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Dedicated to Professor Atsuo Harumoto in commemoration
of his Retirement on the 16th November of 1959

Tectonic Features of the Sambagawa Metamorphic Zone, Japan

By

Isamu NAKAYAMA

Geological and Mineralogical Institute, University of Kyoto

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Abstract

The Sambagawa metamorphic zone is a typically tectonic zone in its *three-dimensional tectonic* which is characterized by the following four aspects: its geological structure, its relation of minor folding and stretching to the geological structure, rock cleavage, and quartz fabric.

Introduction

The Sambagawa zone runs side by side with the Ryoke metamorphic zone, and the latter is characterized by migmatites, biotite schist and granites. Both were originated from Carboniferous-Permian rock suite.

The crystalline schists in the Kinokawa river basin are in the eastern extension of those of central Sikoku which are representative of the Sambagawa metamorphic zone running through southwestern Japan.

The Tenryu river basin, which is generally considered to have been formed by a special geological development, is located in the place where the Sambagawa zone turns in its trend from the east-west to the north-south.

The studies on the Tenryu and the Kinokawa river basins will gain us some insight into all the most characteristic parts of the Sambagawa zone.

In this paper, however, but a brief treatise on it is intended and, as for the details, the writer's previous papers[15,16,18] and another one* in preparation are recommended.

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* The Tectonic Movement and the Rock Structure of the Sambagawa Zone. Monograph of the Association for the Geological Collaboration. (in Japanese)

I. Geological Structure

A) Kinokawa river basin

This region, having been separated by an uplift in the geosynclinal stage into the northern and the southern, was subsided on both sides and underwent dominant depositions of basic volcanic ejecta.

The northern subsidence[18], being continued even to central Sikoku, was subsided not uniformly, but a southward projecting part alone deeper and deposited

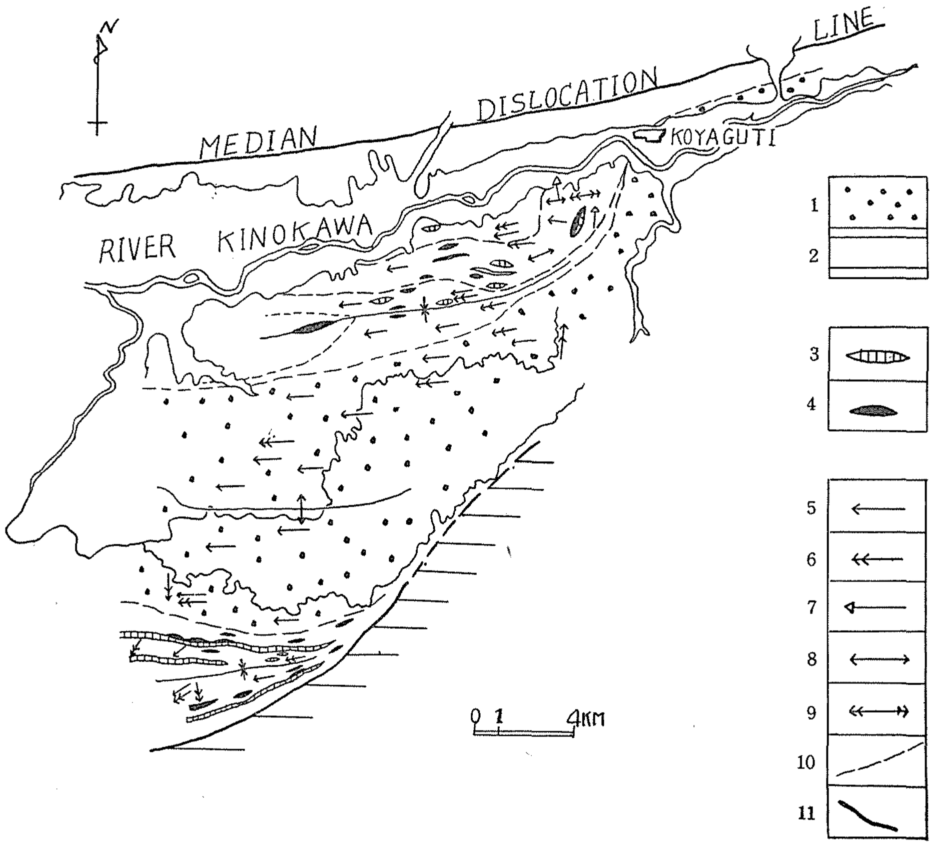

Fig. 1. Geological Map of the Kinokawa River Basin

1 Uplifted Area 2 Non-metamorphic Palaeozoic Strata
3 Basic Intrusive Rocks 4 Ultrabasic Intrusive Rocks
5 Mineral Parallelism with Pitching 6 Minor Folding Axis with Pitching
7 Parallelism of Albite-porphyroblast, showing the deviated direction from that of other minerals
8 Mineral Parallelism without Pitching 9 Minor Folding Axis without Pitching
10 Boundary Line between the Formations 11 Fault

with thicker ejecta than the rest. The area lying in the west of Koyaguti town corresponds to it.

