LOWER CRETACEOUS STRATA COVERING THE ABYSSAL THOLEIITE (THE HIDAKA WESTERN GREENSTONE BELT) IN THE CHIRORO AREA, CENTRAL HOKKAIDO, JAPAN

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Abstract The Hidaka Western Greenstone Belt, which trends north-south over 130 kilometers and is several kilometers wide, is disconformably overlain by the Lower Cretaceous Chiroro Formation in the Chiroro area, central Hokkaido. The greenstones belonging to the Hidaka Western Greenstone Belt are composed dominantly of abyssal tholeiite. The Chiroro Formation, which is over 300 meters thick, consists mainly of turbidite, mudstone and acid tuff. The lowermost part of the formation is composed of (pale) green mudstone 20 meters thick and some blocks which are mainly made up of greenstones and subordinately, cherts. The greenstones have the same features as the underlying greenstones. The green mudstone is considered to be a mixture of siliceous mud and andesite or basaltic andesite tuff, and it is overlain by black mudstone of about 10 meters thick. The lower part of the black mudstone contains some blocks of greenstones and cherts. The green and black mudstones yield late Valanginian to early Barremian radiolarian assemblage. The black mudstone grades upwards into turbidite with acid tuff. Sole markings in the turbidites indicate axial paleocurrents flowing from S to N. The turbidite belonging to the Chiroro Formation is in fault contact with the Lower Yezo Group.

A considerable time gap is assumed to have occurred between the Chiroro Formation and the greenstones of the Hidaka Western Greenstone Belt. The time gap is ascribed to a diastrophism resulting in the dissection of the uppermost part of the oceanic crust and the deposition of the strata containing the blocks of the oceanic crust. These processes must have proceeded under the waters during the late Valanginian, or the time just before, to the early Barremian. The Cretaceous tectonic setting of the Hidaka Western Greenstone Belt and the Yezo Group Graben Belt is considered to be a trapped oceanic crust in the earliest stage and then to be a residual forearc basin.

Introduction

The zonal arrangement of the Mesozoic rocks is apparent in the western part of the Hidaka mountains, viz. Hidaka Frontal Folded Belt, Hidaka Western Greenstone Belt (H.W.G.B.), Yezo Group Graben Belt (Y.G.B.)

and Kamuikotan Belt to the west (Fig. 1).

The Hidaka Frontal Folded Belt is composed mainly of chert, turbidite, mudstone and greenstone. The petrochemical data suggest that the greenstones belonging to the belt were derived from tholeiitic magma (ISHIZUKA, 1981). KIMINAMI & KONTANI (1983) suggest that the belt represents an accretionary zone.

The Hidaka Western Greenstone Belt (H.W.G.B.) trends north-south over 130 kilometers and is several kilometers in width. This belt has been considered to be the western margin of the Hidaka Belt and to be in fault contact with the sedimentary rocks on both sides. The belt is composed mainly of massive basalt,

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Fig. 1. Index map and tectonic division of central southern Hokkaido.

Arrow indicates the area studied.

I : Hidaka Frontal Folded Belt, II : Hidaka Western Greenstone Belt, III : Yezo Group Graben Belt, IV : Kamuikotan Belt.

Blanks are mainly Tertiary and Quaternary deposits.

pillow basalt and hyaloclastite with chert and limestone. The limestones in this belt yield late Triassic conodonts (IGO *et al.*, 1974 ; SAKAGAMI & SAKAI, 1979). The petrochemical study of the greenstones in the belt indicates that the host magma of these greenstones has a transitional affinity from tholeiitic to alkaline series in the Niikappu River (ISHIZUKA, 1981a) and tholeiitic affinity (NAKAGAWA, 1981). The Yezo Group is rarely distributed as small grabens in the belt.

The Yezo Group Graben Belt (Y. G. B.) chiefly consists of the clastics of the Lower, Middle and Upper Yezo Groups, which form a north-south trending synclinorium. The tectonic setting of the Yezo Group is considered to be a forearc basin (OKADA, 1979, 1982, 1983).

The greenstones are frequently distributed as horsts that trend north-south. The strata overlain by the Yezo Group are known as the Nitarachi Formation (KANIE *et al.*, 1981) in this belt. The Nitarachi Formation distributed in the southern part of the belt (Urakawa area) is conformably overlain by the Lower Yezo Group and in fault contact with the greenstones belonging to the H. W. G. B. (KANIE *et al.*, 1981). The formation is about 150 meters thick and consists mainly of claystone and acid tuff with turbidite (KANIE *et al.*, 1981).

