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Sedimentological Study of a Turbidite Cycle, Kii Peninsula, Japan

By

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Abstract

A typical turbidite cycle from rocks of the middle Miocene Kumano Group of the southeastern Kii Peninsula, Japan was studied to determine in particular distinguishing features of the pelite interval. Grain-size and mineralogical composition data are inconclusive in distinguishing the turbidite E-division from the inter-turbidite F-division. However, fabric information revealed by scanning electron microscope study, varies for the two divisions. The sandstone and turbiditic siltstone have random clay flake orientation (suggestive of rapid deposition of flocculated sediments), while preferred orientation exists in the interturbidite unit. The latter fabric may have been produced by deposition of the clay in the dispersed state.

I. Introduction

Numerous studies have been reported concerning sedimentological features of turbidite sandstones. However, only a few consider in detail the petrology and mineralogy of the associated pelitic interval. This unit (division E using BOUMA's classification, 1962) is generally considered to be divided into a turbiditic and hemipelagic or pelagic pelite. Recognition of these subdivisions is, however, still a problem. It is the purpose of the paper to describe in detail features of a typical turbidite cycle and to emphasize in particular those characteristics which distinguish the turbiditic pelite interval.

The area selected for study lies in the outcrop belt of the Miocene Kumano Group in the southeastern Kii Peninsula (Fig. 1). It presents a good area to study turbidite-type sedimentation since many flysch examples are found. The Kumano Group is composed dominantly of siltstones and alternations of siltstone and sandstone, and also includes sandstones and conglomerates (Table 1). The late Early to Middle Miocene age of the Group is indicated by the presence of *Lepidocyclina* (*Nephrolepidina*) *japonica* (YABE), *Miogypsina* sp., *Globigerina praebulloides* BLOW, *Globigerinoides sicanus* DE STEFANI, *Praeorbulina glomerosa curva* (BLOW), *P. transitoria* (BLOW) in the middle formation of the group (NISHIMURA and MIYAKE, 1973; IKEBE *et al.*, 1975).

Studies by the KISHU SHIMANTO RESEARCH GROUP (1975) in the Kii Peninsula also reveal the presence of flysch-type sedimentation in rocks older than those reported here. Sediments forming these older rocks were deposited in the Shimanto geosyncline which

Table 1. Stratigraphy of the area.

Miocene	Kumano Acid Rocks		Granite porphyry Acid pyroclastic rocks Rhyolite
Miocene	Kumano Group	Mitsuno Formation (500 m)	Sandstone Alternations of sandstone and siltstone Conglomerate
Miocene	Kumano Group	Shikiya Formation (1,000-1,200 m)	Massive or bedded siltstone Small amount of sandstone intercalation, muddy conglomerate and limestone
Miocene	Kumano Group	Shimosato Formation (10-1,800 m+)	Siltstone-rich alternation Small amount of thick-bedded sandstone
Oligocene	Muro Group		Sandstone Flysch-type alternations of sandstone and mudstone Conglomerate Pebbly mudstone

started to develop at the early Cretaceous or late Jurassic and ended before the Middle Miocene. Observations of over fifty-eight sample sites in the Kii Peninsula also reveal the numerous examples of flysch-type sedimentation suggestive of deposition by a turbidity current mechanism even into the Middle Miocene Kumano time. One typical turbidite cycle which is representative of the Kumano Group was studied in detail.

II. Outcrop Description

The authors studied numerous examples of turbidite sedimentation which are well represented in the middle Miocene age rocks of the Kii Peninsula. The section studied outcrops near Tawara village, Koza town (Fig. 1). It consists of a lower very fine-grained feldspathic wacke and lower and upper siltstone units (Figs. 2 and 3). The sandstone layer shows features of the Bouma's B-C division and is composed of a lower parallel laminated part and an upper wavy to cross laminated part. The sandstone has graded bedding and gradually grades into the overlying siltstone. Load casts are observed on the sole surface of the sandstone. The siltstone layer can be divided into two parts based upon distinctive weathering features. The more massive dark grey colored lower siltstone shows an abrupt contact with the overlying siltstone. This change initially suggested to the authors that the lower siltstone represents the pelite E-division (that material deposited from the tail of a turbidity current) and the upper siltstone is an

