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OUTLINE OF THE SHEAR ZONES IN THE HIDA MARGINAL BELT

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ABSTRACT

Two groups of shear zones, i.e. the shear zones of group A and group B, were discriminated in the Moribu–Fukuji area of the Hida Marginal Belt, which is lithologically subdivided into three subbelts. Shear zones of group A comprise at least four ductile shear zones with dextral strike-slip component, two of which bound the above subbelts. The four dextral shear zones form, as a whole, a dextral strike-slip fault system resembling a strike-slip duplex. Shear zones of group B, on the other hand, comprise several cataclastic shear zones with sinistral strike-slip component that cut Early Cretaceous strata correlated with the Tetori Group, and that partly overprint the dextral ductile shear zones of group A. Crosscutting relationships between the shear zones and age-known rock bodies in the Moribu–Fukuji area constrain the timing of shearing as follows: the dextral shear zones were formed between Late Triassic and Late Jurassic times whereas the sinistral shear zones were formed between Early and Late Cretaceous times. It is suggested that the constituent rocks of the Hida Marginal Belt were (1) basically gathered through Late Triassic to Late Jurassic dextral duplexing and (2) extended in E–W direction during the Early to Late Cretaceous sinistral shearing.

Key words: shear zone, mylonite, cataclasite, tectonic inversion, Jurassic, Cretaceous, Hida Marginal Belt, Tetori Group, central Japan

大藤　茂・東田和弘・笠原健司・堀田久美子・佐々木みぎわ（2003）飛騨外縁帯の剪断帯概要，福井県立恐竜博物館紀要 2：63–73.

飛騨外縁帯の森部－福地地域で，Ａ・Ｂ２つの剪断帯群を識別・記載した．当地域は，特徴的な構成岩類の組合せから３つの亜帯に区分される．剪断帯群Ａは，右横ずれ変位成分をもつ最低４つの延性剪断帯からなり，その内２つは上記亜帯の境界となる．剪断帯群Ａの延性剪断帯は，全体として右横ずれ複合断層帯をなす．剪断帯群Ｂは，カタクレーサイトを伴う左横ずれ脆性剪断帯からなり，手取層群に対比される下部白亜系を切り剪断帯群Ａの延性剪断帯に重複変形を与える．森部－福地地域の構成岩類と剪断帯との切断関係から，剪断帯群Ａは後期三畳紀～後期ジュラ紀に，剪断帯群Ｂは前期～後期白亜紀にそれぞれ形成されたと推定される．以上より，飛騨外縁帯構成岩類は，後期三畳紀～後期ジュラ紀の右横ずれ複合断層帯形成に伴って集積し，前期～後期白亜紀の左横ずれ運動に伴い東西方向へ伸長したとするモデルを立てた．

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INTRODUCTION

Pre-Tertiary rocks along the eastern margin of Asia were emplaced at the present position through several stages of strike-slip movements (Otoh and Yanai, 1996; Otoh, 1998; Otoh et al., 1999). In Japan, some Cretaceous sinistral shear zones have been well studied: e.g. (1) large sinistral strike-slip faults such as the Median Tectonic Line (M.T.L.; Takagi, 1986), Tanakura Tectonic Line (T.T.L.; Koshiya, 1986) and Hatagawa Tectonic Line (H.T.L.; Koshiya, 1988) and (2) sinistral strike-slip fault systems in the South Kitakami Belt (Sasaki, 2001, 2002MS) and the northern margin of the Mino Belt (Sasaki et al., 2001; Fig. 1). Models for geodynamic reconstruction based on the above studies have been presented (Yamakita and Otoh, 2000a, 2000b; Sasaki, 2001, 2002MS). However, the distribution of the Cretaceous sinistral shear zones has not completely been mapped out, nor have been well studied Jurassic or older shear zones.

The Hida Marginal Belt, the main subject of this paper, is the continual tectonic belt between the Hida and Mino belts in the Inner Zone of Southwest Japan (Fig. 1). Many geologists have studied the Hida Marginal Belt and have revealed the distribution, stratigraphy and age of the constituent rocks of the belt (e.g. Kamei, 1952; Igo, 1956; Igo et al., 1980; Tsukada and Koike, 1997). Moreover the age and provenance of the pebbles in some conglomerate beds have also been discussed (Kano, 1962; Konishi and Omura, 1967; Tanase and Kasahara, 1988; Kawajiri, 1996). In spite of the huge numbers of studies, we have no models for the structural development of the Hida Marginal Belt. Although Sasaki et al. (2001) pointed out the possibility that the sinistral shearing along the northern margin of the Mino Belt affected the Hida Marginal Belt, they did not show specific evidence.

We aim to clarify the structural development of the Hida Marginal Belt by adding the structural data that reflect past geodynamic events to the previous geologic data. As a part of the structural study, we will describe the shear zones in the Moribu–Fukuji area, ENE of Takayama, central Japan in this paper.

OUTLINE OF GEOLOGY

The Hida Marginal Belt lies between the Hida and Mino belts of the eastern part of Southwest Japan and is characterized by long and narrow, sometimes lenticular, distribution of the following rocks: Ordovician to Upper Triassic sedimentary rocks, serpentinite, gabbro and high-P/T type metamorphic rocks of about 400 Ma (Tazawa, 1989). These constituent rocks of the Hida Marginal Belt mainly occur in the Omi–Rengé, Moribu–Fukuji, Naradani and Kuzuryu areas from east to west (Fig. 1). Lower Jurassic Kuruma Group and Middle Jurassic to Lower Cretaceous Tetori Group cover at least part of the Paleozoic rocks. The Kuruma and Tetori groups partly show tectonically controlled long and narrow distribution (Kumazaki and Kojima, 1996; Otoh, 1998).

