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K-Ar dating of recent thrusts: an application to the Tertiary clay gouges in the Northern Apennines of Italy

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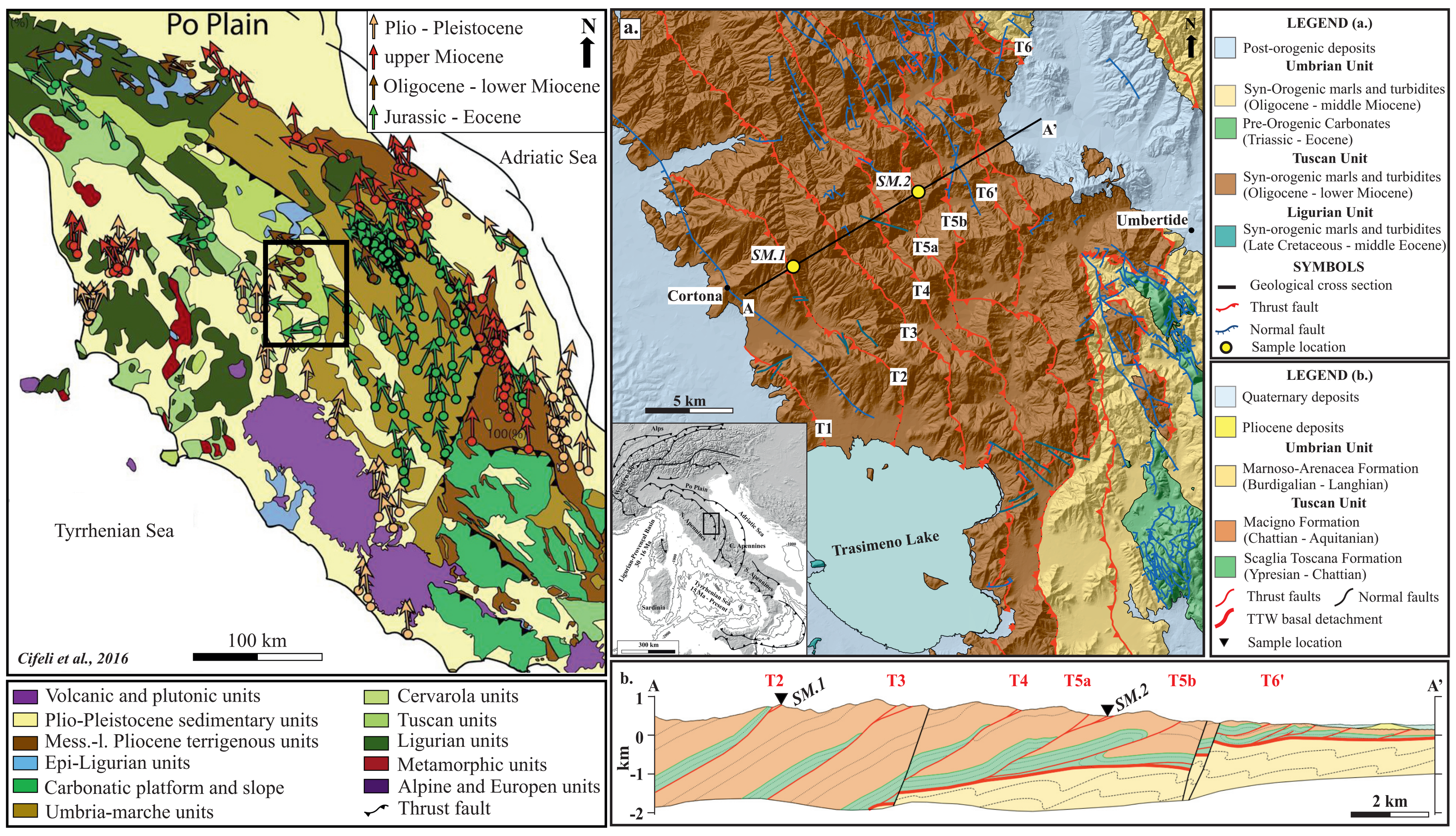
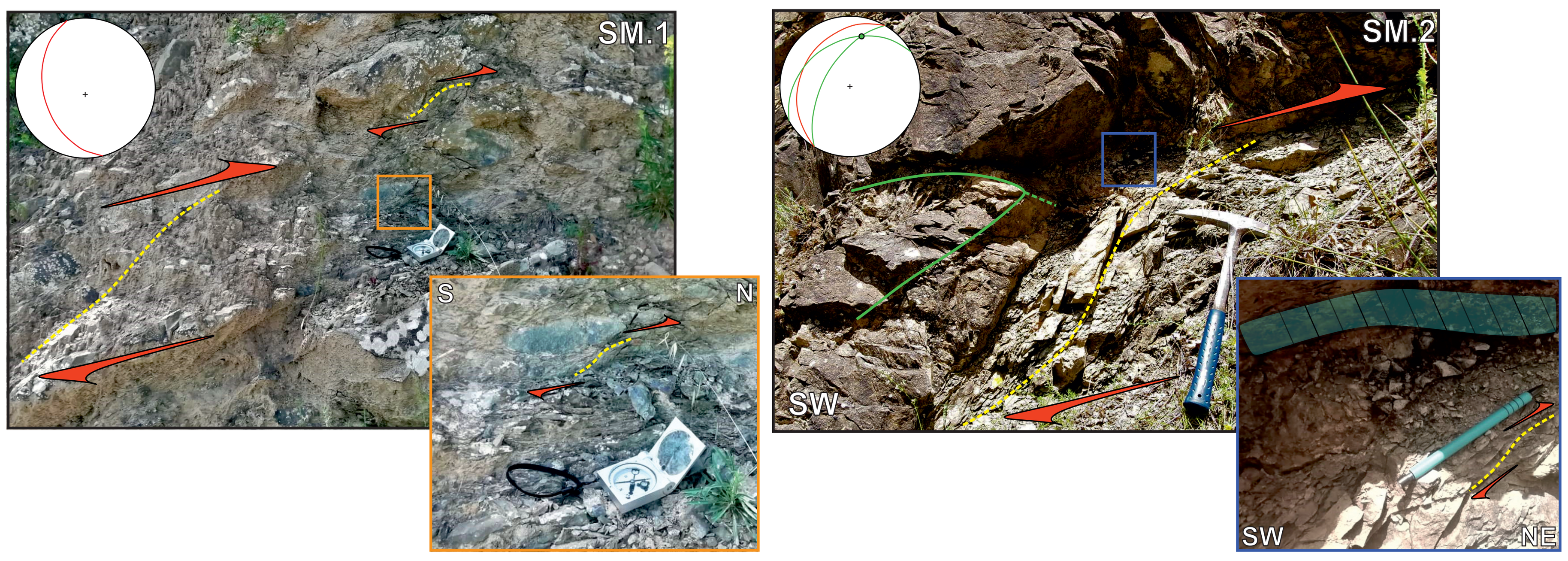
INTRODUCTION

