Regional background information

Water at "world's end" – Laguna Potrok Aike: Introduction to an old and deep lake in southernmost Patagonia (Santa Cruz, Argentina)

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There is increasing evidence that the Southern Ocean plays a key role for a better understanding of the global climate system. The southern hemisphere contains >90% of the worlds ice and 81% of its total surface area is covered by oceans. Globally, the most extreme oceanic character is encountered between 40° and 60°S where 98% of water are juxtaposed to only 2% of land – Patagonia, "world's end". Hence, terrestrial palaeoclimatic archives are extremely scarce and therefore valuable sources of climatic information and may act as a continental counterpart to marine and ice core records, all of which are necessary for a comprehensive understanding of past climate changes. As this area east of the Andean volcanic chain is subject to shifts in polar and mid-latitude winds, pressure fields and precipitation regimes as well as to variations related to the El Nino Southern Oscillation (ENSO) and to the Antarctic Oscillation (AO), it has the potential to provide unique records of long-term variations in (a) the hydrological cycle, (b) changes in aeolian dust deposition, (c) consequences and frequencies of volcanic activities and (d) of other natural forces controlling climatic conditions. Moreover, in Patagonia the longitudinal differences in climate are extreme. Evergreen rainforest with up to 5000 mm of annual precipitation (P) at the Pacific coast west of the Andes contrasts with the dry Patagonian steppe with P <200 mm east of the Andes where most lakes are periodically dry or ephemeral.

One of the very few permanent lakes in this steppe region is the 100 m deep crater lake Laguna Potrok Aike (52°S, 70°W; 113 m a.s.l.; diameter: 3.5 km), a 770 ±220 ka old maar situated in the province of Santa Cruz, Argentina. Reflection and refraction seismic data revealed a lacustrine sediment infill of 200 to 400 m in thickness. As Laguna Potrok Aike has not been reached by the last glaciation (Llanquihue) nor by any other Pleistocene ice advance during the last 1 Ma it is potentially the only site that has archived a continuous and high-resolution sediment record covering several glacial/interglacial cycles for the southern hemispheric mid-latitudes. Moreover, it will provide ideal means for linking this unique terrestrial record to ice cores from Antarctica and to marine records from the Southern Oceans where dust and tephra of Patagonian provenance have been detected. Drilling this sedimentary record should thus achieve highest priority in the framework of the International Continental Scientific Drilling Programme (ICDP).

In addition to climatic and paleoenvironmental research related to its lacustrine deposits this maar opens up also another window for research: investigations into the structure and composition of the diatreme in a relatively young maar structure. Never before scientific drilling was carried out into the deep part of a diatreme underneath a maar lake. Studies of deep maar structures until now include only records from Tertiary or older dry maars. The site of Laguna Potrok Aike for the first time will allow

to analyze the early evolution of a maar probably including its phreatomagmatic formation.

In the framework of the project “SALSA” (South Argentinean Lake Sediment Archives and Modeling) which is part of the German climate research program (DEKLIM) we started to study several lakes with an integrated research approach, finally focusing on Laguna Potrok Aike (Zolitschka et al., 2004, in press). This program includes a wide variety of studies, e.g. geomorphology, limnology, biology, geophysics, sedimentology, geochemistry, stable isotopes and climate modeling. Especially the modeling component is of importance, e.g. in order to decide whether the hydrological balance of this region is mainly modulated by latitudinal migration of the Southern Westerlies as it is common sense in the literature or if other circulation anomalies like polar outbreaks (e.g. Bradbury et al., 2001) play a more important role then previously assumed. As a terminal lake Laguna Potrok Aike is very sensitive to changes in the hydrological regime and thus can be regarded as an ideal site although being located at a very remote location called the “world’s end”.

References

Bradbury, J.P., M. Grosjean, S. Stine & F. Sylvestre, 2001. Full and late glacial lake records along the PEP I transect: their role in developing interhemispheric paleoclimate linkages. *In* Markgraf, V., ed., Interhemispheric climate linkages, San Diego, Academic Press, 265-289.

