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Chert with Sandstone Layers and Lumps

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In the previous papers the senior author discussed that most, if not all, bedded chert would have been derived from deposits principally consisting of broken particles of siliceous skeletons of marine organisms such as sponges and radiolarians, of them the former being usually predominant (IMOTO & SAITO, 1973; SAITO, 1977). Consequently, the original material of bedded cherts are to be regarded as extra-fine-grained clastic sediments, from the stand point of local sedimentation. In many cases, etched surfaces of bedded cherts show various internal and external sedimentary structures such as parallel lamination, cross lamination, grading, cut- and fill-structure, micro-slumping, load cast- and sole-marking like structure which are all common in the ordinary clastic sedimentary rocks (IMOTO *et al.*, 1974; IMOTO & FUKUTOMI, 1975; SAITO & SEKINE, 1976, 1977).

Having examined the Paleozoic rocks came from the southern Kitakami region, northeast Japan, we found a specimen giving another evidence for the clastic nature of chert. In this paper, we intend to give the results of microscopic and scanning electron microscopic observations of the specimen concerned. The rock examined (NSM Petrological collection No. 103347) was collected at the point about 2 km southeast of Omori, Ofunato, Iwate Prefecture, and presented to the National Science Museum by Prof. R. SUGISAKI of Nagoya University.

The rock is fine-grained and shows lamination being composed of pale green and dark grey layers. The lamination is frequently distorted and the two differently colored parts intermingled with each other, particularly along the boundary between them. In pale green part small rounded or lenticular patches of dark material are embedded. On the other hand, dark grey part contains many irregularly shaped or thinly elongated patches of pale green stuff. Usually the boundary between these two parts is not vague but is distinctly recognized even by the naked eyes.

In thin section we can find that the pale green part is chert and the dark grey part is fine-grained sandstone. The chert is not so pure but contains a considerable amount of clay material. However, a number of radiolarian tests showing circular outline and spicules of sponge with rod-like appearance are visible under the microscope (Fig. 1a). On the other hand, the organic fragments are rarely observed in sandstone part consisting of ordinary clastic grains of quartz, feldspar, heavy minerals, lithic fragments and clay matrix (Fig. 1b). As recognized by the naked eyes, the above-mentioned two kinds of material, cherty and sandy, are not highly

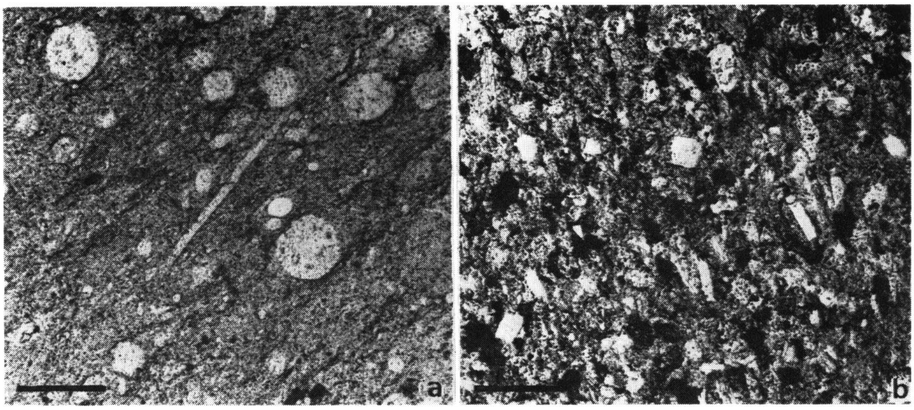

Fig. 1a. Cherty part showing well preserved radiolarian tests and sponge spicule (centre). Polarizer only. Bar: 0.1 mm

Fig. 1b. Sandy part showing ordinary sandstone texture. No organic remain is visible in the field, although the sandy part includes a quite few radioralians and spicules. Polarizer only. Bar: 0.1 mm

