Betpakdalite-NaNa $[Na_2(H_2O)_{16}Na(H_2O)_6][Mo^{6+}_8As^{5+}_2Fe^{3+}_3O_{33}(OH)_4]$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As striated, doubly terminated, prismatic to bladed crystals, flattened on {001} and elongated along [010], to ~0.4 mm. *Twinning*: Ubiquitous multiple penetration twins result in a prismatic aspect, elongated and striated parallel to [010], with wedge-shaped terminations; penetration twinning forms intersecting blades with X-shaped cross-sections.

Physical Properties: *Cleavage*: {001}, perfect. *Tenacity*: Brittle. *Fracture*: Splintery. Hardness = ~3 D(meas.) = 2.87(3) D(calc.) = 2.877

Optical Properties: Transparent. *Color*: Yellow. *Streak*: Colorless to very pale yellow. *Luster*: Vitreous to subadamantine.
Optical Class: Biaxial (+). $\alpha = 1.768(5)$ $\beta = 1.785(5)$ γ(calc.) = 1.850 2V(meas.) = 60(5)º
Pleochroism: None. *Dispersion*: Moderate, $r < v$. *Orientation*: $Y = b$, $X \wedge a = 60º$ in obtuse β.

Cell Data: *Space Group*: *C*2/*m*. $a = 19.2370(12)$ $b = 11.0945(7)$ $c = 15.1459(9)$ $\beta = 130.342(1)º$ Z=2

X-ray Powder Pattern: Chuquicamata mine, Antofagasta, Chile.
8.930 (100), 7.389 (33), 9.640 (30), 11.586 (27), 2.862 (27), 3.697 (25), 3.168 (25)

Chemistry:

	(1)
Na_2O	5.45
K_2O	1.49
CaO	0.12
CuO	0.19
Fe_2O_3	11.15
Al_2O_3	0.01
P_2O_5	1.02
As_2O_5	7.84
MoO_3	53.94
H_2O	[18.78]
Total	99.99

(1) Chuquicamata mine, Antofagasta, Chile; normalized electron microprobe analysis supplemented by CHN, H_2O calculated from stoichiometry; corresponding to $[(Na_{2.86}K_{0.67})_{\Sigma=3.53}(H_2O)_{14.47}(Na_{0.90}Ca_{0.05}Cu^{2+}_{0.05})_{\Sigma=1.00}(H_2O)_6][Mo_8(As_{1.46}P_{0.31})_{\Sigma=1.77}Fe^{3+}_{2.98}O_{33.42}(OH)_{3.58}]$.

Mineral Group: Betpakdalite supergroup, betpakdalite group.

Occurrence: From the upper oxidation zone of a porphyry copper deposit.

Association: Jarosite, iron oxides and oxyhydroxides (e.g., goethite and akaganéite), scorodite, topaz, leightonite.

Distribution: At the Chuquicamata mine, Antofagasta, Chile.

Name: For the Bet-Pak-Dal Desert, Kazakhstan. Two suffixes correspond to the dominant cations in the two different types of non-framework cation sites.

Type Material: Natural History Museum of Los Angeles County, Los Angeles, California, USA (63570 and 63571) and Museum Victoria, Melbourne, Australia (M51648).

References: (1) Kampf, A.R. and S.J. Mills (2011) Betpakdalite-NaNa, IMA 2011-078. CNMNC Newsletter No. 11, Mineral. Mag., 75, 2892-2893. (2) Kampf, A.R., S.J. Mills, M.S. Rumsey, M. Dini, W.D. Birch, J. Spratt, J.J. Pluth, I.M. Steele, R.A. Jenkins, and W.W. Pinch (2012) The heteropolymolybdate family: structural relations, nomenclature scheme and new species. Mineral. Mag., 76(5), 1175-1207.