

Miocene stratigraphy and tectonic process of the Echigo-Yuzawa Basin, Northern Fossa Magna region, central Japan

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Abstract

This study clarified the stratigraphy of the Miocene series that occur in contact with pre-Neogene basement rocks in the Echigo-Yuzawa region. Based on new lithologic assemblages, the Miocene stratigraphy and the tectonic process of the Echigo-Yuzawa Basin were reconstructed. The Miocene formations are distributed in the Shiozawa and Tsuchitaru areas in the Echigo-Yuzawa region. The Shiozawa area comprises the newly proposed Shiozawa Formation (Maiko Breccia Member, Yoshiyama Shale Member and Komatsuzawa Basalt Member) and the Tsuchitaru area comprises the redefined Matsukawa Formation (newly proposed Tsuchitaru Sandstone and Basalt Member, Nakazato Tuff Member and Kandatsu Shale Member). A new record of planktonic foraminifer indicative of Blow's N.9 (Blow, 1969) was discovered from the Kandatsu Shale Member. The tectonic development of the Miocene Echigo-Yuzawa Basin is as follows:

[Stage I] Basin generation due to collapse, forming a lacustrine lake (18-17 Ma).

[Stage II] Subsidence accompanied with marine transgression and bimodal volcanism (17-15Ma).

[Stage III] Continuous subsidence depositing mud (15 Ma).

Key words: Echigo-Yuzawa Basin, Shiozawa Formation, collapse, Miocene stratigraphy, Northern Fossa Magna

Introduction

The Echigo-Yuzawa region is situated on the central east margin of the Northern Fossa Magna's Shinetsu Basin (Fig. 1; Kageyama and Suzuki, 1974) and/or the Joetsu Green Tuff Region and is included in the northeast margin of the Central Upheaval Zone (Kubota, 1988). The Shinetsu Basin (also called the Niigata Tertiary Basin) of the Northern Fossa Magna region is situated in the Cenozoic back-arc region of the eastern margin of the Sea of Japan. Many authors have suggested that the formation of the back-arc region was closely related to the opening of the Sea of Japan, due to the subduction of the Philippine Sea Plate (Tatsumi et al., 1989; Sato and Amano, 1991; Itoh et al., 1997). Tateishi (1988) suggested that the generation and development of the Niigata Tertiary Basin was formed as a collapsed basin under tensional stress field, due to the aulacogen or failed rift of the Fossa Magna. Authors including Fujita (1972, 1986, 1989), Komuro et al. (1977), Komuro (1986), Inaba (1989),

Shibasaki and Fujita (1989), Yamagishi (1988), Yajima and Fujita (1989) and Yoon (1997), have suggested that the sedimentary basins in the back-arc, Fossa Magna and the Green Tuff regions were controlled by vertical crustal movements. The Echigo-Yuzawa Basin is an important area to study because it will provide important information on the Early Miocene tectonic events of the Shinetsu Basin and the Northern Fossa Magna.

Previous geologic studies of the Echigo-Yuzawa region are those of Chihara et al. (1981) and Kubota (1988; Fig. 2). Chihara et al. (1981) investigated the geology and stratigraphy of the Echigo-Yuzawa region and Kubota (1988) analyzed the Tertiary granitoids and discussed its significance to the later stages of development of the Echigo-Yuzawa Basin. The aim of the present study was to clarify the Early Miocene stratigraphy and the tectogenesis of the early stages of generation and development of the Echigo-Yuzawa Basin.

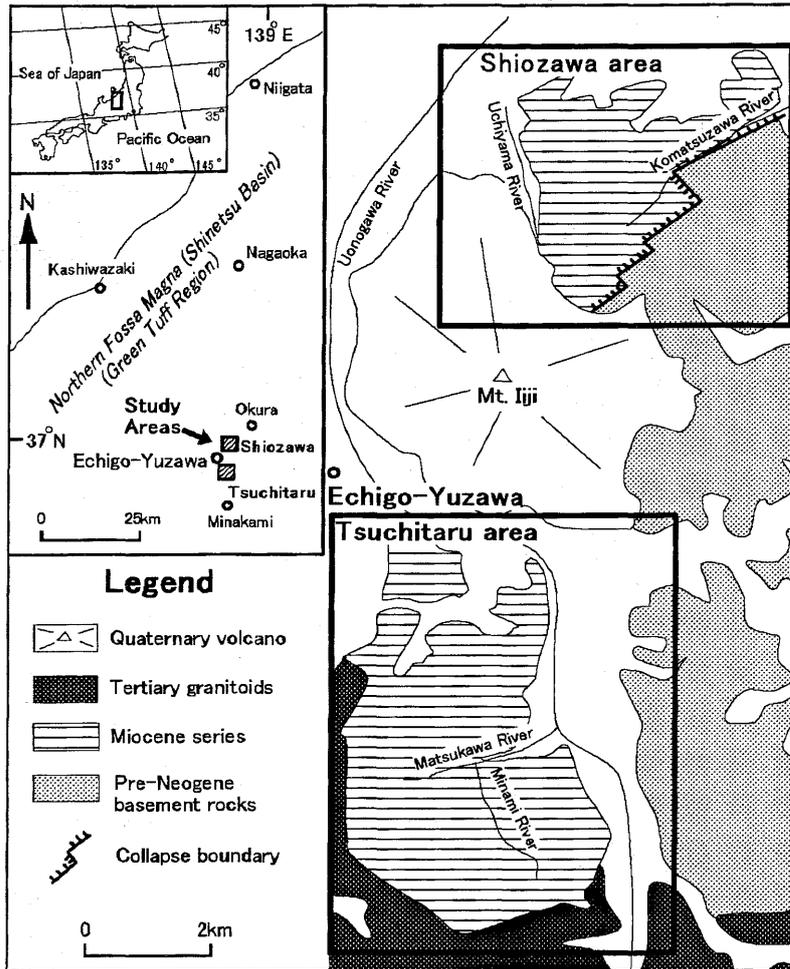


Fig. 1. Index map showing the study areas.

Age	Chihara et al. (1981)	Kubota (1988)	This study	
			Tsuchitaru area	Shiozawa area
Early - Middle Miocene	Shiraita Formation	Matsukawa Formation	Kandatsu Shale Member	Shiozawa Formation
	Matsukawa Formation		Nakazato Tuff Member	
			Tsuchitaru Sandstone and Basalt Member	
Jonai Group	Jo3	Shiozawa Formation	Komatsuzawa Basalt Member	
	Jo2		Maiko Breccia Member	
	Jo1		Yoshiyama Shale Member	

Fig. 2. Comparison of the Miocene stratigraphy in the Echigo-Yuzawa region with previous works.

