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Reply

Invited reply to the Comment on: "Geomorphological, paleontological and $^{87}Sr/^{86}Sr$ isotope analyses on early Pleistocene paleoshorelines to define the uplift of Central Apennines (Italy)"

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In response to the comment of Cosentino and Fubelli (2007) on the stratigraphy of the Middle Valley of Tiber River basin (MVT) and on the chronological attribution of the uppermost paleoshorelines (UPS), we recall that we performed a detailed sampling campaign to date the youngest marine deposits underlying or laterally related to the UPS, through the $^{87}Sr/^{86}Sr$ method.

Unfortunately, we cannot have taken advantage from the new stratigraphic data of the comment, being that all these data are still unpublished. On the sections presented in the comment, which concern only the southernmost tract of the UPS alignment, we do not know exactly how close these sections are to the UPS and how accurate the stratigraphic relationships are. This is due to the absence in the comment of detailed geographic locations of sections and of any stratigraphic scheme or geological map that might help link the data presented in Mancini et al. (2007) with the new ones. In general, the age of the new proposed sections are considered older (Gelasian) than our age estimate (1.65–1.50 Ma, i.e. late Santernian) for the UPS.

As for the UPS age range, we based our considerations on isotopic age dates ($^{87}Sr/^{86}Sr$), foraminifera biostratigraphy, and physical stratigraphy derived from our original field work and bibliographic review. We specified that the proper isotopic age range is 1.90–1.34 Ma, and not 2.27–0.97 Ma as it is stated in Cosentino and Fubelli (2007), and we are surprised to see that the error associated to a single measurement ($\pm 2\times10^{-5}$) is used for the extremes of the entire data set. Indeed, the uncertainty associated with a group of data is always smaller than the one related to a single measurement. Following standard statistical practice (Davis, 1986), our data set (Table 2 in Mancini et al., 2007) has a mean of 0.709084 and a standard deviation of 1.06×10^{-5}, thus indicating a $^{87}Sr/^{86}Sr$ ratio range between 0.709074 and 0.709095, in agreement with the range stated in Mancini et al. (2007). To substantiate the obtained isotopic age range, we present Figure 1, modified after Hodell et al. (1990), where it is clear that the error in measurement refers to the $\delta^{87}Sr$ and is not translated into an age uncertainty.

In our opinion there is no "lack of marker species" in the basin, since there are many sites in both the banks of the Tiber River where either Gelasian or Santernian markers occur (Mancini et al., 2004). These occurrences, together with stratigraphic correlations based on facies analysis where markers are absent, allow us to attribute the upper part of the Chiani-Tevere Formation and UPS to the Santernian. The integration of different stratigraphic data permits to produce correlation schemes, valid for the entire MVT basin, also using data from the Vallericca section (Basili, 1996; Girotti and Mancini, 2003; Mancini and Cavinato, 2005). In particular, Basili (1996) directly correlated the Santernian deposits of Vallericca with the closest paleoshorelines (sites 130–132 in Table 1 of Mancini et al., 2007).

In detail, for the new sections (Cosentino and Fubelli, 2007), we note the following:

(1) The Bocchignano-Castel San Pietro section is 3 km away from the nearest outcrops of UPS (sites 110–112 in Table 1 of Mancini et al., 2007). The Bocchignano-Castel San Pietro area is a part of the Sabina Valleys (Petronio et al., 2002), where two outcrops of fluvio-lacustrine sediments, no longer exposed and bearing Plio-Pleistocene mammal remains, were found (Tuccimei, 1891): (a) the lignite mine of Castel San Pietro, with *Anancus*

