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Hydrological impacts of the works of regulation of superficial water transfers on the Altiplano basin (Bolivia)

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INTRODUCTION

The Bolivian Altiplano (190 000 km^2), is located in the center of Andes (Peru, Bolivia, Chile and Argentina), between Cordillera Occidental and Cordillera Oriental where the highest peaks reach over 6000 m. above sea level.

The Altiplano precipitation and temperatures present a northwest - southeast gradient. This distribution explains the presence of a huge permanent lake in the north, the Titicaca lake, a semi permanent lake (Poopo lake) in the center, and to the south Coipasa and Uyuni Salar.

This hydrosystem seems to be very sensitive to interannual climate variations: in 1983 (El Niño), the Poopo lake dried while en 1986 (La Niña), it covered a 4000 km^2 area. This climatic gradient is a consequence of the southern latitudinal shifting of the Inter Tropical Convergence Zone that reaches the Andes during the austral summer from December to March. Eastern winds and the summer warm thermical anomalies of the Altiplano, allow the penetration of humid winds from the Amazonia.

On the contrary, during the dry season (austral winter), the ITCZ moves to the north, western winds allow only the sporadic penetration of humid amazonic winds that cause occasional and low intensity precipitation.

The glaciers that are sources of supply for aquifers and lakes, have experimented a significant recession during the last two decades, although the precipitation and temperature have not suffered significant variations.

CLIMATIC AND HYDROLOGICAL CHARACTERISTICS DURING THE RECENT QUATERNARY

During recent Quaternary, the earth climate suffered warm and cold periods alternatively (glacial and interglacial). The Altiplano and the Cordilleras preserve a history of these oscillations in their sedimentary deposits.

The paleoclimatic evolution of recent Quaternary as deduced from the Bolivian Central Andes paleohydrology since *ca.* 30 000 yr BP, is very complex. However, we can summarize it as:

- 27 000 yr. BP, Minchin lacustrine phase in North and South Altiplano.
- From 25 000 to 18 000 yrs BP, progressive dry up of the lakes. Nor glacial development neither glacial recession are recognized in this phase.
- From 18 000 to 15 000 yrs BP, no available information, Dry climatic phase.
- From 15 000 to 10 500 yrs BP, Tauca lacustrine phase and glacial development. Cold and moistured climatic phase.
- From 10 500 to 8 000 yrs BP, south lakes dried up completely, an important Titicaca lake water draw down is recognized to the north (approx. 50 m), as well as glacial recession. Dry climatic phase.
- From 8 000 to 3 900 yrs. BP, the water balance improves weakly. The glacial recession continues.
- Since 3 900 yrs BP, the water level of Titicaca lake rises slowly, with short but important dry phases.
- The present levels of Titicaca lake remains constant since 1500 yrs BP, however archeological data reveal an important drought around 1100 yrs BP : it might have been the cause of the disappearing of many American cultures like Tihuanacu.
- During the Little Ice Age, the lake level might have rise 5 meters.
- During the last century (20th century) the level had a variation range of 6.37 m, maximum 2.65 m in 1987 and minimum -3.72 m in 1943 (Roche *et al.* 1991)

REGULATION WORKS

The rise of the Titicaca lake level in 1987, produced floods on the edge of Titicaca lake with an approximate cost of 10 million dollars (ALA/86/03 and ALA87/23 Peru-Bolivia agreements. Executive resume, 1995). In relation to this unique last century event, a bi-national institution was created in 1992 with the name of "Autoridad Autonoma del Lago Titicaca" (ALT) dependant on the Peru an Bolivia chancelleries, and it is in charge of the regulation of the waters of the Titicaca, Desaguadero, Poopo and Salars System (TDPS).

The TDPS system has been divided into one high basin of the Titicaca lake as a bi-national priority, and a lower basin from Aguallamaya to the south as a Bolivian priority.

Regulation floodgates were constructed to the exit of Desaguadero river, in order to regulate the waters of the Titicaca lake through the Southern Altiplano.

One regulation floodgate was constructed at Aguallamaya at 39 km from Desaguadero river, to regulate the waters of Aguallamaya lagoon.

PROGRAMMED WATER TRANSFERS

Programmed Water Transfers:

- Titicaca lake Basin. The following water transfers are programmed from the rivers that flow to the Titicaca lake, towards the Pacific Coast: Ilave river (7.9 m^3/s), Coata river (3.6 m^3/s), Ramis river (1.8 m^3/s), Huenque river (2.3 m^3/s), with 15.6 m^3/s of total flow (ambiental diagnosis, 1996).
- Mauri river water transfer. To use 3.2 m^3/s from the Mauri river waters. Besides 14.1 m^3/s from groundwaters of the Mauri basin (ambiental diagnosis, 1996).

DISCUSSION AND CONCLUSIONS

The Altiplano basin was the scene of great environmental changes due to climatic variations causing floods and droughts. From the results obtained, we can assure that dry periods have been the fundamental characteristic.

Water extraction from the Altiplano endoreic basin may have important climatic consequences on the life of the Altiplano, and particularly in the south region of the TDPS system.

References

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