Conclusions

Mobilization and transport of elements in surface streams is strongly affected by the precipitation- and consequently stream water pH. Six years of monitoring the precipitation- and surface discharge chemistry, as well as the experimental acidification of the monitored stream, proved the chemical fragility of acid soils where the H$^+$ input determinates the release of cations into the surface water. Metals Al and Be appeared as the most sensitive and mobile elements in acidified environment. Results prove importance of current processes such as desulphurisation.

Acknowledgements

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Late Pleistocene Pluvial Phase in Patagonia

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ABSTRACT: A large and deep lake occupied Maquinchao basin (41°S), probably between 13,200 years BP and 11,800 years BP during the great regional deglaciation, and was followed by shallow phase still lasting to about 11,000 years BP. Afterwards, recessive shoreline truncated formerly accumulated deposits during drying of the lake to more or less recent size about 8000 years BP. Presented chronology of events is based on TL dating, the comparison with record from sediments of Laguna Cari Laufquen Chica, and position of two dacite tephra horizons considered here as a regional stratigraphic markers (pre-dating and post-dating) bracketing the pluvial phase. Tephra markers were identified and dated in Andean Laguna El Trebol. Radiocarbon dating of sedimentary carbonates from paleolake suggests scenario about 4000 years older.

KEY WORDS: lakes, Late Pleistocene, climate changes, Patagonia.

Introduction

Several closed catchment areas with lakes in the lowest part occur in Patagonia Steppe. Large inland lake basins, like those from Patagonia, are primarily tectonic in origin. They are formed on long-lasting sags in cratonic areas, they persist for long periods of geological time, theirs margins fluctuate over hundreds of kilometres. Lakes with no surface outflow have shoreline extremely susceptible to fluctuations in water level as a response to the climate changes. This relationship is particularly clear in arid or semi-arid zones.

The last pluvial phase in Maquinchao basin (N-W Patagonia, near Inginiero Jacobacci, Fig. 1) followed by continuous trend of drying has happened after the last glacial maximum. The Size of Cari Laufquen Grande and Cari Laufquen Chica Lakes observed recently in the central part of Maquinchao basin, corresponds to vanishing stages of formerly much larger paleolake (Volkheimer, 1973). Laminated sediments accumulated during the onset of the last pluvial phase form "tercer nivel" of Coira (1979). Maquinchao River cut this "nivel" (Fig. 2).

Methods

Field investigations were carried out in years 1992–1999 by Argentine-Polish team, in the "Proyecto Pangea & Glopas" of IGCP Project 324 UNESCO, and in Argentine

"Proyecto Lagos Comahue" leaded by PROGEBA scientific group from San Carlos de Bariloche. Results of field observation and laboratory determinations have been published on several meetings (del Valle et al., 1993, 1994, 1996; Tatur et al., 1994, 1996). Presented paper includes current (1999 year) field observation related to tephro-chronology, supported by geochemical data of tephra (in preparation). Radiocarbon dating were performed in Lund (Lu), Switzerland (ETH), Oxford (Q) and TL estimation of age in Poland (Wa).

Results

Paleolake sediments

The exposures of paleolake sediments document one well-defined pluvial episode followed by prograding sedimentary sequence (units 1 to 5, Fig. 2 and Fig. 3):

Unit 1. Cross-stratified gravel, sand and silt forset beds, being the evidence of high energy, alluvial environment of sedimentation (glacio-fluvial clastics), interrupted by short lasting standing water episodes, marked by laminated marly silts, with ripple marks. Clastics are derived from hard rock forming the frame of sedimentary basin.

Unit 2. Marly rythmites. Horizontally laminated clay/marly silt (deep lake sediments). Ripple marks occurring sometimes at the base and at top, mark initial stage of transgression, final stage of lake regression, and are common in the east more shallow part. Continuos and homogenous layer of marly rythmites up to 5 m thick near the current lake get much thinner eastward and split into at least three sub-layers separated by sediments of Unit 3.

Unit 3. Marly clastics of shallow lake cover underlying sediments with erosive boundary and consist of material reworked from underlying units. Intercalation of thin continuous layers of marly rythmites occurs few times. Ripple marks are common.