Zolitschka, B., Schäbitz, F., Lücke, A., Wille, M., Mayr, C., Ohlendorf, C., Anselmetti, F., Ariztegui, D., Corbella, H., Ercolano, B., Fey, M., Haberzettl, T., Maidana, N.I., Paez, M. and Schleser, G.H. (2004). Climate changes in Santa Cruz (southern Patagonia, Argentina) inferred from crater lake sediments – The multi-proxy approach of SALSA. PAGES Newsletter 21: 9-11.

Zolitschka, B., Schäbitz, F., Lücke, A., Clifton, G., Corbella, H., Ercolano, B., Haberzettl, T., Maidana, N., Mayr, C., Ohlendorf, C., Oliva, G., Paez, M.M., Schleser, G.H., Soto, J., Tiberi, P., Wille, M. (in press). Palaeoecological potential of crater lakes in the Pali Aike Volcanic Field, southern Patagonia (Argentina). Journal of South American Earth Sciences.

The Pali Aike Volcanic Field

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Pali-Aike, the southernmost back-arc Neozoic volcanic field of South America and one of the youngest in Patagonia, outcrops between latitude 50° and 52°S in the Magellan Basin area, 300 km behind the actual Andean volcanic front. The volcanic outcrops, mostly basaltic and basanitic, appear in an area of 50 km by 150 km. Thirty K/Ar and Ar/Ar age determinations show that most of the volcanic activities occurred between the Late Pliocene (3.82 Ma) and the Holocene. But there is also evidence of earlier Late Miocene basalt layers. Most of the young volcanics lie on top of the Miocene Santa-Cruz Formation or on fluvioglacial gravels and conglomerates.

In Pali-Aike, two principal fracture systems of parallel or sub-parallel faults controlled the outpouring of the lavas and the close alignment of the scoria, ash

cones and maars. Occasionally, some fractures are underlined by long linear depressions (15 km) due to the coalescence of several maars. The predominant fault system has a NW direction, followed by less frequent faults of E and ENE strike.

The NW system is emphasized by a regional alignment of geothermal anomalies (up to 6°C/100 m) developed on the vertical of an underlying Jurassic rift zone that was formed during the breaking up of Gondwana. Seismic information shows a close correspondence between the surficial tectonic structures, 27 sills (30-60 m thick) at around 1000 and 2000 m depth and the Jurassic basement faults. The vertical development of these NW gravitational faults shows that they were active during the Permo-Jurassic and remained active during the Cretaceous and Lower-Tertiary, though with declining throws. The vertical movements seem to have stopped during the Tertiary. Given the absence of modern vertical throws detected in the surface and underground, it is possible to infer that the old NW fractures of the Jurassic rift were rejuvenated by modern strike-slip movements.

The E and ENE fault system is parallel or sub-parallel to the faults and rift systems that seem to have channeled the large glacial valleys sub-perpendicular to the Andes such as the Magellan Strait, some fiords and bays and also the big Cordilleran lakes. All these valleys formed since 3.5 Ma and suggest a possible N-S stretch of the area due to a new strength field in the southern flank of the Magellan Basin.

These two normal fracture systems form a 60° conjugate fault system that allows, depending on the applied stress field, strike-slip transtensional and transcompressional openings accounting for the eruption of volcanics and the setting of scoria and ash cones and maars. Maars and tuff rings are relevant features of this fissural volcanism. Around 100 maars outcrop along this volcanic field, forming circular or oval depressions 500 to 3000 m wide. To the West, East and South, the Pali-Aike volcanics are flanked by till and glacifluvial deposits forming large moraine arches of different age and belonging to different systems (1.15-0.016 Ma). The widespread phreatomagmatic activity is probably related to the great water availability in a glacial or periglacial environment. The water to trigger the explosions could have come from ice, permafrost or soaked sediments during the washout of deglaciation stages.

Different maar morphologies are present. Most are located along faults. Many of them have coalesced forming "in rosary" alignments. Asymmetric ring morphologies are frequent due to strong westerly winds blowing during and after the eruption. Scoria and spatter cones inside or in the periphery of the maar depression is a consequence of the post-maar strombolian eruptive activity under different conditions of water availability. Lava flooded maars are not uncommon.

