Giornata Seminariale REFRESCOS
Dip. di Ingegneria Strutturale e Geotecnica – Politecnico di Torino, Italy
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Analisi microchimiche ed evidenze dirette di reazioni piezonucleari in provini di roccia in compressione

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INTRODUCTION

The experiment recently proposed by Carpinteri et al. represent the first evidence of piezonuclear reactions and neutron emission in inert, stable and nonradioactive solid under compression.

The analysis of the present paper is in strict connection with the results presented by Carpinteri et al. and by Cardone et al.

Carpinteri, A., Cardone, F., Lacidogna, G., "Piezonuclear neutrons from brittle fracture: Early results of mechanical compression tests", *Strain*, 45, 332-339 (2009).

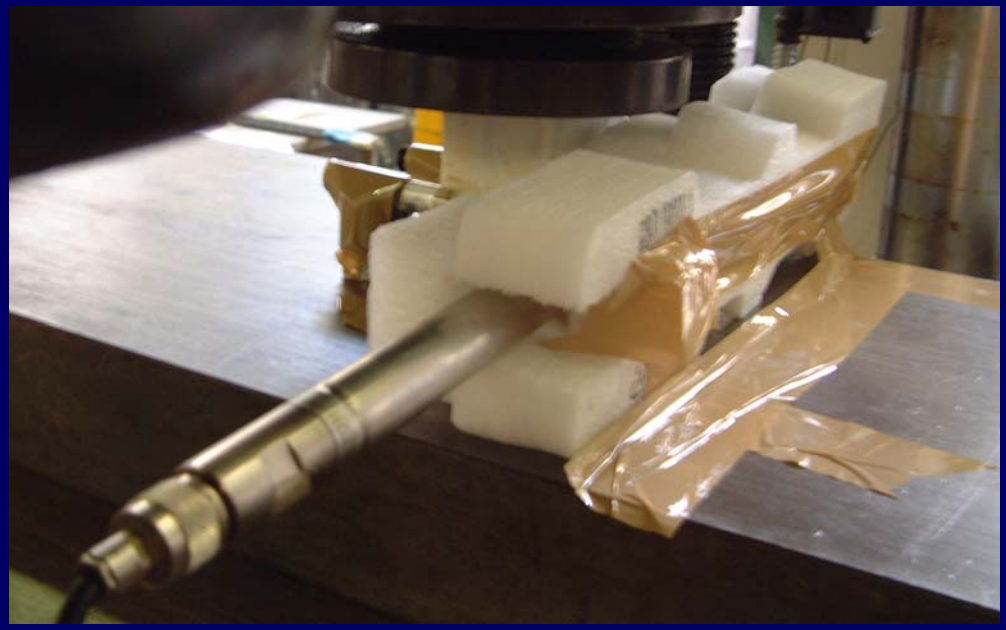
Cardone, F., Carpinteri, A., Lacidogna, G.,"Piezonuclear neutrons from fracturing of inert solids", *Physics Letters A*, 373, 4158-4163 (2009).

Carpinteri, A., Cardone, F., Lacidogna, G., "Energy emissions from failure phenomena: Mechanical, electromagnetic, nuclear". *Experimental Mechanics*, 2009, ISSN: 0014-4851, DOI: 10.1007/s11340-009-9325-7.

NEUTRON MEASUREMENTS

Servo-hydraulic press

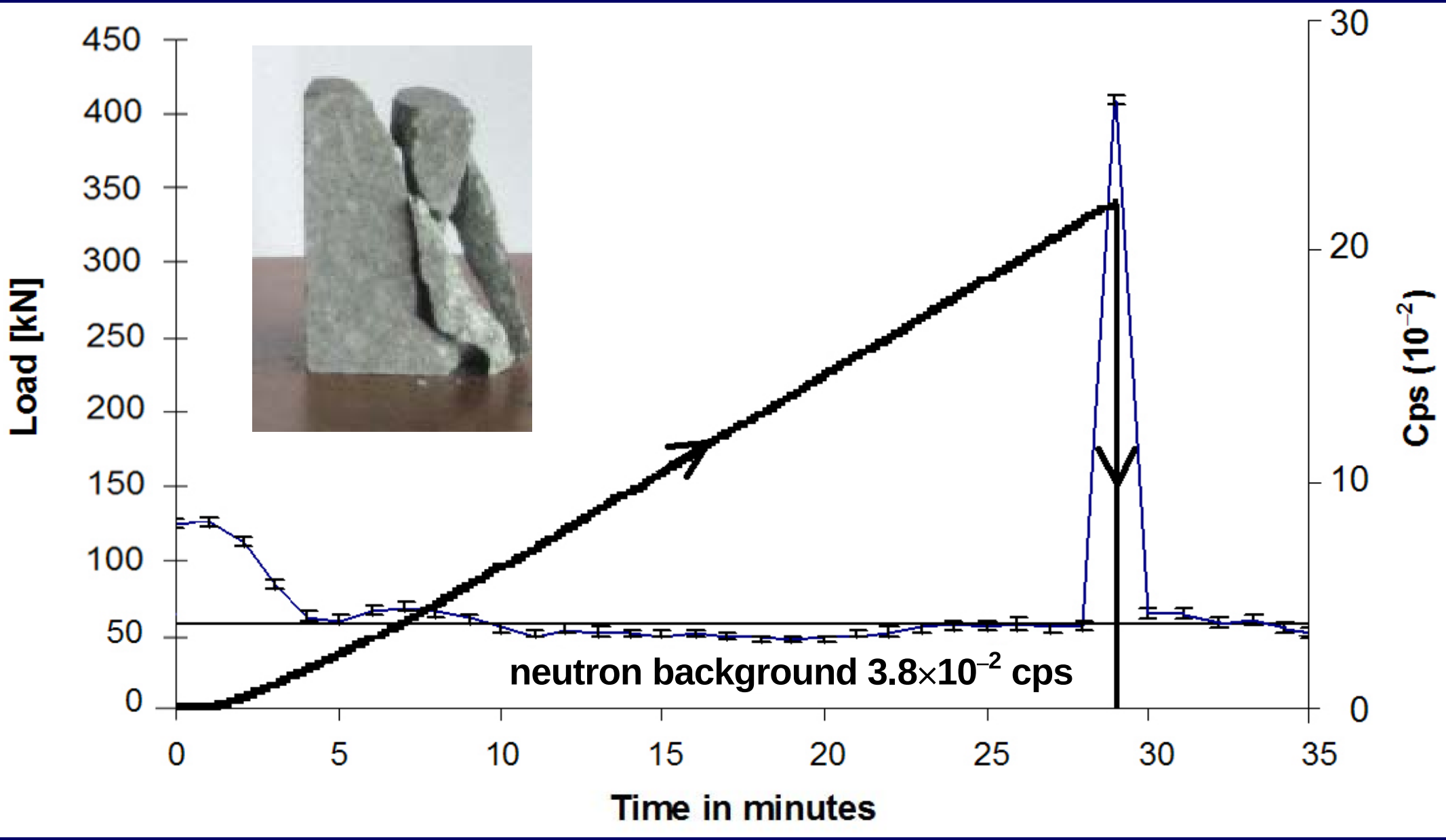
Helium-3 detector



Neutron emission measurements were made by means of a helium-3 detector placed at a distance of 10 cm from the test specimen.

Neutron emissions from the granite test specimens were found to be about one order of magnitude larger than the natural background level at the time of failure.

