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THE IWANAI NAPPE IN THE KAMUIKOTAN TECTONIC BELT, SOUTHERN HOKKAIDO, JAPAN

by

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(with 10 text-figures)

Abstract

The Sarugawa ultramafic mass is interpreted as a nappe, here called the "Iwanai Nappe", resting, with its sedimentary cover, on a unit reworking ophiolitic rocks and Cretaceous Yezo deposits. The Iwanai Nappe has been emplaced toward the south-west from an area situated east of the "Yezo Syncline". The age of movement is inferred to be Eocene, contemporaneous with the beginning of the strike-slip movement in Hidaka belt. This structure is a good explanation for the Lower Cretaceous facies distribution in the concerned area.

Introduction

The geology of the Sarugawa ultramafic mass in the Kamuikotan Tectonic Belt, in southern Hokkaido, has been described (Bamba, 1957; Katoh, 1978; Niida and Katoh, 1978; Katoh, 1982) from a petrographic point of view. The purpose of the present paper is to describe the main structure of this region. The surveyed area (Text-fig. 1)extends from the Saru River in the north to the Nukabira River in the south and from the western boundary of Hidaka Belt in the east to the Mukawa River in the west. The main survey routes are the beds of Niseu, Saru, Nukabira and Chiroro Rivers and their tributaries as well as forest roads of the Hidaka and Furenai districts.

Geological Setting

The following lithologic sets are differentiated in the studied area:

— An ultramafic massif, the Sarugawa ultramafic mass, composed mainly of serpentinite, the original rocks being well preserved in the Iwanaidake peridotites. As regard to petrological data, Katoh (1978) distinguishes two different masses, the western unit and the eastern unit, the latter overlapping the former. The eastern mass centered on Nukabira-yama is covered by sediments related to the Hidaka Super Group (Hashimoto et al., 1961; Takahashi and Suzuki, 1978). According to the geological map, these sediments are "completely surrounded by the serpentinite", and their cen-

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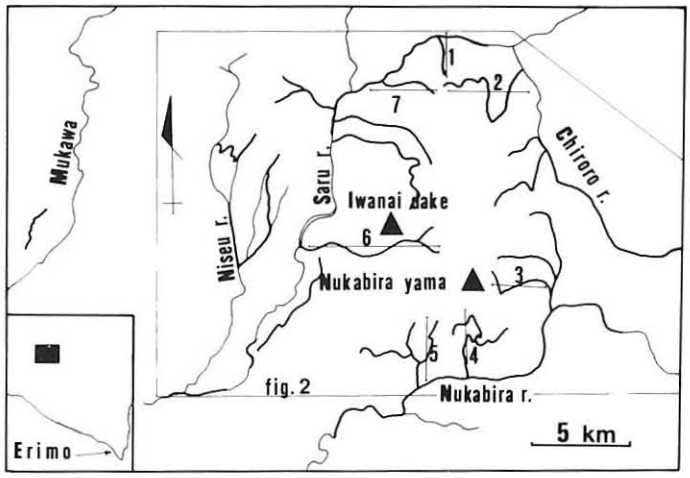
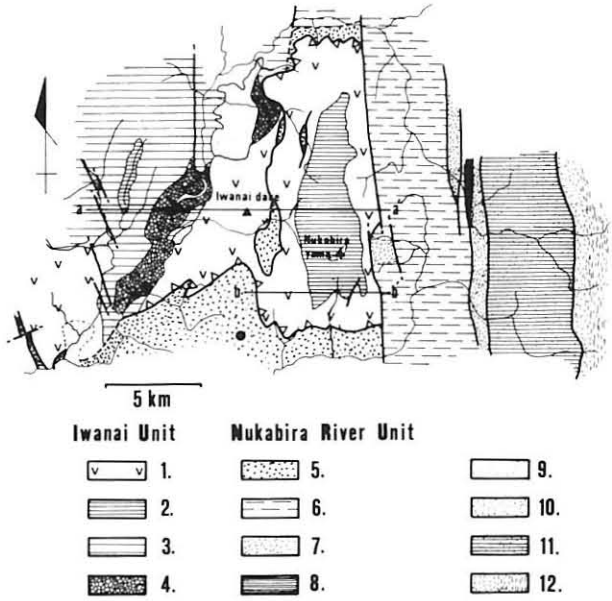


Text-fig. 1 Situation map indicating the survey routes (thick lines). The framed area corresponds to the map of Text-fig. 2. Straight lines (1 to 7) correspond the cross-sections of Text-fig. 3.



