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The mayenite supergroup: A reexamination of mayenite and related minerals

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Mayenite was originally described as an oxide, $Ca_{12}Al_{14}O_{33,}$ space group $I4\text{-}3d$ (Hentschel 1964), and a large number of synthetic compounds of industrial importance are isostructural with mayenite. However, study of material from the type locality yielded a very different composition, which is intermediate between the end-members $Ca_{12}Al_{14}O_{32}Cl_2$ and $Ca_{12}Al_{14}O_{30}(OH)_6$(Galuskin et al. 2012) and has led us to reexamine the crystal structures and nomenclature of mayenite and minerals related to it. The general crystal chemical formula of these minerals can be given as: $X_{12}({}^{IV}T1^{VI}_{8-x}T'1_x)^{IV}T2_6O1_{24}O_{28-x}(O_2aH\ )_{3x}\{W_{6-3x}\}$, where x = 0-2, X – Ca polyhedral site; $T1$ and $T'1$ (modified $T1$ site) – distorted tetrahedral and octahedral sites, respectively, centered by Al and other cations such as Fe^{3+}, Mg, Ti, Si, Fe^{2+}...; $T2$ – a regular tetrahedron filled by Al, Si and Fe^{3+}. The W site is confined to the center of a structural cage $\sim$ 5Å in diameter.

We recommend a new classification in which a mayenite supergroup comprises several groups defined on the basis of the simplified formula $X_{12}T_{14}[O_{32-x}(OH)_{3x}]\{W_{6-3x}\}$ ($T1$ and $T2$, O1 and O_2 sites are combined) and of the anion charge at the W site. There are four recognized minerals, as well as 3 potentially new species, which can be classed into two groups.

I. mayenite group (x = 0 and W = -2), which includes 1) mayenite $Ca_{12}Al_{14}O_{32}\{[]_5O_1\}_{\Sigma 6}$(Hentschel 1964), 2) brearleyite $Ca_{12}Al_{14}O_{32}\{[]_4Cl_2\}_{\Sigma 6}$(Ma et al. 2011); and potentially new minerals: $Ca_{12}Al_{14}O_{32}\{[]_4(OH)_2\}_{\Sigma 6}$(Glasser 1995), $Ca_{12}Al_{14}O_{32}\{(H_2O)_4Cl_2\}_{\Sigma 6}$ (Upper Chegem caldera, North Caucasus, Galuskin et al. 2009), $Ca_{12}Al_{14}O_{32}\{(H_2O)_4F_2\}_{\Sigma 6}$ (Hatrurim formation, Israel, unpublished data).

II. wadalite group (x = 0 and W = -6), which includes 3) wadalite $Ca_{12}Al_{10}Si_4O_{32}\{Cl_6\}$ (Tsukimura et al. 1993, Mihajlovic et al. 2004) and 4) eltyubyuite $Ca_{12}Fe^{3+}_{10}Si_4O_{32}\{Cl_6\}$ (Galuskin et al. 2011).

In addition, there is a potentially new mineral species not belonging to either group: $Ca_{12}Al_{14}O_{30}(OH)_6$ (x = 2 and W = 0), which constitutes about $\sim$38% of the mayenite sample studied by Galuskin et al. (2012).

Galuskin E.V. et al. (2009) E.J.M., 21, 1045-1059; Galuskin E.V. et al. (2011), Min.Mag., 75, 2549-2561; Galuskin E.V. et al. (2012), Min. Mag., 76, 707-716; Glasser F. P. (1995) Acta Cryst., C51, 340; Hentschel, G. (1964) N. J. Min., Mon. 1964, 22–29; Ma C. (2011) Am.Min., 96, 1199–1206; Mihajlović T. et al. (2004) N. J. Min., Abh. 179, 265 -294; Tsukimura et al. (1993) Acta Cryst., C49, 205-207.