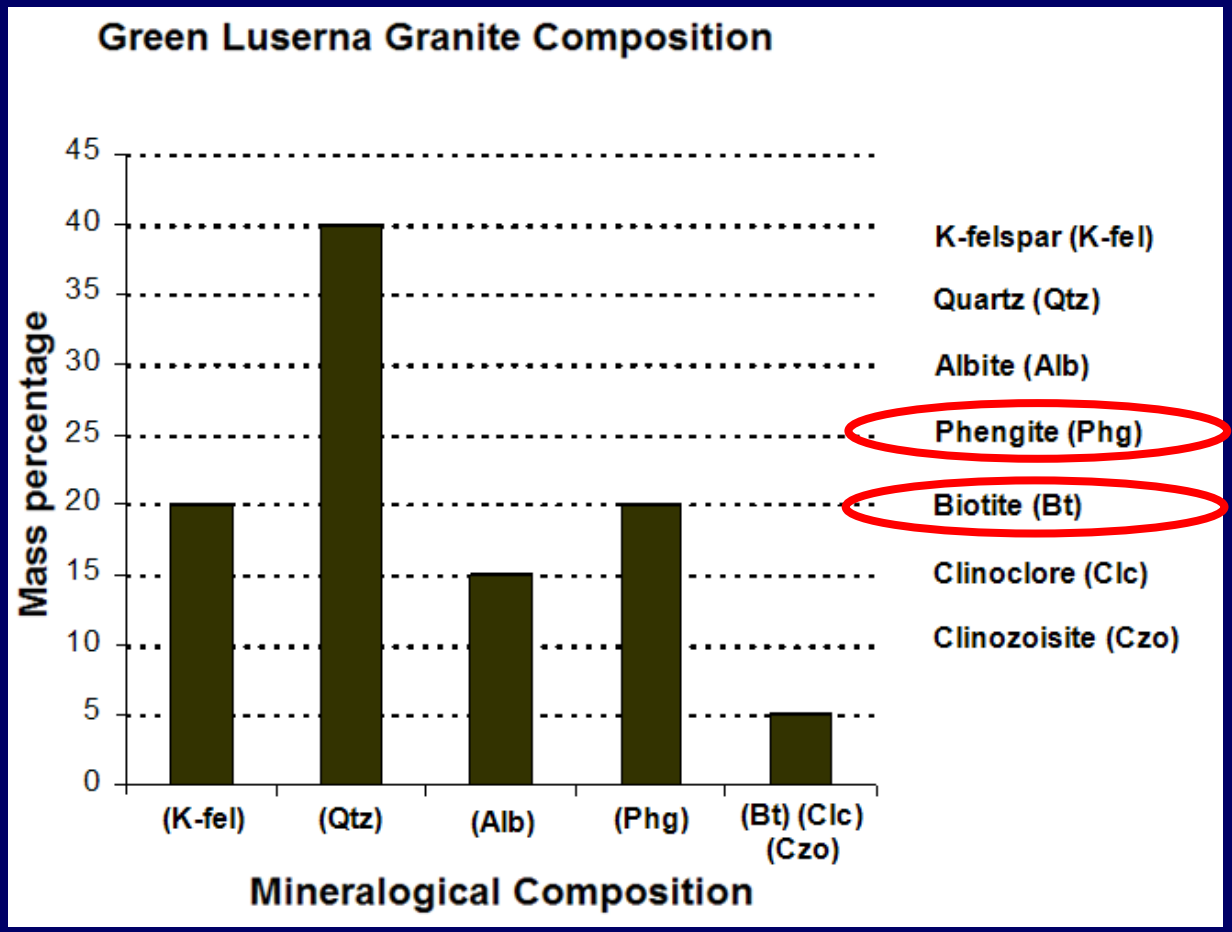
Carpinteri, A., Cardone, F., Lacidogna, G., "Piezonuclear neutrons from brittle fracture: Early results of mechanical compression tests", *Strain*, 45, 332-339 (2009).



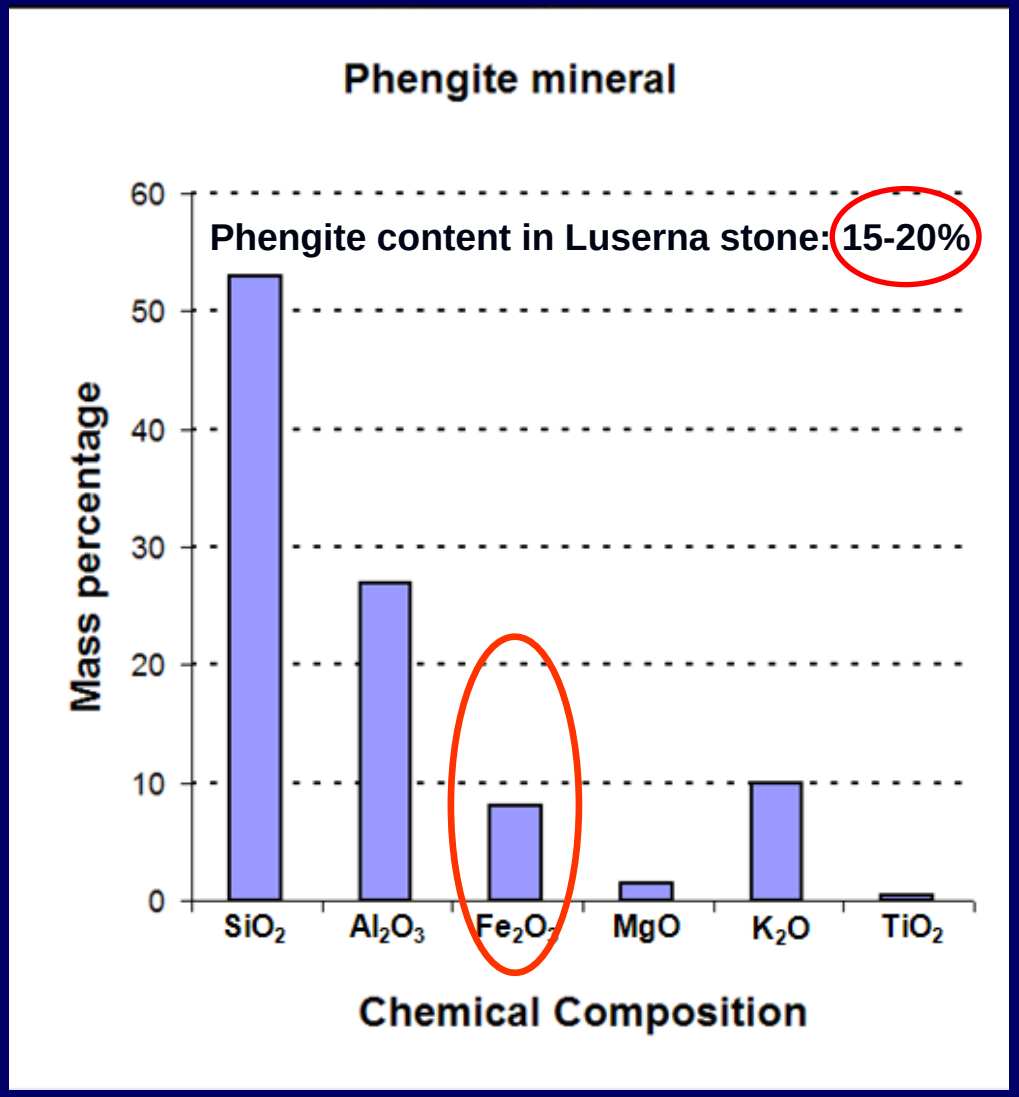
Carpinteri, A., Cardone, F., Lacidogna, G., "Piezonuclear neutrons from brittle fracture: Early results of mechanical compression tests", *Strain*, 45, 332-339 (2009).