The Holocene volcano-tectonic activity is located in the southeastern corner of the Pali Aike Volcanic Field. There, through the NW Diablo Negro fracture, most of the youngest lavas reached the surface. At Laguna Azul an ENE and 700 m wide graben was active during an Holocene eruption.

Glacial history of Patagonia, Southern South America

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Although glaciations are the most important palaeoclimatic changes of the last 2 million years all over the world, geochronological evidences found in southern Patagonia suggests that they have occurred also in previous times. Thick till deposits interbedded with basaltic flows at the northern margin of Lago Buenos Aires tableland suggest that isolated ice-caps with outlet glaciers extended eastwards more than 30 km and existed during the Late Miocene to Early Pliocene.

Evidences of Middle to Late Pliocene glacial events which had been found in the tablelands surrounding Lago Viedma suggest that Pliocene glaciers expanded from the mountain ice-caps to eastwards locations equivalent to those positions that outlet glaciers achieved during the maximum ice expansion of the Pleistocene.

The glacigenic sequences interbedded between lava flows at Cerro del Fraile, near Lago Argentino, allow to recognize at least seven glacial stages which would have taken place during the Late Pliocene and Earliest Pleistocene times, Oxygen Isotope Stages (OIS) 82-84.

The maximum expansion of the ice out of the mountain area, the Greatest Patagonian Glaciations (GPG) would have taken place at 1-1.1 Ma years B.P. (OIS 28-34). These outer limits are well preserved eastwards of the Andes and reach the Atlantic shelf platform at the southern tip of South America.

Glacial deposits corresponding to at least three younger glaciations are located in inner positions nested by GPG moraines. Post GPG 1 and 2 were recognized in many of the main Andean valleys and assigned to the Middle Pleistocene, e.g. since OIS 16 to OIS 6. Cosmogenic dates obtained at Lago Buenos Aires and Magellan Straits show that the Last Glacial Maximum or the Post GPG 3 has occurred in Patagonia at 25 ka cal. B.P. (OIS 2). After that, at least two standstills or minor glacier advances would have taken place during the Late Glacial reflecting both cool stages, the Antarctic Cold Reversal and/or the northern hemisphere Younger Dryas equivalent.

The definitive ice retreat has been mostly established at ca. 10 ^{14}C. ka B.P. The absolute chronology up to now available for the Patagonian Glaciations has become one of the most complete in the world and the best available in the southern hemisphere outside Antarctica.

Cold--dry vs warm-wet events in the South American extratropics since the Last Glacial Maximum

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Recent weather patterns combined with results of high resolution paleostudies indicate that the role of tropical and subtropical areas may have been underestimated as forcing factors of changes within the global climate system. Thus, the study of well-constrained paleoenvironmental records in these regions became critical.

Laguna Mar Chiquita (30°54´S, 62°51´W) is a shallow saline lake in the subtropical Pampean plains of Argentina. Temporal variability of the hydrological balance shows dramatic lake level fluctuations, highlighting the sedimentary record of Laguna Mar Chiquita as a sensitive climatic archive. During highstands, as at present, the lake with a surface area of ca. 6,000 Km^2 becomes not only the largest saline lake in South America but also one of the largest in the world.

^{210}Pb ages from short cores allowed correlating and calibrating the lake sedimentary, isotope and biological response to the last 100 years of documented lake levels changes. The comparison among these sedimentological and geochemical features, the stable isotope signals and the diatom record shows a coherent picture that further allows us to formulate a well constrained multiproxy model for the basin (Piovano et al., 2002, 2004a, b). The study of 4.2 m long sedimentary cores allows the reconstruction of lake level variations covering the hydrological changes that occurred in this area since the Last Glacial Maximum (LGM). A semi-quantitative estimation of paleolake levels (Piovano et al., 2004a) shows a recurrent pattern of highstands since the late Pleistocene often with a magnitude equivalent to present-day conditions. A wet phase followed the negative water balance during the LGM that ended ca. 13,700 ± 100 yr BP. A subsequent abrupt negative hydrological balance (Younger Dryas?) was followed by highstand conditions and thus positive precipitation/evaporation ratios since the Early Holocene until before 4200 yr BP when a hydrological reversal started again. Dry conditions were mostly dominant since the Mid-Holocene, including the Little Ice Age (LIA), until the last quarter of the 20^{th} century when an outstanding humid phase started. The hydrological response during LGM, LIA and the last three decades clearly indicate that dry conditions prevail during cold phases whereas wet conditions occur during warm periods.