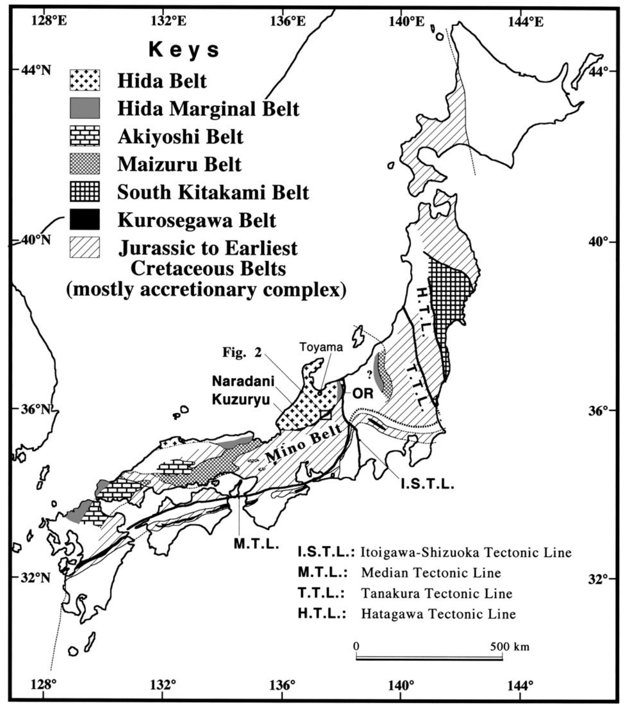

FIGURE 1. Index map showing the geologic outline of Japan and the location of the study area (after Otoh and Yanai, 1996). **OR**: Omi–Rengé area.

At least three groups of Paleozoic strata with different lithologic successions are discriminated in the Hida Marginal Belt in the Moribu–Fukuji area. In this paper, the area occupied by each group of Paleozoic strata is defined as a subbelt. The Moribu–Fukuji area is divided from east to west into the Fukuji, Moribu and Kamihirose subbelts (Fig. 2). Shear zones, described in this paper, bound each subbelt.

The Fukuji Subbelt is characterized by Paleozoic formations: i.e. the Middle Ordovician Iwatsubodani Formation (Tsukada, 1997), Ordovician (?) to Silurian Hitoegane Formation (Harayama, 1990; Tsukada, 1997), Upper Silurian to Lower Devonian Yoshiki Formation (Igo et al., 1980), Lower Devonian Fukuji Formation (Kamei, 1952; Igo, 1956), Carboniferous Ichinotani Formation (Kamei, 1952; Igo, 1956), Lower to Middle Permian Mizuyagadani Formation (Kamei, 1952; Igo, 1956; Tsukada and Takahashi, 2000) and Middle Permian Sorayama Formation (Kamei, 1952; Igo, 1956; Tsukada and Takahashi, 2000). Among them, the Ichinotani, Mizuyagadani and Sorayama formations form a concordant succession with no major angular unconformity (Tsukada et al., 1999; Fig. 3). The Kashiate Formation, consisting of mafic rocks, tectonically lies on the above formations (Tsukada and Takahashi, 2000).

The Moribu Subbelt is further divided into the southeastern

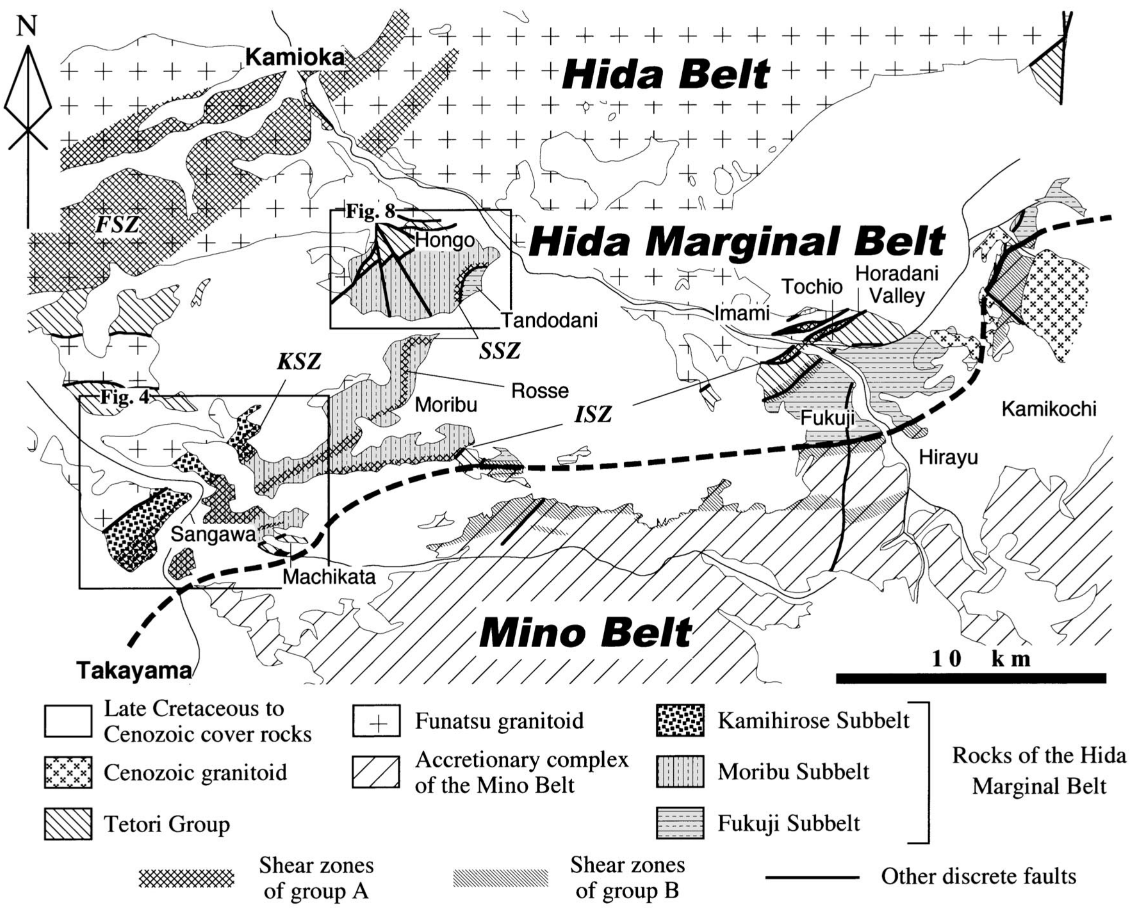

FIGURE 2. Simplified geologic map of the Moribu–Fukuji area showing the distribution of the constituent rocks of the Hida Marginal Belt and the major shear zones described in this paper (after Wakita et al., 2001). ***FSZ***: Funatsu shear zone, ***ISZ***: Imami shear zone, ***KSZ***: Kamisangawa shear zone, ***SSZ***: Sannose shear zone. The Tetori Group in and around Tochio is called the Tochio Formation.

and northwestern parts by the Sannose shear zone mentioned later. The southeastern part of the Moribu Subbelt comprises Carboniferous Arakigawa Formation (Isomi and Nozawa, 1957), unnamed Lower Permian felsic tuffaceous mudstone bed on the east of Rosse (Umeda and Ezaki, 1997) and Upper Triassic Tandodani Formation (Tsukada et al., 1997). The northwestern part of the Moribu Subbelt, on the other hand, comprises Devonian Rosse Formation (Tazawa et al., 2000), Carboniferous Arakigawa Formation (Isomi and Nozawa, 1957) and Middle Permian Moribu Formation (Isomi and Nozawa, 1957). The Arakigawa and Moribu formations form a concordant succession facing to northwest although Lower Permian beds have not yet been discovered (Fig. 3).

