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Fluvial architecture variations linked to changes in accommodation space: Río Chico Formation (Late Paleocene), Golfo San Jorge basin, Argentina

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ABSTRACT

The Upper Paleocene Río Chico Formation is a 50–180 m thick fluvial succession developed in a passive-margin setting, Golfo San Jorge basin, Central Patagonia, Argentina. A detailed description and interpretation of outcrops was carried out, analyzing exposures from the northern basin margin to the most complete successions at the southern depocenter. The unit is characterized by a regional fluvial system that flowed to the south-east. Five main lithofacies associations were defined: (I) active fluvial channels, with three sub-types: braided, meandering and low-sinuosity, (II) sheet-flood deposits, (III) proximal floodplain (natural levee and crevasse-splay), (IV) distal floodplain, and (V) abandoned channels.

Lateral/vertical changes in fluvial architecture of the Río Chico Formation were recognized by variations in preserved thickness, fluvial styles, geometry of fluvial channels, regional paleoflow directions, and channel/floodplain ratios. Close to the northern basin margin, the fluvial succession is 50–60 m thick, composed of braided channels, sheet-flow deposits, and high channel/floodplain ratio. In a basinward direction, the alluvial succession increases to 180 m in thickness, the dominant fluvial styles change to low-sinuosity and meandering channels and channel/floodplain ratio reduces.

The fluvial architecture of the Río Chico Formation shows two main depositional trends that resulted from changes in accommodation space across the basin. The interpreted break-point coincides with the underlying Cretaceous basin-boundary, thus the synsedimentary extensional reactivation of the pre-existing tectonic lineament generated differential subsidence, delimiting two different accommodation settings.

1. Introduction

Distribution of depositional systems and the stacking patterns of alluvial sequences are controlled by a combination of autocyclic and allocyclic processes in sedimentary basins (e.g., Catuneanu et al., 2005). Numerous works have focused on the spatio-temporal variations of alluvial successions related to changes in tectonics, climate, base level and sedimentary influx at several scales (e.g., Bridge and Leeder, 1979; Miall, 1993, 1996; Ethridge et al., 1998; Arche and López-Gómez, 1999; Catuneanu et al., 2005; Catuneanu, 2006; Allen and Fielding, 2007). Some of the most well documented alluvial stratigraphic variations are: (a) changes in fluvial styles, (b) changes in sandbody geometry (width/thickness ratio), and (c) changes in channel/floodplain ratio. In this sense, the presence of isolated, narrow meandering channels in fluvial successions with low channel/floodplain ratios have been related to high-accommodation settings; whereas tabular, amalgamated, braided fluvial channels with high channel/floodplain ratios have suggested low-accommodation settings (Sønderholm and Tirsgaard, 1998; Arche and Lopéz-Gómez, 1999, 2005; Catuneanu and Elango, 2001; Marenssi et al., 2005; López-Gómez et al., 2010; Huerta et al., 2011). Changes in accommodation depend on base level variations (Schumm, 1993) and/or basin subsidence changes (Catuneanu and Bowker, 2001; Catuneanu and Elango, 2001), which are often difficult to decipher from the sedimentary record.

The Golfo San Jorge basin is a Mesozoic extensional basin with several phases of normal fault reactivation. The Río Chico Formation is a continental succession that cover the underlying marine unit (Salamanca Formation), deposited during the first Atlantic ingression in the basin (Legarreta et al., 1990; Legarreta and Uliana, 1994); both units were deposited in a passive-margin setting (Legarreta and Uliana, 1994; Figari et al., 1999) under warm-humid to subtropical–tropical conditions (Brea et al., 2009; Raigemborn et al., 2009; Krause et al., 2010) in an extensional context (Fitzgerald et al., 1990; Figari et al., 1999; Foix et al., 2008, 2012). The aim of this study was to analyze the

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relative influence of the main forcing factors on sedimentation of the Río Chico Formation (Upper Paleocene), based on spatial–temporal changes in lithofacies, lithofacies associations, fluvial styles, geometry of fluvial channels, preservation of floodplain deposits and total thickness of the unit. Detailed correlations of well-logs were used to extend the architectural analysis to unexposed areas.

