# THE SYSTEM OF
# MINERALOGY

*of James Dwight Dana and Edward Salisbury Dana*
*Yale University 1837–1892*

*SEVENTH EDITION*
*Entirely Rewritten and Greatly Enlarged*

*By*

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## VOLUME II

### *HALIDES, NITRATES, BORATES, CARBONATES, SULFATES, PHOSPHATES, ARSENATES, TUNGSTATES, MOLYBDATES, ETC.*

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accept significant amounts of K or $(NH_4)$ in substitution for Na. Alums of the $\beta$-type, such as CsAl alum, in which the $A$ ion is of large size, do not occur in nature. All the alums are highly soluble and occur as surface evaporation products in arid regions or in sheltered places.

**Ref.**

1. Lipson and Beevers, *Proc. Roy. Soc. London,* **148A,** 664 (1935); Lipson, *Proc. Roy. Soc. London,* **151A,** 347 (1935).

29.5.5.1 **POTASH ALUM** $[KAl(SO_4)_2 \cdot 12H_2O]$. Native Alum pt. Kalialaun, Kalinischer Alumsulphat pt. *Germ.* Alumen pt. *Weisbach* (**9,** 1875). Kalinite pt. *Dana* (652, 1868).

**Cryst.** Isometric; diploidal—$2/m\,\overline{3}$.

**Forms:**

*a* 001 *d* 011 *o* 111 *e* 012 *n* 112 *p* 122

***Structure cell.***[1] Space group $Pa3$. $a_0$ 12.133 ± 0.002 $kX$. Cell contents $K_4Al_4(SO_4)_8 \cdot 48H_2O$.

***Habit.*** Octahedral from pure water solution, cubical from alkaline solutions; the habit varies accompanying the adsorption of dyes or other substances present in the crystallizing solution.[2] Natural potash alum is usually massive with a columnar or granular structure; also stalactitic, and as mealy coatings.

***Twinning.*** On {111}, very rare.

***Etch figures.***[7] Etching effects conform to diploidal symmetry.

**Phys.** Fracture conchoidal. Traces of cleavage on {111}. H. 2–2½.[3] G. 1.757; 1.753 (calc.). Luster vitreous. Colorless and transparent; white. Taste sweetish and astringent.

**Opt.** In transmitted light, colorless. Isotropic.

$nD$[5] 1.4562 ± 0.0001

| λ | *B* | *C* | *D* | *E* | *F* | *G* |
|---|---|---|---|---|---|---|
| *n*[4] | 1.4530 | 1.4540 | 1.4564 | 1.4593 | 1.4618 | 1.4661 |

Potash alum together with ammonia alum and other alums frequently shows weak anomalous birefringence.[6] The crystals usually appear as pyramidal composites of uniaxial individuals arranged with their optic axes perpendicular to the external crystal faces. The birefringence appears to be due to internal strain arising from compositional variation; it also may be produced by mechanical deformation.

**Chem.** A hydrated sulfate of potassium and aluminum, $KAl(SO_4)_2 \cdot 12H_2O$. $(NH_4)$ can substitute for K (analysis 2), and a complete series to ammonia alum has been obtained in artificial material. Na does not substitute for K in artificial preparations (but see analysis 2).

***Anal.***

|  | $K_2O$ | $Na_2O$ | $(NH_4)_2O$ | $Al_2O_3$ | $Fe_2O_3$ | $SO_3$ | $H_2O$ | Rem. | Total | G. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | 9.93 |  |  | 10.75 |  | 33.75 | 45.57 |  | 100.00 | 1.753 |
| 2. | 5.75 | 1.35 | 2.42 | 10.40 | 0.80 | 34.00 | 45.37 | 0.77 | 100.86 |  |

1. $KAl(SO_4)_2 \cdot 12H_2O$. 2. Vesuvius.[8] Rem. is $Cr_2O_3$ 0.16, $Mn_2O_3$ 0.01, CaO 0.36, Cl 0.24; Cs, Rb. tr.

**Tests.** Soluble in water (11.4 g. in water at 20°). Melts in its water of crystallization at $\sim$91°. On rapid heating to below red heat intumesces and forms a bulky, porous mass of the anhydrous sulfate ("burnt alum").[10]

**Occur.** Potash alum, together with the other natural alums, commonly occurs as an efflorescence or crevice filling in argillaceous rocks and brown coals containing disseminated pyrite or marcasite. The mineral is derived by the action of sulfuric acid formed during the weathering of the sulfides on alkali-rich aluminous silicates. Similarly by the action of sulfurous vapors or solutions on feldspathic or leucite-rich rocks in fumaroles or solfataras. Associated minerals include alunogen, pickeringite, epsomite, melanterite, gypsum, sulfur. Many localities are known including several that have been of commercial importance. Found in Italy as products of volcanic activity on Vesuvius, in the Grotte Faraglione on Vulcano, and in the solfatara of Miseno. At numerous brown-coal deposits in Germany, as at Duttweiler near Saarbrücken and Arzberg in the Fichtelgebirge. In France at Decazeville and elsewhere in brown-coal deposits in the Plateau Central. Also at numerous places in Galicia and Aragon in Spain. In England at Whitby, Yorkshire, and at Hurlet and Campsie near Glasgow, Scotland. In Chile at Chuquicamata. Found in the United States in Alum Cave, Sevier County, Tennessee. At numerous places in California, including the Sulfur Bank cinnabar mine, Lake County, The Geysers in Sonoma County, and the Nortonville coal mine in Contra Costa County. Near Silver Peak in Esmeralda County, Nevada.