General geology

The Shiozawa and Tsuchitaru areas in the Echigo-Yuzawa region consist of pre-Neogene basement rocks, Miocene series and Quaternary volcanic rocks. The pre-Neogene basement rocks consist of Mesozoic

granite, shale, sandstone, phyllite, chert and mafic rocks, which belong to the Iwamuro Formation and the Okutone and Kamigongendo-yama Groups (Chihara et al., 1981 ; Yanagisawa et al., 1985). Granite and serpentinite mainly crop out in the study area and the granite is composed of pinkish coarse-grained porphyritic granitic, medium-grained granular biotite granite, coarse-grained porphyritic hornblende granite and porphyritic leucocratic hornblende granite (Chihara et al., 1981).

The Miocene series are distributed in the Shiozawa and Tsuchitaru areas (Fig. 1). The newly proposed Shiozawa Formation (Maiko Breccia Member, Yoshiyama Shale Member and Komatsuzawa Basalt Member) consisting of unsorted breccia, conglomerate, shale and basalt lava, is distributed in the Shiozawa area and is unconformably in contact with the pre-Neogene basement. The Matsukawa Formation (newly proposed Tsuchitaru Sandstone and Basalt Member, Nakazato Tuff Member and Kandatsu Shale Member) consisting of sandstone, shale, basalt lava and tuff, is distributed in the Tsuchitaru area (Fig. 3).

Tsuchitaru area

Age	Stratigraphic units	Thickness (m)	Columnar section	Lithofacies	Remarks
Early - Middle Miocene	Matsukawa Formation	Kandatsu Shale Member		Black shale	Occurrence of <i>Martinottiella communis</i> (d'Orbigny), <i>Cribrostomoides</i> sp., <i>Cyclammina</i> cf. <i>pacifica</i> Beck, <i>Globigerina praebulloides</i> Blow, <i>Sphaeroidinellopsis seminulina</i> (Schwager) N.9 (Blow) Occurrence of <i>Makiyama chitani</i> (Makiyama)
		Basalt		Felsic tuff	
				Felsic tuff	
	Nakazato Tuff Member	600m+		Basalt (pillow lava)	
				Black shale	
				Felsic tuff (pumiceous)	
				Black shale	
				Felsic tuff	
	Tsuchitaru Sandstone and Basalt Member	750m+		Sandstone	
				Basalt	
Sandstone					
Black shale					

Shiozawa area

Age	Stratigraphic units	Thickness (m)	Columnar section	Lithofacies	Remarks	
Early - Middle Miocene	Shiozawa Formation	Komatsuzawa Basalt Member		Basalt	Occurrence of Daijima plant fossils (Chihara et al. 1981) Dessication cracks Felsic tuff	
		Yoshiyama Shale Member		250m+		Sandstone
		Maiko Breccia Member		400m+		Congl.

Fig. 3. Schematic stratigraphic sequence of the Echigo-Yuzawa region.

Miocene stratigraphy

1. Shiozawa area

Shiozawa Formation (newly proposed)

We propose the Shiozawa Formation as a new name for the former Jonai Group (Chihara et al., 1981) because the term 'Jonai Group' was originally named by Ikebe (1953) as a general classification of undivided early Miocene andesite, basalt and conglomerate distributed along the eastern margin of the Shinetsu Basin. According to Chihara et al. (1981), the Jonai Group in the Shiozawa area consisted of Jo1 (shale, conglomerate, sandstone), Jo2 (basalt) and overlying unconformably Jo3 (volcanic conglomerate) formations in ascending order (Fig. 2). The Shiozawa Formation typically crops out along the tributaries of the Uchiyama River and based on new litho-stratigraphic assemblage and geological distribution, we propose the Maiko Breccia Member (unsorted breccia and conglomerate; Jo3), Yoshiyama Shale Member (shale, sandstone and minor tuff; Jo1) and Komatsuzawa

Basalt Member (basalt; Jo2) as a stratigraphic division for the Shiozawa Formation (Fig. 3). The Maiko Breccia Member is distributed in the northeastern and western parts of the Shiozawa area, which forms an anticline and syncline (Fig. 4). The Yoshiyama Shale Member (Jo1) and the Komatsuzawa Basalt Member (Jo2) are distributed within the syncline. We found that there is no structural gap between the Jo1, Jo2 and Jo3, and the Maiko Breccia Member (Jo3) does not include clasts of Jo1 or Jo2. Also, the Maiko Breccia Member (Jo3) is distributed within the Yoshiyama Shale Member (Jo1) and Komatsuzawa Basalt Member (Jo2), indicating that the stratigraphic relations between each member are not unconformable, but an interfinger relation between these units (Figs. 4&7).

Maiko Breccia Member (newly proposed)

[Type locality] It is proposed as one of the creek branching off the Uchiyama River approximately 650 m above sea level (Fig. 4).

[Thickness] 400m+.