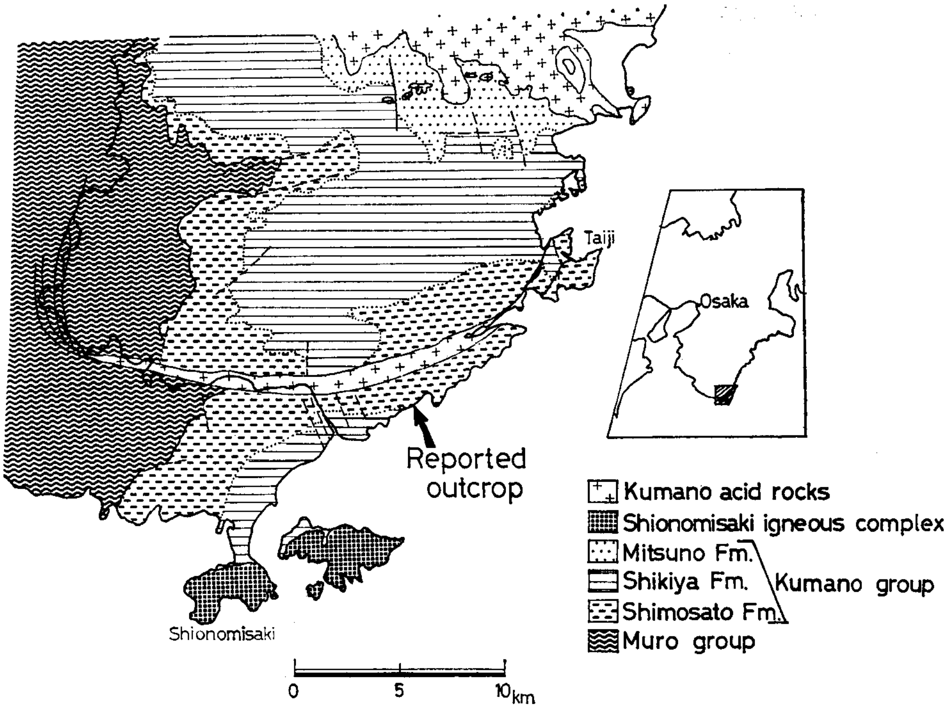

Fig. 1. Geologic map of the southeastern Kii Peninsula. Northeastern part by the data of A. MIZUNO, Geological Survey of Japan.

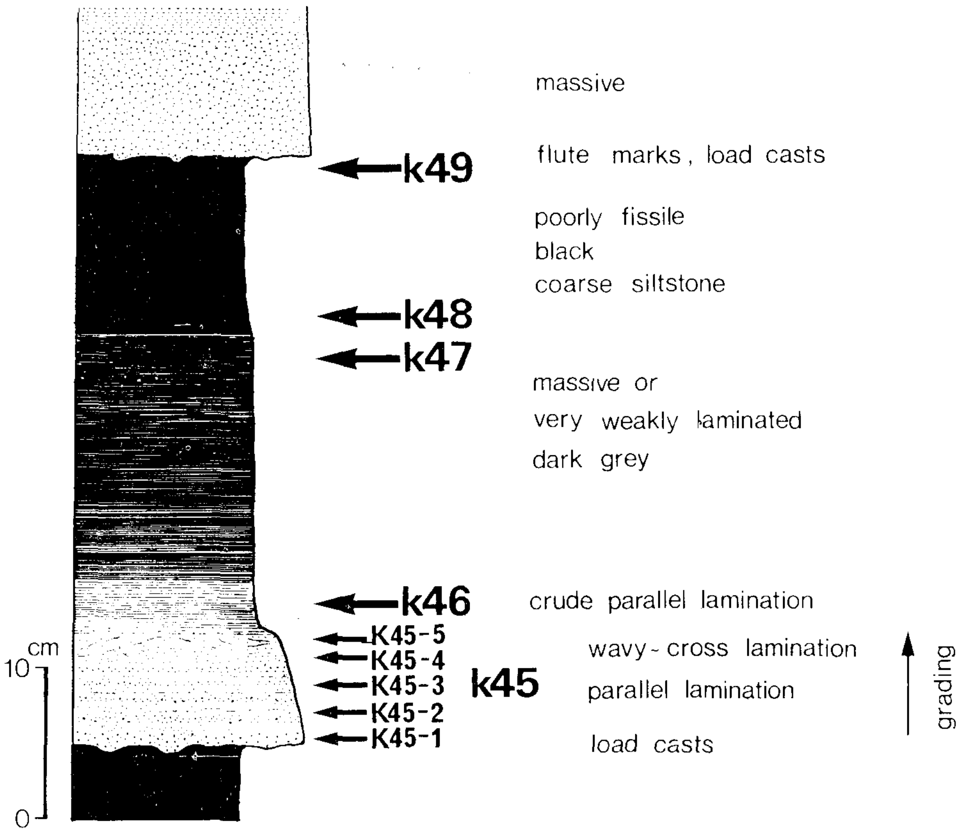

Fig. 2. Columnar section of the outcrop reported. Uppermost part of the Shimosato formation near Tawara village, Koza town. Arrows indicate sample positions (K45-K49).

