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PRE-CRETACEOUS PALEOCURRENTS OF THE NORTHEASTERN HIDAKA BELT, HOKKAIDO, JAPAN

by

Kazuo Kiminami and Yoshihiro Kontani

(with 6 text-figures, and 1 table)

(Contribution from the Department of Geology and Mineralogy,
Faculty of Science, Hokkaido University, No. 1633)

Abstract

Typical Pre-Cretaceous flysch type sediments, called the Yubetsu Group, are exposed on the northeastern part of the Hidaka Belt. The authors have done a three dimensional analysis of internal sedimentary structures utilizing the soft X-ray technique for paleocurrent study of the group. From the data obtained in this study the prevailing current direction in the turbidite of the study area is a lateral current from east to west with minor occurrence of axial current along north-south direction. Therefore, the provenance of the middle to upper Yubetsu Group of the present study is located to the east.

Introduction

To the full understanding of the geologic development of a geosyncline it is essential to explain paleogeography and nature of hinterland. The direction from which the geosynclinal sediments have been transported and the mechanism of deposition for such materials as well as their nature of provenance must be solved. In the Hidaka Belt, Hokkaido, an enormous volume of Pre-Cretaceous geosynclinal sandstones and shales (Hidaka Supergroup of Hasegawa et al., 1961) occur. Although the knowledge of these rocks has been advanced recently through 1:50,000 geologic mapping of the area since 1960s, no reports have yet been available for paleocurrent directions. Also only scanty data are available for the compositions of the sandstones. To fill this gap of knowledge, we have done a sedimentological study of flysch type sediments of the Yubetsu Group exposed on the northeastern margin of the Hidaka Belt (Fig. 1). As flysch type sediments are well developed with comparatively uncomplicated structure in the Yubetsu Group as compared with the rocks of the Hidaka Supergroup distributed elswhere, the study area gave us an unique opportunity for an analysis of paleocurrent directions.

For paleocurrent analysis two major lines of study have been commonly employed; i.e., the study of sole markings which are one of the external sedimentary structures, and the study of cross lamination and grain orientation, both of which are one of the internal sedimentary structures. Since flysch type sediments of the Yubetsu Group were normally brittle due to well developed joints, it was difficult to observe wide enough bedding plains for external sedimentary structures in the field. Also bedding plain shear has obscured sole markings in most cases. Therefore, we had to employ a three dimensional analysis of internal sedimentary structures utilizing the soft X-ray technique for our paleocurrent study. The potential of the X-ray technique for this sort of study has been established through the works of Hamblin(1962, 1965), Bouma(1969), Picha and Cline(1973) and Kiminami(1975a,

