FURTHER DATA ON THE NATURAL ASSOCIATION OF Ca-ZEOLITES

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It is well known that COOMBS (1960) have advocated the possible stability fields of some Ca-zeolites. Later, SEKI (1969) have refined them, adopting further data from some metamorphic rocks of the lower grades in Japan. Stability fields of wairakite and laumontite have been determined by LIU and ERNST (1969) above 500 bars P_{fluid} as equilibrium fields and synthesis field of wairakite using non-quenchable Morey bomb have been determined by HARADA *et al* (1969) at temperatures between 200°–300°C and under P_{vapor} lower than 300 atms. In the present report the writer intend to add some Ca-zeolites on the stability fields proposed by SEKI (1969) from the following viewpoints (Figure 1).

1) SEKI *et al* (1969) found stilbite associated with mordenite in the metamorphic terrain of Tanzawa mountains, central Japan. In his study on the vein minerals CROOK (1961) found heulandite in the burial

depth deeper than the zone of stilbite. Moreover, he stated that heulandite did not found closely associated with stilbite in a single vein of Tamworth and Parry Group, N. S. W. (*Personal communication*). Stilbite is considered to be stable at lower temperature and pressure than heulandite (HARADA and TOMITA, 1967 and HARADA, 1968). In the light of the above, the present writer puts the stability field of stilbite on the lower p - T side of the heulandite field. Furthermore, HARADA and TOMITA (1967) found the specimen closely associated with stilbite, heulandite and laumontite from Onigojō, Mië, Japan, and the specimen shows the sequence of crystallization, laumontite → heulandite → stilbite in a cavity of Miocene granite-prophyry indicating possible decrease of temperature during their crystallization. Figure 1 shows the association of stilbite and laumontite. In fact, NAKAJIMA and TANAKA (1967) found stilbite-laumontite-quartz assemblages in the veinlets of Cretaceous Izumi Group, Southwest Japan.

2) ERD *et al* (1966) found yugawaralite closely associated with stellerite (a valid orthorhombic end member of a continuous series with monoclinic stilbite) from Chena Hot Springs area, near Fairbanks, Alaska. The hand specimen of this yugawaralite and stellerite is covered by very minute crystals of quartz. At the type locality (Hudōnotaki, Yugawara Hot Spring), yugawaralite is closely associated with laumontite and quartz (HARADA *et al*, 1969). In his study on the drill core of Onikōbe active geothermal area, SEKI (1968) found yugawaralite in the intermediate zone (probably intermediate p - T) between the laumontite and the wairakite zones. SEKI *et al* (1969) also found yugawaralite closely associated with wairakite and laumontite in the Tanzawa mountains. Wairakite and yugawaralite in this terrain are in higher metamorphic grade than laumontite (SEKI *et al*, 1969). According to the data mentioned above, the following mineral assemblages bearing yugawaralite and quartz are probable; laumontite-yugawaralite-quartz, stilbite (stellerite)-yugawaralite-quartz, and wairakite-yugawaralite-quartz. Thus, the stability field of yugawaralite can put intermediate site between laumontite (and/or stilbite) and wairakite, regarding to temperature. They should be shown in broad line, because they are not truly polymorphic. At the near

Fig. 1. Possible stability fields of Ca-zeolites proposed by SEKI (1969) and phases of yugawaralite ($\boxed{y}$), stilbite ($\boxed{s}$) and chabazite ($\boxed{c}$) are newly added by the present writer. Note: m , mordenite assemblages; c , chabazite assemblages; h , heulandite assemblages; l , laumontite assemblages; w , wairakite assemblages; p , prehnite assemblages; y , yugawaralite assemblages; s , stilbite assemblages

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of the poase-boundaries, stable coexisting of those two or three phases is expected. Furthermore, the broad lines should also mean the possible shift of the stability fields of each phases, because of their relatively large ionic substitutions. In the present state, the stability relations of Ca-zeolites epistilbite and scolecite are unable to discuss owing to their scarce regional occurrences in nature.

3) In Oahu Island, Hawaii, chabazite seems to occur at relatively low temperature (probably nearly 20°C) in the palagonite tuffs under silica under-saturated condition (Iijima and Harada, 1969). It should be interesting to note that Tomita *et al* (1969) had synthesized Na and K forms of chabazite from volcanic glass in the system; glass-Na (orK) OH solution below 100°C. Crook (1963 and *Personal communication*) found the associations of chabazite-stilbite-quartz-chlorite as well as of chabazite and any two of thomsonite, analcime or phillipsite, with phyllosilicate of probably iron-rich saponite Miyamoto 1957; Matsuda and Kuriyagawa, 1965; Yamagishi, 1965; Read, 1968) at the shallower burial depth than analcime-heulandite stage. Thus, we can put the stability field of chabazite in Figure 1.

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