

## PHYSICAL ENVIRONMENT

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### Geographical location

Chile is a republic located south west of South America between the 17°30' and 90° south latitude and between the 66°30' and the 75°40' west longitude. Its length, between the northern and southern boundaries, that is Peru and Cape Horn respectively, is of approximately 4,200 kms. If included the Chilean Antarctic territory, its longitude exceeds the 8.000 kms.

The region of the Antarctic continent situated between the 53° and 90° longitude west, is also part of Chile, and conforms a triangle ending in the south pole.

The national area, both continental and insular, amounts to 756,626 sq km. and that of the antarctic territory to 1.250.000 sq km.

Chile is very asymmetrical in its length and width; while in the meridian sense it exceeds the 4.200 kms., its mean width is of approximately 177 kms; the maximum insular width is of 468 kms. and is located at the 52°21' south latitude. The maximum continental width is found in Antofagasta, between the Mejillones peninsula and the Bolivian boundary, situated at 27°7' south latitude with 380 kms. The minimum continental width can be found near Illapel, at 31°37' south latitude.

The Chilean borders are: to the north with Peru, through the "Linea de la Concordia"; to the east with Bolivia and Argentina by the huge Andean heights; to the south with the south pole and to the west with the Pacific Ocean.

### Population

The data thrown by the last population census held in 1981 indicate a population of 11.200.000 inhabitants for Chile. Compared with the 9.780.000 inhabitants of 1970, it means an annual increase of 2.13%. The mean density is of 14.3 inhabitants per square km. Almost 60% of the Chilean territory is not habitable land due to its mountains, deserts, glaciers, huge salt deposits and swamps. The rural population is estimated to amount to approximately 25% of the total.

### Physiography

In the Chilean territory it is possible to distinguish three physiographic units that, can be clearly observed length and width wise: The Cordillera of the Andes or the Andean Mountain Range, the

Intermediate Depression and the Cordillera of the Coast or the Coastal Mountain Range. Sometimes another physiographic unit, called the coastal plains, is considered. (See Figure 1 for Broad Topographic Units.)

These physiographic units are subjected to major changes in their longitudinal development and from the combination of these physiographic bodies, eight territorial regions can be distinguished:

1. Big North (Norte Grande): from the septentrional limit to the hydrographic basin of the Copiapó river.
2. Small North (Norte Chico): from the mentioned reliefs to the southern limit of the Aconcagua river basin.
3. Central Region: from the preceding limit to the Bío-Bío river.
4. The Frontier (La Frontera): from the Bío-Bío river to the stripe that divides the Toltén river from the Valdivia river.
5. Lake Region: from the preceding stripe to the Gulf of Ancud.
6. Chiloé: Island of Chiloé, the Chonos archipelago and the Taitao peninsula.
7. Mountain Range and Patagonian islands.
8. Magellanic pampas: territories located east of the Cordillera of the Andes, both in continental Chile and in Tierra del Fuego.

Among these regions, the Central Region, the Frontier and the Lake Region, from now on the Central-Southern region of Chile, conform the area in which Andisols develop, and therefore, we shall limit our discussion to it. It is located between the 33° and 42° south.





In the Central-Southern region of Chile the geomorphological description is done based on the three physiographic units aforementioned, which develop parallel to the coast and which correspond to a depressed fault blocks area - the Central Valley or Intermediate Depression - between two areas of a greater altitude: the Coastal and the Andes Mountain Range. It is believed this formation concluded at the end of the Tertiary and Pleistocene periods, approximately one million years ago.

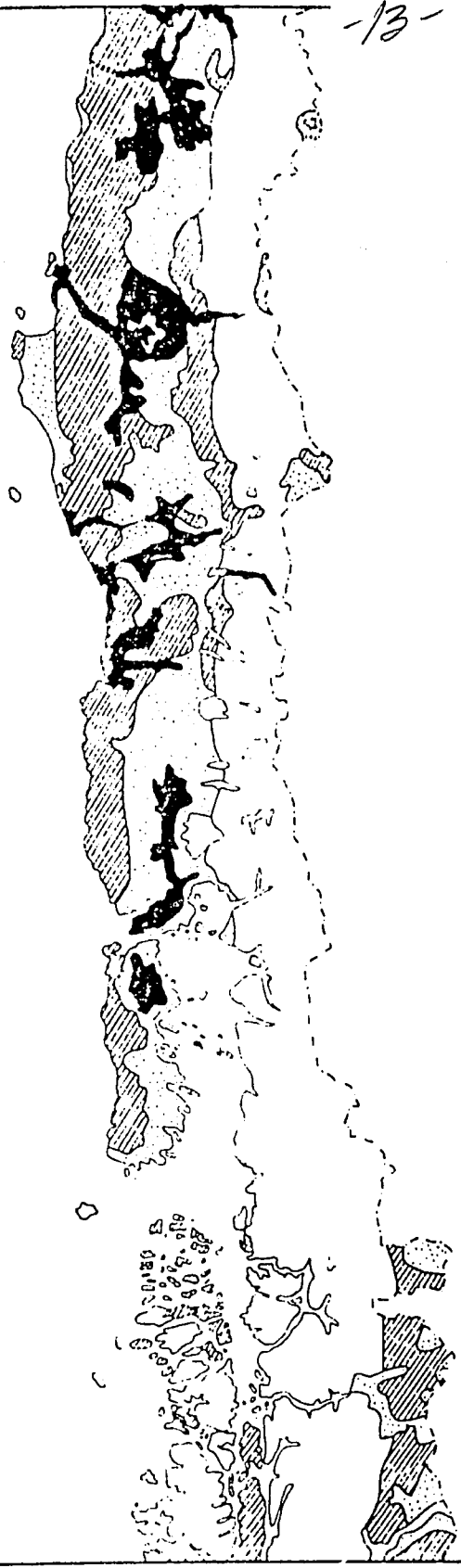
The Coastal Mountain Range shows a mature landscape, with rounded summits, greatly eroded. It has an undulated topography and its width is of approximately 50 km. The highest elevations are eastward and diminish rapidly towards the west. South of the Maule river, the cordillera shows significant ranges which later decrease strongly towards the south.

