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Long-term extension and subsidence of the peruvian forearc since at least 50 Ma.

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ABSTRACT

In this work we provide evidence for the existence of large-scale and long-term subsidence and extension to transtension in the Peruvian forearc. Evidence is based on remote-sensing mapping of lineaments and tectonic basins in the entire forearc, new field-based evidence, onshore and offshore geophysical measurements and a compilation of existing literature.

KEYWORDS

Forearc, continental margin, Peru, Cenozoic, extension, Nazca plate, Nazca ridge

The Peruvian forearc is considered a classical example of an oceanic-continental subduction zone with compression as the dominant tectonic force acting on the forearc (Isacks, 1988; Sobolev and Babeyko, 2005). Flattening of the dowgoing slab, as happened below the central and northern Peruvian forearc, commonly results in compression of the overriding plate as evidence from other parts in the world has demonstrated (e.g. Ramos, 2010). Modelling studies of plate interactions along the Chilean and Peruvian forearc also demonstrate that compression and uplift should occur (Espurt et al., 2008; Martinod et al., 2013; 2015). Field evidence supporting these views however is limited to a particular area of the Peruvian forearc where subduction of the Nazca Ridge occurs and which is not representative of the dynamics of the mayor part of the forearc. In addition, other workers have observed that so-called field evidence in the forearc for compressional tectonics, such as inverse faults and folds, have often been interpreted incorrectly (Sempere and Jacay, 2007). Seismic images, especially those from the 1980´s, were sometimes of suboptimal quality and also attributed to an incorrect interpretation of compressional features (DeVries-Klein et al., 2011). At the same time, among Peruvian geologists it is common knowledge that along the Peruvian coast many extensional features such as normal faults and grabens exist (Macharé et al., 1986; León et al., 2008; Noury et al., 2016). In order to find an answer for these conflicting views, we have carried out a study that combines a thorough review of national and international literature, terrestrial and submarine geophysical data, remote-sensing-based mapping of lineaments and tectonics basins of the entire Peruvian forearc as well as new field evidence of (trans)tensional tectonics. The results of the lineament mapping exercise shows two main sets of lineaments that strike parallel and orthogonal to the trench and that often border flat, sediment-filled areas. Electrical resistivity surveys in those areas show a sedimentary infill that is very homogenous along the entire forearc: maximally 1200 m of sediments consisting of fine-grained, Tertiary material with on top a sequence of coarse-grained clastic material that is attributed to the Quaternary (Gilboa, 1977; Arce, 1984; Teves-Rivas, 1984). These data suggest that the flat areas bounded by lineaments are tectonic basins, as no other mechanism can explain 1200 m of subsidence. Theses inferences are corroborated by new field-based evidence along a 300-km-long transect between Lima and the Paracas Peninsula showing the occurrence of ubiquitous normal to transtensional faulting and graben formation with directions corresponding to the strike of the lineaments that we mapped using remote-sensing techniques. Published offshore-seismic lines also show the occurrence of fault-bounded grabens in the offshore part of the Peruvian forearc (Ballesteros et al., 1988; Clift et al., 2003). We derived a chronological framework for basin initiation from an extensive review of existing literature showing that most of the transtensional basins started to form around the middle-late Eocene (Macharé et al., 1986; León et al., 2008; Decou et al., 2011; Hessler and Fildani, 2015; Noury et al., 2016). Between 6° and 15° latitude transtension and subsidence has been the main mode of tectonic deformation for the past 50 Ma, only interrupted by short pulses of uplift and compression since the middle-late Miocene where subduction of the Nazca Ridge took place. Between 15° and 18° S latitude, uplift and extension prevailed for the past 50 Ma, possibly due to bending of the Bolivian orocline (Noury et al., 2016). We speculate that the formation of the margin-parallel (trans)tensional faults and the regional subsidence of the forearc are related to bending of the overriding plate while it is being dragged down by the subducting plate, and possibly, tectonic erosion. The faults orthogonal to the trench are more difficult to explain, but may be related to subduction earthquakes or changes in the convergence vector of the coupled overriding-subducting plates. A more detailed reconstruction of our findings can be found in Viveen and Schlunegger (2018).

CONCLUSIONS

The Peruvian forearc is undergoing extension to transtension and not compression as current theories advocate. The long-term mode of tectonic deformation can be explained through large-scale plate convergence processes and is not related to local phenomena such as subduction of the Nazca Ridge.

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