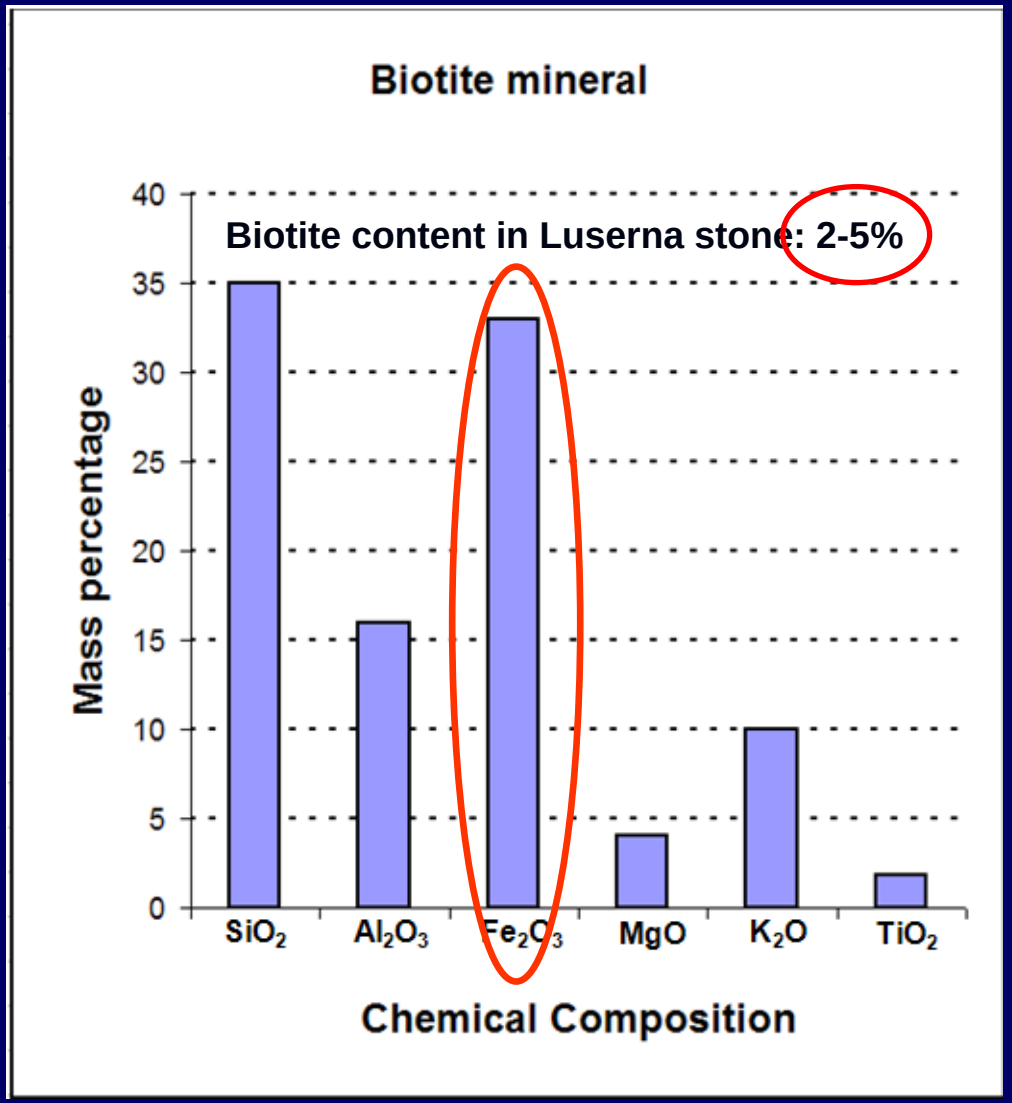
LUSERNA STONE COMPOSITION

In consequence of Luserna stone being a very heterogeneous rock, and to assess mass percentage variations in chemical elements such as Fe, Al, Si and Mg, the EDS analyses have been focused on two crystalline phases: phengite an biotite.



These two minerals of granitic gneiss, that are quite common in the Luserna stone (20% and 2%, respectively), show a mineral chemistry in which the iron content is largely diffused.



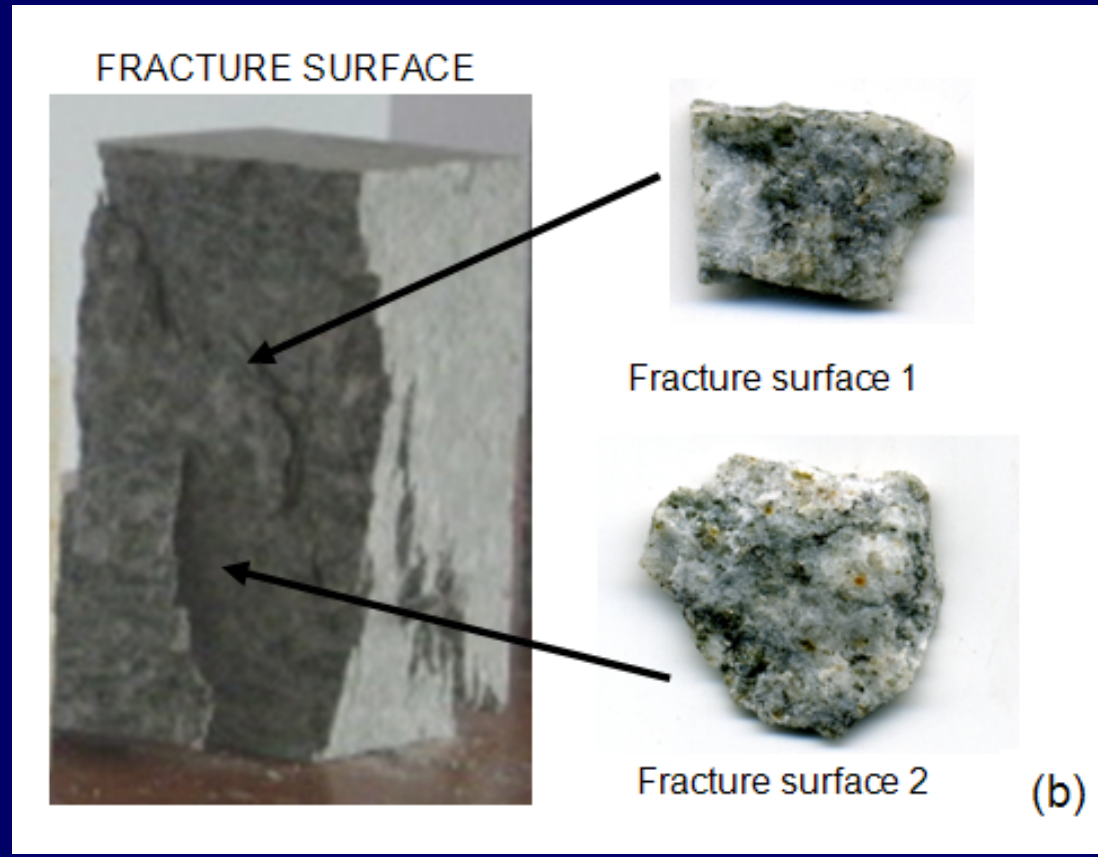


The chemical composition of phengite includes: SiO_2 (~56%), Al_2O_3 (~24%), Fe_2O_3 and FeO (~8%) MgO (~1.5%), Na_2O (~0.2%) and K_2O (~10%).

