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Review article

The global Middle and Late Miocene and the deep earth: Model for earlier orogenies

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ABSTRACT

The 11 Ma Middle and Late Miocene interval forms only 2% of Phanerozoic time but includes two broadly contemporaneous global orogenies—one reaching across southern Eurasia and the other spanning the Circumpacific. These two global orogenies caused many global events, and because they are close to us in time, causality links between these orogenies and these far scattered events are much more apparent than in older orogenies. These teleconnections include establishment of the present world oceanic current system; the beginnings of oceanic cooling at 14 Ma; an increase in hemipelagic mud bordering the continents; changes in continental tilts and river systems; great biological changes; increased desertification; replacement of C_3 by C_4 grasses; a major shift in siliceous microfossils from the Atlantic to the Pacific at 15 Ma; and first development of the earliest hominids in East Africa starting at 10 Ma. In addition, spreading rates of oceanic ridges increased, volcanism increased, there was movement along many transform faults, and continental elevations increased. Short, bulleted statements set forth these near and far field events.

Immediate causes were increased rates of plate motions and/or changes of directions. Only a strong, short 11 Ma pulse of heat from the Earth's core provides the logical ultimate source of this energy. Only such a pulse of heat from the core has sufficient magnitude and acts globally. Thus the deep Earth cycle is a plausible, easy-to-understand, overarching explanation that should be increasingly considered by geologists and geophysicists studying the outer crust. A flow diagram links major earth surface features on the continents to the deep earth. Alternative explanations for these events are considered and seem totally inadequate.

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The 50-some diverse events of the Middle and Late Miocene reported here are best explained by combining the deep earth cycle first proposed by Arthur Holmes in 1929 and 1944 with modern, deep seismic tomography.

1. Introduction

We propose that the major events in Miocene oceans, atmosphere, and continents are all related to plate tectonics, and that these events in turn, are linked to the deep earth cycle as an integrated system extending far back in time. Demonstration of Miocene connections to the deep earth will go far to help identify similar connections in earlier global orogenies.

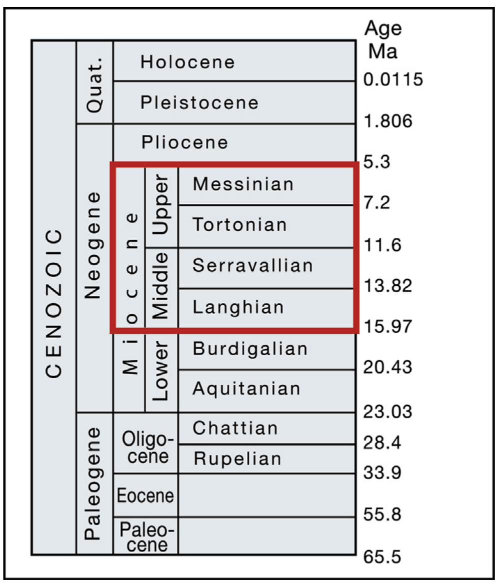

Fig. 1. Neogene and Quaternary nomenclature (after Hilgren et al., 2012, p. 946).

There are two reasons why understanding the interrelationships among the many synchronous global events from the base of the Middle Miocene (Langhian) to the end of the Late Miocene (Tortonian–Messinian) from 16 to 5.3 Ma (Fig. 1), best demonstrate the links between the earth's surface features and its deep earth cycle. First, the Middle and Late Miocene are close to us in time, so their major tectonic processes and consequences are readily studied, making causality links easier to identify than those in earlier orogenies. Second, many, if not most, of the diverse global events of the Middle and Late Miocene are either directly or indirectly related to only two major tectonic events: the Alpine-Himalayan and Circum-Pacific Orogenies (Fig. 2). In broad terms, these two orogenies marked the final replacement of a lingering greenhouse world by an icehouse world. Advances in deep earth seismic tomography link both of these orogenies to the deep earth's major cycle, first proposed by Arthur Holmes, 1929, 1944.

2. Global setting

The Alpine-Himalayan and Circum-Pacific global orogenies both formed over subduction zones along oceanic margins, and both contain new and rejuvenated mountain belts, some of the latter as recent as 84–37 Ma (Gries, 1983; Getz, 2012), the widespread Laramide Orogeny (North America). The Alpine-Himalayan Orogeny extends from Gibraltar into Vietnam, some 13,000 km. This orogeny resulted from the African, Arabian, Indian and Australian Plates impacting southern Eurasia as Gondwana broke up and its fragments moved north over approximately 120 Ma to finally close the Tethys Ocean in the early Miocene. Today, only the Mediterranean, Black, Caspian, and Aral Seas, and some smaller lakes to the east remain. South America first rifted and opened from Africa between 135 and 120 Ma ago. This initial narrow gulf opened

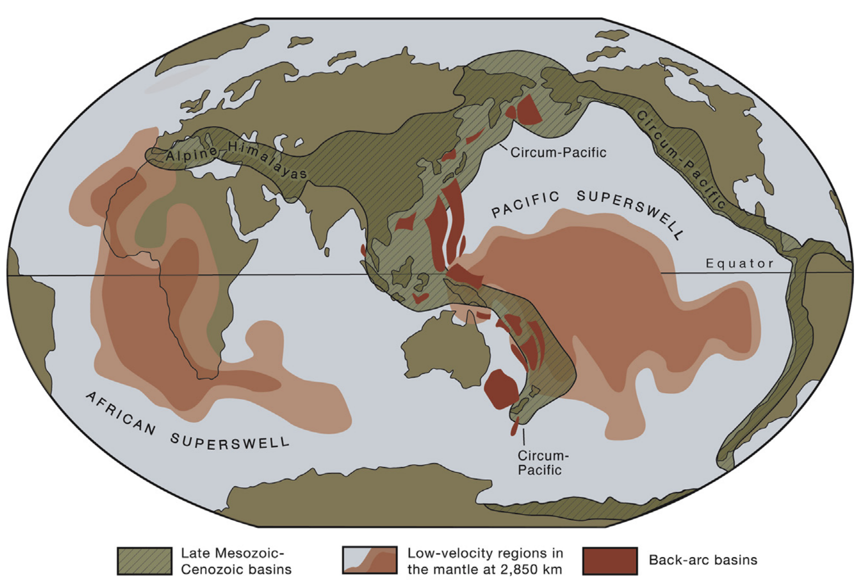

Fig. 2. Global map of two antipodal superswells over large low shear velocity provinces (LLSVPs); back-arc basins of western Pacific, and late Mesozoic–Tertiary orogenic belts. After Courtillot et al. (2003, Fig. 1), Tamaki and Honza (1991, Fig. 1), and Dickinson et al. (1986, Fig. 1.11). The two superswells may be thermal plume clusters (superplumes) or thermochemical piles (Bull et al., 2009).