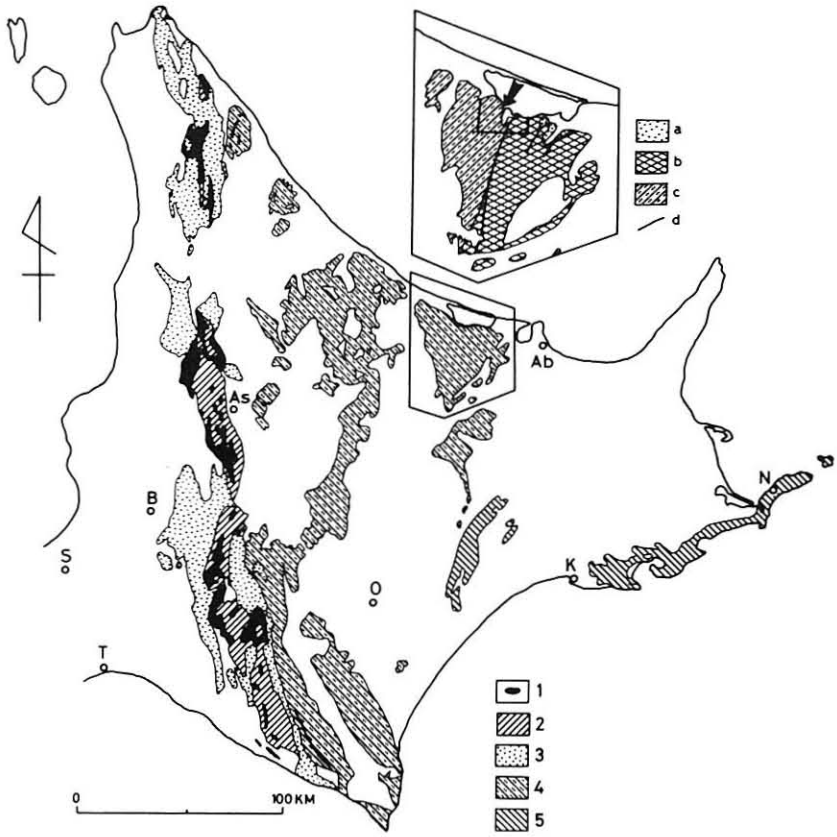

Fig. 1 Index map of the study area
1: Serpentinite, 2: Pre-Cretaceous rocks of the Kamuikotan Belt, 3: Yezo Group (Cretaceous), 4: Pre-Cretaceous rocks of the Hidaka Belt, 5: Nemuro Group (Upper Cretaceous to Paleogene), a: Saroma Group, b: Nigoro Group, c: Yubetsu Group, d: Fault
Locality
S: Sapporo, T: Tomakomai, B: Bibai, As: Asahigawa, O: Obihiro, Ab: Abashiri, K: Kushiro, N: Nemuro.

1976). In this paper our attention will be focused on the sedimentary structures and paleocurrent directions of the Yubetsu Group.

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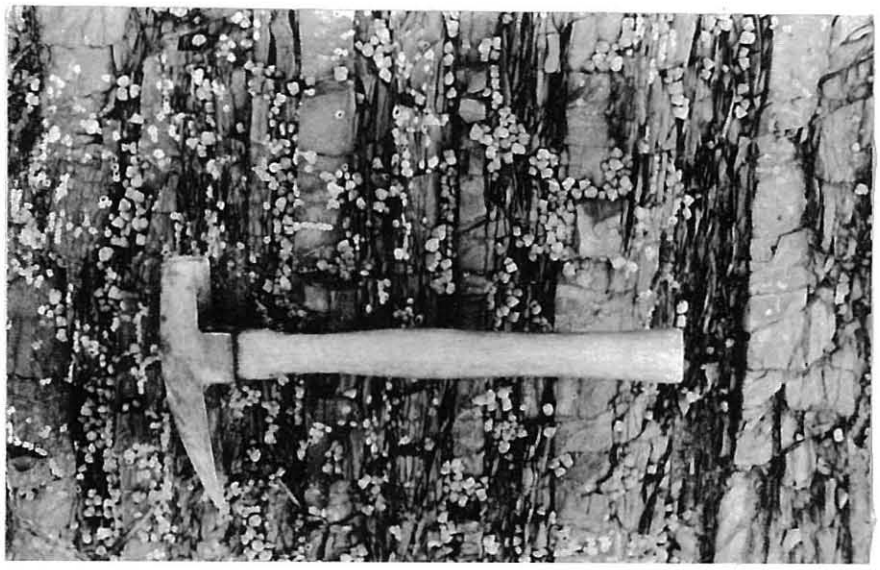
Geologic setting

Pre-Cretaceous rocks of the eastern Hidaka Belt are typically exposed on the south side of Lake Saroma. These include mainly flysch type sediments in western part, whereas basic

volcanic rocks with chert and limestone, and flysch type sediments in the eastern part. The geology of the area has long been studied (Hashimoto, 1952, 1960). Although these studies were not very detailed, the Pre-Cretaceous rocks in the area are divided into the following three groups by Teraoka et al. (1962) and Yamada et al. (1963) based on lithofacies in ascending order, viz. Yubetsu, Nigoro and Saroma Groups (Fig. 1). From the occurrences of the Torinosu type fauna in the Nigoro Group and *Buccia* spp. in the upper Saroma Group, these two groups were correlated to the Sorachi Group of the Upper Jurassic, while the Yubetsu Group to the Kamui Group, respectively. Recently Kontani and Sakai (1978) suggested a possible correlation of the Yubetsu Group of the present area to the upper Nakanogawa Group (Kontani, 1978) of the eastern side of the Hidaka Metamorphic Belt or to the upper Kamui Group of the western side of the same belt. Therefore, the sedimentological study of the Yubetsu Group can throw light to the understanding of the geologic history of the Hidaka Belt.