The chemical composition of biotite includes: SiO_2 (~35%), Al_2O_3 (~16%), Fe_2O_3 and FeO (~33%), MgO (~3.5%), TiO_2 (~1.5%), and K_2O (~10%).

EDS ANALYSIS: COMPOSITIONAL CHANGES

Two different kinds of samples were examined: (i) polished thin sections, finished with a standard petrographic sample procedure for what concerns the external surface; (ii) small portions of fracture surfaces without any kind of preparation for the fracture surface.

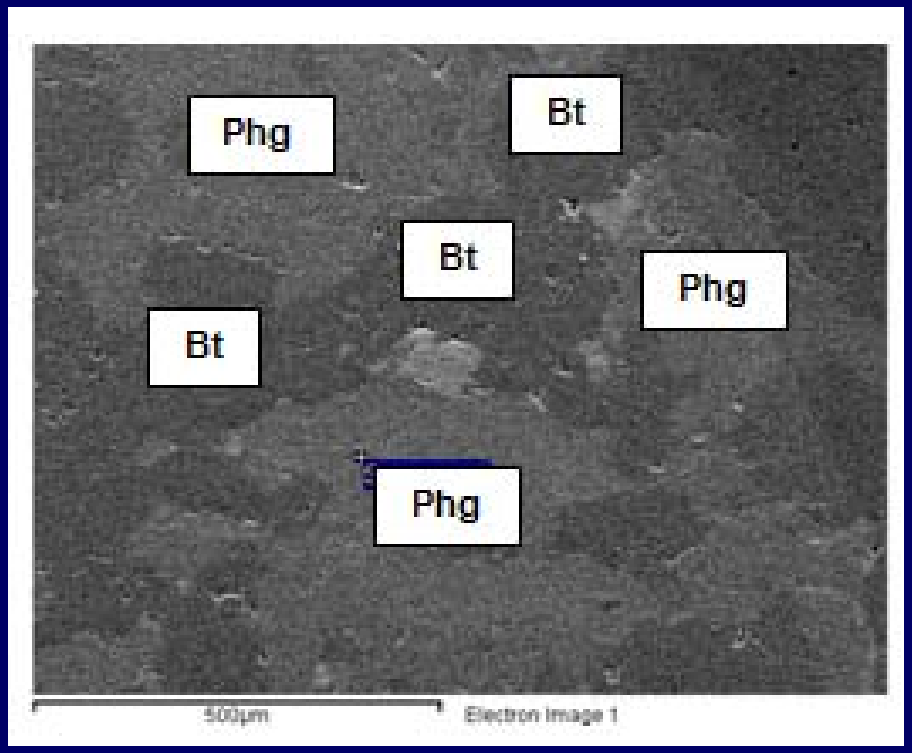


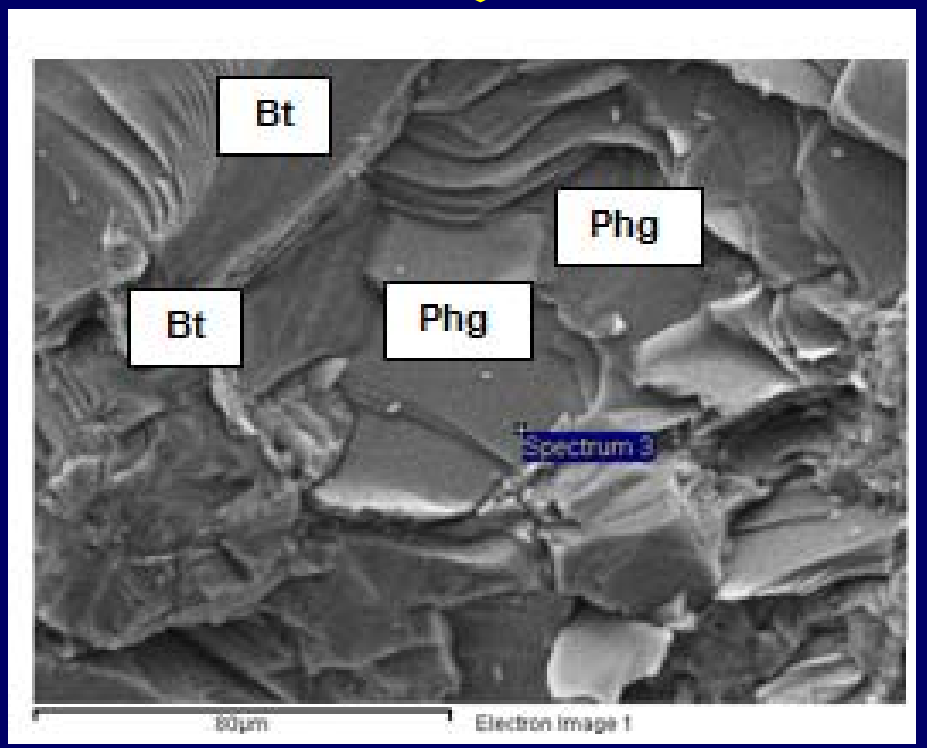
Quantitative analysis was performed on the collected spectra, fixing the stoichiometry of the oxides, in order to correlate the oxides content with the specific crystalline phase and recognized specific variations of each element between external and fracture surfaces.

For the EDS analyses, several phengite and biotite sites were localized on the surface of the polished thin sections and on the fracture surfaces. Sixty measurements of phengite crystalline phase and thirty of biotite were selected and analysed.

