Anne Fetrow
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GEOL 5690

Q5b: What kinds of signals are present in modern analogs like the Apennines/Adriatic Sea and parts of Indonesia?

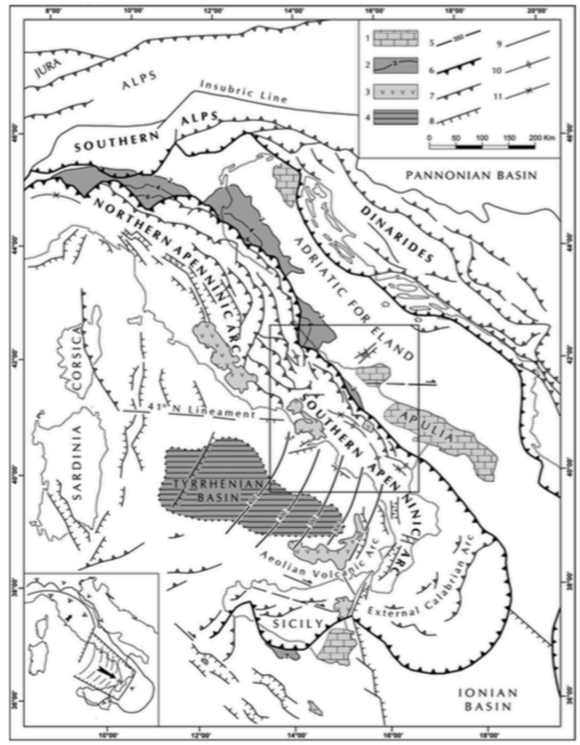

Figure 2. Structural and tectonic map of the Italian Peninsula, most notable for its tight westward curve in the subduction arc (from Patacca et al., 2007). The box in the bottom left corner provides region context and the black arrow demonstrates present-day differential sinking of foreland

Hildebrand argues that even while there was extensive deformation in the Sevier Hinterland during the Jurassic, there was no deformation in the Rocky Mountain shelf, which was only 80-100 km away after being restored to its pre-Basin and Range location (Hildebrand, 2009). This observation could present a major issue for the traditional understanding of the formation of the western US (referred to below as the "back-arc model" (e.g. Decelles and Coogan, 2006; Camilleri et al., 1997)). This might require reconsideration of the model used to explain the development of the US Cordillera. For clarity, the "Rocky Mountain shelf" is synonymous with the North American shelf, which is distinct from the Antler shelf located to the west (Figure 1). Discrepancies arise when these shelves are associated with either the North American continent or the proposed, exotic continent of "Rubia" (Hildebrand 2013, 2009). Two modern analogs, the Southern Apennines and the Java-Sundra subduction system, are examined to understand if such a lack of deformation could realistically exist in a back-arc system.

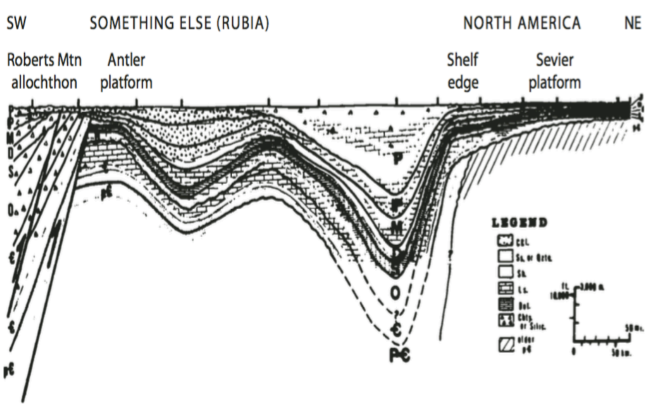

Figure 1. Palinspastic restoration through the North American passive margin (Nevada to Wyoming) shows the relationship between the Antler platform and the North American shelf (from Hildebrand 2009; modified originally from Peterson, 1977).

The Southern Apennines and surrounding region are a modern analog for the convergent processes responsible for the thickened Sevier Hinterland (Hildebrand, 2013; Hildebrand, 2009). The Central Mediterranean, specifically the Southern Apennines and Tyrrhenian Sea, are the result of the convergence between the African and the Eurasian plates (Di Bucci et al., 2009; Cello and Mazzoli, 1998; Cello et al., 1997; Cinque et al., 1993) and active back-arc spreading in the hanging-wall of the Apennine subduction zone (Cuffaro et al., 2011) (Figure 2). These two processes produce a complex system in which major compressional and extensional forces coexist in close proximity (Palano et al., 2015). The Southern Apennines are the result of the thin-skinned deformation and the stacking of low-angle nappes comprised of carbonate platform rocks and a few crystalline units (Scrocca, 2010; Patacca and Scandone, 2007). Among many complexities, this system is notable for the tight westward curvature of the subduction zone that almost fully surrounds the Tyrrhenian Basin (Cello et al., 1997; Cinque et al., 1993). The eastern portion of the Tyrrhenian Sea is approximately 100-150 km away from the spine of the Southern Apennines and, therefore, is a reasonable equivalent of the North American Platform. The Tyrrhenian Sea is a well-studied oceanic basin that has experienced extensional deformation since its formation in the mid-Miocene (e.g. Cuffaro et al., 2011; Palano et al., 2015; Cuffaro et al., 2011; Casciello et al., 2006). Malinverno and Ryan (1986) report extension in the Tyrrhenian Sea attributed to eastward migration of the arc caused by the rollback of the subducting Adriatic microplate. For the sake of this thought experiment simply the presence of deformation corroborates Hildebrand's argument that a lack of deformation in the North American Shelf is unrealistic for a back-arc model.

