Remarks on the Sedimentary Structures Observed in the Older Miocene Marine Formations Developed in Nishi-Murayama and Nishi-Oitama Districts, Yamagata Prefecture, Northeast Honshu, Japan

by

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The stratigraphic sequence of the older marine formations of the Miocene and their relation with the basement rocks of the borderland of the Japan Sea has been considered to be very similar wherever they occur. The general acceptance is that the older marine formations of the Miocene consist of fossiliferous clastic rocks below, which are conformably overlain with hard and less fossiliferous argillaceous deposits above. The former are unconformable with the basement rocks which comprise such as granite, granite porphyry, diorite and Paleozoic sedimentaries or pyroclastics.

The clastic rocks which build the older marine formation consist of sandstone which may range in grain size from very coarse or granular to fine and generally more or less tuffaceous, conglomeratic and may be compact to rather incoherent. The conglomerate contains pebbles that range in size from granule to boulder. The tuff which is sometimes intercalated therein may be agglomeratic, brecciated, pumiceous, coarse to fine. In addition there is also coquina and calcareous sandstone.

These clastic rocks are known to yield abundant marine fossils belonging to the Foraminifera, Porifera, Coelenterata, Brachiopoda, Bryozoa, Echinoidea, Mollusca and others. Among the Foraminifera, *Miogypsina kotoi* HANZAWA and *Operculina complanata japonica* HANZAWA are noteworthy; of the Porifera, *Aphrocallistes* sp. should be mentioned; of the Brachiopoda, *Terebratalia innaiensis* (HAYASAKA), *T. tenuis* (HAYASAKA) and others are common; Bryozoa are abundant, but no work has hitherto been accomplished on them; of the Echinoidea, *Astriclypeus ambigenus* NISIYAMA and *Echinolampas yoshiwarai* P. de Loriol are important. Marine shells are most common and occur widely, of them the following can be mentioned, *Chlamys nisataiensis* (OTUKA), *Patinopecten paraplebejus* (NOMURA and HATAI), *P. kimurai* (YOKOYAMA), *Placopecten akyuensis* (MATSUMOTO), *Ostrea gravitesta* YOKOYAMA, *Anadara abdita* (MAKIYAMA), *Shichiheia yokoyamai* (NOMURA and HATAI), besides many others. *Desmostylus japonicus* TOKUNAGA and IWASAKI is also another interesting fossil, but not of common occurrence. All of the mentioned fossils are neritic in habitat.

The argillaceous deposits conformably overlying the clastics just mentioned consist of hard to flinty siltstone which may intercalate tuffs of variable coarseness and colors, liparite, liparitic tuff, rhyolite, and sometimes the siltstone itself becomes sandy. Fossils are not abundant in the siltstone, but fish scales seem to occur most widely, and less commonly is found the planktonic sponge *Sagarites*. Small

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molluscan shells, impressions of echinoid tests and their spines, fish bones, diatoms and in the basal parts in some areas, plant fragments occur. Whether the argillaceous deposits are neritic or deep water in origin, is a problem to be reserved for future research.

In Nishi-Murayama and Nishi-Oitama districts, where the writers have made field observations, the clastics and argillaceous deposits mentioned above are found to cover the basement of granite, diorite and granite porphyry as will be described in the following lines.

In the vicinity of Arato, Shirataka-machi in Nishi-Oitama-gun, the Shimoyama formation which consists of alternating layers of hard to flinty siltstone intercalating sandstone and liparitic tuff is found to cover directly the basement of granite (Pl. 2, Fig. 1) without the development of coarse clastic and fossiliferous rocks that have hitherto been considered to conformably underlie the argillaceous rocks of the Shimoyama formation. The development of the different rocks intercalated in the formation is remarkable according to area in the Nishi-Oitama and Nishi-Murayama districts. For example, tuffaceous sandstone and conglomeratic tuff occurs in the central part of the Higashi-Oitama district, and therefrom both northwards and westwards the lithological characters change laterally. Northwards, tuffaceous rocks are added as the expense of the sandstones and conglomerates, and further northwards there occurs intercalation and interfingering of siltstones.

The type locality of the Shimoyama formation above referred to is along the Mogami River below Shimoyama in Shirataka-machi above mentioned. The lithological characters of the Shimoyama formation have already been mentioned, and here it should be added that it lies unconformably upon the basement of granite and upwards grades into the next younger Miyajuku formation, which has been described elsewhere (FUNAYAMA, 1952).

Westwards the above mentioned sandstone and conglomerates become thinner while the siltstones increase, and northwestwards both liparite and rhyolite are encountered with, all at the sacrifice of the other rocks. In all of the areas, the basement where observed consists of granite, and the rocks lying upon it interfinger in the directions already referred to. Therefore, so far as field data are concerned, it is inferred that the rocks developed in the different areas are not superposed in vertical sequence, but represent different facies in lateral arrangement.

