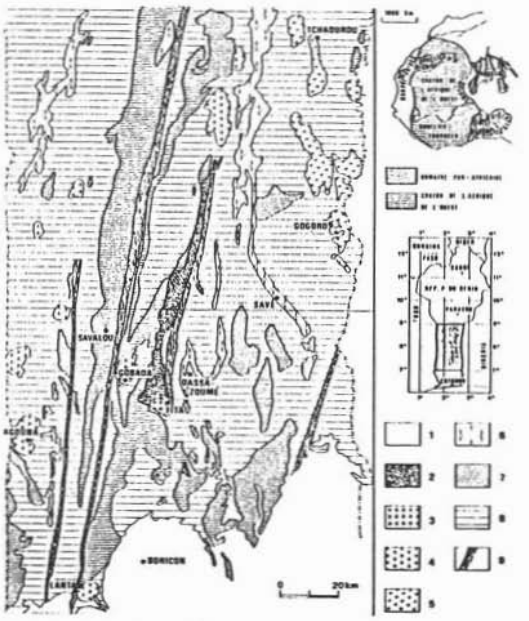

Geological sketch-map of Benin (Breda Ricerche, Divisione Geomineraria, unpublished).

1 - Sedimentary cover
2 - Bimodal sub-volcanic and volcano-sedimentary complex
3 - Alkaline granite of Fita
4 - Granular granite (type Lanta and Gobada)
5 - Porphyritic granite (type Gogoro - Parakou)
6 - Porphyritic metagranite (type Dassa)
7 - Granulite, charnockite, hyperstene-biotite gneiss, quartzite (basement)
8 - Migmatites, amphibole-biotite gneiss (basement)
9 - Mylonite and blastomylonite

except for a late, partial albitization of K-feldspar. Mafic xenoliths, often biotitized, are frequent. Characteristic accessory minerals are titanite, allanite and fluorite. This granite displays overall features of shallow level intrusion.

d) Alkaline granite of Fita is associated with a bimodal subvolcanic and volcano-sedimentary complex, showing a late, almost static, recrystallization in the biotite zone. This granite is very rich in K-feldspar and poor in quartz; mafic minerals are green biotite and hornblende.

The few available radiometric data seem to indicate that all the considered granites belong to the Panafrican cycle, the youngest being probably type d).

28 analyses for major and minor elements reveal a rather limited scatter within each granite group; hence their primary chemical features were not spoiled by post-magmatic phenomena. A comparison based on Rb/Sr and Rb/Nb ratios indicate that the migmatites of the basement show a restitic character. The a)-type granites of Dassa and Tre (characteristically rich in K_2O and poor in Na_2O) show medium values of those ratios, but relatively high contents of Rb, Sr and Nb, whilst lower contents are shown in b)-type granite of Gogoro-Parakou (rich in Na_2O and poor in K_2O). The granite of Agouna shows low Rb/Sr and Rb/Nb ratios as well as a low content of those elements. The c)-type granites of Gobada and Lanta show high Rb/Sr ratio and high Rb and Nb content. The d)-type granite of Fita stands out for its alkaline signature, its high Nb content and low Sr.

If we use the relationship between Rb and Nb + Y as indicator of magma origin, the granite types a) and b) show a clear crustal signature (or at least and important crustal component), whilst types c), and especially d), have a subcrustal derivation.

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Bigioggero B.*, Colombo A.*, Del Moro A.**, Gregnanin A.*, Macera P.***, Tunesi A.* - *The Valle del Cervo pluton: an example of shoshonitic magmatism in the Alps*

Late alpine (mainly oligocenic) magmatic activity is widespread over the whole internal sector of the alpine chain.

A comprehensive study of the dyke magmatism led some of the writers to suggest a sort of zonal arrangement of the magmatic affinity with a change from low K-tholeitic activity to the eastern zone up to shoshonitic and ultrapotassic westwards. Also the plutonic bodies seem to fit well in this general scheme.

In this paper we present new field, geochemical and isotopic data on the Valle del Cervo pluton, intruded into the Austroalpine units of the Western Alps: the Sesia Lanzo Zone. The pluton shows a zonal arrangement with a monzogranitic core and outer rims of qz-syenites and qz-monzonites. Bi-WR Rb/Sr age determinations exhibit no significant differences in the ages of the different portions of the pluton (30 Ma). The general geochemical features show «orogenic» character with shoshonitic affinity. Lower LILE, higher $87_{Sr}/86_{Sr}$ are characteristic for the outer rims (mainly qz-monzonites) whereas, higher LILE and lower $87_{Sr}/86_{Sr}$ contents are typical for the «core» (mainly qz-sienites and monzogranites). These two different trends suggest slight differences in the degree of partial melting of an homogeneous mantle sources, enriched by a crustal component. Assimilation could be an important factor in the observed differences in $87_{Sr}/86_{Sr}$ and trace element contents.

