

Munirite, naturally occurring sodium vanadium oxide hydrate, a new mineral

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ABSTRACT. Munirite was found in the sandstones of Siwaliks formation of mid-Miocene to Pleistocene age. It occurs as small globular clusters of acicular crystals (2 to 3 mm long). Analysis gave V_2O_5 67.46, N_2O 22.91, and H_2O 10.26%. The X-ray powder diffraction pattern shows remarkable similarity to a synthetic compound $NaVO_3 \cdot 1.9H_2O$ (Lukacs and Strausievici, 1962).

THE new mineral was collected from Siwalik sandstones in Bhimber area, Azad Kashmir, Pakistan. It crystallizes as radiating fibrous aggregates on outcrops as well as on the walls of exploratory trenches. The new mineral has been named after Mr Munir Ahmad Khan, Chairman of the Pakistan Atomic Energy Commission, who instituted the Mineral Research Laboratories in the Commission. The name and data have been approved prior to publication by the Commission on New Minerals and Mineral Names, IMA. Type material has been deposited with the Hardrock Division, Atomic Energy Minerals Centre, PO Box 734, Peshawar, Pakistan, and the British Museum (Natural History).

Physical properties. Munirite crystals are pearly white with a slight tinge of apple green. It is soluble in H_2O . Examination in short-wave ultraviolet radiation produces no response. Due to small size of the crystals its hardness was difficult to estimate.

Optical properties. In transmitted light the crystals are colourless. Separate fibres frequently appear to be composed of several crystallites. The boundaries between crystals are straight and show extinction parallel to the crystal outline. The optics of the crystals suggest that they are orthorhombic. Refractive indices were measured by the immersion method: $\alpha = 1.692$, $\beta = 1.757$, $\gamma = 1.800$. It gives a biaxial negative figure with a 2V estimated at 75° . Optical orientation $\alpha = c$, $\beta = a$, $\gamma = b$. Specific gravity was determined to be 2.43 which corre-

sponds closely to the theoretically calculated value of 2.54.

Crystallography. The powder diffraction data, obtained on a film with $Cu-K\alpha$ radiation and Ni filter, are recorded in Table I. Intensities were estimated visually. The crystal system, indexing of powder diffraction lines, and unit cell were deter-

TABLE I. X-ray powder diffraction data for munirite using $Cu-K\alpha$ radiation

d_{obs}	d_{calc}	hkl	I
7.851	7.861	020	100
6.744	6.7552	011	50
4.1344	4.1287	211	70
3.9178	3.9305	040	10
3.7300	3.7404	002	10
3.3694	3.3776	022	15
3.2973	3.3007	141	90
2.9843	2.9845	212	70
2.8506	2.8351	222	30
2.7877	2.7929	151	25
2.7207	2.7096	042	20
2.6847	2.6929	250	80
2.6127	2.6082	400	20
2.3207	2.3175	123	5
2.1301	2.1374	342	10
2.0879	2.0869	441	10
1.9872	1.9886	271	25
1.8934	1.8935	172	20
1.8200	1.8195	024	50
1.7710	1.7688	452	12
1.6639	1.6671	144	20
1.4679	1.4698	025	20

System: Orthorhombic.

$a = 10.4330$; $b = 15.7220$; $c = 7.4809 \text{ \AA}$; $Z = 12$; $D = 2.54$ (calc).

mined by an analytical method of indexing (Klug and Alexander, 1974). Pending a detailed structural analysis the indexing recorded in Table I is the most probable.

Chemistry. A pure sample was hand picked under a binocular microscope and dissolved in HNO_3 . Vanadium was determined in the solution against a BDH multi-element standard on a Ziess FMD 4 atomic absorption spectrophotometer. Sodium determinations were made on the emission mode and the water content was determined by the Penfield method. The analytical results are given in Table II and given a V:Na atomic ratio of 1:1. Vanadium is reported as V_2O_5 as this seems appropriate to the oxidizing environments of the present-day exposures of Siwalik sandstones which have yielded several mineral species of hexavalent uranium. The absence of low valency states was also tested by dissolving a milligram of munitrite in HNO_3 and drop of very dilute KMO_4 added; the latter retained its colour.

Norblad (1875) has described NaVO_3 and $\text{NaVO}_3 \cdot 2\text{H}_2\text{O}$. He found that $\text{NaVO}_3 \cdot 2\text{H}_2\text{O}$ is stable but loses all its water over H_2SO_4 . Lukacs and Strausievici (1962) found that $\text{NaVO}_3 \cdot 1.9\text{H}_2\text{O}$ lost its water over P_2O_5 at 100°C to yield $\beta\text{-NaVO}_3$. The dehydration behaviour of munitrite was also investigated and it lost all its water at 100°C to yield an X-ray diffraction pattern similar to $\beta\text{-NaVO}_3$ (Lukacs and Strausievici, 1962). The chemical analysis of munitrite contains only half the water in $\text{NaVO}_3 \cdot 1.9\text{H}_2\text{O}$ (Table II). Considering the similarity in dehydration behaviour of munitrite to $\text{NaVO}_3 \cdot 1.9\text{H}_2\text{O}$ and $\text{NaVO}_3 \cdot 2\text{H}_2\text{O}$, as well as its X-ray powder diffraction pattern, it is proposed to be a partially dehydrated $\text{NaVO}_3 \cdot 2\text{H}_2\text{O}$.

Discussion. A variety of secondary uranium and uranium-vanadium minerals have been described from Siwalik sandstones of Pakistan. The list includes carnotite, tyuyamunitite, metatyuyamunitite, bayleyite, andersonite, and uranophane. These are considered to be products of the oxidation of

TABLE II. *Chemical analysis of munitrite and theoretical wt. % of synthetic $\text{NaVO}_3 \cdot 1.9\text{H}_2\text{O}$*

Oxide	wt. %	$\text{NaVO}_3 \cdot 1.9\text{H}_2\text{O}$ theoretical wt. %
V_2O_5	67.46	58.23
Na_2O	22.91	19.85
H_2O	10.26	21.92
Total	100.63	100.00

uraninite from uraninite-coffinite assemblages in unaltered sandstones. The existence of minerals like uranophane suggests extreme oxidation by the action of meteoric waters on earlier-formed secondary uranium minerals (Fron del, 1958). Break-down of vanadium bearing hexavalent uranium minerals and consequent leaching of highly soluble hexavalent uranium may have caused a local enrichment of vanadium and subsequent precipitation of munitrite through evaporation of ground-water.

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