We studied strata in the Chiroro area corresponding to the Nitarachi Formation to make clear the relationship between the strata and greenstones belonging to the H. W. G. B..

These strata occur along the boundary between the H.W.G.B. and Y.G.B. in the Chiroro area studied. They were correlated with the Iwashimizu Formation in the Kamuikotan Belt by HASHIMOTO *et al.* (1961) or the Penkenushigawa Formation in the Hidaka Frontal Folded Belt by SAKO & OSANAI (1962). We renamed the strata as Chiroro Formation in this paper because we consider on the basis of the distribution and facies of the strata that the previous correlation attempted by HASHIMOTO *et al.* (1961) and SAKO & OSANAI (1962) is not reasonable.

The relationship between the Chiroro Formation and the greenstones is very significant to clarify the origin of the Yezo Group Forearc Basin and the emplacement of the greenstones with oceanic nature. This paper presents the relationship as an example of facies change from oceanic crust to forearc deposits.

Hidaka Western Greenstone

The greenstones of the Hidaka Western Greenstone Belt exposed in the Chiroro River are composed mainly of pillow and massive basalts, dolerite and subordinate hyaloclastite. These rocks are frequently crushed to produce network shaped calcite veins. Therefore, the original lithofacies are obscured in places. Uncrushed rocks trend about N30°E and dip steeply east or west. The configuration of the pillow basalts indicates westward facing in the upper part (Fig. 2). There are also some feeder dykes which trend north-south and dip gently west.

The pillow basalts are close-packed, and the size of each pillow ranges from a few tens centimeters to one meter in diameter. The fact that no vesicles more than 0.2 millimeters in diameter are found suggests that the pillow lava extruded in the deep waters (MOORE, 1965, 1970). In some places the pillow lava grades into massive basalt, dolerite or hyaloclastite. The dolerites or massive basalts occur usually as concordant layers of several meters thickness. Hyaloclastites are composed of various sizes of basaltic fragments. The shape of the fragments is very angular, suggesting that brecciation occurred nearly in situ.

Fig. 2. Geologic map of the Chiroro Area.

Dips and strikes in the greenstone are inferred from pillow form.

Uncrushed rocks preserve the original igneous texture, i.e., ophitic to subophitic (dolerite), intergranular (pillow core) and variolitic (margin of pillow) textures. Clinopyroxenes are well preserved and show weak or no pleochroism, and most plagioclases are albitized due to secondary processes.

Abundant metamorphic minerals such as chlorite, pumpellyite, albite, prehnite, calcite and quartz occur replacing plagioclase, glass and in amygdaloids. No actinolite or epidote is observed in the studied samples. The assemblage of these minerals indicates that these greenstones underwent low-grade metamorphism under the prehnite-pumpellyite facies conditions.

Nine samples preserving original textures were analysed. The results are shown in

Sample No.	1 82819A	2 82907	3 82910	4 82824	5 82814	6 ChGS	7 78-15	8 78-111	9 78-119
SiO ₂	46.94	48.31	49.66	48.72	48.08	50.04	47.64	47.92	47.94
TiO ₂	1.04	1.16	1.05	1.14	1.07	1.06	1.07	1.15	1.35
Al ₂ O ₃	14.39	14.51	14.15	13.53	15.27	14.19	13.56	13.71	13.19
Fe ₂ O ₃	1.83	2.59	2.47	2.96	2.12	2.80	2.25	2.40	3.14
FeO	8.83	8.64	8.41	8.82	7.90	7.65	8.42	9.35	10.15
MnO	.18	.17	.18	.20	.15	.17	.18	.19	.24
MgO	8.15	7.69	7.85	7.70	7.15	8.06	8.55	8.45	7.65
CaO	10.58	11.27	10.29	8.70	10.74	10.43	10.45	9.19	9.03
Na ₂ O	2.55	2.40	2.87	3.43	2.62	2.22	3.16	3.58	3.68
K ₂ O	.58	.27	.66	.75	.98	.35	.08	.47	.46
P ₂ O ₅	.09	.10	.09	.10	.09	.09	.10	.12	.13
L.O.I.	4.38	2.94	3.60	3.59	3.38	3.52	4.36	3.98	2.45
Total	99.55	100.04	101.28	99.63	99.55	100.58	99.82	100.51	99.41
Cr(ppm)		321	268	176	290				
Ni(ppm)		93	81	89	103				
CIPW NORMS (Fe ₂ O ₃ /FeO = 0.15)									
Q	—	—	—	—	—	.40	—	—	—
Or	3.43	1.60	3.90	4.43	5.79	2.07	.47	2.78	2.72
Ab	21.6	20.3	24.3	29.0	22.2	18.3	26.7	27.5	28.6
An	26.1	28.0	23.8	19.3	27.0	27.7	22.6	19.9	18.1
Ne	—	—	—	—	—	—	—	1.51	1.39
Di	21.1	22.4	21.9	19.1	21.1	19.2	23.3	20.4	21.3
Hy	3.32	12.1	8.70	2.62	2.75	24.6	2.87	—	—
Ol	15.4	8.05	10.8	16.9	13.2	—	14.0	19.7	19.3
Mt	2.01	2.10	2.04	2.20	1.88	1.95	3.26	2.21	2.49
Il	1.97	2.20	1.99	2.16	2.03	2.01	2.03	2.18	2.56
Ap	.21	.23	.21	.23	.21	.21	.23	.28	.30
FeO*/MgO	1.29	1.43	1.36	1.49	1.37	1.26	1.22	1.36	1.70