Recent advances in K-Ar dating of brittle fault rocks were mostly possible by the study of Mesoproterozoic, Paleozoic and Mesozoic faults developed in basement rocks, which, generally, do not host fine graned illite. With the exception of only one K-Ar dating study on Oligo-Miocene deformation on the Elba Island (Viola et al., 2018), the reliability of this method toward the accurate dating of Neogene deformation has not yet been extensively tested. The well-known stratigraphy and emplacement ages of the NA tectonic units make this belt well-suited to further test and develop techniques to directly date Neogene thrusts, deforming siliciclastic flysch deposits. Here we focus on the Trasimeno Tectonic Wedge (TTW *sensu* Carboni et al., 2019), an early Miocene imbricate thrust system made up of Tertiary sequences, which represents the outermost imbricated front of the so-called Tuscan Nappe located in the inner-central part of the NA.

GEOLOGICAL FRAMEWORK AND SAMPLE DESCRIPTION



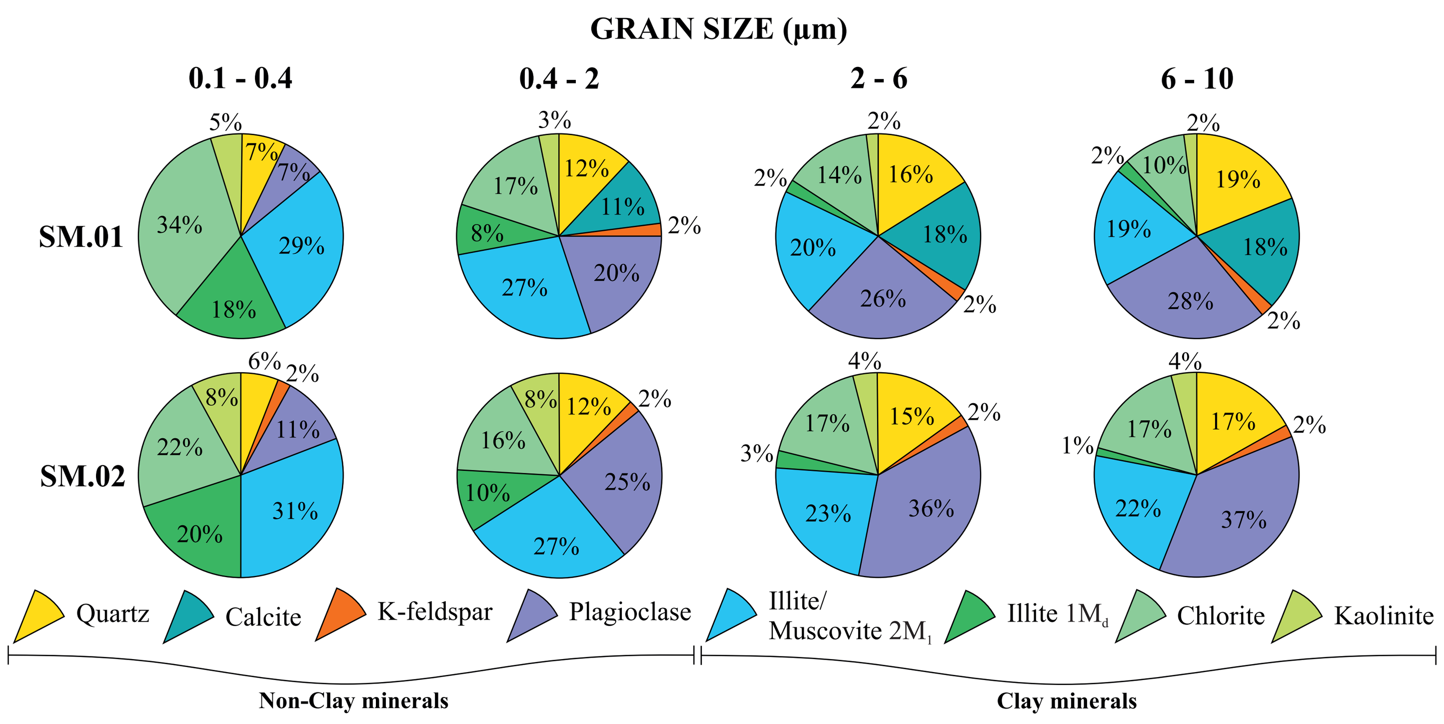


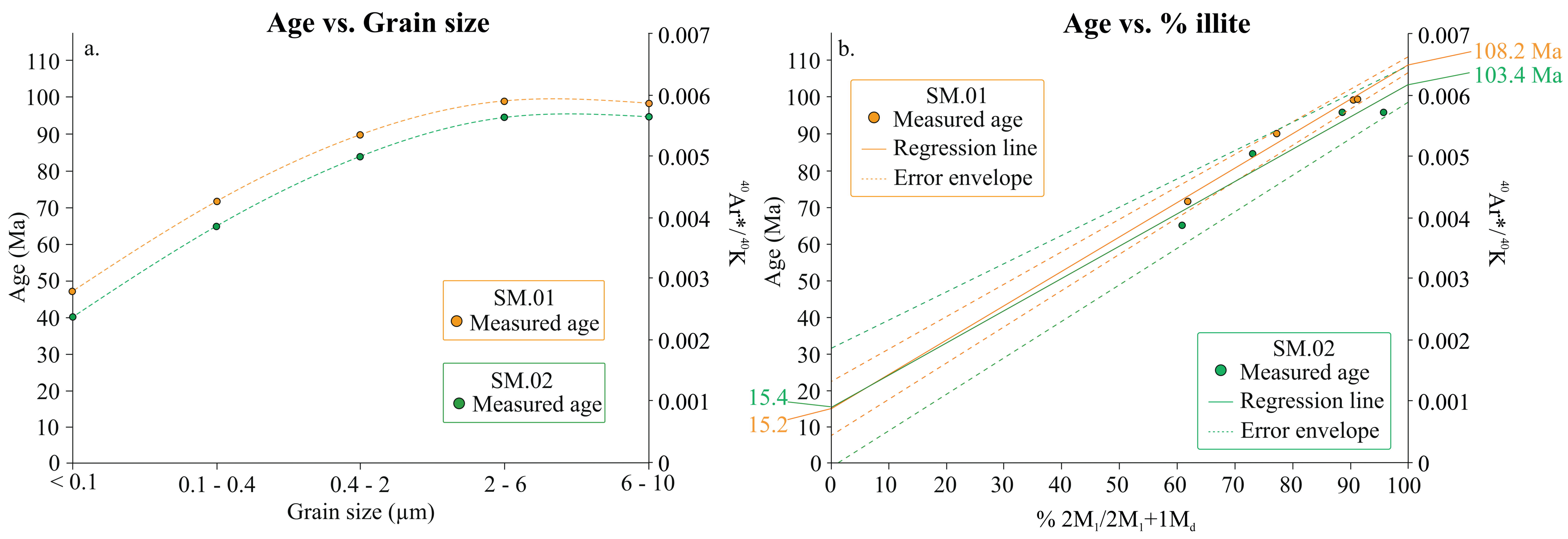
The two sampled fault gouges shows a pervasive S-C fabric formed at the expenses of the pelitic component. Sample SM.1 comes from a brownish-blueish fault gouge, 20 to 35 cm thick, containing west-dipping C planes oriented 245°/45°. Sample SM.2 was collected in a light-grey, greenish fault gouge up to 30 cm thick, characterized by a pervasive S-C fabric within a fault core with overall orientation of 300°/30°; a mesoscopic, E-verging fold, is associated with the thrust with an axis plunging 13° to 27°.