The Kamihirose Subbelt comprises the Kamihirose Formation (Isomi and Nozawa, 1957) and overlying Sangawa Formation (newly proposed). The Kamihirose Formation consists mainly of conglomerate, andesitic tuff and sandstone, whereas the Sangawa Formation consists of mudstone, felsic tuff and sandstone. The Kamihirose and Sangawa formations form a concordant succession that strikes northeast, dips southeast and faces to southeast. Although the Sangawa Formation has so far been included in the Moribu Formation, we propose to separate the two formations from the following reasons: (1) the Sangawa Formation faces to southeast whereas the Moribu Formation faces to northwest; (2) the Sangawa Formation contains much felsic tuff and is lithologically different from the Moribu Formation in the adjacent area; and (3) the Kamisangawa shear zone, described later, bounds the Sangawa and Moribu formations (Fig. 4).

The limestone cobbles from the conglomerate of the Kamihirose Formation yield *Collenia*-type algal stromatolite (Konishi and Omura, 1967) and *Chaetetes* sp. (Tanase and Kasahara, 1988). They are not good index fossils although the latter is a dominant reef-forming organism in Late Paleozoic time. Moreover the cobbles and pebbles of granitoid from the conglomerate have CHIME zircon ages of 459–353 Ma; i.e. Middle Ordovician to Early Carboniferous (Kawajiri, 1996). On the other hand, the Funatsu granitoid that has Rb–Sr whole

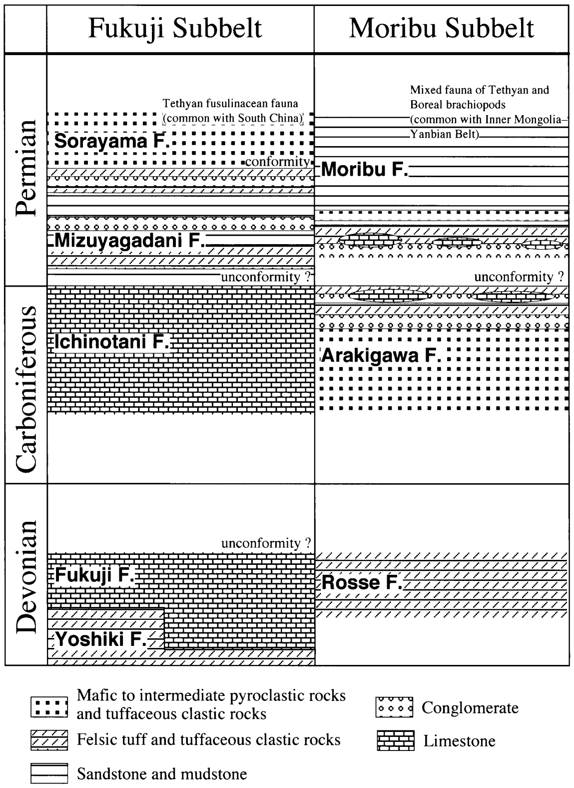

FIGURE 3. Schematic columnar sections of the Fukuji and Moribu subbelts (after Wakita et al., 2001).

rock isochron age of 188.9±4.4 Ma (Shibata and Nozawa, 1984), i.e. Early Jurassic time, cut the Kamihirose Formation. Hence the age of deposition of the Kamihirose Formation is mildly constrained to be between Early Carboniferous and Early Jurassic times (Kawajiri, 1996).

Middle Jurassic (?) to Early Cretaceous sedimentary strata correlated to the Tetori Group sporadically occur in the Moribu–Fukuji area. Middle Jurassic (?) conglomerate, which is assumed to be an eastern extension of the Tanemura Conglomerate Formation in the Hida Furukawa area (Maeda, 1958) several kilometers to northwest of Sangawa in Fig. 2, occurs in the northern margin of the Moribu Subbelt. Moreover, Early Cretaceous strata sporadically occur between the Moribu and Fukuji subbelts in the Tochio, Yokoo and Machikata areas; the strata in the Tochio area are called the Tochio Formation (Harayama, 1990) whereas those in the Yokoo area are called the Yokoo Conglomerate Formation (Kasahara, 1979). Late Cretaceous pyroclastic rocks of the Oamamiyama Group (Kasahara, 1979) and Neogene volcanic rocks cover all these rocks of the Hida Marginal Belt (Fig. 2).

DESCRIPTION OF SHEAR ZONES

Although our study is still in progress, we found two groups of shear zones in the Hida Marginal Belt. One group, which we will call group A, consists of ductile shear zones with dextral shear component. The other group, which we will call group B,

