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## Crystal chemical principles of classifying the Eudialyte group

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Scientific interest in eudialyte, a worldwide abundant zirconosilicate, is due, in particular, to its role in the mineralogy and geochemistry of Zr. The heteropolyhedral framework of eudialyte is made up of three- and nine-membered rings of silica tetrahedra and six-membered rings of  $M(1)O_6$  octahedra joined by isolated  $ZrO_6$  octahedra. The cations of alkali and alkali-earth metals, hydronium, and transition elements, additional large anions, and water molecules are disposed in the cavities of the framework [1]. Species with relatively low-ordered 12-layer structure described by a hexagonal unit cell with  $a \sim 14 \text{ \AA}$  and  $c \sim 30 \text{ \AA}$  are the most abundant in the eudialyte group. The ordering of cation occupancy, which can touch on almost all intraframework and framework sites (except for Si sites of Si,O-rings), gives rise to the formation of superstructures in some eudialyte-group minerals with multiple  $c$  period about  $60 \text{ \AA}$  discovered by A.P. Khomyakov in the Lovozero and Khibiny plutons, Kola Peninsula, Russia.

According to the rules accepted by the CNMNC IMA, the definition of a new mineral species within the eudialyte group should be based on the general crystal-chemical principle of the predominance of a new element at one or several key sites. To date, 25 minerals of the eudialyte group have been approved in line with this recommendation. Additionally, 52 samples (including potential new species) have been investigated using IR spectroscopy and X-ray analysis. The new data require the modification and complementation of the current systematics of the eudialyte group. The eudialyte-type structures contain unique fragments that involve species-forming key sites. The crystal chemical classification that developed [2,3] is based on the hierarchical principle that takes into account the following features (listed in order of their lowering classification rank):

- (i) simple or modular character of the crystal structure and value of  $c$  parameter (about  $30$  and  $60 \text{ \AA}$  for 12- and 24-layer minerals, respectively);
- (ii) symmetry determined by cation ordering in the octahedral ring, i.e., the possibility of dividing site  $M(1)$  into  $M(1a)$  and  $M(1b)$ ;
- (iii) the distribution of different components into five  $M(2)$  square-based sites;
- (iv) the water content (subdivision of the eudialyte-group minerals into low- and high-hydrous species with  $Na > (H_2O + H_3O)$  and  $Na < (H_2O + H_3O)$ , respectively).

The 12-layer minerals are subdivided into eudialyte- and oneillite-type species. The further subdivision of these two types into subtypes is based on the predominance of octahedra, tetrahedra, or vacancies at sites  $M(3)$  and  $M(4)$  in the centers of nine-membered Si,O-rings and different combinations of these variants. Both type and subtype terms are used here in the crystal chemical sense. Among 24-layer minerals, the first subdivision is based on the degree of hydration; the second subdivision into subtypes takes into account combinations of predominant components ( $Zr + Zr$ ,  $Ti + Ti$ , or  $Zr + Ti$ ) in  $Z$  octahedra of different modules (floors).

The proposed crystal chemical approach to the systematic of the eudialyte-group minerals makes it possible to characterize all minerals of this group in the same terms and to predict the discovery of new minerals and their varieties. The introduction of rational principles into the systematic and nomenclature of eudialyte-group minerals could be useful for the development of the taxonomy of

other groups of minerals characterized by the complex mechanism of isomorphic substitutions at several structural sites.

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*References:*

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