Meteoritics & Planetary Science 32, 733–734 (1997)

Addendum

Mineralogy of meteorite groups: An update

ALAN E. RUBIN

Institute of Geophysics and Planetary Physics, University of California, Los Angeles, California 90095-1567, USA
Author's e-mail address: rubin@igpp.ucla.edu

(Received 1997 May 8; accepted in revised form 1997 June 9)

Abstract–Twenty minerals that were not included in the most recent list of meteoritic minerals have been reported as occurring in meteorites. Extraterrestrial anhydrous Ca phosphate should be called merrillite, not whitlockite.

ADDITIONAL METEORITIC MINERALS

Rubin (1997) listed ~275 mineral species that have been identified in meteorites. Since publication of that paper, 20 additional meteoritic minerals have come to light; most of these are listed in Table 1, which is in the same format as Table 2 of Rubin (1997). Not included in Table 1 are two new unnamed species: an $MgSiO_3$ phase with the ilmenite structure found in shock veins in the L5-6, S6 chondrite, Acfer 040 (Sharp *et al.*, 1997) and a nesosilicate of formula $(NaKCaFe)_{0.973}(Al,Si)_{5.08}O_{10}$ found in the shocked matrix of L6 Peace River (El Goresy *et al.*, 1997). The list of presolar minerals (Table 4 of Rubin, 1997) should also include spinel (A. M. Davis, pers. comm., 1997). The list of minerals in martian meteorites (Table 5 of Rubin, 1997) should also include ringwoodite and majorite.

MERRILLITE AND WHITLOCKITE

There has been great confusion over the names merrillite and whitlockite (Mason, 1971). The *Mineral Reference Manual* of Nickel and Nichols (1991) lists merrillite as a synonym for whitlockite, and most authors use the terms interchangeably when describing anhydrous Ca phosphate in lunar rocks and meteorites. However, there appear to be chemical and structural differences between the phases. Merrillite, $Ca_9MgNa(PO_4)_7$, in Estacado (H6) and the Angra dos Reis angrite has a structure essentially identical to that of synthetic β-$Ca_3(PO_4)_2$ (Gopal and Calvo, 1972; Prewitt and Rothbard, 1975; Dowty, 1977). In contrast, in natural and synthetic whitlockite, $Ca_9MgH(PO_4)_7$, one of the tetrahedral PO_4 groups is inverted, thus forming a structure somewhat different than β-$Ca_3(PO_4)_2$ (Gopal and Calvo, 1972; Gopal *et al.*, 1974; Calvo and Gopal, 1975).

According to e-mail dated 1996 April 17 from E. Nickel, vice chairman of the Commission on New Minerals and Mineral Names (CNMMN) of the International Mineralogical Association (IMA), to B. Mason, a proposal by E. Dowty to revalidate merrillite was approved by the CNMMN in 1976. Thus, extraterrestrial anhydrous Ca phosphate should be called merrillite.

ERRATA

The oxide of formula $MgTiO_3$ called geikielite was misspelled in Table 2 of Rubin (1997). The correct name for the phosphate of formula $Ca_5(PO_4)_3OH$ is hydroxylapatite. Presolar SiC is cubic; the proper name for this mineral is beta-moissanite. The inosilicate, Sc-fassaite, should more properly be termed "Al-Ti diopside, scandium bearing." The mineral entry in Table 2 of Rubin (1997) labeled monosulfide solid solution should be omitted. This phase does not occur at room temperature; at S-poor compositions, it exsolves pentlandite below 610 °C, forms two miscibility gaps below 300 °C (one at each side of the Fe/Ni = 1 composition) and finally breaks down to form troilite or pyrrhotite below 100–200 °C (Craig and Scott, 1974).

Acknowledgments–I thank B. Mason, E. J. Olsen, G. R. Huss, A. M. Davis and F. Ulff-Møller for comments and discussions, and an anonymous senior mineralogist for pointing out some mistakes (as discussed in the errata). I also thank M. Kimura for sending a copy of his paper on meteorite minerals to me. I am grateful to D. W. G. Sears for suggesting that I publish this update. This work was supported by NASA grant NAGW-3535 (J. T. Wasson).

Editorial handling: D. W. G. Sears

TABLE 1. Additional minerals in meteorites.