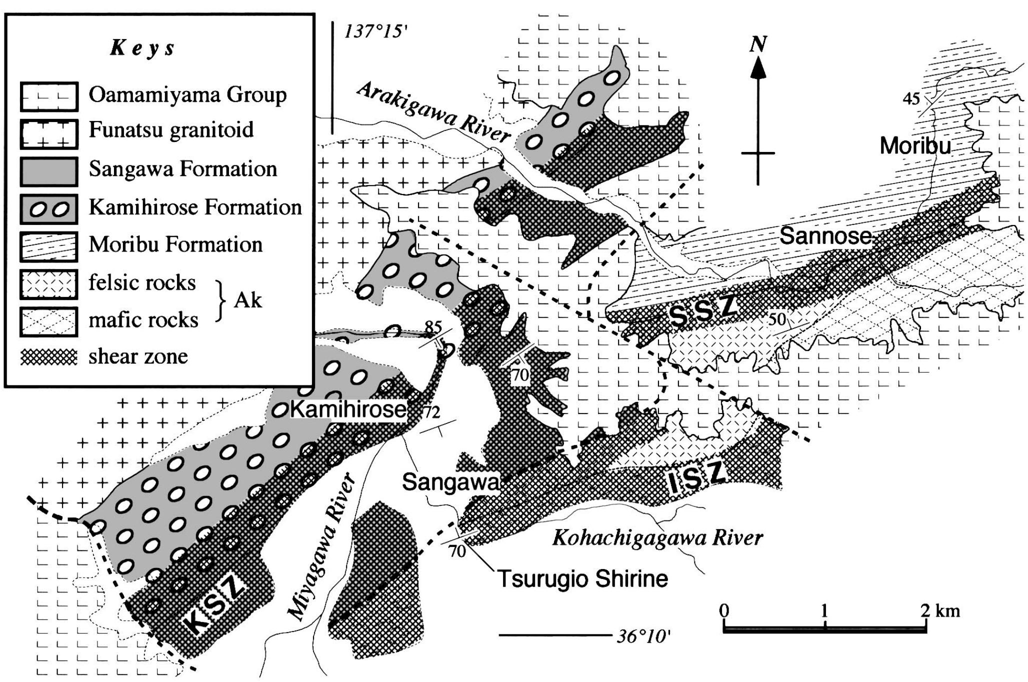

FIGURE 4. Geologic map of the southwestern part of the Moribu–Fukuji area, showing the distribution and divergence of the shear zones of group A. Ak: Arakigawa Formation, **ISZ**: Imami shear zone, **KSZ**: Kamisangawa shear zone, **SSZ**: Sannose shear zone.

consists of brittle to ductile shear zones with sinistral shear component. Here follow the descriptions of shear zones in each group.

Shear zones of group A

Group A comprises at least four shear zones with dextral strike-slip component that collectively constitute a dextral strike-slip fault system. The four shear zones are the (1) Funatsu shear zone, (2) Kamisangawa shear zone, (3) Sannose shear zone, and (4) Imami shear zone (Fig. 2). The dextral shear zones that were previously reported from the Hida and Hida Marginal belts (Yanai et al., 1985; Komatsu et al., 1993; Takagi and Hara, 1994; Otoh and Yanai, 1996) are likely coeval shear zones formed under the same tectonic setting. Here follow brief descriptions of the four shear zones of group A.

Funatsu shear zone (Komatsu et al., 1993)

The Funatsu shear zone (Komatsu et al., 1993) runs in east direction from Tamotsu, 20 km to the west of the western margin of Fig. 2, to southwest of Funatsu. It bends to northeast there and further runs to Kamioka (Fig. 2). The shear zone cuts the Funatsu granitoid that lies along the southern boundary of the Hida Belt. Ductile fault rocks such as mylonite and/or augen gneiss originated from the Funatsu granitoid characterize the shear zone. The mylonite has foliation defined by the planar arrangement of very fine-grained quartz and feldspar formed by shearing and lineation defined by the dimensional preferred orientation of K-feldspar porphyroclasts. The preservation of very fine grains of quartz and feldspar indicates that there was no substantial static grain growth, which is usually accelerated by heat, after the mylonite formation. The mylonite was likely cooled down immediately after formation and no substantial thermal event followed. Asymmetric tails on the porphyroclast systems of the mylonite show dextral sense of shear.

Kamisangawa shear zone (proposed)

The Kamisangawa shear zone runs from NE to NNE direction along the boundary between the Kamihirose and Moribu subbelts (Figs. 2 and 4). Mylonite originated from the clastic rocks of the Sangawa and Kamihirose formations characterizes the shear zone.

