LAJSBA
LATIN AMERICAN JOURNAL OF SEDIMENTOLOGY AND BASIN ANALYSIS | VOLUME 29 (1) 2022, 61-65

IMPROVING THE FACIES MODEL FOR SYN-ERUPTIVE FLUVIAL SUCCESSIONS: LESSONS FROM THE CHAITÉN VOLCANO AND BLANCO RIVER, CHILE

A. Martín Umazano [1,2,], Emilio Bedatou [1], J. Marcelo Krause [3], Eduardo S. Bellosi [4], Pablo M. Villegas [2]*

[1] Facultad de Ciencias Exactas y Naturales, Universidad Nacional de La Pampa. Av. Uruguay 151, 6300 Santa Rosa, La Pampa, Argentina.
[2] INCITAP (CONICET-UNLPam). Mendoza 109, 6300 Santa Rosa, La Pampa, Argentina.
[3] CONICET-Museo Paleontológico Egidio Feruglio. Av. Fontana 140, 9100 Trelew, Chubut, Argentina / Universidad Nacional de Río Negro. Av. Roca 1422, 8332 General Roca, Río Negro, Argentina.
[4] CONICET-Museo Argentino de Ciencias Naturales. Av. Ángel Gallardo 470, 1405 Ciudad Autónoma de Buenos Aires, Argentina.
* Corresponding author: amumazano@gmail.com

ARTICLE INFO

Article history
Received May 12, 2022
Accepted June 2, 2022
Available online June 2, 2022

Handling Editor
Sebastian Richiano

Keywords
Fluvial environment
Explosive volcanism
Syn-eruptive successions
Facies model
Chile

ABSTRACT

Typically, the stratigraphic record of syn-eruptive fluvial successions is a pyroclastic-rich one. It includes an alternation of braided channel deposits and sheet-like floodplain strata, in which the occurrence of paleosols with *in situ* trees and primary pyroclastic deposits is common. The participation of facies formed from sediment-laden flows is also a conspicuous feature in these successions. Nevertheless, the disturbances occurred in the chilean Blanco River in 2008, as a consequence of the large tephra influx from the Chaitén Volcano eruption, result in discrepancies with the mentioned conceptual background including the plan-view form and filling of channels, and lateral compositional changes along the river. These discrepancies would response to local conditions such as precipitation, vegetation, topography, and type and amount of available sediment. Furthermore, the connection between the Blanco River and the Pacific Ocean, adds an additional feature to syn-eruptive fluvial successions, represented by associated delta plain deposits composed of volcaniclastic sands.

INTRODUCTION

The stratigraphic record of syn-eruptive, fluvial successions is relatively well stablished after Smith's (1991) pioneer ideas, who proposed a widely used facies model (Fig. 1a-b). It is typically pyroclastic-rich and characterized by short-lived, braided fluvial channel bodies, which are interbedded with sheet-like floodplain strata having paleosols with *in situ* trees, common primary pyroclastic deposits and facies formed from hyper-concentrated to debris-flow continuum. In comparison with the inter-eruptive fluvial successions, the channel deposits have larger width/thickness ratio and composing facies that suggest shallower flows with high sediment concentration and minor lithological diversity. Moreover, some syn-eruptive intervals register mostly unconfined fluvial conditions, a situation that has been linked to extreme pyroclastic sediment influx (Umazano *et al.*, 2017). On the other hand, the channel deposits of inter-eruptive intervals register perennial, more sinuous patterns and coarser bedload, which represent the norm in this type of fluvial environments. Classically, the recurrent