Since the Oligocene, the NA evolution was steered by the W-dipping subduction of the remnant oceanic lithosphere of the late Mesozoic Western Tethys and of the thinned continental crust of the passive margin of Adria. The eastward retreat of the subducting Adria Plate generated the back-arc extension of the Ligurian-Provençal Basin (Oligocene – lower Miocene), coeval with the eastward migration of the compressional front and the stacking of the Ligurian, Tuscan and Umbrian paleo-geographic domain sequences into a well-imbricated tectonic wedge.

The TTW is made up of a set of ENE-verging imbricated slices, bounded by discrete brittle thrusts that brings the Ypresian - Aquitanian Tuscan units over the Triassic - Miocene Umbrian units. Available bio-chronostratigraphic data constrain the timing of emplacement of the TTW to between the Late Aquitanian and the late Burdigalian - earliest Langhian.

METHOD AND RESULTS





During brittle deformation, fault slip can develop cataclasites and gouges composed of crushed rock fragments and authigenic syn-kinematics clay minerals (i.e. Illite). In the case of fault gouges developed at shallow depths and formed at the expense of siliciclastic turbidites or pelites, the contamination of the finest fractions with original no authigenic/synkinematic K-bearing minerals affect the Age vs Grain size relationships, giving meaningless ages of deformation. The K-Ar fault gouge dating approach used in this study is therefore based on the Illite Age Analysis approach (IAA) to distinguish between authigenic 1Md (low-temperature) vs. detrital 2M1 (high temperature illite + cataclasitically derived muscovite) illite polytype by XRD analysis (Pevear, 1999). The finest fraction consists of neo-crystallized illite, derived from syn-kinematics grains or corresponds to tiny syn-kinematics individual crystallites (Toergensen et al., 2015). The age of the last faulting event recorded by the studied gouge samples corresponds to the intercept of the regression lines above for 0% 2M1, that is for the conditions where the fault rock contains no protolithic high-temperature illite but only authigenic, synkinematic and lower temperature illite. The obtained ages of fault activity are 15.2 Ma for SM.1 and 15.4 Ma for SM.2.