2. Geological setting

2.1. Basin evolution

The Golfo San Jorge basin is a mainly extensional basin related to the fragmentation of the Gondwana paleocontinent during the Late Jurassic and Early Cretaceous (Fitzgerald et al., 1990). The basin is broadly E–W oriented and located in the southern Argentina (Patagonia) (Fig. 1A). The study area is located in the Northern Flank of the Oriental Region of the basin, where extensional tectonic processes were dominant (Fig. 1B, C).

The initial Mesozoic synrift stage is represented by the Marifil Complex, composed of acid volcanic rocks and volcaniclastic flows of Jurassic age that crop out in the northern part of the study area (Fig. 2A). The main synrift stage is represented by the mainly lacustrine sedimentary rocks of the Las Heras Group (Uppermost Jurassic to Lower Cretaceous), followed by a thermal subsidence stage in the remainder of the Cretaceous period, where deposition of a thick pile of continental successions (Chubut Group) occurred (Hechem and Strelkov, 2002). Since the uppermost Cretaceous, the basin behaved as a wide tectonic depression with moderate thermal subsidence (Legarreta et al., 1990) in a passive-margin setting (Legarreta and Uliana, 1994; Figari et al., 1999), covering areas outside the boundaries of the Cretaceous extensional basin (Feruglio, 1949; Lesta et al., 1973; Andreis et al., 1975).

Paleocene sedimentary rocks in the basin are represented by the marine Salamanca Formation (Early Paleocene) and the continental Río Chico Formation (Late Paleocene). The remainder part of the Cenozoic succession is completed with the Sarmiento Formation, Chenque Formation, Santa Cruz Formation and the glaciofluvial gravel strata known as "Rodados Patagónicos" (Fig. 2B).

2.2. Stratigraphy and sedimentology

The Río Chico Formation was originally defined by Simpson (1933) and its Late Paleocene age was established from mammalian fauna and radiometric/magnetostratigraphic data (Simpson, 1935, 1948; Marshall et al., 1981, 1983). Recently, an Upper Paleocene to Lower–Middle Eocene age was assigned based on stratigraphic relationships (Krause and Bellosi, 2006; Krause et al., 2010; Raigemborn et al., 2010). The unit attains a maximum thickness of 250 m in the subsurface of the basin (depocenter), decreasing northward to ~50 m at Bahía Bustamante. Feruglio (1949) defined the unit as a continental succession composed of conglomerates, sandstones, claystones and tuffs. He also demonstrated a gradational basal contact from the marine Salamanca Formation, suggesting mainly fluvial and rarely lacustrine paleoenvironmental conditions during evolution of the unit.

The paleontological record of the Río Chico Formation indicates subtropical to tropical paleoclimatic conditions (Pascual and Odreman Rivas, 1971; Brea et al., 2009); similar climatic conditions were inferred from lateritized tephric paleosols preserved in the basin boundary (Krause et al., 2010). Clay mineral composition studies and analysis of paleobotanical assemblages of the Río Chico Formation support the interpretation of a Paleocene–Eocene climatic shift from temperate warm, humid and highly seasonal precipitation conditions to subtropical–tropical, with more continuous year-round rainfall conditions throughout the unit (Raigemborn et al., 2009).

