ALKALI-SILICA POTENTIAL REACTIVITY OF UNDULATORY EXTINCTION QUARTZ IN THE WESTERN ALPINE ARCH

G. Barisone and G. Restivo
Dip. Georisorse e Territorio, Politecnico di Torino,
Italy.

This work aims to verify the correlation between undulatory extinction angles and potential reactivity of stressed quartz. The chemical method (ASTM-C 289) was choosen for reactivity testing despite some problems in the evaluation of the danger degree of slowly reacting minerals, of the lower importance in a phase in which a "qualitative" correlation may be considered satisfactory. The extinction angle of stressed quartz was determined by means of petrographic analysis, operating on thin sections in polarized light. In the conclusions, the correlation between the UEA and the position of the samples in the Rc-Sc diagram is discussed.

INTRODUCTION

A common enough kind of cristalline quartz, characterized by the phenomenon of undulatory extinction (i.e., the non simultaneous extinction, in polarized light and with crossed nicols, of the whole area of each cristal observed in a thin section, due to deformations of cristalline structure connected to tectonic stresses) is often indicated in literature as a potentially alkali-silica reactive mineral; nevertheless, the problems linked to its reactivity degree (in terms of time and entity of the reaction) and to the connected undulatory extinction angle (UEA) are still subject to discussion (Andersen and Thaulow (1)).

The study here described is an attempt to establish a correlation between UEA and the potential reactivity degree of stressed quartz; the tests were carried out on quartzitic materials of high purity (more than 90% of quartz) and on four control samples: two of feldspatic quartzites (respectively with 20% and 45% of feldspars), one of opal and one of flint.

The quartzites to be tested were collected "in situ" along the entire extension of the Alpine western range (Italian side), that runs for about 250 km from the Gesso valley (on the South) to the Ossola valley (on the North). A schematic map of the sampled area is shown in Fig.1, where the location of the collected samples is also indicated.

The samples come mainly from metamorphic formations (quartzites, lenses and dikes of quartz in gneisses and micaschists, etc.) and from old sedimentary formations (quartzitic sandstones and conglomerates). The age of these formations varies from Permian to Miocene, and consequently the rocks were affected from one or both the great orogenic events that occurred in the region (Ercinic and Alpine orogenesis).

The opal and flint samples come, respectively, from a Quaternary deposit near Turin (Caselette) and from flint nodules occurring in Cretaceous limestones in the Biferno valley (Molise region).

TESTING METHODS

The chemical method (ASTM-C 289) was chosen for reactivity testing because of its rapidity and repetitivity, and despite the problems it presented for the correct estimation of the danger degree of some italian aggregates; in effect, these problems seem to be connected mainly to the presence of carbonates and to the speed of reaction, and they may be of negligeable influence in the determination of an experimental correlation between UEA and the relative reactivity of stressed quartz.

The samples for the tests were obtained by quartering original samples of about 500 g, preliminarly crushed to 0.30-0.15 mm; after a 24 hour etching in a 1N NaOH solution at 80 C, the reduction in alkalinity and the dissolved silica were determined (ASTM (2)). The tests were usually carried out on 25 g samples; a certain number of determinations were also made using samples weighing 10 g (quartz), 5 g (flint) and 2 g (opal), in order to verify the influence of reactive minerals concentration: the results, althought obviously changed, confirmed the general trend obtained with the 25 g samples.

The undulatory extinction angles were measured using the petrographic microscope, operating on thin sections (0.020 mm thick) and, obviously, with crossed nicols in polarized light. Enlargements used varied between 30x and 150x, and about 50 angle determinations on quartz cristals were made, distributed on almost two thin sections for each specimen.

The results obtained from the tests are summarized in Tab.1, whilst in Figs.2 and 3 the location of the samples in the Rc-Sc diagram is shown.

CONCLUSIONS

Often, in scientific literature, undulatory extinction quartz is indicated as a reactive component of aggregates. In particular, Buck (3) concluded that an aggregate containing more than 20% of undulatory extinction quartz with an extinction angle greater than 15 degrees must be classed as potentially dangerous.