The study area extends 10 km in EW and 8 km in NS directions from Toppushi in the east to Baro in the west. In the study area the Yubetsu and Nigoro Groups show faulted contact, the direction of which is roughly north-south, and exposure of which is observed at a point between Wakasa and Tokarochi on the shore of Lake Saroma as a zone of fault clay over 50 m wide.

The Yubetsu Group mainly consists of flysch type alternation of sandstone and shale intercalated with massive sandstone, shale and tuff. The flysch type sediments are best exposed on the lake shore (Fig. 2). Most of the sandstone beds are between 5 and 30 cm thick and have well developed graded bedding. Massive sandstones are generally coarse-



→ upper

Fig. 2 Occurrence of flysch type sediments (locality B).

grained and often contain penecontemporaneous shale pebble. They are several tens of meters to 150 m thick and intercalated in a few horizons. In some massive sandstones in the upper part of the group many calcareous nodules occur. Massive shales tend to be restricted to the lower half of the group. In the shales often seen are basic to intermediate tuffs (about 0.5 to 1.5 m thick). The Nigoro Group is distributed on the eastern part of the study area. This group is mainly composed of tuffaceous sandstone, basalt and basic tuff, and siliceous shale. The distribution of the above facies is shown in Fig. 3. In the Ikutawara area to the south of this study a detailed lithostratigraphic sequence has been established (Yamada et al., 1963) and the total thickness was estimated to be over 10,000 m. Based on the lithologic characteristics the Yubetsu Group of the present study is correlatable to the upper half of that of the Ikutawara area such as the Nakazono, Wakasa, Mizuho and Onari formations.

The structure of the Yubetsu Group of the study area is trending north-south facing to the east and forms a homocline. Very rarely graded beddings indicating westward facing directions occur. However, they are understood to be local anomalies. The beds of the group in the study area are commonly steeply dipping or even overturned.

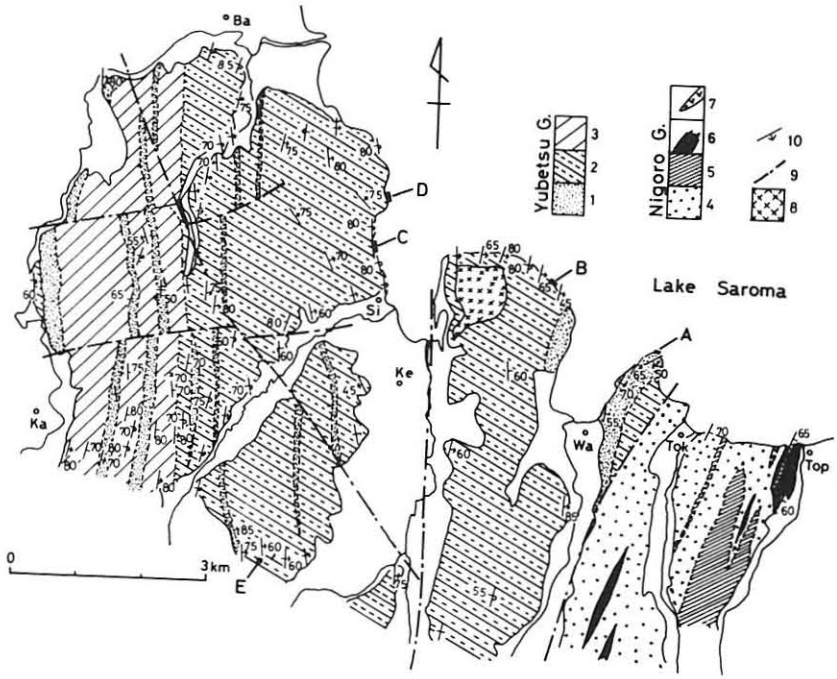


Fig. 3 Lithologic sketch map of southern shore of Lake Saroma with sample localities.
A~E: Sample localities, 1~3: Yubetsu Group (1: Sandstone, 2: Alternation of sandstone and shale, 3: Mainly shale intercalated with sandstone, 4~7: Nigoro Group (4: Tuffaceous sandstone, 5: Siliceous shale, 6: Mafic volcanic rock 7: Basaltic andesite), 8: Rhyolite, 9: Fault, 10: Dip and strike.
Locality
Ba: Baro, Ka: Kamibaro, Ke: Kerochi, Wa: Wakasato, To: Tokarochi, Top: Toppushi.