[Distribution] It is distributed between the Quaternary

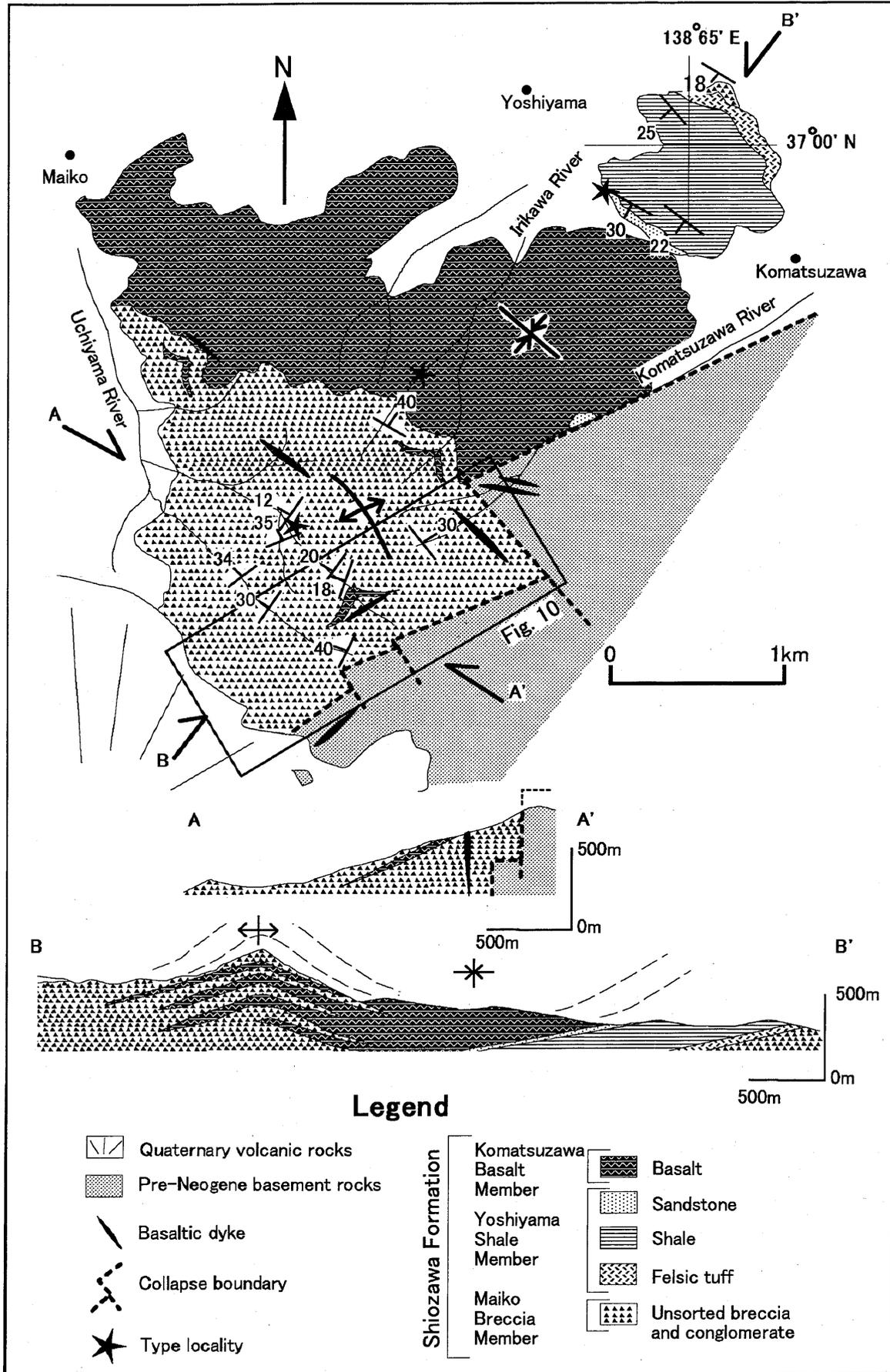


Fig. 4. Geological map and cross section of the Shiozawa area.

ry Mt. Iiji volcano and the pre-Neogene basement, and the northeastern part of the Shiozawa area. It crops out along the creeks, which branch off the Uchiyama River, and the upper reaches of the Irikawa River.

[Lithofacies] It is composed of unsorted breccia and conglomerate. The unsorted breccia consists of angular basement clasts of mainly granite, serpentinite and diabase, which are poorly sorted and are set in a finer brecciated matrix of the same lithology (Fig. 5A&B). The clasts range from pebble to large cobble-size, of up to 40cm. Many of the granite clasts are red-orange in color. The conglomerate occurs as thin beds (1-2m) and as thick beds (5-10m), which are intercalated within the unsorted breccia. It consists mostly of sub-rounded basement granite clasts, up to 1m in diameter with a muddy and silty matrix (Fig. 5C&D). The paleocurrent direction obtained from pebble imbrication of the conglomerate indicates source from the neighboring basement in the southeast.

[Stratigraphic relation with the underlying unit] It interfingers with the Yoshiyama Shale Member and the Komatsuzawa Basalt Member. The relationship with the pre-Neogene basement is not a fault (will be discussed later in the text).

Yoshiyama Shale Member (newly proposed)

[Type locality] It is proposed as the outcrop along the road cut between Yoshiyama and Komatsuzawa villages (Fig. 4).

[Thickness] 250m+.

[Distribution] It is distributed between Yoshiyama and Komatsuzawa villages.

[Lithofacies] The shale shows rhythmic and repetitive lamination of mud layers in millimeter scale (Fig. 5E) and in places includes desiccation cracks on the bedding surface (Fig. 5F). The sandstone is medium to coarse-grained and massive, alternating with the shale. The tuff is green in appearance due to chlorite alteration and shows a welded structure.

[Stratigraphic relation with the underlying unit] It interfingers with the Maiko Breccia Member.

[Fossils] The sandstone and shale include many plant fossils (Fig. 5G)

[Geological age] Chihara et al. (1981) correlated the plant fossils to the Daijima stage, which is about 17-18 Ma.

Komatsuzawa Basalt Member (newly proposed)

[Type locality] It is proposed as the Irikawa River (Fig. 4)

[Thickness] 100m+.

[Distribution] It is distributed north of the pre-Neogene basement between Maiko and Komatsuzawa villages and sporadically crops out within the Maiko Breccia Member along the tributaries of the Uchiyama and Komatsuzawa Rivers.

[Lithofacies] The basalt is mainly aphyric, which has undergone chlorite alteration therefore having a greenish appearance.

[Stratigraphic relation with the underlying unit] It overlies the Yoshiyama Shale Member and interfingers with the Maiko Breccia Member. The relationship with the pre-Neogene basement is not a fault (will be discussed later in the text).

2. Tsuchitaru area

Matsukawa Formation (redefined after Kubota, 1988)

Previous study by Kubota (1988) showed that basalt and shale, which typically cropped out along the Matsukawa River, comprised the Matsukawa Formation. However, we discovered widely distributed sandstone and felsic tuff, which cropped out along the upper reaches of the Matsukawa River and its tributaries (Fig. 6). Field investigations clarified a new litho-stratigraphy (Figs. 3&7) for the Matsukawa Formation, therefore is divided into the newly proposed Tsuchitaru Sandstone and Basalt Member, Nakazato Tuff Member and the Kandatsu Shale Member in ascending order.

Tsuchitaru Sandstone and Basalt Member (newly proposed)

[Type locality] Upper reaches of the Minami River approximately 720m above sea level (Fig. 6).

[Thickness] Approximately 750m+.

[Distribution] It is distributed between the Minami and Uonogawa Rivers.

[Lithofacies] Newly discovered sandstone and basalt are the primary rock units of this member, as well as minor shale and felsic tuff. The sandstone is medium to coarse-grained and from thin section analysis, it can be classified as greywacke. It is altered to the hornfels metamorphic facies as evident by the numerous presence of secondary biotite. The sandstone contains many angular and poorly sorted quartz grains and minor plagioclase, which are set in a very fine siliceous matrix. The high content of primary quartz, minor presence of fresh and broken plagioclase feldspars, and biotite implies a granitic source. Bouma divisions a, b, c and e can be seen in some of these sandstone beds (Fig. 5H). The basalt and felsic tuff show chloritic alteration and appear green.

[Paleocurrent] Paleocurrent direction was obtained from grain orientation of the sandstone. The paleocurrent directions indicate an origin from the neighboring granitic basement to the east (Fig. 7).

[Stratigraphic relation with the underlying unit] The relationship with the neighboring basement is not clear, because alluvium cover the contact. Stratigraphic correlation with the Shiozawa Formation will be discussed later in the text.

