Composition of Mixed-Layered Illite/Smectite in a Continental Eocene Succession (Quebrada de los Colorados Formation, Salta Province, Argentina)

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INTRODUCTION.

We have identified mixed layered illite/smectite (I/S) by X ray diffraction in continental sediments of the Quebrada de Los Colorados Formation (Díaz and Malizzia, 1984), at the north end of Calchaquí Valley in Salta Province, northwest Argentina. The Quebrada de Los Colorados Formation (Middle Eocene) is the basal unit of the Payogastilla Group and consists of a 1500-m thick upward-thickening and upward-coarsening continental succession composed by siltstones, sandstones and conglomerates. This unit was deposited in fluvial and alluvial fan systems and constitutes the first filling of the foreland basin linked with the shortening and uplift of the Central Andes. We have carried out a mineralogical study of this unit, which comprises the analysis of more than 60 samples from Tin Tin, Cº Bayo and Saladillo sites by X- ray diffraction (XRD) from bulk sample and in the < 2 µm fraction with the aim to examine vertical and regional changes in clay mineralogy (Do Campo et al., 2008). During this study we identified I/S mixed layered minerals in several levels from the base of Saladillo site. At this site three irregularly distributed sedimentary sequences were identified by Hongn et al. (2007).

MATERIALS AND METHODS.

In order to study in depth the I/S mixed layer present in these sediments we have chosen two samples from Saladillo, that according to previous XRD data exhibited the highest mixed-layered I/S contents (411-4 and 1611-1). For both samples we performed XRD slow step scan with a Philips PW1050 (INGEIS). Besides, in order to determine the morphology and composition of individual I/S mixed-layered particles we have studied this samples by transmission electron microscopy (TEM). Investigations were carried out with a Philips CM-20 working at 200kV (Universidad de Granada) on dispersed powders on Au-coated grids. Chemical analysis were performed with and EDAX microanalysis system. The structural formulae of mixed-layered I/S was calculated on the basis of 22 negative charges $O_{10}(OH)_2$. For sample 411-4 the morphology of individual particles was also observed in fresh cut in the SEM.

XRD, SEM AND TEM RESULTS.

Whole rock samples are composed by quartz, muscovite and plagioclase, plus potassic feldspar, detrital biotite, calcite and haematite in many cases. In most of the analyzed samples from the three sites illite-muscovite plus smectite account for 78 to 100 % of the clay minerals in the fine fraction. Although, in Saladillo site several samples from the base of the succession contain, in addition to predominant detrital micas, significant amounts of mixed layered I/S, plus kaolinite, chlorite or smectite (Fig.1). Deconvolution performed over XRD traces of Ethylene Glycol treated samples let us discriminate between contribution arisen from detrital micas and mixed layered I/S phases (Fig.2). The latter do not present a unique predominant component, on the contrary several different peaks could be identified in the zone from 5-9º2θ (15.5, 12.2, 11.0 and 10.1 Å) and also in the zone from 15-18º2θ: 5.31, 5.16, 5.01, 4.90, 4.76 and 4.73 Å. Peaks at 5.31 and 5.16 indicate R1 type of ordering and illite contents in I/S around 65 and 85% respectively (Moore and Reynolds, 1997). Peaks at 4.90, 4.76 and 4.73 Å probably correspond to RO smectite-rich I/S. Under SEM and TEM, I/S mixed layered grains present a rose like morphology, very similar to the smectite grains, which indicates their authigenic origin. On the contrary, the morphology exhibited by mica grains is coherent with detrital origin.

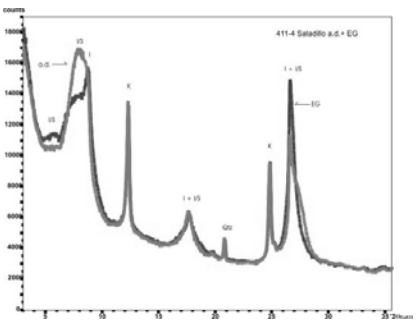

fig.1. XRD patterns of the <2 µm air dried and Ethylene Glycol treated mount of sample 411-4.

AEM RESULTS.

Mixed-layered I/S depict a broad compositional range with Si contents from 3.24 to 3.72 a.p.fu., Fe + Mg contents from 0.19 to 0.76 a.p.f.u., sum of interlayer charges from 0.24 to 0.67 a.p.fu., and sum of octahedral cations frequently in excess of 2.15 a.p.fu. In order to evaluate the respective influence of the compositional vectors usually present in dioctahedral micas (Abad et al., 2006); namely, illitic, phengitic and ferrimuscovitic, in the composition of mixed-layered I/S we employed Si – Fe + Mg and Si – Interlayer charge diagrams (Fig. 3). The compositional trend depicted by mixed-layered I/S in the Si – Fe + Mg diagram indicates a lack of a noticeable phengitic component. The scattering of data in this diagram could be explained by variable ferrimuscovitic substitution