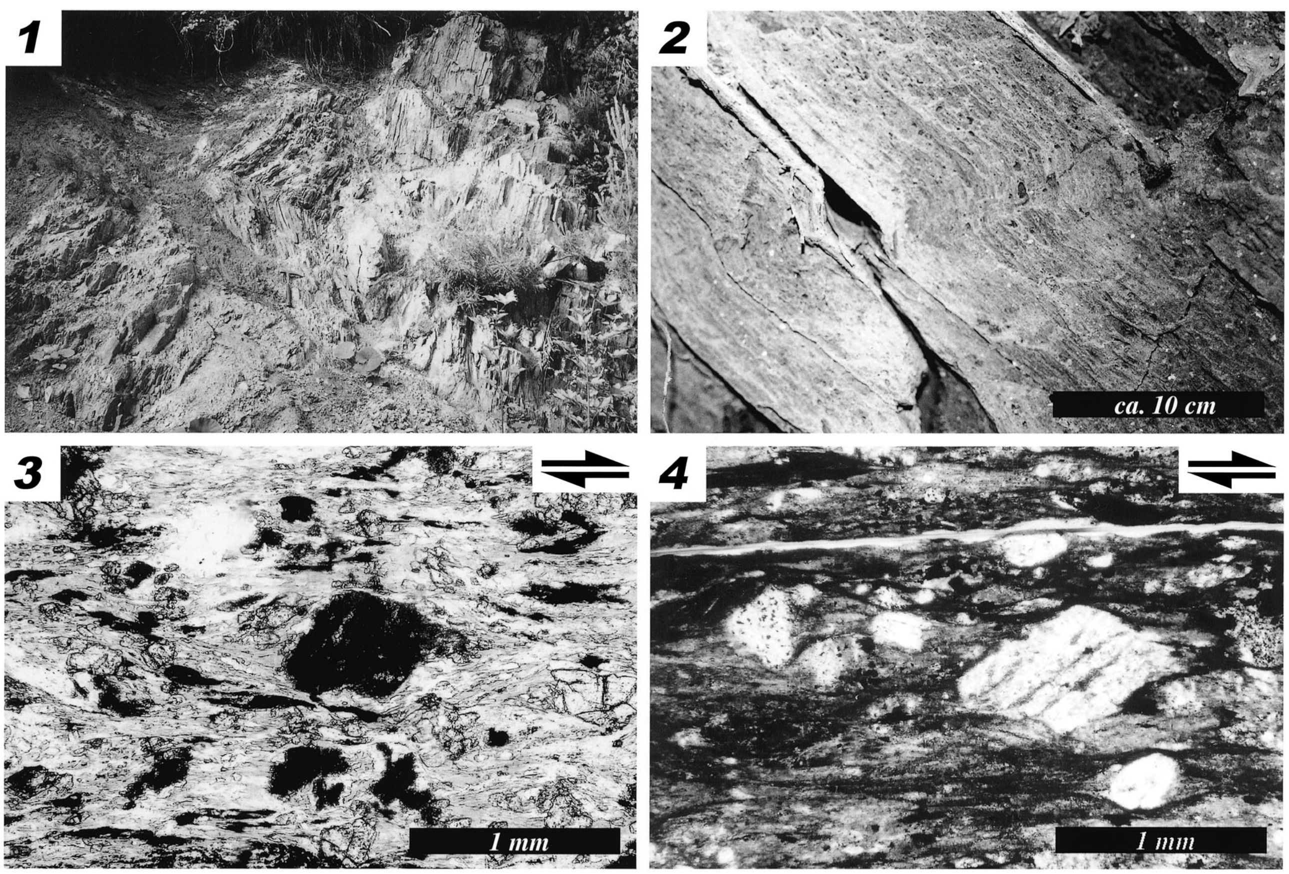

FIGURE 5. Sheared rocks in the Kamisangawa shear zone. ***1***, Outcrop of the mylonite originated from tuffaceous mudstone; ***2***, Close up view of the same outcrop showing kink folds of the foliation of the mylonite; ***3***, ***4***, Photomicrographs of asymmetric microstructures in the mylonite showing dextral sense of shear.

The mylonite from the mudstone and felsic tuff of the Sangawa Formation has salient foliation, which shows kink folds with the wavelength of several centimeters to several tens of centimeters (Fig. 5-1 and 5-2). The foliation is parallel to bedding and is defined by a dimensional preferred orientation of fine-grained phyllosilicates such as illite, muscovite and chlorite. Lineation defined by a dimensional preferred orientation of stretched clastic grains is often seen on the foliation. The attitude of the foliation is N30°–50°E・65°–90°SE whereas the lineation lies on the foliation and plunges 10°–80°E. Asymmetric tails in porphyroclast systems show dextral sense of shear with a substantial reverse slip component (Fig. 5-3 and 5-4). The mylonite from the conglomerate of the Kamihirose Formation, on the other hand, has weaker foliation and lineation defined by a preferred orientation of deformed pebbles and cobbles having the aspect ratio of up to 1:3:5. The attitude of the foliation is N30°–50°E・70°–90°SE whereas the lineation lies on the foliation and plunges 40°–90°E.

Adachi and Shibata (1991) made a K–Ar age determination of a partly mylonitized, small metagabbro body in the Kamisangawa shear zone. They showed that the age of the hornblende in the metagabbro is 254 Ma, and that the metagabbro suffered greenschist facies metamorphism after 254 Ma. On the other hand, the mylonite in the Kamisangawa shear zone, originated from mudstone, has K–Ar whole rock age of 174 Ma (Shibata and Nozawa, 1974).

Sannose shear zone (proposed)

The Sannose shear zone divides the Moribu subbelt into two parts and is well traced, in a sigmoid manner, from Sannose through Rosse to Tandodani (Fig. 2).

From Sannose to Rosse, the Sannose shear zone bounds the Moribu Formation on the northwest and the Arakigawa Formation on the southeast. The shear zone typically exposes along the Arakigawa River at Sannose (Figs. 6 and 7). Here, the gradual increase of the amount of strain toward the center of the shear zone can be detected from the shape change of pebbles of conglomerate (Moribu Formation). In the central part of the shear zone, the pebbles are so intensely stretched that the conglomerate partly looks like laminated felsic tuff (Fig. 7-4). The sheared conglomerate, in other words, has salient foliation defined by the external shape of the stretched pebbles. The attitude of the foliation is N60°E・70°N, whereas stretching lineation lies on the foliation and plunges 30°–70°N.

Previous studies on the Paleozoic rocks of the Moribu Subbelt suggested that the Moribu Formation along the above route conformably or unconformably overlies the Arakigawa Formation. Although the two formations may have originally been in sedimentary contact, the Sannose shear zone bounds the two formations at present. At Rosse, the Devonian Rosse Formation (Tazawa et al., 1997, 2000) occurs in the shear zone between the Arakigawa and Moribu formations. The constituent rocks of the Rosse Formation have been moderately sheared and have bedding parallel foliation that trends north and dips 40°W.

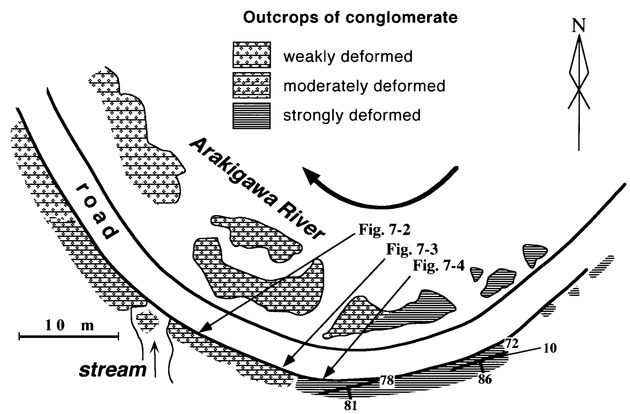

FIGURE 6. Route map along the Arakigawa River in the Sannose area, showing the distribution of the sheared conglomerate in the Sannose shear zone.

Along the Tandodani Valley, the Sannose shear zone bounds the Carboniferous Arakigawa Formation on the north and the Upper Triassic Tandodani Formation on the south (Tsukada et al., 1997; Figs. 2 and 8). The two formations along the Tandodani Valley have bedding-parallel foliation defined by the dimensional preferred orientation of deformed constituent grains and subhorizontal stretching lineation. The foliation strikes N20°–90°E and dips 70°NW or N, and the subhorizontal lineation lies on the foliation.

Imami shear zone (proposed)

The Imami shear zone likely runs between the Paleozoic rocks of the Moribu and Fukuji subbelts, although it is mostly covered by Late Cretaceous to Quaternary pyroclastic rocks. Ductile fault rocks of the shear zone sporadically occur near the Tsurugio Shrine (Fig. 4), Imami and the Horadani Valley (Fig. 2).