Flysch type sandstones and paleocurrent directions

To study the direction from which the clastic materials have been supplied to the Yubetsu Group, about 50 oriented sandstone bed samples, whose thickness are 3 to 10 cm from base to top, are collected from sandstone-shale alternations. One hundred and twenty-three slices were cut from 40 samples suitable for an X-ray study. The method employed was: (a) several slices about 5 to 6 mm thick at right angle to the bedding surface were cut from each sample and ground on a diamond-lap to the thickness of 2 to 3 mm. (b) with Softex CSM at 45KV and 12A, the samples were exposed to X-ray for about 50 seconds.

Due to outcrop conditions, sampling (Sample localities shown in Fig. 3) was limited mainly to the lake shore (localities A to D), while sample no. 40 (locality E) was from a road side cutting near the southern margin of the map area.

Internal sedimentary structures of flysch type sandstones

With the help of X-ray, we can observe clear shape of lamina and distribution of heavy minerals and carbonaceous matters (Fig. 4a, b and c). A summary of observations is given in Table 1. A brief description is as follows.

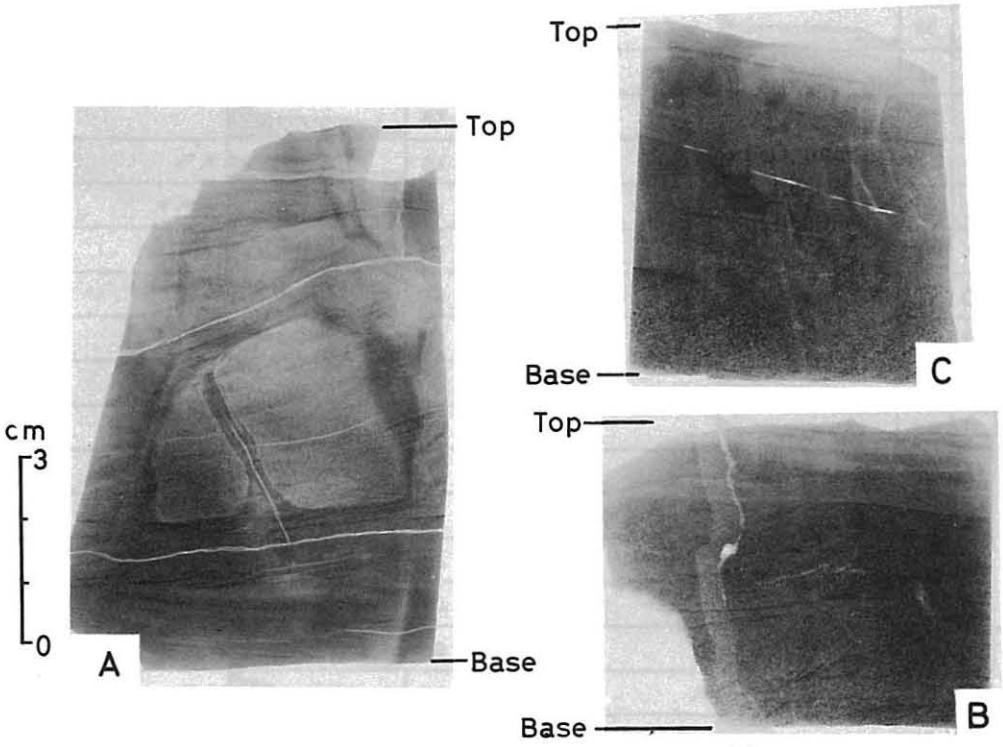


Fig. 4 Internal sedimentary structures of sandstones shown by X-ray photographs. A: Sample no. 2, B: Sample no. 28, C: Sample no. 29.