In the northern subsidence lies a sedimentation with imbricate structure[5,6,11], in which the depositions of strata were transferred from the north to the south.

The southern subsidence is discontinuous in some parts through south-western Japan. In the southern subsidence of Kinokawa river basin, the depositions of basic volcanic ejecta are more dominant on the south side than on the north.

Like the southern subsided area, the uplift area is projected toward the southern non-metamorphic Palaeozoic region, and is consisted of argillaceous and arenaceous schists with some thin schists derived from volcanic ejecta.

While the orogenic movement was in progress, both basic and ultrabasic hypabyssal intrusions occurred in these subsided areas. Those intrusions were accompanied by conversion from the geosyncline to the geanticline.

As the result of the orogenic movement, gentle synclinal structures were formed in the subsided areas and a gentle anticlinal structure was formed in the up-lifted area.

What a subside area is to an uplift resembles what an intrageosyncline is to an intrageanticline, and the latter relation was established already by BELOUSOV[1].

B) Tenryu river basin

This region[15,16], spread from the north-east to the south-west, is characterized by the imbrication[5,6,11] of successive depositions. It contains two subsided areas each deposited of dominant basic volcanic ejecta. One of them is the deposition of Zihati formation and the other a sequence of the depositions including the upper Sibuta and the lower Iinoya formations.

The conversion of the geosyncline to geanticline indicates a movement process of rectangular direction inside the upper and lower formations of this basin. Namely, first, the principal differential movement of the upper was north-south, while that of the lower was east-west, and then all the strata were put in an east-west differential movement.

The conversion of geosyncline to geanticline is accompanied by intrusions of basic and ultrabasic hypabyssal rocks. The geological structure formed by the conversion is a gentle monoclinal structure that dips to west or south-west.

What are in common with the two river basins are these: such a conversion was caused by the intrusions of basic and ultrabasic hypabyssal rocks, and the geological structure is so gentle that it made no forward movement. It seems, as a matter of course, that there the geological deposit was not very thick.

According to field evidences and chemical composition, the ultrabasic rocks often found in these regions seem to have been of basaltic magma origin[9,19]. It may follow, therefore, that the bottom of the deposition was never breaking into peridotite shell in the geosynclinal stage.

