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Authigenic K-feldspars as part of the adularias

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Abstract. Authigenic K-feldspars form from low-temperature (usually lower than 200°C) solutions during diagenesis of sediments, including their transformations before the stages of regional metamorphism. They possess all distinctive features which characterize adularias from hydrothermal mineral associations in various genetic types of mineralization — transparency (not always obligatory), morphology, variations in structural state, chemical composition. On the understanding that all K-feldspars, formed from solutions at temperatures close to or below 400° C, are adularias (A r n a u d o v a, A r n a u d o v, 1995) the authigenic K-feldspars are considered as lowest temperature ones among adularias. The comparison of the main features of adularias formed in alpine veins, pegmatites, metasomatic altered rocks and hydrothermal ore-mineralizations with those of authigenic K-feldspars reveals the general tendencies of the mineralogy of the whole association of low-temperature K-feldspars (adularias) as well as the peculiarities distinguishing the lowest temperature, authigenic adularias from the relatively higher-temperature ones. The most characteristic feature of authigenic adularias is the high content of Or (> 98 mol %). The trend of compositional variations of adularias, formed in a wider temperature interval, confirms the tendency of increasing Or content and correspondingly decreasing Ab content with the decreasing temperature of formation.

Key words: authigenic K-feldspar, adularia, morphology, structural state, chemical composition
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А р н а у д о в, В., Р. А р н а у д о в а. 1997. Аутигенните К-фелдшпати — част от адуларите. — *Геохим., минерал. и петрол.*, **32**, 17—21

Аутигенните К-фелдшпати се образуват от нискотемпературни (обикновено по-ниски от 200° С) разтвори при диагенезата на утайките, обхващаща преобразуванията в тях, които предшестват етапа на метаморфизъм. Те притежават всички отличителни черти, с които се характеризират адуларите от хидротермалните асоциации в различни генетични типове минерализации — прозрачност на индивидите (незадължителна), морфология, вариации в структурното състояие, химизъм. Изхождайки от схващането, че всички К-фелдшпати, образувани от разтвори при температури под 400°С са адулари (А р н а у д о в а, А р н а у д о в, 1995), аутигенните К-фелдшпати се разглеждат като най-нискотемпературни техни представители. Сравненията на главните характеристики на адуларите, образувани в алпийски тип жили, пегматити, метасоматично изменени скали и хидротермални рудни минерализации, с тези на аутигенните К-фелдшпати открояват както общите тенденции в минералогията на цялата асоциация нискотемпературни К-фелдшпати (адулари), така и особеностите, които отличават най-нискотемпературните аутигенни адулари от относително по-високотемпературните адулари. Най-характерният белег на аутигенните адулари е високото съдържание на Or молекула (> 98%). Трендът на вариациите в химизма на образуваните в по-широк температурен диапазон адулари подчертава тенденцията за увеличаване съдържанието на Or и съответно намаляване съдържанието на Ab в адулара с понижаване на температурата на кристализация.

Ключови думи: аутигенен К-фелдшпат, адулар, морфология, структурно състояние, химизъм
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On the understanding that all K-feldspars, formed at temperatures close to or below 400°C, are adularias (A r n a u d o v a, A r n a u d o v, 1995), we refer to that group the authigenic K-feldspars, too.

Authigenic K-feldspars have been defined as a separate group among alkali feldspars on the basis of their genesis, or rather the environment of their formation — sedimentary rocks (limestones, sandstones, shales) at low temperatures. Although they have been described by a variety of genetic (largely overlapping) definitions such as authigenic, epigenetic, metasomatic, hydrothermal or secondary feldspars (K a s t n e r, 1971; M o r a d, 1989; S e n d e r o v et al., 1991) it can be safely accepted that authigenic K-feldspars form from low-temperature solutions during diagenesis of sediments, including their transformations before the stages of regional metamorphism.

