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Hydrological variations and their climate forcing at 52˚S for the past 56 ka from the site of ICDP lake drilling project "PASADO" (Laguna Potrok Aike, Argentina)

B. Zolitschka (1), **F.S. Anselmetti** (2), D. Ariztegui (3), H. Corbella (4), T. Haberzettl (5), A. Lücke (6), C. Mayr (7), C. Ohlendorf (1), F. Schäbitz (8), M. Wille (8)

(1) University of Bremen, Institute of Geography (Geopolar), Celsiusstr. FVG-M, 28359 Bremen, Germany (zoli@uni-bremen.de / Fax: +49-421-218-9658), (2) Swiss Federal Institute of Aquatic Science & Technology (Eawag), Ueberlandstrasse 133, 8600 Dübendorf, Switzerland, (3) University of Geneva, Section of Earth Sciences, Rue des Maraîchers 13, 1205 Geneva, Switzerland, (4) Argentine Museum of Natural History, Av. A. Gallardo 470, 1007 Buenos Aires, Argentina, (5) Sedimentology and Environmental Geology, Geoscience Center, University of Göttingen, Goldschmidtstr. 3, 37077 Göttingen, Germany, (6) Institute for Chemistry and Dynamics of the Geosphere (ICG) V: Sedimentary Systems, Research Center Jülich, 52425 Jülich, Germany, (7) GeoBio-Center LMU and Dept. of Earth & Environmental Sciences, University of Munich, Richard-Wagner-Str. 10, 80333 Munich, Germany, (8) Seminar for Geography and Education, University of Cologne, Gronewaldstr. 2, 50931 Cologne, Germany

For mid to high austral latitudes climate reconstructions extending well beyond the Holocene are mostly restricted to either marine sediments or to Antarctic ice cores. Records from the continental realm are rare or inexistent. Here we start to close this gap for southern South America by investigating a piston core transect linked by volcanic ash layers from a 30 m lake level terrace to the 100 m deep centre of Laguna Potrok Aike, a maar lake formed 770 ka ago in the dry steppe of southern Patagonia, Argentina (52˚S, 70˚W). This terminal lake is highly sensitive to hydrological changes. Multi-proxy sediment investigations reach back to 56 ka BP and yield reconstructions that are merged with modern process studies to improve our understanding

of the underlying synoptic climate forcing.

Lake level high- and low-stands are documented by detailed levelling of terraces in the catchment area and by surveying the lake basin with a 3.5 kHz seismic system. One low stand (8600-7300 cal. yrs BP) and two high stands (1480-1930 AD, >13,200 cal. yrs BP) have been determined. Process studies demonstrate that such changes in water volume influence the formation of endogenic calcite which is preserved in the sedimentary record. An understanding of the underlying climatic forcing is achieved by a comparison of modelled lake level variations with instrumental meteorological data indicating that the lake level is mainly driven by precipitation and related wind strength as well as wind direction. Lake level and precipitation decrease during periods of persistently high westerly winds, whereas both increase during periods of enhanced easterly winds. Such a relation is explained by strengthening of the Southern Hemispheric Westerlies (less rain) or more frequent occurrences of cyclones from the South Atlantic (more rain). Since lake volume controls autochthonous lacustrine carbonate precipitation, the amount of sedimentary carbonate content as well as its isotopic composition archives these recurrence patterns of weather conditions.

Reconstructions for the last 1500 years document a lake level high-stand preceeded by pronounced cyclicities of calcite precipitation. The distinct Holocene drought between 8600 and 7300 cal. yrs BP is highlighted by a seismically and lithologically detected unconformity 33 m below the present lake level and increased values for inorganic carbon, high sedimentation rates and a distinctly different isotopic composition of organic matter in the centre of the lake. This points to a lower lake level with increased inwash of soil material from the former lake shore which has fallen dry. Before 13,200 cal. yrs BP carbonates disappear completely and we assume that this is the time of highest lake levels which is related to the formation of an outflow. During this period Ti and Fe concentrations are mainly influenced by the transfer of weathered basaltic rock material from the catchment area to the lake and mirror variations in minerogenic influx as controlled by runoff. Accordingly, slightly drier conditions are observed between 22 and 38 cal. ka BP. Within the error margins of the applied dating methods, this timing agrees with the maximum of dust deposition as recognised in Antarctic ice cores.

This lacustrine record from Patagonia provides unique continental data of variations in climate, hydrology and related dust deposition and may thus act as a cornerstone for paleodata-model comparison of the Southern Hemisphere. Within the ICDP-funded “Potrok Aike maar lake sediment archive drilling project” (PASADO), more than 400 m of sediment are scheduled to be recovered extending this terrestrial record to 770 ka BP. This will increase the comparability to Antarctic ice cores considerably.