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# Preservation of the Miocene Atacama Gravels in Vallenar area, northern Chilean Andes: Climate, stratigraphic or tectonic control ?

Nalpas, T. [1], Dabard, M.-P. [1], Pinto, L., [2], Loi, A.[3]

(1) Géosciences Rennes, Université de Rennes 1, Campus de Beaulieu, 35042 Rennes cedex, FRANCE.
(2)Departamento de Geología, Universidad de Chile, Plaza Ercilla 803, Casilla 13518, Santiago, CHILE.
(3) Dipartimento di Scienze della Terra, Universita degli studi di Cagliari, Via Trentino 51, 09127 Cagliari, ITALIA.

*thierry.nalpas@univ-rennes1.fr*

## Introduction

The links between deformation and climate in orogenic systems have been intensely debated [e.g. 1, 2]. Recent studies show that changes in the magnitude of mass transfers must be considered to explain north–south variations in tectonic style of the Andean system [3, 4, 5]. Lamb and Davis [2] have suggested that the aridity observed at the latitude of the Atacama Desert, during the Cenozoïc, is one of the causes of the Andean plateau uplift. During the Cenozoïc, the Miocene deposits are represented by continental sediments, described in the literature as Atacama Gravels [4, 6, 7]. In Vallenar area (28-29°S), southern Atacama Desert, Atacama Gravels extending from the Western Cordillera to the sea throughout the Coastal Cordillera (Fig. 1).
Our aim is to determine the factors responsible of their preservation, which can be: i) tectonic, with creation of a physical barrier, ii) climatic, with a decreasing of mass transfer towards the ocean, or iii) stratigraphic in relation to variation of the base level.

## Miocene gravels

Neogene gravels, called Atacama Gravels, are widely exposed in the Atacama Desert region, until the south of Copiapo, in Vallenar region. In this last area, (Fig. 1). they are mostly preserved in the Coastal Cordillera domain and poorly preserved in the Eastern part of the Western Cordillera. In the Coastal Cordillera (Vallenar zone), the Atacama Gravels contain ignimbrite of ages ranging from 12,6 ± 0,5 to 9,0 ± 0,3 My [8], while in the Eastern part of the Western Cordillera (Laguna Grande zone, Cerro Gravels) an ignimbrite at the base of the deposits is dated at 22 ± 0,6 My [9].

At a regional scale, the gravels of the Vallenar zone appear to represent a giant arid-region alluvial fan system as defined by Hooke [10], whose the main source-area was the Western Cordillera (see current direction in figure 1 and stratigraphic column). They are filling a wide Neogene paleo-valley system from the Pacific Ocean (where the top gravel surface is at 200m) to the limit between the Coastal Cordillera and the Western Cordillera (where the top gravel surface is at 800m). The total thickness of the deposit in this zone is not know but could be at least 150 to 200m (Fig. 1b). In the Eastern part of Vallenar near the Rio Huasco, the Atacama Gravels are filling a sharp globaly ESE-WNW Neogene paleo-valley system (Fig. 1c) with a present day thickness of 400 to 500m.
In the Laguna Grande zone (Western Cordillera), the Atacama gravels are deposited on a smooth erosive surface. The base and the top of the deposits are situated respectively between 3250m and 4350m in the southern part, and between 4000 and 4500 in the northern part. These data show a progressive decreasing thickness from the south (1100) to the north (500m). On the other hand the base of the deposits show in the southern part a progressive decrease of 400m from west to east. These deposits are limited in space by quaternary erosion in the northern, western and southern part while in the eastern zone they are in contact with the basement by a fault. The internal stratification is globally a monocline without important deformation (even near the fault). The stratigraphic organization is characteristic of fluvial to alluvial fan system with a progressive coarsening upward (in the upper part with plurimetric boulders, Fig. 1d,e,f).

Discussion

Three factors (eustasy, tectonics, climate) may have controlled depositional environments in the studied region during the Miocene. The Atacama Gravels of the same ages than those located in the Coastal Cordillera are in connection with marine deposits located towards the South (Coquimbo Formation, [11]). A suggestion for the preservation of the Atacama Gravels in a paleo Huasco valley in the Coastal Cordillera could be a paleo hight base level in relation with the relative sea level. Before the deposits of the Gravels, the base level was certainly lower than the present one, because in the zone between Huasco and Vallenar it is impossible to find the base of the Atacama Gravels paleo valley. That means that the base level in this zone was lower than present time somewhere during the Lower Miocene and higther than present time somewhere during Late Miocene.
In the zone of Vallenar and eastwards, the observation of the facies correspond to a mega fan in arid to semi-arid conditions and we suggest that a dry climate may induced a decrease of the transport capacity of the river and the preservation of the gravels [12].
In the Western Cordillera, the geometry of the base of the Atacama Gravels, their internal stratification, the progressive coarsening upward of the deposits and the presence of a fault in the Eastern zone suggest a tectonically controlled preservation and a syndeformation sedimentation. According to the geological map of El Transito [9], the fault is a reverse fault but the geometry of the limit between basement and gravels

indicates a dip plane in direction to the West, with the gravels on the hanging wall. All these features are compatible with a normal fault, as suggested by the absence of deformation inside the deposits and with the decreases of the base of the Atacama Gravels in direction to the East and the fault.