Mineral	Formula	References
	native elements and metals	
rustenburgite	$(Pt,Pd)_3Sn$	1
	sulfides and hydroxysulfides	
digenite	Cu_9S_5	1
	arsenides and sulfarsenides	
irarsite	(Ir,Ru,Rh,Pt)AsS	1
	oxides	
zirkelite	$(Ca,Th,Ce)Zr(Ti,Nb)_2O_7$	1
	hydroxides	
feroxyhyte	δ-FeO(OH)	1
	sulfates	
coquimbite	$Fe_2(SO_4)_3 \cdot 9H_2O$	1
kieserite	$MgSO_4 \cdot H_2O$	1
slavíkite	$NaMg_2Fe_5(SO_4)_7(OH)_6 \cdot 33H_2O$	1
szomolnokite	$FeSO_4 \cdot H_2O$	1
voltaite	$K_2Fe_8Al(SO_4)_{12} \cdot 18H_2O$	1
	phosphates	
galileiite	$NaFe_4(PO_4)_3$	2
K-Na-Fe phosphate	$(K,Na)Fe_4(PO_4)_3$	2
	silicates	
nesosilicates (independent SiO_4 tetrahedra)		
britholite-(Ce)	$(Ce,Y,Ca)_5(SiO_4,PO_4)_3(OH,F)$	1
goldmanite	$Ca_3V_2(SiO_4)_3$	1
inosilicates (continuous single or double chains of SiO_4 tetrahedra)		
donpeacorite	$(Mn,Mg)Mg(SiO_3)_2$	1
kanoite	$(Mn,Mg)SiO_3$	1
tectosilicates (continuous framework of SiO_4 tetrahedra)		
marialite	$Na_4(Si,Al)_{12}O_{24}Cl$	1
stilbite	$NaCa_4(Si_{27}Al_9)O_{72} \cdot 30H_2O$	1

References: 1 = Kimura (1996); 2 = Olsen and Steele (1997).

REFERENCES

CALVO C. AND GOPAL R. (1975) The crystal structure of whitlockite from the Palermo Quarry. *Am. Mineral.* **60**, 120–133.

CRAIG J. R. AND SCOTT S. D. (1974) Sulfide phase equilibria. In *Sulfide Mineralogy* (ed. P. H. Ribbe), pp. CS1–CS110. Mineralogical Society of America, Washington, D.C.

DOWTY E. (1977) Phosphate in Angra dos Reis: Structure and composition of the $Ca_3(PO_4)_2$ minerals. *Earth Planet. Sci. Lett.* **35**, 347–351.

EL GORESY A., WOPENKA B., CHEN M., WEINBRUCH S. AND SHARP T. G. (1997) Evidence for two different shock induced high-pressure events and alkali-vapor metasomatism in Peace River and Tenham (L6) chondrites (abstract). *Lunar Planet. Sci.* **28**, 329–330.

GOPAL R. AND CALVO C. (1972) Structure relationship of whitlockite and β-$Ca_3(PO_4)_2$. *Nature Phys. Sci.* **237**, 30–32.

GOPAL R., CALVO C. ITO J. AND SABINE W. K. (1974) Crystal structure of synthetic Mg-whitlockite, $Ca_{18}Mg_2H_2(PO_4)_4$. *Can. J. Chem.* **52**, 1155–1164.

KIMURA M. (1996) Meteorite minerals (in Japanese). *J. Mineral.* **25**, 49–60.

MASON B. (1971) Merrillite and whitlockite or what's in a name? *Mineral. Rec.* **2**, 277–279.

NICKEL E. H. AND NICHOLS M. C. (1991) *Mineral Reference Manual.* Van Nostrand Reinhold, New York, New York. 250 pp.

OLSEN E. J. AND STEELE I. M. (1997) Galileiite: A new meteorite phosphate mineral. *Meteorit. Planet. Sci.* **32 (Suppl.)**, A155–A156.

PREWITT C. T. AND ROTHBARD D. R. (1975) Crystal structures of meteoritic and lunar whitlockites (abstract). *Lunar Sci.* **6**, 646–648.

RUBIN A. E. (1997) Mineralogy of meteorite groups. *Meteorit. Planet. Sci.* **32**, 231–247.

SHARP T. G., LINGEMANN C. M., DUPAS C. AND STÖFFLER D. (1997) Natural occurrence of $MgSiO_3$-ilmenite and amorphized $(Mg,Fe)SiO_3$-perovskite in a shocked L5-6 chondrite (abstract). *Lunar Planet. Sci.* **28**, 1285–1286.