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## DELIMITATION OF GEOCRYOGENIC (PERIGLACIAL) REGIONS AND ASSOCIATED GEOMORPHIC BELTS AT 33° S.L. ANDES OF MENDOZA, ARGENTINA

### Abstract

The geocryogenic (periglacial) belts in the Cordillera de los Andes at 33° S.L. are defined. The permafrost region is located above 3200 m; within this belt two sub-regions are distinguished: the zone of active layer, above permafrost on rock glaciers, from 3200 till 5000 m with a mean annual air temperature from 0°C to -10°C. The upper zone of intense freezing, permafrost widespread, over 5000 m with a mean annual air temperature below -10°C. The lowest belt, the parageocryogenic belt (paraperiglacial) is located below the lowest terminus of rock glaciers (sporadic permafrost) or the mean annual air temperature of 0°C. The lowermost boundary of the parageocryogenic belt is located where needle-ice ceases to up-root vegetation.

### INTRODUCTION

When inventoring glaciers and rock glaciers in the Central Andes at 33° S.L. (CORTE, 1976, 1978; CORTE *et al.*, 1981), it was indicated that the lowest tongues of rock glaciers can be used as the lowest permafrost appearance at about 3200 m elevation with a mean year temperature of 0°C (Fig. 1). The thickness of the active layer above those permafrost bodies decreased continuously upwards till the level of 4800 m at a mean year temperature of -10°C (temperature extrapolated).

Regarding zonation, GARLEFF (1977) indicated the periglacial belts all along the Andes from 30° S.L. till 55° S.L. For the region of the present delimitation GARLEFF indicates four stages or belts: (1) the glacial, (2) the periglacial, (3) the belt of mild frost action, and (4) the lowermost belt of the zone of sheet wash and dissection.

KARTE and LIEDTKE (1981) are defining zonation and the term periglacial from the geographically oriented research. They are relating the periglacial geomorphic features to the mean annual air temperature, precipitation and the presence of continuous, discontinuous and sporadic permafrost. Regarding the altitudinal zonation they are presenting three zones for the medio latitudinal regions: upper periglacial, the middle one and the lower periglacial. For the subtropical and tropical regions only one zone.

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Recently BUSTOS (1983) has indicated a zonation of periglacial belts for the Aconcagua region. The zone of maximum periglacial intensity for BUSTOS is the zone of rock glaciers activity (3200–4700 m).

In a recent letter by KOWALKOWSKI<sup>1</sup> he defines the concept of paraperiglacial as follows: a temperate climate zone with periodic freezing and thawing of soils and waste, seasonal snow and underground ice.

Data regarding the freezing belts in the Andes mountain regions at 33° S.L., their altitudinal distribution, mean annual temperature and precipitation, and the geocryomorphic characteristics of each of these belts are here presented.

Most of temperature data is presented from two meteorological stations, one located at 2500 m in Vallecitos and other at 2200 m in Aguaditas. The other temperature data are derived from extrapolation using a rate of 0.6°C in 100 meters according to measurements made by BUK in the eastern slope of the Cordón del Plata.

#### GEOCRYOGENIC BELTS

According to figure 1 the following geocryogenic regions can be differentiated:

Y — the geocryogenic or permafrost region: its lowest limit is indicated by the lowest terminus of rock glaciers at 3200 m with a mean annual temperature of 0°C (Fig. 1). This region is separated into two subregions: the W sub-region is the permafrost with active layer region which in rock glaciers is decreasing continuously upwards till 4800 m where it tends to become small under a mean year temperature of –10°C. The X sub-region of intense freezing. This is the least known geocryogenic region. The tops of the mountains at 7000 m are at about –20°C.

Z — the parageocryogenic or paraperiglacial region: this is the seasonal ground freezing region. Its lowest terminus cannot be determined with precision but it can be set at the level where needle-ice ceases to up-root vegetation. For the Mendoza region it is at 850 m or the 13° or 14°C mean year temperature.

#### THE GEOMORPHIC IMPLICATIONS OF CRYOGENIC BELTS

The W sub-region. It is characterized by the following geocryogenic features:

1. Active rock glaciers are located in the range of 3200 m till 4700 m. The debris thickness on the surface of rock glaciers decreases upwards (Fig. 1). Values of the active layer above 4800 m are not available.

<sup>1</sup> The paraperiglacial environment, letter of Sept. 20th 1982.