Sheared volcanic rocks of the Arakigawa Formation, consisting of basaltic tuff, pillow lava and pillow breccia, occur along the Kohachigagawa River near the Tsurugio Shrine. The basaltic tuff has salient foliation defined by parallel arrangement of phyllosilicates such as chlorite and medium- to high-angled stretching and/or mineral lineation that lies on the foliation. The attitude of foliation is N70°–80°E・60°–80°N, whereas the lineation plunges 30°–60°NW. Asymmetric tails in porphyroclast systems show dextral sense of shear with a substantial reverse slip component. Pillow lava and pillow breccia are also exposed along the Kohachigagawa River near the Tsurugio Shrine. They are uniaxially stretched mylonite having salient subvertical lineation, but very weak foliation. The shape of a pillow is well observed on a horizontal surface, but is hardly seen on a vertical surface.

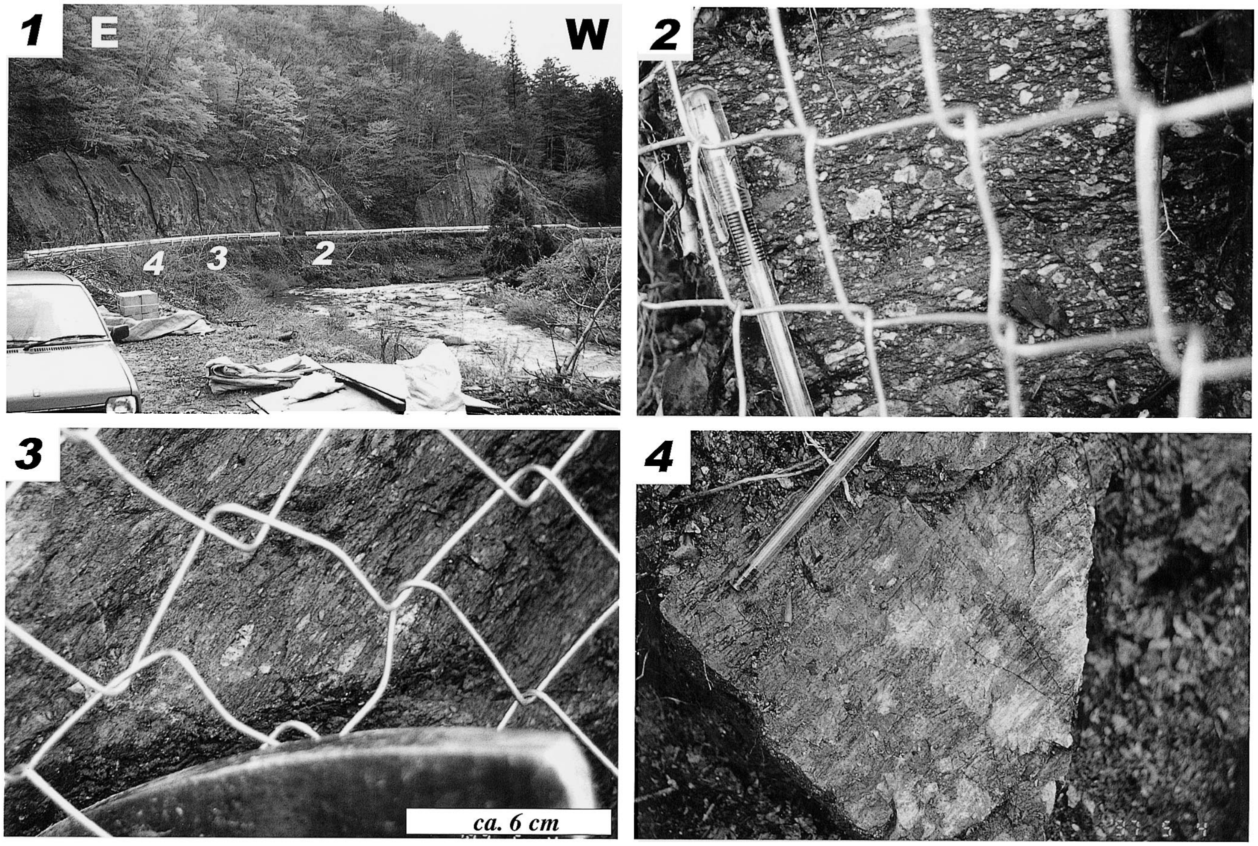

FIGURE 7. Photographs of the sheared conglomerate in the Sannose shear zone mapped in Fig. 4. The locality of each photograph is shown in Fig. 6. ***1***, A distant view of the outcrop of the Sannose shear zone; ***2***, Weakly deformed conglomerate having weak foliation; ***3***, Moderately deformed conglomerate that has salient foliation and stretched pebbles; ***4***, Strongly deformed conglomerate. The pebbles of the conglomerate are so intensely stretched that the conglomerate looks like laminated rock.

Shear zones of group B

Group B comprises several cataclastic shear zones with sinistral strike-slip component that at least partly cut the Early Cretaceous strata correlative to the Tetori Group.

The most conspicuous shear zone of this group runs along the southern boundary of the Tochio Formation (Fig. 2). The cataclasite originated from the sandstone and mudstone of the Tochio Formation is well exposed along the Kashiate-dani Valley. Here the cataclasite has composite foliations defined by planar concentration of finely crushed materials, and lineation defined by a dimensional preferred orientation of spindle-shaped aggregates of a porphyritic sand grain and surrounding finely crushed materials. The attitude of the foliations is N40°–70°E•70°–90°NW, whereas the lineation is subhorizontal and lies on the foliation. The attitude of composite foliations as shown in Fig. 9 indicates sinistral sense of shear.

Sinistral cataclastic shear zones also occur along the northern margin of the Mino Belt. The cataclastic shear zones form a sinistral strike-slip imbricate fan, although the configuration is not illustrated in Fig. 2. The sinistral cataclastic shear zones consist of E-trending major shear zones and WNW-trending shear zones that converge into the major shear zones (Sasaki et al., 2001). We interpret that these cataclastic shear zones in the Mino Belt were formed coevally with those in the Hida Marginal Belt, as will be discussed later, under similar physical conditions. Narrow sinistral cataclasite zones are also discriminated in mylonite of the Funatsu shear zone (Otoh, 1998).

DISCUSSION

Timing of dextral shearing: Formation of the shear zones of group A

The timing of dextral shearing along the shear zones of group A was between Late Triassic and Late Jurassic times from the following reasons.