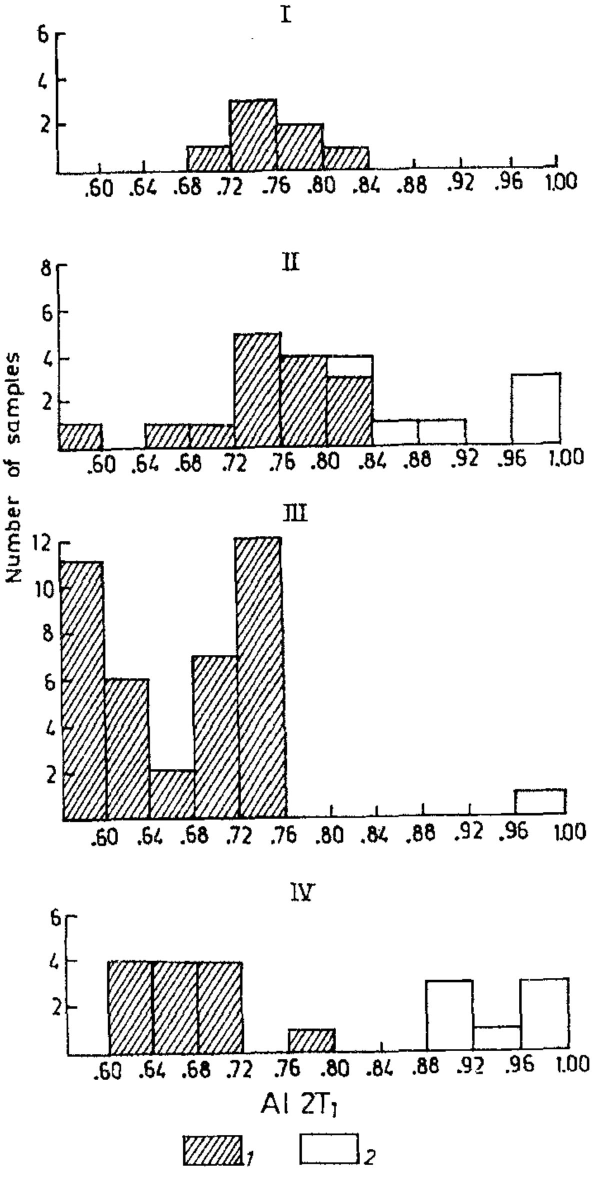
The authigenic K-feldspars possess all distinctive features which characterize adularias from hydrothermal mineral associations in various genetic types of mineralization — transparency (not always obligatory), morphology, variations in structural state, chemical composition.

The comparison of the main features of adularias formed in alpine veins, pegmatites, metasomatic altered rocks and hydrothermal ore-mineralizations with those of authigenic K-feldspars reveals the general tendencies of the mineralogy of the whole association of low-temperature K-feldspars (adularias) as well as the peculiarities distinguishing the lowest temperature, authigenic adularias from the relatively higher-temperature adularias.

Authigenic adularias are formed at temperatures lower than those at which most adularias from alpine veins, pegmatite and skarn mineralizations crystallize. The most frequent values of temperatures determined for their crystallization range from 100 to 200°C (H e a r n et al., 1987) but their formation under nearly atmospheric *P-T* conditions have also been reported (W o o d a r d, 1972; M o r a d, 1989; De R o s et al., 1994).

The morphology of the most frequent sub-rhombic authigenic K-feldspars in sedimentary rocks, described usually as "diamond-shaped crystals" or "adularia-like crystals", confirms the tendency of adularia habit change depending on the temperature of formation. However, in low-temperature hydrothermal, pegmatite, metasomatic or ore mineralizations sub-rhombic adularias display predominantly Felsöbanya and Maderaner habit types dominated by {110} and $\{10\bar{1}\}$, whereas in similar sub-rhombic authigenic adularia, most researchers, following R e y n o l d s (1929) and B a s k i n (1956), identify crystals with {110} and {001} only. The small size of authigenic adularias (usually < 0.1 mm) makes it difficult to precisely determine their crystal forms . R e y n o l d s (1929) had observed habit types with predominant development of {001} as well as {010}, forms that are more characterisic of high-temperature K-feldspars and poorly developed even in adularias from alpine veins. R e y n o l d s (1929) described also authigenic K-feldspars of Drachenfels habit type as well as typical sanidine-type crystals dominated by {010}, {001}, {110}, $\{10\bar{1}\}$ and strongly flattened along {010}. It may well be that the morphology of authigenic adularias depends on the temperature of solutions and to a great extent on the growth rate in a specific environment during diagenesis of sedimentary rocks.