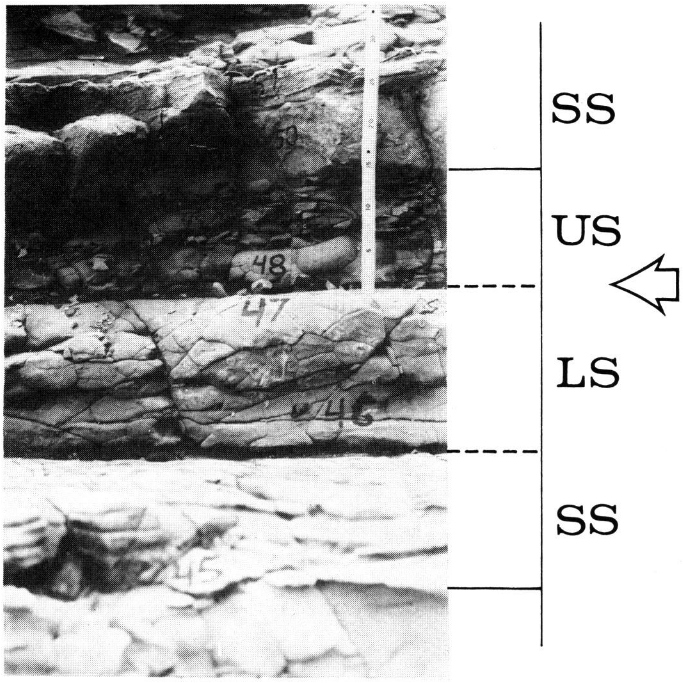

Fig. 3. Photograph of outcrop. SS (sandstone); LS (lower siltstone); US (upper siltstone). Notice abrupt contact between siltstones at the arrow.

example of an interturbidite layer (representing an F-division, using the terminology of VAN DER LINGEN, 1969). The top of the siltstone is truncated by the sandstone of the next turbidite cycle, which has flute markings and load casts on its sole surface.

III. Results and Conclusions

Grain-size analysis

Grain-size analysis was done on 9 thin-sections from 5 samples, using the point-counting method. The apparent long diameter of grains larger than 5 phi was measured on the enlarged screen (100 magnification) of profile projector. In the analysis more than 500 points which were on the intersections of 0.25 mm mesh, were measured.

A C-M diagram (Fig. 4) of the Kumano sample was made based on the result. The C-M diagram characterizes the coarsest fractions of the samples, where C is the one percentile and M is the median of the grain-size distribution. (PASSEGA, 1957). PASSEGA (1957) showed that "the most complete C-M pattern can be subdivided by points N, O, P, Q, R and S into segments each of which corresponds to a particular sedimentation

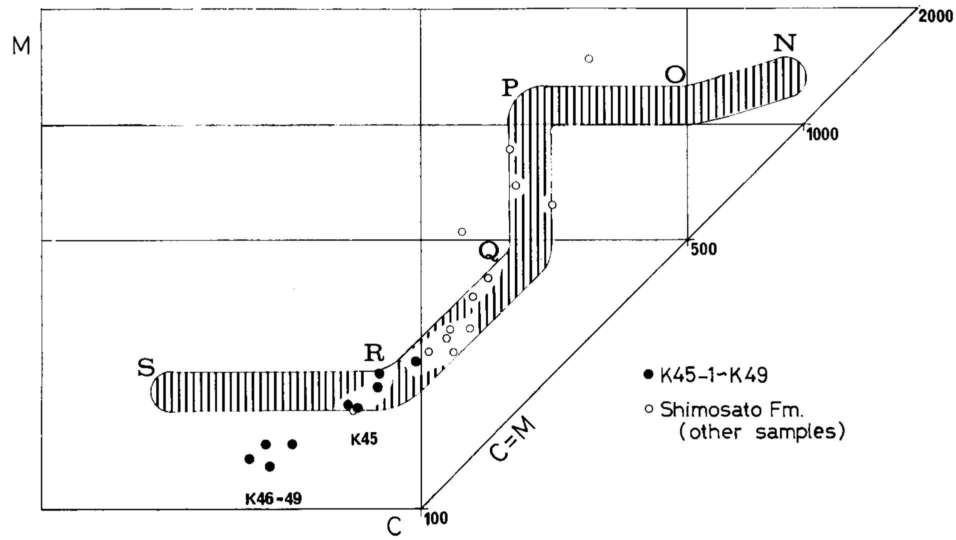

Fig. 4. A C-M diagram of sandstones and siltstones of the Shimosato Formation. Ruled part represents the complete C-M pattern of tractive current deposits (PASSEGA and BYRAMJEE, 1969).