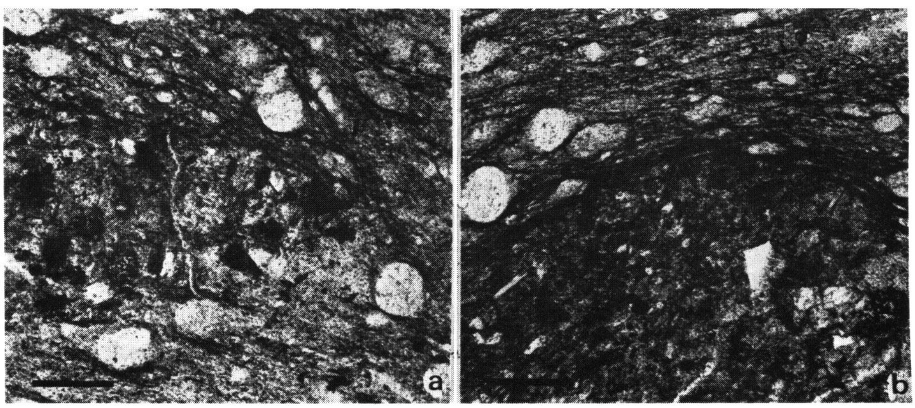

Fig. 2 a, b. Wavy and flowing structure of clayey matrix surrounding sandstone lumps in chert. The circular outlines of radiolaria are neither deformed nor distorted. Polarizer only.
Bar: 0.1 mm

mixed up but form fairly clearly separated parts. Furthermore, sandy patches in chert are observed to be surrounded as if they are wrapped with the latter showing wavy and flowing structure. But even in such cases, radiolarian tests in the surrounding chert are not deformed and retain their circular outlines (Fig. 2a and 2b).

As will be discussed later, it is highly important, concerning to the origin of chert, to point out here that the mixing of cherty and sandy parts in this rock has never been

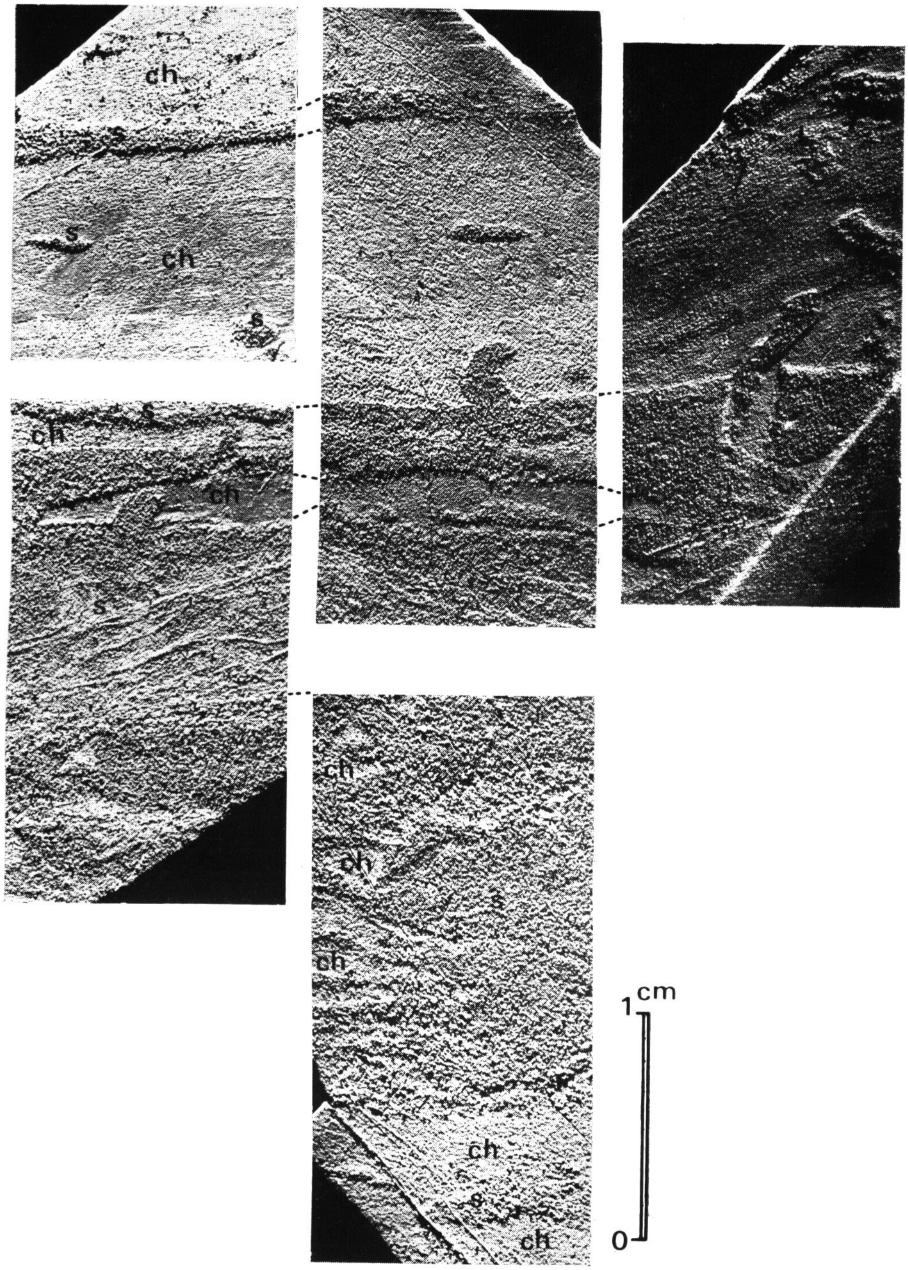

Fig. 3. Etched surface vertical to the bedding plane. Ch: cherty part, S: fine-grained sandstone.