Table 1. Chemical composition of the greenstones from the Hidaka Western Greenstone Belt.

1, 4, 6, 8, 9 : dolerite,
2, 5 : pillow basalt,
3, 7 : massive basalt.

Table 1. The H₂O contents(L. O. I.) do not exceed 4.5wt. % and the Fe₂O₃/FeO ratios are not so high(0.2 to 0.3), suggesting that the analysed samples have not encountered serious secondary alteration. The range in FeO*/MgO ratio of the analyses is narrow, i. e., from 1.22 to 1.70, indicating that extensive fractionation did not occur. Systematic increase in TiO₂ and FeO* contents with increasing FeO*/MgO shows that these rocks belong to tholeiitic suite (e. g., MIYASHIRO, 1973). Most of the present analyses correspond with those on olivine tholeiite (YODER & TILLEY, 1962) based on the CIPW norms in which Fe₂O₃/FeO is normalized as 0.15.

In plots of FeO*/MgO versus TiO₂ and FeO*, the greenstones analysed fall in the field of abyssal tholeiite, however, the TiO₂ contents are slightly low comparing with those of the abyssal tholeiite with the same FeO*/MgO value (Fig. 3). It may be partially caused due to secondary processes such as ocean floor weathering or low-grade metamorphism resulting in a decrease of the MgO content and an increase of the FeO* content of the basalt. On the other hand, TiO₂ and P₂O₅ are generally believed to be the most immobile elements during the secondary processes. The plots of P₂O₅ versus TiO₂ indicate that these greenstones are akin to ocean floor basalt

Fig. 3. FeO^*/MgO versus TiO_2 and FeO^* diagrams for the greenstones of the Hidaka Western Greenstone Belt.

solid circle : this study, solid triangle : analyses from literatures (SAWADA & KANMERA, 1973 ; SUZUKI, 1977), AT : trend of abyssal tholeiite after MIYASHIRO (1973), SK : trend of liquid of the Skaergaard intrusion after WAGER & BROWN (1967), ATG : field of glass of abyssal tholeiite after Basaltic Volcanism Study Project (1981), H : field of basalt and dolerite for Horokanai ophiolite in the Kamuikotan zone after ISHIZUKA (1981b), FeO^* : total Fe as FeO .

(Fig. 4). Furthermore, preliminary analyses of minor elements such as Cr and Ni which have been postulated as being relatively insensitive to secondary mobilization (PEARCE, 1975) were carried out using atomic absorption spectro-photometer. These analyses fall in the ocean-floor tholeiite field of the empirical discriminative diagram Ti/Cr versus Ni (BECALUVA *et al.*, 1979) as shown in Fig. 5.

Chiroro Formation and Lower Yezo Group

The Chiroro Formation is exposed in a limited area along the western margin of the H. W. G. B. and in fault contact with the Lower Yezo Group in the Chiroro area (Fig. 2). The relationship between the formation and greenstones will be described in another section. The total thickness of the Chiroro Formation exceeds 300 meters, and the general strike and dip are north-south and 50° – 70° east, respectively. The graded bedding and sole marking indicate that the beds are overturned. The Chiroro Formation consists mainly of turbidite, mudstone and acid tuff. The acid tuffs are traceable as key beds in the mapped area.

