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A NOTE ON THE CRETACEOUS IZUMI GROUP

Minoru SAITO and Yuji BANDO

Introduction and Acknowledgements

The Cretaceous Izumi Group which stretches in belt form from west to east in Ehime and Kagawa Prefectures in the northern part of Shikoku has been studied as to its geology and paleontology by many authors, but very little is known concerning the sedimentary structures of its different parts. For this reason the writers wish to make note of several of the sedimentary structures observed by them at several localities and in different parts of the Izumi Group with the view that their interpretation may contribute to the knowledge on the conditions under which the stratigraphical unit was deposited.

Although this note is merely preliminary to the survey planned to be undertaken it is thought worthy in that it may contribute to the knowledge concerning the conditions of the sedimentary basin in which the massive sandstone was deposited and also serve in interpreting some of the many problems known to date.

At this place the writers wish to thank Professor Kotora HATAI of the Institute of Geology and Paleontology, Tohoku University, for his kindness in the field and laboratory concerning the present study.

Gesho, MiKi-cho, Kida-gun, Kagawa Prefecture

In the small valley of Gesho, MiKi-cho in Kagawa Prefecture, there was observed alternating layers of bedded sandstone with intercalated thin dark shaly layers. These alternating layers of sandstone are well graded and form many cycles, each of which is incomplete in lacking the lutite deposits which, in a complete cycle, would occur in the uppermost part. The sandstone are grayish in color, medium grained in the larger part and coarse in the lower. The lower coarse part may sometimes incorporate pebbles of chert or slate derived from the Paleozoic System and in the upper finer part detached shale fragments which originally are considered to have been part of the lutite.

The graded sandstone layers are noteworthy for the many interesting structures they preserve such as many problematica resembling burrows of marine annelids, soft rock pebbles and fragments, strings and slices of dark colored lutites, very small scale cross-laminations, apparent flowage sands and distortion features. These features are considered to be important in the interpretation of the conditions under which the sands were deposited and also of the sedimentary basin. These sands attain a great thickness and make up the large part of the Izumi Group. These features will be described in the following lines and their interpretation in later ones.

The sandstones as already mentioned consist of graded deposits interpreted to be due to turbidity currents and therefore comprise turbidites. These graded sands occur in cycles measuring from 20 to more centimeters in respective thickness, and interesting is that the lutite deposits which generally form at the uppermost are generally lacking and when present usually ill-developed. This indicates that the turbidity currents were succeeded one after the other whereby there not sufficient time for the deposition of the suspended lutites.

The conditions necessary for the occurrence of repeated turbidity currents may be varied and among them the rising of the hinterland and migration of the sedimentary basin may be important although it is understood that other causes could be sufficient for their development. Whatever the real cause be it is certain that the instability of the sedimentary environment may have had intimate relationship.

The graded deposits after deposition were subjected in many cases to subsequent or continual movement

by flowage as is evidenced from the upper part of one cycle laterally and sometimes also upwards grading into another cycle or even extending in tongue-like aspect laterally, obliquely or at any other angle into the next cycle. Also various concentric ridges and small grooves extending in fan-shape in the direction of the slope, presenting a remarkable wavy undulating and irregular upper surface due to lateral flowage of the water-saturated sand mass downslope. Also another evidence is the irregularly and scaly breaking of the apparent massive graded sands when struck with a pick.

Other features proving the same phenomenon is that strings and streaks of lutite occur in different levels in a cycle of the graded sands. These strings or streaks of lutite show pinching, thinning out or differences in thickness towards the downslope. Also rarely there can be observed the curling, bending, detaching, pinch-and-swell structures of the lutite strings to be unidirectional in many cases, and the direction is towards the downslope. Also the development of minor cross-laminations within the graded sands, all unidirectional as are the elongated sandy patches appear to have the same significance.

Although the sand layers are significant as already mentioned it is interesting to notice that megafossils have not been reported from them, and this is because they are turbidites. The continuous traction flow in the lower parts of the turbidity currents, suspension sediments in the tail portions and partially suspended deposits in its middle parts should be a very unfavorable condition for the living of both micro and macro-organisms and also for their larvae to settle. Since the sediments are deposited rapidly the conditions would be unfavorable for burrowing, crawling or benthonic animals because of the difficulty in obtaining food and the unstability of the sea-bottom.

