STRATIGRAPHIC ARCHITECTURE OF THE GALLO RUMI MEMBER, SAQUISILI FM. : THE UPPER PALEOCENE COMPLEX FAN IN THE CENTRAL CORDILLERA OCCIDENTAL OF ECUADOR.

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INTRODUCTION

The Cordillera Occidental of the Andes of Ecuador (Fig. 1, COE) is composed of two oceanic terranes, the San Juan and Guaranda terranes, accreted to the Andean margin in the Late Campanian and late Maastrichtian, respectively (Reynaud et al., 1999; Lapierre et al., 2000; Mamberti et al., 2003; Jaillard et al., 2004). These two terranes represent the former Pallatanga terrane of Hughes & Pilatasig (2002). Farther West, in the costal zone and in the foothills, the Piñón terrane (PT) and the Macuchi terrane (MT), were accreted to the margin in the early Late Paleocene (Jaillard et al., 1995) and in the lower to middle Eocene (Hughes & Pilatasig, 2002; Toro & Jaillard, 2003), respectively.

Mainly clastic sediments (Fig. 2) sealed the accretions of these terranes (Toro & Jaillard, 2005a). The Gallo Rumi Member (GRM) of the Saquisili Fm. (Jaillard et al., 2004) is interpreted as the sedimentary response to the accretion of the Piñón terrane to the margin of Ecuador.

OBJECTIVES

One of the aims of the *IRD* (*Institut de Recherche pour le Développement*) – Petroproducción (Filial of Petroecuador) scientific agreement, is the study of the Late Cretaceous-Paleocene clastic series located in the Western Cordillera (COE) of central Ecuador (Figs. 1, 2). This study is focused on the GRM of the Saquisilí Fm. (Jaillard et al., 2004), which unconformably overlies the Yunguilla Group and is overlain by the Apagua Fm. (middle Eocene).

This article presents the analysis of the facies and environments, sequence organization, paleogeographic framework and stratigraphic architecture of the GRM. The outcrop analysis were carried out at 1 : 100 scale, using the Shell's Co. code.

GEOLOGICAL FRAMEWORK

Tschopp (1948) originally named the conglomerates cropping out in the Gallo Rumi area, along the Riobamba-San Juan-Guaranda road, central part of the COE, as the Gallo Rumi Conglomerates.

Later, Kehrer and Kehrer (1969), and Randel and Lozada (1976) interpreted the Gallo Rumi Conglomerates as the lower member of the Cretaceous Yunguilla Fm., whereas Savoyat et al. (1970) and Santos and Ramírez (1986) correlated this unit with the Rumi Cruz Conglomerates of the Latacunga – Quevedo road. These conglomerates were also interpreted as part of the red beds of the Silante region (Egüez, 1986). Savoyat et al. (1970) proposed that the Cayo (Gallo) Rumi conglomerates overlie the Yunguilla Fm. and was of Paleocene age. Santos (1986) developed the first environmental and paleogeographic study of this unit.

The GRM crops out in the central part of the COE (Figs. 1, 2), between the Gallo Rumi settlement and the Cerro Amosayana (2.5 km NNE of Gallo Rumi settlement, San Juan – Guaranda road, Figs. 2 & 3); and farther South along the Cóndor Corral stream ~ [734, 98083], South of the Picota and Cóndorloma hills, Sicalpa – Santiago road. The type locality is considered the hills surrounding the Gallo Rumi settlement.

This member consists mainly of conglomerate and sandstone beds ; however siltstones occur. Texturally the conglomerates of the GRM are very fine to fine (length diameter between 4 and 65 mm), and moderately sorted. They are mainly orthoconglomerates (clast concentration of 75 to 90%), with subrounded to subangular clasts. The granulometric profile shows a sawed model, thickness variation, fining upward sequences, and sedimentary discontinuities. The sandstones are very fine- to very coarse-grained. The silts are black and gray, laminated, and they are clayey debrites too.

Near Gallo Rumi, the base and top of the unit have not been seen; however, along de Cóndor Corral stream the GRM overlies the shelf very fine to fine sediments of the Lower Saquisilí Member. According to the study of the GRM in the Gallo Rumi road (261 m thick) and in the C. Amosayana sections (284 m thick, Fig. 3), the thickness of the unit can be estimated as 350 m to 700 m.