The lowermost part of the formation is

composed mainly of (pale) green mudstone with some blocks which are mainly made up of greenstones and subordinately, cherts (Fig. 6). The thickness is 20 meters. The green mudstone is almost massive with rare bedding and not sheared, and the maximum size of the blocks is a few meters. The shape of the blocks is variable from complex shape to ellipsoidal or lenticular shape. Under the microscope, the green mudstone is ill-sorted and contains a fair amount of radiolarian fossils, feldspar and pyroxene grains and volcanic rock fragments. Most volcanic rock fragments are of groundmass origin. These are mostly hyalopilitic, pilotaxitic and occasionally, intersertal textures. The green mudstone is considered to be a mixture of siliceous mud and andesite or basaltic andesite tuff.

This green mudstone is overlain by black mudstone of about 10 meters thick. The lower part of the black mudstone contains some blocks of greenstones and cherts. The mudstone yields well-preserved radiolarians belonging to an assemblage indicating the Lower Cretaceous.

This mudstone grades upwards into turbidite with acid tuff, massive sandstone and

Fig. 4. TiO_2 versus P_2O_5 diagram.

Fields for various basalt-types are after RHODES (1973).

AT : abyssal tholeiite, OIT : oceanic island tholeiite, OIA : oceanic island alkali basalt.

Fig. 5. Ti/Cr versus Ni diagram.

IAT : island arc tholeiite, AT : abyssal tholeiite.

The boundary between IAT and OFI is after BECCALUVA *et al.*, (1979).

mudstone. The facies represented by the turbidites constitute the middle and upper parts of the Chiroro Formation. In the lower part of the turbidite strata, two or three acid tuff beds are found. The acid tuff, which

Fig. 6. Stratigraphic column of the greenstone, Chiroro Formation and Lower Yezo Group.

X : radiolarian fossil localities (detailed localities are shown in Figs. 7 and 8).

is gray to white in colour and fine to medium grained, represents devitrified vitroclastic texture with feldspar and biotite grains. The thickest one is about 40 meters. Tuffaceous sandstone and tuffaceous mudstone commonly occur at top or base of the tuff beds. The turbidites constructing the main part of the Chiroro Formation alternate with the black mudstone. The thickness of the turbidite beds ranges from one meter to several centimeters. Almost all turbidites represent distinct graded bedding with many sole markings, indicating overturned westwards facing. The turbidite is in fault contact with a massive sandstone belonging to the Lower Yezo Group. The sandstone in the Chiroro Formation re-

Fig. 7. Geologic route map around the boundary between the Hidaka Western Greenstone and the Chiroro Formation.

Arrows and sample Nos. indicate the localities of sketches and radiolarian assemblage shown in Fig. 8 and Table 2, respectively.

sembles that of the Lower Yezo Group in appearance.

The lowermost part of the Lower Yezo Group consists of massive, medium to coarse grained quartzose sandstone, which is very similar in appearance to the "Tomitai Sandstone" known as the basal facies of the Lower Yezo Group in general. The massive sandstone is overlain by a thick sequence composed of muddy turbidites. The Lower Yezo Group dips steeply west and is not overturned in most cases.

The relationship between the Chiroro Formation and the greenstones

The relationship between the greenstones

and the Chiroro Formation is well observed along the Chiroro River. The route map around the boundary between the greenstones and the Chiroro Formation is shown in Fig. 7.

The greenstones belonging to the H.W.G.B. near the boundary between the Chiroro Formation and the H.W.G.B. in the Chiroro River are made up of massive basalt, dolerite and hyaloclastite. The greenstones are covered by ill-sorted greenish fine sandstone and sandy mudstone containing many feldspars, pyroxenes and andesite and basaltic andesite fragments, in addition to a few radiolarian fossils. These grains are floating in a clayey matrix in many cases and are fairly closely packed in some cases. The unit di-

Fig. 8. Sketches showing the occurrence of greenstone and chert blocks. Localities are shown in Fig. 7.

chevron : greenstone, swung dash : chert, diagonal line : black mudstone, dashed line : green mudstone.

rectly covering the greenstones is several meters thick. No fault is found between the greenstones and the unit.

The unit composed of ill-sorted greenish sandstone and sandy mudstone is overlain by green mudstone containing feldspars, pyroxenes and andesite to basaltic andesite fragments of silt to sand size, and some blocks made up of greenstones and cherts. Almost all of the cherts are recrystallized. The greenstones are mainly dolerites which are partly crushed. These blocks are nearly similar with the underlying greenstones in terms of their petrographic features. Many well-preserved radiolarian fossils coexist together with the grains of crystals and rock fragments in the green mudstone (Plate I-1, 2, 3). The unit is 15 meters thick.