Grading

Graded bedding is well developed in most samples except samples no. 2, 19, 21, 23 and 31 (Fig. 5). When it is well developed, basal boundary is sharp and clear. Sample no. 2 is rich in laminae and the coarsest part is found in the lower middle part of the bed. Sample no. 19 shows a sudden increase of grain size at the uppermost part of the bed where cross lamination is also developed. Two inversely graded cycles are observed in the lower and upper parts of Sample no. 21. Grain size change is transitional in the case of lower inverse grading while it is abrupt in the upper one. Sample no. 23 consists of two amalgamated graded cycles each of which comprizes cross laminated and parallel laminated parts, and the boundary of which is clearly defined. Sample no. 31 is rich in laminae and inverse grading occurs in the middle part of the bed.

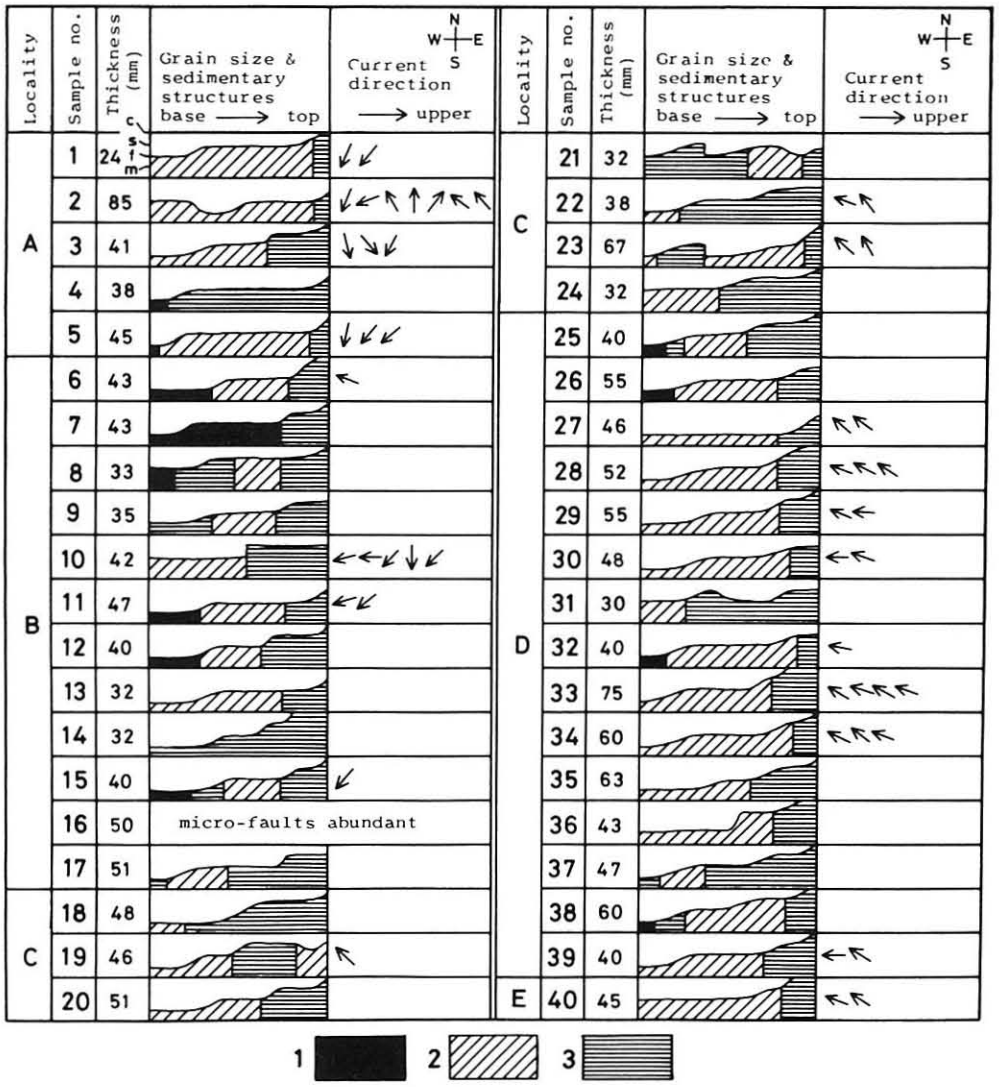


Fig. 5 Internal sedimentary structures and paleocurrent directions of the X-rayed samples.
1: Portion where no sedimentary structures other than grading observed, 2: Cross laminated, 3: Parallel laminated, m: Medium-grained sandstone, f: Fine-grained sandstone, s: Siltstone, c: Claystone.