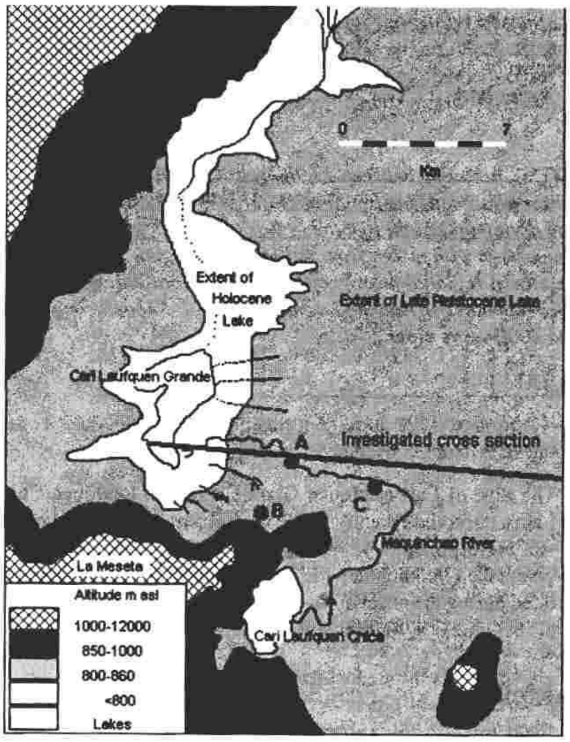

Fig. 1. Map of Maquinchao basin.

Unit 4. Recessive shoreline clastics, truncate underlying sediments. Several recessive cycles marked by large-scale erosive boundaries can be recognised. Clastics are derived mainly from hard Tertiary rock forming the frame of sedimentary basin.

Unit 5. Terrestrial features: soils, dunes, recent alluvial deposits and mass gravity flows.

Stromatolites

Numerous stromatolites up to 1 metre in diameter were found in two places at the similar altitude about 810 m a.s.l., that is 40 m above the current lake level (Fig. 2). Stromatolites developed around the hard boulders or pebbles near the ancient, rocky shoreline. They are just laying on the soil surface (locality B in Fig. 1) or are included as reworked elements into shoreline clastics of unit 4 (locality C in Fig. 1). Lamination visible in the field appeared to be much denser in thin sections. About 500 pairs of laminae were counted in some thick specimens under the microscope.

Tephra horizons

Two important dacite tephra horizons were recognised in the outcrops along the Maquinchao River (Fig. 2). The lower horizon pre-dated pluvial phase, whereas the upper one post-dated it. The lower horizon (up to 1.5 m thick) can be observed in few sites just above the river level, it contains material reworked during alluvial transport and mixed with lake sediment, and then deposited in the mouth of the river entering the lake. The upper horizon continues for about five kilometres. It consists of 30-cm thick tephra changing from white silt of dacite close to rhyolite at the base to grey sand of andesite-trachyandesite normative composition at the top. It has been deposited in the shallow lake environment.

Dating

The radiocarbon age of deep paleolake sediments (Unit 2) was determined from carbonates, because of lack of organic remains. Marl samples relatively rich in carbonates and almost pure carbonate stromatolite were used for analyses. The results yield artefacts (Table 1). The order of ages is turned upside-down.

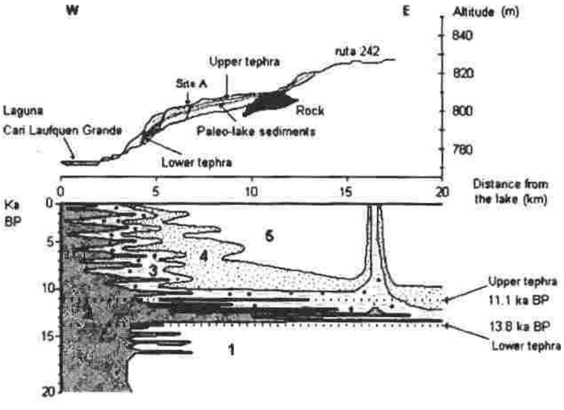

Fig. 2. Outcrop of paleolake sediments in banks of Maquinchao River and litho-stratigraphic facies (from 1 to 5 described in text). Tephra marked by black bars extrapolated as dotted lines.

