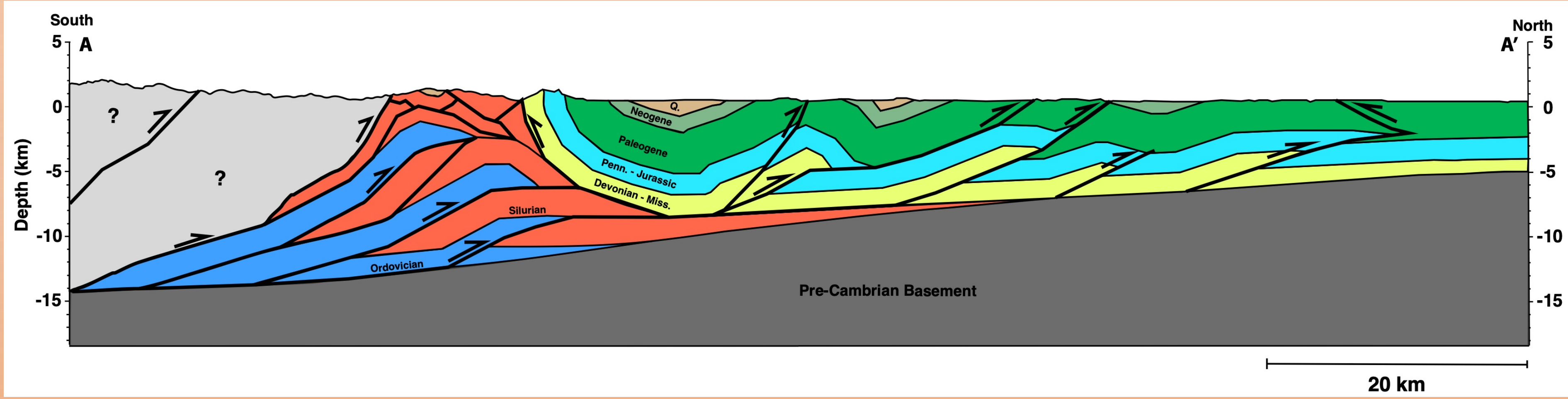
Shortening of the Camisea Basin in the Central Peruvian Subandean Zone

David Cantillo, GEOS 304



Nicolas Espurt, Jocelyn Barbarand, Martin Roddaz, Stéphane Brusset, Patrice Baby, Marianne Saillard, Wilber Hermoza; A scenario for late Neogene Andean shortening transfer in the Camisea Subandean zone (Peru, 12°S): Implications for growth of the northern Andean Plateau. *GSA Bulletin* ; 123 (9-10): 2050–2068.

System of Structures

The Camisea Basin contains regional shortening that is easily illustrated through the presence of thrust faults. In the southern area of the cross-section, there is a large internal duplex comprised of multiple imbricate thrust faults. This pillar of thrust faults results in a series of thrust-related anticlines in this same area. In the center of the cross-section, this duplex encounters a region of strata and transfers compressional energy into folding, creating synclines and anticlines. Farther north, there is a blind thrust fault that creates a set of fault propagation folds. In the northern-most section lies an antithetic thrust fault that creates a triangle region of deformation.

Fault Structures

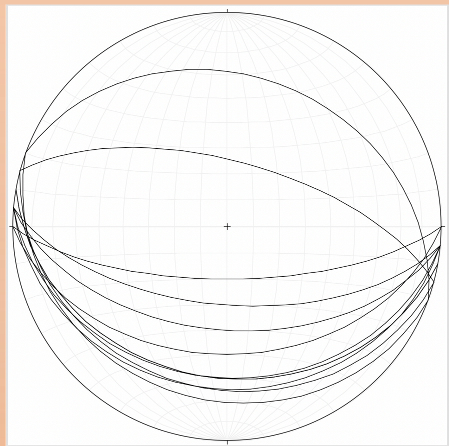
- Thrust faults, which occur at a dip angle of less than 45°
- Reverse faults, which occur at a dip angle of more than 45°
- Listric faults, which dip steeply at the surface and curve at depth
- Blind faults, which fail to reach the surface
- Anithetic faults, which dip in the opposite direction as most faults in the region