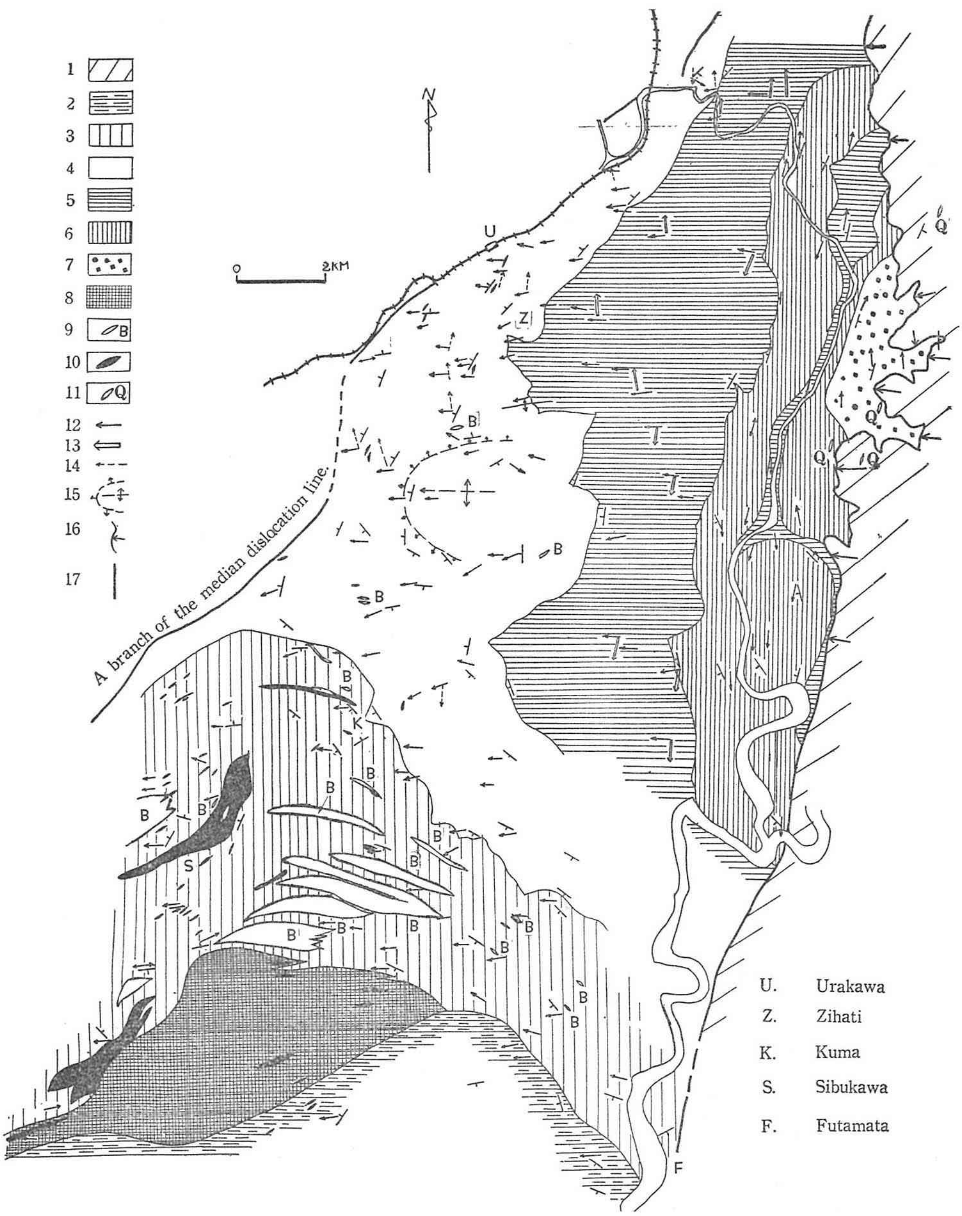

Fig. 2. Geological Map of the Tenryu River Basin

1 Mesozoic Strata, 2 Iinoya Formation 3 Sibukawa Formation
4 Zihati Formation 5 Kasiyama Formation 6 Tatuyama-Meta-diabase
7 Funayo Formation 8 Basic intrusive rocks and Green schist
9 Basic intrusive rocks 10 Ultrabasic rocks 11 Quartz Porphyry
12 Mineral Pallalelism 13 Corrugation-type Lineation
14 Such a Lineation as Slickenside Lineation
15 Assumed Plunging Folding Structure 16 Thrust 17 Fault

Table 1.
Chemical composition of ultrabasic rocks of two regions
(Analyst: T. SASABE*)

I		II		III	
SiO_2	44.51	SiO_2	40.84	SiO_2	38.02
Al_2O_3	8.14	Al_2O_3	0.98	Al_2O_4	4.34
Fe_2O_3	2.57	Fe_2O_3	5.01	Fe_2O_3	4.31
FeO	8.12	FeO	3.34	FeO	8.91
MgO	23.75	MgO	31.48	MgO	29.65
CaO	7.69	CaO	7.23	CaO	4.56
TiO_2	tr	TiO_2	tr	TiO_2	tr
Ig. Loss	4.94	Ig. Loss	12.24	Ig. Loss	10.56
Total	99.72	Total	101.12	Total	100.35
Mg/Fe: 4.1		Mg/Fe: 7.2		Mg/Fe: 4.1	

I: Serpentinite in the northern subsidence of the Kinokawa basin
II: Serpentinite in the southern subsidence of the Kinokawa basin
III: Serpentinite in the Zihati formation of the Tenryu basin (at Kumadaira)

II. Rock Structure

Minor folds, rock cleavages, lineations and petrofabrics, all are reflecting the peculiarity of the orogenic movement here in Sambagawa zone.

A) Foliation and Cleavage

In the Sambagawa zone, the foliation being parallel to the bedding plane, the mineral parallelism is in the foliation plane which, consequently, is in agreement with the schistosity plane.