## Conclusions

The Atacama Gravels in the Huasco-Vallenar-Laguna Grande region fill an early or pre-Miocene incised surface and keep a record of the interactions between climate, variation of base level, tectonic and preservation of the deposits

(1) In the western zone near the ocean (Huasco area) the preservation is controlled by the variation of the base level (or sea level).

(2) In the central zone around Vallenar the preservation is controlled by a dry climate and the low capacity of transport of the rivers.

(3) In the eastern zone near Laguna Grande the preservation is controlled by deformation and fault.

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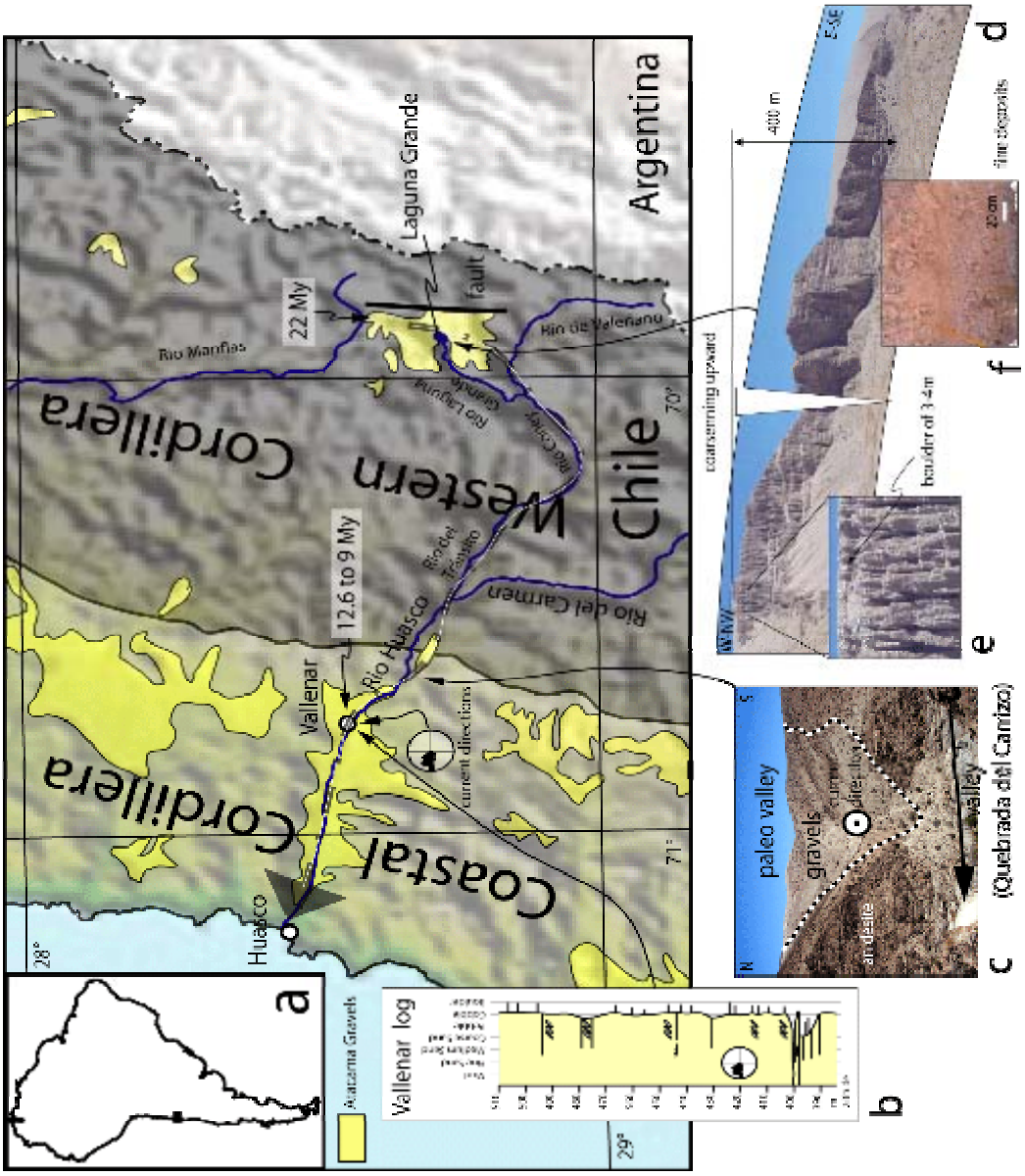


Figure 1: Location of the studied area, southern Atacama Desert, northern Chile. (a) Main structural units and location of the Atacama Gravels (AG). (b) Stratigraphic column of the AG in Vallenar. (c) Incised paleo-valley fill with AG. (d) AG cliff in front of Laguna Grande with example of (e) coarse deposits and (f) fine deposits.