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On Diatoms from the Jigoku Valley and its Neighbourhood, the Tateyama Volcano, Toyama Prefecture, Japan

by

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Introduction

In July of 1951, Prof. T. Ueki of the Toyama University sent me some recent diatoms collected from Mikuriga-ike which is a small crater lake on the Tateyama volcano. It is to be desired to know what species of diatoms occur in this water of the high mountain.

In the summer of 1955, Mr. S. Fujii of the same university geologically investigated the Jigoku valley, and he sent me several specimens of sulphur deposit collected in this valley. Thereafter, he has also continued to investigate into geology of this valley. The sulphur deposit near a stream from which was collected samples is distinctly stratified as many seams, and is made up into banded layers which differ in both thickness and colour. In general, the colours of layers are whitish gray, but some of which are inserted betweem them dark. Fujii desires to make an occurrence of these layers clear geologically and micro-palaeontologically.

In October of 1955, Mr. K. Kojima who is an assistant in the Faculty of Science, the Kanazawa University made a survey of the Tateyama volcano, and he collected some specimens from Mikuriga-ike and one of small pools on Tengu-daira which is a plateu composed of andesite flows.

The Jigoku valley lies between from 2,300 to 2,400 m above the sea level and it is a part of the low valley which belongs to the upper course of the River Shomyo. The word Jigoku of the valley derived from a Buddhist phrase meaning torment. In the Jigoku valley, like many others of its type in Japan, the solfataric condition is still active and fumaroles are found in many places.

I wish to render grateful acknowledgment to Prof. T. Ueki who sent me usefull specimens ; to Mr. S. Fujii who cooperated with me in this work ; to Mr. K. Kojima for his trouble in bringing several specimens to our laboratory.

Topography and Geology

The Jigoku valley and its neighbourhood are a eastern part of the Tateyama volcano. The valley is a low ground which was formed by explosions of the Tateyama volcano, and this extends laterally about 700m from east to west and 300 m from north to south. The running waters have eroded this basin, and now the chief four streams become one and flow in the direction of NE cutting a ravine. The ravine stream becomes the head-water of the River Shomyo which is a branch of the River Joganji.

Mikuriga-ike lies on the western side along the road from the Murodo hut to the Jigoku valley. It is 1 km round, and a small crater filled up with water. The bed rocks of this place are composed of the Hida gneiss and intrusive granitic rocks, and they are superficially covered by some sheets of lava. This fact shows distinctly near the western part of the Tateyama volcano. According to the data of T. Ōtsuka and M. Ueno (1951), the sheets of lava amount to several in number, and all the lavas are lithologically augite andesite.

A sedimentary sulphur deposit occurs in the north-eastern low ground of the Jigoku valley. The deposit is still believed to have been precipitated originally in the activity of sulphuric gases since the last lava flow, but to have been enriched at a later stage by aqueous solution.

According to Ōtsuka and Ueno, the deposits in the valley are separated into two types by their occurrences. One is a sedimentary deposit, and the other is a sublimation deposit.

Fujii points out that the area are buried under snow for 9 months in a year (from October to June of the next year). Spring has come and snow begins to melt. The water runs from west to east along the land slope, and thus materials which were eroded every year carry and deposit on the eastern side of the area many banded layers. In the Jigoku valley, the earth heat amounts to considerable quantity, and this is connected with the occurrences of many small faults which are found in the deposits here and there.

The sublimation deposit ocupies the eastern part of the Oyama hut, and extends over about 250 m from east to west and about 100 m from south to north. In this place, there are many small or large fumaroles, and some of these are still active. The total number of fumaloles is close upon two hundred including twenty active ones.