resulted from any tectonic transformation but may have taken place under the ordinary sedimentary conditions or at the utmost by small-scale intraformational disorder.

Some selected etched surfaces normal to the bedding plane are shown in Fig. 3. It shows a thin alternation of chert and sandstone, but its appearance is different from ordinary bedded chert. Occasionally parallel and contorted laminations are partly developed in the chert and sandstone, respectively. The grain-size gradation cannot be observed. As shown in the figure, chert has intercalations of thin sandstone layers and contains many small lumps of sandstone. Isolated sand grains are sometimes observed in the chert part. On the other hand, the sandstone intercalated with a thin lens of chert contains many small lumps of chert. Also spicules and radioralian tests are isolatedly contained in the matrix of sandstone. The latter of them is not fractured but maintain rather well their original shapes. Such features as the internal structure above-mentioned indicate that the distortion and mixing of sandy and cherty sediments were performed before their lithification in the time when their mechanical properties were not so different from each other. This suggests that the formation of the chert could not be resulted from the condensation of colloidal particles of silica, for such chemical deposit has to be strikingly different from sandy one in physical nature. If the chert layers were formed from the condensation of colloidal silica, sedimentary environment must have been calm, and contortion and mixing of sediments must have not occurred. It is considered that the mixing of chert and sandstone may have soon taken place after the deposition because such distorted texture or structure can not be deformed one accompanied with compaction after burial.

On the etched surface of the chert radiolarian skeletons and siliceous sponge spicules are exposed under the scanning electron microscope, although the preservation of their shapes is not so well (Fig. 4). The interstice between radiolarians is filled up with the spicules and their fragments. Most of the spicules are broken into smaller fragments, but relatively thick ones are well preserved (Fig. 4b). Most thinner

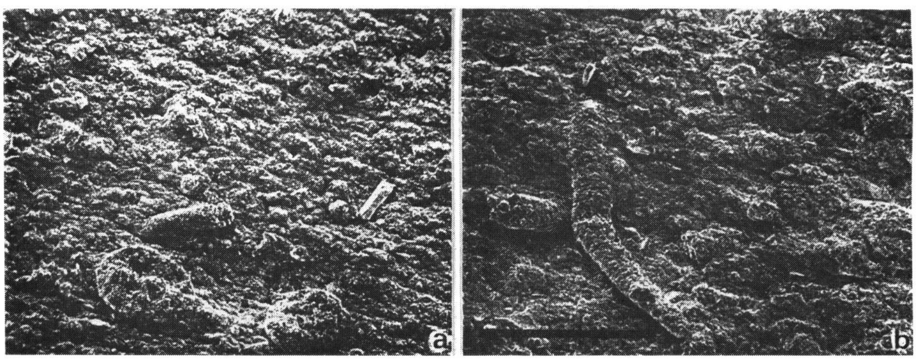

Fig. 4. Scanning electron micrograph of the cherty part. Bar: 0.1 mm. a: fragmentary siliceous sponge spicules with radioralian tests, b: interstice between radioralian tests.

spicules in the deposit probably have been destroyed by fracturing at the time of deposition and by dissolution in diagenesis. Consequently, the cherty part represents the siliceous spicule deposit with radiolarian tests, and the source of silica for cherty deposits is biogenous.

All the described structural and textural features of the examined chert-sandstone rock are explained by the following sedimentary and diagenetic processes. The chert as well as the sandstone were deposited side by side as clastic powdered materials, although they formed the respective layers originally separated from each other. When both materials were not sufficiently hardened yet, local disturbance took place and resulted in the slumping-like structures along the boundary. But organic remains as well as sand grains were neither deformed nor strained. The finer clayey material alone showed plastic flow particularly arround the radiolarian tests and the slightly indurated sandy lumps. If we consider colloidal silica, which must be fairly viscous as compared with sea water in the sediments, as the original material of chert, it would be very difficult to explain the above-described features of the chert-sandstone mixture.

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