mechanism." Samples from the Kumano Group are plotted mostly on a single line parallel to the line C=M. This C-M pattern is formed mostly by segments QR, which indicates the transportation by the graded suspension, and the pattern of turbidites (PASSEGA and BYRAMJEE, 1969). Five values from the sandstone (K45) plot concordantly with the line made by other samples from the Shimosato Formation. These results show that sandstone layer were transpoted by a turbidity current. However, four siltstone samples (K46-K49) plot slightly above the line. These siltstones might have been influenced by uniform flow. The grain-size data of siltstones are not conclusive to distinguish lower and upper siltstone units.

Mineralogy

The clay mineral composition and fabric of the siltstone were studied to determine if these features varied vertically and thus could provide clues as to changing sedimentological conditions. The mineral composition of the less than 2 micron size fraction is dominantly chlorite and illite with minor quartz and feldspar. It is significant that there is only a little vertical clay mineral variation emphasizes the minimal affect of diagenesis on the clay fabric. The mineral composition of the sediment delivered to the depositional site obviously remained constant throughout, thus it is not useful as a distinguishing feature for separating the two siltstone units (Fig. 5).

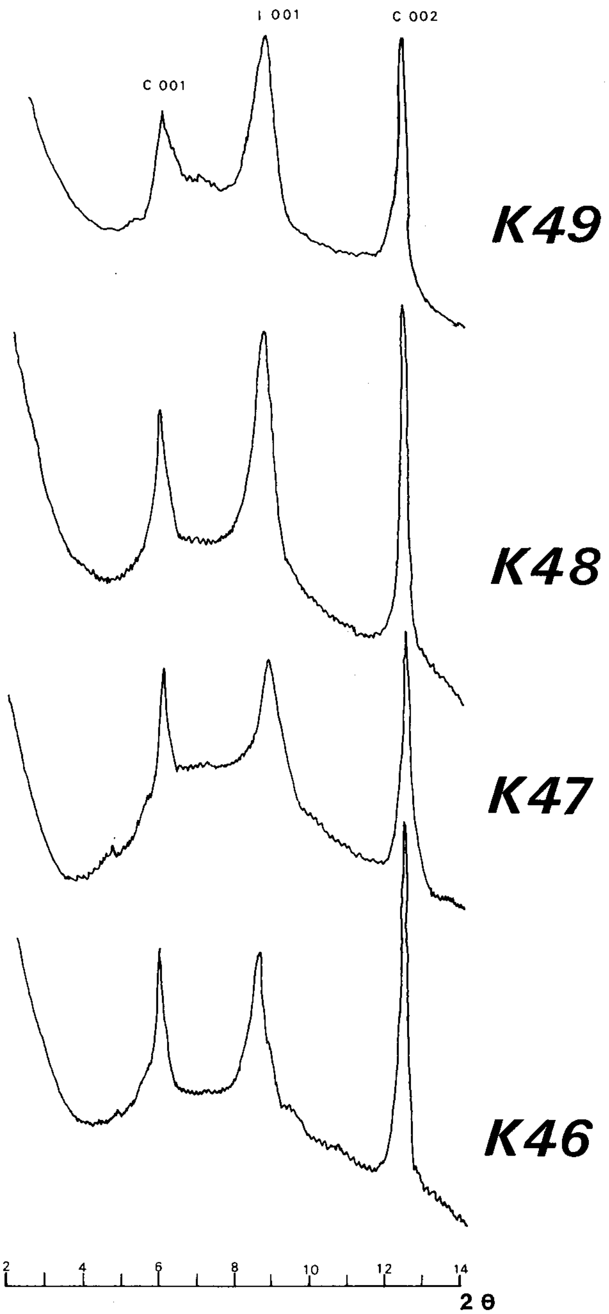

Fig. 5. X-ray diffraction traces of the less than 2 micron size fraction. C, chlorite; I, illite.