Combination of internal sedimentary structures

About ten per cents of samples among 40 studied show complete Bouma sequence and about twenty per cents show internal structures lacking either in B or C interval of Bouma sequence (Fig. 5). About the half of samples consist of lower cross laminated and upper parallel laminated parts.

Heavy minerals and carbonaceous matters

Most heavy minerals in the sandstones occur in laminae but some are scattered. Distribution of heavy mineral loaded laminae decreases to the upper part or is restricted to the bottom of a bed. In sample no. 2, in which an inverse grading is observed, heavy minerals occur at the part where grain size is coarsest. No such regularity has been observed in heavy mineral concentration of samples nos. 21 and 31 in which inverse grading occurs. In samples with well developed grading, carbonaceous matters tend to concentrate towards the upper part of a bed.

Paleocurrent directions

Fifty three-dimensional sets of cross lamination were obtained from 20 samples among 40 studied (Figs. 5 and 6). Cross lamination itself was observed in most samples, but three-dimensional analysis was not always possible.

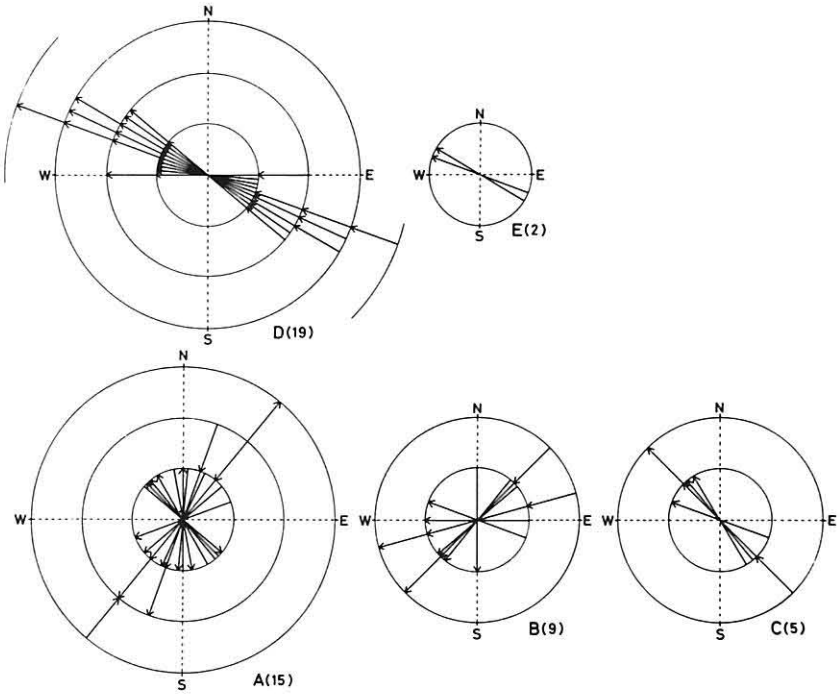


Fig. 6 Paleocurrent directions of the study area.

Flysch type alternation of locality A occurs in massive sandstone of the uppermost Yubetsu Group. Thickness of the sandstones in the alternation is between several to 20 cm. Four among five X-rayed samples have revealed 15 sets of cross lamination suitable for paleocurrent analysis. Sample no. 2, which has unusually well developed laminae and inverse grading, shows extremely variable paleocurrent directions which amount to 180° (Fig. 5). The variation of directions at locality A is solely due to sample no. 2. If we exclude the data obtained from sample no. 2, the paleocurrent here shows stable direction either from north to south or from northeast to southwest.

Sandstones from locality B are a part of thick alternation of sandstone and shale. Individual thickness of sandstone is several to 10 cm. Nine sets of cross lamination suitable for paleocurrent analysis were obtained from four samples among twelve X-rayed samples. The paleocurrent direction is comparatively stable and mostly from NE to SW or from E to W.

