BASIN INVERSION IN THE EASTERN CORDILLERAS

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KEY WORDS: basin-inversion, fault reactivation, basin modelling.

INTRODUCTION

The sub-Andean basins show excellent examples of the geometry and kinematics of structural basin inversion, illustrating the processes by which half-grabens rotate and shorten, with coeval expulsion of the basin-fill. Fig. 1 shows an example from one of the basins in northern Peru. The original extensional fault may be locally and partially reactivated as a steep reverse fault, curving to develop a new flatter thrust profile upwards. The basin fill may be expelled in moderate to low-angle antithetic thrusts, which may form triangle zones with their own backthrust systems. Footwall shortcuts may develop, synthetic to the original normal fault and these may form their own triangle zones and back-thrust systems. The result is a thickening of the syn-rift and post-rift succession above the original half-grabens. Without seismic data or regional modelling, it is often difficult to determine the location and original position of the normal fault. Many structural interpretations ignore the basin inversion and concentrate on the thin-skinned aspects of the deformation, even sometimes attributing the deformation to salt migration.

The same arguments apply to the larger inverted basins forming the Eastern Cordilleras of Colombia, Ecuador, Peru and Bolivia. The original basins range in age from Ordovician to Cretaceous; the sharp curvature of the Andes in northern Peru is due to reactivation of two sets of orthogonal rift systems.

EASTERN CORDILLERA OF BOLIVIA

The eastern edge of the Altiplano Basin in Bolivia displays an excellent example of large-scale basin inversion. Cretaceous source rocks are essentially confined to this basin; knowledge of its geometry is therefore critical for modelling subsequent oil maturation and migration.

The northern part of the Eastern Cordillera is characterised by a major E-dipping normal fault system of Paleozoic age, reworked to form a Cretaceous basin which, when reactivated by Andean compression, forms a series of E-dipping, W-verging thrusts, formed on the footwall of the original extensional fault (Fig. 2). However, to the S, the extensional structures had a different polarity. Here the Andean structure involved back-steepening of the basin-bounding W-dipping fault and westward tilting of the Paleogene and Neogene sediments towards the Altiplano. There was only small-scale basement fault reactivation on the flanks of the Eastern Cordillera.

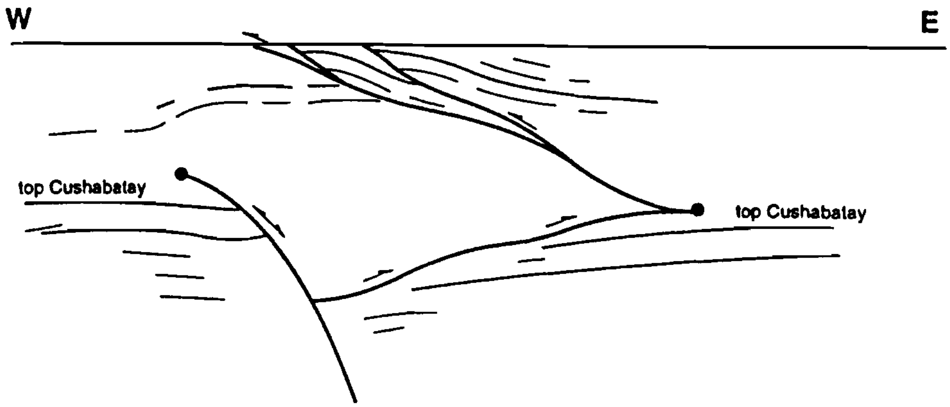
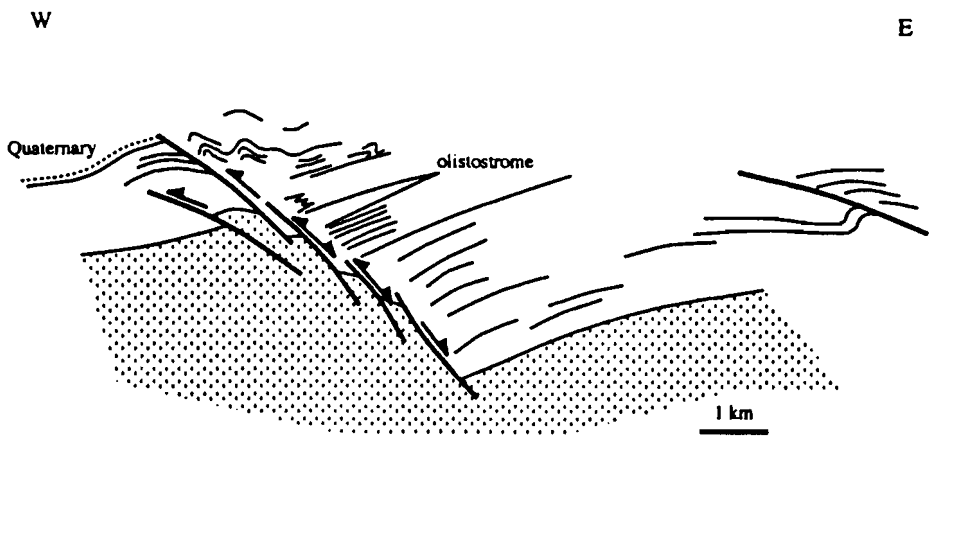


Fig.1: Inverted half-graben, northern Peru.