Fold Structures

- Anticlines, which are convex in the direction of younger strata
- Synclines, which are convex in the directions of oldest strata

Geometric Analysis

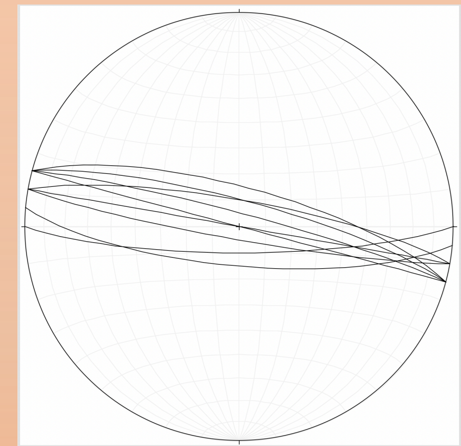
Fault Plane Beta Diagram

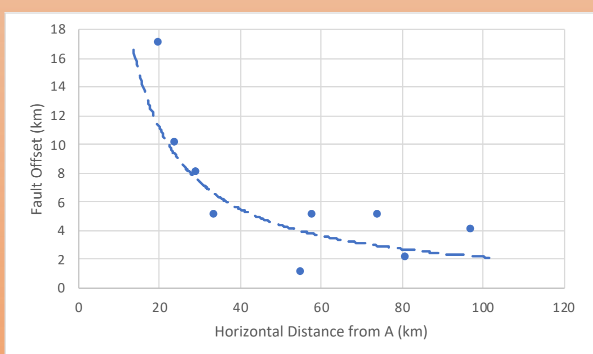


(Left): As illustrated in the fault plane beta diagram, dips of faults varied by large values while strike remained somewhat constant. The two antithetic faults with opposite strike values appear to dip further off the E-W hinge line.

(Right): The beta diagram containing axial planes shows that the dip for all planes in the cross-section is nearly vertical. Like the fault planes, there is a clear preference for strike in the E-W direction.

Fold Axial Plane Beta Diagram

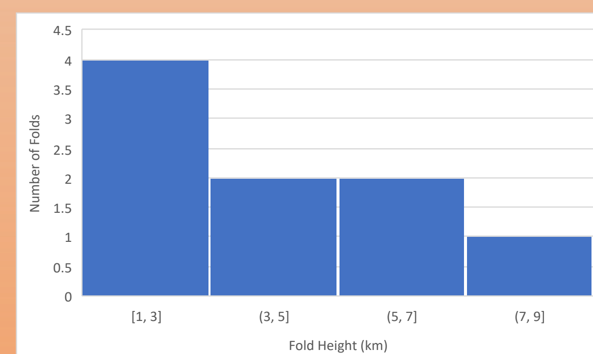




Fault Offset and Location

(Left): As horizontal distance from A on the cross-section increases, fault offset tends to decrease. This relationship most closely follows a power-law relationship with an R^2 value of 0.49

(Right): Histogram displaying the number of folds corresponding to fold heights with a bracket size of 2 km. There are generally more folds with a lower fold height.