In the valley extending eastwards from the shrine at Shimoyama along the Mogami River about three kilometers north of Arato, the Shimoyama formation is observed to overlie the granite basement with about a two meter thick layer of arkose sandstone, subsequently hardened, in which angular and subangular to more or less rounded fragments of siltstone measuring about five to ten centimeters in diameter occur. The boundary between the arkose sandstone and granite could not be determined even though exposures existed, probably due to the arkose sandstone which was derived from the granite, having been subsequently hardened by solution, thus giving the appearance of gradually merging into the granite.

The arkose sandstone as here considered, consists of large, well rounded quartz and feldspar grains, larger and more closely accumulated than in the granite mass itself, and, biotite is seen to be sporadically distributed. The siltstone fragments included in the arkose sandstone consists of angular, subangular to more or less rounded blocks measuring from five to ten centimeters in diameter and they show no sorting nor definite arrangement. Further, the quartz and feldspar grains are frequently found within many of the siltstone blocks. This particular zone consisting

of arkose sandstone with siltstone blocks seems to be limited in its thickness which does not exceed two meters and in its distribution. It must also be added that none of the siltstone blocks show evidence of having been metamorphosed by the granite, nor do the overlying alternating layers of siltstone show evidence of having been effected by contact metamorphism. Therefore, the granite cannot be considered to be of Tertiary age even though the siltstone blocks above referred to give the impression of representing xenoliths.

Close examination of the siltstone blocks or fragments occurring in the arkose sandstone suggests that their origin may be due to disturbance by faults, a result of soft rock deformation, or by slip bedding. From the distribution of the alternating siltstones and their relation with the underlying granite, it appears that the assumption of disturbance by faults, whether normal, reverse or thrust, should be abandoned. Upholding this view is the difficulty for the explanation of how the arkose sandstone could be entirely enclosed within a siltstone block, fill small crevices and fractures whose sides are not disturbed, and the variously shaped siltstone blocks, their distribution and density in the two meter zone. Further, fault clay, siltstone breccia and other data for fault evidence are lacking.

Simple load casts may also be an explanation for the siltstone blocks which characterize the about two meters thick zone. However, if such is the case, the arkose sand must have been quite mobile to receive such inclusions and furthermore, there should be evidence to prove the condition. Examined in detail it is found that the under-surface of the alternating layers of siltstone overlying the arkose sandstone show incipient flow markings, the fragments or blocks of siltstone embedded in the arkose sandstone enclose sand in some, show variously curved shapes without the development of soft rock pebbles, and are angular, subangular to more or less rounded. These facts seem to be evidence to assume that sliding of the overlying silts prior to its consolidation, over the arkose sands resulted in the development of the two meters thick zone mentioned in earlier lines. The fragments or blocks of siltstone are merely parts of the overlying silt which was torn away during its sliding to be embedded in the highly saturated arkose sands.

Along the floor of the Mogami River at the southern part of Kamigo in Asahimachi in the southern part of Nishi-Murayama district, there is developed several interesting sedimentary structures, one of rather large scale and the other of small magnitude yet of considerable interest. These will be described in the following lines.

The upper part of the Shimoyama formation which consists of alternating layers of siltstone intercalating some tuff layers and with an about ten meters thick massive sandstone with several layers of about thirty to thirty-five centimeters thick siltstone layers is well exposed along the river floor of the Mogami River at the southern part of Kamigo, above referred to. In the thick and massive sandstone is developed some pull-apart structures (Pl. 2, Fig. 2), each of the chunks have more or less rounded extremities and thus resemble boundinage structures. Measuring about 30~35 centimeters in thickness, separated by intervals of 20~30 centimeters, the largest one exceeds 70 centimeters in length, while the smaller ones measure only about ten centimeters in their longer diameter. In a similar or possibly the same horizon nearby is developed a more complex type of pull-apart structure. Here the largest chunk measures about 1.50 meters in length and 40 centimeters in thickness, one end is pointed and the other bifurcated with smaller chunks of irregular shape filling the interspace. Above and below this large chunk are found smaller ones of

various shapes and sizes, while in front of the bifurcated portion of the largest one are many slabs and chunks of various sizes and shapes, some of which are gently curved and with rounded extremities (Pl. 2, Fig. 3). These structures all show that their development was a result of sliding on a slope when still in an unconsolidated state. It is in this horizon that incipient load casts are also developed.

Stratigraphically below the sandstone containing the above mentioned structures the alternating siltstones are unmolested and their general strike is about 17 degrees towards the east with the dip of nearly 33 degrees towards the southeast. Within this unmolested series of alternating siltstones which intercalate some layers of tuff and sand, there is developed a peculiar structure consisting of very large bent chunks, semicircular in structure; irregular lenses of conglomerate (Pl. 2, Fig. 5) in which some soft rock pebbles are included; bent chunks of tuffaceous siltstone in which soft rock pebbles are entombed; squeezed slabs as if representing incipient pull-aparts or boudinages; and, variously oriented layers of siltstone, that is to say, their strikes and dips are so varied that their measurements are almost without significance in so limited an area (Pl. 2, Fig. 4).