Text-fig. 2 Structural map of the Sarugawa ultramafic mass area: *Iwanai Unit*: 1. Serpentinie and peridotite; 2. presumed Lower Cretaceous; 3. presumed Upper Cretaceous; 4. Green rocks; *Nukabira River Unit*: 5. reworked green rocks; 6. Upper Cretaceous Yezo sediments; 7. Green rocks; 8. Lower Cretaceous-Chiroro Formation-; 9. Miocene; 10. Western Greenstone Belt Unit; 11. Idonnappu Zone; 12. Meta Ophiolitic Zone.

troclinal dip in the western flank of the eastern mass has been interpreted as a "semi-basin structure" (Katoh, 1982).

— Sedimentary sequences: the Sarugawa Formation composed mainly of greenrocks, sandstones and minor limestones which is widely distributed in the surveyed area along Saru and Nukabira Rivers (Takahashi and Suzuki, 1978) and the Niseu Formation, composed of sandstones, shales and tuffs (Takahashi and Suzuki, 1978) outcropping

along the Niseu River and its tributaries. The contact between Niseu and Sarugawa Formations is drawn as a vertical fault on the geological map "Iwachishi". The Yezo Syncline, made of Upper Cretaceous flysch, with a north-south structural trend separates the Kamuikotan Tectonic Belt and the Hidaka Belt.

Description of the Nukabira River and Iwanai Tectonic Units

The result of a field survey done during Summer 1983 allows to distinguish two structural units lying on top of each other (Text-fig. 2 and cross sections around Nukabira-yama, Text-figs. 3 and 4):

— The upper tectonic unit is composed of the serpentinite mass showing horizontal fault planes and the underlying sediments. The basal contact appears, on the map, rather flat — even if it is sometimes reworked by younger vertical faults. The serpentinite is covered with the Hidaka Super Group sediments which lie by a horizontal contact on their ultramafic basement.

— The lower tectonic unit, Nukabira River Unit, is made of reworked mafic rocks, sandstones, limestones and green lavas showing pillow structure and of the Cretaceous flysch deposits of Yezo Group.

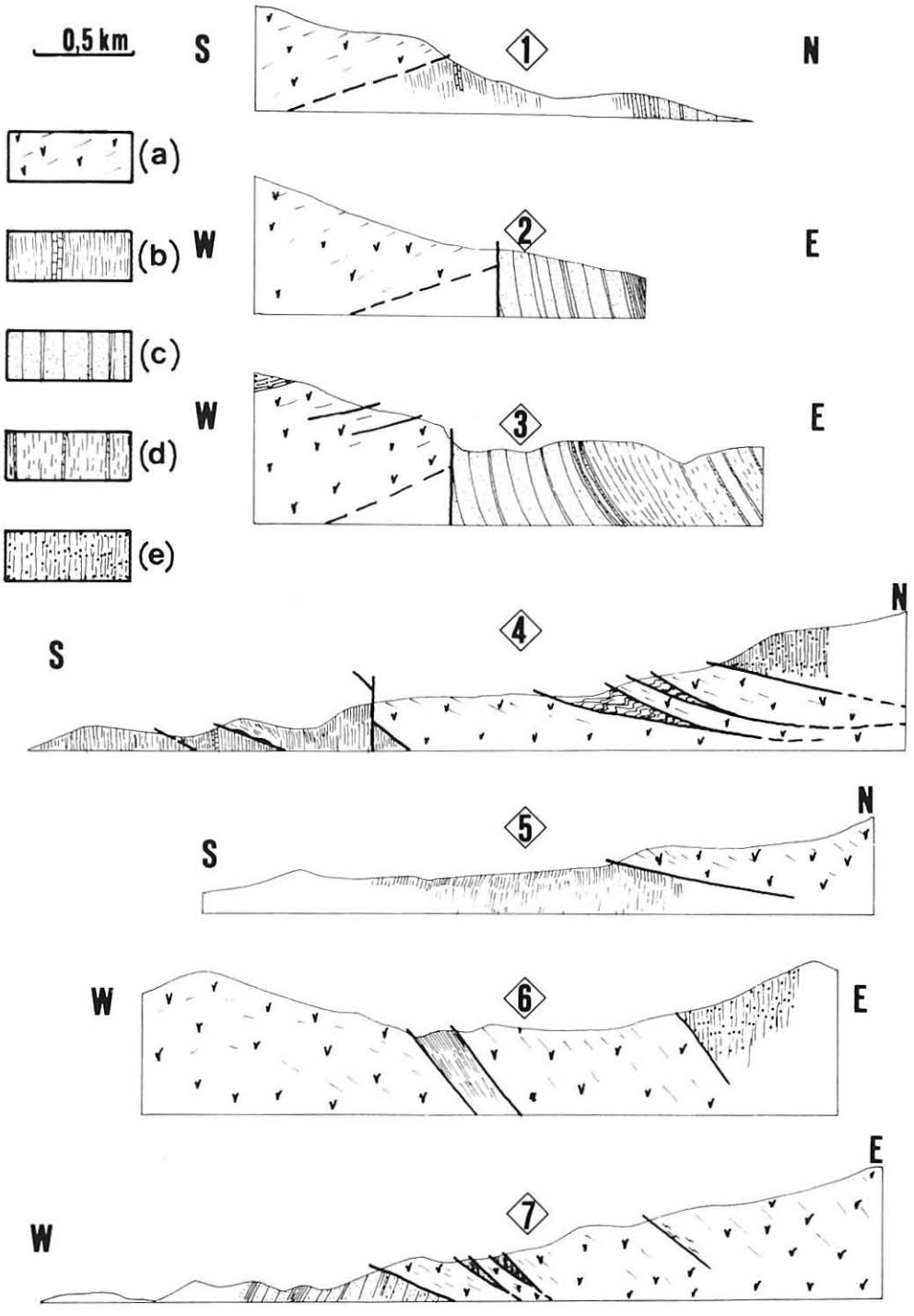
A complete cross section of the two tectonic units is clearly observable along the forest road following the stream of the Penkehayushininai River on the southern flank of Nukabira-yama (localisation on Text-figs. 2 and 5). This cross section is described below from south to north.