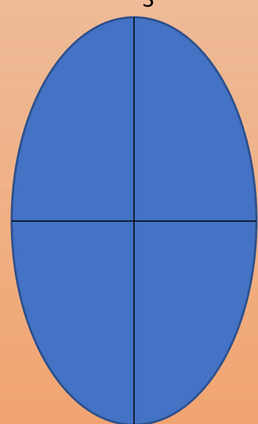


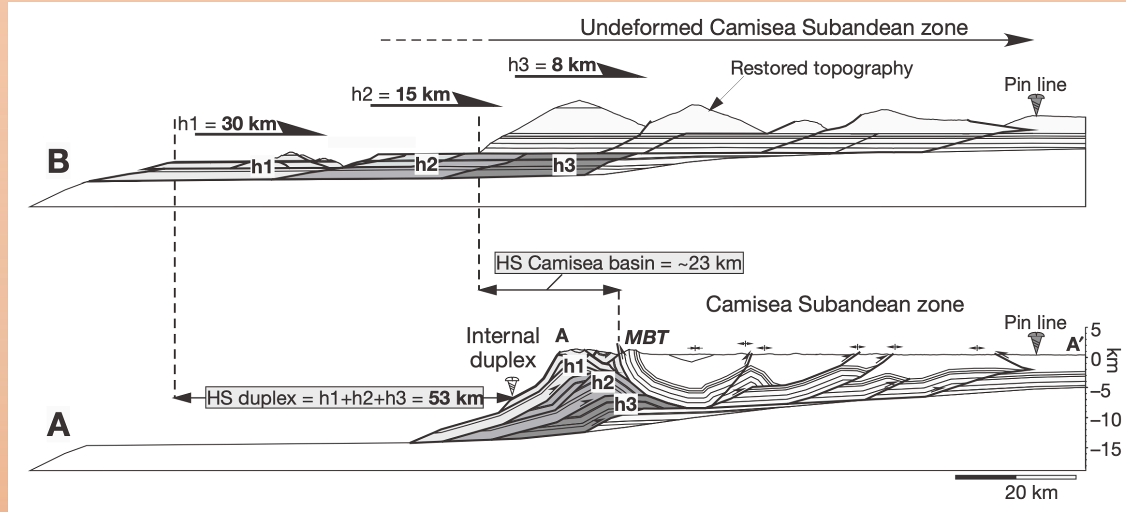
Fold Height Distribution

Kinematic Analysis

Overall, the region is dominated by thrust-slip faults that formed due to N-S compressional forces. As illustrated in Geometric Analysis, greater fault offset is observed in the southern region of the cross-section in the internal duplex. This may be because there is more shortening in the Camisea basin than in the Subandean zone (see text below restored cross-section). In the southern section of the cross-section, the anticlinal set formed in the internal duplex consists of similar folds, indicating the potential role of plastic deformation at high temperature/pressure. The northern section of the cross-section features concentric fold structures.

(Right): Strain Ellipse illustrating the stretch directions in cross-sectional view. S_3, the direction of minimum stretch, occurs in the direction of N-S due to shortening. S_1, the direction of maximum stretch, occurs along the line of elevation. As compressive deformation occurs, rock is forced upwards in imbricate faults.





(Above): Restored and balanced cross-sections of the Camisea Subandean zone. By unraveling strata to their original horizontal position, it is possible to create a restored version of the cross-section that illustrates the original placement of beds. Espurt et al. (2011) found that 53 km (39%) of shortening took place from horse 1-3 in the southern region of the cross-section. In the Camisea Subandean zone, the authors transformed the folded beds back into the original, horizontal beds from deposition. They found that roughly 23 km of shortening was accommodated into this region. The remaining 30 km of shortening was likely accommodated by the Mainique back thrust.

Dynamic Analysis

The Camisea Basin lies adjacent to the Andean Plateau, which experiences large-scale shortening due to convergence of the Nazca and South American Plate. However, the Camisea Basin experiences shortening in the N-S direction, while the Nazca plate is subducted towards the E-NE direction. This shift in shortening is a result of the Bolivian Orocline, the curvature in Andes orogeny in South America. As compressive forces reach this geological feature, they are deflected north in what's known as the "central Andes rotation pattern" (CARP) coined by Somoza et al. (1996).

Espurt et al. (2011) found the last 23 km of shortening occurred in the past 6 Ma, resulting in an average shortening rate of 3.8 mm/yr that is consistent with earthquake data from the region. From this, the authors predicted that the Camisea Basin first began experienced shortening at approximately 14 Ma.

(Right): Cross-sectional view of stress ellipse. The direction of greatest stress, $\sigma_{1,}$ runs from N-S, while σ_3 is up/downwards.