The 20^{th} century sequence of variations in the hydrological balance of Laguna Mar Chiquita is synchronous and in phase with other hydrological changes observed in SE South American (SESA) rivers (e.g., Río Paraná) pointing towards the fact that the reconstructed paleohydrology can be extrapolated to the wider region of SESA. Conversely, the hydrological balance in SESA is in antiphase related to conditions in Patagonia and the Central Andes as shown by an important number of limnogeological records (i.e. Lagunas Potrok Aike, Cardiel, Frías and Aculeo among others). In particular, the Medieval Climate Anomaly and the LIA correspond to warm-dry and cool-moist conditions in Patagonia, central Chile and Central Andes but to warm-wet and cool-dry conditions in SESA. Thus, the Laguna Mar Chiquita climate archive has the potential to pinpoint changes at a decadal time scale, affording the opportunity to compare paleo-circulation dynamics and antiphased hydrological

changes in southern South America during the Late Pleistocene and the entire Holocene.

References

Piovano, E., Ariztegui, D. and Damatto Moreira, S., 2002. Recent environmental changes in Laguna Mar Chiquita (Central Argentina): A sedimentary model for a highly variable saline lake. Sedimentology 49:1371-1384.

Piovano, E., Ariztegui, D., Bernasconi, S.M, and Mckenzie J.A., 2004a. The isotopical record of hydrological changes in subtropical South America over the last 230 years. The Holocene. 14 (4):525-535.

Piovano, E. L., Larizatti F.E., Favaro D., Oliveira S.M., Damatto S.R., Mazzilli, B. and Ariztegui, D., 2004b. Geochemical response of a closed-lake basin to 20th century recurring droughts/wet intervals in the subtropical Pampean plains of South America. Journal of Limnology 63 (1), 21-32.

Modern vegetation in the Pali Aike Volcanic Field

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The vegetation of the Potrok Aike area was explored based on 73 Braun Blanquet vegetation censuses performed in the neighboring Potrok Aike experimental field (Humano et al., 2005). This data was analyzed using PCA and cluster analysis, that enabled a supervised classification of a Landsat TM image (December 2001). The vegetation comprises 65 species with variations of the basic tussock grasslands of *Festuca gracillima* typical of the Magellanic Steppe.

(1) Tussock Grass Steppes occupy most of the plateaus and fluvial terraces in good condition, with 61% cover and 16% of tussocks, 26% of short grases, 6% herbaceous dicots and 13% of dwarf shrubs.

(2) Tussock-Dwarf Shrub Steppes are found in more heavily grazed areas of the plateaus and terraces and may be interpreted as a degraded state of the first vegetation unit, with 50% total vegetation cover, 13% tussocks, 21% of short grasses, 5% of herbs and 11% of dwarf shrubs.

(3) Mixed Tussock–Shrub–Dwarf Shrub Steppe incorporate deep rooted shrubs of *Juniellia tridens* and are found in the slopes of basaltic plateaus. They show 67% cover, with 15% tussocks, 26% short grasses, 8% herbs and 16% dwarf shrubs and 2% of shrubs.

(4) Dry Riparian Steppes occupy the lower terraces and river beds of the Carlota stream, with 59% total cover, 13% of tussocks (*Festuca pallescens*), 35% dwarf grasses, 5% herbs, 5% dwarf shrubs.