Since the age of the Lower Saquisilí Member is early to middle Paleocene (Hughes et al., 1998; McCourt et al., 1998; Jaillard et al., 2004), the GRM in the central and austral parts of the COE is ascribed to the Late Paleocene (Toro and Jaillard, 2005a), with a possible extension into the basal part of the lower Eocene.

FACIES, ENVIRONMENTS, SEQUENCES AND STRATIGRAPHIC ARCHITECTURE

The GRM presents numerous facies corresponding to several sedimentary environments : marine, transitional and continental.

In the Gallo Rumi and C. Amosayana sections, we identified nine main sedimentary environments, plus the debrites (part of the gravites facies of Gani, 2004). They are : proximal (conglomeratic) and distal alluvial fan, braided stream river, fan delta *s.s.*, continental plain, delta plain, delta front (tidally influenced), prodelta and shelf, and turbidic basin (Fig. 4). These environments are represented by 37 facies (Figs. 4, 5).

The most variable, vertical and lateral, facies and environments changes may be seen along the Gallo Rumi sections, between the kms. 15.5 and 16.1 of the San Juan (km 0.0) - Guaranda road; suggesting an important lateral variability and a high migration capacity (Georgieff & González Bonorino, 2000).

With respect to the Cerro Amosayana section, the GRM at the Gallo Rumi section presents less continental facies; more marine *s.s.* facies, more gravites of turbiditic basin environment; and an important contribution of fan delta facies (Figs. 4, 5).

The facies, environment and stratigraphic architecture analysis carried out in the Gallo Rumi and Cerro Amosayana sections suggest that the GRM was deposited in a large conglomeratic and sandy composite fan (Fig. 6), including (1) alluvial fan, fan delta *s.s.*, delta plain and delta front environments (proximal facies, C. Amosayana section), and (2) continental and paralic environments, arriving abruptly and directly into (3) a marine turbiditic basin (distal facies, Gallo Rumi section).

All paleocurrent indicators (clast imbrications, base of channels, spill ripples) gave an homogeneous general current direction orientated toward the SW, indicating that the clastic source was located toward the NE (Cordillera Real of Ecuador), suggesting that the feeding system followed a NE-SW trending (ancient structures), transverse to the COE, and pointing out that this fan was bordered by a cordilleran paleogeography (highlands). This assertion is corroborated by the occurrence of a high proportion of conglomeratic facies (proximal and distal alluvial fan, fan delta, braided stream river and continental plain facies) at the C. Amosayana section (Figs. 4 to 6), the proximal section, and the high proportion of sandy and silty facies (delta front, turbiditic and debrites facies) at Gallo Rumi settlement section, the distal section.

In general, the facies and sequences conform thick (15 to 90 m) transgressive system tracts (TST, most developed and preserved in the distal Gallo Rumi section) and thin (less than 25 m) highstand system tracts (HST, more preserved in the proximal C. Amosayana section), separated by major facies dislocations (*sensu* Milton & Emery, 1996) between marine and fluvial and alluvial sediments, and their associated sequences boundaries (SB). The falling standing system tracts (FST) are not preserved or are not evident. The thick TST of the Gallo Rumi section start with continental (alluvial, braided) facies (the proximal fan), and, grading progressively, end with marine shelf and turbiditic facies (the distal fan). The most deep are the facies the most frequently appear the debrites.

SW of the Gallo Rumi settlement (~ distal marine fan), this high proportion of sandy and silty turbidites point out an abrupt deepening of facies at the occurrence of steep clinoforms deriving from the proximal fan. Right there, the frequent occurrence of gravites in the turbiditic basin indicates sediment remobilization (instability), common in this type of basins (Kleverlaan, 1994). The large composite fan of the GRM (Fig. 6) shows characters similar to the conglomeratic, sandy and silty fan of the Tarbernas basin, Spain (Kleverlaan, 1989; 1994; Kleverlaan and Reeder, 2000).

CONCLUSIONS

The upper Paleocene GRM of the Saquisilí Fm., was deposited by a large conglomeratic and sandy composite fan (alluvial fan, fan delta *s.s.*, braided stream river and delta plain), which arrived abruptly and directly into a marine sandy and silty turbiditic basin, thet was surrounded by highlands.

The most proximal facies may be seen in the Cerro Amosayana outcrop, and, the most distal facies are visible, in part, in the Gallo Rumi section.

Paleocurrent indicators indicate transport toward the SW, pointing out that the GRM was sourced from the NE (Cordillera Real), and that deposition occurred along a NE-SW axis explaining the elongated shape of this large fan. The continental feeding system likely followed transverse inherited structures, and was bordered by highlands.

