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Nature, origin, transport and deposition of andosol parent material in south-central Chile (36–42°S)

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Abstract

The andosols of south-central Chile (36–42°S) are developed on yellow-brown loams that cover the region with a thickness of several meters. In the literature, several hypotheses concerning the nature, origin, mode of transport and deposition of the andosol parent material have been advanced but no general agreement has been found. In this paper, we test these hypotheses by analyzing new representative outcrops located around Icalma (38°50′S) and Puyehue (40°40′S) lakes by a pluri-methodological approach. Our data demonstrate that the andosol parent material has the typical mineralogical and geochemical signature of the regional volcanism and that these deposits are post-glacial in age. The grain size of the deposits and the morphology of the coarse grains evidence that most of these particles haven't been re-transported by wind but are direct volcanic ash falls deposited throughout the Late Glacial and Holocene. Because of the prevailing westerly winds, most of these volcanic ashes have been transported to the East. Following the deposition of the volcanic particles, weathering and pedogenetic processes have transformed part of the volcanic glasses and plagioclases into allophane and have wiped out the original layering. This work demonstrates that most of the andosols that occur in the Andes and in the eastern part of the Intermediate Depression of south-central Chile are developed on volcanic ashes directly deposited by successive volcanic eruptions throughout the Late Glacial and Holocene.

Keywords: Andosol; Volcanic ashes; Volcanic glasses; Allophane; Chile

1. Introduction

Volcanic soils cover over 50% of south-central Chile (36–42°S). Although regional variations exist, these soils are mainly developed on yellow-brown soft deposits covering the area with a thickness of several meters (Laugenie, 1982). These deposits cover the Andes and the eastern part of the Intermediate Depression and constitute a nearly continuous formation between 36° and 47°S (Besoain, 1985). This distribution is imposed by the location of the regional active volcanoes at the western side of the southern Andes, which is part of the Southern Volcanic Zone of Chile (SVZ, 33–46°S, Gerlach et al., 1988). The soils developed on these soft deposits are locally called Trumaos, *i.e.* the Araucanian name for andosols signifying "dust accumulation" (Langhor, 1971).

The nature, origin and mode of transport and deposition of the Trumaos parent material have often been discussed in the literature but up to today no agreement has been reached (for a review, see Besoain, 1985; Moreno and Valera, 1985; Veit, 1994). It seems that each author finds his own explanation depending on the study location. For south-central Chile, three main hypotheses have been proposed: (1) direct volcanic ash falls (Wright, 1965 In: Besoain, 1985); (2) loess-like deposits (Laugenie et al., 1975) or (3) glacial transport with ablation moraine-like deposition (Langhor, 1974). Authors sometimes propose a mixed depositional pattern (Besoain, 1985). Locally, pyroclastic flows, lahar deposits and fluvial sediments might have participated to the accumulation of particles on which the andosols further developed (Wright, 1965 In: Besoain, 1985). The main objective of this paper is to analyze new representative outcrops located around Icalma and Puyehue

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lakes by a pluri-methodological approach, in order to test the diverse hypotheses about the nature, origin, transport and deposition of the andosol parent material in south-central Chile.

2. Geological setting

Icalma lake (71°20′W, 38°50′S) is small water body (11.65 km^2) located in the Andes at an elevation of 1140 m (Fig. 1). Its watershed covers 147 km^2 and is flanked westward by three active volcanoes: Lonquimay, Llaima and Sollipulli. On the other hand, Puyehue lake (72°20′W, 40°40′S) is a larger lake located at the foothill of the Andes. Its watershed reaches 1267 km^2 and is characterized by the occurrence of Antillanca and Puyehue–Cordón de Caulle volcanic complexes eastward, with the Osorno volcano being nearby to the south (~50 km). The whole region is dominated by westerly winds coming from the Pacific Ocean. Combined to the rough topography of the Andes, these winds are responsible for high precipitation in the area, with an annual rainfall reaching 2000–3000 mm/year around Icalma (Mardones et al., 1993) and 2000–5000 mm/year at Puyehue (Muñoz Schick, 1980). Occasionally, a Foehn type easterly wind locally called "Puelche" blows down from the Andes (Aravena et al., 1993).

The watersheds of both lakes are covered by unconsolidated and weakly stratified yellow-brown loams, several meters thick. As in many locations of the Intermediate Depression and the Andes in south-central Chile, andosols – *i.e.* soils developed on volcanic ashes – are developed on these deposits (Fig. 2). In many locations and particularly at Icalma and Puyehue, these deposits sit on top of glacial or fluvio-glacial sediments.