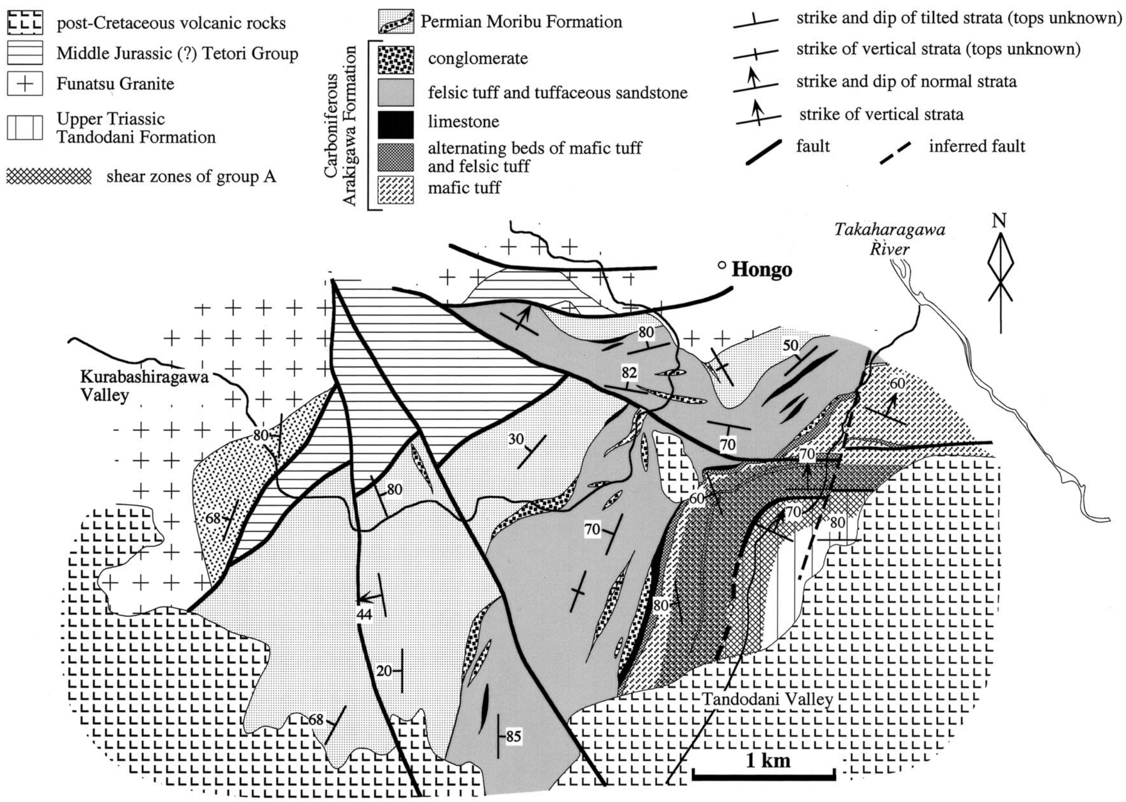

FIGURE 8. Geologic map of the Hongo area, northern part of the Moribu–Fukuji area, showing the northeastern extension of the Sannose shear zone along the Tandodani Valley.

The dextral shearing commenced after the deposition of the Upper Triassic Tandodani Formation, because the Sannose shear zone of group A cuts the Tandodani Formation and carries it beneath the Carboniferous Arakigawa Formation. In the Moribu–Fukuji area, the Tandodani Formation is the youngest formation that was involved in the dextral shearing. The timing of cessation of the dextral shearing, on the other hand, is harder to constrain. The Middle Jurassic(?) conglomerate in the northern margin of the Moribu Subbelt contains many cobbles of sheared granitoid. The fact suggests that the shearing of the Funatsu granitoid in the Funatsu shear zone had ceased before the deposition of the Middle Jurassic(?) conglomerate, although no age-determinable fossils have been obtained from the conglomerate in the Moribu Subbelt. Moreover, the Early Cretaceous strata in the Machikata, Yokoo and Tochio areas show no signs of dextral ductile shearing although the distribution of the strata parallel to the Imami shear zone between the Moribu and Fukuji subbelts may indicate the influence of dextral shearing during the deposition of the Early Cretaceous strata. For these reasons, we roughly constrain the age of cessation of the dextral shearing to be before Early Cretaceous time, and possibly before Late Jurassic time.

The above conclusion is concordant with some previous studies. The hornblende K–Ar age of 254 Ma for partly mylonitized metagabbro in the Kamisangawa shear zone (Adachi and Shibata, 1991) shows that the shear zone was formed after 254 Ma. The K–Ar whole rock age of 174 Ma for the mylonite in the Kamisangawa shear zone, originated from mudstone (Shibata and Nozawa, 1974), is likely close to the age of mylonitization. The dextral Honam shear zone in Korea, which was presumably a western extension of the dextral shear zones in the Hida and Hida Marginal belts (Yanai et al., 1985), was also active until Middle to Late Jurassic time (e.g. Kwon and Lee, 1997), and the tectonic inversion to sinistral shearing took place before the deposition of the Early Cretaceous Gyeongsang Supergroup (Otoh and Yanai, 1996; Otoh, 1998).

Timing of the sinistral shearing: Formation of the shear zones of group B

The sinistral cataclastic shearing was active at least between Early and Late Cretaceous from the following reasons. The sinistral shear zone cuts the Early Cretaceous strata between the Moribu and Fukuji subbelts, suggesting that the sinistral

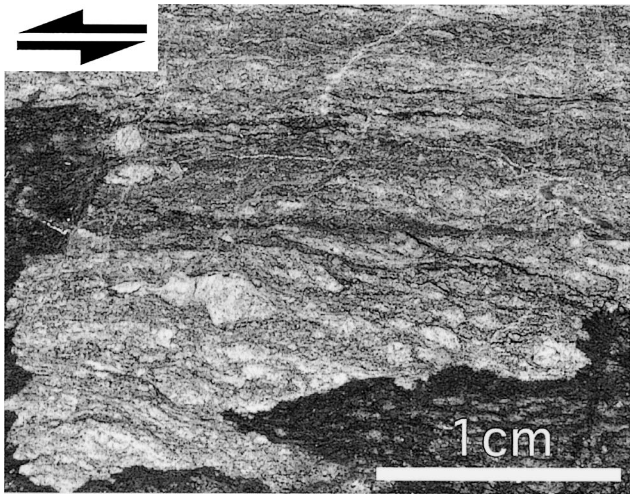

FIGURE 9. Polished surface of a sample of cataclasite originated from the sandstone of the Tochio Formation. The sample was taken from a shear zone of group B and has composite foliations showing sinistral sense of shear.