Nakazato Tuff Member (newly proposed)

[Type locality] The tuff typically crops out behind the Yuzawa Fishing Park, along the Uonogawa River and at the top of Mt. Shomenzan (Fig. 6).

[Thickness] Approximately 600m+.

[Distribution] It is distributed throughout Mt. Akibazan and Mt. Shomenzan and crops along the

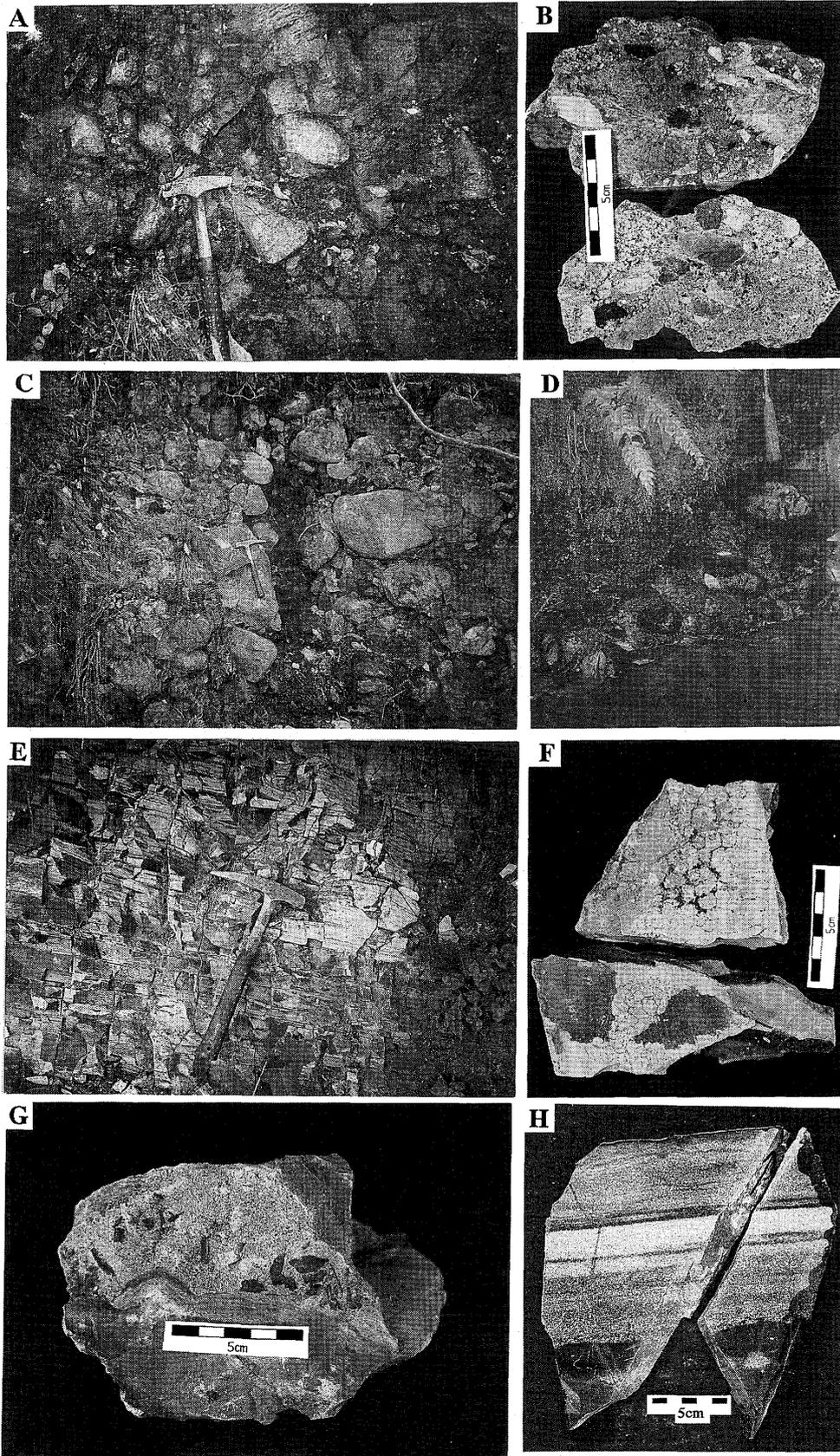


Fig. 5. Photographs A and B are unsorted breccia, C and D are conglomerate, E is finely laminated shale, F is desiccation (mud) cracks of E on the bedding surface, G is shale and sandstone which include plant fragments, and H is medium grained sandstone showing Bouma divisions a, b, c and e. Photos A-G belong to the Shiozawa Formation, and H belongs to the Matsukawa Formation.