This large fan exhibits important lateral variability and high migration capacity. Its stratigraphic architecture displays numerous facies corresponding to nine main sedimentary environments grading from continental to marine. These environments are: proximal (conglomeratic) and distal alluvial fan, braided stream river, fan delta *s.s.*, continental plain, delta plain, delta front (tidally influenced), prodelta and shelf, turbiditic basin and gravites.

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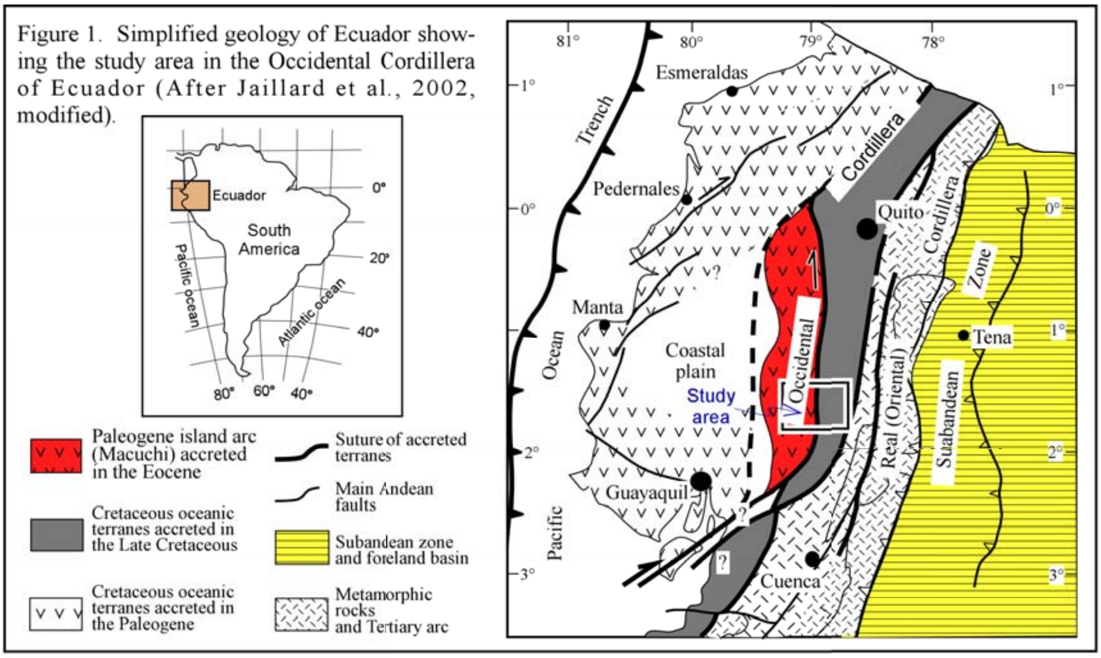

Figure 1. Simplified geology of Ecuador showing the study area in the Occidental Cordillera of Ecuador (After Jaillard et al., 2002, modified).

