UPLIFT AND ACTIVE DEFORMATION OF THE PASTAZA ALLUVIAL FAN (SUBANDEAN ZONE OF ECUADOR)

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INTRODUCTION

The Pastaza megafan constitutes the largest humid tropical fan in the world (Räsanen et al., 1992). The apex of this megafan is situated between the Ecuadorian Subandean domes of Cutucú and Napo at the outlet of the Rio Pastaza (Fig.1), whose catchment is situated in the Interandean depression. Actually, the Rio Pastaza runs across the Cordillera Oriental before debouching into the megafan. It drains the flanks of the Ecuadorian stratovolcanoes Cotopaxi, Sangay, Tungurahua, Altar, Chimborazo and Carihuairazo, and continues to receive massive amounts of volcanoclastic debris (Hall, 1977).

The Pastaza megafan is made up of Miocene to Pleistocene deposits (Chambira Fm.), including the late Pleistocene Mera Formation (Tschopp, 1953) mainly composed of catastrophic volcanoclastic (andesitic) debris flows from the Tungurahua volcano, interfering with pure fluvial sedimentation.

The Eastern Cordillera constitutes a relatively narrow thrust and fold belt, which overrides the Subandean Zone (Baby et al., 1999) along the Abitagua batholite thrust (Fig. 2 and 3), still active to day as revealed by the Baeza seismic event (Ms = 6.9, 1987). Both the Eastern Cordillera and Pastaza megafan are incised by the Pastaza River and principal tributaries, which indicates general uplift in the orogen. The present paper is aimed at comparing incision and incision rates in the megafan and the Eastern Cordillera in order to distinguish overall and local incision and analyze their causes by means of a study of the construction of the fluvial terraces.

THE UPPER PASTAZA VALLEY

In most of the Upper Pastaza valley (Fig.3), large-volume catastrophic deposits and lava flows interferes with the normal pure fluvial deposits. These deposits form a series of aggradations terraces and lava (flows) deeply incised by the present-day Pastaza River, which have been used as geomorphic and age markers for incision rate measurements.

The most spectacular example is provided by an andesitic lava-flow, the "Juive Chico Pre-historic" flow produced by the Tungurahua volcano, which filled the Pastaza valley over at least 30 km. It sealed a fluvial pebbles level and provides actually an excellent geomorphic surface. Dating of the basis and top of this lava flow has given ages of 1470 +/- 85 y.BP and 2215 +/- 90 y.BP (Hall *et al.*, 1999). Differential GPS measurements show that the height of the lava above the present-day stream bed varies between 65 m along the 30 km elongate lava flow. Incision rate thus appear as ranging here from **4.74 to 7.14 cm/year**.

The importance of incision is also spectacularly shown in the small Santa Ines – Rio Negro piggy-back basin formed on the rear of the Abitagua thrust sheet, where are preserved rather thick and wide terraces (Fig.3). There, charcoal from the best-preserved fluvial terrace, 54m above present-day river level, gives a ^{14}C age of 1 ky BP, which indicates an incision rate of **5.4 cm/year**.

THE PASTAZA MEGAFAN

Morphoscopic studies show that the upper surface of the Pastaza fan constitutes, at least in the whole upper part of the fan, a well characterized geomorphic marker which can be used as a reference surface because of the scarcity of post-depositional tectonic structures. This surface is incised by the antecedent Pastaza River and main tributaries, which now shifted toward the southeast.

On the apex of the alluvial fan (near Mera), where the Pastaza River emerges onto the lowlands (Oriente basin), a thick unit of andesitic breccias with chaotic internal structure typical of debris avalanche deposits (lahar) forms a broad terrace (Mera Fm.; Tschopp, 1953). It constitutes the remnant mounds of a massive avalanche related to a sector collapse that followed the Tungurahua I constructional period (Hall *et al.*, 1999).