Nukabira River Tectonic Unit

The strike and dip of the beds range from N 90° vertical to N40°W vertical. These sediments belong to the Sarugawa Formation.

1) Black sandstones exhibiting a slight schistosity: they contain angular grains of quartz and minor plagioclase and epidote grains. They alternate with black shales and light green quartzites (recrystallized acidic tuffites). The thickness of the beds varies from 10 cm to 2 m.

2) Alternation of red and green schists with limestone beds characterizes the Nukabira River Unit. The vertical schistosity appears in the finest-grained beds and makes an angle of 15° to 20° with the stratification plane. In the most deformed levels the schistosity is associated with tight folds of pluricentimetric scale. Some pressure shadows with a right handed asymmetry are observed settled on opaque minerals. These features are similar to those observed in the Hidaka Shear Zone (Jolivet and Miyashita, 1983). The fine-grained green schists consist of angular quartz grains and phyllitic minerals. Some coarse-grained red schists show a matrix rich in opaque minerals, recrystallized calcite and secondary chlorite containing angular quartz grains, plagioclase, epidote, opaque minerals and basaltic fragments. Some serpentine grains are also observed. Blocks of green rocks of 30 cm in size are included in the red schistose matrix. This sequence reworked the Kamuikotan ophiolitic rocks, mainly the spilitic rocks as it is shown by occurrence of numerous epidote grains.

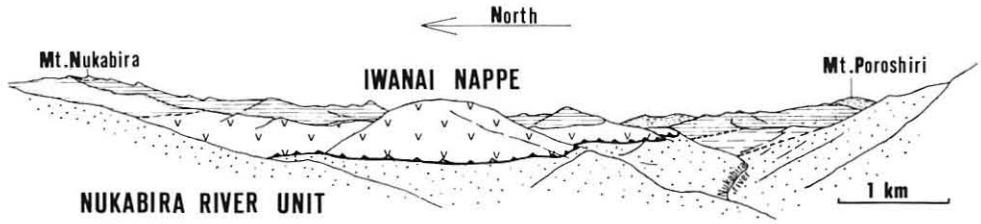


Text-fig. 3 Seven cross-sections around Nukabira-Yama, for localisation refer to Text-fig. 1.
a: Serpentinite and peridotite. b: Reworked green rocks, green and red schists and limestone. c: Yezo Group: Nukabira formation. d: Yezo Group: Niikappu formation. e: Hidaka Super Group sediments.

In the lack of further data we include in the same tectonic unit the peculiar green rocks outcropping along Nukabira River (huge mass of light green pillow lavas very different from the normal ophiolitic green rocks in the Kamuikotan Belt).

3) Grey limestone occurs as a five meters thick bed. The concordance between the limestone bedding plane and the schists bedding plane and some recurrent limestone beds on each side of the main bed points to an in-situ limestone. Such in-situ limestones can be observed along several other cross sections around Nukabira-yama.