Most interesting is the occurrence of numerous pipe-like structures in the lower parts of the turbidites especially near the lower parts of the Izumi Group (Pl. 1, Figs. 1—4). These pipe-like structures are circular in cross-section, elongated, straight to variously curved along their length, sometimes with a swollen or bulge near the middle of their length and more frequently without such expanded portions. These structures are usually about two to two and a half centimeters in diameters and ones measuring up to about 30 centimeters in length have been observed in the field. Observed in detail it is noticed that their surfaces are sometimes with weak concentric rings, weak more or less obscure inverted v-shaped ridges having the wings extending alternately and in general no distinct sculptures can be noticed. The true nature of such problematica should be retained for future study because of the difficulty of obtaining good specimens. But here it may be added that at least three distinct types can be distinguished among them, these are, one with concentric sculpture, another with inverted v-shaped sculpture with the ridges of the respective wings alternately developed, and the third in which there is developed an expanded, swollen or bulge in the middle of the length of the pipe-like structure.

From the features of the pipe structure it may be necessary to make three interpretations, one for each of the three types. But as stated that if these represent some kind of a marine annelid, then it may be accepted that their living in such an environment was not altogether a favorable one because they do not occur in still higher horizons. But their shapes and occurrence suggest strongly their endurance to rather diverse conditions.

Considering from the features above mentioned it may be worthy to give an interpretation of the sedimentary environment of the graded sandstone layers. It is thought that the graded sandstones which are typical of the Izumi Group were deposited by turbidity currents and therefore represent turbidites. These turbidites deposited by turbidity currents have developed on their lower or undersurface numerous load casts, striations and sometimes also grooves, whereas their upper surfaces strongly suggest movement after being deposited in having wrinkled fan-shaped structures, irregularly undulating or wavy surface, show apparent churning. These features indicate that there must have existed a slope along which movement of the deposited sand continued even after settling from the turbidity currents. Since, incomplete

graded deposits occur in succession making a thick sequence, it is also certain that the conditions necessary for the making of so repeated layers must have been the instability of the sedimentary basin and also of the hinterland which is the chief source of the clastic sediments. In other words it can be postulated that the uplifting hinterland assisted with rapid erosion was the chief cause for producing abundant clastic deposits, and the instability of the sedimentary environment favored the development of the graded deposits, whatever the trigger causing the turbidity currents may have been.

Nakato, Kotonami-mura, Nakatado-gun, Kagawa Prefecture

The outcrops along the Doki River below Nakato, Kotonami-mura, Nakatado-gun, Kagawa Prefecture, exposes abundant oyster shells incorporated in turbidites chiefly graded sands (pl. 1, Figs. 5, 6). These oyster shells are detached, complete to broken, horizontal to vertical in position, upper or lower valves facing downwards, accumulated but not crowded, occur in more or less restricted masses, have rather even lower but very irregular upper surfaces and are not continuous within the deposits in which they occur. These features strongly suggest that they were transported from their original habitat which was the neritic zone near to the coast-line by turbidity currents to their place of burial. The shells are not broken as seen in the shells accumulated in shallow water by the influence of agitating waves and all still preserve the details of surface sculpture and the majority are still intact. The matrix filling the spaces between the oyster shells consist of graded sands.

The occurrence of oyster shells derived from the inner neritic zone clearly points to the origin of the turbidity currents and also illustrates the transporting power of the turbidity currents which instead of eroding the shells preserved them *in situ*.

Sea-coast of the Naruto Park, Naruto City, Tokushima Prefecture

Good outcrops of the Izumi Group are found along the sea coast below the Naruto Park in Naruto City, Tokushima Prefecture (Pl. 2, Fig. 6 — 8, Pl. 3). Here the sandstones of the Izumi Group are mostly graded and ill-development of lutites can be observed. That these turbidites are typical is easily recognized from the development of the graded sands, lutites, abundant sedimentary structures in association, common occurrence of rubble conglomerates which are distributed from the vicinity of the Naruto Park in Tokushima Prefecture westwards along the northern sea-coast of Tokushima Prefecture. Also observed pebbly mudstones and pebbly sandstones of turbidity current origin. Another striking feature is the abundant occurrence of graded sandstone layers in which are incorporated lutite flakes, soft rock pebbles and on the undersurfaces of the sandstone layers are found good development of flow markings or flute casts. The incorporation of erratic cobbles in the graded sands is noticed at several localities.