In the Icalma region, the andosol parent material reaches a maximum thickness of 6 m and bury all the underlying Pleistocene deposits, whether they are glacial, fluvial or lacustrine (Mardones et al., 1993). In addition, the deposits contain two distinct pumice layers that have been attributed to the Holocene explosive eruptions of Sollipulli (Naranjo et al., 1993) and Llaima (Naranjo and Moreno, 1991) volcanoes, respectively dated at 2900 yr BP (Naranjo et al., 1993; De Vleeschouwer et al., 2005) and 9000 yr BP (9030 yr BP, De Vleeschouwer et al., 2005 or 8830 yr BP, Naranjo and Moreno, 1991). Westward, *i.e.* closer from Llaima and Sollipulli

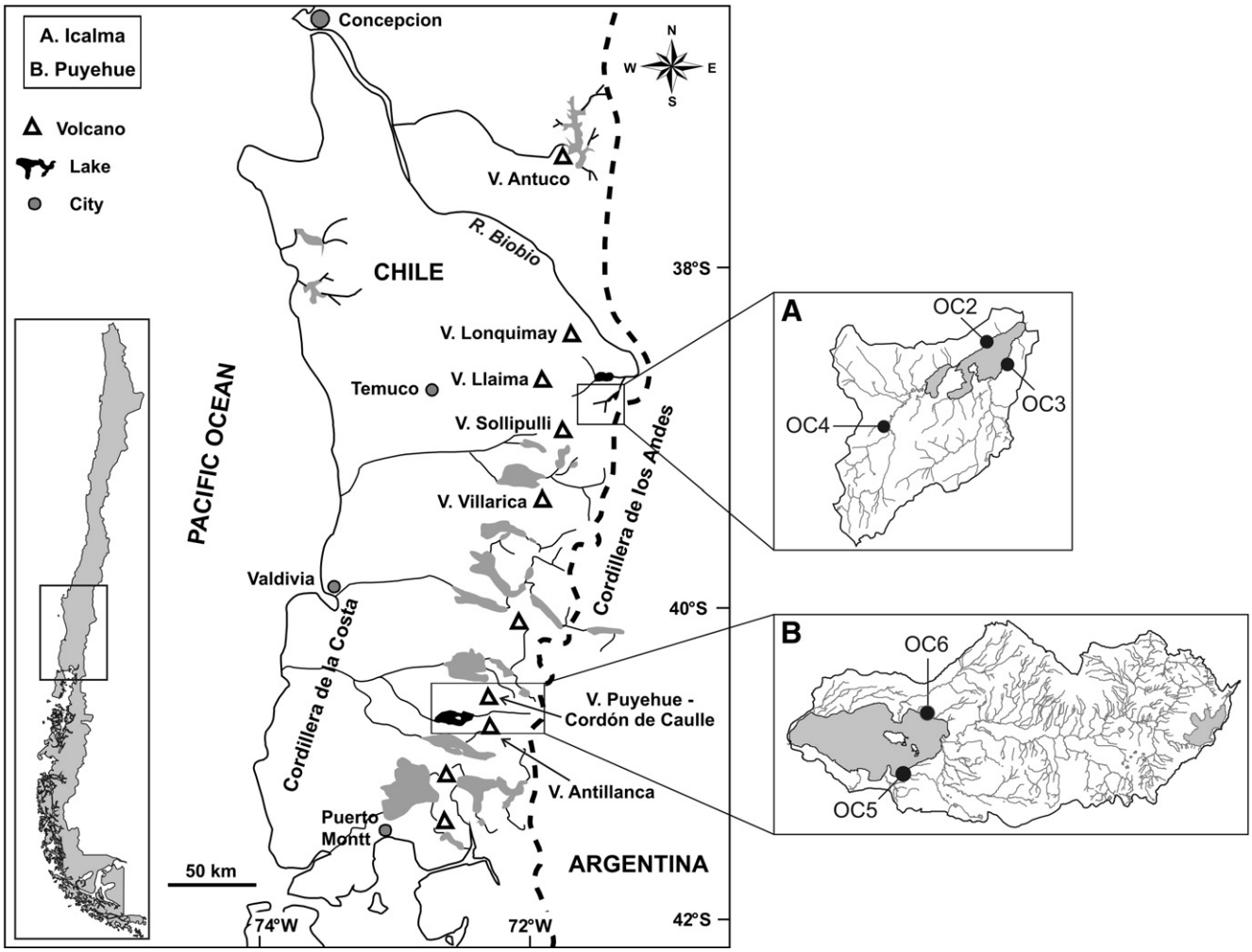

Fig. 1. Study area and sampling sites.