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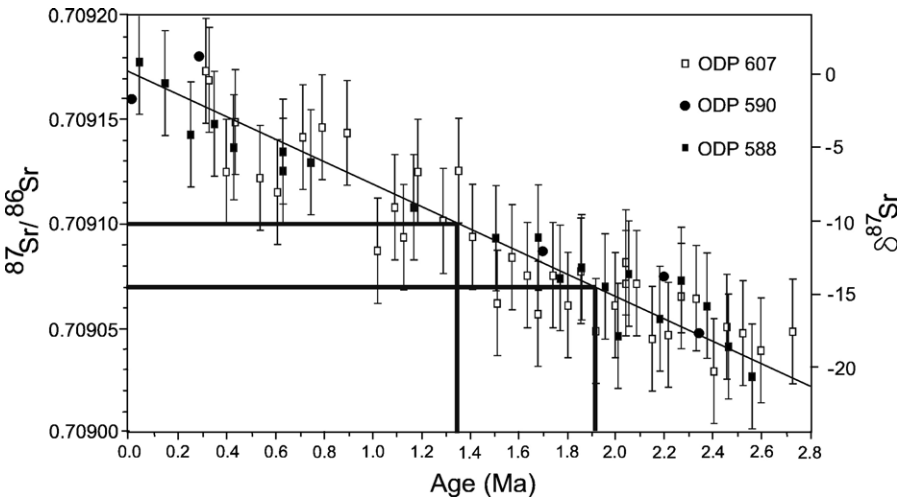

Figure 1. Regression line for Sr isotope data for the last 2.6 Ma, modified after Hodell et al., 1990. The thick black lines correlate the extremes of our data set to the corresponding ages.

arvernensis, *Stephanorhinus etruscus*, *Castor fiber*, *Leptobos* sp.; and (b) the Bocchignano mine, with *Equus stenonis*, *Hippopotamus antiquus*, *Mimomys polonicus* vel *M. pliocaenicus*.

The first fossil assemblage is assigned to the Late Pliocene (Petronio et al., 2002) on the basis of the concomitant range of taxa. It should be remembered, however, that a chronological attribution of *A. arvernensis* to early Pleistocene is also proposed (Zanchetta and Mazza, 1996). The second assemblage is not homogeneous given the concomitant occurrence of a typical Pliocene rodent (*Mimomys*) and *Hippopotamus*, which is widespread in Europe in the early Pleistocene.

The Sabina Valleys thus represent a case where mammalian biochronology cannot be used for precise chronostratigraphic attributions of encasing sediments. The latter may be Pliocene or Pleistocene in age. Limitations in the applicability of biochronology in Italy are extensively dealt with in Palombo (2004). A modern use of the mammalian record arises from the integration of biochronological analyses with physical stratigraphy (Milli and Palombo, 2005), which may permit correlation between marine and non-marine deposits. This approach requires (a) modern facies analyses of outcrops and (b) detailed taphonomic analyses. Unfortunately, such conditions cannot be met in the Sabina Valleys using fossils recovered in the 19th century from sediments that are no longer exposed.

(2) The Stazzano section is considered of Gelasian age, based on the occurrence of *Mohrensternia angulata*, which ranges from the Miocene to Pliocene. However, several species that were previously attributed to the Pliocene (Malatesta, 1974), such as *Sinodia brocchii* and *Ficus conditus*, presently are also found in lower Pleistocene deposits (Mancini, 2000; Mancini et al., 2004). Indeed, these mollusks are associated with Pleistocene foraminifera in the same strata. For instance, the *S. brocchii* featured in Figure 3D of Mancini et al. (2007) are found in association with *Bulimina etnea*; this photograph refers to the stratigraphic Log 23 in Girotti and Mancini (2003). Similarly to the abovementioned mollusks, it is possible that the chronological distribution of *M. angulata* could cross the Plio-Pleistocene boundary.

(3 and 4) It is probable that the Castel Chiodato and Molino del Moro sections are Gelasian in age, but their elevation and stratigraphic position are well below the UPS. They are at about 170 m a.s.l., while the UPS in the surrounding areas are located between 220 and 250 m a.s.l. (sites 121 to 132 in Table 1 of Mancini et al., 2007). The stratigraphic and altitude relations between UPS and lower paleoshorelines in this area somewhat resemble the schematic cross section in Figure 2b of Mancini et al. (2007), where older paleoshorelines are also represented.

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