Reply to comment by V. Picotti and F. J. Pazzaglia on "Shale diapirism in the Quaternary tectonic evolution of the Northern Apennine, Bologna, Italy"

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[1] We appreciate the comment of *Picotti and Pazzaglia* [2007] on our work [*Borgia et al.*, 2006], which considers shale diapirism as one of the fundamental processes in the tectonic evolution of the Northern Apennine. Indeed, their comment shows the relevance of our conclusions, even if some of the details we provided could have been improved. In our reply, we will not engage in unfruitful polemics; instead, we will address only the main issues they raise, leaving to future work a more detailed discussion.

[2] Point 1 refers to their statement that "The rheology of the Liguiran shale precludes it from behaving like a 'clay glacier'." This is a very important point; in fact, once it was realized that the chaotic shales were ductile, most of the field observations, which appeared to be contradictory, became pieces of a puzzle that came together. Shales (and gypsum) tend to be rigid if subject to small stresses (in the order of 10^6 Pa), small lengths (in the order of $10–10^2$ m) and short periods of time (in the order of 10^3 years). For larger stresses (in the order of 10^7 Pa), lengths (in the order of 10^4 m), and longer periods of time (in the order of 10^5 years), such as those encountered in the Apennine, they tend to deform even if at slow rates. In general, given sufficient stress and duration, all rocks deform, just like the Earth's mantle. Also, the silicon putty we used for the experiments fractures if stresses are applied very rapidly, being perfectly fluid for longer periods of time. Correspondently, for any reasonable human-scale experience a viscosity of 10^{18} Pa s (as the one we attribute here to the shales) cannot be distinguished from that of a truly rigid body. Within the time frame and stress field we are concerned with, the plastic and liquid limits are not relevant. Regarding the concern that the train tunnels have not deformed in the past 10 years, we underscore the relevance of actual differential uplift within the tunnel's length, not of absolute uplift, and the fact that 10 years is probably too short a time to register a deformation that is averaged over 10^5 years.

[3] Point 2 refers to their statement "the field observations of a basal detachment for the Ligurian units." We agree that many outcrops show the base of a detachment; however, we see no evidence of detachment in our study area. In addition, where the base of a detachment is observed, the top of the detachment is not present. This is because the deformation is distributed within the viscous chaotic shaly units as a whole and not just along a focused detachment plane (with footwall and associated overlying hanging wall). We argue that many of the observations reported and the criticisms made by Picotti and Pazzaglia may be correctly interpreted in terms of a gravitational (diapiric) tectonic model. We will provide a detailed response to these points in a forthcoming paper.

[4] Point 3 refers to their statement "field and seismic data of a deformed, rather flat 'rigid basement' of the Ligurian units." The fact that the basement is deformed by regional tectonics is not in contrast with the fact that this basement behaved rigidly on a 10 to 100 times shorter timescale and at a later time.

[5] Point 4 refers to their statement "an incorrect age for uplifted and deformed 'marine' surfaces." We do not agree with this comment of Picotti and Pazzaglia. We believe our interpretation is correct. However, we feel that they have misinterpreted some of our statements.

[6] We believe the evidence of diapiric tectonics is so compelling that, as Picotti and Pazzaglia state, in the past some authors had to consider their existence. The paradigm of rigid tectonism that is still pervading the geologic literature of the Apennine left them no alternative but to call them "mud volcanoes" or "pseudodiapirs" [*Pini*, 1999].

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