At the top of this Mera lahar terrace (Figs. 1 and 3), an organic soil recognized under braided-stream deposits, gives a ^{14}C age of 17 920 +/- 70 y.BP. These fluvial sediments are now located 80 m above the present-day Pastaza stream, which indicates an incision rate of at least **0.44 cm/years.**

DISCUSSION AND CONCLUSIONS

The incision measurements in the Pastaza megafan indicate values ten times lower than in the Upper Pastaza. Since no tectonic event has deformed significantly the fan surface from late Pleistocene to present-day and no base level comparable with the measured incision was recorded during this period, the incision measured in the fan is likely to represent the overall orogen uplift.

The much higher incision rated measured in the Upper Pastaza valley indicates the occurrence of local events. The high incision rate, measured in the Santa Ines – Rio Negro back limb basin, can be attributed to the uplift due to the Abitagua thrust, which limits the Cordillera Oriental from the Subandean zone (Figs. 2 and 3). The modern activity of this fault is attested by the strong seismicity of the Subandean region (see Baby et al., this issue). This strong incision indicates that active headward erosion was associated with thrusting. Although somewhat higher, the values of incision rates measured in the Upper Pastaza valley are actually comparable with those obtained in the outer Himalayan thrust and folds (Avouac, 1991; Van Der Woerd et al., 2001). These high incision rates are thus likely to have a result of local tectonics accompanying overall orogenic uplift.

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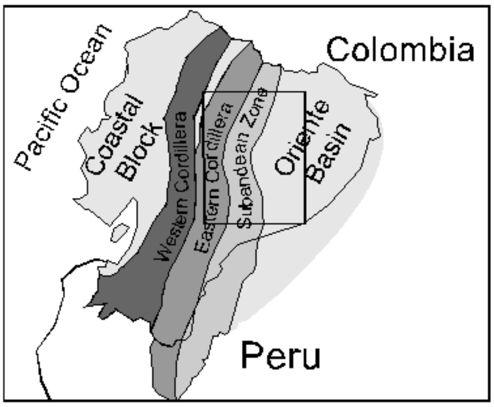