A marking feature is the occurrence of completely overturned detached layers, bent-chunks and scrambled muddy sediments in which are found variously oriented detached portions of the sandstone layers. The muddy sediments themselves appear as if somewhat scaly in large scale, variously folded as if due to churning and together with the sandy layers show often a slump structure. Minor convolutions is also not rare. Thus in the cliffs below the Naruto Park there can be observed rather large scale slumping structures with the features above mentioned whereas the undersurfaces of the graded sand layers show various features as of flow markings, flute casts, load casts, striations and groove casts. And with the complete overturning of closed anticlinal fold-structures appearing like major bent chunks aside from the many pull-aparts are all features which characterize rapid deposition upon a sloping sea-bottom.

**Sea-coast between Ushinohana in Tokushima Prefecture and
Hiketa-cho in Kagawa Prefecture**

In this area the Izumi Group is also distributed and from several of its outcrops there could also be observed the development of graded sands, lutites and sedimentary structures on the undersurface of the sand layers as well as within the layers of graded sands. The massive muddy sediments when observed in detail also show evidences of scrambling, the incorporation of small detached portions of the sand layers, soft-rock pebbles and rubble conglomerates, pebbly mudstones and pebbly sandstone layers are not rare.

Detail descriptions of the features observed in this area are planned to be published at another opportunity in parallel with the geology of the area.

From the remarks given in the foregoing pages it is evident that turbidites form a major part of the Cretaceous Izumi Group and without their study it is not expected to know the details of the stratigraphic unit. The overwhelming evidence of rapid deposition by turbidity currents makes it necessary to reconsider the sedimentary basin in which the Izumi Group was deposited and to make a reexamination of the geology of those parts and to find their relation with other parts of the unit in order that our knowledge concerning the Izumi Group be brought to date.

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Explanation to Plate 1

- Figs. 1-4, 8- All from the small valley of Gesho, Miki-cho, Kagawa Prefecture. A typical locality of the Cretaceous Izumi Sandstone.
- Figs. 1, 2, 3- Rather large problematica found in the lower part of the Izumi Group. These probably represent a marine annelid.
- Fig. 4 - Small problematica probably of a marine annelid resembling more or less *Tosahelminthes curvata* КАТТО, described by КАТТО⁽³⁾ (1960) from the Eocene Naharigawa formation in Tokushima Prefecture.
- Figs. 5, 6- Detached oyster shells transported by turbidity currents. All the shells are without definite orientation and occur in a graded sandstone. Loc. - A river cliff at Nakato, Kotonami-mura, Kagawa Prefecture.
- Fig. 7 - Load cast observed in the alternating layers of bedded sandstones intercalated with thin dark shaly layer. Loc. - A cliff at Hirama, Ebara-cho, Tokushima Prefecture.
- Fig. 8 - Sole marking of a graded sandstone layer showing striations.

