Occurrence of lawsonite in pelitic schists from the Sanbagawa metamorphic belt, central Shikoku, Japan

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Abstract. The occurrence of lawsonite is described from pelitic schists of the lower-grade part of the pumpellyite-bearing subzone of the chlorite zone in the Asemi River area of central Shikoku. The lawsonite-bearing parageneses are consistent with the generally accepted view that the Sanbagawa facies series represents higher pressures than the lawsonite-bearing facies series in New Zealand.

Key-words: Japan; lawsonite; pelitic schists; Sanbagawa metamorphic belt

INTRODUCTION

Within the Sanbagawa metamorphic belt, lawsonite is known from the central Kii peninsula and eastward. It has been described mostly from greenstones (Asai, 1949; Seki, 1957, 1958; Seki, Aiba & Kato, 1959; Hashimoto, 1960; Hada, 1967; Isogai, 1977) and rarely from metacherts and pelitic schists (Seki, 1958). Metamorphic zonation using lawsonite in greenstones as an index mineral has been attempted, but is currently not used (Banno, 1980). This note reports the occurrence of lawsonite in pelitic schists of the chlorite zone in the Asemi and adjacent areas (Fig. 1).

OUTLINE OF METAMORPHIC ZONING IN CENTRAL SHIKOKU

On the basis of the mineral parageneses in pelitic schists, three metamorphic zones, i.e., chlorite, garnet, and biotite zones with increasing grade, are widely accepted in central Shikoku (Banno, Higashino, Otsuki, Itaya & Nakajima, 1978; Brothers & Yokoyama, 1982; Enami, 1983). The chlorite zone is divided into pumpellyite-bearing and pumpellyite-free subzones based on the parageneses present in mafic schists. Pelitic schists derived from chert–laminite (Yoshida, 1981) are the predominant lithofacies in the chlorite zone, accompanied by small amounts of basic and siliceous schists. Stable mineral assemblages, excluding lawsonite, in rocks of the pumpellyite-bearing subzone of the chlorite zone are as follows: phengite–carbonaceous material–quartz–albite–chlorite–epidote–calcite–sphene–pyrite in pelitic schists; epidote–chlorite–actinolite–pumpellyite–albite–quartz–calcite–sphene–pyrite in hematite-free basic schists; and, epidote–chlorite–winchite–albite–quartz–calcite–sphene–hematite in hematite-bearing basic schists (Higashino, Sakai, Otsuki, Itaya & Banno, 1981).

MODE OF OCCURRENCE OF LAWSONITE AND PETROGRAPHY

Localities where lawsonite-bearing pelitic schists are found in the Asemi River area are shown in Fig. 1. Under the microscope, fine-grained lawsonite (0.01–0.05 mm in length) is distinguished from phengite by its negative elongation, higher refractive indices and stout prismatic habit. Lawsonite occurs in most of the pelitic schists collected from the lower-grade parts of the pumpellyite-bearing subzone in the studied area. A representative microprobe analysis of the lawsonite performed with a slightly defocused beam is shown in Table 1. The slightly low total is probably due to the fine-grain size of the mineral. The iron content is as low as the lawsonite which occurs in quartzofeldspathic schists of the Sangun metamorphic belt (Watanabe, Kobayashi & Sengan, 1983), but slightly lower than that occurring in some Franciscan metagraywackes (Ernst, Seki, Onuki & Gilbert, 1970). The following representative X-ray powder diffraction peaks of lawsonite are recognized: 6.58 Å(020); 2.73 Å(141); 2.62 Å(240), (301); and, 1.55 Å(460).

The pelitic schists always consist of two compositional layers, either quartz-rich or phengite-rich. If calcite is present in the schists, the quartz-rich layer is further divided into two: a coarse-grained quartz-rich layer, containing