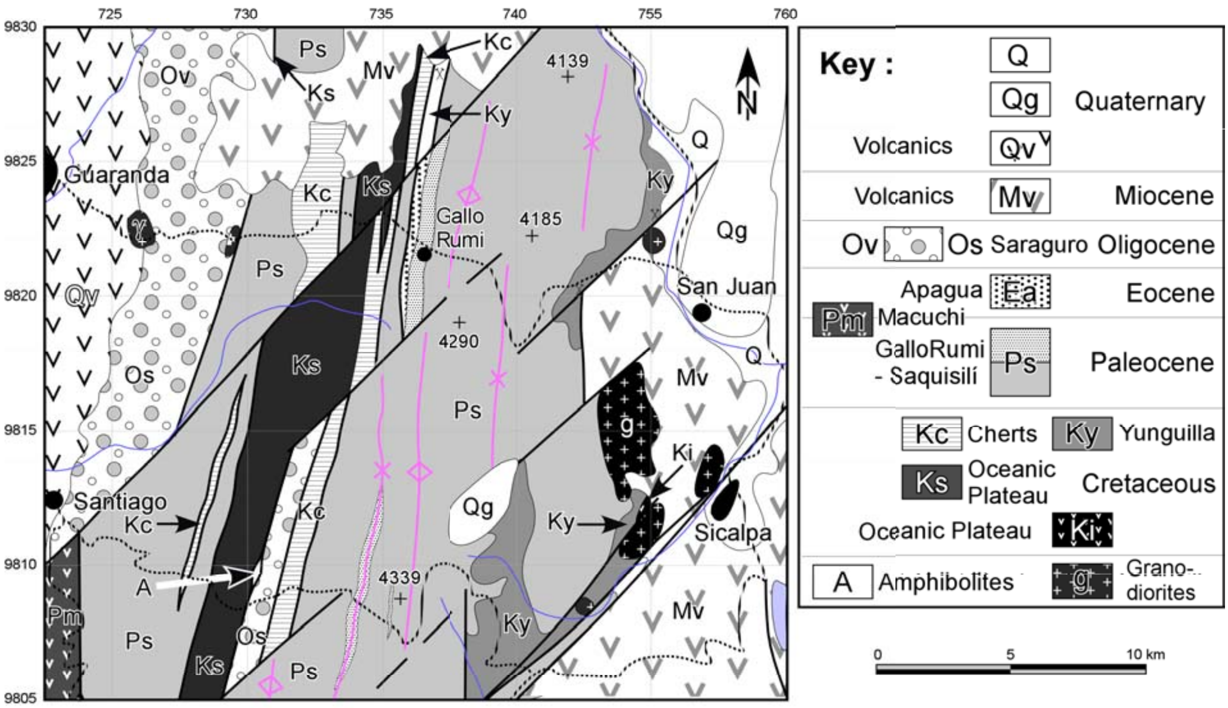

Figure 2. Geological setting of the central part of the Occidental Cordillera of Ecuador, in between of the Guaranda city and the Sicalpa town, showing the Gallo Rumi Member outcrops (After Jaillard et al., 2004, modified).

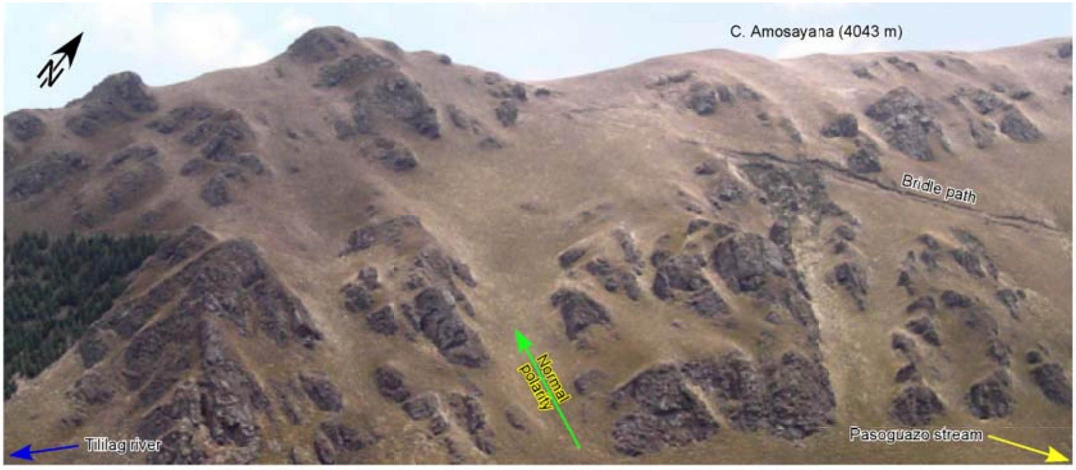

Figure 3. Big outcrop of conglomerates and sandstones of the Gallo Rumi Member at the Cerro Amosayana, km 15.5, San Juan (km 0.0) - Guaranda road cut. N0296