Authigenic adularias like adularias from other genetic types of mineralizations are known by their diversity in structural state. Wide variations in structural state ranging from high sanidine to maximum microcline (Al in $2T_1$ positions from 0.60 to 1.00) have been reported (B a s k i n, 1956; Č e r n ý, C h a p m a n 1984; 1986; S e n d e r o v et al., 1991; A r n a u d o v a, A r n a u d o v, 1995). It is known that a predominant part of studied adularias from alpine veins, pegmatites and other types of mineralizations are monoclinic with a low degree of Al/Si order (Č e r n ý,



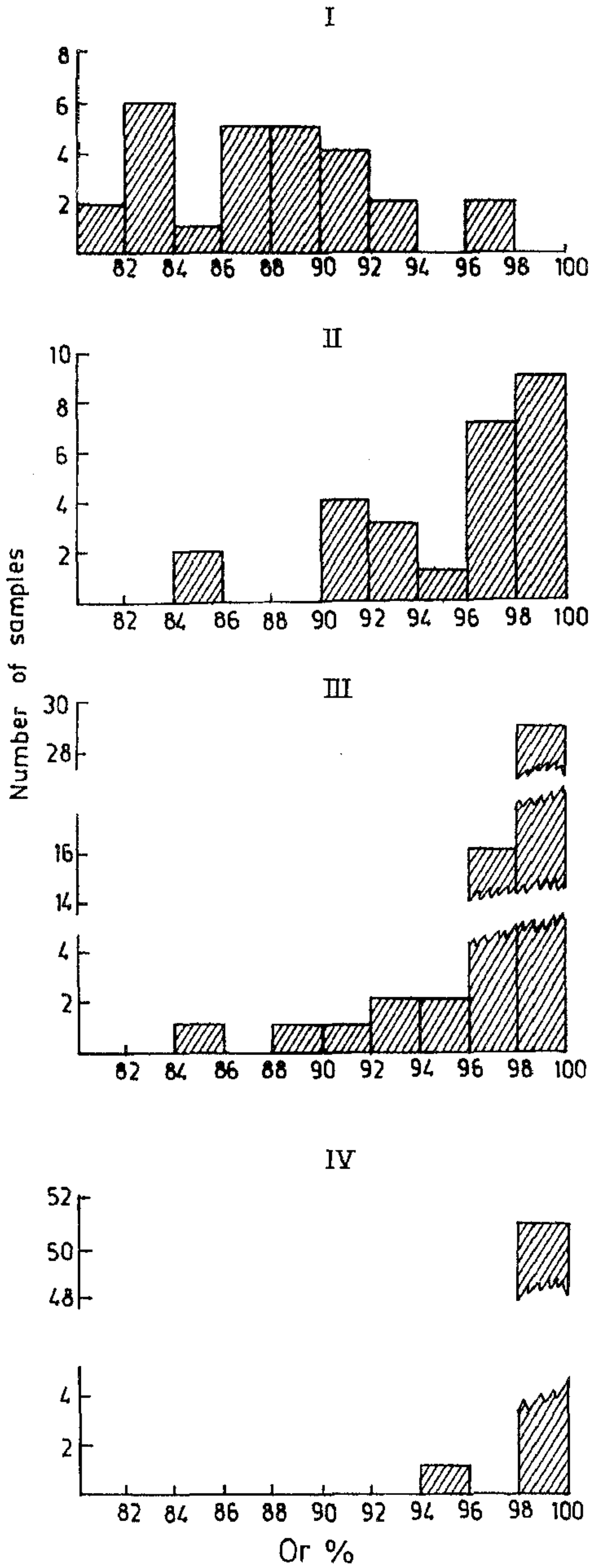


Fig. 1. Histograms of Al/Si order in adularias from: I — alpine veins; II — pegmatites; III — hydrothermal ore mineralizations; IV — sedimentary rocks (authigenic adularias); *1* — monoclinic adularias; *2* — triclinic adularias