The most diverse sites are the Mixed tussock-dwarf shrub-shrub sites, with 47 species per site. The other units showed 28 species per site (units 1 and 2) and 23 species per site in (unit 4). Dominant tussocks are *Festuca gracillima* and *F. pallescens*, short grasses are dominated by *Poa dusenii*, *Carex argentina*, and dwarf shrubs are represented by *Nardophyllum brioides* and *Perezia recurvata*. Other vegetation units are only found in highly degraded areas or overgrazed areas:

- Dwarf shrublands of Nardophyllum brioides, observed in degraded Potrok Aike lake terraces,
- Stipa Tussock grasslands, in aeolic depositions east of the Carlota river and
- Short grass steppes in the vicinity of the stations and in highly used paddocks.

Reference

Humano, G. Goliva, G. Battini, A, Mascó M, Koflat, R. and Barria, D., 2005. La Vegetación del Campo Experimental Potrok Aike. In: Gonzalez, Liliana, Roberto Iglesias and Andres Cibils. Eds. 2005. Campo experimental Potrok Aike. Resultados de 15 años de labor técnica. Ediciones INTA. N 119 en Serie Documentos Institucionales. 131pp. Buenos Aires, Argentina.

Modern regional pollen rain in southern Patagonia-a pollen trap study to provide background information for pollen-based climate reconstruction[1]

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Studies of the relation between pollen and climate undertaken along ecologic gradients in Patagonia have shown that paleoecological and paleoclimatic interpretations for the Holocene are possible using “modern-along” techniques (Mancini, 1993, 1998; Prieto *et al*., 1998; Paez *et al*., 2001; Schäbitz *et al*., 2003). This method was applied for southern South America between 51-53°S and 68-72°W. The study includes 48 pollen spectra taken from surface samples collected between the cities of Río Gallegos, Río Turbio, Punta Arenas and Cabo Vírgenes. Interpretation of the main regional vegetation systems based on pollen analysis and its correlation with the most important climate parameters along the climate gradients reaches from the Atlantic coast to the Andes. Climate data for this approach is obtained from the database of Leemans & Cramer (1991). Based on 18 pollen taxa with percentages exceeding 5% which have been selected by statistical procedures from the entire pollen spectra of the surface samples, three groups with a typical pollen composition were identified by PCA-analysis: Sub-Antarctic forest (BS), humid graminaceous steppe (EGH) and dry graminaceous steppe (EGX). The cumulative variance of these three groups accounts for 65,77% of the total variance.

Pollen spectra of these three groups (BS, EGH, EGX) correlate positively with annual and winter precipitation sums ($r \approx 0,8$). In addition, there is a negative correlation with mean summer temperatures. The BS-group including *Nothofagus* t. *dombeyi* correlates with an annual precipitation sum between <800 and >300 mm, a winter precipitation sum between <60 and ≥24 mm and a mean summer temperature between 10 and 8,7ºC. EGH is represented by Poaceae and associated with *Rumex* and Asteraceae subf. Cichoroideae as well as with *Empetrum* correlates with an

[1] **Modern pollen-vegetation distribution between 51°-53° S, southern South America.* Quintana, F.A., M.M. Paez, M.V. Mancini, A.R. Prieto and F. Schäbitz (a enviar al Journal of Biogeography), es parte de la Tesis Doctoral de F.A. Quintana (UNMdP) y ha sido financiado por el Proyecto SALSA.

annual precipitation sum between ≤400 and ≈240 mm, a winter precipitation sum between ≈32 and ≈18 mm and a mean summer temperature between 10,7 and 9,5ºC. EGX is represented by Poaceae associated with Caryophyllaceae, Asteraceae subf. Asteroideae, *Azorella, Ephedra* t. *frustillata* and *Nassauvia* and correlates with an annual precipitation sum amounting to between <300 and ≥140 mm, a winter precipitation sum between ≈20 and >10 mm and mean summer temperature between 10,7 and 12,5ºC. Morever, the mean winter temperature correlates well with some individual pollen taxa of the EGH-group, like Poaceae in the range between 0,4 and 1,3ºC and *Empetrum* with values from 1,8 to 2,2ºC. But it also correlates with the entire EGX-group for values between 1 and 2ºC.

