# Environmental controls on clay minerals of the Mata Amarilla Formation, Austral Basin, Argentina

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The Mata Amarilla Formation is 100 to 350 m-thick and includes gray and black mudstones, alternating with beds of white and gray-yellow fine- and medium-grained sandstones deposited in littoral and continental environments. X-ray diffraction analyses permit the recognition of five main authigenic clay minerals in this succession, which are in variable proportions regarding the sedimentary facies and the section of the succession analyzed (Varela *et al.*, 2013). In addition, clay morphologies were determined by SEM, and EDS analysis shows their composition.

The porpoise of this study is to deal the relation between the genesis (in situ) of the main clay minerals regarding the paleoenvironmental conditions and processes associated.

Smectite: is the dominant clay mineral of the whole succession with abundances than in average are near 91%, is related to moderate to poorly drained palaeosols developed in floodplain facies associations. It has in general sharp and symmetrical peaks with well-defined reflections and high crystallinity. SEM analyses reveal that smectite shows as curled flakes with open-air voids having small interfacial zones and mutual, and as flaky particle morphology (Fig, 1A). EDS shows that Si is the major cation, followed by Al, Na, K, Mg and Fe in order of abundances (Fig. 1 A), and in some cases minor Ca.

Kaolin minerals: with abundances of 5% in average, these are concentrated at the sandy levels related to levees and crevasse facies associations. The patterns under XRD allow to identify very well defined peaks with high crystallinity. Under SEM, vermicular or platy kaolinite grows out (Fig. 1B). This type of kaolin mineral with Fe in the EDS shows as the most frequent morphology a well-crystallized book-like kaolinite, vermiform texture and vermicular stacks of plates (Fig. 1B). The characteristic texture of kaolinite which has crystallized from solution within a cavity typically is one of euhedral plates, 5-15µm in diameter, which occur as singles or face to face in packets in loosely expanded books up to 20 µm in thickness. SEM analysis reveals that illite replaced small kaolinite crystals.

Illite-smectite mixed layers (I/S): this interstratified clay mineral is usually scarce (2% in average) and occurs in moderate to poorly drained palaeosols developed in floodplain facies associations. The X-ray diffraction patterns of this I/S show a broad diffraction peak suggesting low abundance of illite in the I/S which corresponds to a random or R0 variety. The microstructure of the I/S is very similar to those of smectite as curled flakes but with higher K content showed in EDS. The presence of Fe in the EDS of the I/S and their main occurrence in edaphized facies suggest a pedogenetic origin.

Illite: this clay mineral represents only the 1% in average show under XRD irregular reflection near 9.98 Å with broad basal section. SEM microphotographs show the typical micromorphology of the 1M type with authigenic lattices that in the EDS analysis show Si, Al, Na, Mg, K and Fe (Fig. 1C). This authigenic lattice shape illite is associated with is coastal-plain facies associations with palaeosols development under poorly drained conditions.

Palygorskite: this clay mineral is only present in abundant proportions in restricted levels corresponding to the lower and upper sections (~30 to 60% of the fine fraction) of the Mata Amarilla Formation, is related to coastal-plain facies associations (lagoon and estuary palaeoenvironments) with palaeosols development under poorly drained conditions. Palygorskite shows a broad basal peak of 10.4 Å, that remains typically unaffected after glycol saturation and heating. Microphotographs by SEM show the presence of dolomite rhombs in the same levels.

Clay-mineral analyses indicate that smectite is the dominant clay mineral in the complete sedimentary succession, and is related to the weathering products of volcanic glass mass with $Na^+$ as the dominant interlayer cation. The crystallinity of this clay mineral decreases with the progress of weathering. Also is observable the neoformation of kaolinite, I/S and illite, related to pedogenesis during the eodiagenetic regime and controlled by paleoenvironmental conditions. The dominance of smectite, formed by alteration of volcanic glass coming from contemporaneous Late Cretaceous ash fall from the proto-Andes volcanic arc, is likely the result of intense pedogenesis under a greenhouse climatic context. Illitization of smectite is here associated with superficial environments commonly seen in vertisols as a pedogenic product. In this regard, the presence of authigenic mixed-layer illite–smectite near the superficial horizons of paleosols points to the same assumption. In addition, incipient kaolin illitization make possible to suggest that the Mata Amarilla Formation was not exposed to maximum burial depth. For instance, kaolinitization of smectite can be associated with periods of interaction with phreatic fluids of low pH in levees and crevasse deposits of the Mata Amarilla Formation. This is related to high topographic relief with well-drained to moderately-drained conditions, which drives a wash of high-solubility ions, promoting the generation of kaolinite over smectite.