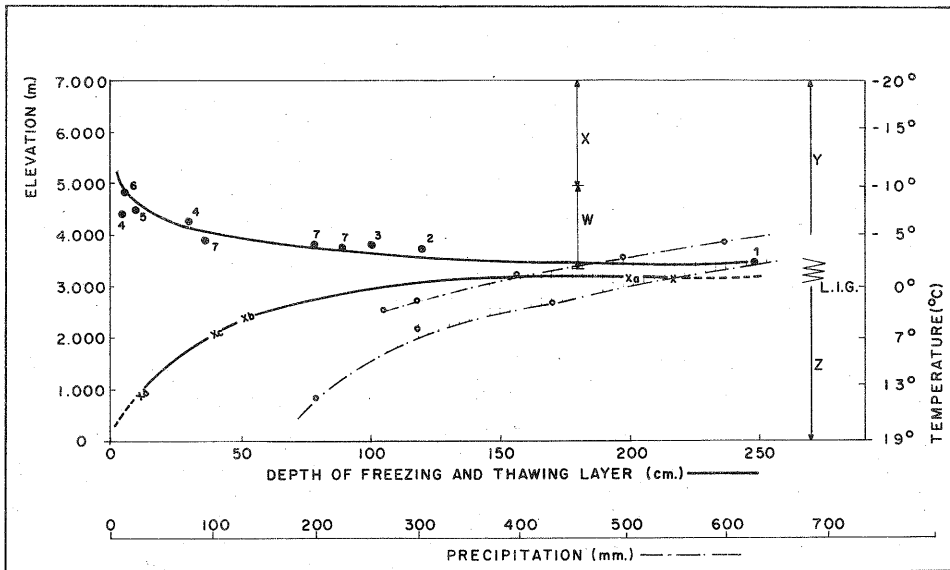


Fig. 1. Geocryogenic regions, depth of seasonal freezing, depth of the active layer and precipitation as a function of the elevation. Central Andes (W) and eastern slope of El Plata (Z), Mendoza, Argentina, 33° S.L.

Y — geocryogenic region (permafrost); Z — paragocryogenic region (seasonal freezing); X — intense geocryogenic region; W — geocryogenic region with active layer, above rock glaciers; L.I.G. — lower geocryogenic limit, mean annual temperature of 0°C; black points denote active layer on rock glaciers: 1, 3, 5 and 6. Cuevas river (CORTE 1980); 2. Lagunita del Plata; 4. Volcán river, San Juan (Aguado, oral com., 1983); 7. Cajón del Rubio (AHUMADA, oral com., 1983); x-xd denote seasonal freezing: a. El Salto (BUK, 1983); b. Vallecitos (BUK, 1983); c. Aguaditas (inferred); d. Univ. Nac. de Cuyo Ing. Krause (oral com., 1983)

2. Large gelifluction lobes, steps and benches.

3. Vertical sorting on the debris cover of rock glaciers, taluses are well developed in layers up to two meters thickness.

4. Large sorted features of 1–4 m diameter.

5. Thermal contraction cracking.

6. Planation surfaces. It is not possible to say if this planation features, within this sub-region, are active at the present time or they are a product of a past colder climate.

7. Asymmetry.

8. Stratified debris in slopes.

9. Thermokarst features.

The X sub-region. This is the intense freezing region: permafrost widespread. Because of its elevation this region is little known. Values of the active layer above 4800 m are not available. The following geocryomorphic features characterize this sub-region:

1. Large cryoplanation surfaces: these planation surfaces are present over the range of 5000 m.

2. Debris slopes "acarreos": BUSTOS (1983) indicates them for the Aconcagua region.

The Z region. This is the mild cryogenic or parageocryogenic region with a mean annual air temperature higher than 0°C. In this sector of the Andes it is located below the lowest terminus of the active rock glaciers at 3200 m. This is also the seasonal ground freezing (Fig. 1). This term, parageocryogenic is used as an equivalent of KOWALKOWSKI's paraperiglacial. The following features characterize this region:

1. Gelifluction and solifluction.
2. Needle-ice growth.
3. Cryoweathering in rocks forming pits and hollows with vertical sorting.
4. Stratified debris in slopes.
5. Up-rooted vegetation by needle-ice (mainly grasses).
6. Small sorted features, 10–20 cm in diameter, by freeze-thaw action and also by desiccation.

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