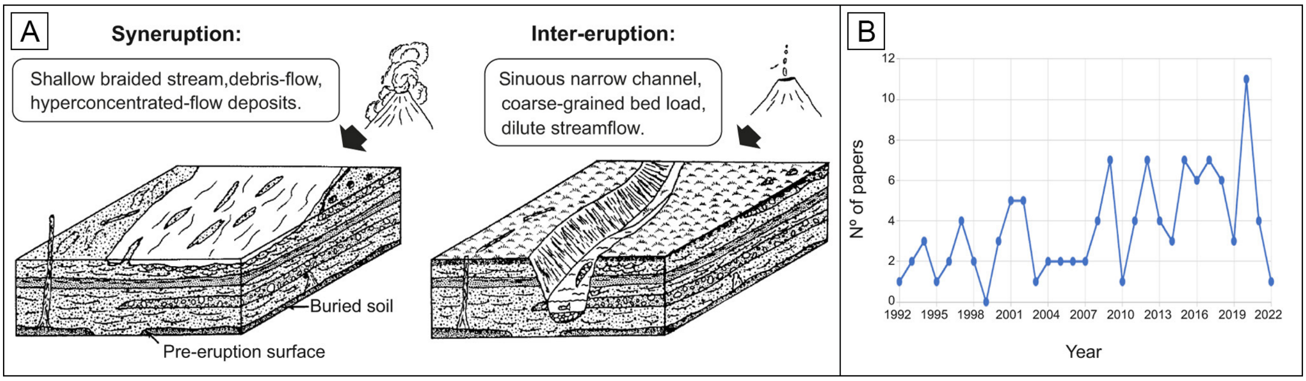

Figure 1. a) Geomorphic, sedimentologic and stratigraphic characteristics of syn- and inter-eruptive fluvial conditions (modified from Smith, 1991). **b)** Use (1991-2022) of the classical facies model to interpret volcaniclastic fluvial successions according to the Scopus citation database (www.scopus.com).

alternation of syn- and inter-eruptive intervals is related with the temporal variability in the pyroclastic sediment supply. Nevertheless, recent contributions have evaluated others auto and allocyclic signals to make consistent paleoenvironmental interpretations including tectonic activity (*e.g.* Paredes *et al.,* 2015), climatic changes (*e.g.* Umazano *et al.*, 2008), and development of complex hydrometeorological events triggered by logjam breakups (*e.g.* Umazano *et al.*, 2014). The main goal of this contribution, resulting from the study of the indisputably syn-eruptive sedimentary record generated from the interaction between the Blanco River and the recent rhyolitic explosive eruption of the Chaitén Volcano (Chile), is call attention about some differences regarding the Smith´s conceptual background, and present an additional syn-eruptive depositional feature valid for rivers with oceanic connection.

CHAITÉN VOLCANO AND BLANCO RIVER

The Chaitén Volcano, located in the X Region of Chile, has a genesis linked with the convergence between the Pacific and South America Plates (Fig. 2a). During May 2008, the volcano experimented four Plinian explosive eruptions as well as minor ash emissions, seismic activity, episodic extrusion of a dome accompanied by lateral blasts, and pyroclastic flows after the partial collapse of eruptive columns (Umazano *et al.,* 2014 and references therein). Explosive eruptions affected three adjacent fluvial basins, in which there are short trunk rivers connected with the Pacific Ocean via delta plains. In particular, the Blanco River catchment (~77 km^2) supports a dense evergreen forest under temperate wet climate conditions (annual precipitation in Chaitén town in the decade before the eruption ranged from 2600 to 4300 mm), and exhibits steep topographic gradients (up to 2.8 %) along the main and tributary channels as well as in cross-sections to them. Owing to the eruption the Blanco River catchment was overfeeded with pyroclastic sediments that together with rains, steep topography and forest vegetation, triggered sudden geomorphic modifications and the generation of an episodic sedimentary record (Umazano *et al.,* 2014). Main syn-eruptive perturbations, which occurred no later than May 20, included overflow and flooding, changes in dimension and pattern of fluvial channels, avulsion, and later filling of abandoned channels and coast-line progradation (Umazano *et al.,* 2014; Fig. 2b-c).

REFINING THE SYN-ERUPTIVE FACIES MODEL

Two main differences with respect to Smith´s model were detected, which are characterized below.