EXTERNAL SURFACE

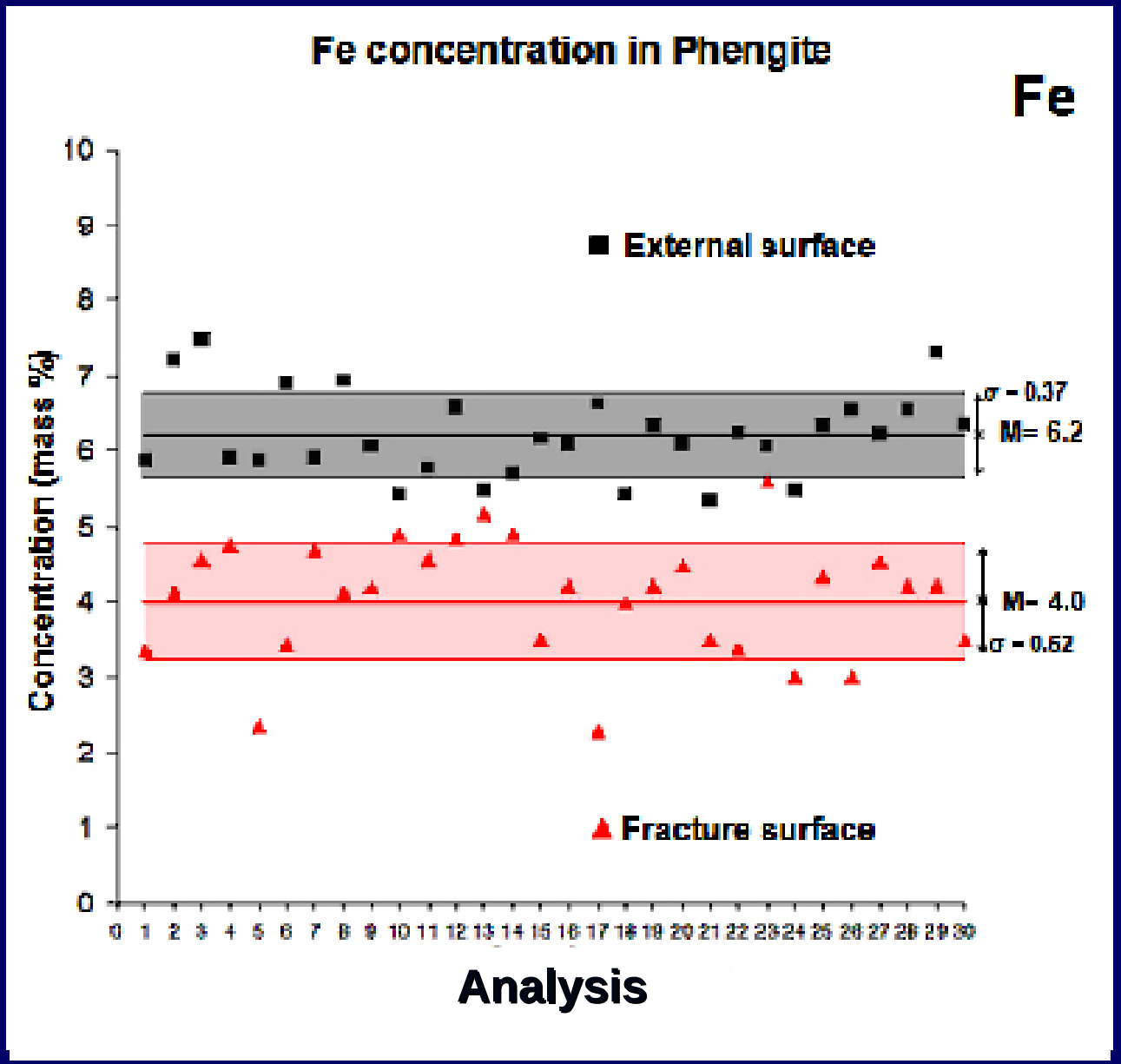
FRACTURE SURFACE





FESEM images of phengite and biotite in the cases of external and fracture sample

Phengite: Fe concentrations



External Surf.:

Fe content M= 6.20%

Fracture Surf.:

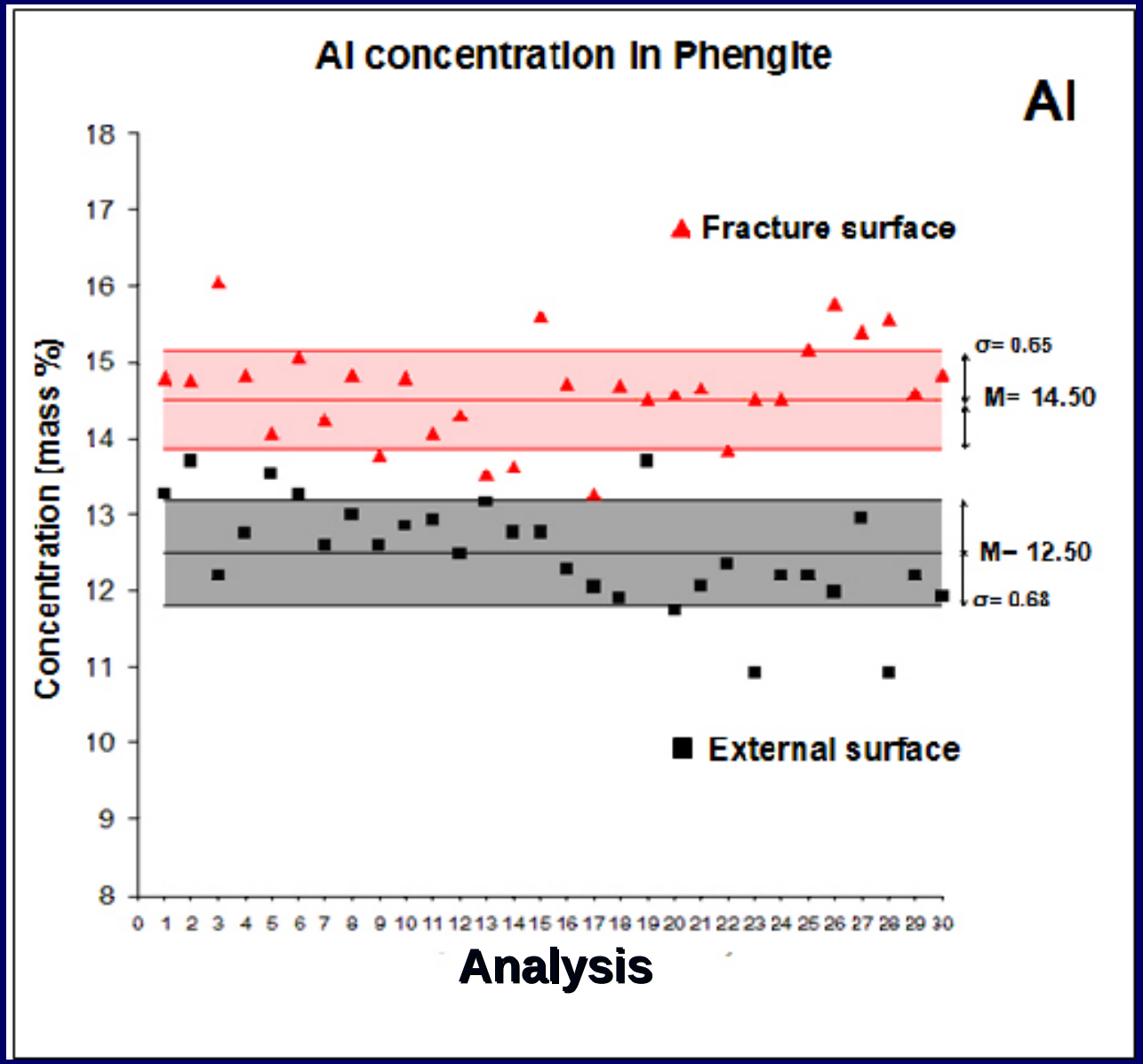
Fe content M= 4.00%

Fe content decrease

–2.20%

The distribution of Fe concentrations for the external surfaces, represented in the graph by squares, show an average value equal to 6.20%. The distribution of Fe concentrations on the fracture samples shows a mean value equal to 4.0%, considerably lower than the previous one (6.20%). The iron decrease is 2.20%

Phengite: Al concentration



Fracture Surf.:

Al content M= 14.50%

External Surf.:

Al content M= 12.50%

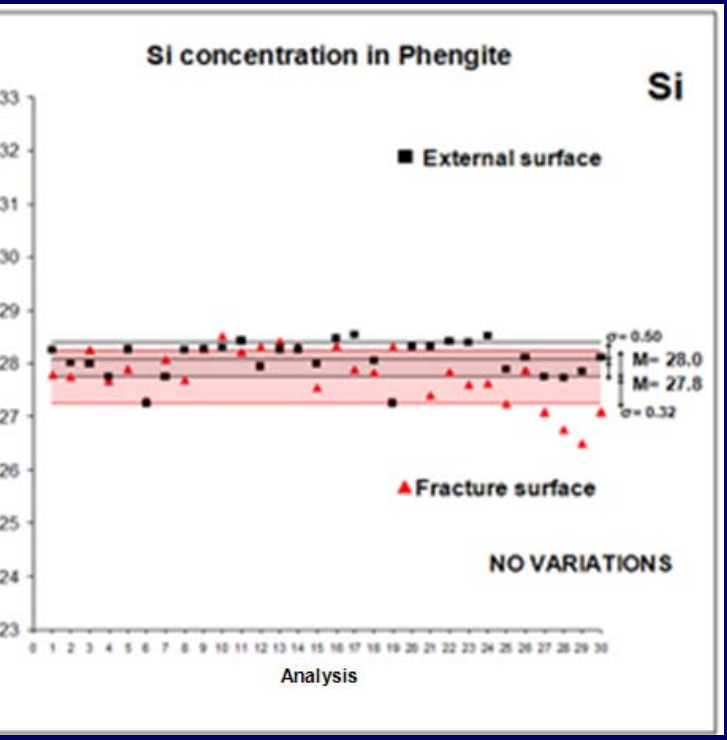
Al content increase

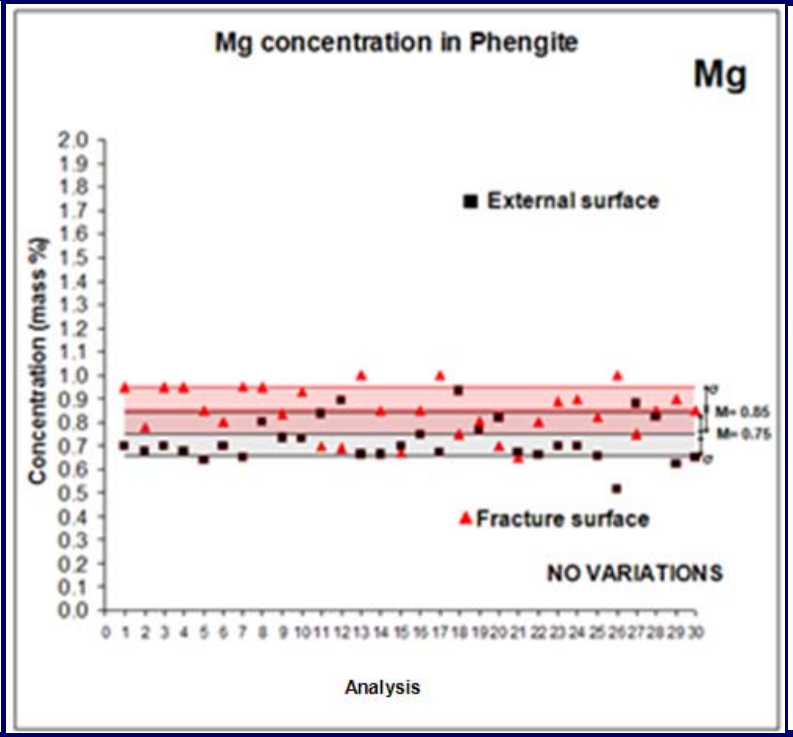
+2.00%

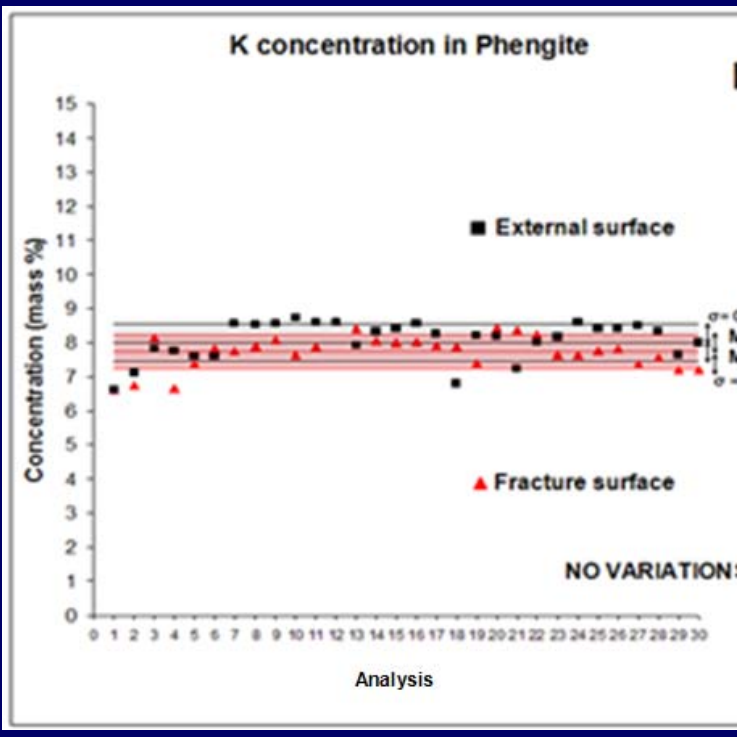
For Al contents, the observed variations show a mass percentage increase approximately equal to that of Fe. The average increase in the distribution, corresponding to the fracture surfaces (indicated by triangles), is about 2.00% of the phengite composition.

Phengite: Si, Mg and K concentrations

Trends of the other chemical elements constituting the mineral chemistry in phengite are considered.







The Si, Mg, and K concentration distributions are reported for external and fracture surfaces. In this case, no appreciable variations can be recognized between the average values.

he evidence emerging from the EDS analyses, that the two values for the iron decrease -2.20%) and for the Al increase (+2.0%) are approximately equal, is really impressive. his iron content reduction corresponds to an absolute decrease of 35% with respect to the revious Fe content, The absolute increase in Al content is equal to 16%.