4) On other cross sections (north and east of the surveyed area) the Lower Tectonic Unit includes the upper Cretaceous Yezo deposits. The Nukabira River Unit is cut, in the southern area, by horizontal or slightly north-dipping brittle fault planes. The meaning of horizontal one with apparent southward motion is discussed in a later section. The most conspicuous plane is observed along Penkehayushininai River, where some limestone blocks have been dragged along the fault plane (Text-fig. 6).



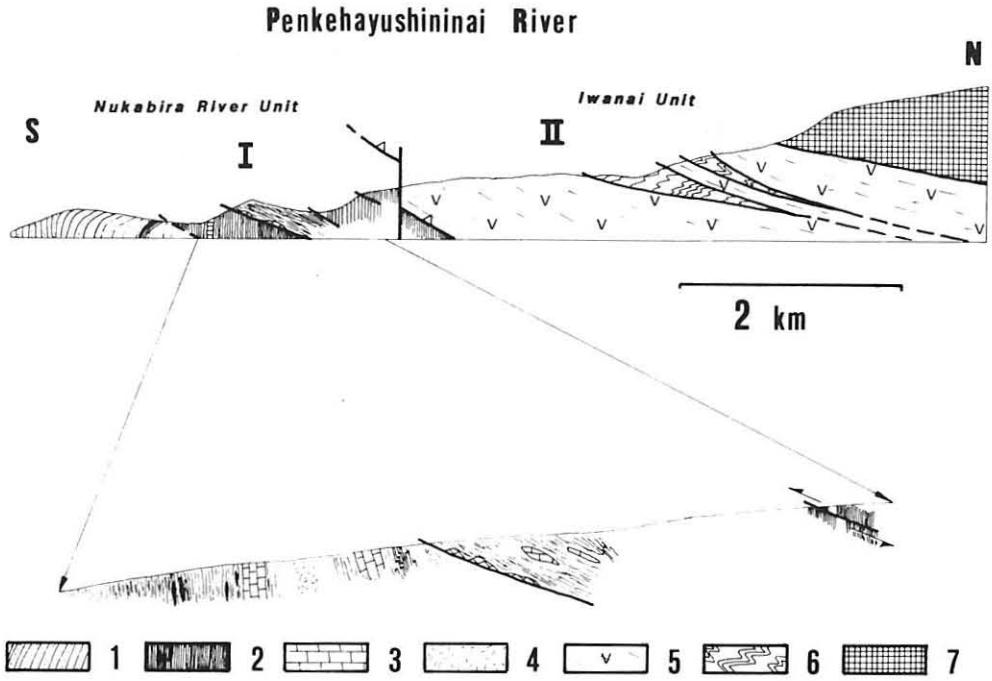
Text-fig. 4 Landscape observed from the Nukabira River Unit (the black point in the southern part of Text-fig. 2 is the observation point). For caption see Text-fig. 2.

Iwanai Tectonic Unit

It is mainly constituted by the serpentinite and the overlying detrital sediments. This unit lies nearly horizontally over the Nukabira River Unit (Text-fig. 4) with some imbrications of serpentinite schists and sediment slices at the contact, as for instance along the Penkehayushininai River where one slice of intensively folded sandstones, with E-W horizontal axes, is observed in the serpentinite showing conspicuous horizontal shear planes. The upper contact between the serpentinite and the overlying sediments is flat as revealed by the map, at least in this area where a precise mapping was possible. The overlying sediments cannot be described as a consistent stratigraphic sequence because of the lack of outcrops. Anyway, along the Penkehayushininai River they are represented by fine-grained slates and sandstones with minor acidic tuffaceous beds similar to the Lower Cretaceous sediments described in the Idonnappu zone (Jolivet et al., 1983).

Regional extension

The sediments which characterize the Nukabira River Unit, namely the green and red schists reworking green rocks and the associated limestone, can be followed in the Sarugawa Formation, toward the west, along Nukabira River and Saru River south of Iwachishi. Following the stream of the Saru River from south to north we recognize the

