VERGENCE OF THE CORDILLERA OCCIDENTAL, ECUADOR: INSIGHTS FROM THE GUARANDA-RIOBAMBA AND ALOA-S. DOMINGO DE LOS COLORADOS STRUCTURAL TRAVERSES

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Resumen

Un levantamientos estructural de campo ha permitido reconstruir el estilo de deformaciòn y el sentido de transporto en la parte central de la Cordillera Occidental. A la latitud de Riobamba se encuentran pliegues cierrados hasta "chevron" con immersion constante del piano axial a ONO. Algunos pliegues son cargados con el fianco oriental reverso. Las fallas son inversas con inmersiòn dominante al oeste. A la latitud de Aloa, la deformaciòn principal es de tipo fragil con fallas inversas inclinadas hacia el ONO y algunos pliegues abiertos con eje N-S.

Key Words: tectonics, folds, faults, vergence, Ecuador.

Introduction

The Ecuadorian Andes are formed by the parallel mountain ranges of Cordillera Occidental (CO) and Cordillera Real (CR), separated by the Interandean Valley (IV). The CO is mainly formed by Cretaceous volcanic rocks with island arc affinity (Macuchi Fm.) (Henderson, 1979) covered by discontinuous flysch-like deposits and carbonatic rocks of Cretaceous to Eocene age. The CO is considered an allochtonous terrane accreted onto the South American margin during a major tectonic phase in early Tertiary time (Lebras et al., 1987; Roperch et al., 1987; Wallrabe-Adams, 1990), while during Plio-Quaternary times was affected only by minor tectonic activity (Pasquarè et al., 1990; Ferrari and Tibaldi, 1992).

The suture between the CO island arc and the continental paleomargin represented by the CR is concealed under the Tertiary and Quaternary volcanic and continental deposits of the IV, as confirmed also by geophysical prospecting (Feininger and Seguin, 1983). The geometry of the suture zone fault system has important implications on the deformation models for the IV and for the whole Ecuadorian Andes. Juteau et al. (1977) recognized ophiolitic slices of the CO dipping steeply towards the East and interpreted this setting as resulting from accretion along east-dipping thrust planes. Nevertheless some field inspections in selected areas of the CO (Tibaldi and Ferrari, 1992a), showed that the main faults have a relatively constant NNE-SSW strike and WNW dip.

Here we present structural data collected along two E-W transects crossing the CO at the latitude of Riobamba and S. Domingo de Los Colorados (30 km) which contribute to clarify the vergence problem of the CO, at least in its central part.

Geological and structural setting

The CO, along the studied transects, is made of three main geological units (Fig. 1). The western part of the area is made of andesite rocks belonging to the Cretaceous Macuchi Formation. In the main part of the section are exposed late Cretaceous carbonatic rocks of the Yunguilla Formation which are covered toward the east by pliocenic andesite lava flows.

The Cretaceous andesites show only brittle deformations in the form of closely-spaced fractures along vertical and sub-vertical north striking planes. Reverse faults (pitch between 60° and 90°) are are also present and dip mostly westward at variable angles (10°-80°, dominant 10°-20°). A few E dipping planes are also found with inclination of 10°-15°. The contact between the Macuchi andesites and the marine sediments of the Yunguilla Formation is vertical.

The whole Yunguilla succession is folded with variable intensity and style. Going eastwards along the traverse of Figure 1, the strata are arranged in moderately closed folds with hinge lines striking between NNW and NNE. Reverse faults have a strongly dominant W to WSW dip and their inclination is usually high (60°-70°). About 3 km eastwards of the limit with the Macuchi Fm. the Yunguilla strata depict moderately closed decametric folds. Hinge lines strike N-S with a clear and constant W dip of fold planes. More to the east, along the E-W course of the Ganquis river the Yunguilla Formation is involved in a sequence of large east-vergent folds which culminate with an eastward recumbent fold. All these folds have NNE striking hinge lines. Some west dipping reverse faults also cut this section. Where the Ganquis river course passes to an ESE strike, a large eastward recumbent anticlinal is associated to west dipping reverse faults. From this point up to Mount Cangagua, large moderately closed folds are dominant. Hinge line azimuth is NNE while vergence, when present, is towards ESE. As in other cases, the hinge line of a given fold sometimes changes from a NNE to a NNW direction. Eastwards of Mt. Cancagua, deformation rate increases; large recumbent synclines and anticlines with NNE striking hinge line are followed by densely spaced chevron folds with N-S hinge lines and west dipping axial planes. A reverse fault dips westwards at low angle (5°) with the sense of shear marked by small drag folds with NNW striking hinge lines. Near the contact with the Pliocene andesites, sedimentary rocks are arranged in closely spaced folds with axial planes dipping towards NW. Pliocene andesites show a low grade of deformation. They are cut by small fractures and faults dipping mainly towards NE with inclination angles between 60° and 70°. Slikensides indicate reverse motions with pitches ranging between 80° and 90°.

The Aloa-S. Domingo de los Colorados structural traverse is characterized by brittle deformations interesting mainly the Macuchi Formation. The main structures are represented by west dipping reverse faults with inclination from 45° to 75° (Fig. 2). The general bedding arrangement suggests broad anticlines with N-S to NNE-SSW hinge lines. Nevertheless this section is covered by very dense jungle and, as a consequence, data are less abundant than in the other traverse.