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Blasi A.*, De Pol Blasi C.* - *Mineralogical and genetic aspects of alkali feldspars from granites and related rocks*

In the last two decades the use of a variety of experimental techniques and the development of theoretical approaches have considerably extended and

refined our current understanding of the mineralogy of alkali feldspars. The behavior of these minerals is now generally believed to be largely dependent on their crystallization history, subsolidus evolution, interactions with deuteric or hydrothermal fluids, and deformational events. Many challenging petrological problems can be recognized merely by routine optical examination of alkali feldspars. However, the investigation of composition, structural state, lattice strain, and microtextures in these minerals is mandatory for a thorough interpretation of genetic conditions. This contribution will focus attention on the behavior of alkali feldspars from granites and related rocks, including migmatites and pegmatites, with the aim of deciphering selected genetic aspects.

The occurrence of alkali feldspars of different generations in separate portions of the same rock body or in the same hand specimen is often deduced on the basis of petrographic evidence. However, the interpretation of sequences of crystallization may be rather complex, as in the case of coexisting megacryst and groundmass alkali feldspars in granites and migmatites. In addition to metric and structural data, appropriate investigation of variation of chemical substitutions in alkali feldspar lattice may be effective in unravelling crystallization sequences. In other circumstances, when the different feldspar generations consist of coexisting Na-rich phases exsolved at various times from the same parent crystal, information useful for reconstructing the stages of exsolution processes is obtained from close examination of geometrical relationships and degrees of coherency between the lattices of the individual perthitic components.

The origin of subsolvus alkali feldspar mineralogy in small Ca-poor granitic bodies closely associated with hypersolvus rocks at shallow crustal levels in many anorogenic complexes is widely debated. A number of lines of evidence indicate that such association derives from a single haplogranitic melt, and the relevant two-feldspar mineralogy could be the product of a magmatic or post-magmatic history in response to influxes of water of different origin. Some constraints on the interpretation of the relevant subsolvus mineralogy might be obtained from investigation of the alkali feldspars in the two types of associated rocks by exploring the degree of systematic variation in their chemical substituents sensitive to igneous fractionation and their textural and structural features. Further support for a magmatic or post-magmatic pattern of water distribution might be gathered by parallel stable isotope studies.

Hydrothermal experiments indicate that ordering reactions in alkali feldspars are hastened or inhibited, depending on whether the chemical environment is peralkaline or peraluminous in character, respectively. Peralkaline fluids have also been found to be clearly operative in hastening the ordering rate in natural specimens. By contrast, the order-inhibiting effect of peraluminous chemistry does not always appear to be efficient in natural alkali feldspars. This needs to be further investigated in suites of specimens from appropriately selected geological environments, in which the effect of peraluminous chemistry should not be overshadowed by other ordering controls. Estimates of the degree of Si, Al order in K-rich phases representing stranded structural states should be accompanied by careful inspection of spots in single-crystal X-ray or electron-diffraction photographs. Either of them should also be thoroughly investigated in order to recognize any preserved states of exsolved Na-rich phases.

Undulatory extinction in K-rich feldspar is often a symptom of significant structural complexities that may be independent of deformational events affecting the host rock. This phenomenon is, in fact, commonly observed in monoclinic and triclinic K-rich feldspars from totally undeformed granites and related rocks, and may be produced by a variety of fine-scale domain textures, formed in response to increasing degrees of Si, Al order. These submicroscopic textures include modulated patterns in ordered monoclinic K-rich feldspar and twin domains in high-to-intermediate microcline. In other cases, major complexities arise from the formation of non-ideal twin relations at submicroscopic scale in low microcline. The crystallographic and genetic significance of undulatory extinction in K-rich feldspar deserves much more investigation, especially by single-crystal X-ray diffraction techniques and transmission electron microscopy.

Coexistence of different structural states in the same crystal of K-rich feldspar represents a metastable situation that is common in granitoid rocks. The symmetry of the individual components in such mixtures may be the same, but much more frequently it appears to be different. The coexistence of ordered monoclinic feldspar and high-to-intermediate microcline is of significant mineralogical and petrological interest: it is the result of quenched inversion from monoclinic to triclinic symmetry, which is supposed to occur at ~ 500°C. This situation, which is suspected in specimens showing undulatory extinction grading into small patches of cross-hatching, should be appropriately documented. Diffractions sensitive to symmetry change should give broad peaks with poorly resolved doublets in X-ray powder patterns. Single-crystal diffraction patterns, both with X rays and electrons, should show one spot from the monoclinic material associated with two to four spots from the triclinic material. Transmission electron images should show areas of tweed textures along with twinned triclinic domains.