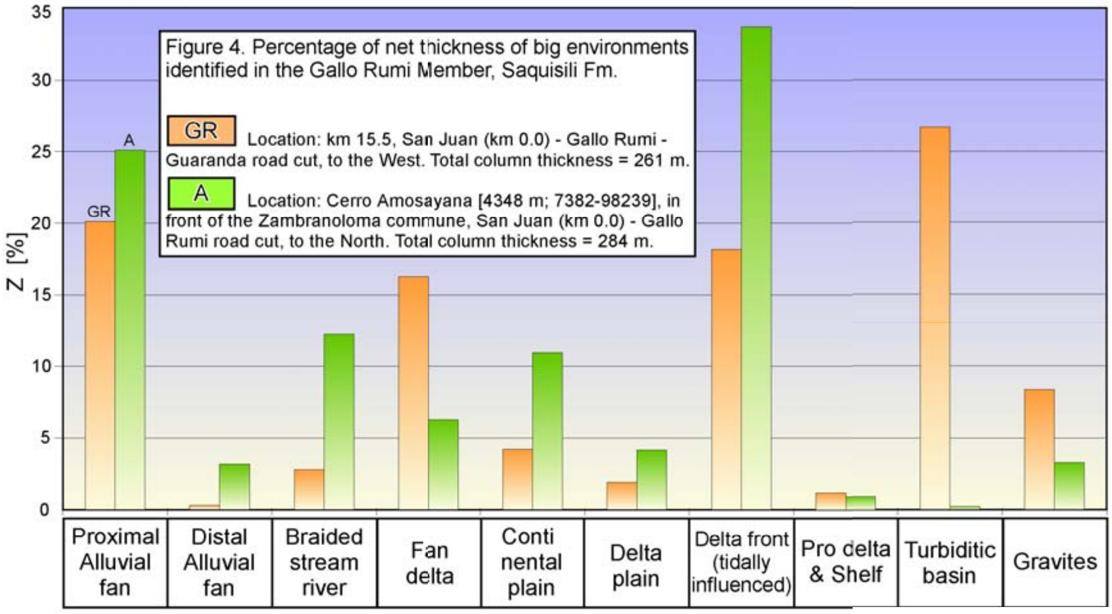

Figure 4. Percentage of net thickness of big environments identified in the Gallo Rumi Member, Saquisili Fm.

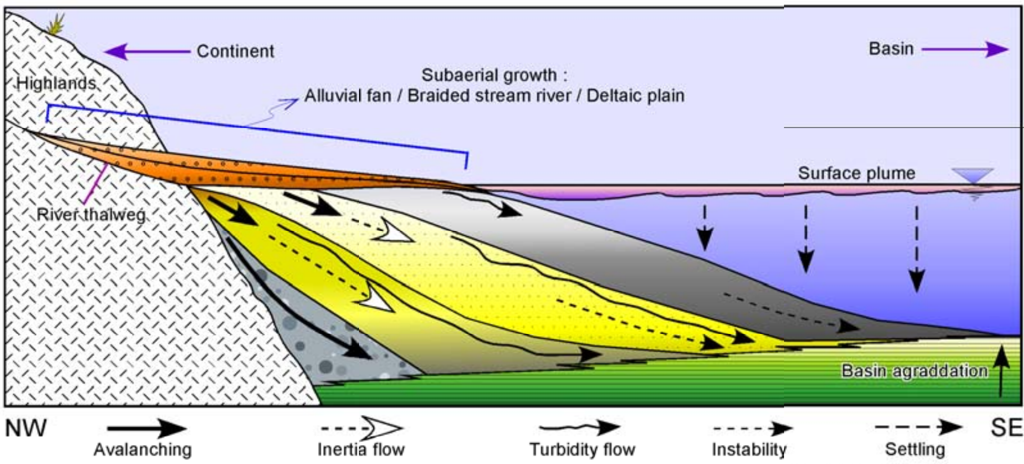

Figure 6. Conceptual fan-delta development sequence applied to the Gallo Rumi Member, Saquisili Fm., reflecting reduction in sediment supply to the underwater slopes as the subaerial fan component grows and off-shore relief declines (After Prior & Bornhold, 1990; *in*: Kleverlaan & Reeder, 2000, modified).