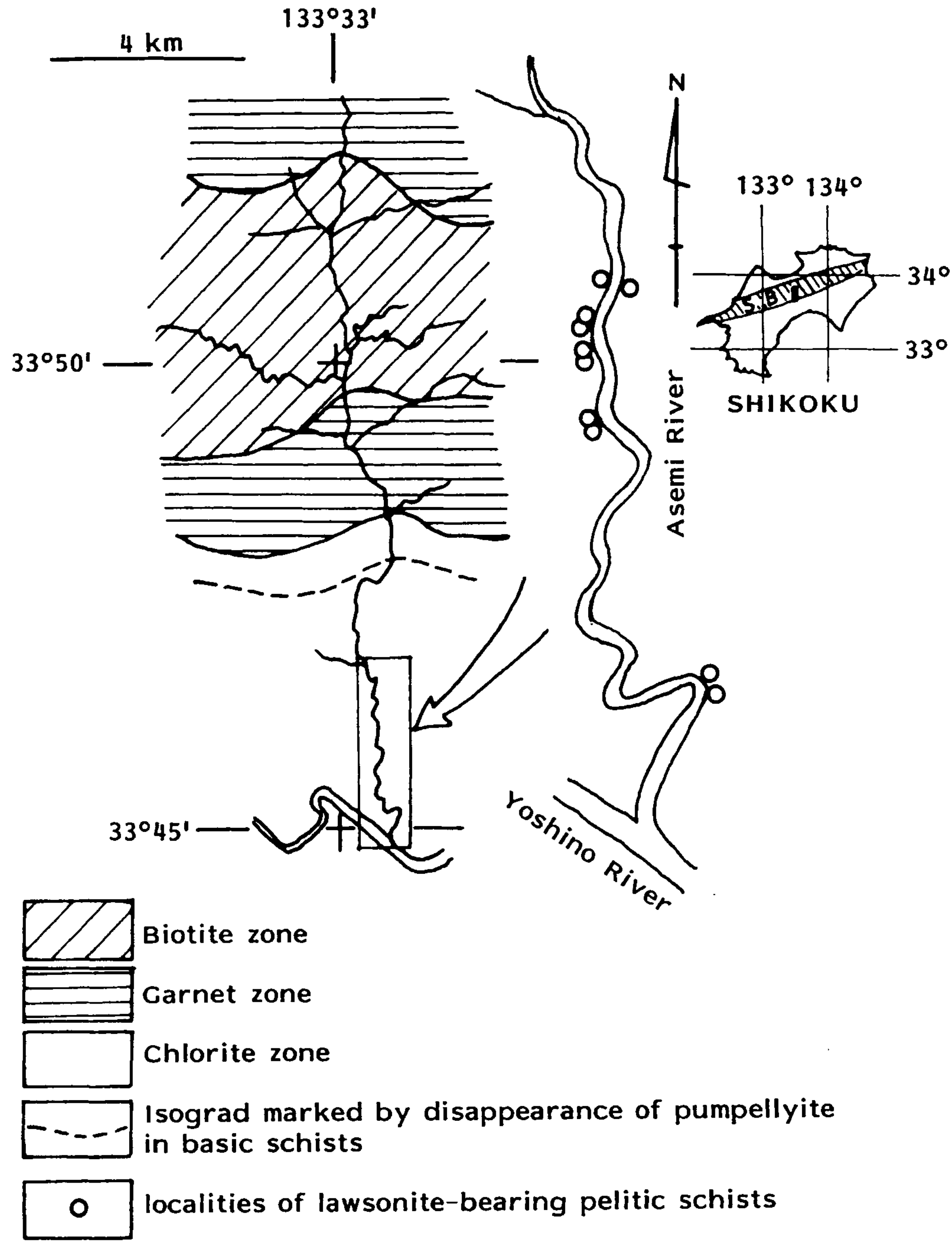

Fig. 1. Map showing localities of lawsonite-bearing pelitic schists along the Asemi River. Metamorphic zoning is based on Banno *et al.* (1978). SB: distribution of the Sanbagawa metamorphic belt in Shikoku.