The Central Depression is a rift valley or graben, and the limiting cordilleras constitute the blocks of the "horst". This tectonic depression has been the sedimentation basin of glacial, glaci-fluvial, fluvial and volcanic deposits from the Andean Mountain Range and to a lesser extent, from the Coastal Mountain Range. Evidence exists (Laugenie *et al.*, 1975; ) that the sediments in it alternate with quaternary laharc deposits of a significant thickness. The height of the

BROAD TOPOGRAPHIC UNITS

FIGURE 1.

-  Flat
-  Undulating to strongly rolling
-  Hilly
-  Steep



Central Depression ranges from 25 to 800 mts. with a width of 50 to 65 kms. and a level or nearly level topography.

A particular physiographic feature between the Andean Range and the Central Depression takes place beginning in Talca (35°50' L.S.): the pre-Cordillera of the Andes. It has an undulated topography, with heights that do not exceed 1,000 mts. and a width that increases towards the south. Glacial, lacustrine, glacialfluvial, volcanic and alluvial deposits are the sediments that form this unit. It is plenty of valleys relatively dry during the summer, and by some other deep cut valleys holding low flow rivers. This pre-cordillera, parallel to the Andes, is interrupted by consequent rivers coming from the Andes and running to the lower zones of the Central Valley. In fact, this rivers are the continuation of the Central Valley towards the Andes.

The Andean Mountain Range. It runs from north to south following the eastern border of the Chilean territory. It is one of the biggest mountain ranges in the Earth. It is a young cordillera, consolidated during the Tertiary and Quaternary periods and in the Big and Small North its elevations reach spectacular heights (Llullaillaco Volcano: 6.730 mts; Socompa: 6.050 mts; Ojos del Salado: 6.908 mts; Cerro de las Tórtolas: 6.323 mts. etc.). The vulcanism reappears in the Central Region towards Santiago (Tupungato Volcano: 6.550 mts.), gradually decreasing in height towards the south where the maximum elevations coincide with the presence of volcanoes. In Curicó and Talca the highest elevations are coincident with volcanic cones: Peteroa (4.903 mts.); Descabezado Grande (3.850 mts.); Descabezado Chico (3.250 mts.); Quizapú (3.050 mts.). Facing Ruble (37° S.L.), the Nevados volcano does not surpass the 3.180 mts. Southward, the Cordillera has been affected by a severe glacial and fluvial erosion resulting in very deep valleys with steep slopes, giving it a basically alpine appearance (Fajardo, 1975), where relict peneplain zones of the Tertiary topography can be observed. The volcanoes of the Lake Region are somewhat higher: Llaima (3.050 mts.); Villarrica (2.840 mts.); Choshuenco (2.360 mts.); Puyehue (2.240 mts.); Puntagudo (2.490 mts.); Osorno (2.660 mts.). Southward of the Reloncaví Bay, the Andean relief becomes more complex and receives the name of Patagonian Cordilleras; it is also extremely weared out by glacial action, so in fact its base is sea-occupied. In the Magellan region the fiords cut the cordillera, with a broken up appearance, forming numerous islands.

### Geology

The oldest rocks, supposedly pre-cambrian, constitute the metamorphic base formed by micaschists, amphibolites, gneisses and phyllites. Outcroppings are located in the narrow and discontinuous coastal strip of the Coastal Mountain Range, in front of Santiago; they become wider towards the south, specially in front of Valdivia (39-40° S.L.) where the lowest part of the Cordillera of the Andes can be found.