First. There is an abandoned and filled channel with sinuous (meandering-like) pattern in the distal part of the Blanco River fluvial system (Fig. 2c), which was probably active no later than May 15-20 when the avulsion occurred. In comparison with the pre-eruptive geomorphological scenario, this abandoned channel exhibits similar sinuosity and greater width (Fig. 2b-c). After the first volcanic explosion and while the abandoned channel was active, it was fully filled by three depositional episodes that generated a succession up to ~2.75 m thick of reworked lapilli and ash (both pumice-rich) mainly deposited

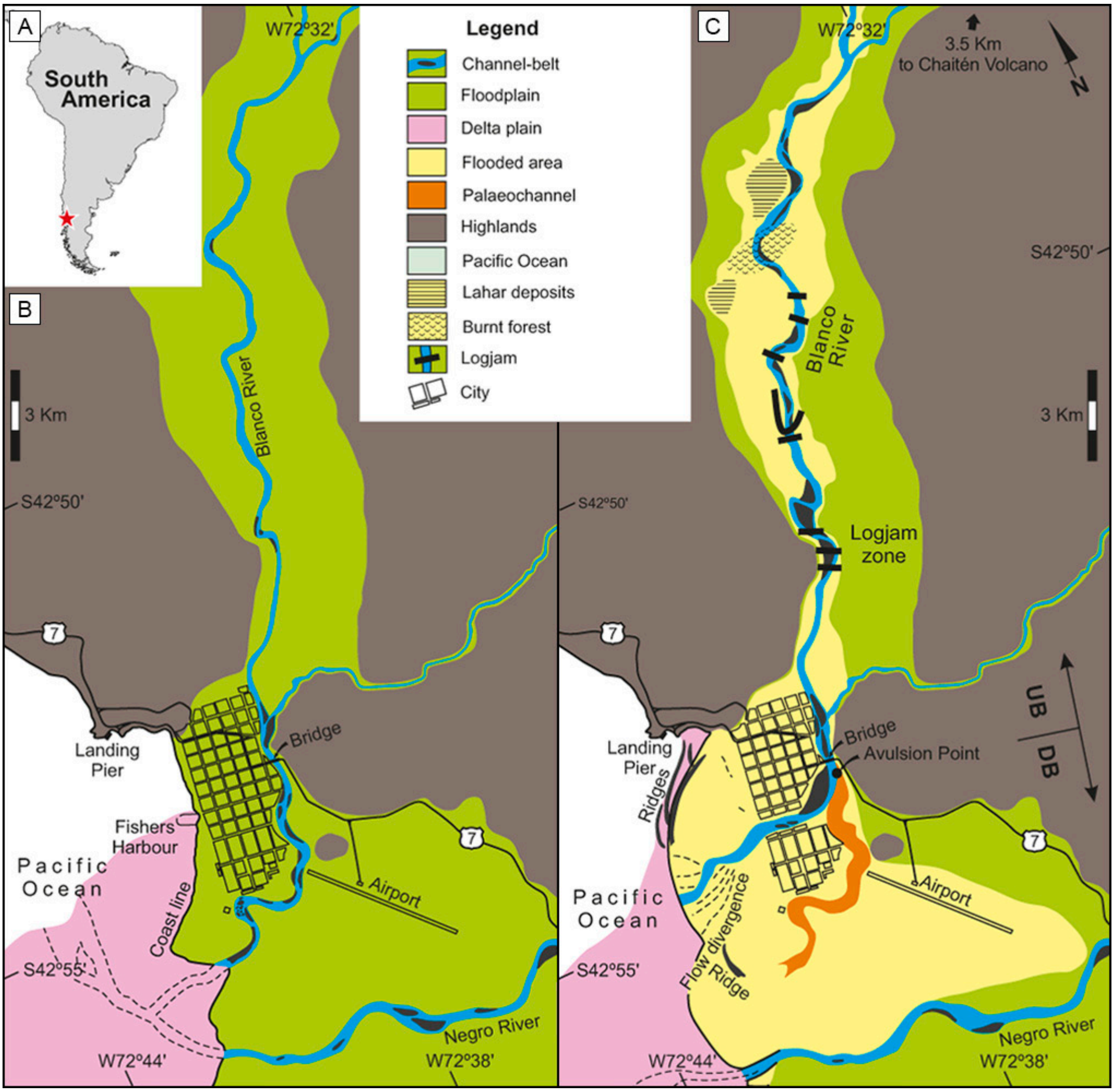

Figure 2. a) Location map of Chaitén Volcano and Blanco River, Chile. **b) – c)** Pre and syn-eruptive scenarios of the study zone, respectively.

from diluted and hyper-concentrated flows, with local participation of deposits formed by sub-aqueous settling of suspended sediments (Fig. 3a-b). Therefore, the preservation of meandering-like fluvial channels fully filled by pyroclastic sediments in syn-eruptive conditions can occur. In this case, the generation of the abandoned meandering-like channel with pyroclastic filling could be related to a combination of several factors including rapid avulsion, and presence of cohesive/vegetated floodplain zones.