The thrusts along the western edge of the Cordillera are clearly Paleogene structures, reactivated during the Neogene. There is no outward migration of the mountain front and the structures locally back-step. Paleogene shortening exceeds Neogene shortening so that the Paleogene sections of the thrusts are longer than their reworked Neogene sections and many of the Paleogene folds and thrusts in the eastern Altiplano are unconformably overlain by only gently tilted Neogene sediments.

Thrusts along the eastern edge of the Cordillera are thin-skinned but modified by basement reactivation and local basin inversion. The thin-skinned structures can be modelled in terms of the eastward expulsion of the basin-fill, away from the main depocentre in the western part of the Cordillera. However, the amount of overthrusting across the Chaco Basin does not balance total crustal deformation without some large lateral eastward translation of the original rift basin. The deeper parts of the Eastern Cordilleran rift system probably underlie the Altiplano.

Fig. 2. Section through the western bounding fault of the Eastern Cordillera , Bolivia



EASTERN CORDILLERA OF COLOMBIA

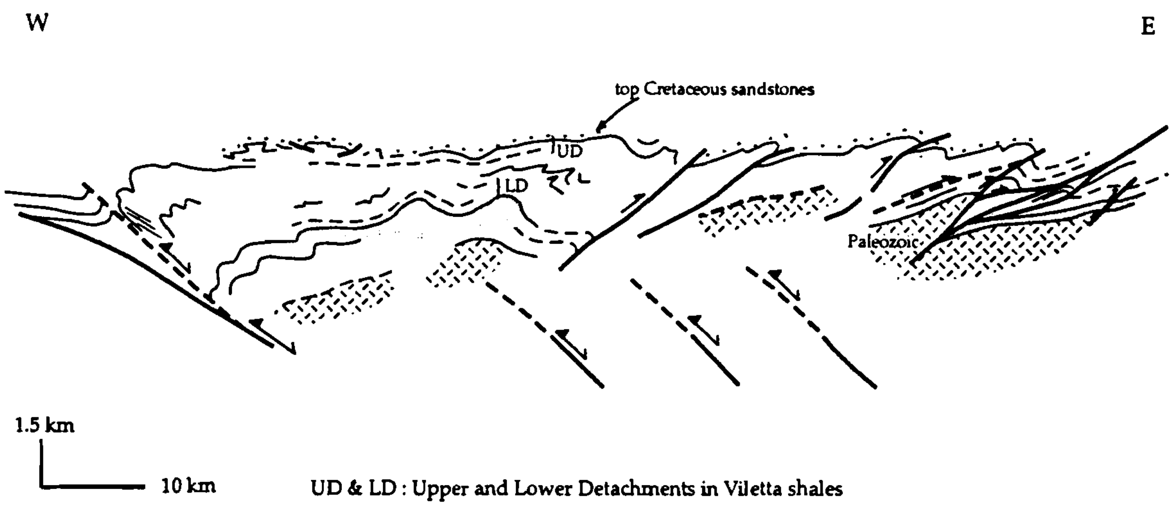
Many of the recent structural sections through the Eastern Cordillera of Colombia have emphasised the importance of thin-skinned deformation and shown how the surface structures can be modelled in terms of fault bend and fault propagation folds. Thin-skinned models are clearly applicable to the eastern edge of the Cordillera in the Yopal-Cusiana area. However, there are two arguments against the general thin-skinned footwall-propagating thrust model:

(i) There is no general migration of the thrust structures or foreland basin depocentre eastwards away from the Cordillera; several of the structures appear to cut back and the flexural basin has grown in situ rather than migrated. It does not fit a typical Alpine or Himalayan model for a foreland basin.

(ii) Along strike of main part of the Eastern Cordillera, the structures can be traced into the Upper Magdalena Basin, where they clearly involve basin inversion. Many of the original normal faults dip east. antithetic to the thin-skinned thrusts on the eastern margin of the Cordillera. Shortening of the half-grabens has involved displacements along bedding-parallel detachments in the syn-rift Viletta Formation shales.

The simplified composite structural section in Fig. 3 illustrates the reinterpreted structure and essentially incorporates aspects of previous thin-skinned (Colletta et al., 1990) and thick-skinned models (Dengo and Covey, 1993). Fig. 4 illustrates a simplified reconstruction.

Fig. 3. Simplified west-east section through the Eastern Cordillera, north of Bogota



UD & LD : Upper and Lower Detachments in Viletta shales

CONCLUSIONS

The interpretation of seismic data as well as field data in many parts of the Eastern Cordillera and sub-Andean basins has allowed new or modified interpretations to be made of the structure. These interpretations may be combined with regional tectonic data to develop models for whole crustal deformation in the eastern Andes. The new models are critical for understanding basin evolution, particularly involving hydrocarbon source rock location, maturation and subsequent hydrocarbon migration. The inverted basin concept allows the different hydrocarbon kitchen areas to be located and modelled through time.

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Fig. 4. Simplified reconstruction of section shown in Fig. 3.