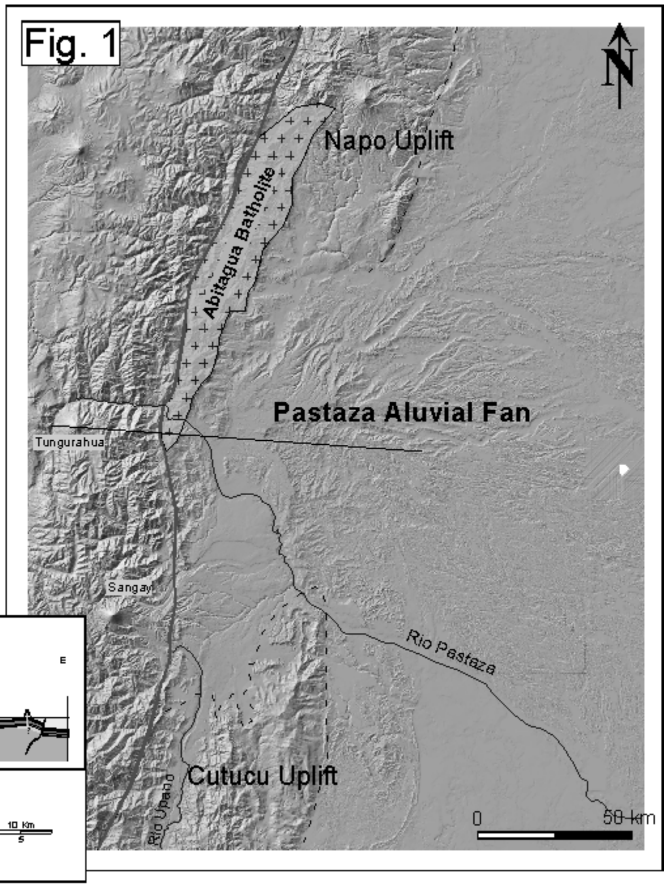

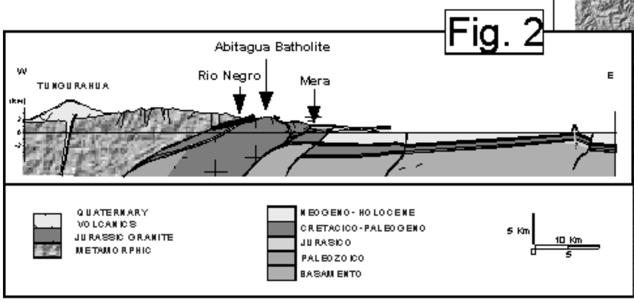

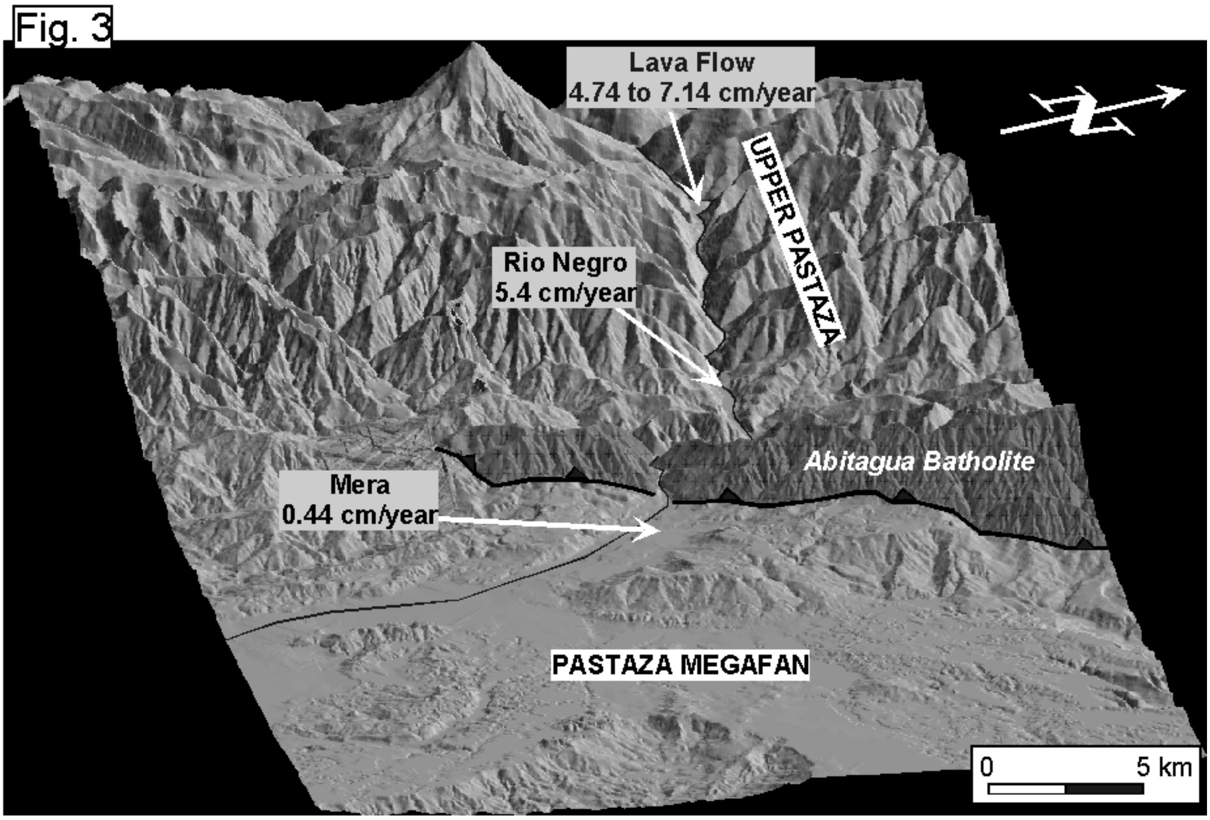

Fig. 1: Detailed topography (from *Savane* processing of 1: 50000 topographic maps) of the Pastaza alluvial megafan and its relationships with the Ecuadorian Eastern Cordillera and Subandean zone. Fig. 2: Structural cross-section across the Eastern Cordillera and the Pastaza megafan (location on fig. 1). Fig. 3: 3D detailed topography (from *Savane* processing of 1 : 50000 topographic maps) of the Upper Pastaza and Pastaza megafan.