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Pliocene volcanism in the Cordillera Oriental of Colombia

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Introduction

Volcanic activity from subduction of the Cocos plate is common along the plate margin that forms the Colombian Andes. Tephra deposits commonly cover the Andes in Colombia, and they are usually attributed to the chain of active volcanoes along the Western and Cordillera Central, however volcanic activity to the east in the Cordillera Oriental has generally been dismissed. Recently, however, several authors have proposed that the volcanic rocks that occur in the localities of Paipa and Iza in the Cordillera Oriental originated from the subduction of the Caribbean plate. (Taboada, et al., 2000, Faure et al., 2003). Here we present data to support the existence of a thick, 20-40m, layer of volcanic ashes that most likely originated from volcanoes in the Cordillera Oriental. These newly discovered tephra deposits are partially covered by a thinner layer of volcanic ash falls that in fact originated to the west from volcanoes of the Cordillera Central. One of the important aspects of these volcanic deposits is that their age is poorly known and as such, it is difficult to determine stratigraphic position and regional relationships.

The recognition of Volcanic activity in the area during the last 5 to 10 million years must have increased the thermal gradient of the area therefore cause a significant impact in the timing of oil generation and oil migration in the Eastern Cordillera and Eastern Foothills.

Study Area

The study area is in the Altiplano Condi-boyacense, located in the central part of the Cordillera Oriental of Colombia between 6° and 4° North (Fig.1). Here the Altiplano is a high plain with mean elevations of about 2600 meters above sea level. The plain resulted from the filling of a paleo-topography by Plio-Pleistocene fluvial and lake sediments (Julivert 1961, Van der Hammen, 1966, 1973, Helmens, 1990). The Tierra Negra site is located along the main road from Bogotá to Tunja, about one and a half kilometers north from Tierra Negra village in Boyacá. The elevation at the site is 2650 meters above sea level, with annual mean temperature of 13°C and annual rainfall of 1000 mm.

According to existing geological maps (INGEOMINAS, 1964), the bedrock at the Tierra Negra (TN) locality consists of folded and faulted Upper Cretaceous marine sediments. Although not indicated in the maps, a thick layer of tephra deposits covers the Cretaceous sediments. At TN we have studied and sampled an excellent exposure on a road cut about 35 m high. The road cut exposes about 10 paleosoil sequences developed one on top of each other on successive volcanic ash fall deposits.

Results and discussion

Geochemistry. Major and trace elements analysis of three soil samples, TNA-7, TNA-13 and TNA-21 are shown in Tables 1 and 2. The major element content of three soil samples and one rock sample, POX-10A from Paipa Volcano, a volcano located in the Eastern Cordillera, about 50 km. North of TN, are shown in Figure 1. The graphic shows that the soils samples TNA-7, TNA-13 and TNA-21 have higher content of Al_2O_3, Fe_2O_3 and TiO_2 and much lower contents of CaO, MgO, K_2O and Na_2O than sample POX-10A.

The relative enrichment in Al, Fe, and Ti and the reduction of highly soluble cations: Ca, K and Na requires that the soils developed under well drained, humid and hot weather, quite different from the current weather in the Altiplano that is cold and relatively dry.

Figure 2 show the chondrite normalized Rare Earth Element, REE, pattern of one paleosoil sample: TN-A21 and two rock sample from the Olitas Volcano for comparison. The conclusion from this graph is that the paleosoil REE pattern is quite similar to the REE pattern of volcanic rocks from the same region.

Geochronology. In order define the age of the paleosoils and there parental rocks we used Fission Track dating of zircon. Figure 3 shows four FT age histograms for zircon grains separated from an equal number of samples labeled TNA7, TNA13, TNA 18 and TNA21 (see Figure 1 for location in the stratigraphic column, and Table 2 for data).

Conclusions

We can estimate the depositional age of thephras and tuffs in the Eastern Cordillera based on the zircon fission track age determinations for four samples. These samples (TNA-7, 13,18 and 21) have a mean age of 4.1 Ma +0.5 –0.6 (based on 91 grains). Individual age estimates on single samples are within error of one another. This result indicates that a large region in the Tierra Negra saw a series of explosive volcanic events between about 3.6 and 4.7 Ma. However one must note that this is a minimum age range since the dated material does not include the base or the top of the paleosoil sequence.

Helmens, K., 1990, describes similar reddish brown paleosoils on top of Marichuela Fm., the Tibagota member of Tilata Fm. and the Chorrera Fm. and suggest that they probably mark a period of regional stability and hot climate at the end of the Pliocene or during one of the earlier interglacial periods. Contrary to this view and based on the results of this study we propose that the reddish brown paleosoils that are very widespread in the "Altiplano" of the Eastern Cordillera of Colombia developed in Early Pliocene before the Uplift of the Cordillera.

References

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