Especially, the sample from the top of the sequence gave result falsely too old. Termoluminescence estimation of age from the top of unit 1 is clearly younger and proposed tephra stratigraphy support that age. Both tephra horizons from Maquinchao basin are linked (felt in the same cluster groups) with geochemically outstanding white tephra horizons in the sediment core of Andean El Trebol Lake (in prep.). These two tephra horizons (from depth 555–556 cm and 690–699 cm) were distinguished from 55 horizons recognised in the post-glacial history of El Trebol Lake. The age of tephra horizons (considered here as regional stratigraphic markers) might be estimated to 11,100 (upper) and 13,800 (lower) years BP on the base of interpolation of radiocarbon dating from the sediments bearing organic matter but being free of carbonates (Table 1).

Discussion

Coira (1979) reported abandoned beaches of large (surface about 1500 km²) paleolake up to 68 meters above the modern lake level, that is at about 860 m a.s.l. Laguna Cari Laufquen Chica was also included in this water body covering the large structural depression of Maquinchao basin (Fig. 1).

The age of pluvial phase

The influence of hard water effect on age determination can be neglected according to some authors, if algal tufa or much better-defined stromatolites (both composed of carbonates) are used for dating. The stratigraphy based on algal tufa age determination was proposed for reconstruction of Cari Laufquen Grande (Galloway et al., 1988) and Cardiel (Stine and Stine, 1990) Lakes history. Carbonate dating in Cardiel Lake was positively verified by comparison with *Chara* detritus age determination.

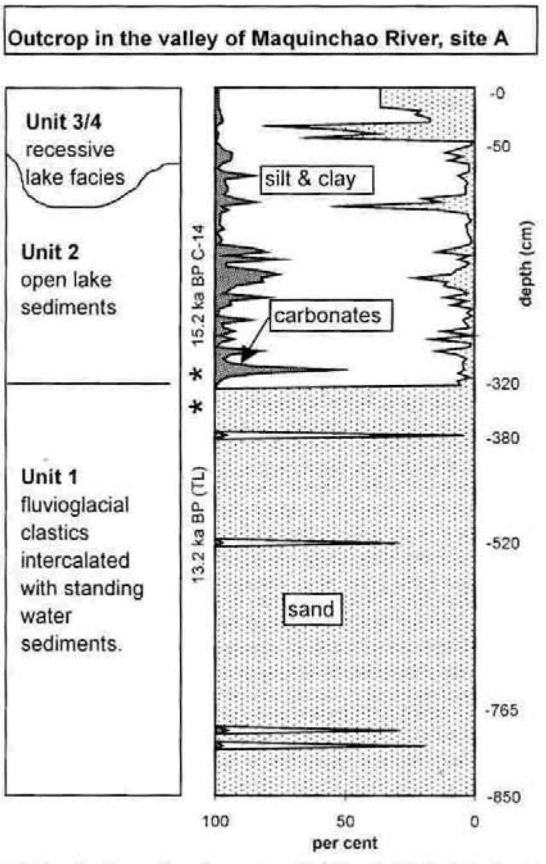

Fig. 3. Cross-section through paleolake sediments in site A (see Fig. 2).

Dating of stromatolite gave the age (16,500 years BP for optimum of pluvial phase) older than questionable age determination of sedimentary carbonates at the base of marly rythmites (15,200 years BP for beginning of the pluvial phase). Radiocarbon age determination of carbonates from the top of marly rythmites gave evidently false result (33,200 years BP), probably because the sample was taken from the top of waterproof level bearing dissolved "old bicarbonates", coming from Tertiary limestones building watershed. Thus, radiocarbon dating of carbonates documents pluvial phase in Maquinchao basin between 15,200 and 17,000 years BP (including considered later duration of the event). This age estimation is in good agreement with former timing proposition for this area presented by Galloway at al. (1988).

