning the tephrochronology and history of this important volcanic massif still poorly known.

3) the FUCINO records allowed to build a reference tephrostratigraphy between 200-430 ka, however as any record it is biased because of its location (i.e. east of the main volcanic provinces). As a consequence, a new project with the same partners from Germany, Italy and England started on a marine core located east of the volcanic sources in the Tyrrhenian Sea and spanning the same time period (i.e DED 87-08). This marine core is also a tephrostratigraphic reference between the Holocene and 200 ka (Paterne et al., 1998; Paterne et al., 2008). A Master student will start in February 2022 to work on this core and we are confident that we will find common tephras with Fucino allowing to compare and synchronize independently from the paleoclimatic signals continental and marine paleoclimatic and environmental records. The final goal is to provide to the community a more complete tephrostratigraphic record between 200 and 430 ka that will include western and eastern records. This have major implications on synchronization in the Mediterranean realm the paleoclimatic archives and to improve our knowledge of the temporal distribution of the explosive activity of the peri-Tyrrhenian potassic volcanism.

Nombre de publications, de communications et de thèses

Publications : 4 : Giaccio et al., 2019 (https://doi.org/10.1016/j.quascirev.2V019.106003); Pereira et al., 2020 (https://doi.org/10.1016/j.quascirev.2020.106470); Monaco et al., 2021 (https://doi.org/10.1016/j.earscirev.2021.103706); Giaccio et al., 2021 (https://doi.org/10.1016/j.quascirev.2021.106976)

Communications in congress: 7 : Nomade et al., Goldschmidt (2021) ; Monaco et al., AIV-INGV-UNICT Conferenza A. Rittmann (2020); Nomade et al., and Monaco et al., colloque Q12 (2020); Monaco et al., Congresso congiunto SGI-SIMP-SOGEI Parma (2019) ; Giaccio et al., EGU (Vienna (2018) ; Wagner et al., Colloque DFG IODP/ICPD Bochum (2018).

Ph D Thesis : 1 : Lorenzo Monaco (Univ. Sapienza I Roma). Title “timing, dynamics and evolution of the peri-Tyrrhenian Quaternary Italian potassic volcanoes. Study based on the investigation of both distal tephra sequences hosted in inter-Apennine basins and proximal (i.e., near vent) pyroclastic deposits” PHD defense in december 2021.