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The crichtonite group of minerals: a review of the classification

WÜLSER P.-A., BRUGGER J. (*CRC-LEME, University of Adelaide & South Australian Museum, Australia),*
MEISSER N. (*Musée Cantonal de Géologie de Lausanne, Suisse)* (pierre-alain@wulser.com)

The minerals of the crichtonite group belong to the oxide class. The group contains eleven species: crichtonite, senaite, davidite-(La), davidite-(Ce), landauite, mathiasite, lindsleyite, loveringite, dessauite-(Y), gramaccioliite-(Y) and cleusonite. All the crichtonites are isostructural, crystallizing in the trigonal system with space group $R\bar{3}$, Z = 3 and unit cell with a_{hex}= ~10,4 Å and c_{hex}= ~21 Å. The structural formula of the group is: $^{XII}A^{VI}B^{VI}C_{18}{}^{IV}T_2(\Phi)_{38}$, where ^{XII}A = Ba, K, Pb, Sr, La, Ce, Na, Ca; ^{VI}B = Mn, Y, U, Fe, Zr; $^{VI}C_{18}$ = Ti, Fe, Cr, Nb, V, Mn; $^{IV}T_2$ = Fe, Mg, Zn; Φ_{38} = O, (OH), F; the cations known to dominate in natural samples are underlined. This formula allows describing a great variability for the compositions of the mineral, and only Ti and Fe are systematically present. Crichtonites may contain water as hydroxyl and small amounts of fluorine. Hence, it is not possible to calculate Fe^{2+}/Fe^{3+} ratios in crichtonites reliably from the electron microprobe analysis, and the definition of the correct chemical formula requires independent measurement of the Fe^{2+}/Fe^{3+} ratio and/or water content.

In general, the chemical composition of the crichtonite group minerals shows a close relationship to the geological environment of formation and appears to be controlled by several factors: for example, (1) high-pressure is required for enabling very large cations such as Ba and K to enter the ^{XII}A-site; (2) oxygen fugacity controls the Ti/Fe ratio in the ^{VI}C-site: Ti content ranging from 10 to 16 apfu are record environments ranging from oxidized to reduced; (3) low sulphur fugacity favours the incorporation of chalcophile elements (^{XII}A = Pb, ^{IV}T = Zn); (4) the host rock trace elements signature (Nb, Cr, V, Mn, Mg) may be reflected in the composition of the crichtonite-group minerals and (5) factors such as high-temperature and low-SiO_2 contents for ^{VI}B = Zr

Crichtonites are divided into two genetic groups: magmatic & metamorphic. The magmatic group distinguishes three petrological subdivisions (syenites, granites, ultrabasic rocks) comprising five mineral sub-groups: mathiasite, loveringite, davidite, landauite and an unnamed subgroup; these subgroups contains 6 named species and 4 new species. Genesis of crichtonites in the magmatic group is mainly pegmatitic, but also metasomatic over wide ranges of physico-chemical conditions. The metamorphic group comprises only one sub-group (senaite) containing 5 species (senaite, gramaccioliite-(Y), cleusonite, crichtonite, dessauite-(Y) and a new species). All of the chemical compositions in the literature fit into the classification.

CRICHTONITE GROUP								
		SUB-GROUPS	SPECIES	^{XII}A	^{VI}B	$^{IV}T_2$	$^{VI}C_{18}$	$(\Phi)_{38}$
ULTRABASICS	**MAGMATISM ± metasomatism**	**Mathiasite sub-group** Mantle K-metasomatism (Kimberlites, and as inclusions in diamond). (High-T, very high P)	Mathiasite	(K, Ba, Sr)	Zr,Fe	$(Mg, Fe)_2$	$(Ti, Cr, Fe)_{18}$	O_{38}
			Lindsleyite	(Ba, K)				
		Loveringite sub-group Ultrabasic intrusions metasomatism, Ca-rich evolved residual melts	Loveringite	(Ca, TR)	Zr,Fe	$(Mg, Fe)_2$	$(Ti, Fe, Cr, Al)_{18}$	O_{38}
			Unnamed	(La, Ce, Ca)				
GRANITES		**Davidite sub-group** Granodiorite, granite, alkali-granite & syenite pegmatites. High-T-granulite metamorphism	Davidite-(La) *yttro-, urano- types*	(La, Ce)	U,Y	$(Fe, Mg)_2$	$(Ti, Fe, Cr, V)_{18}$	$(O,OH, F)_{38}$
			Davidite-(Ce)	(Ce, La)	Y,U			
SYENITES		**Unnamed sub-group** Carbonatite-alkaline rocks pegmatites & metasomatism	Unnamed	(Sr, Ba, Pb,Ca)	Fe,Mn,Sc	$(Fe, Zn)_2$	$(Ti,V,Fe,Nb)_{18}$	$(O,OH)_{38}$
			Unnamed	(Ba, Sr, Pb)				
		Landauite sub-group Alkali-granite, syenite pegmatites	Landauite	(Na, Pb)	Mn, Y	$(Zn, Fe)_2$	$(Ti, Fe, Nb)_{18}$	$(O,OH,F)_{38}$
			Unnamed	(Pb, Na)	Y, Mn			
	METAMORPHISM	**Senaite sub-group** Greenschist metamorphism (300-500° C, 2-8 kb). Diverse geological contexts: hydrothermal veins, fissures, schists, gneiss, and marbles.	Senaite	(Pb, Sr, Ba)	Mn,Y,U	$(Fe, Zn)_2$	$(Ti,Fe,Cr,V)_{18}$	$(O,OH)_{38}$
			Gramaccioliite-(Y)		Y,Mn,U			
			Cleusonite		U,Mn,Y			
			Crichtonite	(Sr, Pb, Ba)	Mn,Y,U			
			Dessauite-(Y)		Y,U,Mn			
			Unnamed.		U,Mn,Y			