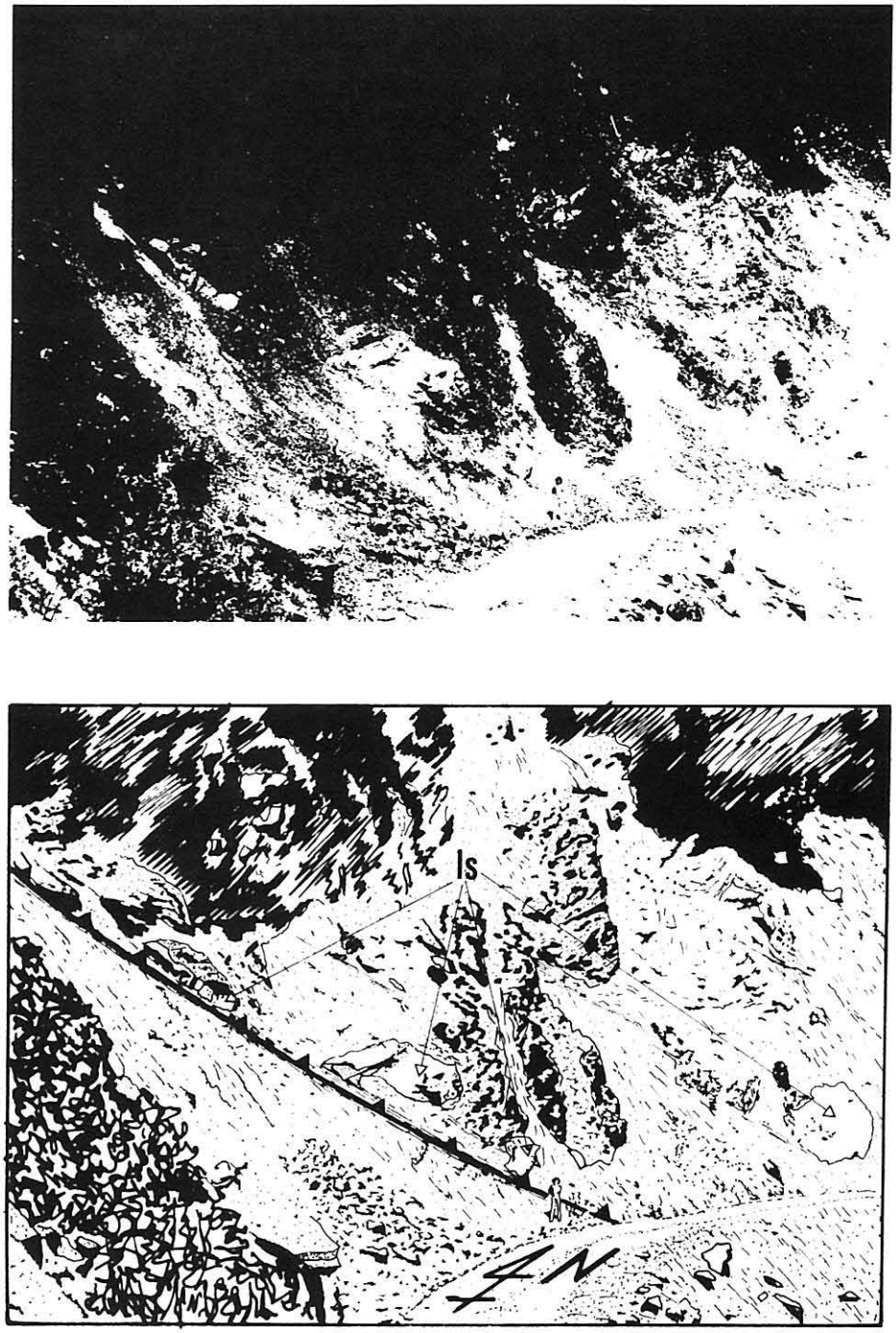


Text-fig. 5 Cross-section along Penkehayushininai River.
I: Lower Tectonic Unit = Nukabira River Unit. II: Upper Tectonic Unit = Iwanai Unit.
1. Black sandstones; 2. Red and green schists including green rock blocks; 3. Limestone; 4. Green rocks; 5. Serpentinite; 6. Folded sandstones; 7. Hidaka Super Group sediments.

same structure with sediments of the Nukabira River Unit thrust on the serpentinite (in Katoh and Niida, 1983). This is comparable with the cross section observed along the Penkehayushininai River and suggests that all the Sarugawa sepentinite mass is allochtonous as a nappe over the reworked green rocks (Text-fig. 7). We, therefore, extend westward the nappe structure described in the Nukabira-yama area. We include in the same nappe structure both the Eastern and the Western Units of Katoh (1978). We do not deny the differences established by Katoh between the two masses, but the juxtaposition of these two different masses is an event older than the nappe emplacement.

