Three dimensional history of orogenic flexure around the western alpine arc

Ford, M. [1, 2], Bourlange, S. [1, 2] , Leseur, N.[1],and Bourgeois, O. [1, 3], Le Carlier de Veslud, C. [1, 3] and Mollier, M. [1]
(1) Nancy Université, Ecole Nationale Supérieure de Géologie, rue Doyen Marcel Roubault, BP 40, 54501-Nancy, France
(2) Nancy Université, Centre de Recherche en Pétrographie et Géochimie, Rue Notre Dame des Pauvre, 54501 Vandoeuvre les Nancy, France
(3) Laboratoire de Planétologie et Géodynamique, Université de Nantes - Faculté des Sciences, 2 rue de la Houssiniere - BP 92208, 44072 Nantes Cedex 3, France
(4) Géosciences Rennes, UMR 6118, Université de Rennes 1

Below the western Alpine arc the subducted European plate curves through over 90° as imaged recently by seismic tomography. This arcuate plate geometry evolved during collision between the Apulian indentor and the southward subducting European plate from Late Cretaceous to Miocene. We reconstruct the migration of the foreland basin across the European foreland with time and compare the evolution of the foreland system on three cross sections in eastern Switzerland, western Switzerland and SE France. The Eocene foreland basin stratigraphy (55-34 Ma) records the gradual change from frontal flexure to increasingly arcuate flexure of the European plate during the subduction-accretion phase of rapid north-south plate convergence. The foreland basin stratigraphy (Nummulitic Trilogy) is remarkably consistent around the Alps during this period. The underfilled character of the basin fill indicates that nappe stacking within the subduction channel did not create significant orogen relief, implying that primarily subduction forces generated this early flexural basin. An abrupt change occurred in the early Oligocene when plate convergence slowed at the beginning of the main collision phase. The flexural basin of the western sidewall (SE France) was gradually abandoned while subsidence in the frontal flexural basin increased as it became overfilled due to high sediment supply from the orogen. Basin migration slowed during the Miocene and terminated due to the development of the Jura fold and thrust belt at around 11 Ma above Triassic evaporites. The presence (west) and absence(east) of triassic evaporites strongly influenced the alpine load distribution and hence late flexure of the European plate.
The present day flexure of the European plate to the north of the alpine orogen was analysed using a 3D model of the base Trias and of the European Moho constructed from compiled published structural and stratigraphic data for an area of 80 000 km² of the Alpine foreland. Plate flexure was then analysed along 12 profiles drawn orthogonal to the Alps from eastern Switzerland to the Chambery region of eastern France. The observed curvature of both crustal boundaries was compared to the 2D flexure model of a thin elastic and semi-infinite plate and incorporating lateral variations of the position of maximum deflection, the elastic thickness of the European plate and the position of the point load. In eastern Switzerland a good correlation is observed between observed profiles and the 2D flexure model with the load placed below the Aar external crystalline massif (at a depth of between 6 to 11 km). The elastic thickness increases eastward in agreement with previous authors. In the Jura region, west of the Upper Rhine Graben, the 2D flexure model no longer fits observed 3D surface geometries. The forebulge crest on the base Trias and on the Moho shifts northward by 90 km to form an arc that mirrors that of the Jura fold belt. In addition, the base Trias surface flattens out below the Jura. In order to improve correlation with the numerical model it is necessary to move the application point of the load northward by about 30 km and to increase the elastic thickness of the European plate. These observations indicate that the Jura behaved as a

late, locally imposed load to the north of the Alps which generated an additional flexure. These results challenge flexural modelling that does not take into account the Jura's role in modifying the late flexure in the Alpine foreland.