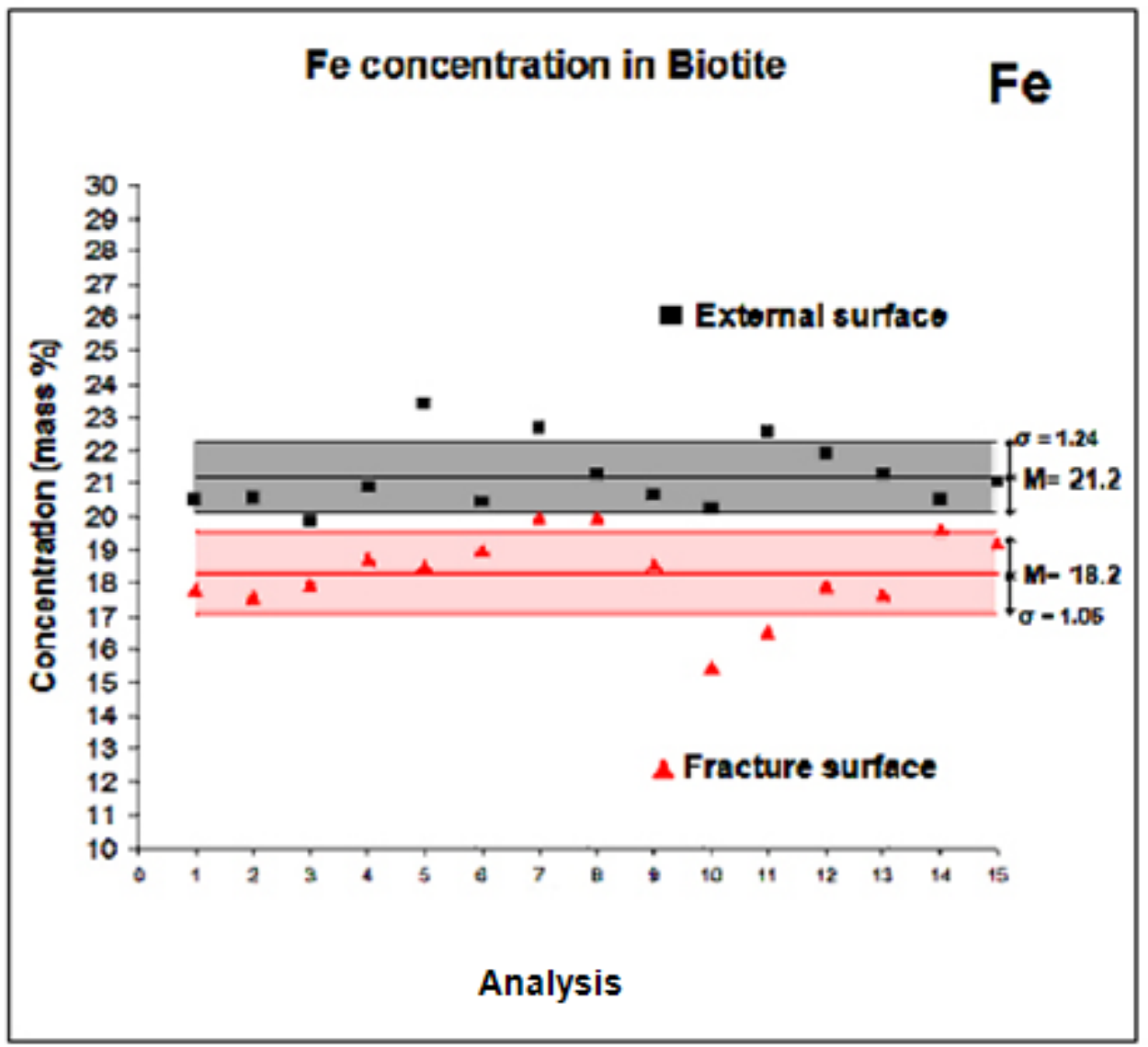
	External surface mean value (wt%)	Fracture surface mean value (wt%)	Increase/ decrease with respect to phengite	Increase/ decrease with respect to the same element
Fe	6.20	4.00	–2.20%	–35%
Al	12.50	14.50	+2.00%	+16%
Si	28.00	27.80	NO VARIATIONS	NO VARIATIONS
Mg	0.75	0.85	NO VARIATIONS	NO VARIATIONS
K	8.00	7.75	NO VARIATIONS	NO VARIATIONS

The results of these quantitative analysis represent a direct evidence that piezonuclear reaction

$$\mathrm{Fe}_{26}^{56} \rightarrow 2\,\mathrm{Al}_{13}^{27} + 2\ \text{neutrons} \qquad (1)$$

has been occurred into the rock specimens.

Biotite: Fe concentrations



External Surf.:

Fe content M= 21.20%

Fracture Surf.:

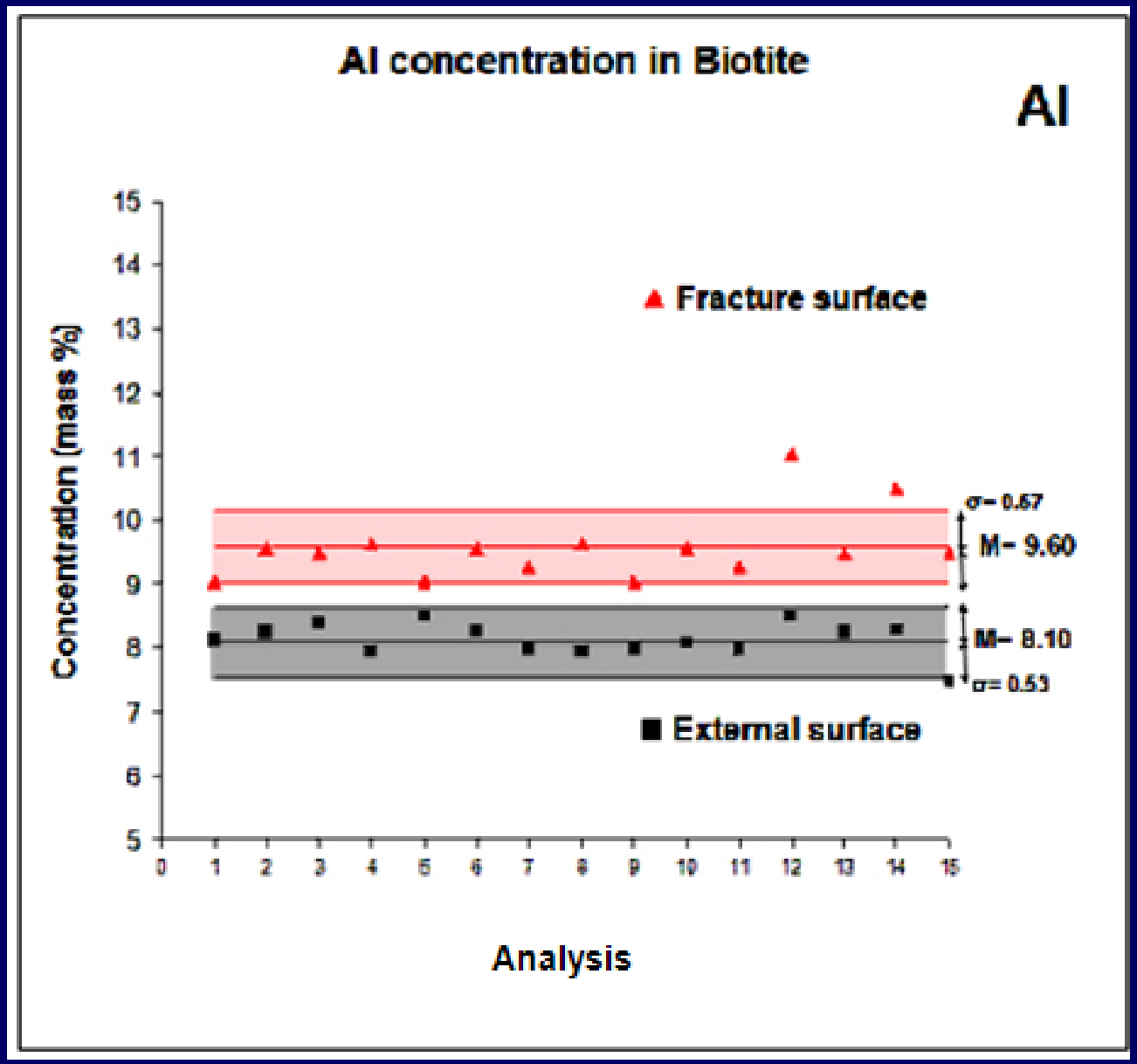
Fe content M= 18.20%

Fe content decrease

–3.00%

Similar analysis can be done for biotite. In this case the distribution of Fe concentrations for the external surfaces shows an average value of the distribution equal to 21.20%. On the other hand, the distribution of Fe concentrations on fracture samples is equal to 18.20%.