Sporadically, Paleozoic rocks can be found in the Lake Region, province of Valdivia, between the lakes Calafquén and Ranco, where

conglomerates, sandstones, slates and phyllites outcrop, probably of the permocarboniferous age, they conform a sequence deposited in a marine environment (Fajardo, 1975). While plutonic granite-like outcroppings occupy great extensions as intrusive bodies in the crystalline base of the Cordillera of the Coast. Most probably granitic rocks are related to the evolution of the Paleozoic geosyncline.

The continental Triassic outcrops in the central-southern area, from the 8th. Region -Quilacoya- to the south, and is represented by shales and marine slates including fossils of live origin and intercalations of anthracitic coal layers (Cautín). No triassic sediments are found south of Cautín.

The marine Triassic is present in the region of the Bío-Bío and includes invertebrated fossils in sandstones and shales with scarce limestone evidences.

The plain surface of the Triassic constituted the occidental border of the south american continental mass, which produced an instability zone of the surface crust during the Jurassic, Cretaceous and probably during the Lower Tertiary periods. The orogenic movements of the Middle Cretaceous, both in central Chile as in the Patagonia, produced the intrusion of the Andean Batholith-Andean diorite (Fuenzalida, 1950) -which greatly conforms the Earth crust and which is itself formed by plutonite, tonalite to granodiorite and gabbros.

The instability of the surface provoked the development of vast geosynclinal basins which, as the batholith, were longitudinally elongated. Within the Chilean territory, this process came along with an intense volcanism developing deformation processes of granitic intrusions and of accumulation of a great mass of marine sediment (Fajardo, 1975).

At the end of the Lower Tertiary, and possibly, during the Oligocene periods the instability of the territory originated orogenic phases of deformation and folds which were rather continuous during the Plio-Pleistocene period originating mountain ranges that later suffered erosion. During the Oligocene tectonic phase, the Cordillera of the Coast begins its formation process and, also during this period, an intense volcanic activity takes place, giving way to an accumulation of clastic continental deposits which joined the volcanic series.

South of parallel 33°, the great outcroppings of volcanic rock -andesitic and basaltic- are practically horizontally arranged over rocks of the Lower Tertiary.

During the Miocene period, an advance of the sea takes place, and marine deposits develop in a special way in the coastal region of Concepción, Nuble, Arauco and Valdivia.

During the Pliocene period, the land was a peneplain area with an enormous volcanic cover invaded by small bays in the western part

towards the inland. Also, during this period occur orogenic movements that throw the waters to places near the present coast binding the various pieces of the Andean Cordillera, which, then, acquires a unitary character. This orographic configuration is emphasized during the Quaternary period.

### Volcanism

The Tertiary geological activity continued during the Pleistocene period, characterized by an intense volcanism and strong tectonic movements; thus producing the differential outburst of great magnitude blocks which originated and definitely separated the Andean Mountain Range, the Central Depression and the Coastal Mountain Range.

The Central or Intermediate Depression, which is a tectonic basin or Graben, has been the receptacle of fluvial, glacial, glacio-fluvial and lahatic sediments, all coming from the Andean Mountains, which have reached 500 mts. of thickness in the area of Santiago and more than 2.000 mts. in the area of Chillán.

Volcanism during the Pliocene and Miocene periods continued uninterruptedly up to the Quaternary period, though less intense or decreasing. The products of this volcanism, pyroclastic rocks and particulate tephra gave origin to the volcanic soils. The Quaternary volcanism is limited mainly to the Andean Mountain Range; the Coastal Cordillera lacks the presence of young volcanism (Zeil, 1965).

The Chilean Quaternary period has produced, in the central-southern region abundant volcanic ejecta, covering vast areas. This activity together with the glacial actions from the Pleistocene period, has shaped the present landscape. Glacial, fluvial or glacio-fluvial deposits are somewhat subordinated, directly or indirectly, to the volcanic activity.

Notwithstanding, a number of observations indicate that the Chilean volcanism is on the way to extinction, due to the fact that a great number of volcanoes have been destroyed by erosion or have been inactive for long periods and that others simply limit their activity to vapor emissions. Besides, the explosive phases of basaltic volcanoes and the presence of feldspar phenocrystals in some lava flows are symptomatic. Illies (1960) has come to the conclusion that the volcanic chain from the south of Chile, the liquid emissions of the Early Pleistocene period have concluded. Today volcanism is characterized by isolated emissions, particularly ashes. A similar opinion is asserted by Casertano (1962) and by Stone Ingerson (1934).

Young vulcanites, petrographically, are composed of olivine basalts which vary from vitreous to aphanitic, andesitic, biotitic or augitic forms (Segerstrom, 1964). Tephra vary from basaltic to rhyolitic terms. In Muñoz's (1950) opinion, old lava are hypersthene basalts and the young ones are olivine basalts. Volcanic products comprise, mainly, "aa" type lava or blocky lava and above all, ashes widely dispersed in the central-southern region of the country.