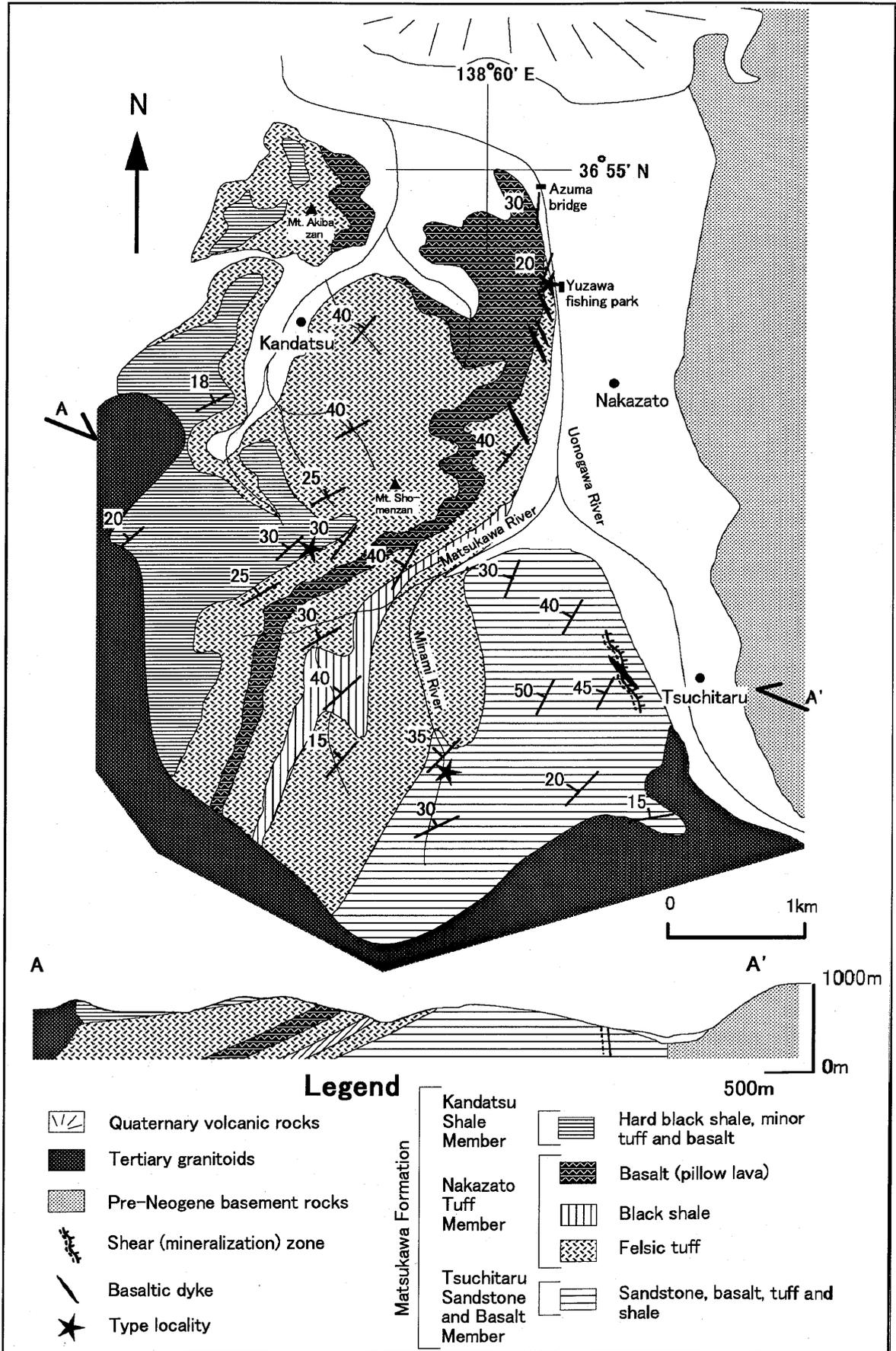


Fig. 6. Geological map and cross section of the Tsuchitaru area.

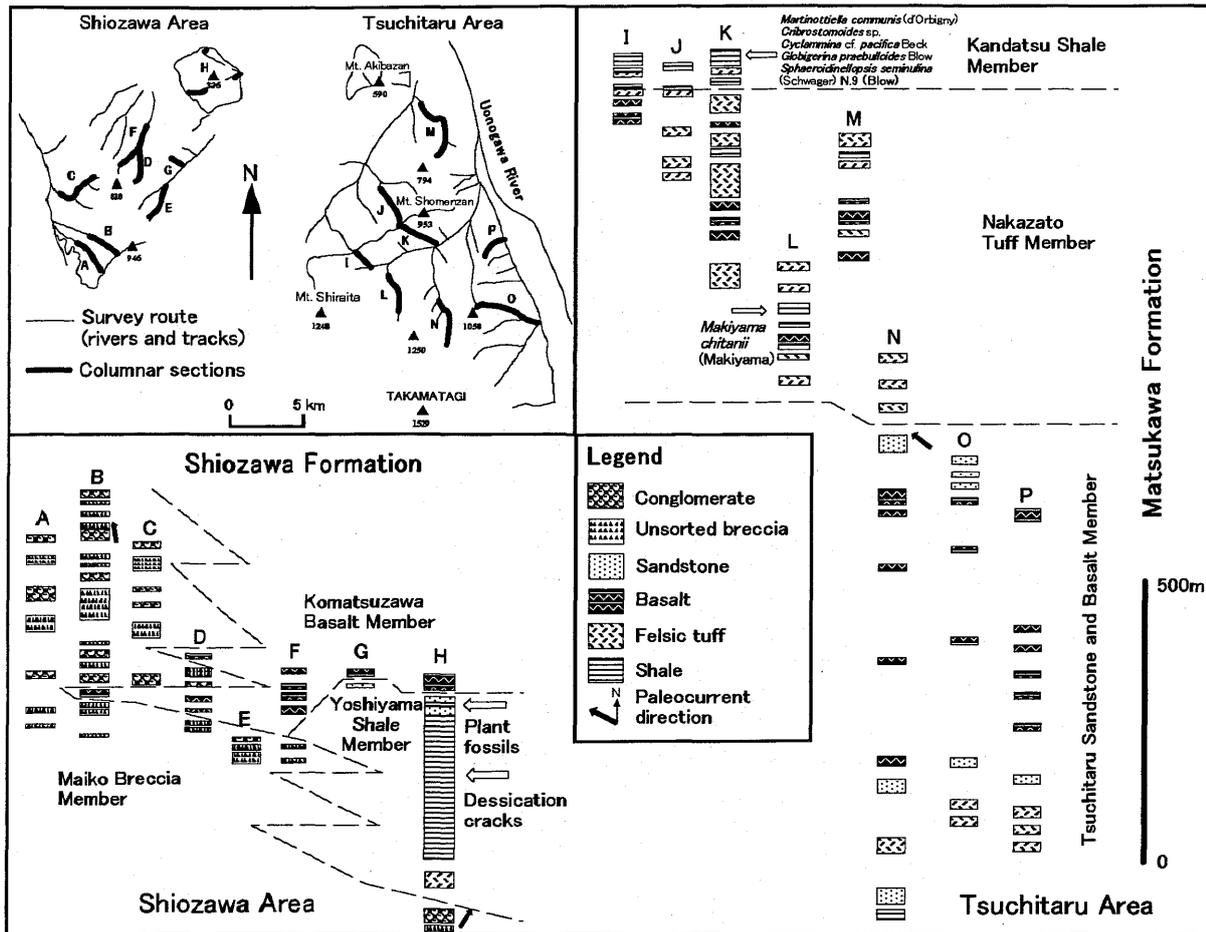


Fig. 7. Columnar sections of the Miocene series in the Echigo-Yuzawa region.

Matsukawa and Minami Rivers.

[Lithofacies] The basalt unit, which includes numerous vesicles, is very green in color due to chlorite alteration and pillow structures are seen in places. The felsic tuff unit, which is pumiceous show occasional flow-banding structures and is whitish green in color due to chlorite alteration. The shale is black, massive and in places includes pyrite (secondary) mineralization.

[Stratigraphic relation with the underlying unit] The Nakazato Tuff Member conformably overlies the Tsuchitaru Sandstone and Basalt Member.

[Fossils] This study newly discovered the marine fossil, Makiyama chitanii (Makiyama) in the shales.

Kandatsu Shale Member (newly proposed)

[Type Locality] The flat ridge west of Mt. Shomenzan (Fig. 6).

[Thickness] 200m+.

[Distribution] It is distributed west of Mt. Shomenzan and a part of Mt. Akibazan.