On the western side of the Saru River, the serpentinite is covered by the sediments of the Niseu Formation. The lower part of this formation is made of black shales alternating with minor light green quartzite beds and is covered by a thick accumulation of sandstones including scarce limestone nodules. There is no sharp differences between these sandstones and those of the Sarugawa Formation of the Iwanai Unit. We shall consider in the following that all these sandstones belong to the same sedimentary sequence resting on the ophiolitic green rocks.

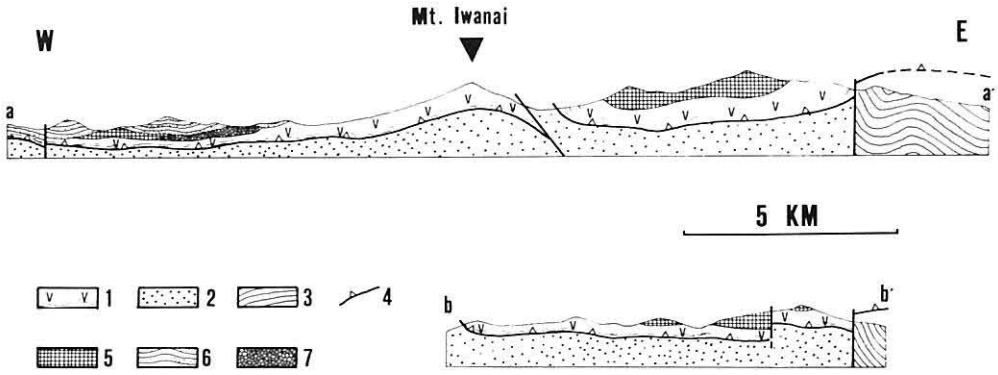
In Niseu area, although a rather intense faulting and some minor scale folds can be observed, the sedimentary sequence as a whole is poorly deformed as it is shown by the trace of the contact between the lower black shales and the upper sandstones on Text-



Text-fig. 6 Photograph of a flat lying fault along Pankehayushininai River. The white blocks are limestones dragged along the fault.

fig. 2. This feature contrasts strongly with the folding and schistosity observed in the Nukabira River Unit.

The detrital sediments of both Sarugawa and Niseu Formations are interpreted as the Cretaceous unconformable cover of the Iwanai Unit ophiolite, here represented by the Iwanaidake peridotites and the Saru River green rocks. The general structure corresponds to an ophiolitic nappe with its Cretaceous sedimentary cover emplaced over reworked green rocks and the Cretaceous sandstones of Yezo Group.



Text-fig. 7 Cross sections of the Iwanai Nappe (localisation on Text-fig. 2)
1. Serpentinite and peridotite; 2. Reworked Gren Rocks of the Nukabira River Unit; 3. Yezo Group; 4. Nappe contact; 5. Presumed Lower Cretaceous; 6. Presumed Upper Cretaceous; 7. Green rocks of Iwanai Unit.

Discussion

Direction of movement

We can offer only limited evidences about the setting movements of this nappe. In the Iwanai Unit:

1) The contact between the serpentinite and the Sarugawa Formation sediments is reworked by a low angle fault (Katoh and Niida, 1983) dipping toward the north-east, the slicken-side exhibits a north-south striation.