To verify this fact for the quartzs collected in the Western Alpine range, four specimens artificially made and containing respectively: 40% of undulatory extinction quartz with an UEA of 32 degrees; 30% of undulatory extinction quartz with an UEA of 10 degrees and 20% of microcristalline quartz; 30% of undulatory extinction quartz with an UEA of 6 degrees; 35% of quartz without UEA, were tested.

TABLE 1 - Synthesis of petrographic and chemical analysis results.

Sample	Weight	Microscope exam.	UEA		Rc	Sc
	[g]	(Minerals %)	[deg.]	(**)	[mM/l]	
MDD5	25	Qzv 95%, Mus 5%	21	70	45	24
MDD2	25	Qzl 99%, Mus tr.	17	50	42	29
CMP1	25	Qzs 80%, Plg 18%	6	70	67	19
CMP1	10	Qzs 80%, Plg 18%	6	70	36	12
CMP5	25	Qzs 95%, Mcr 5%	27	90	72	54
MCG3	25	Qzl 99%, Clo tr.	32	95	57	30
MCG3	10	Qzl 99%, Clo tr.	32	95	25	25
MCG5	25	Qzm 100%	35	100	51	44
PDC2	25	Qzs 100%	5	10	112	17
PDC5	25	Qzm 90%, Mus tr.	17	90	36	32
MDD1	25	Qzl 98%, Mus tr.	16	90	32	21
MDD4	25	Qzs 100%	26	100	50	36
ACC1	25	Qzm 79%, Qzc 20%	10*	75*	5	49
ACC1	10	Qzm 79%, Qzc 20%	10*	75*	4	40
ACC5	25	Qzm 90%, Qzc 10%	16*	90*	22	47
QRN1	25	Qzv 98%, Cal tr.	25	95	42	17
QRN5	25	Qzm 95%, Clo 5%	27	90	38	26
ALG1	25	Qzm 90%, Cal 8%	0	90	37	8
ALG1	10	Qzm 90%, Cal 8%	0	90	18	4
ALG5	25	Qzs 95%, Cal 5%	2	95	43	10
VLD2	25	Qzm 100%	33	100	60	35
VLD5	25	Qzs 100%	32	100	65	44
FNZ1	25	Qzv 100%	30	100	65	17
FNZ5	25	Qzm 99%, Mus tr.	34	99	72	33
MCG1	25	Qzv 100%	8	90	8	12
GTT1	25	Qzm 50%, Mcr 45%	22	50	67	18
GTT5	25	Qzl 70%, Mcr 25%	21	70	55	15
MCG2	25	Qzm 100%	10	80	7	25
MCG4	25	Qzs 100%	12	90	14	28
SPP1	25	Qzl 100%	5	30	25	11
SPP4	25	Qzm 98%, Clo tr.	14	60	32	22
OPC	25	Opal 100%	Amorphous		467	612
OPC	2	Opal 100%	Amorphous		90	254
SRM	25	Flint 100%	Criptocrist.		277	346
SRM	5	Flint 100%	Criptocrist.		86	210

Quartz cristals size: Qzv (very large), Qzl (large), Qzm (medium), Qzs (small), Qzc (micro)
Plg = plagioclases, Mus = muscovite, Clo = clorite, Cal = calcite
Mcr = microcline, Epi = epidote
* Data referred to Qzm
** Percentage of quartz having undulatory extinction

The largest part of the tests were carried out by simulating aggregates with a 100% content of quartz, and consequently making the chemical test on 25 g of crushed quartz.