The Río Chico Formation was divided in the Las Violetas Member and Visser Member by Andreis et al. (1975), each representing meandering fluvial subcycles draining to the southeast. The basal cycle represents high-energy conditions and has a predominance of volcanic/pyroclastic components in coarse-grained channel-fills; the upper cycle shows reduced sediment transport capacity and abundance of medium-grained sandstones (Andreis et al., 1975). Legarreta and Uliana (1994) defined the Río Chico Group, made up

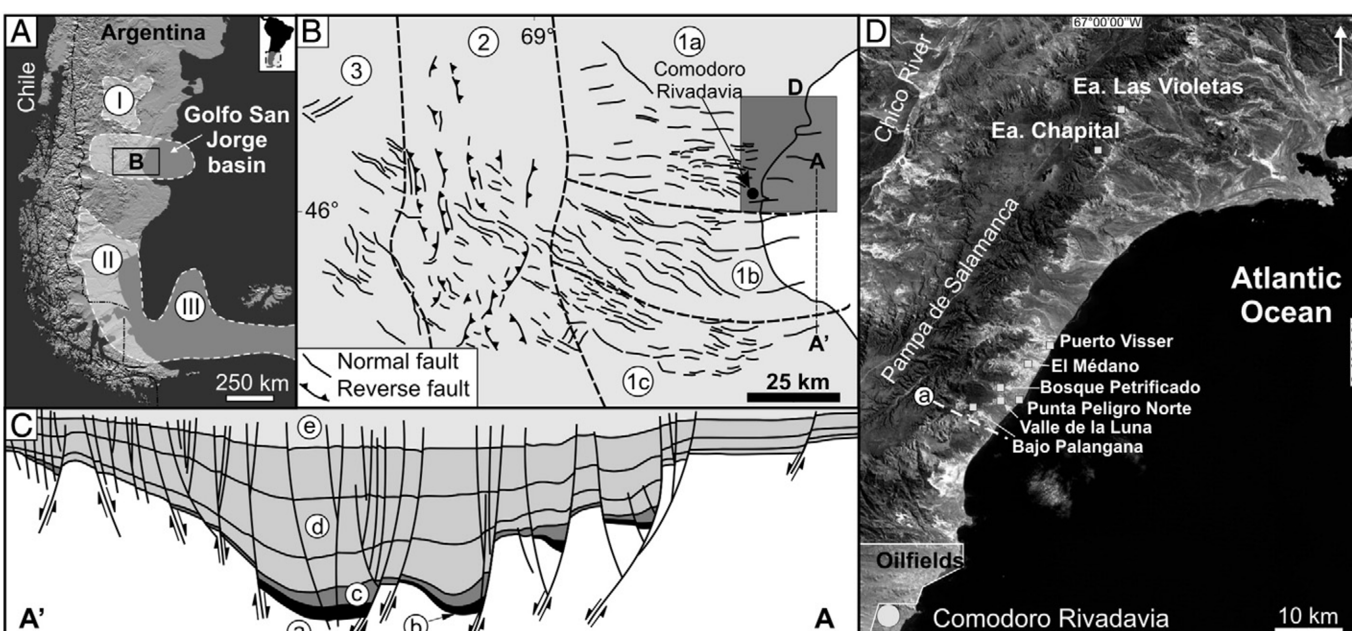

Fig. 1. (A) Radar image with the location of main Mesozoic basins in the southern end of South America. I — Cañadón Asfalto basin and II — Austral basin and III Malvinas basin. Location of B. (B) Main structural regions of the Golfo San Jorge Basin (modified from Figari et al., 1999). Key: 1) Oriental Region: 1a) Northern Flank, 1b): Center of Basin, 1c): Southern Flank, 2) San Bernardo Fold Belt and 3) Western Flank. (C) North–South seismic section (A–A′) showing the asymmetric basin profile and distribution of principal units. Key: a) Paleozoic basement, b) Marifil Complex (Jurassic), c) Las Heras Group (Neocomian), d) Chubut Group (Cretaceous) and e) Cenozoic. (D) Satellite image of the studied area in the Northern Flank of the Golfo San Jorge basin. Dashed line (a) indicates the southernmost outcrops of Río Chico Formation. Subsurface data used corresponds to oilfield areas.