The evidence just mentioned seems to be inexplicable by only taking crustal disturbance into consideration because the underlying layers of siltstone are unmolested. Differential folding also fails to explain the observed phenomena because both overlying and underlying alternating siltstone layers are not disturbed. Therefore, some kind of submarine sliding prior to full consolidation of the silt and at the time of partial consolidation, and with the ability to transport beds of conglomerate or gravels. Consequently a rather viscous flow may have accompanied the initial load or it may have been the controlling agency responsible for the construction of the peculiar sedimentary structure. Whatever be the case it is evident that gravity sliding took place on a slope prior to full consolidation of the silt and that the flow was sufficiently dense to transport gravels having a maximum diameter of about 20 centimeters (rare) and an average diameter of only about five centimeters (most abundant).

From the facts that the clastic and argillaceous rocks mentioned in the earlier lines of this article and from their contained fauna as well as relationship with the basement, it is clear that we are dealing with deposits of different sedimentary environments. That of the former is typically of shallow water while that of the latter is of deeper water. Further, it should be added that sedimentary structures occur in the argillaceous rocks but not in the clastic ones. From such evidences, it is inferred that the clastic rocks were deposited on the undathem while the argillaceous ones are sediments formed on the clinoforn. The undathem and clinoforn characteristics are well exhibited in the sediments and the sedimentary structures described herein are those of the latter environment. Areas of interfingering as observed in several parts of the area under consideration seem to represent the sub-unda facies, the clastics the unda facies and the alternating siltstones signify the clino facies.

Another interesting feature observed along the Mogami River about two kilometers north of Arato in Shirataka-machi, is described in the following lines.

Along the Mogami River at the locality above cited there is developed a rather broad, cut river terrace with no sediments on its surface. The surface at first glance appears to be flat, but when viewed closely it is found to be arrayed with numerous rounded projections of various sizes and without definite orientation. The rounded projections all consist of granite while the general flat surface of the

terrace consists of arkose sandstone, and it is interesting to notice that the boundary between the former and latter is very vague or indistinguishable in many cases. That the general surface comprises arkose sandstone was found only by digging into its surface and finding rounded quartz and feldspar grains in contrast with the angular ones in the projecting rounded parts.

At first glance it was thought that the rounded projections may be a result of differential erosion or to be the remnants of enlarged and elongated pot-holes. However, after close examinations we have arrived at the conclusion that the rounded projections which are granite, are to be taken as representing boulders and the arkose sandstone as its matrix, thus the whole represents a basal conglomerate (Pl. 2, Fig. 6).

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山形県西村山および西置賜地域に発達する第三紀中新世海成層中 に見られる Sedimentary Structure について

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(摘 要)

山形盆地の西部地域には、海棲化石を豊富に埋蔵する砂岩・礫岩・凝灰岩等よりなる碎屑岩、および化石の少い硬質ないし珪質の頁岩・淤泥岩等より成る泥質岩が、基盤の花崗岩類を不整合に被覆して広い発達を示しているが、この泥質岩中には、いろいろの興味ある sedimentary structure が認められる。とくに、白鷹町荒砥以北の最上川に沿うて標式的に発達する下山層中には、この構造の発達が著しく、主として硬質ないし珪質淤泥岩の薄層互層よりなる本層に挟在される砂岩・凝灰岩中に、pull-apart structure, boudinage structure, chunk, bent chunk, slab, soft rock pebble 等の発達が数多く認められる。また、下山層は花崗質砂岩を最下部として、基盤の花崗岩類を不整合に被覆しているが、この花崗質砂岩を被う硬質淤泥岩の下面には flow marking が認められる。これらの種々なる sedimentary structure は、bottom slope に於ける未固結の状態での sliding によるものと考えられる。

Explanation to Plate

- Fig. 1. Relation between the Shimoyama formation(upper) and basement of granite (lower). Locality-valley east of Shimoyama, Shirataka-machi, Nishi-Oitama-gun, Yamagata Prefecture.
- Fig. 2. Pull-apart structure in the massive sandstone. Locality-cliff bordering the Mogami River below the southern end of Kamigo, Asahi-machi, Nishi-Murayama-gun, Yamagata Prefecture. Notice the rounded extremities of the chunks, they resemble boudinage structure.
- Fig. 3. Complicate pull-apart structure observed at the cliff bordering the Mogami River. Locality-river cliff below southern end of Kamigo, Asahi-machi, Nishi-Murayama-gun, Yamagata Prefecture.
- Fig. 4. Semicircular chunks on the river floor. Locality-floor of the Mogami River below southern end of Kamigo, Asahi-machi, Nishi-Murayama-gun, Yamagata Prefecture.
- Fig. 5. Conglomerate lenses embedded in the siltstones which are variously distorted after viscous flow by consolidation. Locality-floor of the Mogami-River below southern end of Kamigo Asahi-machi, Nishi-Murayama-gun, Yamagata Prefecture.
- Fig. 6. Peculiar protruding, rounded projections on the youngest terrace of the Mogami River. Locality-river floor of the Mogami River at Makizawa, Shirataka-machi, Nishi-Oitama-gun, Yamagata Prefecture.