As can be seen clearly in Figs.2 and 3, the tests showed:

- all the samples are placed in the non-dangerous field, with the exception of all quartzites containing microcristalline quartz (hardly distinguishable with the enlargements used) and of the control samples containing flint or opal;

- a clear difference in the location appears, because of the different UEA, among the samples placed in the non-dangerous field. In particular, four distinct areas, although partially superposed, can be identified (corresponding respectively to: one of the samples with an UEA > 25 degrees, one of those with an UEA between 15 and 25 degrees, two to those with an UEA less than 15 degrees), the distance of each area from the line separating the non-dangerous and dangerous fields being increasing with the decreasing of UEA;

- the percentage of undulatory extinction quartz in a sample, provided that it is higher than 20-30%, has little influence on the position of the sample itself in the reactivity diagram;

- far more important, from this point of view, appears to be the size of quartz cristals: on the decreasing of the size, in effect, the location of the sample in the Rc-Sc diagram (UEA being constant) is progressively nearer to the dangerous field.

The number of samples tested (about thirty) is at the moment insufficient to establish definite conclusions; nevertheless, it seems clear that the reactivity degree of undulatory extinction quartz is mainly related both to UEA and to the size of the quartz cristals, with perhaps a greater importance (for UEA > 15 degrees) on this latter factor.

ACKNOWLEDGEMENTS

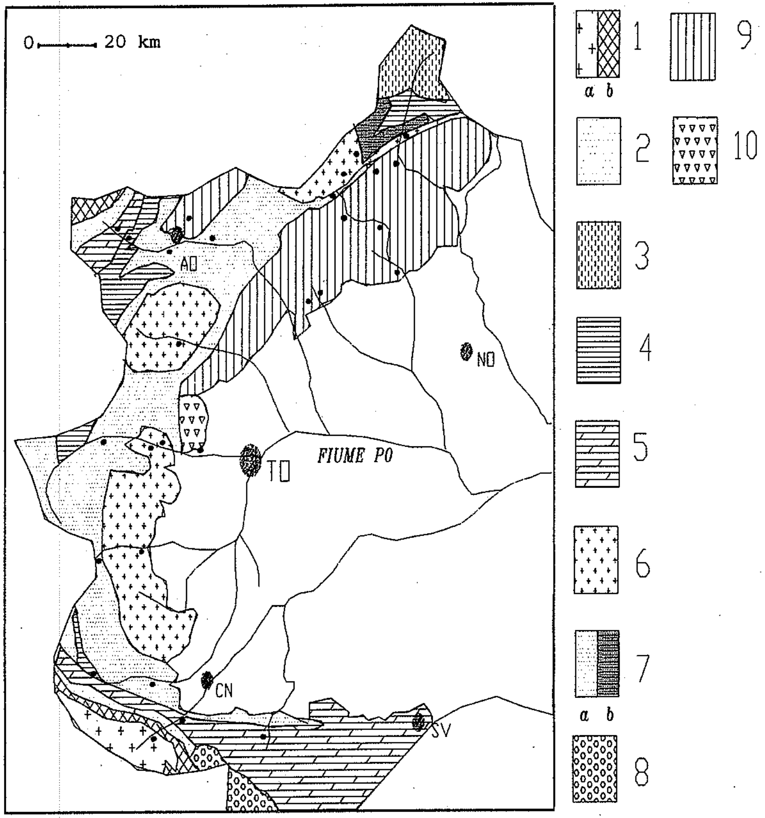
Mr.G. Comazzi for his valuable thin sections, Mr.R. Pavia and Dr. G. Mandrone for computer drawings are gratefully acknowledged.

REFERENCES

1. Andersen, K.T., and Thaulow, N., 1990, "The application of undulatory extinction angle (UEA) as an indicator of alkali-silica reactivity of quartz", RILEM internal report.

2. ASTM, 1952, "Standard Method of Test for Potential Reactivity of Aggregates (Chemical Method)", Annual Book of ASTM Standards.

3. Buck, A.D., 1987, "Alkali reactivity of strained quartz as a constituent of concrete aggregate", Cement, Concrete and Aggregate, ASTM, V, 2.