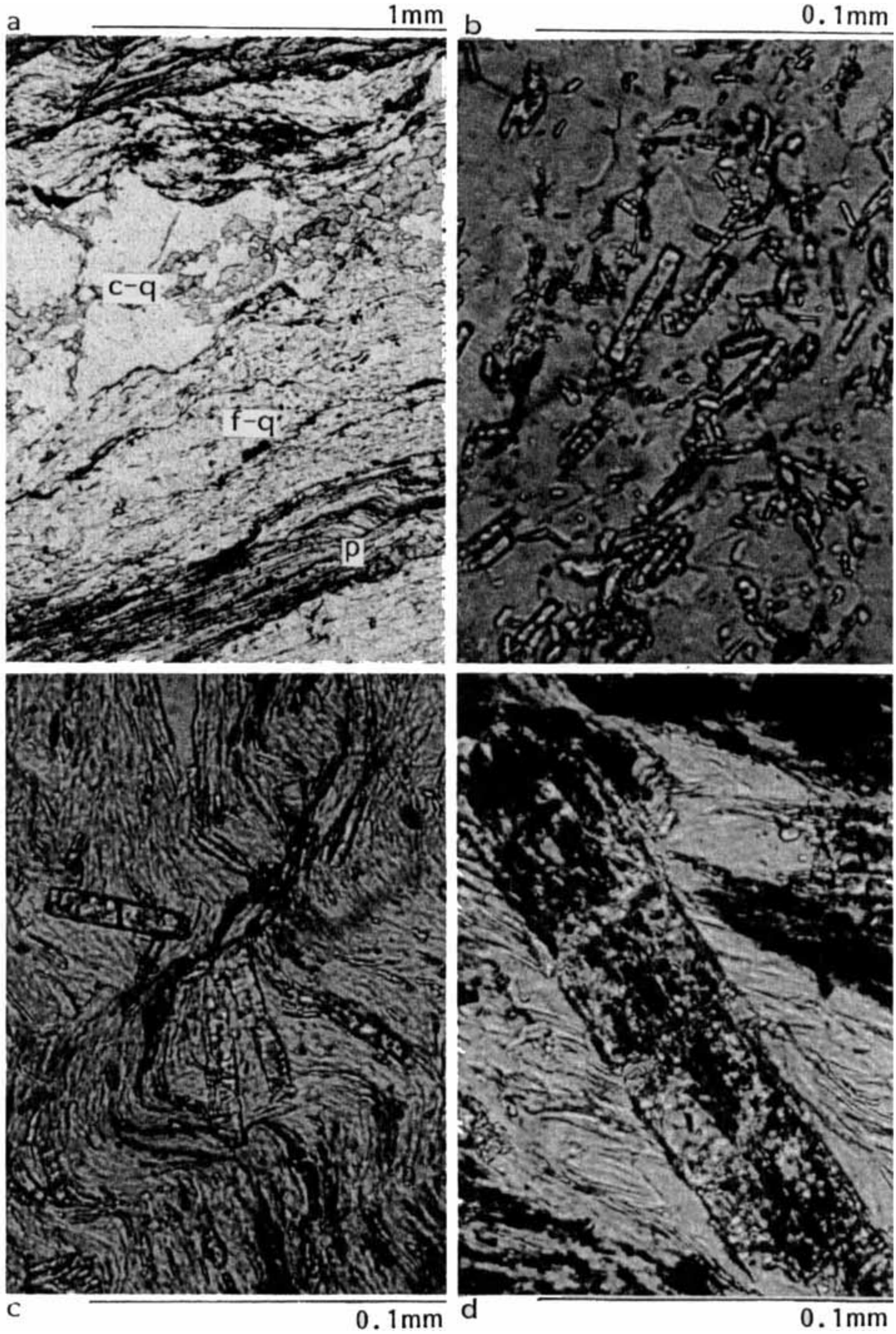

Fig. 2. (a) Photomicrograph showing the occurrence of a coarse-grained quartz-rich layer containing calcite(c–q), a fine-grained quartz-rich layer(f–q), and a phengite-rich layer(p). The latter two parts contain lawsonite (sample number 815504). (b) Lawsonite in fine-grained quartz-rich layer (sample number 815502). (c) Lawsonite in phengite-rich layer (sample number 815502). (d) Comparatively coarse-grained lawsonite in a rock rich in carbonaceous materials (sample number 82112510).

Table 1. EPMA analysis of lawsonite

	Lawsonite	
$ASiO_2$	38.20 wt %	cation ratio
TiO_2	0.09	Ca = 1.000
Al_2O_3	31.57	Al + Fe = 1.977
Fe_2O_3	0.20	Si = 2.080
CaO	17.36	
Total	87.42	
expected H_2O	(11.50)	

H_2O is calculated on the basis of mineral formula.

calcite, quartz, and minor albite with rare phengite and chlorite; and, a fine-grained quartz-rich layer, containing quartz, albite, and minor phengite and lawsonite with rare sphene and anhedral pyrite. Euhedral pyrite may also occur in the coarse-grained quartz-rich layers, which are separated from the fine-grained quartz-rich layers, and which are composed of quartz, pyrite and minor chlorite. Boundaries of the coarse-grained quartz-rich layers against the fine-grained quartz-rich layers and the phengite-rich layers are sharp (Fig. 2a). Lawsonite occurs only in the latter two parts (Fig. 2b and c), but never in the coarse-grained quartz-rich parts containing calcite or euhedral pyrite. Relatively coarser-grained lawsonite occurs in black pelitic schists rich in carbonaceous materials (Fig. 2d), of which $C/(C+H+O)$ ratios are approximately 0.83–0.89 (Higashino *et al.*, 1981). A small amount of epidote occurs in some lawsonite-bearing pelitic schists, but epidote and lawsonite are never in contact with each other. The closest approach between them is about 0.4 mm. We therefore conclude that lawsonite does not coexist with epidote. Pumpellyite does not occur in the pelitic schists in the studied area. Jadeite and aragonite are absent. The restricted occurrence of lawsonite as shown in Fig. 1 suggests that the lawsonite-bearing assemblages may have broken down at lower temperatures than the breakdown of pumpellyite in basic schists. According to the stability relationship between lawsonite and pumpellyite of Brown & O'Neill (1982), the lawsonite was formed at less than 6 kbar and less than 350 °C. The lawsonite-bearing assemblages in the Asemi River area, as well as those of the Sangun belt (Watanabe *et al.*, 1983), occur in the actinolite stability field for basic schists, but in New Zealand the lawsonite zone is located on the lower-grade side of the actinolite zone (Coombs, 1960; Landis, 1971; Kawachi, 1975). As the stability field for lawsonite + albite shifts to lower temperature with decreasing pressure, the current notion that the Sanbagawa and Sangun lawsonite-bearing assemblages were formed under higher pressure conditions than those of New Zealand is supported.

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