**Artif.**[9] As crystals, which can be grown to very large sizes, from a water solution of the component salts.

**History.** The *alumen* of Pliny and later ages included a number of naturally occurring efflorescent sulfates. KAl alum—the "alum" of commerce and popular usage—was not clearly recognized as a separate entity until the analysis of Vauquelin in 1797. The massive, fibrous forms of the mineral continued to be confused with other minerals of similar appearance or constitution in the various descriptive mineralogies of the early nineteenth century. Alum was an important article of trade in the fifteenth century and earlier as a mordant in dyeing. The substance was then largely obtained by the calcination and lixivation of alunite—alumstone—obtained from various places in the Near East under Turkish control and after about 1460 from the alunite deposit at Tolfa in Italy. Alum was manufactured in competition with Roman alum in the seventeenth century and later in Yorkshire, England, by the roasting and lixivation of pyritic, aluminous schists. This method was supplanted by the extraction of leucite rocks or calcined aluminous shales with sulfuric acid. Ammonia alum, using by-product ammonia from the coal-gas industry, has been used in place of the potassium salt.

**Ref.**

1. Lipson and Beevers, *Proc. Roy. Soc. London*, **148A**, 664 (1935) on artificial crystals.
2. For literature see Groth (**2**, 565, 1908) and Frondel, *Am. Min.*, **25**, 91 (1940).

On the growth rate of various faces see Spangenberg, *Zs. Kr.*, **61,** 189 (1925); *Jb. Min., Beil.-Bd.*, **57,** 1197 (1928), and Valeton, *Zs. Kr.*, **56,** 434 (1921).

3. On the variation of hardness with direction see Pfaff, *Sitzber. bayer. Ak. Wiss.*, 255 (1884).
4. Indices of Soret, *Arch. sc. phys. nat. Genève*, **12,** 376 (1884) on artificial crystals.
5. Wendekamm, *Zs. Kr.*, **85,** 169 (1933).
6. For description and interpretation see Brauns, *Die opt. Anom. der Kristalle*, Leipzig, 1891, and *Jb. Min.*, II, 102 (1883), I, 96 (1885); Klocke, *Jb. Min.*, I, 56 (1880), II, 267 (1881); Beckenkamp, *Zs. Kr.*, **51,** 492 (1913); Pockels, *Jb. Min., Beil.-Bd.*, **8,** 217 (1892).
7. See Bauhans, *Verh. Nat. Ver. Heidelberg*, **12,** 319 (1913); Klocke, *Zs. Kr.*, **2,** 126 (1878); Wulff, *Zs. Kr.*, **5,** 81 (1881); Friedel, *C.R.*, **179,** 796 (1924).
8. Alfani, *Per. Min.*, **4,** 395 (1933).
9. On the system $K_2SO_4$-$Al_2(SO_4)_3$-$H_2O$ see Britton, *J. Chem. Soc. London*, **121,** 982 (1922).
10. For dehydration data see Spangenberg and Baldermann-Fiola, *Jb. Min., Monatsh.*, Abt. A, 113 (1949).

29.5.5.2 **SODA ALUM** [$NaAl(SO_4)_2\cdot 12H_2O$]. Soda Alum pt., Natronalaun pt. *older authors.* Mendozite pt. *Dana* (653, 1868). Sodalumite *Winchell* (259, 1931).

**Cryst.** Isometric; diploidal—$2/m\,\bar{3}$.

**Forms:**

(artificial) *o* 111 *a* 001

***Structure cell.***[1] Space group *Pa*3. $a_0$ 12.19 ± 0.02 *kX*. Cell contents $Na_4Al_4(SO_4)_8\cdot 48H_2O$. Soda alum is not isostructural with potash alum.

***Habit.*** Artificial crystals are octahedral.

**Phys.** Fracture conchoidal. H. ~3. G. 1.67. Luster vitreous. Colorless and transparent.

**Opt.**[2] In transmitted light, colorless. Isotropic.

| λ | *B*(686mμ) | *C*(656mμ) | *D*(589mμ) | *E*(527mμ) | *F*(486mμ) | *G*(431mμ) |
|---|---|---|---|---|---|---|
| *n* | 1.4356 | 1.4365 | 1.4388 | 1.4418 | 1.4441 | 1.4480 |

**Chem.** A hydrated sulfate of sodium and aluminum, $NaAl(SO_4)_2\cdot 12H_2O$. Analyses of natural material known to belong to this species are lacking. K does not substitute for Na to a significant extent.[4]

**Tests.** Soluble in water (110 g. of the anhydrous salt in 100 ml. of water at 15°). Fuses in its water of crystallization at about 63°. Loses $6H_2O$ at about 50°, forming tamarugite.

**Occur.** The name soda alum is here applied to the isometric compound $NaAl(SO_4)_2.12H_2O$. A number of occurrences of NaAl alum in nature have been reported (see *mendozite*), but none can be referred with certainty to the present species.

**Artif.**[3] As crystals from a water solution of the component salts. Soda alum crystallizes with more difficulty than potash alum.

**Ref.**

1. Lipson, *Proc. Roy. Soc. London*, **151A,** 347 (1935).
2. Soret, *Arch. sc. phys. nat. Genève*, **13,** 9 (1885), on artificial crystals.
3. Dobbins and Addleston, *J. Phys. Chem.*, **39,** 637 (1935), and Mellor (**5,** 342, 1924).
4. Krickmeyer, *Zs. phys. Chem.*, **21,** 78 (1896).