Cross-hatched microcline is believed to derive from a monoclinic precursor at the temperature of the inversion from monoclinic to triclinic symmetry. In a few well-documented specific exceptions, M-twinning may have developed from triclinic domains, which in turn formed from monoclinic material. By contrast, the situation is more controversial as regards the origin of optically untwinned microcline or partly cross-hatched microcline. The genetic inferences of such specimens, and hence of their host rock, may stem from investigation of submicroscopic aspects. Provided that some exsolution took place in these specimens, additional important data may be obtained from the composition of bulk alkali feldspar and from possible twin-relations in the Na-rich phase.

Granites and related rocks are particularly suitable natural environments for an investigation of the process of Si, Al ordering in K-rich feldspars. All the data

available on natural specimens are consistent with a two-step process, which gives rise to multiple paths of ordering. Their courses are determined by the amount of Al that is able to migrate from *T2* into *T1* sites before inversion from monoclinic to triclinic symmetry. These multiple paths of ordering contrast with the single path of disordering in the one-step type artificially produced in the laboratory by dry-annealing low microcline. The resultant hysteresis loops are due to the idiosyncratic feature of K-rich feldspar in producing domain textures as ordering increases from low sanidine to intermediate microcline. Thus, the degree of hysteresis observed gives indirect insight into the role played by parent environmental conditions controlled by the thermal and hydrous hystory of the host rocks.

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Blasi A.*, De Pol Blasi C.*, Zanazzi P.F.** - *Structure refinement of a high sanidine produced by dry annealing a Bedford low microcline for 200 days at 1050°C*

Highly disordered K-rich feldspar is commonly found in a variety of high-temperature geological environments in the form of high sanidine and, more rarely, in low-temperature veins as adularia, grown metastably in the stability field of maximum microcline. The identification of the extreme possible disorder in such structures is of great interest for a better understanding of polymorphism in the alkali feldspar group and for an appropriate definition of the high-sanidine end-member. The metric and structural properties of the latter, along with those of the companion end-members high albite (analbite), low albite, and low microcline, find significant application in the formulation of methods for determining the Al content of *T* sites in alkali feldspars. Because of the scarcity in nature of fully disordered K-rich feldspar, the vast majority of studies on high sanidine have so far involved the use of specimens of orthoclase or incompletely disordered sanidine, in which the degree of disorder has been artificially increased in dry-annealing experiments. However, the fine-scale domain textures that characterize monoclinic K-rich feldspar may act as a barrier to further disordering in such experiments. This does not occur if specimens of low microcline are used, because the latter is free of fine-scale domain textures. Thus, a cleavage fragment of a perthitic coarsely cross-hatched low microcline from Bedford County pegmatite district, Virginia, U.S.A., was subjected to dry annealing at 1050°C for 200 days, followed by quenching to room temperature. This fragment was taken from the same feldspar material as that employed by Blasi et al. (1984), to produce a one-step disordering series by dry-heating treatment at 1050° for times of up 150 days. The minor substituents other than K and Na are present in limited amount in this material (Blasi et al., 1984), and should not affect the metric and structural properties of the K-rich phase in which they are contained. X-ray precession and oscillation photographs show that, after annealing, the microcline selected for the present study was transformed to an untwinnned homogeneous high sanidine, with sharp diffraction-maxima. The metric and structural properties were determined by an automated single-crystal, 4-circle X-ray diffractometer. The lattice parameters refined by least-squares techniques using 2θ values of 40 independent diffractions measured with graphite-monochromatized Cu$K\alpha$ radiation are: $a = 8.5646(2)$, $b = 13.0334(3)$, $c = 7.1747(2)$ Å, $\beta = 115.984(2)°$. The cell volume $V = 719.93(2)$ Å^3 gives an N_{Or} content of 0.91. The values of b and c indicate that the degree of disorder achieved in the sanidinized Bedford microcline is: (1) virtually indistinguishable from that of the extreme end-member of the disordering series prepared by Blasi et al. (1984); (2) slightly higher than that of the other specimens of high sanidine used in structure refinements; and (3) appreciably lower than that of the specimens of adularia recently studied by Černý & Chapman (1984, 1986). The crystal structure of the high sanidine investigated here was refined by least-squares methods to an unweighted R value of 0.022, using the amplitudes of 817 diffractions collected with graphite-monochromatized Mo$K\alpha$ radiation. The mean T-O distances are $\langle T1\text{-O}\rangle = 1.643$ and $\langle T2\text{-O}\rangle = 1.640$ Å. These values indicate a degree of disorder slightly higher than that shown by the corresponding data for all the other specimens of high sanidine used in structure refinements. Within experimental error, the new data are consistent with almost complete disorder. The results obtained in this study agree closely with those of Blasi et al. (1984), in indicating that the achievement of complete disorder in dry-annealing experiments is an extremely sluggish process. The occurrence in nature of high sanidine showing incipient order is a common rule, which indicates that the preservation of complete disorder is very difficult. The specimens of adularia studied by Černý & Chapman (1984, 1986) represent exceptional cases of preservation of extreme disorder in highly metastable conditions. These findigs will need to be confirmed by structure refinements, which have already been anticipated by the above-mentioned authors.

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