Geophysical Research Abstracts
Vol. 17, EGU2015-9014, 2015
EGU General Assembly 2015

The stratigraphic distribution of large marine vertebrates and shell beds in the Pliocene of Tuscany

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The record of 337 shark fossils, 142 cetaceans and 10 sea cows from the Pliocene of Tuscany, mostly from historical museum collections, is revised. The majority of these fossils are concentrated at a few geographic sites from separated hinterland basins, on the South-Western side of the Northern Apennines. To better understand the meaning of these concentrations, the sequence stratigraphic distribution of more recent findings of large marine vertebrates is reconstructed against a high-resolution framework based on sedimentary facies analysis. These remains are usually covered by, or included in mudstones deposited far from the coast (N=12), skeletons being usually articulated, slightly displaced, and often bioeroded. A minor part of better preserved articulated skeletons is associated with sandstones from deltaic paleonenvironments (N=2).
Marine mammal and shark remains may be associated with laterally-continuous shell accumulations, a type of concentration occurring at maximum flooding surfaces, separating relatively coarse-grained facies from open marine mudstones. Shell beds were bulk-sampled at 66 locations from six basins, covering a wide range of sedimentary facies, and spanning a chronologic interval of about 2.5 million years. A dataset of 62,655 mollusc specimens belonging to 496 species formed the basis of a statistical study to reconstruct the structure of the benthic communities, and to estimate paleodepths from intertidal to upper bathyal settings. Mollusc associations closely mirror the distribution of sedimentary facies, allowing for a fine tuning of the sequence stratigraphic architecture.
Merging paleogeographic, stratigraphic and paleoecologic data, we conclude that the more abundant and diverse accumulations of large vertebrates took place in settings under the influence of coastal upwelling. A modern analogue occurs today in the Ligurian Sea, on the Tuscan offshore, where abundant nutrients carried by deep-marine currents of Western origin, within an otherwise oligotrophic Mediterranean Sea, sustain a rich and diverse cetacean and shark, epipelagic and mesopelagic community. The modern steep bathymetric gradient was displaced towards the East during the Pliocene, before the latest phases of uplift of the Northern Apennines. An open marine, nutrient-rich ecosystem influenced hinterland basins during major transgressive pulses, leading to a higher productivity and the formation of laterally-continuos accumulations of biogenic hard parts.
A comparison with the few available studies on the sequence-stratigraphic distribution of large marine vertebrates and shell beds suggests that a model integrating high-productivity and sea level rise, favouring bone bed and shell bed formation, can be applied at other settings, and other geologic intervals.