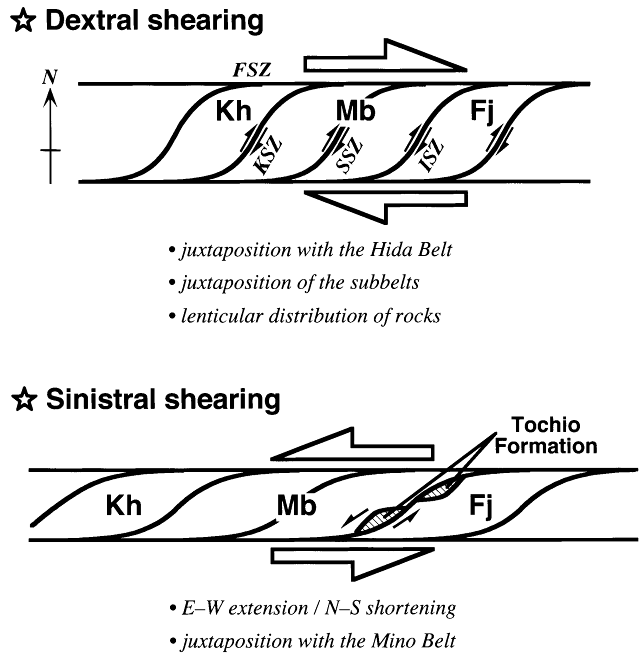

FIGURE 10. A new model for the formation of the Hida Marginal Belt in the Moribu–Fukuji area, inferred from the history of shearing. **Fj**: Fukuji Subbelt, ***FSZ***: Funatsu shear zone, ***ISZ***: Imami shear zone, **Kh**: Kamihirose Subbelt, ***KSZ***: Kamisangawa shear zone, **Mb**: Moribu Subbelt, ***SSZ***: Sannose shear zone.

shearing lasted after the deposition of the Early Cretaceous strata. The sinistral shear zones, on the other hand, cannot be traced in the Late Cretaceous Oamamiyama Group. Hence the sinistral shearing ceased before the deposition of the Oamamiyama Group. Early Cretaceous sinistral shearing was also detected in the Kurosegawa Belt (Yamakita and Otoh, 2000a), South Kitakami Belt (Sasaki, 2001, 2002MS) and Mino Belt (Sasaki et al., 2001). In particular, Sasaki (2001) described sinistral cataclasite zones in the northern margin of the Mino Belt and suggested a possibility that the formation of the cataclasite zones took place during the juxtaposition of the constituent rocks of the Mino and Hida Marginal belts. The cataclasite in the Mino Belt has east-trending subvertical foliation and subhorizontal lineation. The age of formation of the cataclasite is constrained to be between Late Jurassic to Late Cretaceous times (Sasaki et al., 2001). In this way, the sinistral shear zones in the Mino and Hida Marginal belts has similar attitude of structural elements, similar deformation condition (in sense that the sinistral shear zones in the two belts are both characterized by cataclasite), and similar age of formation. Hence we also suggest that the sinistral shear zones in the Hida Marginal Belt were formed, together with those in the northern margin of the Mino Belt, when the constituent rocks of the two belts juxtaposed.

A new model for the formation of the Hida Marginal Belt

From the foregoing description and discussion, we made a tentative model for the formation of the Hida Marginal Belt (Fig. 10).

The configuration of the Hida Marginal Belt is characterized by elongated, sometimes lenticular, distributions of constituent rocks. Our study revealed that the boundaries of the lenticular distributions are in many cases dextral shear zones, at least in the Moribu–Fukuji area. The Kamisangawa shear zone (*KSZ* in Fig. 10) that bounds the Kamihirose and Moribu subbelts and the Imami shear zone (*ISZ* in Fig. 10) that bounds the Moribu and Fukuji subbelts are good examples. Moreover, the dextral shear zones show a systematic distribution that resembles the distribution of shear zones in a dextral strike-slip duplex. Since the dextral shear zones cut the Hida Belt as well as the Hida Marginal Belt, we conclude that the constituent rocks of the Hida Marginal Belt were gathered along the southern margin of the Hida Belt through dextral strike-slip duplexing between Late Triassic and Late Jurassic times.

The tectonic inversion from dextral to sinistral shearing took place before or during the deposition of the Tetori Group (Otoh, 1998). The Cretaceous sinistral shearing in the Moribu–Fukuji area mainly occurred along the trace of the Imami shear zone. The trend of the sinistral shear zone is anticlockwise oblique to the main trend of the Hida Marginal Belt by some 30°. The sinistral shearing in this direction must have caused the E–W extension or N–S shortening of the Hida Marginal Belt as shown in Fig. 10. The present-day, elongated distribution of the constituent rocks of the Hida Marginal Belt was thus completed through the Cretaceous sinistral shearing.

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* : in Japanese with English abstract

** : in Japanese

*** : in Korean with English abstract

＜ 地　名 ＞

Arakigawa ……荒城川	Fukuji ……福地	Funatsu ……船津
Gamata ……蒲田	Hatagawa Tectonic Line ……畑川構造線	Hida ……飛騨
Hida Marginal Belt ……飛騨外縁帯	Hitoegane ……一重ヶ根	Ichinotani ……一の谷
Imami ……今見	Iwatsubodani ……岩坪谷	Kamihirose ……上広瀬
Kamisangawa ……上三川	Kohachigagawa ……小八賀川	Kuruma Group ……来馬層群
Kuzuryu ……九頭竜	Machikata ……町方	Median Tectonic Line ……中央構造線
Mino Belt ……美濃帯	Mizuyagadani ……水屋ヶ谷	Moribu ……森部
Naradani ……楢谷	Oamamiyama ……大雨見山	Omi ……青海
Rengé ……蓮華	Rosse ……呂瀬	Sangawa ……三川
Sannose ……三之瀬	Sorayama ……空山	South Kitakami Belt ……南部北上帯
Takayama ……高山	Tanakura Tectonic Line ……棚倉構造線	Tandodani ……谷戸谷
Tanemura ……種村	Tetori Group ……手取層群	Tochio ……栃尾
Tsurugio Shrine ……劔緒神社	Yokoo ……横尾	Yoshiki ……吉城