However, our TL dating supported by the proposed tephra stratigraphic markers, suggest younger age for the pluvial phase. It could develop after 13,800 years BP (lower tephra), probably at about 13,200 years BP (TL). However, the lake could be in the recessive stage about 11,200 years BP (higher tephra), prior to being dried out to about current size (the level not higher than 8 metres above lake) at 7900 years BP (C-14 age of algal tufa) (Galloway et al., 1988). This younger age for pluvial phase, placed it exactly at the beginning of large and rapid regional deglaciation well documented (C-14) at the same latitude in the Andes (Clapperton, 1991; Heuser, 1991; Margraf, 1991), and as a wetter phase in the other sites of Patagonia Steppe (Schäbitz, 1991; Garleff at al., 1994). Moreover, sedimentary record from Cari Laufquen Chica perfectly supports timing and duration of events according to the younger scenario. The interpolation of radiocarbon dating from organic matter (?) of sediments in this lake (Garleff et al., 1994), evidence enhanced clay content (50–65%) between about 13,200 and 11,800 years BP and than, after short lasting input of clastics, still high content (35–45%) was continued until about 7000 years BP, interrupted only by silt input after about 11,000 years BP. Afterwards, the clay content decreased to 5–20% and mainly sandy sediment have been accumulated until now. The highest clay content between 13,200 and 11,800 years BP marks probably the onset of pluvial phase, decreasing trend between 11,800 and 7000 years BP corresponds to recessive phase of lake, enhanced silt content after about 11,000 years BP may result from the upper tephra fallout.

Thus, there are two propositions for age of the pluvial phase. The first based on radiocarbon dating of carbonates (17,000–15,200 years BP). The second one based on TL age, analogy with record from sediments of Cari Laufquen Chica, and estimation from tephra chronological markers (13,200–11,800 years BP). Calibration of carbonate dating by comparison with radiocarbon age of aquat-

Material	Description	Lab. No	Age (years BP)	C-13 (‰)
C-14				
carbonates	CLG Base of paleolake sediments	Lu-3676	15220 ± 180	- 4.6
carbonates	CLG Stromatolite	Lu-3677	16520 ± 210	+3.9
carbonates	CLG Top of paleolake sediments	Lu-3792	33200 ± 2600	- 0.3
organic matter	Trebol L. Core 525 cm	ETH	10489	
organic matter	Trebol L. Core 650-660 cm	Q-2951	13120	
TL				
Fluvial sand	Under base of paleolake sediments	Wa-26/93	13200	

Tab. 1. Radiocarbon and TL dating of sediments.

ic plants, might give falsely too old ages (McDonald et al., 1987), especially when the lake is feed by old waters from meting glaciers and permafrost (Björck et al., 1991). Anyway, suggested here younger age for pluvial phase need better confirmation.

Duration of the pluvial phase

Tephra markers suggest that pluvial phase would have been lasting for less than 2000 years. Counting of lamination in stromatolite suggests the duration time of environment suitable for its growth longer than 500 years, suppose the lamination is annual (Park, 1976). The counting of clear annual lamination in the west, thickest cross-sections of paleolake sediments (Fig. 2) gave at least 1000 years as the most probably lasting time of pluvial phase. The real thickness of paleolake sediments is uncertain because their upper part has been eroded during recession of shorelines. So, we suggest the highest level of lake since 13,200 to at least 12,200 possibly to 11,800 years BP, as suggest evidence from Cari Laufquen Chica.

Timing of pluvial phases in Patagonia Steppe

Post-glacial pluvial phase occurred in many places along east site of Andes in Patagonia Steppe. However, latitudinal differences in the timing of its onset are observed as a rule. Pluvial phase in Laguna Bebedero at 33/S was dated by Gonzales at al. (1981) to 18,000–13,000 years BP, in Maquinchao basin at 41/S we suggest age from 13,200 to 11,800 years BP, in Lago Cardiel at 49/S onset of post-glacial pluvial phase happened 9800 years BP (Stine and Stine, 1990), Esperanza basin in Tierra del Fuego at 54/S was drained 7800 years BP (del Valle et al., 1988,1996; for pollen diagram see Markgraf, 1983). Palynological investigations delivered climatic proxies suggesting consequently latitudinal southward shift in timing of high precipitation. Our current and former (del Valle at al., 1990) data suggest that this shift also comprises complex environmental changes resulted directly from shifted deglaciation. Abundance of water derived from rapidly throwing glaciers in the Andes and from local glaciers and permafrost (Trombotto, 1994) caused flooding of flat Patagonia areas situated at the foot of mountains. Andean glaciers supplied streams with huge amount of water, that more frequently than today were oriented eastward (del Valle et al., 1993). Glaciers, snow-caps and permafrost extended also in the Patagonia Steppe northward to Rio Colorado (Trombotto, 1994). Around Maquinchao basin glacial features probably occurred on numerous elevated (1100–1300 m a.s.l.) plains and mountains (up to 2019 m a.s.l. - Cero Anecon Grande). Thus, beside the higher precipitation (being the response to the global changes in atmospheric circulation), also abundance of water derived from local sources and changes in hydrologic net, were also shifted southward along the east site of Andes during Late Pleistocene and lower Holocene.

