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Weathering profiles in granites, Sierra Norte (Córdoba, Argentina)

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Abstract

Two weathering profiles evolved on peneplain-related granites in Sierra Norte, Córdoba province, were examined. Several weathering levels, of no more than 2 m thickness, were studied in these profiles. They had developed from similar parent rock, which had been exposed to hydrothermal processes of varying intensity. Fracturing is the most notable feature produced by weathering; iron oxides and silica subsequently filled these fractures, conferring a breccia-like character to the rock. The clay minerals are predominantly illitic, reflecting the mineral composition of the protolith. Smaller amounts of interstratified I/S RO type are also present, as well as scarce caolinite + chlorite that originated from the weathering of feldspar and biotite, respectively. The geochemical parameters define the weathering as incipient, in contrast to the geomorphological characteristics of Sierra Norte, which point to a long weathering history. This apparent incompatibility could be due to the probable erosion of the more weathered levels of the ancient peneplains, of which only a few relicts remain. Similar processes have been described at different sites in the Sierras Pampeanas. Reconstruction and dating of the paleosurfaces will make it possible to set time boundaries on the weathering processes studied and adjust the paleographic and paleoclimatic interpretations of this great South American region.

Keywords: Granites; Sierras Pampeanas; Weathering profiles

Resumen

En la Sierra Norte de Córdoba se reconocieron perfiles de meteorización desarrollados sobre granitos vinculados a peneplanicies. Estos perfiles no superan los 2 m de potencia en los que se reconocieron varios niveles meteorización, a partir de una roca madre similar, que estuvo expuesta a procesos hidrotermales de diferente intensidad. El rasgo más destacado producido por la meteorización es la fracturación; estas fracturas fueron luego rellenadas por óxidos de hierro y cuarzo microcristalino, que confieren a la roca un carácter brechoide. Los minerales de arcilla son predominantemente illíticos, reflejando la composición mineralógica del protolito; subordinadamente están presentes interestratificados I/S tipo R0 en forma escasa caolinita + clorita, estas últimas originadas por la meteorización de feldespatos y biotita, respectivamente. Los parámetros geoquímicos de la meteorización la definen como incipiente, en contraposición con las características geomorfológicas de la Sierra Norte, que indican un relieve resultante de una larga historia de meteorización. Esta aparente incompatibilidad podría deberse a la probable erosión de los niveles más meteorizados de antiguas peneplanicies, de las que se conservan sólo algunos relictos. Procesos similares fueron descriptos en diferentes puntos de las Sierras Pampeanas. La reconstrucción de las paleosuperficies y su datación permitirá acotar en el tiempo los procesos de meteorización estudiados, así como ajustar las interpretaciones paleogeográficas y paleoclimáticas de esta extensa región de Sudamérica.

1. Introduction

Most outcropping rocks are subject to conditions that differ markedly from those prevalent during their formation. Weathering consists of thermodynamic readjustment of these rocks to surface conditions.

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Environmental conditions change over the geologic time scale, and these variations potentially can be recorded in weathering profiles. Subsequently, erosional processes ensure that only relicts of this weathering history remain, and many features are undoubtedly lost forever. Nevertheless, reconstruction of continental paleosurfaces and an understanding of the weathering processes that formed them constitute valid tools for the investigation of paleoenvironmental problems. In addition, these ancient surfaces are important indicators of global changes (Thiry et al., 1999).

Riggi and Feliu de Riggi (1964) undertook one of the first investigations of rock weathering in Argentina on Cretaceous basalts in Misiones. Their study provides a detailed description of the physical, mineralogical, and geochemical changes produced in different profiles of the region. Iñiguez et al. (1990) describe the paleosoils of the Tandilia System, Buenos Aires province, in a careful analysis of the petrography, clay mineralogy, and geochemical evolution of various profiles stratigraphically assigned to the Cambrian period.