Sandstones from locality C are also a part of thick alternation of sandstone and shale. Thickness of sandstone is normally several to 15 cm. Five sets of cross lamination were obtained from three samples. Paleocurrent direction is stable and from SE to NW.

Characteristics of the alternation of sandstone and shale at locality D are similar to those of locality C. Nineteen sets of cross lamination from eight samples were measured. Paleocurrent direction is stable and from SE to NW or from E to W.

Locality E is the only sample collected away from the lake shore. Sandstones are mostly 10 to 30 cm thick in the sandstone-shale alternation. Two sets of cross lamination were measured in one sample. Paleocurrent is from SE to NW similar to the directions measured at localities C and D.

Discussion

Kiminami (1975a, b) has discriminated two contrasting types of flysch type sandstones of the Nemuro Group. One is sandstone deposited from turbidity current (Type I) and the other is the one from normal bottom current (Type II). Characteristics of both types of sandstones are summarized in Table 1. Characteristics of the Type II sandstones of Kiminami (1975a, b) are similar to those of contourite described by Hollister and Heezen (1972), Field and Pilkey (1971) and Fritz and Pilkey (1975). Most of the X-rayed samples of the present study show characteristics of Type I sandstones and so can be classified as turbidite. However, those rich in laminae and often inversely granded with variable paleocurrent directions like sample no. 2 are interpreted as derived from normal bottom current. Likewize, samples no. 21 and 31 are possibly derived from normal bottom current. Sample no. 19 is interpreted to be a turbidite reworked by normal current at the top.

At localities A and B, which are at the upper horizons of the Yubetsu Group, the paleocurrent directions are either from north to south or from east to west. East to west direction seems to prevail in locality B (Fig. 6). Paleocurrent observed in the middle Yubetsu Group of the map area (localities C, D and E) is rather uniform and concentrates in the directions from east to west and from southeast to northwest. Elongation of the Hidaka geosyncline at the Pre-Cretaceous time is congruous to the structure of the Yubetsu Group and is north-south (Hunahashi and Hashimoto, 1951; Minato et al., 1956; Hunahashi, 1957).

Table 1 Characteristics of sandstones originated from turbidity current (Type I) and normal bottom current (Type II)

(modified after Kiminami 1975a, b)

	Type I	Type II
thickness	several to 100cm	< several cm
grain size	coarse to fine	fine
graded bedding	yes	no (sometimes inverse grading)
nature of lower boundary	sharpe and clear	sometimes transitional
lamination	lamination partly developed	parallel + cross lamination well developed throughout the bed
heavy minerals concentration	highly concentrated; rich at bottom; gradually decrease towards upper part	not very concentrated; concentrated part not well defined, but sometimes in the middle of the bed
type of heavy minerals	weathering resistant and nonresistant speces	weathering resistant species
mode of occurrence of carbonaceous matters	upper part or top of the bed	scattered throughout the bed
paleocurrent directions	stable	highly variable

Thus north-south current directions represent an axial current whereas east-west ones a lateral current. From the data obtained in this study the prevailing current direction in the turbidite of the study area is a lateral current from east to west with minor occurrence of axial current along north-south direction. Therefore the provenance of the middle to upper Yubetsu Group of the present study is located to the east.

Existence of the paleo-continent to the east of the Hidaka Belt in the Pre-Cretaceous time has been deduced (Paleo-Kitami Land of Minato et al., 1956, or Paleo-Okhotsk Land of Hashimoto, 1958) from various reasons. Our conclusion here obtained is conformable to the above hypothesis. Kiminami et al., (1978) also has deduced the existence of Paleo-Okhotsk Land consisting of older sediments, granites, volcanics and metamorphics to the northeast of Hokkaido during Late Cretaceous to Paleogene based on a sedimentological study of the Nemuro and Urahoro Groups (Upper Cretaceous to Paleogene) of eastern Hokkaido. Characterization of the eastern paleo-continent (Paleo-Okhotsk Land) is essential to the understandings of the geologic development of Mesozoic Hokkaido. Similar line of study in the future all horizons of the Yubetsu Group would contribute very much to this goal.

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