Biotite: Al, Si and Mg concentrations



Fracture Surf.:

Al content M= 9.60%

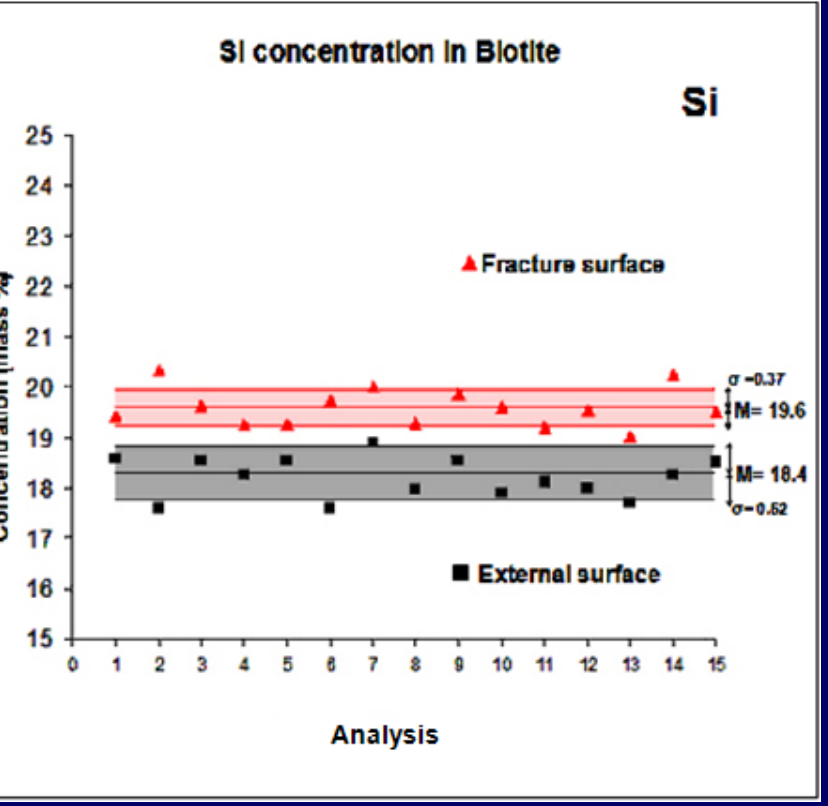
External Surf.:

Fe content M= 8.10%

Al content increase

+1.50%

Similarly Al mass percentage concentrations are considered in both cases of external and fracture samples. For Al contents the observed variations show an average increase of about 1.50% in the biotite composition.



Fracture Surf.:

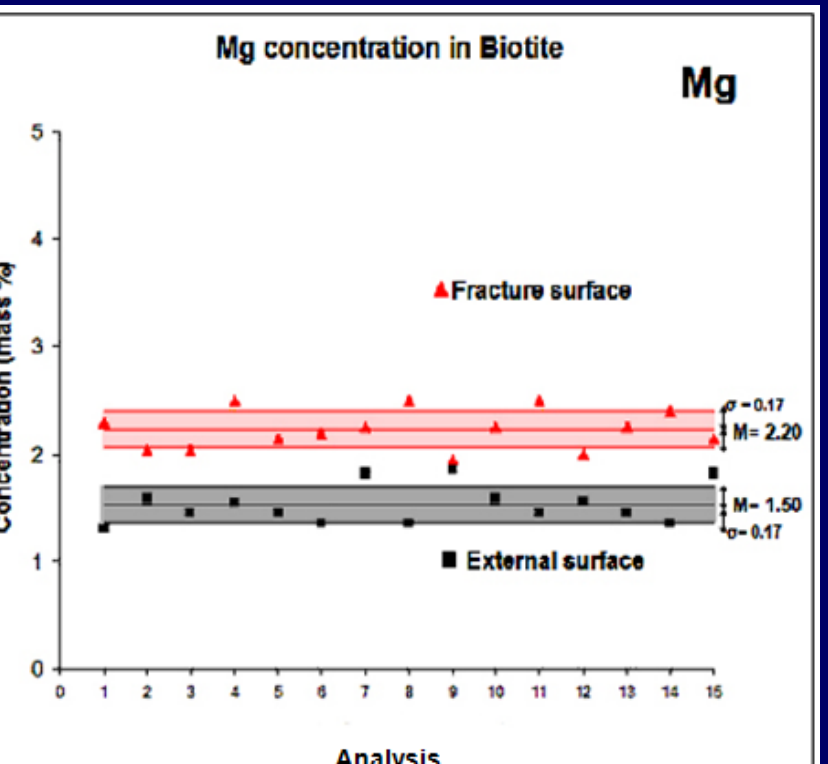
Si content M= 19.60%

External Surf.:

Si content M= 18.40%

Si content increase

+1.20%



Fracture Surf.:

Mg content M= 2.20%

External Surf.:

Mg content M= 1.50%

Mg content increase

+0.70%

Biotite: Fe, Al, Si, Mg, and K weight percentage mean values on external and fracture surfaces. Variations with respect to the mineral (biotite) and to the same element

	External surface mean value (wt%)	Fracture surface mean value (wt%)	Increase/ decrease with respect to biotite	Increase/ decrease with respect to the same element
Fe	21.20	18.20	–3.00%	–14%
Al	8.10	9.60	+1.50%	+18%
Si	18.40	19.60	+1.20%	+6%
Mg	1.50	2.20	+0.70%	+46%
K	6.90	7.10	NO VARIATIONS	NO VARIATIONS

Therefore, the Fe decrease (–3.00%) in biotite is counterbalanced by an increase in Al (+1.50%), Si (+1.20%), and Mg (+0.70%). Considering these evidences, in analogy to the previous results, it is possible to assess that another piezonuclear reaction, in addition to (1), has been occurred in biotite crystalline phase during the piezonuclear tests:

$$\mathrm{Fe}_{26}^{56} \rightarrow \mathrm{Si}_{14}^{28} + \mathrm{Mg}_{12}^{24} + 4 \text{ neutrons} \quad (2)$$

CONCLUSIONS

Considering the results for phengite and biotite, and also their abundances in the Luserna stone composition, a considerable reduction in the Fe content (~25%) is observed. This iro decrease is counterbalanced by an increase in Al, Si, and Mg. In particular, the increase in Al content corresponds to the 85% of the iron decrease.

The Fe decrease in phengite is about 2.20%. For Al contents, the mass percentage increase is approximately equal to that of Fe (2.00%). This piezonuclear reaction should have occurred:

$$\mathrm{Fe}_{26}^{56} \rightarrow 2\,\mathrm{Al}_{13}^{27} + 2\ \text{neutrons}$$

The Fe decrease in biotite (–3.00%) is counterbalanced by an increase in Al (+1.50%), Si (+1.20%), and Mg (+0.70%). Considering this evidence for the biotite in analogy to the results of phengite, it is possible to conjecture that an additional piezonuclear reaction should have occurred.

$$\mathrm{Fe}_{26}^{56} \rightarrow \mathrm{Si}_{14}^{28} + \mathrm{Mg}_{12}^{24} + 4\ \text{neutrons}$$

Finally the piezonuclear fission reactions considered above can be generalized from the laboratory to the Earth's crust scale, where mechanical phenomena of brittle fracture, du to tectonic activity, take place continuously in most seismic areas.