These results show the great potential of the analysed data in terms of reconstructing climate gradients. They also allow to develop calibration models for pollen and climate data to improve paleoecological and paleoclimatic interpretations of samples from Laguna Poterok Aike.

(translation: FS & BZ)

Spanish original:

Los estudios de la relación polen – clima realizados a lo largo de gradientes ambientales en Patagonia (Mancini, 1993, 1998; Prieto *et al*., 1998; Paez *et al*., 2001; Schäbitz *et al*., 2003) han demostrado su potencial como análogo moderno para las interpretaciones paleoambientales y paleoclimáticas del Holoceno. Esta metodología ha sido aplicada en el rango 51º - 53º S, 68º - 72º O, en el extremo sur de Sudamérica. El estudio comprende el análisis 48 espectros polínicos provenientes de muestras de sedimento superficial ubicadas entre las localidades de Río Gallegos, Río Turbio, Punta Arenas y Cabo Vírgenes; la interpretación de las principales formaciones vegetales del área en términos polínicos y la correlación de estos patrones con las principales variables climáticas que ocurren en el gradiente cordillera-costa. Los datos climáticos provienen de la base de datos elaborada por Leemans y Cramer en 1991. En este análisis se seleccionaron 18 tipos polínicos con porcentajes mayores a 5% y se realizó un análisis de agrupamiento que permitió definir tres grupos polínicos atribuidos al Bosque Subantártico (BS), la Estepa Graminosa Húmeda (EGH) y la Estepa Graminosa Xérica (EGX). En base a estos resultados se realizó un análisis de ordenación (PCA, varianza acumulada 65,77%). Los espectros polínicos del BS- EGH-EGX se correlacionan (r≈0,8) con el gradiente de la precipitación anual e invernal (correlación positiva) y con la temperatura media de verano (correlación negativa). El grupo BS con *Nothofagus* t. *dombeyi* se correlaciona con valores <800 - >300mm anuales, < 60 - ≥24mm invernales y 10º - 8,7º C; la EGH, caracterizada por Poaceae asociado con *Rumex* y Asteraceae subf. Cichoroideae y por *Empetrum*, con valores ≤400 – ≈240 mm anuales, ≈32 – ≈18 mm invernales y 10,7º - 9,5º C y la EGX representada por Poaceae asociado con Caryophyllaceae, Asteraceae subf. Asteroideae, *Azorella, Ephedra* t. *frustillata*, y *Nassauvia*, con <300 - ≥140mm anuales, ≈20 - >10mm de invierno y 10,7º - 12,5º C. La temperatura media de invierno se correlacionaron las dos asociaciones polínicas de la EGH, la de Poaceae (0,4º-1,3º C) y la de *Empetrum* (1,8º-2,2º C) y con la EGX (1º- 2º C). Estos resultados señalan el alto potencial climático explicativo del gradiente analizado y garantizan la elaboración de modelos de calibración polen – clima para la interpretación paleoclimática de los testigos lacustres de Patagonia sur.

References

Leemans, R. & Cramer, W., 1991. The IIASA database for mean monthly values of temperature, precipitation and cloudiness of a global terrestrial grid. International Institute for Applied Systems Analysis (IIASA). RR-91-18.

Mancini, M. V., 1993. Recent pollen spectra from forest and steppe of South Argentina: a comparison with vegetation and climate data. Review of Paleobotany and Palynology 77: 129 - 142.

Mancini, M. V., 1998. Vegetational changes during the Holocene in Extra - Andean Patagonia, Santa Cruz Province, Argentina. Palaeogeography, Palaeoclimatology and Palaeoecology 138: 207 - 219.

Paez, M.M., F. Schäbitz & S. Stutz, 2001. Modern pollen-vegetation and isopoll maps in southern Argentina. Journal of Biogeography 28, 997-1021.

Prieto, A. R., Stutz, S. y Pastorino, S., 1998. Vegetación del Holoceno en la Cueva Las Buitreras, Santa Cruz, Argentina. Rev. Chil. Hist. Nat. 71: 277 - 290.

