

Phosphates, Tungstates, Vanadates

- Phosphates are based on $P^{5+}O_4$
- Tungstates and Vanadates are based on $W^{6+}O_4$ and $V^{5+}O_4$ tetrahedra.

Phosphates

H																	He		
Li	Be	B	C	N											O	F	Ne		
Na	Mg	Al	Si	P											S	Cl	Ar		
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr		
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe		
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn		
Fr	Ra	Ac																	
		Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu				
		Th	Pa	U															
		88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	

Apatite $Ca_5(PO_4)_3(OH), F, Cl$



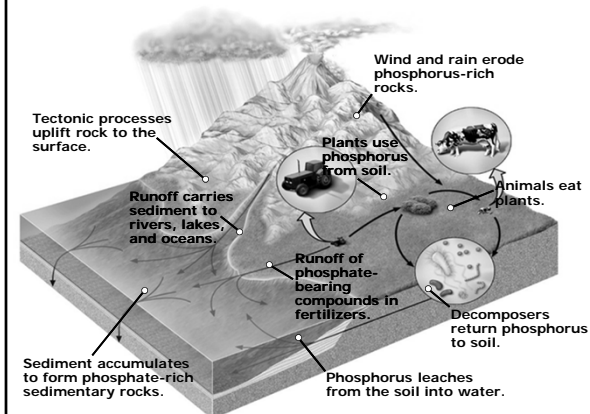
Occurrence: Accessory in Igneous and Metamorphic Rocks

Uses: Teeth, Bones

Apatite $Ca_5(PO_4)_3(OH, F, Cl)$

- Apatite is the most abundant phosphate mineral.
- It is a common accessory phase in igneous, sedimentary, and metamorphic rocks.
- The crystal structure has two large Ca sites that can incorporate U, Th, and REEs.
- The mineral can be used for fission-track dating to date the time a rock mass cooled below the healing temperature of tracks.
- Allows dating of uplift and erosion.

THE PHOSPHORUS CYCLE



Phosphorus Cycle:

(your teeth and bones)

- $Ca_5(PO_4)_3(OH)$ Apatite in rocks
- $H(PO_4)$ in soils
- Phosphorus is essential for plant growth.
- P is limiting nutrient in oceans
- P in runoff causes algal blooms and eutrophication (oxygen depletion in water)

Other Phosphates

Xenotime YPO_4

Monazite (Ce, La, Th) PO_4

Whitlockite $Ca_9(MgFe)(PO_4)_6PO_3OH$

Phosphates

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Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe																		
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn																		
Fr	Ra	Ac															Rf	Db	Sg	Bh	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
		Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu																				
		Th	Pa	U																															

Vanadates

Vanadinite $Pb_5(PO_4)_3Cl$
(Apatite structure)

Phosphates

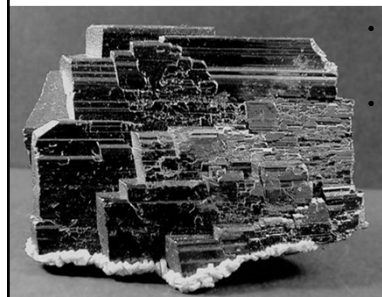
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		Th	Pa	U																															

Scheelite $CaWO_4$



- Occurrence: High T Hydrothermal
- Density = 6 g/cm³
- (It's heavy)
- Uses: Major Ore of W

Wolframite (Fe,Mn)WO₄ Ferberite FeWO₄ Huebnerite MnWO₄



- Occurrence: High T Hydrothermal
- Uses: Major Ore of W