Second. Abrupt compositional changes in alluvial deposits are recorded along the longitudinal profile of Blanco River (Fig. 3a-b-c). The near-vent positions are characterized by the presence of volcaniclastic sands and gravels deposited from debris flows and dilute currents, which are replaced downstream by reworked ash and lapilli mainly deposited from hyper-concentrated and dilute flows with scarce occurrence of facies formed by settling. These proximal-distal changes are related to the temporal storage of sediments in logjams and generation of

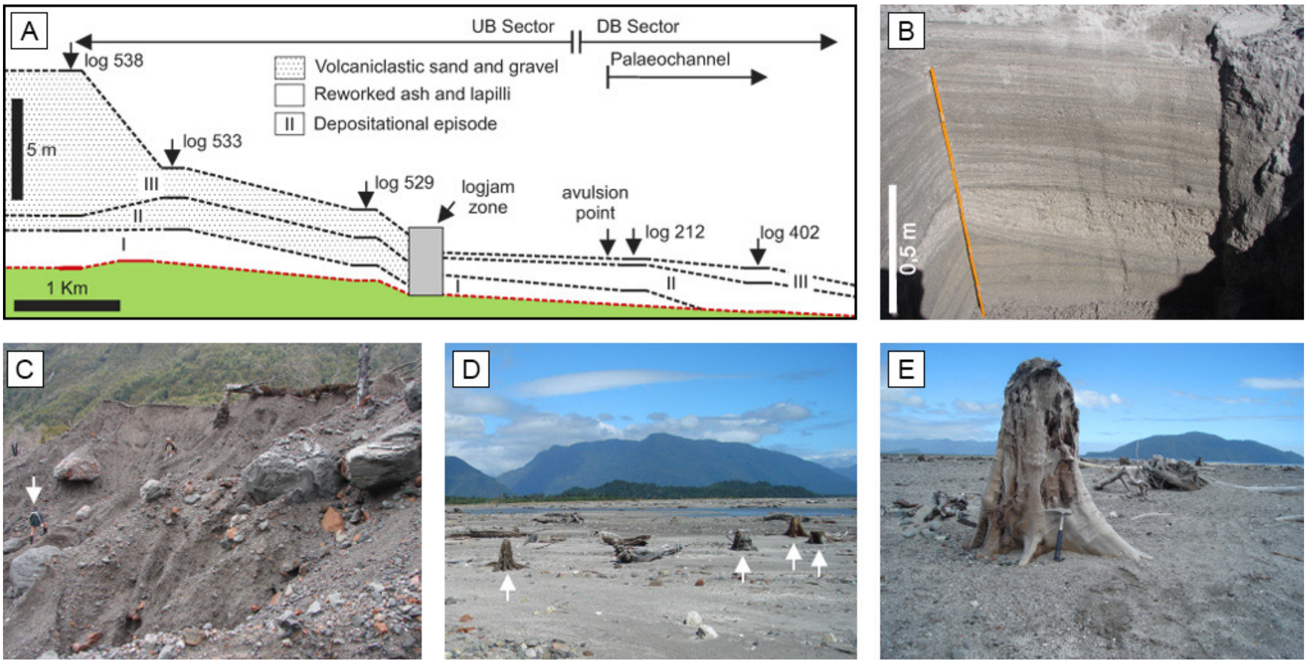

Figure 3. a) Compositional variations in alluvial deposits along the longitudinal profile of Blanco River; see details in Fig. 2. **b)** Open pit in abandoned channel; note the fully pyroclastic filling constituted of cross-bedded and laminated, reworked lapilli and ash; measuring tape is 1 m long. **c)** Massive volcaniclastic gravel deposited from debris flow upstream of the logjam zone; upright person is 1.75 m high. **d)** Delta plain volcaniclastic sand deposits; note the presence of transported trees in life position (white arrows). **e)** Detail of tree stump in life position; hammer is 28 cm long.