[Lithofacies] It consists of black shale, which in places shows sets of grading in centimeter scale and lamina structures. Minor basalt lava and felsic tuff is intercalated in places. Near the quartz diorite intrusion, the shale is silicified.

[Stratigraphic relation with the underlying unit] The contact was directly seen and showed that the Kandatsu Shale Member conformably overlies the Nakazato Tuff Member.

[Fossils] A new discovery of benthic and planktonic foraminifers was made at the newly proposed type locality in the shales. The species are: *Martinottiella communis* (d'Orbigny), *Cribrostomoides* sp., *Cyclamina* cf. *pacifica* Beck, *Globigerina praebulloides* Blow and *Sphaeroidinellopsis seminulina* (Schwager) that were identified by Dr. Kikuo Watanabe.

[Geological age] The *Sphaeroidinellopsis seminulina* (Schwager) based on the stratigraphic distribution chart of planktonic foraminiferal species of the Echigo-Yuzawa region (Akimoto et al., 1999) is indicative of Blow's N.9 (Blow, 1969). Blow's N.9 can be correlated to the chronologic division of the Nanatani stage (15Ma) of the Niigata Tertiary Basin (Kano et al., 1991).

Intrusive rocks

Many basaltic dykes (green in color due to chlorite alteration) intrude the Miocene series in both the Shiozawa and Tsuchitaru areas. These show two distinct concentrations, majorities that strike NW-SE

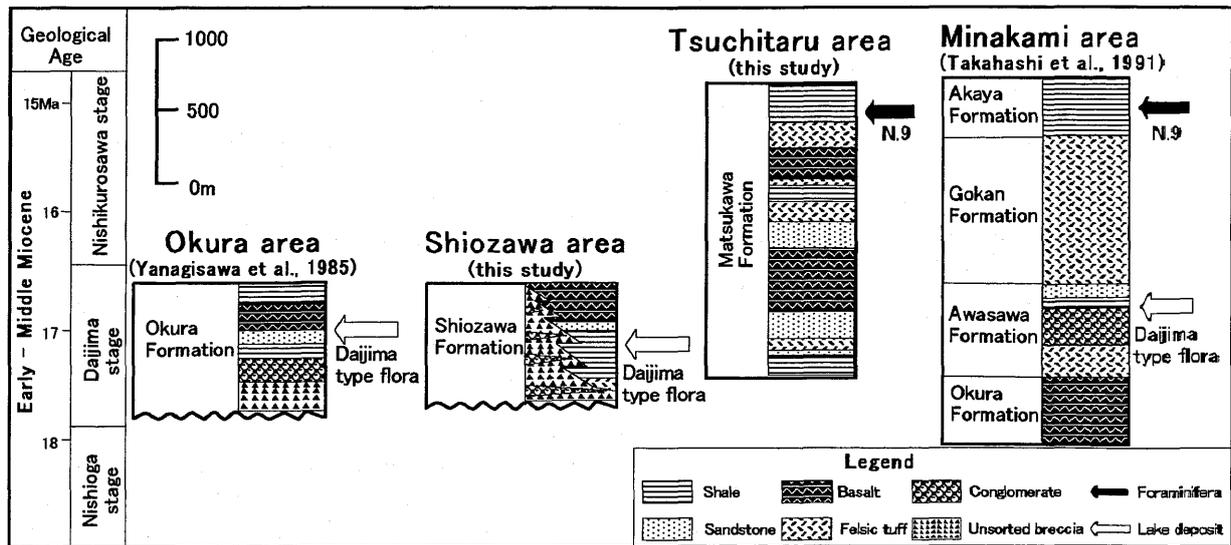


Fig. 8. Stratigraphic correlation of the Miocene series in the Echigo-Yuzawa region with nearby areas.

and others that strike NE-SW. The Tertiary granitoid disconcordantly intrudes the Miocene formations and the pre-Neogene basement rocks in the Tsuchitaru area and is composed mainly of quartz diorite and granodiorite accompanied by fine-grained diorite and gabbroic rocks (Chihara et al., 1981).

Geological structures

The pre-Neogene basement rocks are distributed to the east of the Echigo-Yuzawa region and the Miocene series have a monoclinic structure, which in general strike at NE-SW and dip 12 to 50 degrees NW away from the basement. However, in the Shiozawa area, the beds between the Yoshiyama and Komatsuzawa villages strike NW-SE and dip SW and in the upper reaches of the Irikawa and Komatsuzawa Rivers strike NW-SE and dip NE, forming a syncline in the Komatsuzawa Basalt Member and an anticline in the Maiko Breccia Member (Fig. 4). In the Tsuchitaru area, a shear zone (N15W70E) approximately 1.2km long and several hundred meters wide runs through the Tsuchitaru Sandstone and Basalt Member (Fig. 6). Within this zone the bedrock is sheared as well as some mineralization. Chihara et al. (1981) reported serpentinite and rhyolitic dykes within this zone.

Discussions

1. Regional stratigraphic correlations

The stratigraphic relationship between the Shiozawa and Tsuchitaru areas is difficult to discuss because the Quaternary Mt. Iiji volcano, which is distributed between these two areas, covers the Miocene series.

The Miocene series of the Tsuchitaru and Shiozawa areas can be stratigraphically correlated based on its lithofacies and fossil age to the nearby areas of

Minakami and Okura (Fig. 8). The Okura area is situated about 10km to the northeast of the Shiozawa area, and the Minakami area is situated about 10km to the south of the Tsuchitaru area as shown in Figure 1. The Miocene formations in the Minakami area have been studied by Takahashi et al. (1991) and the Okura area by Yanagisawa et al. (1985). The Shiozawa Formation in the Shiozawa area can be stratigraphically correlated to the Okura Formation in the Okura area based on similar lithological characters as well as the Dajjima-type plant fossils. The Kandatsu Shale Member in the Tsuchitaru area can be correlated to the Akaya Formation in the Minakami area based on foraminiferal data.

2. Generation of the Echigo-Yuzawa Basin
Depositional facies of the Shiozawa Formation

The breccia of the Maiko Formation is poorly sorted and consists of angular clasts of pre-Neogene basement rocks and the matrix also consists of smaller fragmented clasts of the pre-Neogene basement rocks (Fig. 5A&B). These features suggest that they have not traveled far, therefore can be interpreted as talus deposits, which were derived from the adjacent pre-Neogene basement.

The conglomerate unit, on the other hand, indicates transport as suggested from the roundness of the clasts and pebble imbrication (Fig. 5C&D). The conglomerate unit is intercalated sporadically within the talus deposits and is considered to have been debris-flow deposits (Fig. 9). The paleo-current direction obtained from pebble imbrication indicates source from the neighboring pre-Neogene basement.