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together with illitc substitution, which could also account for the negative correlation in Si – interlayer charge diagram. Nevertheless, the chemical effect of illitic substitution can be originated in this particular case by variable proportions of illite and smectite layers. In turn, the ferrimuscovitic (or nontronitic) component depicts a wide variation; this component usually reflects the influence of the parental material and/or the chemical environment at very local scale (Guidotti et al, 1994). Evidence pointing to both factors has been obtained in the SEM and TEM study of the Quebrada de Los Colorados Formation samples. First, muscovite grains depicting an important ferrimuscovitic substitution were found in samples 411-4 and 1611-1 (Fig. 3a). Then, authigenic minor nontronite coexisting with predominant beidellite-montmorillonite in the same sample were identified in one of the pelites studied by SEM.

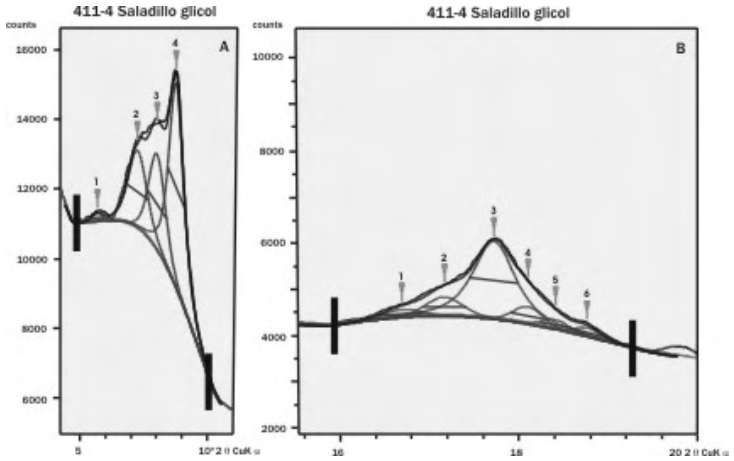

fig. 2. Decomposition of the low-angle region of the XRD pattern depicted in figure 1 *(obtained with MacDiff); (a) Region between 5 to 10 °2θ. (b) Region between 16 to 19°2θ. See text for position of the peaks.*

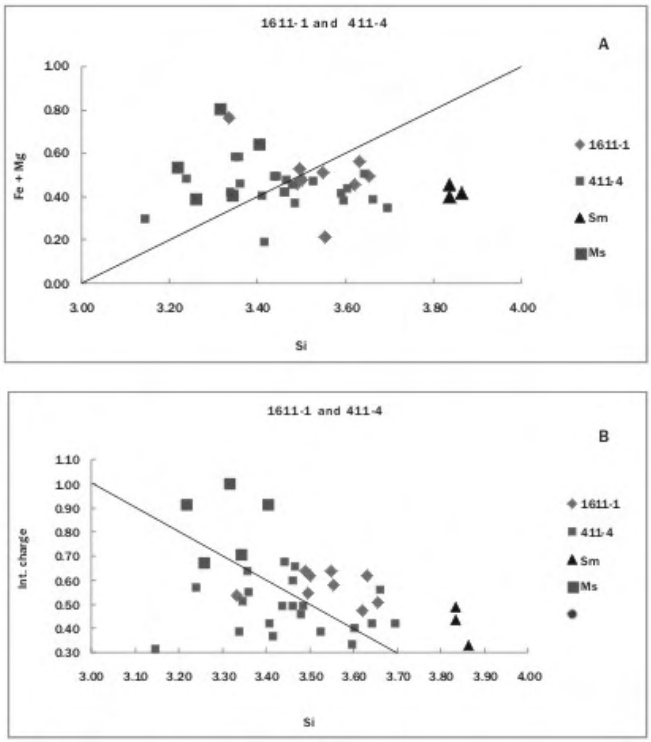

fig 3. Plots of Si vs. Fe+Mg and Si vs. Interlayer charge of mixed-layered I/S, smectites and dioctahedral micas corresponding to samples 1611-1 and 411-4.

DISCUSSION.

The wide range of compositional variation depicted by the studied mixed-layered I/S is characteristic of metastable phases formed under low-temperature conditions, which follow the Ostwald Step Rule. The composition of each individual grain is a consequence, not only of temperature and pressure conditions, but also of the parent material and chemical environment at micron scale.

The lack of illite-rich mixed-layered I/S in the other sites suggests that burial diagenesis solely could not explain the formation of this phase in Quebrada de Los Colorados Formation at Saladillo site. Hongn et al. (2007) have found evidence of syndepositional deformation at this site such as an unconformity with the underlying Salta Group (Paleogene), internal unconformities and changes in facies succession and provenance. This stress could have acted as a driving force that gathered burial diagenesis at the R1 mixed-layered I/S stage in these young continental sediments.

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