The second modern analog of interest is the continental retro-arc system of the Indonesian orogeny (figure 3). Active subduction of the Indo-Australian plate under the Eurasian plate has resulted in compressional deformation, seismic activity, and volcanism that makes up Indonesia, notably the islands of Sumatra and Java (Simones et al., 2004; Letouzey et al., 1990; Hamilton, 1976). Overall the Indonesian orogeny is a complex system, for example it has several interacting microplates, but the western portion of the Sumatra subduction zone provides a relatively simple example of a convergent system similar to what is interpreted for the western US in the Cretaceous (Decelles, 2004). Similarities include a seismically and volcanically active arc, and a transition between contractional (foreland style) and transtensional tectonics (Decelles, 2004). The Sunda Shelf, to the north of the island of Sumatra, is one of the largest shelves in the world and is up to 800 km wide with average water depth of 70 m (Hanebuth et al., 2002). By interpreting seismic profiles, Letouzey et al. (1990) showed that the Sunda Shelf underwent first a period of extensional deformation followed by compressional deformation, due to in part to variation in subduction rates and plate convergence

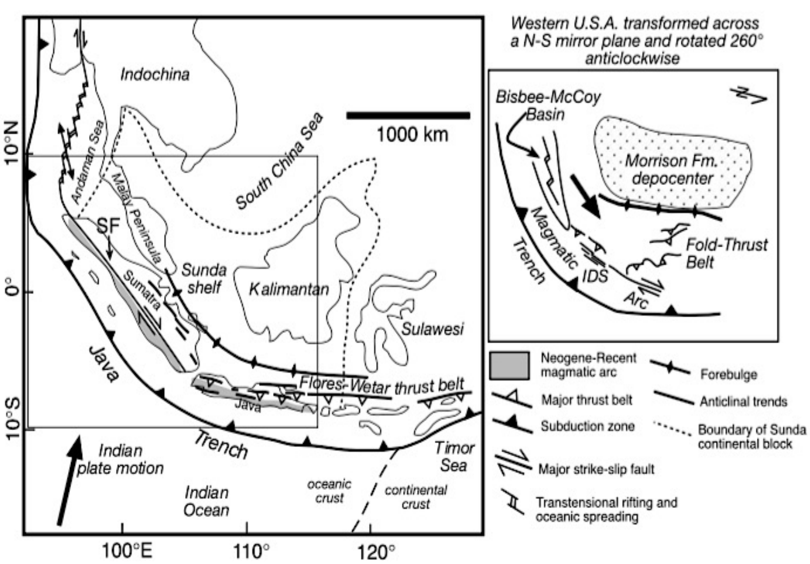

Figure 3. Structural and tectonic map of the Java-Sumatra subduction zone (left) and the proposed United States Cordilleran orogenic system (right) (from Decelles, 2004). Note that the scale for the two maps are equivalent.

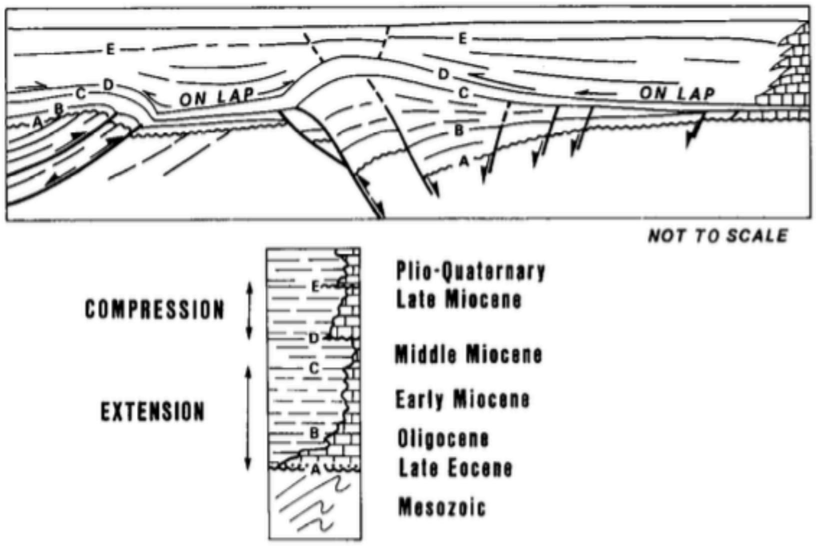

Figure 4. Schematic illustrating periods of deformation for the Sunda shelf and the manifestation of that deformation in the structure of the region (Letouzey et al., 1990).

direction (Figure 4). The presence of deformation in the Sunda Shelf again hints that absence of deformation in the North American shelf is perplexing and presents a troubling issue for the classic back-arc model.

These two regions show different styles and progressions of deformation, but they both demonstrate that complete inactivity and stability so close to an active convergent plate boundary is unlikely. The use of modern analogs can only go so far when trying to better understand the geologic past, but they can provide useful basic frameworks upon which to build and verify models.

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