In the Sierras Pampeanas (SP), previous workers have outlined the weathering of Sierra Grande, Córdoba (Roman Ross et al., 1998; O'Leary et al., 1998), where indications of incipient weathering were defined. Similar degrees of weathering were also found in Sierra Norte, Córdoba (Kirschbaum et al., 2000; Kirschbaum et al., 2002) and Sierra del Aconquija, Tucumán (Kirschbaum, 2002).

The geomorphological features of Sierra Norte encouraged us to find well-developed profiles. Our research goals were to recognize the mineralogical and geochemical effects of weathering in granitic rocks. Our final goal is to attain a better understanding of the processes of rock destruction under surface conditions, which constitutes the first step in sediment production.

2. Geological setting

The SP emerge as a group of southerly directed mountain chains in central and northwestern Argentina. The mountain blocks, separated by tectonic valleys, resulted from uplift and tilt on reverse faults during an Upper Tertiary stage of the Andean orogeny (Rapela et al., 1998). A division between eastern and western SP has been recorded (Caminos, 1979). The eastern SP correspond to an orogen generated during the Proterozoic, with a collision next to the Precambrian–Cambrian limit that gave rise to the magmatism and metamorphism of this age (Ramos, 1999). The Sierra Norte represents the easternmost emergent block of the eastern SP system. It is the only range of this unit oriented NE-SW and is bounded by structures that separate this uplifted block from the surrounding young sediment-covered plains. Lucero (1969, 1979) accurately mapped and described the major and most representative lithological units in the region.

The Sierra Norte batholith intruded a dominantly metasedimentary basement of Precambrian–Cambrian age (K/Ar: 598 ± 20, 517 ± 15 My, Castellote, 1985). The scarce basement outcrops appear as roof-pendant septa within the plutonic rocks, and the contacts between metasedimentary rocks and granitoids are generally fault bounded. The basement is mainly composed of quartzo feldspathic-biotite or sericite-chlorite schists and cordieritic cornubianites, evincing low pressure thermal metamorphism (Kirschbaum et al., 1997).

Local relicts of preintrusive quartz arenites with high textural and mineralogical maturity, forming part of a collapse breccia, have been described in the northern area (Millone et al., 1994). Regional series of enclave-rich granodiorite-monzogranite, locally intruded by a large dacite-rhyolite porphyry stock, prevail in the northern region. These units were subsequently intruded by highly evolved granitoids (miarolitic monzogranites, granite porphyries, and aplite dykes), whose emplacement was controlled by old regional structures (Lira et al., 1997). A porphyry-style hydrothermal alteration system associated with the dacite-rhyolite intrusion also has been identified (Lira et al., 1995). The effect of this alteration is visible in the rocks immediately surrounding the stock.

The magmatism in the southern region of the batholith is predominantly granitic, with scarce grandiorites whose field ratios suggest a subsequent setting. All the rocks are enclave rich, and aplites are frequent (Kirschbaum et al., 1997).

Geochronological data suggest that that the main magmatic activity in Sierra Norte reached its peak in the Lower Ordovician (494 ± 11 My) (Rapela et al., 1991). There is no geochronological information on the few sedimentary rocks in Sierra Norte. Lucero (1969) describes La Lidia Formation arkosic psammites and psephites in two meridian belts in the western sector of the sierra, tentatively assigning them to the Upper Cambrian.

In the Cerro Colorado area (Fig. 1), a continental succession of sandstones with interbedded conglomerates lies with nonconformity on a granitic basement. There is insufficient information about the age of these sedimentary rocks. A post–Cambrian Triassic age is suggested on the basis of petrographic and geomorphological evidence (Herrero et al., 1998). Quaternary sediments rest directly on the granitic basement in topographic lows, surrounding Sierra Norte on the east and west (Fig. 1).

3. Geomorphological setting

One of the most notable features of the Sierra Norte Massif is the presence of three topographic highs, each located at different heights (500, 700, and 900 m above sea level) and separated by abrupt escarpments. These slope variations limit areas where the hills have similar heights, with flat tops and generally convex slopes (Herrero, 2000). Dome-shaped hills, corestone or boulder tors, inselbergs,