Фиг. 1. Хистограми за степента на Al/Si подреденост в адулари от: I — алпийски жили; II — пегматити; III — хидротермални рудни минерализации; IV — седиментни скали (аутигенни адулари); *1* — моноклинни адулари; *2* — триклинни адулари

Fig. 2. Histograms of Or (mol %) content in adularias from: I — alpine veins; II — pegmatites; III — hydrothermal ore mineralizations; IV — sedimentary rocks (authigenic adularias)

Фиг. 2. Хистограми за съдържанието на Or (мол.%) в адулари от: I — алпийски жили; II — пегматити; III — хидротермални рудни минерализации; IV — седиментни скали (аутигенни адулари)

Chapman, 1984; 1986; Arnaudova, Arnaudov, 1995). Although most of the authigenic adularias are monoclinic (Woodard, 1972; Senderov et al., 1991; De Ros et al., 1994), triclinic equilibrium structures — intermediate to maximum microclines (Kastner, 1971; Morad, 1989; Senderov et al., 1991) — are more common among them than among adularias from the relatively higher-temperature hydrothermal mineralizations (Fig.1). However, such large variations in the structural state — from extremely disordered structures with $2T_1$ values (Al in $2T_1$ positions) even lower than 0.5 (Černý, Chapman, 1986) to maximum microcline, are observed in adularias from pegmatites as well. Evidently, the structure of adularia depends on the temperature regime as well as on the rate of crystal growth as a function of concentration, pH and oversaturation of SiO_2 of mineral-forming solutions (Černý, Chapman, 1984; Senderov et al., 1991).

The most characteristic feature of authigenic adularias is the high content of Or (> 98 mol%) (Kastner, 1971; Smith, 1974; Ali, Turner, 1982; Milliken, 1989; Morad, 1989; Duffin et al., 1989; Senderov et al., 1991; De Ros et al., 1994), by which they approach the ideal end-member composition of $KAlSi_3O_8$. The composition of authigenic adularias, as well as the trend of compositional variations of adularias from alpine veins (Deer et al., 1963; Rybach, Nissen, 1967; Phillips, Ribbe, 1973; Akizuki, Sunagawa, 1978; Constantinescu, Săbăn, 1983; Arnaudova, Arnaudov, 1995), pegmatites (Borutskii et al., 1984; Černý, Chapman, 1984; 1986; Černý et al., 1984; Ferguson et al., 1991; Peytcheva et al., 1994; Arnaudova, Arnaudov, 1995) and hydrothermal ore mineralizations (Radonova, 1970; Rusinova et al., 1975; Akizuki, Sunagawa, 1978; Bargar, Melvin, 1981; Černý, Chapman, 1986; Rainov, Yanev, 1991; Dong, Morrison, 1995) formed in a wider temperature interval, confirms the tendency of increasing Or content and correspondingly decreasing Ab content with the decreasing temperature of formation (Baskin, 1956; Arnaudov, Arnaudova, 1995; 1996), (Fig.2).

In contrast to the main components (K,Na,Ca), the content of barium in adularias, and probably of other trace elements (Sr,Rb,Pb,Tl) characteristic for the potassium feldspars, depend mainly on their concentration in the mineral-forming solutions.

Summarizing the above considerations, we may place the authigenic K-feldspars within the group of the lowest-temperature adularias characterized by predominantly sub-rhombic morphology and high (> 98 mol%) Or content.

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