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Buried Floodplain Soils as Evidences of the Holocene Environmental Changes in Eastern Europe

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ABSTRACT. In the floodplains of rivers in the central part of Eastern Europe the sequences of buried soils were found. Soils were formed during the periods of low floods, when alluvial sedimentation stopped. Numerous ^{14}C and archaeological dates indicate the following intervals of intensive soil formation on the floodplains of Russian Plain: 6500–4500, 4000–2800, 2200–900 BP.

KEY WORDS: paleosols, Holocene, floodplain, radiocarbon dating, climate change.

Introduction

The floodplains are characterised by high dynamics of all landscape elements, including soils. In the Holocene, the processes of river valley development, accumulation of alluvium, changes in flood levels and intensity resulted in periodical destruction and burying of older soils and development of new ones (Mandel, 1992).

Methods and material studied

Methods of studying soil evolution and soil age for paleoenvironmental reconstructions included the analysis of soil profiles, soil chronosequences and soil catenas based on pedality, geomorphology and palynology, and using historical, radiocarbon and archaeological methods of dating (Ivanov and Alexandrovskiy, 1987; Alexandrovskiy, 1988).

In the floodplains within the basins of Volga, Oka, Moskva, and Dnieper rivers, the sequences of buried soils were found. Their age, determined by ^{14}C dating and archaeological findings, reaches 5000–6000 BP (Fig. 1).

Results and analyses

In the floodplain of the middle Oka, some multilayered (from Neolithic to the Medieval period) settlements are found. Their cultural deposits are mostly allocated to buried soils (Alexandrovskiy et al., 1987). The soils were formed during the time when the plain was not flooded and the sedimentation of alluvium was interrupted. Four main buried soils dated by radiocarbon and archeological methods were identified in the of in a series of principal sections through the multilayered floodplain settlements:

S1 Young alluvial soil of the floodplain, 300–100 BP;
S2 Early Iron age and Early Medieval cultural deposits, Luvisol (Grey forest soil), 2200–1000 BP;
S3 Bronze age, alluvial meadow soil, 4000–2800 BP;
S4 Neolithic cultural deposit, deep alluvial meadow soil, 6000–4500 BP.

When the Grey forest soil (S2) was formed, its profile developed downwards (illuvial Bt horizons were formed). The soil processes have worked on the underlying alluvial deposits, which caused their compaction and structural changes.

The rates of alluvial accumulation calculated from the layers thicknesses and dating have considerably varied and notably lowered during the formation of the Grey forest soil (S2).

The changes in hydrology of the floodplain led to multiple migrations of human settlements to the elevated positions and back.

Discussion and conclusion

In the floodplains of larger rivers as well as their smaller tributaries in the basins of Upper and Middle Volga, Oka, Moskva River, Upper Dnieper the sequences of buried soils were found. Soils were formed during the periods of low floods, when alluvial sedimentation stopped. Numerous C14 dates (Table 1) and archaeological evidences indicate the following intervals of intensive soil formation on the floodplains of Russian Plain: 6500–4500, 4000–3000, 2200–900, 300–0 BP (non-calibrated age). Second soil (S2) in many cases is a Luvisol (Grey Forest soil). Climate changes cause synchronous development of floodplain soils. However, both external and internal factors can desynchronize soil development in different parts of floodplains. Sometimes, the soils of different ages merge together (e.g. S2