The shale unit of the Yoshiyama Shale Member includes numerous plant fossils (Fig. 5G) and the sedimentary structures which show repetitive and rhythmic lamina of mud layers in millimeter scale with desiccation cracks on the bedding surface (Fig. 5E&F)

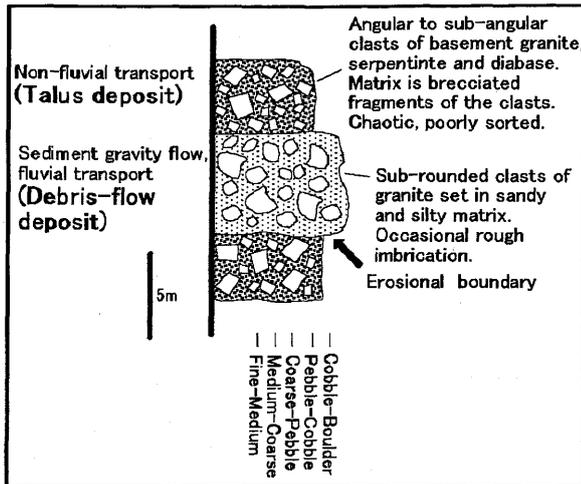


Fig. 9. Vertical profile of the Maiko Breccia Member at the type locality.

indicate sedimentation in a relatively quiet environment with times of dry out, possibly a lacustrine lake. **Relationship between the Miocene series and pre-Neogene basement**

The relationship between the Miocene series and the pre-Neogene basement in the Shiozawa area can be inferred from features observed in the field (Fig. 10) such as: 1) the talus deposits and the pre-Neogene basement cropped out only several to tens of meters away from one another in several places and when connecting the boundary it becomes linear, not undulated; 2) the strike direction of the topographic linear ditches in the pre-Neogene basement was found to be the extensions of the linear boundary and in places the topographic linear ditches coincided exactly with the actual linear boundary; 3) the strike direction of the basaltic dykes is parallel to the boundary indicating that the dykes came up along fractures as the same trend as the boundary. When considering these features, it is difficult to postulate that the boundary is undulated and low-angled but rather a high-angled zigzag linear boundary. Based on these evidence the linear and zigzag linear boundary can be considered to be the fault scarp at the basin generation stage, which supplied the talus deposits of the Maiko Breccia Member. The Shiozawa Formation deposited against the steep dipping fault scarp forming an abut unconformity.

From the above descriptions, it can be inferred that the Echigo-Yuzawa Basin was generated due to collapse of the pre-Neogene basement, forming a lacustrine lake.

3. Tectonic history of the Echigo-Yuzawa Basin

We propose three stages (stage I-III) for the tectonic history of the Echigo-Yuzawa Basin based on the preceding descriptions. The tectonic history can be summarized as follows (Fig. 11).

Stage I: Generation of the collapse basin, forming a

lake-18-17Ma

The depositional facies and geologic structures in the Shiozawa area strongly imply that the basin was generated due to collapse. The collapse occurred along the paleo-fault scarp, which produced the talus and debris-flow deposits (Maiko Breccia Member). The collapse also induced the formation of a lake (Yoshiyama Shale Member). Therefore, as continuous collapse occurred, talus and debris-flow deposits were supplied into the lake, hence the interfinger relationship between the Maiko Breccia Member and the Yoshiyama Shale Member.

Stage II: Volcanism and marine transgression-17-15 Ma

As continuous influx occurred into the lake, the basalt of the Komatsuzawa Basalt Member deposited therefore, the basalt is found to interfinger with the unsorted breccia and debris-flow deposits of the Maiko Breccia Member. This indicates that volcanic activity took place after the collapse. The overwhelming thickness of the basic and acidic volcanic rocks of the Matsukawa Formation indicate vigorous volcanic activity took place, in the Tsuchitaru area. The marine fossil *Makiyama chitanii* (Makiyama) found in the shales of the Nakazato Tuff Member indicates a marine environment. Therefore, the marine transgression must have taken place between the Yoshiyama Shale Member (approx. 17-18Ma) and Kandatsu Shale Member (15Ma). The Nishikurosawa Transgression took place at approximately 16Ma (Matsumaru et al., 1982), and prior to this, a transgression at approximately 17Ma into the central part of the Fossa Magna occurred (Kosaka et al., 1990, 1992). The marine transgression into the Echigo-Yuzawa region may be closely related to the above transgressions.

Stage III: Subsidence in a marine environment - 15Ma

Basin subsidence continued in the Tsuchitaru area. The environment in the Tsuchitaru area was marine, as evidenced by the shales of the Kandatsu Shale Member of the Matsukawa Formation, which included foraminifers.

The Echigo-Yuzawa Basin continued to further develop accompanied by intermediate to felsic volcanism (Kubota, 1988).

Conclusions

On the basis of the detailed field study, the authors newly established the Miocene stratigraphy of the Echigo-Yuzawa Basin, and reconstructed geological history and basin development of the area. A new record of planktonic foraminifer indicative of Blow's N.9 (Blow, 1969) was discovered in the Kandatsu Shale Member and can be correlated to the Nanatani stage (15Ma) of the Niigata Tertiary Basin. It was concluded that the Echigo-Yuzawa Basin formed as a collapsed basin in the Early Miocene; starting as lacustrine