The blocks are found up to the lower part of the black mudstone unit of about 10 meters thick overlying the green mudstone. The black mudstone contains a very small amount of sand to silt size grains of feldspar, pyroxene, hornblende and andesitic rock fragments and a considerable amount of silt size quartz grain. Many radiolarian fossils coexist together with these grains (Plate I-4).

The following evidences refute the assumption that the blocks are tectonic in origin.

i) No faults are observed between the

host rock and the block in general (Fig. 8 A, B).

ii) The host rock is not sheared in appearance.

iii) Well-preserved radiolarian fossils coexist together with sand size grains in the host rock, even just around the blocks.

iv) Under the microscope, conspicuous shearing and recrystallization are not observed in the host rock, although the greenstone blocks are fairly crushed in some cases and the chert blocks are recrystallized.

The evidences indicate that the blocks are sedimentary in origin. The greenstone blocks are most likely derived from the underlying greenstones. It is inferred that the relationship between the greenstones of the H. W. G. B. and the overlying strata is in sedimentary contact. This assumption is supported by the evidence that the sandy mudstone attached just above to the greenstone contains a fair amount of radiolarian fossils. The depositional mechanism of the strata containing blocks is probably debris flow or debris flow -rock fall with tuffaceous muddy matrix, judging from the sedimentary facies and microscopic texture. The dissection of the greenstones and the strata which possibly overlay the greenstones originally and the deposition of the debris flow deposits must

Fig. 9. Paleocurrent directions inferred from flute casts (arrows), prod casts (arrows) and groove casts (lines) in the Chiroro Formation.

Fig. 10. Ternary diagram showing the composition of sandstones from the Chiroro Formation.

Q : quartz, F : feldspar, R : rock fragment.

have occurred in the deep waters.

Paleocurrents and sandstone mineralogy

Many sole markings are found in the turbidites constructing the middle and upper parts of the Chiroro Formation. The types of sole markings observed are flute, groove and prod casts. The general orientation of each type of directional sole marking in a single sandstone bed is represented by only one reading. For directional readings of the sole markings, post-depositional tilting of the strata was removed by rotating the strata around the horizontal axis. The current direction inferred from the sole markings is stable and from S to N (Fig. 9). This current system must be axial current, judging from the structural trend of the Chiroro Formation.

The turbidite sandstones of the Chiroro Formation can be classified into feldspathic arenite or wacke (Fig. 10). Most quartz

grains are monocrystalline and do not show any wavy extinction. The monocrystalline quartz grains contain liquid inclusion as a rule. Feldspars are mostly plagioclases. Microcline-perthite content is 1 to 3 percent in modal analysis. Lithic fragments are composed of volcanic rocks, granitic rocks, chert, semischist, fine clastics, muscovite-quartz schist and hornfels. Volcanic rock fragments are the main components of the lithic fragments and reach 15 to 20 percent in modal analysis. Among the volcanic fragments, those of acid composition prevail, followed by those of intermediate composition, judging from textures. Welded tuffs are rarely identified except for these volcanic fragments. Lithic fragments composed of quartz, K-feldspar and plagioclase, which are considered to be granitic rocks, reach 2 to 6 percent in modal analysis. Semischist, fine clastics, muscovite-quartz schist and hornfels are minor components. Heavy mineral is of low (less than 1 percent in modal analysis) content,

Table 2. List of radiolarian from the Chiroro Formation.

	Sample No.	83080208	83080211	83080101	83080212	82080514	81082801	81082802
Radiolaria species								
<i>Acaeniotyle diaphorogona</i>		X						
<i>A. umbilicata</i>			X X X					
<i>Alievium helenae</i>		X				X		
<i>Staurosphaera septemporata</i>					X			X
<i>Sphaerostylus lanceola</i>					X			
<i>Staurocyclus martini</i>			X	X				
<i>Triactoma echiodes</i>		X						
<i>Archaeodictyomitra apiara</i>			X					
<i>A. sp. cf. A. apiara</i>				X				
<i>A. vulgaris</i>						X		
<i>A. sp.</i>		X X X	X X X	X X				
<i>Eucyrtis micropora</i>					X			
<i>Hemicryptocapsa sp. cf. H. capita</i>			X X X	X X				
<i>Parvicingula boesii</i>		X X X	X X X	X X				
<i>Sethocapsa uterculus</i>		X X X	X X					
<i>S. tracheostraca</i>					X		X	
<i>S. sp. cf. S. tracheostraca</i>		X X X						
<i>Siphocampium? davidi</i>					X			
<i>Thanaria pulchra</i>		X X						
<i>T. conica</i>			X	X		X		X
<i>Xitus spicularis</i>					X X			
<i>Pseudodictyomitra sp. cf. P. carpatica</i>		X X						
<i>P. sp.</i>		X X X	X X					
<i>Williriedellum gilkeyi</i>					X			
<i>Archaeospongoprimum sp.</i>		X X X	X X					X
<i>Podobursa sp.</i>		X						
<i>Crucella sp.</i>						X		

