6th International Symposium on Andean Geodynamics (ISAG 2005, Barcelona), Extended Abstracts: 767-769

Active tectonics in the volcaniclastic fan "Abanico del Quindio" near to Armenia city (Colombia)

Carlos A. Vargas [1], Hugo Monsalve [2], Marco A. Nieto [1], Mireya Valdes [1], Germán Camacho [1], & Armando Espinosa [2]

[1] Dpto. Geociencias, Universidad Nacional de Colombia, Bogotá, Colombia; cavargasj@unal.edu.co
[2] Facultad de Ingeniería, Universidad del Quindio, Armenia, Colombia

INTRODUCTION

On 25 January 1999, at 18:19:16 UTC, an earthquake of magnitude M_w 6.2 took place in the central region of Colombian Andean, claimed 1185 victims, caused more than 4370 injuries, and left about 160.000 people homeless. The epicenter was located near the Armenia city (Figure 1). The hipocentral distribution of aftershocks has allowed defining a rupture longitude of about 10km. The epicentral zone is dominated by a complex geology where the main Quaternary unit is the volcaniclastic fan nominally named "Abanico del Quindio" (AQ). The AQ is crossed by several active faults associated to Romeral Fault System (RFS). One branch of RFS, the Cordoba fault has been related to main earthquake. However, other minor faults of RFS as "Armenia", "El Danubio", "Hojas Anchas" and "La Isabela" faults that are crossing the Armenia city suggest a major hazard in the area that the one taken place by the last important earthquake in 1999. In this paper we presented a brief description of the AQ structure based on geological observations, geophysical measurements and estimations of the scarp-fault ages associates to recent neotectonic activity. This information constitutes a well supported condition to re-evaluate the local seismic hazard and for understands the RFS and its tectonic implications in north Andean region.

GEOLOGICAL SETTING

The region near to Armenia city is composed of a pre-Mesozoic, polymetamorphic basement including oceanic and continental rocks such as Cajamarca complex, covered by several volcanic sequences related to subduction (Arquia complex, Quebradagrande complex and Amaime Formation) and intruded by several Mesozoic and Cenozoic plutons (Igneous complex of Cordoba and Ingeous of Navarco river) that are covered by continental deposits (Penderisco, Cauca Superior, La Paila and Zarzal formations). In general these rocks show a complex disposition of tectonic flakes covered by the AQ, alluvial deposits and recent volcanic deposits which are affected by the RFS (Maya and González, 1991). Espinosa (in press) has described several geomorphological units in the AQ and suggested that they correspond at least to fourteen volcaniclastic minor fans that were emplaced from the volcanic activity of the Ruiz-Tolima volcanic complex - RTVC.

The RFS extends along the western boundary of the Central range of Colombia and marks the limit between two lithologic domains: continental and oceanic towards the east and the West, respectively. In the AQ, RFS is spread in an ample area limited by "San Jeronimo" fault at east and "Silvia – Pijao" fault at west. Minor branch of RFS are crossing the AQ near Armenia city and are suggesting at least three structural tendencies: NNE associated to Armenia fault; NNW associated to El Danubio fault; and E-W associated to Hojas Anchas and La Isabela faults. Although microtectonic and seismological analysis have indicate that Armenia fault is a strike-slip left-lateral with inverse component fault with dip toward East, the field recognition suggests at least three relay dips from South to North. On the other hand, the NNW and E-W trends constituting normal faults with dip toward West and South respectively.

ANALYSIS METHOD AND DATA

Initially we have analyzed geomorphological evidences in the study area based on aerial photos to determine neotectonic structures associated to Armenia, El Danubio and Hojas Anchas faults. Then we have done 458 gravimetric and 259 magnetometric measurements to estimate the AQ thickness and confirm the presence of these faults. The gravimetric and magnetometric data was processed to determine regional anomalies and then modeled for calculate the thickness of AQ.

Following Hanks et al. (1984) we have applied the diffusion equation representation under transport-limited conditions with eight (8) fault-scarp triplet's data $(2a, \theta_f, \theta_s)$ along Armenia (5) and El Danubio (3) faults. In Hojas Anchas fault did not was possible did measurements because the landscape does not offer scarp-fault outcrops. Then we have compiled the ^{14}C dates reported by Lalinde (2004) associate to "El Cestillal" fault (one paleoseismological trench near to Pereira city). Similarly we have compiled others ^{14}C dates reported by Osorio et al. (2005) in the "Ibagué" alluvial fan associated to "Ibagué" fault (other paleoseismological trench near to Ibagué city). Although this fan corresponds to other alluvial structure located on the East flank of the Central range (Figure 1), it has similar climate, erosion and source rocks conditions as in AQ. In the first case, "El Cestillal" fault is cutting the ashy-volcanic layer of 2630 ± 80y B.P with an average effective displacement of $2a = 1.4m$. Likewise, Ibagué fault is cutting recent volcanoclastic deposits of 1900 ± 80y B.P. with an average effective displacement of $2a = 1.5m$.