Explanation to Plate 2

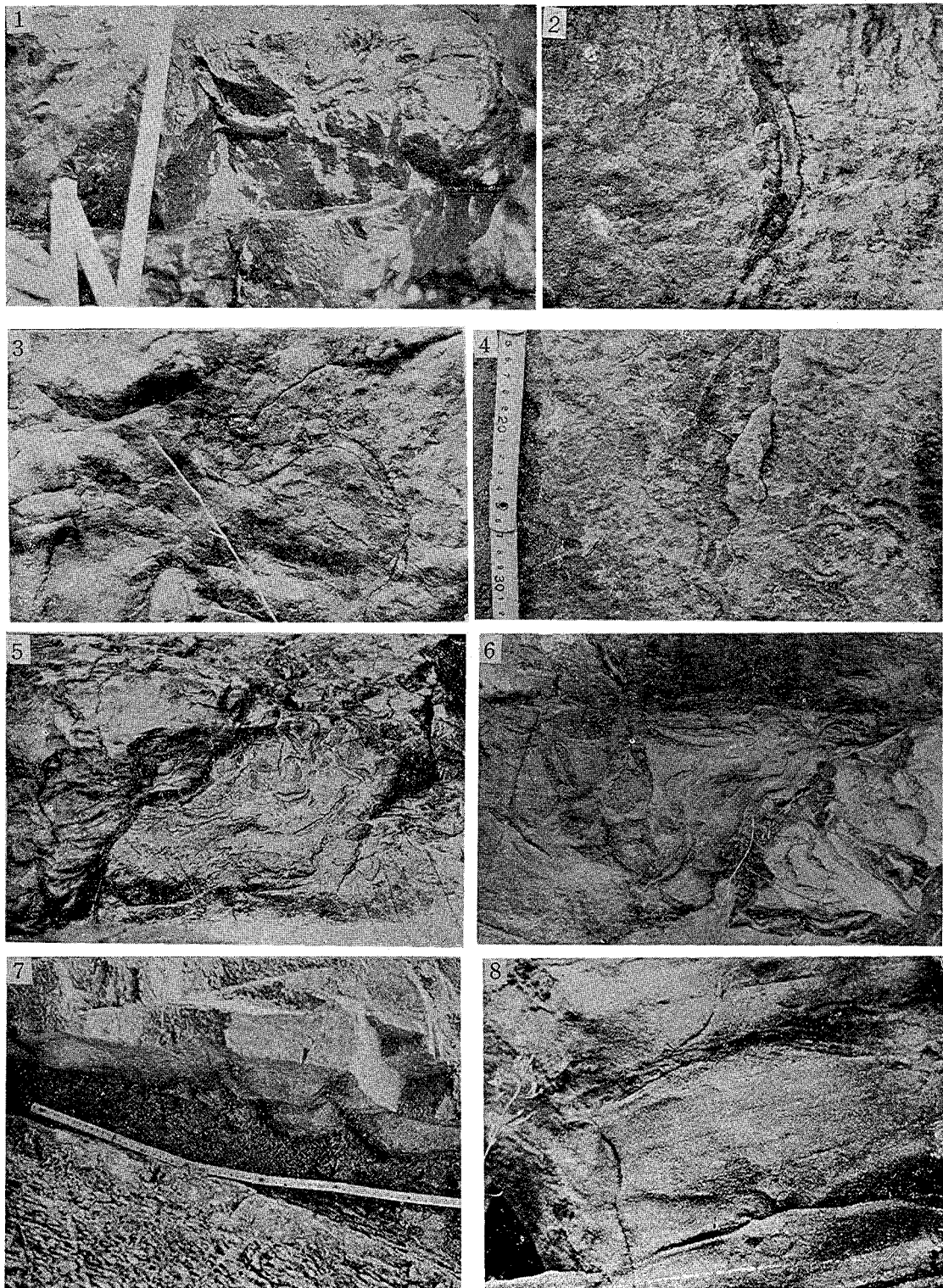
- Fig. 1 - A deformed and rough soft rock pebbles in a graded sandstone. Loc. - A river cliff at Hirama, Ebara-cho, Tokushima Prefecture.
- Fig. 2 - A typical graded sandstone at the locality mentioned above.
- Fig. 3 - Another view of soft rock pebbles in a graded sandstone. Loc. - A cliff at the small valley of Gesho, Miki-cho, Kagawa Prefecture.
- Fig. 4 - Partially rolled load cast on the undersurface of a graded sandstone. Locality same as above.
- Fig. 5 - Patches of lutite in a graded sandstone. Locality same as above.
- Figs. 6-8, - All from the sea cliff below the Naruto Park, Naruto City, Tokushima Prefecture.
- Fig. 6 - Flow marks observed on the undersurface of bedding plane of a graded sandstone.
- Fig. 7 - Deformed aspect of detached snow-balls, pull-aparts and lutite patches in a graded sandstone.
- Fig. 8 - Small pebbles of hard rocks sporadically distributed in the lower portion of a graded sandstone.

Explanation to Plate 3

All from the slumping zone exposed along the sea-cliff below the Naruto Park, Naruto City, Tokushima Prefecture.

- Fig. 1 - Scrambled aspect of sandy mudstone with detached and deformed sandstone and shale fragments.
- Fig. 2 - Completely overturned arenaceous layers in argillaceous sediments. Notice crushed silty sediments in middle or crest of folded portion.
- Fig. 3 - Graded very coarse sediments making significant load casts at base and partially injected downwards into argillaceous sediments which also show incipient convolution.
- Fig. 4 - Folding of layers of argillaceous sandy sediments as if forming a cut anticlinal crest.
- Fig. 5 - Churning of graded sediments which captured a silty fragment.
- Fig. 6 - Aspects of detached sandy layers occurring as pull-aparts but well rounded at margins in silty and graded sediments of the turbidite series.

