Geochemistry, provenance and environmental conditions of Holocene sediments of Upper Manso river basin-Lake Mascardi, Argentina

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The Upper Manso River drainage basin and Lake Mascardi (*c.*, 41°S, 72°W) are located in Patagonian Andes, Argentina. The very steep Upper Manso River is 23 km long, has its headwaters at the Manso glacier (Mount Tronador, 3554 m a.s.l.) and discharges into Lake Mascardi (793 m a.s.l.). Turbid glacial melt water feeds the system, as well as rain and snowfall between May and July. The geology of the area includes phillitic, porphyric and granitic rocks, as well as Tertiary volcanic and sedimentary rocks. Varves, tephras, and glacial/ glacio-fluvial deposits are widely distributed throughout the basin.

Rocks, suspended and river bed sediments, as well as lake bottom sediments, and material from sediment traps deployed in Lake Mascardi, were collected in the area of study. Samples from an AMS radiocarbon-dated sediment core obtained in Lake Mascardi at 30 m water depth were also included. Lake Mascardi sediments record variations in the transport of glacially-derived clay and silt to the basin, which reflects variations in Southern Hemisphere climatic characteristics for the last 15.0 kyr BP (Ariztegui *et al.*, 1997).

All the samples were analysed for 25 major and trace elements using instrumental neutron activation (INAA) in the RA-6 research reactor (S.C. de Bariloche, Río Negro, Argentina).

In this paper we analyse the chemical variability of glacio-fluvial sediments in a pristine area, also examining inorganic inputs in a lake core since Late Pleistocene.

Glacial environments are characterized by low chemical weathering rates. However, the production of fine-grained, easily weathered material, may compensate this well-known fact and introduce an important variable in global weathering. In this particular case, a regenerated glacier at the upper-most reaches, introduces an important debris load into the river. The mineralogical composition of such debris, derived from basalts, shows a dominance of feldspars, pyroxenes and amphiboles. Feldspars are sensitive to weathering and their transformation to clays is indicative of the reached degree of alteration. In order to quantify such process, we have used the chemical index of alteration (CIA) and the chemical index of weathering (CIW). CIA values for present-day sediments suggest a clear dominance of plagio-clase. A relatively uniform variation of CIW/CIA also indicates a constant mineralogical composition.

The geochemistry of the Upper Manso river drainage basin is controlled by a weathering limited regime (Stallard and Edmond, 1983). Hence, detrital materials exhibit a close relationship with source rocks (Tronador Fm. Miocene basalts). This is clearly shown by *REE* normalized patterns, Eu/Eu* values and the relative distribution of immobile elements. The main deviations from this trend were observed for high-mobility elements (U, Na, Sr) and those selectively adsorbed in clay-size materials (Cs, Rb). The available evidence also suggests an Nd enrichment in the finer size fractions.

Although the textural differences are favoured by selective sorting, the immobile element distribution of source rocks is preserved in sediments of Upper Manso drainage basin.

Due to the presence of plagioclase-bearing basalts in the drainage basin, the sediments offer excellent conditions for the study of the Eu behaviour during sedimentary processes. Following the Albarède and Semhi's approach, the modelling of the Eu fractiona-tion in relation with trivalent *REE* suggests little reworking of sediments, with a total loss of soluble or weathered material of 36%.

Material collected in sediment traps moored off the mouth of the Manso River has exhibited features

which are worth stressing: shallower cups appear as more diluted by biogenic silica, whereas deeper cups have a Eu/Eu* signature closer to plagioclase, suggesting contributions via turbid bottom currents. The strong seasonal changes to which the basin is subjected are not manifested in the chemical composition of the sediments. The lacustrine sediment trap samples show uniformity in their general composition and coherent behaviour for most of the elements during weathering.

Ariztegui *et al.*(1997) defined four stages in the lacustrine record, according to grain size variations, organic matter, pollen and other biological remains. Their results show that unstable climatic conditions dominated the Late-glacial-Holocene transition in Argentina at this latitude. Furthermore, a significant advance of the Tronador ice-cup occurred during the Younger Dryas Chronozone. Their findings for the last 15 kyr BP were used to asses the compositional variations in the lake core during this period. The geochemical parameters are sensitive to climatic changes and their fluctuations are consistent with the picture depicted by these authors. The Cr/Th, La/Sc, Th/Sc y Th/Co ratios and Eu/Eu* appear as the most useful indicators.

The results obtained from Lake Mascardi core, which includes Late Pleistocene-Recent detritus, suggests: a) the existence of a relatively constant source (basaltic) of sedimentary material, b) the constant dominance of weathering limited regime, with clear fluctuations in weathering intensity; c) that such dominance becomes pronounced during cold events (e.g. during the Younger Dryas), which seem associated to minimal losses of soluble or weathered materials (less than 5%); d) that CIA and CIW indices are good indicators of environmental changes occurred since the Late Pleistocene, pointing to likely shifts in material provenance.

During the early Holocene climatic warming, the glacier retreat triggered an increase in median grain size and abundant embedded volcanic tephra. The proportion of the original bedrock lost to weathering oscillates between 25 and 30%. The warming triggered a retreat of the Tronador ice-cap and was accompanied by increased weathering and erosion. Present-day data show that the trend initiated in the early Holocene, still continues with minor variations.

Erosional processes are currently perceived as a spectrum which fluctuates between transport and weathering limited denudation regimes. The situation in the Manso River drainage basin and Lake Mascardi is clearly one of the latter kind, where transport rapidly removes detritus, mostly produced by physical processes. This rapid removal of weathered material is the main process which controls the geochemistry of the sediments in this glacio-fluvial system. Holocene climatic amelioration brought about increased weathering and erosion, which continues today.

References

Albarède, F. and Semhi, K. (1995) *Chem. Geol.*, **122**, 129–45.

Ariztegui, D., Bianchi, M.M., Masaferro, J., Lafarque, E. and Niessen, F. (1997) *J. Quat. Sci.*, **12**, 333–8.

Román Ross, G., Ribeiro Guevara, S. and Arribére, M.A. (1995) *Earth Planet. Sci. Lett.*, **133**, 47-57.

Stallard, R.F. and Edmond, J.M. (1983) *J.Geoph. Res.*, **88**, 9671–88.