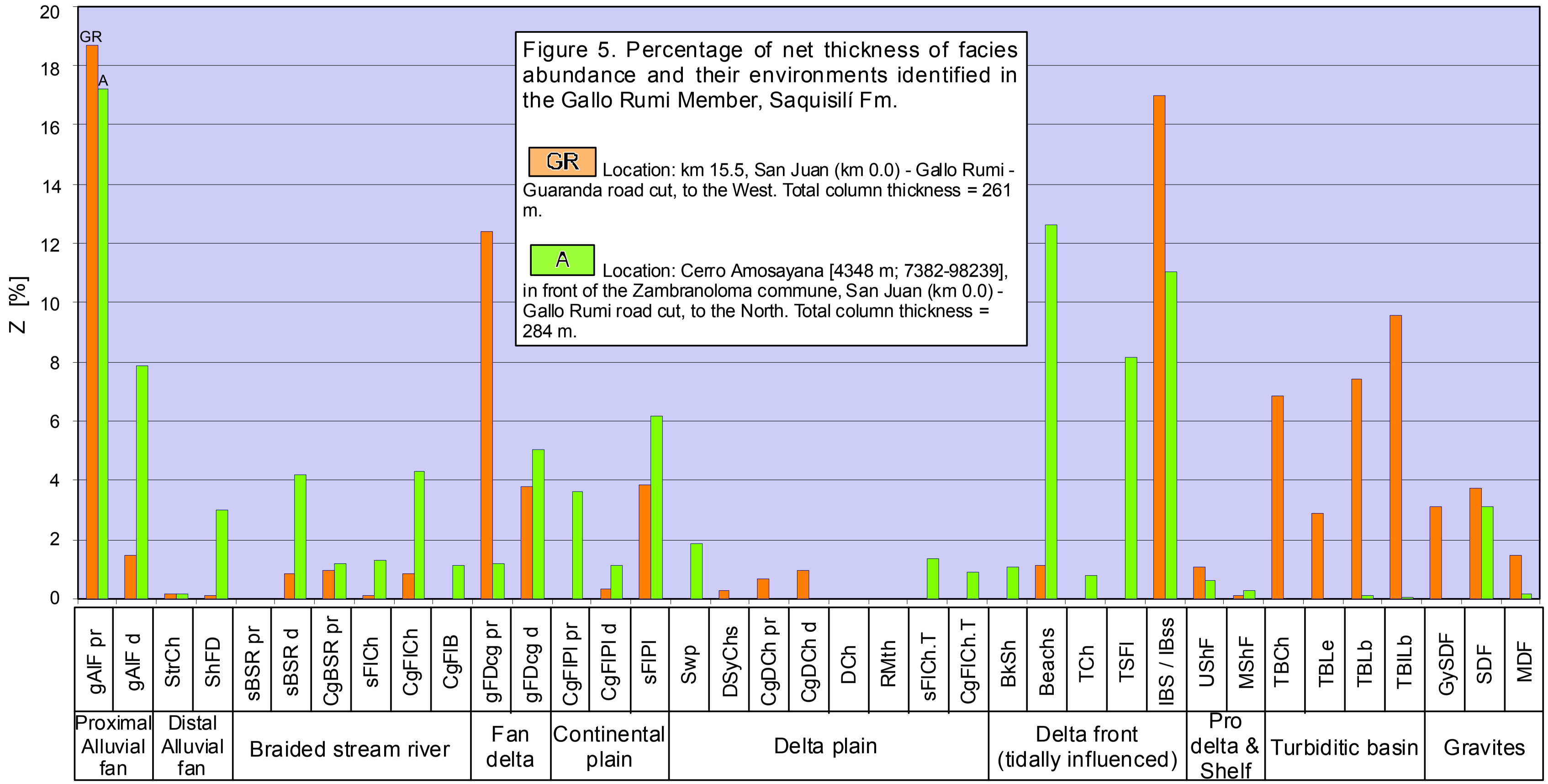

Figure 5. Percentage of net thickness of facies abundance and their environments identified in the Gallo Rumi Member, Saquisilí Fm.

Facies key :

Gravelly alluvial fan proximal and distal (gAlF pr, gAlF d), stream channel (StrCh), sheet flood deposits (ShFD), sandy braided stream river proximal and distal (sBSR pr, sBSR d), conglomeratic braided stream river proximal (CgBSR pr), sandy fluvial channel (sFlCh), conglomeratic fluvial channel (CgFlCh), conglomeratic fluvial bar (CgFlB), gravelly fan delta conglomerate proximal and distal (gFDcg pr, gFDcg d), conglomeratic fluvial plain proximal and distal (CgFlPl pr, CgFlPl d), sandy fluvial plain (sFlPl), swamp (Swp), distributary splay channel sands (DSyChs), conglomeratic distributary channel proximal and distal (CgDCh pr, CgDCh d), distributary channel (DCh), river mouth (RMth), sandy and conglomeratic fluvial channel with tidal influence (sFlCh.T, CgFlCh.T), back shore (BkSh), beach sands (Beachs), tidal channel (TCh), tidal sand flat (TSFl), interdistributary bay siltstone and sandstone (IBS, IBss), medium and upper shore face (MShF, UShF); turbiditic channel, levee, lobule and interlobule (fringe of Mutti, 1977) (TBCh, TBLe, TBLb, TBlLb, of Shanmugam & Moiola, 1988); gully sandy debris flow (GySDF), and sandy and muddy debris flow (SDF, MDF). Z, thickness.