※ green mudstone, ※※ black mudstone.

and is mainly biotite and zircon.

Age

Many well-preserved radiolarian fossils are obtained from the tuffaceous green mudstone and black mudstone (Plate II). The radiolarian assemblages (Table 2) from the green mudstone and the overlying black mudstone are very similar and bear a close resemblance to the *Staurosphaera septemporata* Zone (RIEDEL & SANFILIPPO, 1974; SCHAAF, 1981) and *Sethocapsa trachyostraca* Zone (FOREMAN, 1975). The assemblage suggests that the lowermost part of the Chiroro Formation is late Valanginian to early Barremian in age. The same radiolarian assemblage has been reported by KANIE *et al.* (1981) from the Nitaraichi Formation in the Urakawa area and by MINOURA *et al.* (1982) from the Sorachi Group in the Furano area.

Discussion

NAKANO (1978) and NAKANO & KOMATSU (1979) showed that the greenstones from the southern part of the H. W. G. B. were tholeiitic basalt on the basis of the clinopyroxene compositions. NAKAGAWA (1981) who presented several figures of the clinopyroxene and bulk rock compositions obtained from many localities of the H. W. G. B. concludes that the greenstones are dominantly abyssal tholeiite. On the other hand, ISHIZUKA (1981a) considered that the greenstones exposed in the Niikappu River area, which is located about 20 kilometers south of the area investigated by us, are transitional from tholeiitic to alkaline affinity on the basis of the clinopyroxene compositions. However, the occurrence of such "transitional" clinopyroxene in abyssal tholeiite is not uncommon. Tholeiitic basalts from the oceanic ridge often contain such transitional clinopyroxene, being comparatively rich in Al_2O_3 and TiO_2 , as reported by FREY *et al.* (1974), BUNCH & LABORDE (1976), SHIBATA *et al.* (1979a, 1979b), MEVEL *et al.* (1978), PERFIT *et al.* (1982), NISBET & PEARCE (1977), KIRKPATRICK (1978) and LAROEEX *et al.* (1981). Thus the greenstones of the H. W. G. B. are considered to be tholeiitic affinity, though the data are still not sufficient. Very poor development of vesicles characterizes the pillow lava of the H. W. G. B. (NAKANO, 1978; ISHIZUKA, 1981a), suggesting that these pillow lavas extruded at deep sea environments (MOORE, 1965, 1970). On the other hand, the metamorphic conditions of these greenstones are zeolite to prehnite-pumpellyite facies over a fairly extensive area of the H. W. G. B. (SAWADA & KANMERA, 1973; NAKANO, 1978, 1981; ISHIZUKA, 1981a). Thus, the greenstones from these extensive areas of the H. W. G. B. have similar features in respect to their mode of occurrence, magmatic type and metamorphic conditions. These characteristics suggest that these greenstones were a part of the upper portion of oceanic crust.

The late Valanginian to early Barremian Chiroro Formation covers the greenstones with

sedimentary contact. Limestones and cherts in the H. W. G. B. yield late Triassic conodonts (IGO *et al.*, 1974, 1980; SAKAGAMI & SAKAI, 1979) and Triassic Bryozoan fossils (SAKAGAMI & SAKAI, 1979). Although there is a possibility that the limestones and cherts in the H. W. G. B. are blocks, a considerable time gap is assumed between the Chiroro Formation and the greenstones. The evidence of greenstones and cherts existing in the lowermost part of the Chiroro Formation as blocks supports the assumption. The facies and features of the strata just above the greenstones indicate that the time gap is ascribed to a diastrophism resulting in the dissection of the uppermost part of the oceanic crust and the deposition of the strata containing some blocks. These processes probably proceeded under the waters during the late Valanginian, or the time just before, to the early Barremian. On the basis of the above interpretation, the relationship between the greenstones and the Chiroro Formation is considered to be a "disconformity".

