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(1) Dip. di Scienze della Terra. Univ. di Siena, Italia

(2) Instituto Andaluz de Ciencias de la Tierra. CSIC-Universidad. Granada, España

Origin of intergrown phyllosilicate stacks from Verrucano metasediments (northern Apennines, Italy): a transmission and analytical electron microscopy study

Giorgetti G (1), Nieto F (2) and Memmi I (1)

Introduction

Grains of intergrown phyllosilicates (IPG) widely occur in cleaved and low-grade metamorphosed clastic rocks from Verrucano Group (northern Apennines, Italy). These stacks have been re-examined after Franceschelli et al. (1989; 1991) using SEM and HRTEM in order to better characterize them and to clarify their origin.

Different types of IPG have been recognized with high resolution techniques: 1) Chl+Ms±Kln; 2) Chl+Ms+Pg±Kln; 3) Ms+Prl±Pg; 4) Ms+Prl+Su; 5) Ms+Prl+Chl+Su; 6) Su+Ms (mineral abbreviations according to Kretz, 1983). All them can be basically divided in two groups: (i) type (1) and (2) are constituted of Chl with micas and Kln forming thin lamellae parallel intergrown or crosscutting Chl packets; this is also the case of type (6) IPG with sudoite as an optically continuous mineral and minor muscovite packets. (ii) In type (3), (4), (5) IPG, muscovite can be recognized as a continuos mineral whose packets are crossed and splitted by the other phyllosilicates. Sometimes, IPG present a mineralogical association which is different from the phyllosilicate association of the rock matrix: this feature, together with textural evidences, indicates that IPG represent isolated microsystems which have not re-equilibrated with the whole rock.

TEM results.

In IPG of the former group, Chl is the most abundant phase: it occurs in several hundred angstrom thick packets with undeformed and defect-free 14Å-layers. Micas are always a two-layer polytype and they occur either as isolated layers interstratified with Chl, or in packets of variable thickness. In highly altered samples, Kln is also present as a 1T polytype with different degree of crystallinity; it occurs in packets of 7Å-layers intercalated with mica packets. Textural relations between the various phyllosilicates are as follows:

Chl - Mica: they are generally intergrown with parallel (001), showing coherent grain boundaries; in this case, lateral transformation from one 14Å-layer to one 10Å-layer can be observed. Analytical electron microscopy permitted to identify as mica the contamination produced by these 10Å-layers. Low- or high-angle grain boundaries can rarely occur.

Ms - Pg: coherent or low-angle grain boundaries are observed; Pg is always a discrete phase and no intermediate sodium-potassium mica is recovered.

Ms - Kln: they have parallel basal planes or slightly different orientation along the c* direction. Grain boundaries are not parallel to one layer but they are indented with lateral transitions from two 10Å-layers to three 7Å-layers.

In type (6) IPG, sudoite occur in hundred angstrom thick packets, defect-free and with straight lattice fringes. Ms occur in small packets, highly defective and disoriented along c. Also in this case Su and Ms may have coherent or low- / high-angle grain boundaries. Lateral transition from 14Å-layer to 10Å-layer can be observed.

IPG of the latter group are mainly constituted of muscovite and pyrophyllite. Muscovite occur as a two-layer polytype; HR images show that Ms is present both in several hundred angstrom thick packets, undeformed and with straight lattice fringes, and in small packets with slightly different orientation along the c* direction. Prl is present in thick packets as a 2M or 1T polytype; it is easily recognizable from Ms for its different contrast. Chl and Su occur as minor phases, in thick packets (Chl) or in wedges terminating inside Ms packets (Su). Sometimes, thin packets of Pg are present.

Ms - Prl, Ms - Su, Ms - Chl, Ms - Pg may be perfectly parallel intergrown: SAED show 00l row with two sets of reflections and HR images show pachets with contacts parallel to the basal planes. Low-angle grain boundaries can also be observed: the c* directions have different orientation and (001) of one phase abut against (001) of the other phase.

As proposed by Franceschelli et al. (1991), morphology and texture of IPG suggest that they originated from pristine grains (chlorites or muscovite) through a combination of metamorphic and tectonic events. The ultimate origin of pristine grains is detritic and they predate the deformation event: they are deformed, and metamorphic phyllosilicates grow at highly strained sites.

TEM data confirm this model and allow to characterize the reaction mechanisms involving phyllosilicates: topotactic growth is facilitated along the basal planes and transformations occur through dissolution-crystallization reactions. Nucleation is favoured by strain. Pristine phyllosilicates were so replaced by newly-formed phyllosilicates originating a mineral association in equilibrium with metamorphic P-T conditions.

References

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