DISCUSSION AND CONCLUSIONS

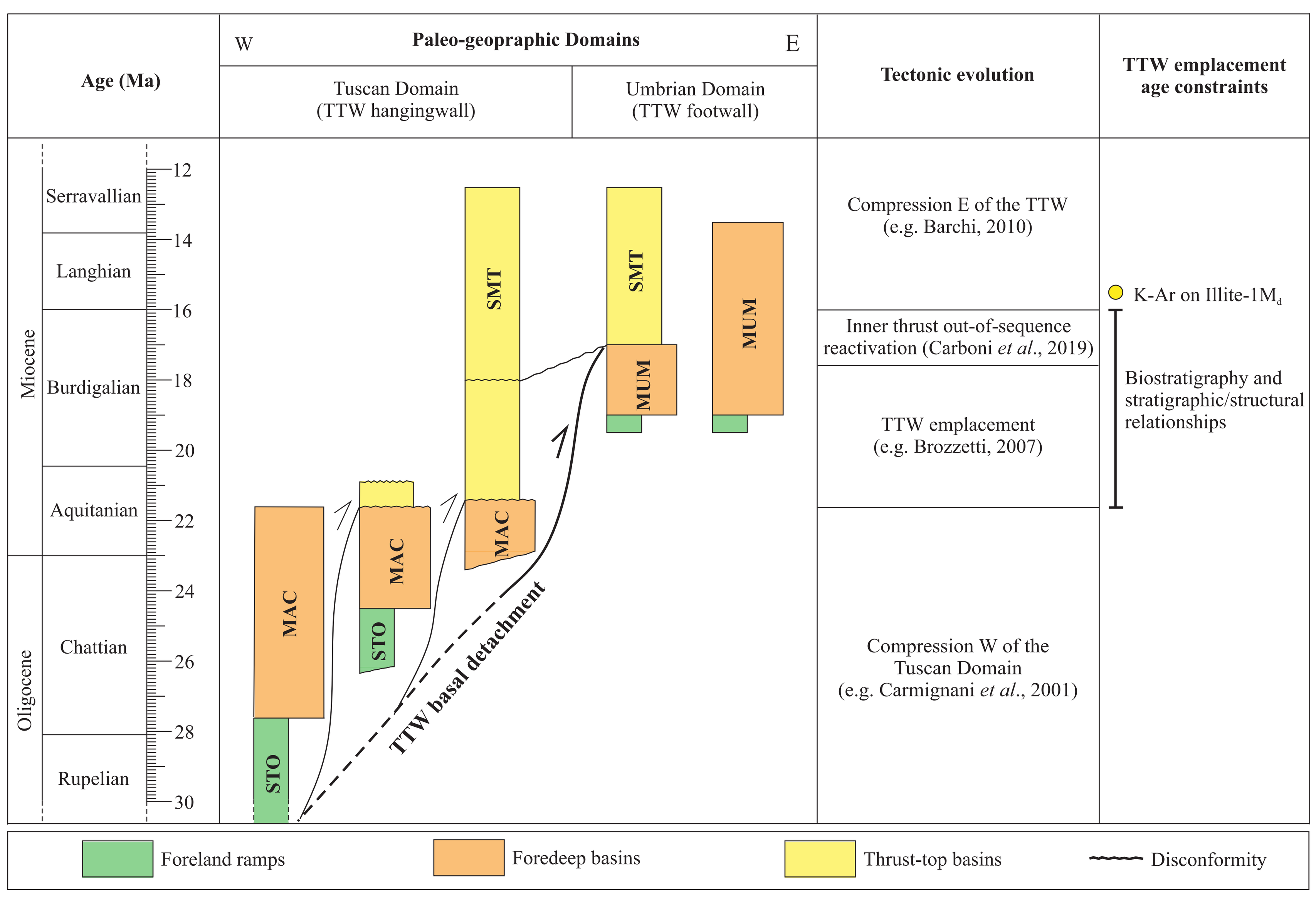
In this work, independent dating of the emplacement of the TTW is constrained by applying the K-Ar IAA approach to fault gouges from two wedge thrusts, splaying out from the TTW basal detachment.

The obtained IAA ages are 15.2 ± 7.6 Ma and 15.4 ± 16.6 Ma for sample SM.01 and SM.02, respectively. The large uncertainties (~49% on sample SM.01 and ~104% on sample SM.02

9 reflect the lack of sufficient sample mass to complete the XRD analysis of the < 0.1 µm fractions, but also, the similar %2M1/1Md+2M1 ratios for the plotted fractions worsens the regression toward 0% illite-2M1.

Results are analytically identical for both thrusts. Unrelated relative and absolute dating approaches have led to compatible results for the age of emplacement of the TTW.

This work represents a further successful application of K-Ar illite dating to Neogene faults, demonstrating that IAA analysis is indeed a powerful tool for unravelling the timing of brittle deformation also for fault gouges formed at shallow depth at the expense of flysch successions.



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