Here the (h01)-fracture plane is universal, while in black and quartz schists predominant is the fracture cleavage parallel to the axial plane of minor folds, whereas flow cleavage is absent. Even in the middle and the lower parts of Kasiyama formation with "second cleavage structure"[7] (Tenryu river basin) not a primary banding structure (foliation) has ever been disordered by any cleavage parallel to the axial plane of an intraformational fold.

Flow cleavages, say KOJIMA and SUZUKI[13], are seen in black schists of the shear zone of southern periphery of the Sambagawa metamorphic region in central Sikoku. The very plates they offer contradict their report. For those plates show no trace of any foliation ever disorded by a cleavage.

One of the structural peculiarities of the Sambagawa zone is that here foliation has never been disturbed by any cleavage, while it is often disorded by flow

* A member of the Nara Technical Institute. The writer wishes to express his sincere thanks to Mr. SASABE.

cleavage in many other parts of the world, namely, Norway[14], Scotland[20,22], Swiss Alps[8], the Appalachia[2,3,4] and U.S.S.R.[1]

B) Minor Fold and Lineation

In the Sambagawa metamorphic region, SAGAWA[21] says, the linear structure is in agreement with the pitching direction of "bedded deposit of chalcopyrite"—*Kieslager*—. Later on the agreement of mineral parallelism with fold axis in this region was emphasized by HORIKOSI and KAMIYAMA[10].

The writer agrees with them only except the following two points:

1) The a-lineation and a-fold are formed, in a later stage of tectonic movement, as a result of local compressions caused by the stretching of rocks in the direction of folding axis (namely, in the direction of the least resistance); and a-structures are in reality nothing but b-structures of three-dimensional tectonic.

   In the Sambagawa a-structures are seen not everywhere, but only in *movable* beds or minerals:

   a) *movable* in the later stage of the orogenic movement, and
   b) *movable* in and about subsided area.

The Kotu district[12] in Sikoku, is the best example of this, while Kinokawa region is less abundant in a-structures. For, above said two conditions were more satisfied in the former than in the latter.

2) The later folding movement, being different in direction from the former movement of an orogenic movement, deforms the previous structure and, thus, the relations of mineral parallelism and of minor fold to geological structure are confused.

   In the Tenryu river basin, mineral parallelism is obvious on the schistosity plane which is in accord with foliation plane parallel to bedding plane. Here both in the Kasiyama and in Zihati formations, it is to be noted that a remarkable cross relation can be seen between the strike of formation and the direction of lineation. The mineral parallelism, having the range of N60°E–N60°W and pitching nearly to the west, is in agreement with the axes of minor folds and plunging structure of the folding movement of the first phase. In the middle and the lower parts of Kasiyama formation with second cleavage structure, the mineral parallelism running east-west is found on the foliation plane, and corrugation running north-south is seen on axial plane cleavage of intraformational folding. By the second phase folding movement east-west in movement direction, the primary structure was deformed, and the relation of mineral to the geological structure was changed.

Thus, in the Sambagawa metamorphic zone, dimensional parallelism is rectangular to the movement direction which caused the mineral parallelism.

In the recumbent or the overturned folds, the forward movement works, and stands at maximum, in a-axis alone, and the deformation is, to a large extent, *two-dimensional* and goes on in the ac-movement plane perpendicular to the fold axis.

Thus, in many parts of the world, as mentioned already, the stretching and the mineral parallelism in a-axis occur on the flow cleavage.

In the Sambagawa metamorphic region, the folding structures are so gentle that the forward movement in a-axis is slight. The stretching in b-axis is larger than in a-axis. Hence, the deformation is *three-dimensional*[17].

C) *Petrofabrics*

In the previous papers[15,16,18], the writer reported petrofabrics of the Tenryu and the Kinokawa river basins except the southern subsided area of the latter.

In the Kinokawa river basin the quartz fabric is characterized by b-girdle, and the quartz crystals are most strongly stretched out in b-axis. In the Tenryu river basin, it is characterized by imperfect b-girdle in which the symmetry was diminished by $B \perp B'$ movement.

In many metamorphic regions, having the flow cleavage with a stretching in a-axis, the quartz fabric is characterized by a-girdle or a-point maximum with or without b-girdle. The quartz fabric of Sambagawa metamorphic zone differs from those of the above mentioned regions in the fact that the movement is *three-dimensional* in the former, but *two-dimensional* in the latter.

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