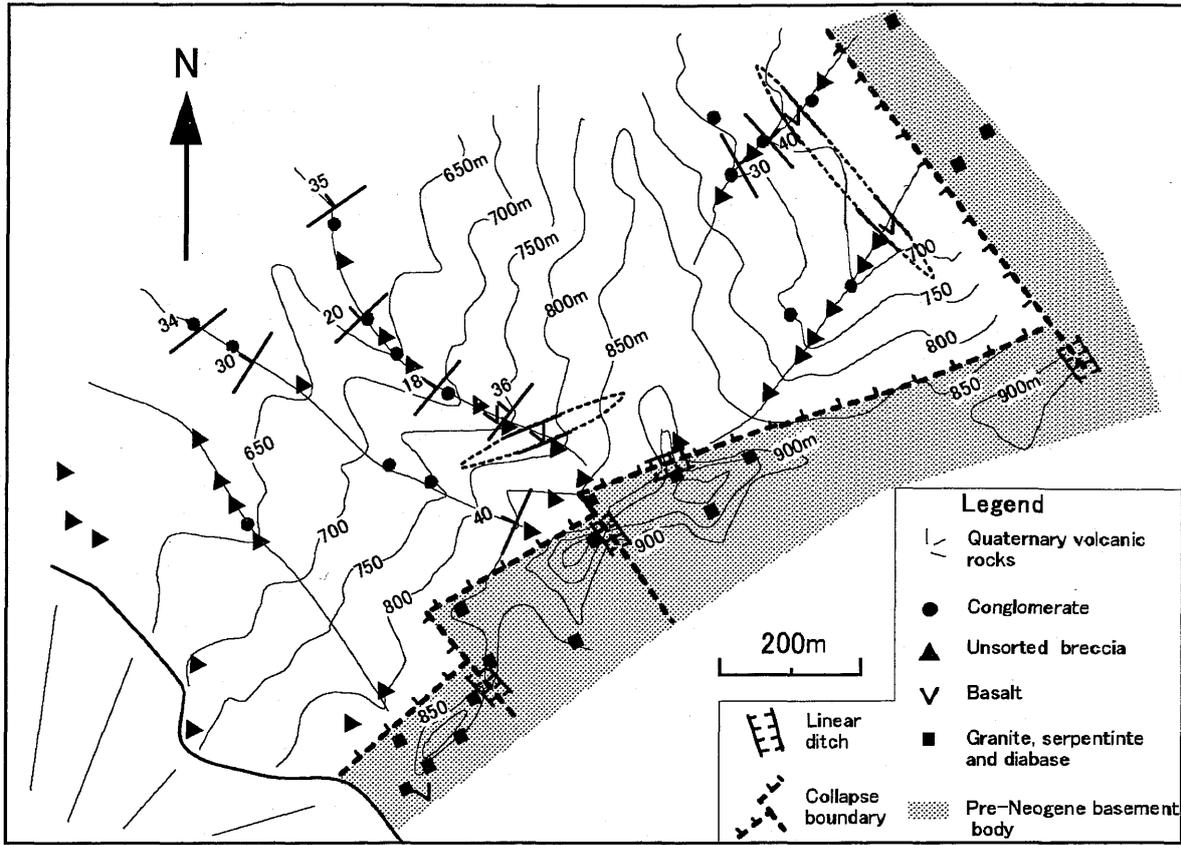


Fig. 10. Enlarged portion near the Miocene and basement boundary showing localities of outcrops, Shiozawa area (refer to Fig. 4).

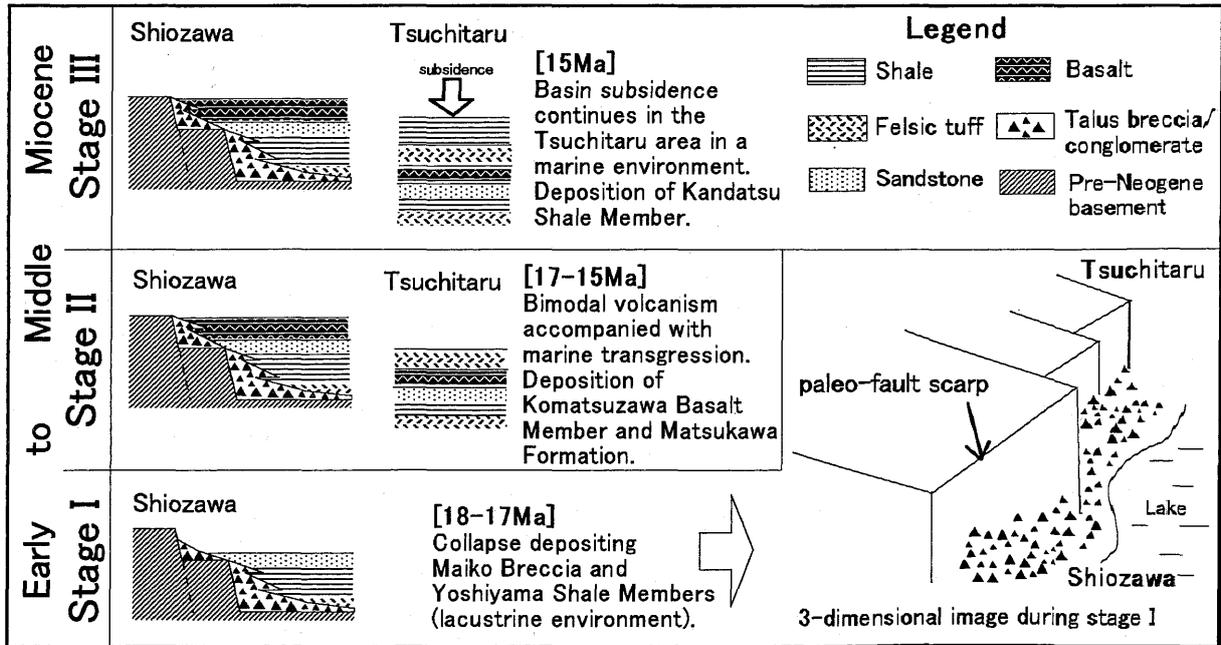


Fig. 11. Tectonic history of the Echigo-Yuzawa Basin.

lake, then marine incursion with volcanisms and subsidence, followed by a continuing large subsidence. It is summarized as follows :

[Stage I] Basin generation due to collapse, forming a lacustrine lake (18-17 Ma).

[Stage II] Subsidence accompanied with marine transgression and bimodal volcanism (17-15Ma).

[Stage III] Continuous subsidence, depositing mud (15 Ma).

The Echigo-Yuzawa collapsed basin is one of many similar basins in the Northern Fossa Magna of Japan, which characterize the tectonic development of Green Tuff region in the Late Cenozoic.

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* in Japanese with English abstract

** in Japanese

(要 旨)

Choi, T.J. and Kubota, Y., 2000, Miocene stratigraphy and tectonic process of the Echigo-Yuzawa Basin, Northern Fossa Magna, central Japan. *Jour. Geol. Soc. Japan*, **106**, 521-533. (チョイ タッド ジェイムズ・久保田喜裕, 2000, 北部フォッサマグナ地域の越後湯沢堆積盆地における中新統層序とその構造発達過程. 地質雑, **106**, 521-533.)

本研究は新潟県越後湯沢堆積盆地縁辺部の中新統の層序を明らかにし, その発達過程を復元したものである. 調査地域は塩沢地域と土樽地域に二分される. 塩沢地域には, 新称, 塩沢層 (舞子角礫部層, 吉山頁岩部層, 小松沢玄武岩部層) が分布する. 土樽地域には松川層 (新称, 土樽砂岩・玄武岩部層, 中里凝灰岩部層, 神立頁岩部層) が分布する. 神立頁岩部層からは今回新たに浮遊性有孔虫を確認し, Blow (1969) による N. 9 に対比される.

越後湯沢堆積盆地の発達過程は, 以下のステージにまとめられる.

- [I] 陥没による盆地発生および湖沼性環境の形成 (18-17Ma)
- [II] 海進を伴う沈降とバイモダル火山活動 (17-15Ma)
- [III] 引き続き沈降による厚い海成泥岩の堆積 (15Ma)