LEGEND

1	Helvetic basement (a) and cover (b)
2	Subbrianconnais Zone
3	Lower Pennine Nappes
4	Bernhard Nappe and Brianconnais Zone : pre-Carboniferous
5	Bernhard Nappe and Brianconnais Zone : late-Paleozoic sequences
6	M. Rosa - Gran Paradiso - Dora Maira Nappes
7	Piemonte Zone (a) and Antrona metaophiolite syncline (b)
8	Helminthoid Flysch
9	Austroalpine Units and Southern Alps
10	Lanzo Lherzolite
●	Collected samples

Figure 1 - Schematic map of the sampled area

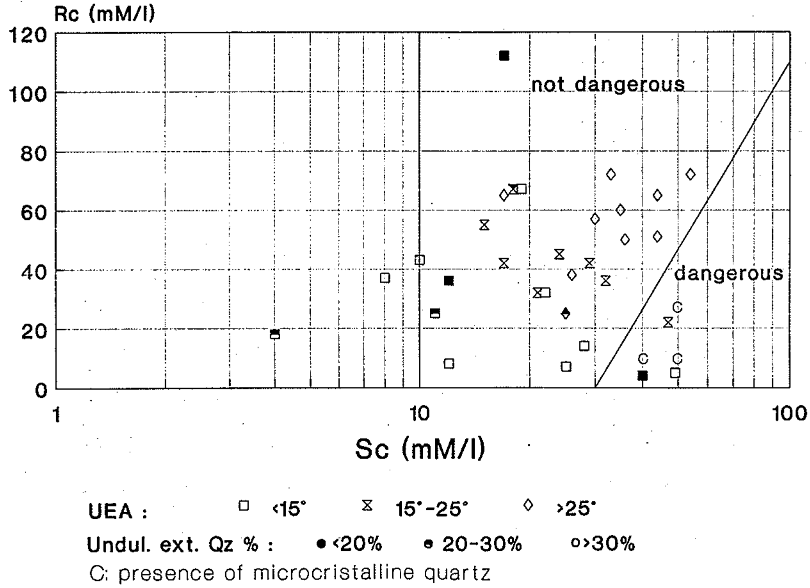


Figure 2 - Location of the samples in the Rc-Sc diagram according to the UEA and the undulatory extinction quartz content

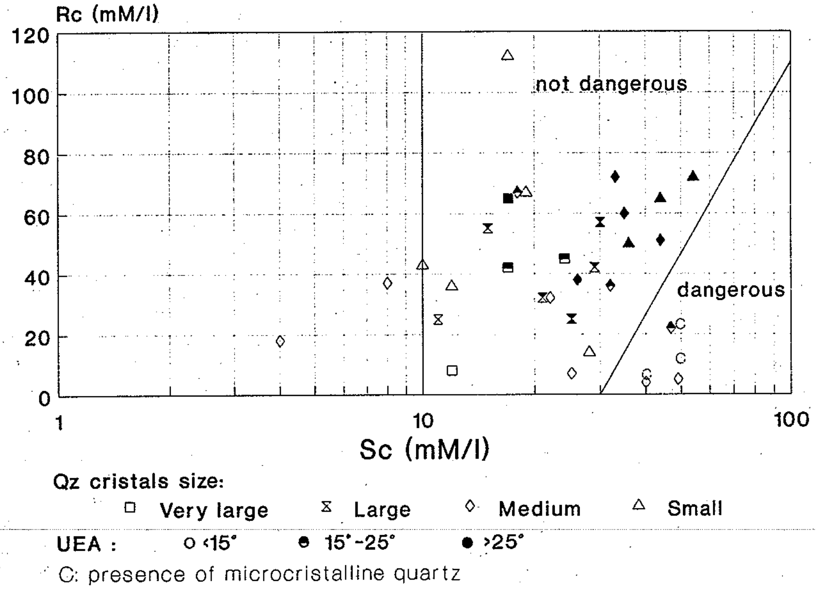


Figure 3 - Location of the samples in the Rc-Sc diagram according to the UEA and the quartz cristals size