Plate. 1



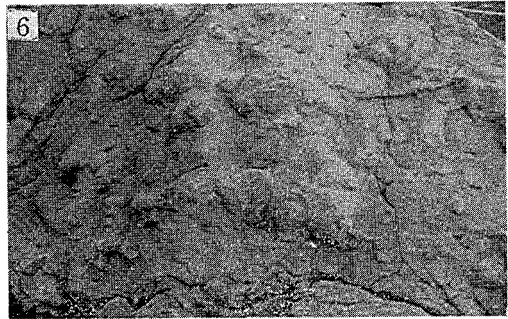
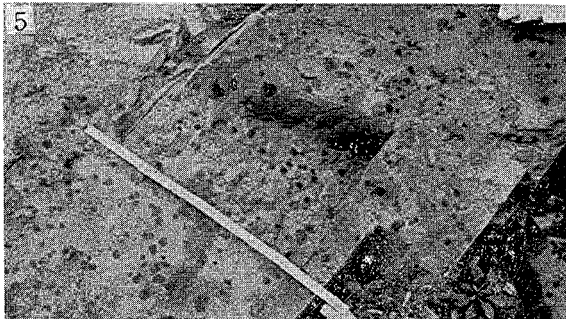
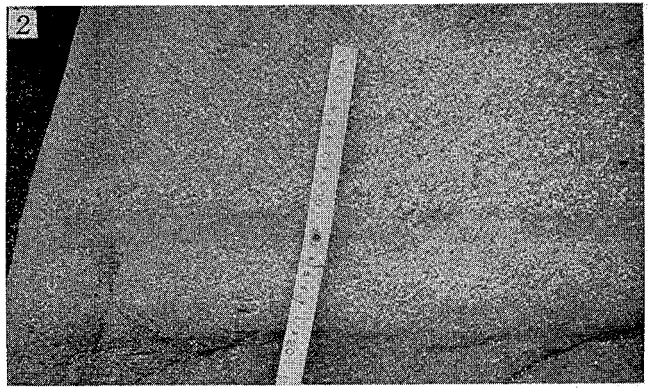
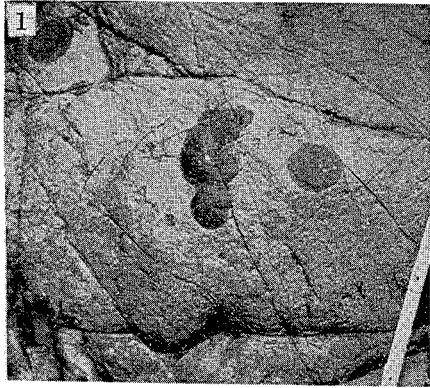
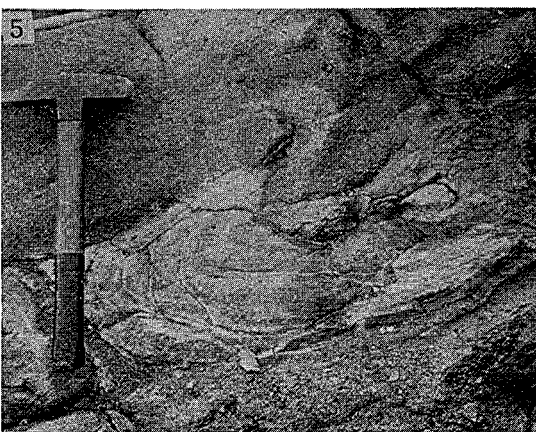
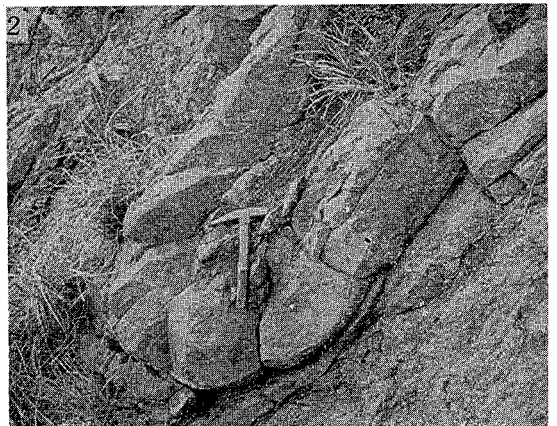


Plate. 3



和泉層群についての二、三の問題

齊藤 実, 坂東 祐司

摘要 四国の北部に、東西に帯状に発達する和泉層群についての地質学的又は古生物学的研究は、数多くなされている。

しかしながらその *sedimentary structure* 及び *sedimentary basin* の状態については、従来あまり検討されていない。筆者らは、かゝる見地から現在調査中であるが、こゝに予報的に幾つかの *sedimentary structure* 及び *problematica* について報告することにした。

そして和泉層群の大部分が *turbidity current* により推積した *turbidite* であり、この研究なくしては和泉層群の詳細な層序を知ることはできないであろうことを指摘した。