The green mudstone and black mudstone constructing the lowermost part of the Chiroro Formation contain many basaltic andesite and andesite rock fragments and pyroxenes of sand and silt sizes. As mentioned before, these strata are considered to be debris flow deposits with tuffaceous muddy matrix. On the other hand, the middle part mainly composed of turbidites is frequently intercalated with thick acid tuff beds. The Early Cretaceous volcanics and plutonics are found in Moneron Island (PISKUNOV & KHVEDCHUK, 1976), Rebun Island (NAGAO *et al.*, 1963), the Kumaneshiri area (HASHIMOTO *et al.*, 1960), Okushiri Island (SHIBATA & YAMADA, 1978), the Oshima Peninsula (KAWANO & UEDA, 1967) and the Taro Belt in the northern Kitakami Mountains (KAWANO & UEDA, 1964; SUGIMOTO, 1974). The Moneron-Rebun-Kumaneshiri-Taro zone, which is clearly expressed in the gravity field as a band of intense high, has been assumed to be a magmatic arc in the Early Cretaceous (OKADA, 1974, 1979, 1982, 1983; KIMINAMI & KONTANI, 1983, 1984). The

volcanogenic elements in the tuffaceous deposits and acid tuffs in the Chiroro Formation may have been derived from the arc region. Also, the volcanogenic materials become felsic as they advance to the later stage in the Chiroro Formation.

The basin was gradually transformed into an environment in which the terrigenous clastics were fed during the sedimentary stage of the middle part of the Chiroro Formation. The turbidites in the middle and upper parts were transported from the south along the long axis of the basin. The excellent axial transport suggests that the basin geometry was trough shaped. The transported direction agrees with that of the Lower Yezo Group in Hokkaido (TANAKA & SUMI, 1981). The sandstone composition of the Chiroro Formation indicates that the source area was mainly made up of acid volcanic rocks and granitic rocks, and subordinately, chert and fine clastics.

In the Y. G. B. the strata overlain by the Yezo Group are known as the Nitarachi Formation in the Urakawa area (KANIE *et al.*, 1981), situated 60 kilometers south of the area investigated by us. The age, rock facies and stratigraphy of the Nitarachi Formation are very similar to those of the Chiroro Formation, although the facies containing blocks are not reported in the Nitarachi Formation. There is a large possibility that the Nitarachi Formation was deposited on the greenstones by the same processes as the Chiroro Formation.

On the basis of the stratigraphical relationship between the greenstones, the Lower Cretaceous strata (the Chiroro and Nitarachi Formations) and the Yezo Group, we consider that the Cretaceous tectonic setting of the H. W. G. B. and the Y. G. B. was a residual forearc basin (defined by DICKINSON & SEELY, 1979) floored by a trapped oceanic crust. The trap of the oceanic crust probably resulted from a jump of plate boundary that took place toward the earliest Cretaceous from the northern Kitakami Mountains-Oshima Peninsula to the western margin of the Hidaka Belt (the Hidaka Frontal Folded Belt) (KIMINAMI & KONTANI, 1984).

of which tectonic setting was suggested to be a Lower Cretaceous accretionary prism (KIMINAMI & KONTANI, 1983, 1984). This point will be discussed in detail based on additional data in another paper.

Conclusion

1) The greenstones belonging to the Hidaka Western Greenstone Belt are inferred to be abyssal tholeiite.

2) The Chiroro Formation disconformably overlies the greenstones.

3) The Chiroro Formation is mainly composed of turbidite, mudstone and acid tuff. The lowermost part of the formation is made up of green mudstone and black mudstone with blocks of greenstones and cherts. The strata which cover the greenstones are probably debris flow or debris flow-rock fall deposits with a tuffaceous muddy matrix.

4) The volcanogenic materials in the Chiroro Formation were probably derived from the arc region which had existed to the west.

5) The lowermost part of the Chiroro Formation is late Valanginian to early Barremian in age.

6) The turbidites in the Chiroro Formation were transported by axial paleocurrents from S to N.

7) The sandstone composition of the Chiroro Formation indicates that the source area was mainly made up of acid volcanic rocks and granitic rocks, and subordinately, chert and fine clastics.

8) A considerable time gap is assumed between the Chiroro Formation and the greenstones of the Hidaka Western Greenstone Belt. The time gap is ascribed to a diastrophism resulting in the dissection of the uppermost part of the oceanic crust and the deposition of the strata containing the blocks.

