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Significance of silica karst in ignimbrite landscapes in the Peruvian Andes and their vulnerability to land degradation

Erik Cammeraat and Harry Seijmonsbergen

University of Amsterdam, IBED, Earth Surface Science, Amsterdam, Netherlands (l.h.cammeraat@uva.nl, +31 (0)20 5257431)

In the high Andes of Peru spectacular silicakarst landscapes have developed in ignimbrite deposits which have not yet been studied in detail. These striking geomorphological features are locally known as 'Bosques de Rocca' and are widespread between 3200 and 4000 m altitude and until now believed to be the result of Aeolian processes. This study discusses their occurrence in the 'Cumbemayo area' close to Cajamarca, in northern Peru. In this region, high rainfall amounts are combined with low temperatures and land use becomes more and more prominent.

This studies aims at understanding the major factors explaining their occurrence and origin, as well as the vulnerability of this landscape for increased land use and degradation. For that, a geomorhological inventory was made, supplemented by morphometric measurements, geochemical analysis of surface water and groundwater originating from springs at the interface of ignimbrites and the underlying low permeable rock strata, as well as an assessment of soil degradation vulnerability.

The ignimbrites are composed of predominantly fine grained silicate-rich deposits with at least 5-7 different superimposed beds. A major difference in grain-size exists between beds, which dictate the resistance to weathering. Large isolated, but also interwoven complexes of vertical pinnacles are present ranging from 5-30m height with often near vertical slopes. Local fracturing and the presence and spacing of joints strongly dominate the orientation and presence of the tower karst pinnacles. At the basement of the pinnacles concave foot slopes and narrow valleys are present. Soils here mainly consist of shallow vitric Andosols. The preferential occurrence in the landscape of such groups of pinnacles is at the front of horizontally bedded rock plateaus, which are often influenced by massive tensional fissuring, leading to toppling and widening of joints. This process speeds up the infiltration and karst processes. The rock towers also disintegrate by toppling and consequently break up locally, creating debris slopes covering the foot slopes. The detailed surface morphology of the pinnacles show prominent fluting or rillen karst, with rills up to 50 cm wide and 20 m high. At a finer scale honeycomb weathering occurs, often restricted to the lower part of pinnacles. Spring zones at the base of the silica karst formation cause undermining and produce water with relative high concentrations of dissolved silicates, indicating that the dissolution of silicate rocks is important and an ongoing process, despite low temperatures. Remnants of rounded weathering pits and hollows, originally created below the soil surface, and present at the basis of the pinnacles could be used as an indicator for landscape lowering. This latter process is accelerated by increasing land use pressure, leading to complete loss of soils at the foot and around these pinnacles, leaving parent material directly at the surface. It is concluded that the spectacular silica karst morphology is the result of a combination of material properties, mass fabric and low temperature chemical weathering. This is in contradiction with other silica weathering areas which normally occur in wet climates with high temperatures. Furthermore these areas are under increased risk of land degradation due to encroachment and intensifying land use causing a major threat to these fragile environments.