Schäbitz, F., Paez, M. M., Mancini, M. V., Quintana, F. A., Wille M., Corbella, H., Haberzettl, T., Lücke, A., Prieto, A. R., Maidana, N., Mayr C., Ohlendorf, C., Schleser, G. H., Zolitschka, B., 2003. Estudios paleoambientales en lagos volcánicos de la Región Volcánica de Pali Aike, sur de Patagonia (Argentina): palinología. Revista del Museo Argentino de Ciencias Naturales V (5)2: 301-316.

Lake level fluctuations during the last decades in southern Patagonia – an approach using satellite images[2]

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This study evaluates the changes registered in surface water availability in depressions in the southern part of Santa Cruz, Argentina. The years 1986, 1999, 2002 and 2004 were taken into account, in which precipitation fluctuated between 160 and 416 mm per year.

The methodology used is based in the visual analysis and digital processing of satellite images and their integration in a Geographical Information System (G.I.S.). The area studied has an area of 15.000 km^2 and is included in Landsat image 228-96. It lies between parallels 50º 50' and 52º south and the Atlantic coast in the East and meridian 70º40' in the West. Within these limits 106 depressions, with a diameter larger than or equal to 1 km were identified.

Water availability in these basins showed important changes in the analyzed periods, corresponding to the differences in registered precipitation of the area (weather station Río Gallegos). The amount of water available in all the depressions together varied in the area between 12.000 and 30.000 hectares, with important depth variations. This parameter was inferred from the spectral behavior of the ponds, although it must be said that the sediment in the water may modify their spectral signature.

[2] Proyect: Cuencas endorreicas de la Patagonia Austral: Geomorfología y Dinámica del Paisaje. Director: Lic. Elizabeth Mazzoni

Potrok Aike is a lake of greater size in the study area, and one of the few with a permanent water regime. In the analyzed period dimensions varied between a maximum of 792 ha in 1986 and a minimum of 751 ha in 2001.

The results obtained up to now show the importance of closed basins as water gatherers in the semiarid region of Patagonia, as they temporarily store precipitation, thus avoiding quick surface runoff.
(translation: EM)

Spanish Original:

FLUCTUACIONES EN EL NIVEL DE LOS LAGOS DEL SUR DE LA PATAGONIA EN LAS ULTIMAS DECADAS: UNA APROXIMACIÓN USANDO IMÁGENES SATELITALES

El presente trabajo evalúa los cambios registrados en la disponibilidad superficial del agua en las depresiones ubicadas en la porción austral de la provincia de Santa Cruz, Argentina. Se tomaron en consideración los años 1986, 1999, 2002 y 2004, en los cuales el registro pluviométrico ha sido muy variable, fluctuando entre 160 y 416 mm anuales.

La metodología utilizada está basada en el análisis visual y procesamiento digital de imágenes satelitales y su integración en un SIG. El área de estudio comprende unos 15.000 km^2, incluidos en la imagen Landsat 228-96. Se extiende entre los paralelos 50º 50' y 52º S, la costa atlántica al E y el meridiano de 70º 40' al O. Dentro de estos límites se identificaron 106 depresiones con un diámetro mayor o igual a 1 km.

La disponibilidad de agua en las cubetas mostró importantes cambios en los períodos analizados, en correspondencia con las diferencias pluviométricas registradas en la región (estación meteorológica Río Gallegos).

La cantidad de agua disponible en el conjunto de las depresiones varió entre 12.000 y 30.000 hectáreas, con importantes variaciones de profundidad. Este parámetro fue inferido a partir del comportamiento espectral de las lagunas, aunque debe destacarse que el contenido de sedimentos en el agua puede modificar su signatura espectral.

Potrok Aike es la laguna de mayor tamaño del área de estudio, y una de las pocas de régimen permanente. En el período analizado, sus dimensiones variaron entre 792 Ha de superficie máxima (1986) y un mínimo de 751 Ha en el año 2001.

