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Origin and evolution of the Laguna Potrok Aike maar (Patagonia, Argentina)

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Laguna Potrok Aike, a maar lake in southern-most Patagonia, is located at about 110 m a.s.l. in the Pliocene to late Quaternary Pali Aike Volcanic Field (Santa Cruz, southern Patagonia, Argentina) at about 52°S and 70°W, some 20 km north of the Strait of Magellan and approximately 90 km west of the city of Rio Gallegos. The lake is almost circular and bowl-shaped with a 100 m deep, flat plain in its central part and an approximate diameter of 3.5 km. Steep slopes separate the central plain from the lake shoulder at about 35 m water depth. At present, strong winds permanently mix the entire water column. The closed lake basin contains a sub saline water body and has only episodic inflows with the most important episodic tributary situated on the western shore. Discharge is restricted to major snowmelt events.

Laguna Potrok Aike is presently located at the boundary between the Southern Hemispheric Westerlies and the Antarctic Polar Front. The sedimentary regime is thus influenced by climatic and hydrologic conditions related to the Antarctic Circumpolar Current, the Southern Hemispheric Westerlies and sporadic outbreaks of Antarctic polar air masses. Previous studies demonstrated that closed lakes in southern South America are sensitive to variations in the evaporation/precipitation ratio and have experienced drastic lake level changes in the past causing for example the desiccation of the 75 m deep Lago Cardiel during the Late Glacial. Multiproxy environmental reconstruction of the last 16 ka documents that Laguna Potrok Aike is highly sensitive to climate change.

Based on an Ar/Ar age determination, the phreatomagmatic tephra that is assumed to relate to the Potrok Aike maar eruption was formed around 770 ka. Thus Laguna Potrok Aike sediments contain almost 0.8 million years of climate history spanning several past glacial-interglacial cycles making it a unique archive for non-tropical and non-polar regions of the Southern Hemisphere. In particular, variations of the hydrological cycle, changes in eolian dust deposition, frequencies and consequences of volcanic activities and other natural forces controlling climatic and environmental responses can be tracked throughout time. Laguna Potrok Aike has thus become a major focus of the International Continental Scientific Drilling Program. Drilling operations were carried out within PASADO (Potrok Aike Maar Lake Sediment Archive Drilling Project) in late 2008 and penetrated ∼100 m into the lacustrine sediment.

Laguna Potrok Aike is surrounded by a series of subaerial paleo-shorelines of modern to Holocene age that reach up to 21 m above the 2003 AD lake level. An erosional unconformity which can be observed basin-wide along the lake shoulder at about 33 m below the 2003 AD lake level marks the lowest lake level reached during Late Glacial to Holocene times. A high-resolution seismic survey revealed a series of buried, subaquatic paleo-shorelines that hold a record of the complex transgressional history of the past approximately 6800 years, which was temporarily interrupted by two regressional phases from approximately 5800 to 5400 and 4700 to 4000 cal BP.

Seismic reflection and refraction data provide insights into the sedimentary infill and the underlying volcanic structure of Laguna Potrok Aike. Reflection data show undisturbed, stratified lacustrine sediments at least in the upper ∼100 m of the sedimentary infill. Two stratigraphic boundaries were identified in the seismic profiles (separating subunits I-ab, I-c and I-d) that are likely related to changes in lake level. Subunits I-ab and I-d are quite similar even though velocities are enhanced in subunit I-d. This might point at cementation in subunit I-d. Subunit I-c is restricted to the central parts of the lake and thins out laterally.

A velocity-depth model calculated from seismic refraction data reveals a funnel-shaped structure embedded in the

sandstone rocks of the surrounding Santa Cruz Formation. This funnel structure is filled by lacustrine sediments of up to 370 m in thickness. These can be separated into two distinct subunits with i) low acoustic velocities of 1500-1800 m s-1 in the upper part, and ii) enhanced velocities of 2000-2350 m s-1 in the lower part. Below these sediments, a unit of probably volcanoclastic origin is observed (>2400 m s-1). This sedimentary succession is perfectly comparable to other well-studied sequences (e.g. Messel and Baruth maars, Germany), confirming phreatomagmatic maar explosions as the origin of Laguna Potrok Aike.