9) The Cretaceous tectonic setting of the Hidaka Western Greenstone Belt and the Yezo Group Graben Belt is considered to be a residual forearc basin floored by a trapped oceanic crust.

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* : in Japanese with English abstract

** : in Japanese

日高西縁緑色岩に重なる千呂露地域の下部白亜系

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(要 旨)

日高山脈の西側には、幅数 km、長さ 130 km 以上にわたり、主に緑色岩から構成される日高西縁緑色岩が南北に分布する。化学組成の検討に基づけば、日高西縁緑色岩帯中の緑色岩類は、深海底ソレアイトに極めて類似した性格を示し、海洋地殻を構成していた岩石である可能性が高い。日高町南東方の千呂露地域では、この緑色岩類を“非整合”におおう千呂露層が分布する。上位の下部エゾ層群と断層で接する千呂露層は、主に陸源性碎屑物から成るタービダイト砂岩、泥岩および酸性凝灰岩から構成され、その厚さは 300 m 以上である。緑色岩と接する千呂露層の最下部は、数 cm~3 m の緑色岩およびチャートのブロックを含んだ厚さ 20 m の緑色泥岩から構成される。この緑色泥岩上には厚さ 10 m の黒色泥岩が重なり、この黒色泥岩の下半部にはやはり緑色岩とチャートのブロックを含む。この緑色岩ブロックは、下位の日高西縁緑色岩と極めて類似する。黒色泥岩上には千呂露層の主体をなす厚い酸性凝灰岩を挟んだタービダイト砂岩が重なる。緑色泥岩および黒色泥岩からは late Valanginian~early Barremian を示す放散虫化石が得られる。鏡下観察より、緑色泥岩は凝灰質な泥岩と考えられる。ブロックを含む千呂露層最下部の岩相は、安山岩質の凝灰質泥を基質とした debris flow や rock fall により堆積した。一方、緑色岩と千呂露層の間には

かなりの時間間隙が想定される。この時間間隙は、late Valanginian もしくはその直前から early Barremian 位にかけて起きた変動に起因し、この変動が海洋地殻の上部メンバーの解析とブロックを含む岩相の堆積を引き起こしたと推定される。これらの諸過程はかなり深い海の底で進行した可能性が高い。また、日高西縁緑色岩から千呂露層にかけての岩相変化は、トラップされた海洋地殻が residual forearc basin に転化していく過程を示していると考えられる。

(地 名)

Chiroro	千呂露
Furano	富良野
Horokanai	幌加内
Iwashimizu	岩清水
Kumaneshiri	隈根尻
Niikappu	新冠
Nitarachi	ニタラチ
Okushiri Island	奥尻島
Oshima Peninsula	渡島半島
Penkenushigawa	ペンケヌシ川
Rebun Island	礼文島
Taro	田老
Urakawa	浦河

Explanation of Plates

Plate I : Photomicrographs of the green and black mudstones in the lowermost part of the Chiroro Formation (open nicol).

Scale bar is 200 μm for 1 to 4.

1—3 : Ill-sorted green mudstones with volcanic rock fragments (VRF), plagioclases (Pl), clinopyroxenes (Cpx) and radiolarian fossils.

4 : Black mudstone with volcanic rock fragments (VRF) and radiolarian fossils.

Plate II : Radiolaria from the Chiroro Formation. Scale bar is 100 μm .

1 : <i>Thanarla pulchra</i> (SQUINABOL)	(83080211)
2 : <i>Hemicryptocapsa</i> sp. cf. <i>H. capita</i> TAN	(82080514)
3 : <i>Acaeniotyle diaphorogona</i> FOREMAN	(83080211)
4 : <i>Sphaerostylus lanceola</i> (PARONA)	(83080212)
5 : <i>Xitus spicularis</i> (ALIEV)	(82080514)
6 : <i>Alievium helenae</i> SCHAAF	(82080514)
7 : <i>Staurosphaera septemporata</i> PARONA	(83080212)
8 : <i>Staurocyelia martini</i> (RÜST)	(83080212)
9 : <i>Parvicingula boesii</i> (PARONA)	(83080212)
10 : <i>Acaeniotyle umbilicata</i> (RÜST)	(83080212)
11 : <i>Eucyrtis micropora</i> (SQUINABOL)	(83080212)
12 : <i>Sethocapsa uterculus</i> (PARONA)	(83080211)

———— 1, 2, 4, 5, 6, 7, 8, 9, 10, 11

———— 3 ———— 12