sediment-laden flows by logjam breakup or overflow. In these situations, the different floatability of pumice (lapilli and ash) and denser fragments (gravel and sand) generates that the latter were trapped in the logjams and preferentially concentrated upstream. Moreover, there are similar compositional variations in the deposits underlying those of the 2008 eruption, which suggest recurrent hydrosedimentary behaviour of the fluvial system (Umazano and Melchor, 2020). In this way, the pyroclastic-rich lithological homogeneity, as an important feature to recognize syn-eruptive fluvial successions, should be carefully used. In this case, the heterogeneity of syn-eruptive successions is related to local sources of sediments and/or generation-rupture of logjams.

Besides these differences, the Chaitén Volcano - Blanco River case provides an additional feature to the Smith´s model, formerly proposed for rivers without oceanic connection. This additional feature consists in the occurrence of delta plain deposits (Fig. 2c) composed of volcaniclastic sands deposited from dilute flows with variable sediment concentration. Within this facies transported tree stumps in life position are very common (Fig. 3d-e). This must be a warning when describing tree stumps as *in situ* without an adequate description of the sedimentary context where they are (*e.g.* absence of other paleosol features). The compositional change is related to the mixing between fluvial and marine sediments.

FINAL REMARKS

As a summary, the Smith model is a good starting point to recognize and analyze syn-eruptive fluvial successions, but it must be recalled that: i) there are discrepancies including the plan-view form and filling of channels, and lateral compositional changes along the river probably related to local controls such as precipitation, vegetation, topography, and type and amount of available sediment; and ii) there is an additional feature represented by associated delta plain deposits composed of volcaniclastic sands.

Acknowledgements

This contribution is included in the following projects: 16G (FCEyN of UNLPam), PICT 2019-00114 (ANPCyT) and PIP 11220200100146CO (CONICET).

R.N. Melchor, J.F. Genise, M.V. Sánchez, L.C. Sarzetti, J. Farina, D. Speranza and M. Perez helped during the field work. Governmental authorities of Chaitén village and Palena province are thanked for assistance during field activities. The journal reviewers, J. Bucher and J.M. Paredes, as well the editorial assistance by S. Richiano are much thanked.

REFERENCES

Paredes, J.M., Foix, N., Allard, J.O, Colombo, F. and Tunik, M.A. (2015). Alluvial architecture of reworked pyroclastic deposits in peri-volcanic basins: Castillo Formation (Albian) of the Golfo San Jorge Basin, Argentina. *Revista de la Asociación Geológica Argentina* 72: 38-58.

Smith, G.A. (1991). Facies sequences and geometries in continental volcaniclastic sediments. In: Fisher, R.V. and Smith, G.A. (Eds.), *Sedimentation in Volcanic Settings*, SEPM Special Publication 45, USA, pp. 109-121.

Umazano, A.M., Bellosi, E.S., Visconti, G. and Melchor, R.N. (2008). Mechanisms of aggradation in fluvial systems influenced by explosive volcanism: an example from the Upper Cretaceous Bajo Barreal Formation, San Jorge Basin, Argentina. *Sedimentary Geology* 203: 213-228.

Umazano, A.M, Melchor, R.N., Bedatou, E., Bellosi, E.S. and Krause, J.M. (2014). Fluvial response to sudden input of pyroclastic sediments during the 2008-2009 eruption of the Chaitén Volcano (Chile): The role of logjams. *Journal of South American Earth Sciences* 54: 140-157.

Umazano, A.M., Krause, J.M., Bellosi, E.S., Perez, M., Visconti, G. and Melchor, R.N. (2017). Changing fluvial styles in volcaniclastic successions: A Cretaceous example from the Cerro Barcino Formation, Patagonia. *Journal of South American Earth Sciences* 77: 185-205.

Umazano, A.M. and Melchor, R.N. (2020). Volcaniclastic sedimentation influenced by logjam breakups? An example from the Blanco River, Chile. *Journal of South American Earth Sciences* 98: 102477.