Conclusions

The data collected along the two structural traverses are consistent and show a vergence towards the angular sector comprised between E and ESE. This is expressed by dominant folding with WNW dipping axial planes in the carbonatic rocks. Reverse faults are widespread and represent the only evident deformation in the volcanic units. The dominant westward dipping of the fault planes is consistent with the fold vergence, although a small amount of backthrusts is also present. High angle reverse faults with near vertical motions (fault plane inclination > 50°, pitch > 70°) could indicate the presence of rotated motion planes and therefore a polyphase deformation history with no major changes of motion vectors. As a whole, the southern and more complete traverse is characterized by a gradual changing in the deformative style toward the east, passing from nearly symmetric, moderately closed folds to recumbent and chevron folds with west dipping axial plane. The majority of these deformations should have occurred between Paleocene and Miocene. Pliocene rocks are only cut by fractures and a few NE dipping reverse faults.

If these two traverses are representative of the style and geometry of deformation of the central CO front, they suggest a tectonic transport of this CO segment towards ESE and a WNW dip of the fault system buried under the IV filling. On the other hand another possibility is that this fault system would be vertical, while a ESE dip should be considered unlikely. A high angle WNW dip, as proposed in Baldock (1982, 1985), seems more coherent with the interpretation of the CO structure as due to obduction and is consistent with the hypothesis of Tibaldi and Ferrari (1992b) that the IV could be a basin carried piggyback (passively) on a transpressive thrust complex.

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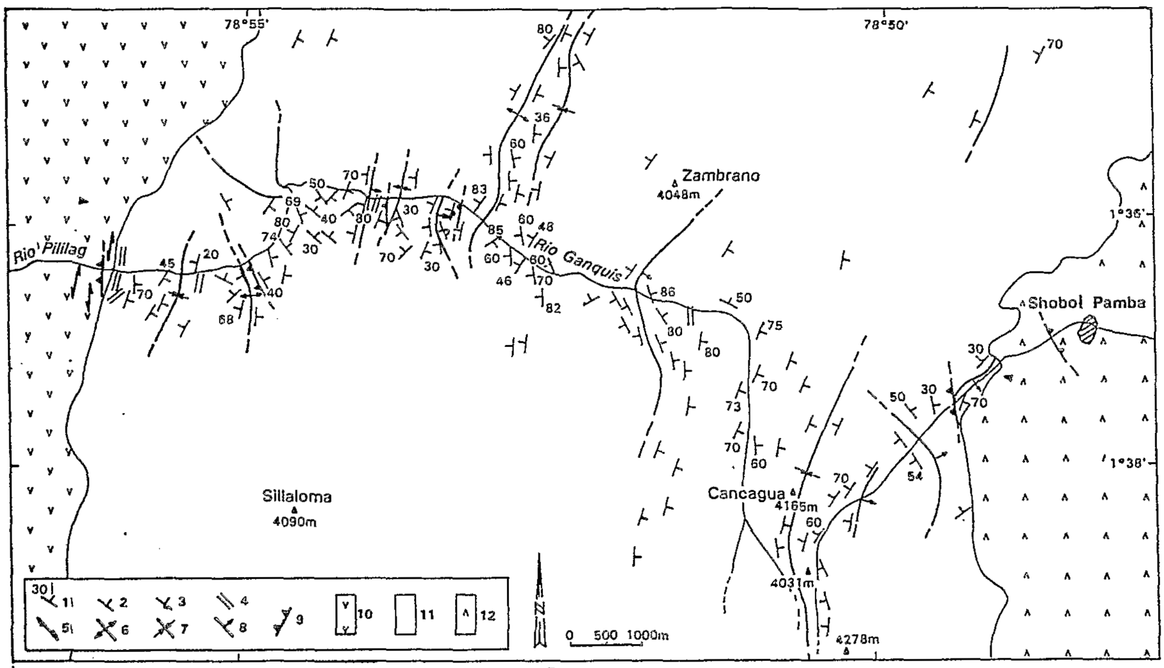

Figure 1. Structural map of the Guaranda - Riobamba traverse. 1 = Bedding attitude (with inclination) measured in the field. 2 = Bedding attitude deduced by aerial photograps. 3 = Recumbent strata. 4 = Vertical strata. 5 = Average direction of fractures. 6 = Anticline axis. 7 = Syncline axis. 8 = Recumbent fold. 9 = Reverse fault. 10 = Cretaceous volcanics (Macuchi Fm.) 11 = Late Cretaceous carbonate rocks (Yunguilla Fm.) 12 = Pliocene andesites.

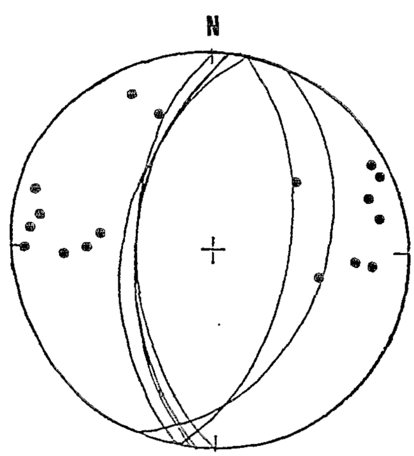

Figure 2. Main structures in the Aloa-S. Domingo de los Colorados traverse. Great circles represent major reverse faults; dots are poles to bedding. Schimdt projection, lower emisphere.