Geophysical Research Abstracts
Vol. 18, EGU2016-15386, 2016
EGU General Assembly 2016

Tectonic origin for polygonal normal faults in pelagic limestones of the Cingoli anticline hinge (Italy)

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Polygonal faults are a relatively-recent new class of normal faults which are thought to be formed during early burial and diagenesis as a consequence of heterogeneous lateral volume changes. Polygonal faults are non-systematically oriented and, in map view, they form rhombus-, pentagon-, or hexagon-like pattern, suggesting a non-tectonic origin. Furthermore, polygonal faults are layer bound and they are restricted to particular stratigraphic level. Predicting the pattern of polygonal normal fault results crucial for geofluid exploration and exploitation, but, despite the large number of studies, the origin of these faults remains still largely controversial. One of the main reason for this uncertainty is that they are poorly known in outcrops. Polygonal faults have been identified in few localities within Mesozoic chalk (United Kingdom, France, and Egypt), in Paleogene claystone (Belgium), and in the Cretaceous Khoman Formation (Egypt) where polygonal faults have been observed in an extensive exposure of chalk.

In this study, we describe an outcrop in the Cingoli anticline hinge, which is located at external front of the northern Apennines fold-thrust belt (Italy), showing normal faults that we interpreted as syn-tectonically (syn-thrusting) polygonal faults. The outcrop shows three vertical exposures of sub-horizontal fine-grained marly limestones with chert interlayers of Albian-Turonian age. Intraformational short normal faults affect the carbonate and chert beds. These faults are poorly-systematic and they cut through the carbonate beds whereas usually stop against the chert layers. The fault surfaces are often characterized by slickolites, clayey residue, and micro-breccias including clasts of chert and carbonate. Fault displacement is partly or largely accommodated by pressure solution. At the fault tips, the displacement is generally transferred, via a lateral step, to an adjacent similar fault segment.
The aim of our study is to understand the nucleation and growth of the normal faults observed in the study outcrop. The major novelty of this work is that the described faults are, in our interpretation, polygonal faults that were tectonically (syn-thrusting) rather than diagenetically driven. According to our interpretation, these faults nucleated in response to multi-directional stretching processes occurred at the Cingoli triply-folded anticline extrados. Furthermore, considering the fault tip stress distribution, we suggest a model where the faults produced an associated bed-parallel pressure solution on sub-horizontal carbonate beds that is an unprecedented or very rare case in syn-thrusting settings.