RESULTS AND DISCUSSION

The gravimetric map (Figure 2.a) has allowed us to identifier a zone of major thickness (700m) at NE that represents the feed area toward other minor fans located at SW. The magnetometric map (Figure 2.b) is showing two important zones that can be associated to Cretaceous basement rocks in the east and the presence of the AQ in the west. The limit between these zones could be a prolongation of Cordoba fault toward north. We interpreted that this fault could be related to El Danubio fault, and then the system associated to Armenia, Silvia-Pijao, Hojas Anchas and La Isabela faults have generated a differential horizontal displacement that has segment the Cordoba fault. In this scenario, the Armenia fault could be the last structure near to Armenia city that has had the most recent movement.

We have estimated for all this fault segments that surrounding Armenia city, without including the Armenia fault, a $5.1<M_w<5.9$. Because Paris (2003) has estimated a maximum magnitude of M_w 6.3 for Armenia fault, therefore we can hope in this zone a maximum magnitude interval of $5.1<M_w<6.3$. This interval is coherent with the presence of paleo-liquation in ashy-volcanic deposits in Armenia city suggesting a seismic source located very near. On the other hand, we have estimated a last movement for Armenia fault after 3130 ± 280y B.P. and for El Danubio fault after 2820 ± 620y B.P. These values are reflecting a recent activity coherently with the presence of seismic activity located along these faults (superficial events) with $0.1<M_L<3.6$. The Observatorio

Sismológico del Quindio (OSQ) has reported several earthquakes felt in Armenia city and associate to Armenia fault. In these circumstances, we can suppose that although there are not superficial ruptures associated to historical events in the zone, the hipocentral distribution of aftershocks after 1999 earthquake could be a prior manifestation of an important event in Armenia city.

CONCLUSION

In this study we have detected evidences of active tectonics in the volcaniclastic fan AQ near to Armenia city by means geophysical and geomorphological data. Because the most recent movement in the zone could be related to Armenia fault with a maximum magnitude of M_w 6.3, the hipocentral distribution of aftershocks after 1999 earthquake could be the prior manifestation of a destructive event in Armenia city and other near cities.

References

Espinosa, A. (*In press*). *Un modelo del Cuaternario del Quindío y Risaralda.* Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales. Bogotá.

Maya, M., y González, H., (1995) *Unidades litodémicas de la Cordillera Central de Colombia.* Instituto Colombiano de Geología y Minería INGEOMINAS. Boletín Geológico. Vol 35, 2 –3, 43-57. Bogotá.

Hanks, T.C., Bucknam, R.C., Lajoie, K.R., Wallace, R.E., 1984. *Modification of wave-cut and faulting-controlled landforms.* J. Geophys. Res. 89: 5771-5786.

Lalinde, C., Toro, E., Velásquez, A. y Audermard, F. (2004). *Evidencias paleosísmicas en la región Pereira – Armenia, Colombia.* Proceedings in: Firths Latin-American Congress of Seismology, Armenia (Colombia).

Osorio, J.A., Montes, N., Velandia, F., Acosta, J. Nuñez, A., Audemard, F. and Diderix, H. (2005). *Paleosismología de la Falla Ibagué.* INGEOMINAS, Bogotá – Colombia. Inedited report.

Paris, G. (2003). *Estudio de Geológico, Hidrológico y de Amenaza Sísmica en el sector del Parque la Secreta. Municipio de Armenia, Departamento del Quindío.* Corporación Autónoma Regional del Quindío. Armenia - Colombia. Inedited report.

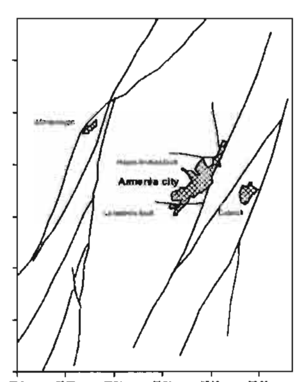

Figure 1. Main structural trends in the study area.

Figure 2. (a) Gravimetric map with faults detected in field.
(b) Magnetometric map with faults detected and inferred.