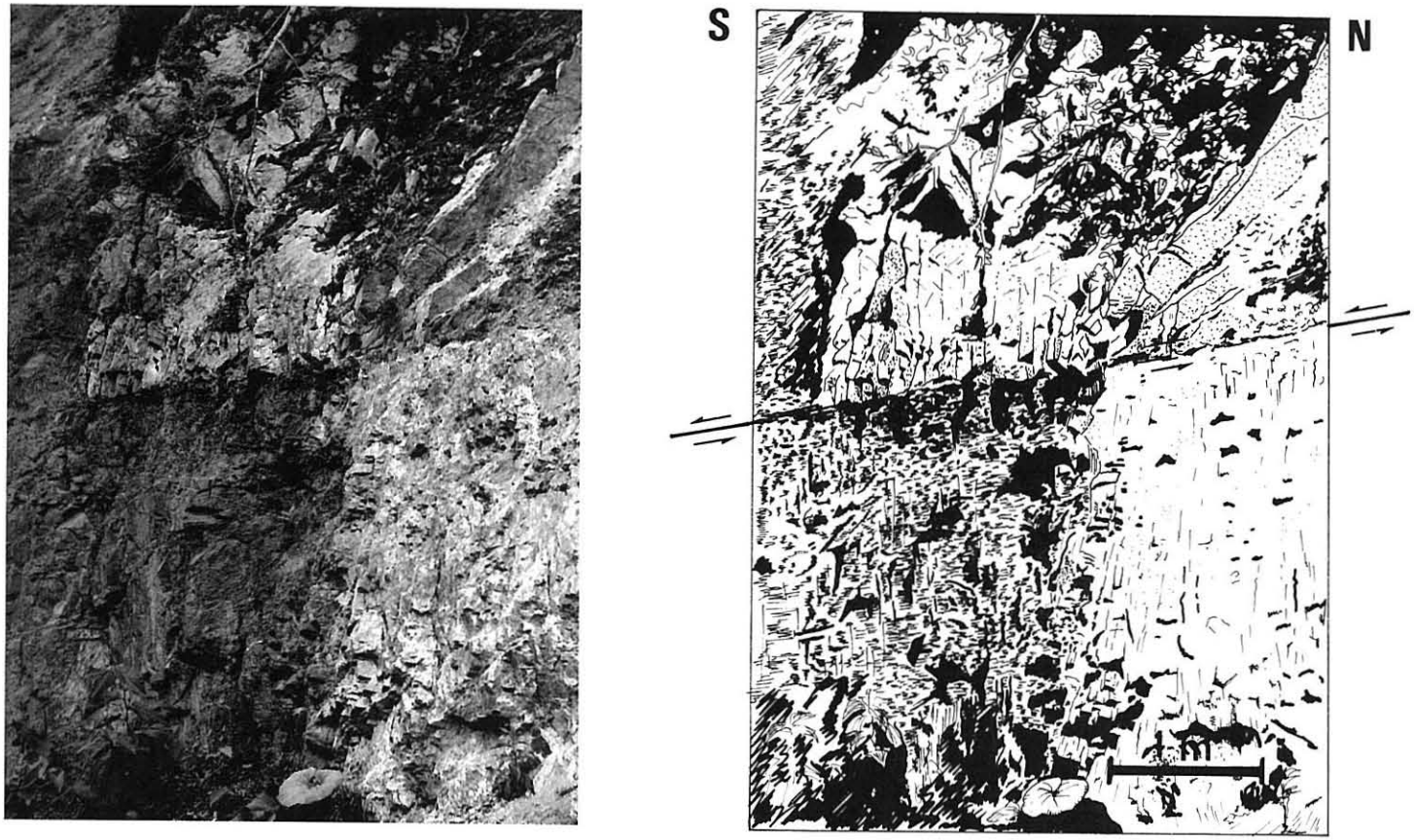
2) The sandstones of Sarugawa and Niseu Formations suffered cataclastic deformation along shear zones (1-2 meters thick) with a north-east dip. Inside these shear zones, sigmoidal features indicate a movement toward the south-east.

In the Nukabira River Unit, we have observed:

1) Asymmetric folds with southwestward vergence along Nikabira River.

2) Flat lying fault planes cutting sharply the red and green schists along Penkehayushininai River, for instance, with NE-SW striation and southwestward offset of the upper comportment (Text-fig. 8).

We conclude to a southwestward vergence for the emplacement of the Iwanai nappe. Such a vergence reveals a common history with the Hidaka strike-slip movement and fits the constrictive component inferred for this strike-slip movement in the Meta-Ophiolitic Zone (Jolivet and Miyashita, 1983).

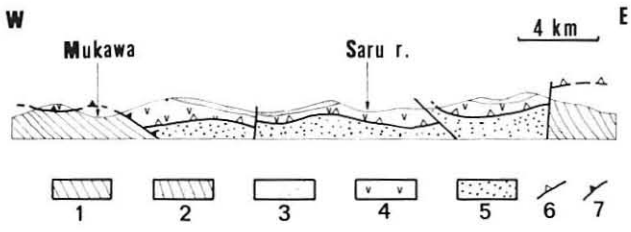


Text-fig. 8 Photograph of a horizontal fault in the red and green schists of Nukabira River Unit, offset of the Upper compartment toward the South.

Age of emplacement

The Iwanai nappe lies over the Yezo deposits of upper Cretaceous age and the Nukabira River Unit is affected by a deformation similar to that of the Hidaka Shear Zone. Later the nappe is cut by north-south vertical faults probably contemporaneous of the movemnt in the Hidaka Shear Zone. We can thus conclude that the settling of the nappe occurred after the upper Cretaceous, later than the beginning of the strike-slip movement and before the end of the same movement. The radiometric data (Shibata, 1968; Shibata and Ishihara, 1979) indicate an Oligo-Miocene age for the metamorphism in the Hidaka Shear Zone. It is K-Ar data and, therefore, the Oligo-Miocene is a minimum age. In fact the lack of Eocene deposits between the Upper Cretaceous Hakobuchi sandstones and the continental Oligocene deposits might be the evidence of a strong orogenic stage. We suggest that the Hidaka Shear Zone movement began during the Eocene time, at the same time as, or slightly before, the emplacement of the Iwanai nappe.