In conclusion, the stratigraphic variations in clay-mineral assemblages reveal a strong environmental control on their distribution. The transformation of smectite into illite and kaolinite is considered as product of pedogenesis, whereas the presence of palygorskite indicates a coastal environment with paleosols development under poorly drained conditions.

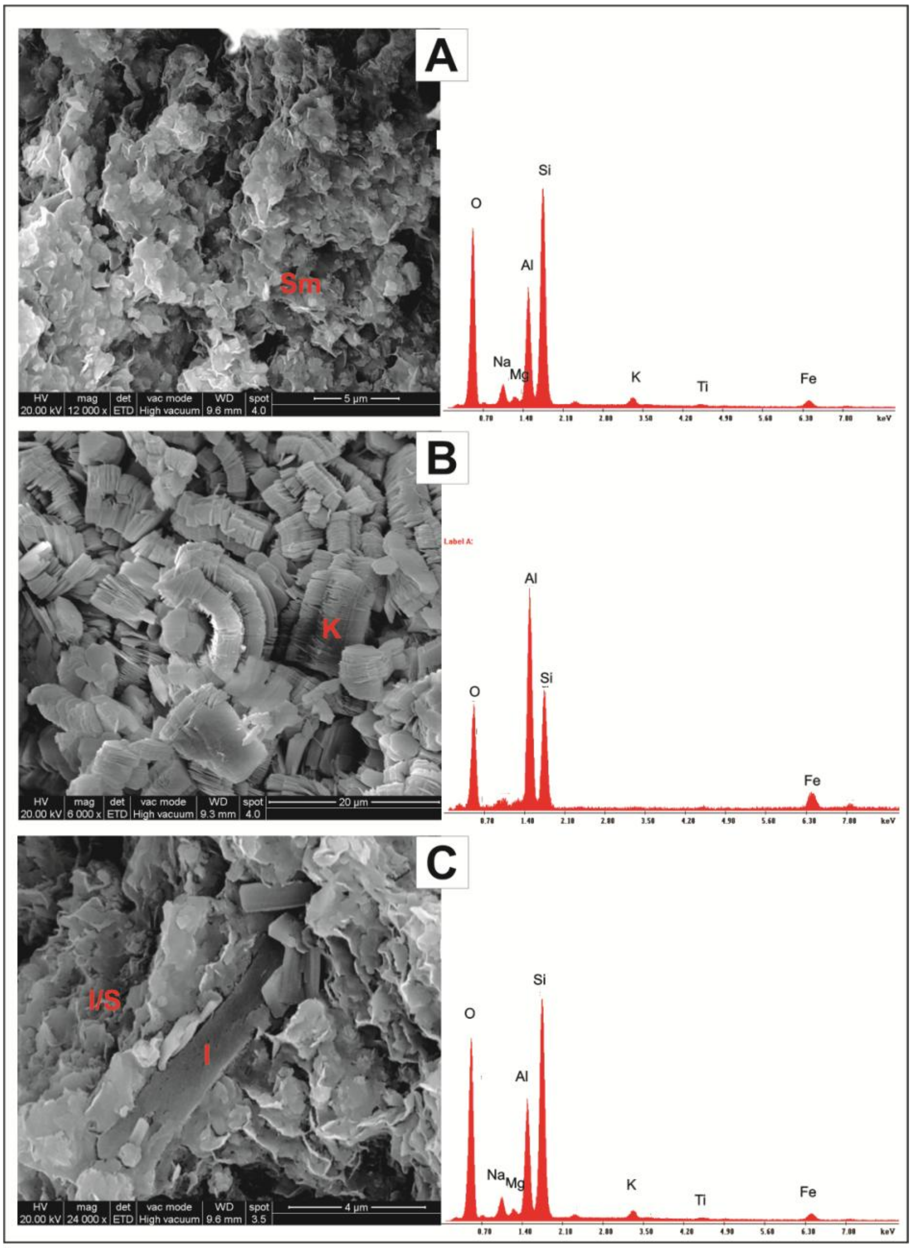


**Figure 1**. A) SEM image of smectite (Sm, at left) and EDS analysis (right). B) kaolinite (K) with book-like, vermiform texture and vermicular stacks of plates with the EDS analysis . C) I/S and illite (I) (1M) with EDS analysis.

**Varela, A.N., Gómez-Peral, L.E., Richiano, S.** and **Poiré, D.G.** (2013) Distinguishing similar volcanic source areas from an integrated provenance analysis: implications for Foreland Andean Basins. *Journal of Sedimentary Research*, **83**, 258–276.