Basement geometry of Lago Fagnano (Tierra del Fuego)

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Abstract. Lago Fagnano, an E-W elongated basin located in the central part of Isla Grande de Tierra del Fuego, occupies a structural depression originated along a segment of the Magallanes-Fagnano fault system. Its evolution was mostly conditioned by tectonic process, and later was affected by glacial and glacio-lacustrine depositional events. New high-resolution single-channel seismic data, integrated with published seismic profiles and geological information acquired in the surroundings of the Lago Fagnano, allows us to reconstruct the basement surface of the lake, and the geometry and thickness of glacial and glacio-lacustrine sequences. We recognized three main sub-basins within the Lago Fagnano: (1) a medium-size (ca. 21 x 5 km), deep (373 m), and asymmetrical basin to the east; (2) an E-W trending (44 x 3 km), shallow (150 m) central sub-basin; and (3) a smaller (3.5 x 1.3 km), shallow (128 m) sub-basin to the west. The shape of the sub-basins and their location in relation with the Magallanes-Fagnano fault system, along with the distribution, geometry, and thickness of the sedimentary units, show that the general morphology of the Lago Fagnano was mostly controlled by pre-existing tectonic features.

Keywords: Lago Fagnano, Tierra del Fuego, Magallanes-Fagnano Fault System, Single-channel Seismic Profiles, Basement geometry.

1 Introduction

Lago Fagnano (LF) is located in the central part of Isla Grande de Tierra del Fuego (TdF; Fig. 1). It occupies part of the tectonic depression originated by a segment of the South America-Scotia transform boundary, which traverses broadly E-W the TdF region (Lodolo et al. 2003). The lake has an area of 587 km² and it extends over than 100 km, with an average width of 6 km.

In the past, a glacier originating from the Cordillera Darwin, has expanded eastwards through this tectonic depression now occupied by the lake, with its external front reaching a maximum advance identified at about 35-40 km east of the present-day eastern shore (Caldeñius 1932). Glacial sediment accumulation covers the entire Holocene, and may date back to the Last Glacial Maximum (Coronato et al. 2009).

In the last ten years, a series of geophysical surveys and geological expeditions have been conducted in the TdF region, focusing primarily in the tectonic evolution of the South America-Scotia plate during the Cenozoic. As a result, the bathymetry of the lake, its glacio-lacustrine deposits and the main tectonic features that triggered the depression now occupied by the LF has been studied, mainly through high-resolution seismic reflection data. In this work, seismic profiles were used to reconstruct the surface of the basement of LF. This information was then used to analyze the relationship between pre-existing tectonic structures and depositional events in this sector of the TdF region. The results were integrated with previous published data from the lake itself and the surrounding areas.

2 Method, Samples, Results

2.1 Data and methods

Between 2009 and 2010, 42 high-resolution single-channel seismic profiles (for a total of 179.5 km) acquired using a Boomer seismic source and a single-channel, 10-m-long streamer, were integrated with previous published seismic profiles (Waldmann 2008 and Waldmann et al. 2010) and correlated with the geologic units outcropping around LF. The methodology consisted on the identification and interpretation of three major seismic stratigraphic units from profiles, firstly recognized by Lodolo et al (2003, 2007), Lippai et al (2004) and Waldmann et al. (2010) previously described.

2.2 Basement map of Lago Fagnano

The basement map (Fig. 1C) shows, three sub-basins: the eastern main sub-basin, the western main sub-basin and a third minor sub-basin, located in the LF western tip. Two basement highs of less than 90 m depth are located between the sub-basins. The eastern one is located just in the Río Claro outlet and the western one is located southwest of Punta Catamarca.

The eastern main sub-basin, south of Sierra de Las Pinturas, is relatively small (ca. 21 x 5 km) and it reaches a depth of 373 m; the area deeper than 150 m is about 71 km². This sub-basin shows an E-W elongated shape with a steeper northern flank near the Río Turbio-Sierra Las Pintura fault and a smooth southern flank.

The western main sub-basin is bigger in size and shallower than the eastern one. It presents an elongated shape (ca. 44 x 3 km) and reaches a maximum depth of 215 meters.
Almost 90 km² of the basin has a depth greater than 150 meters. In a N-S section, the western part of this sub-basin has a broadly symmetrical profile, which becomes slightly asymmetrical towards east, near the Co. Hope-Catamarca-Knokeke fault. Between the two main sub-basins, in correspondence of the Río Claro outlet, the structural high rise at about 90 m depth below mean lake level. This feature has been interpreted as a pressure ridge or, alternatively, a transfer zone between the two main sub-basins constituting the LF, and controlled by the principal master faults (Lodolo et al. 2003).

In the western tip of the lake, there is a minor sub-basin (ca. 3.5 x 1.3 km) with a maximum depth of 128 m with an oblate shape and a slightly steeper northern slope. Between this minor sub-basin and the western main sub-basin there is a structural high ( < 100 m) that extends ca. 6 km. with a WNW-ESE trend.

3 Discussion and Conclusiones

The fact that the three sub-basins and the highs recognized in the basin show a good correlation in terms of location, shape, size and relative depth with the depocenters shown in the bathymetric map of Zanolla et al. (2011), and N-S asymmetry basement sections (perpendicular to the paleoglacier flow) indicate that the LF general morphology has been mainly controlled by the tectonic activity, as has been previously suggested by Lodolo et al. (2002a and 2003) and Lippai et al. (2004).

In the eastern sector of LF, over the eastern main sub-basin, the basement has a strong asymmetry, with its greater depth trend that parallels the strike of the Río Turbio-Las Pinturas fault (Fig. 1D), which would correspond to an assymetric pull-apart basin as described by Ben-Avraham (1992). In the Río Claro outlet area, the basement structural high, possibly corresponding to a mid-basin ridge (Lodolo et al. 2003).

In the central sector of the LF, between Co. Kranck and the Río Claro outlet (eastern sector of the western main sub-basin), is the area where the more intense glacial activity (Coronato et al. 2009) occurred probably erasing the different tectonic features that might have exist, probably because the presence of a transfer zone.

To the west, between Co. Kranck and Punta Catamarca (western sector of the western main sub-basin), the basement is slightly asymmetrical, with its deepest zone towards the Cerro Hope-Catamarca-Knokeke fault, probably reflecting the development of an incipient asymmetrical pull-apart basin.

Between the western main sub-basin and the minor sub-basin, near the Punta Catamarca, we propose the existence of a structure (most likely a sinistral strike-slip fault) limiting both basins. This fault, named “Martínez”, would run across the LF from Laguna Palacios, trough the Isla Martínez northern shore just to Punta Catamarca. It would merge the Co. Hope-Catamarca – Knokeke fault at the north of Co. Hope. This structure would explain the 100 m depth basement difference between the two sides of the fault and the abrupt end of the sedimentary units. Preliminary AMS studies in the Chilean sector of the LF (Espinoza et al. 2011) along with GPS studies of crustal deformation (Mendoza et al. 2011) would confirm the fault direction.

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References

Figure 1. A) Tectonic framework of South America. B) Principal system faults related to the South American-Scotia plates. C) Depth (in meters below the mean lake level) of the basement top. The depth was calculated assuming water sound velocity of 1432 m/s and sediment sound velocity of 1500 m/s. Contour lines (in black) are every 50 meters. HCK: Co. Hope-Catamarca-Knokeke fault. RTP: Rio Turbio-Sierra de Las Pinturas fault. SR: San Rafael fault. D) and E) Examples of seismic profiles. Top of the metamorphic basement (in green) and top of the glacial horizons (in blue) are shown. Major faults are indicated in black. Locations in C.