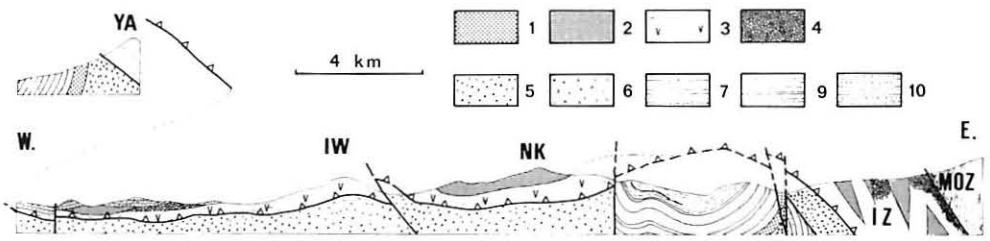
This Eocene age raises the problem of the structural relationship between the serpentinite and the Miocene Takinoue deposits in the western most part of the surveyed area along the Mukawa River. Here, north of Tomiuchi, the serpentinite, and only the serpentinite, is thrust by a very flat contact onto the Takinoue sediments which are rich in serpentine detriti. This movement is the result of a late tectonic event which caused the tectonic gliding of the front of the Eocene nappe in the sedimentation basin of the Takinoue sediments (Text-fig. 9).



Text-fig. 9 Cross-section of the Iwanai Nappe, relation with Miocene at the front. Later movement and thrusting of the serpentinite over the Miocene Takinoue Formation.
1. Takinoue Formation; 2. Yezo Group; 3. Cretaceous to Jurassic Nappe; 4. Serpentinite; 5. Reworked green rocks of Nukabira River Unit; 6. Eocene Nappe contact; 7. Miocene thrust contact.

Conclusion

The sediments which cover the ophiolitic rocks of the Iwanai Unit, alternation of black shales and green quartzites and acidic tuffaceous rocks, can be correlated with the lower Cretaceous sediments of the Idonnappu Zone (Jolivet et al., 1983). In the Chiroro River, Kiminami et al. (1983) described the occurrence of a Lower Cretaceous (Valanginian) sequence rich in acidic tuffites, sandstones and shales. This sequence is similar to that described in Shupparo and Saku Rivers (Jolivet et al., 1983) of, also, Lower Cretaceous age (cf. "Eo-Cretaceous Sequence"). By comparison with the Idonnappu Lower Cretaceous, the Chiroro Shupparo sequence is richer in sandstones and the tuffaceous beds are much thicker and more numerous. Two types of Eocretaceous are therefore distinguished: a western type rich in sandstones and tuffites and an



Text-fig. 10 General cross-section of the Iwanai Nappe: Eastern type Lower Cretaceous over Western type Lower Cretaceous.
YA: Yubari-Ashibetsu area IW: Mount Iwanai NK: Mount Nukabira IZ: Idonnappu Zone MOZ: Meta Ophiolitic Zone
green rocks; 5. Reworked green rocks of the Nukabira River Unit; 6. Green rocks of the Hidaka Western Greenstone Belt; 7. Yezo Group, Nukabira Formation; 8. Yezo Group, Niikappu Formation; 10. Presumed Upper Cretaceous of the Iwanai Unit.

eastern type rich in black shales and tuffites. The Chiroro Formation is in an anomalous position in this simple pattern. The discovery of the Iwanai nappe can bring an explanation to the Lower Cretaceous facies distribution pattern. The emplacement of the Iwanai nappe brought upon a western unit with a "Western type" Lower Cretaceous an eastern unit with a "Eastern type" Lower Cretaceous (Text-fig. 10). The Cretaceous "Yezo Syncline" is therefore a tectonic window in a nappe coming from a northeastern area.

Nappe structures were previously described in central Hokkaido by several authors (see for instance the post-Paleogene nappes and klippes of the Ishikari coal field in Minato et al. (1965) or the "Ishikari"and "Yezo" nappes described by Nagao (1938). Nappe structures are also described in southern Hokkaido in the Horoman area (Owada, oral communication, Hokkaido Tectonics Research Group meeting, August 22, 1983). The structure of Hokkaido Central Belt must therefore be seen as a pile of nappes emplaced during Cenozoic time.

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