Precipitation origin and evaporation of lakes inferred from stable isotopes ($\delta^{18}O$, $\delta^{2}H$) in southeastern Patagonia (Argentina)

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Water balance calculations with stable isotope approaches require background information about hydrogen and oxygen isotope variability of lakes and their potential inflows. In the framework of the project "SALSA" a stable isotope database ($\delta^{2}H$ and $\delta^{18}O$) was established for estimating evaporation to inflow ratios (E/I) of lakes from semi-arid southern Patagonia. Water samples of 23 lakes and ponds were sampled during three subsequent austral summers. Two crater lakes, Laguna Azul and Laguna Potrok Aike, were studied in more detail during a two-years monitoring. Isotope composition of precipitation, groundwater and water vapor of the air were also investigated. The data imply that the isotopic composition of rainfall in southeastern Patagonia is predominantly determined by precipitation amount and moisture source area. The first meteoric water line and evaporation line in $\delta^{2}H$ vs. $\delta^{18}O$ space for the investigated area were derived. E/I calculations for Laguna Azul and Laguna Potrok Aike suggest that about 50% and 60%, respectively, of the water entering the lakes via surface and subsurface inflow evaporates. The modern isotope data can serve as a starting point for the interpretation of isotope records from e.g. lacustrine cellulose or carbonates.

Archaeology of the Pali Aike Lava Field

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The archaeology of the human colonization of Southern Patagonia is relatively well known. Human populations were inhabiting at least at four different Patagonian areas since c. 11,000 yrs BP. The Pali Aike Lava Field is one of these areas, and it was the first Patagonian area to produce convincing evidence of the human presence at the end of the Pleistocene. The association of hearths, artifacts and megamammal bones was clearly indicated in the 1930s at Fell Cave. In the 1950s and 1970s a radiocarbon chronology for human occupations of the cave was constructed,

that covered the end of the Pleistocene and the Holocene. However, recent research at other sites introduced some changes in this chronological scheme. A discussion of the evidence obtained at Fell Cave, Las Buitreras Cave and other archaeological sites will be presented, indicating a pattern of discontinuous use of caves and rockshelters during the last 11,000 radiocarbon years. The distribution of late Holocene sites near Laguna Azul and Laguna Potrok Aike indicates that these water bodies were important nodes for human settlement.

Scientific background and aims of INTA research at Potrok Aike

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The experimental field of Potrok Aike, a 2.500 ha station, is managed by INTA through a joint agreement with the Province of Santa Cruz since 1985. It is adjacent to Laguna Potrok Aike, in the Magallanic steppe, a 3 M ha ecological unit in southern continental Patagonia and north of Tierra del Fuego. The landscape includes volcanic and glacifluvial features at 150 m a.s.l., 5º C mean annual temperature and 240 mm of annual rainfall. Vegetation is a Festuca gracillima steppe with about 60% cover. The field has 14 paddocks, four bores, a shearing shed, and lodging facilities for small research groups. The baseline of the management is to provide an example of a sustainability managed system according to the Extensive Management Technology. They include yearly forage evaluations and stock adjustments to prevent overgrazing, optimize animal production and avoid unfavorable transitions in the vegetation. Baseline studies include maps of vegetation, range condition, soils and topography. Forage production and quality was analyzed. Sheep production alternatives were evaluated comparing production of Merino, Corriedale, Cormo and Corino breeds. Nutritional gaps for animal production were assessed through the Cordero model and Emergency (winter) and strategic (spring) forage supplementation schemes developed. Forage species were introduced in experimental plots in the most productive sites. The introduction of Llamas and Cattle in mixed grazing schemes was tried to diversify production. Progeny tests to objectively analyze the genetic merit of Corriedale rams have been in place since 2000. Sheep behavior was analyzed using GPS collars. Research on water ecology included soil and leaf water potentials in 3 topographic situations. These studies have recently been collated in a GIS information system and a comprehensive review of this research was published (Gonzalez et al., 2005). Ongoing research includes the spatially explicit Savanna model. The field is open to host extension, research and education efforts in collaboration with other institutions.

Reference

Gonzalez, Liliana, Roberto Iglesias and Andres Cibils (Eds.), 2005. Campo experimental Potrok Aike. Resultados de 15 años de labor técnica. Ediciones INTA. N 119 en Serie Documentos Institucionales. 131pp. Buenos Aires, Argentina.