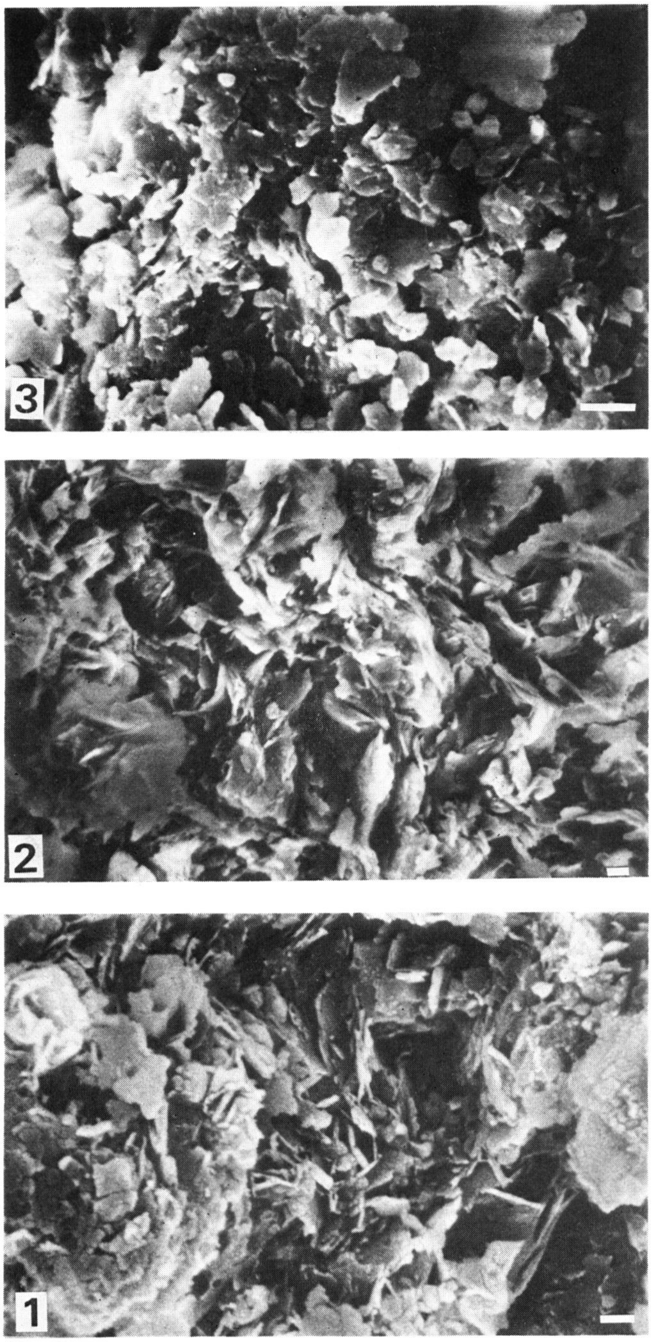

Fig. 6. Scanning electron micrographs parallel to the bedding plane. 1. K45; 2, K46; 3, K49. Scale represents 1 micron.

Clay Fabric

Clay fabric, however, is remarkedly different for the lower and upper siltstones. For scanning electron microscope study, samples were broken parallel to the bedding plane and gold showered for viewing. Random flake orientation is most obvious in both the sandstone and the lower siltstone unit (Figs. 6-1, 2). The fact that random clay flake orientation still prevails from sandstone into siltstone indicates a similar mechanism of deposition for these two units. Preferred clay flake orientation is dominant in the upper siltstone unit (Fig. 6-3). Previous SEM stuby by O'BRIEN (1970) showed a difference in the clay fabric of shales and mudstones which, he indicated, may result from different conditions of sedimentation. Random orientation suggests deposition in the flocculated state and preferred orientation deposition as dispersed clay.

Regardless of the exact mechanism, the results here indicate a difference in clay fabric in the lower and upper siltstone which may be a result of a variation in the conditions of sedimentation.

IV. Conclusion

Two mechanisms of deposition existed during the deposition of the turbidite cycle studied in the Kii Peninsula. Outcrop observations, grain-size analysis data, mineralogy and fabric information show that the sandstone (K45) and the lower siltstone (K46-K47) formed under similar sedimentological conditions. The obvious change in outcrop appearance between the lower and upper siltstone (K48-K49) indicates a change in depositional conditions which is confirmed by fabric data.

The authors propose the following model for the deposition of the turbidite cycle, with special emphasis on the siltstone deposition. Both sandstone and siltstone were deposited from a density gravity flow or a turbidity current. Rapid sedimentation from the concentrated turbidite "cloud" of flocculated randomly oriented clay flakes occurred. Upon passage downslope of the more highly concentrated portion of the sediment flow, water in the environment contained a much more dilute sediment concentration. It was during this time that the slower sedimentation of dispersed clay occurred, resulting in the dominant parallel flake orientation of the upper siltstone unit.

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