Timing of the Ibero-Armorican Arc. Paleomagnetism, shear zones and more

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The Paleozoic Variscan orogeny was a large-scale collisional event involving amalgamation of multiple continents. The present-day arc curvature of the Variscan has inspired many tectonic models, with little agreement between them. While there is general consensus that two separate phases of deformation occurred, various models consider that curvature was caused by: dextral transpression around a Gondwana indentor; strike-slip wrench tectonics; or a change in tectonic transport direction due to changing stress fields (an orocline). Deciphering the kinematic history of curved orogens is difficult, and requires establishment of two deformation phases: an initial compressive phase that forms a relatively linear belt, and a second phase that causes vertical-axis rotation of the orogenic limbs. Historically the most robust technique to accurately quantify vertical axis-rotation in curved orogens is paleomagnetic analysis, but recently other types of data, including geochronology and structural reconstructions using joints have provided more robust constraints to date the orocline development. From this point of view, if vertical axis rotation occurs subsequent to magnetization acquisition, then the magnetization will record all ensuing rotations. Consequently, if magnetizations are found that vary systematically as a function of strike around a curved orogen, then secondary oroclinal buckling, regardless of the mechanism, is likely the most viable kinematic model for curvature

Most geologic, structural and paleomagnetic studies done to test the orocline hypothesis for the Ibero-Armorican Arc have been done in its central core — the Cantabrian Zone. Early paleomagnetic studies in the Cantabrian Zone were used to test the various proposed rotational models, and demonstrated that at least some of the arc's curvature is of a secondary nature. However, the ability to establish robust evidence for oroclinal buckling was limited due to a lack of sufficient data around the entire arc, and the failure to recognize and distinguish between secondary syn-tectonic and post-tectonic remagnetizations.

More recent paleomagnetic investigations from around the arc have established the Cantabrian–Asturian Arc (The core of the Ibero-Armorican Arc) as an orocline that tracked the entire progression from an early linear orogen to a secondarily folded arc. When all available B and C component paleomagnetic site means are compared to deviations in structural trend around the outer provinces of the Cantabrian–Asturian

Arc, a strike test slope of 0.98±.06 is established, indicating that the orocline end-member model is the best kinematic model for the Cantabrian Orocline. The later Permo-Triassic (P–T) component has seen little to no distortion since the time of magnetization acquisition, and it is within error of reference P–T paleomagnetic poles for stable Iberia.

Paleomagnetic data from Early Permian samples from the northern Cantabrian–Asturian Arc yielded expected Early Permian paleomagnetic pole positions for stable Iberia, with no indication of vertical-axis rotation since the Early Permian. Consequently, the Early Permian is argued to mark termination of oroclinal buckling. This result placed a well-constrained time window of about 10 Ma for oroclinal buckling.

In the outer part of the Ibero-Armorican Arc, a data set of $^{40}Ar/^{39}Ar$ ages obtained from five shear-zones, some of which display curved traces parallel to the Ibero-Armorican structural grain in NW Iberia and are interpreted to have been generated coevally to it. The $^{40}Ar/^{39}Ar$ ages were obtained by laser-rastering induced step-heating on single muscovite crystals that grew synkinematically during shearing. All five samples yielded ages that cluster tightly at 308±3 Ma providing direct evidence for the age of oroclinal bending. This age is consistent with the age constraints obtained from paleomagnetic and structural data that place the onset of oroclinal bending in Moscovian times. Our $^{40}Ar/^{39}Ar$ age determinations therefore provide a reliable absolute constraint on the age of buckling of the Variscan orogen around a vertical axis and provide further evidence that oroclinal bending is unrelated to Variscan convergence/collision or the subsequent extensional collapse of the mountain belt.