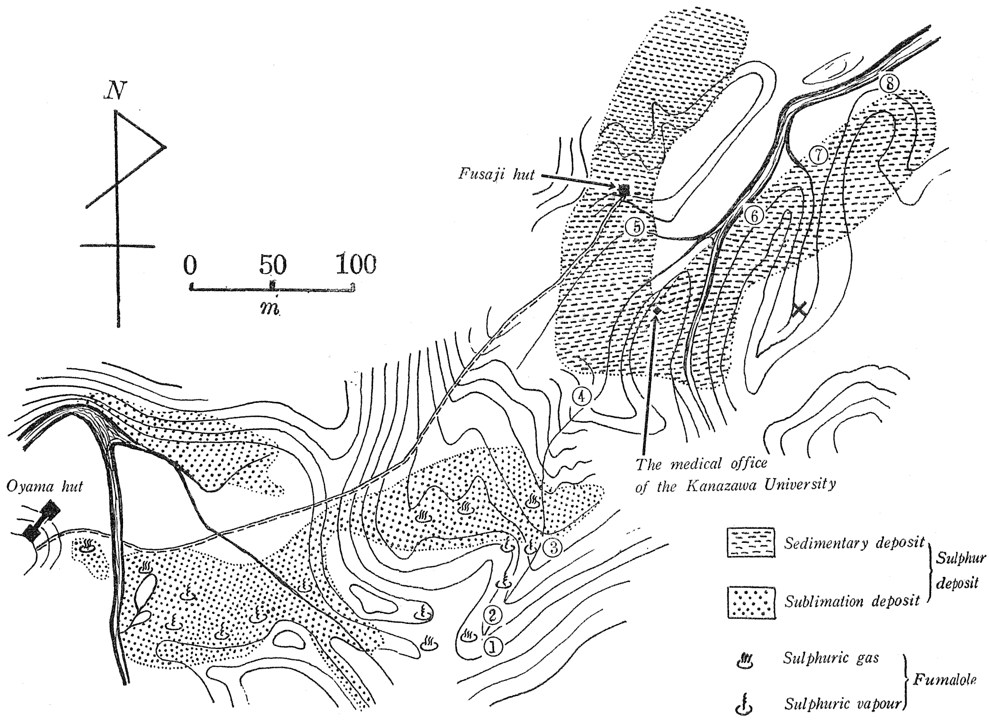
The sedimentary deposit lies on a flat land near a swamp where the water runs from east to west, and its extent reaches about 130m in width, and about 230m in length. This is an elliptical sulphur deposit which is elongated nearly in the direction of NE-SW. Fujii points out that the banded muddy layers are composed of two different types in situ ; one is a bluish gray-black thin silt or clay lamina (0.1–2mm in thickness), and the other a yellowish white thin silt lamina (0.1–20mm in thickness). These laminae regulary alternate in the deposit, and the former is generally thinner than the later. These laminae are cut by many small faults which are found only in the deposit. The deposit contains sulphur in large quantity and attain to the thickness of 5–10m in the central portion of the deposit. The deposit gradually increases in number of gravels towards the lower layers, and at last turns into the basal sand and gravel bed. Distribution of the deposit will be shown in the text-figure **1**.

The figure also shows that almost all active fumaloles are situated on the south-western part of this valley. The word of fumalole is applied to fissures or holes in the rocks, from which stream and other heated vapours escape with more or less force. When the fumaroles give off sulphuric vapours they are often termed solfataras. In here the solfataric condition is still active and forming a sublimation deposit.

Text-figure **1**

A rough sketch of the Jigoku valley, Tateyama volcano, Japan

(Text-figure after Ōtsuka, Ueno and Fujii)



①…⑧ The positions upon which the samples are based.

× The situation good for breeding many algae

Investigation of Materials

All materials which I was received from Fujii are divided into two main classes ; one is fine muddy sediments, but others are some algae in the stream and water of the thermal spring. The sediments contain a large quantity of sulphur.

For the purpose of microscopical examination, firstly sulphur contents must be removed from the materials. As the best method of sulphur removal, I made use of Soxhlet's extractor. In this case, first a fixed quantity of material is tied up in a filter-paper, and it is put in the extractor, and then it is treated by a vapour of some carbon bisulphide. After that, the remains still more is treated by some sulphuric acid, and washed away several times, and at last dried up in a thermostat.

Another materials like algae and suspended materials in the thermal spring are also treated by some sulphuric acid. That which contain many organic matters is burnt in a electric furnace, and then washed away several times, and treated by acid and dried up as described above.

The samples which was collected in my hand from the Jigoku valley and its neighbourhood are divided into four main classes as follows :

(1) Subfossil diatoms in the sulphur-bearing sediments.

(a) Diatoms in the bluish gray or black muddy sediments.

(b) Diatoms in the yellowish white silty sediments.

(2) Diatoms in the thermal spring.

(3) Diatoms in the water of Mikuriga-ike.

(4) Diatoms in the water of a pool on Tengu-daira.

The habitats of the above mentioned diatoms belong to the mountain region lying about 2.300–2.400m above the sea level. This fact is of deep interest in comparison with those living in such an open field as the Toyama plane. But I think that such lower organism as diatoms so easily adapt themselves to its natural enviroment where they live that we cannot simply find such differences on their froms in every habitat. At present the problem remains unanswered, but the future will find a key to it in the minute observation of their species and varieties.

Habitats of Species

(1) Subfossil diatoms in the sulphur-bearing sediments.

The sublimation deposit occurs near fumaroles in beds of porous volcanic ash. This is unusually high-grade in quantity of sulphur, and has directly no relation to other aquous sediments in this area.

The sulphur-bearing sediment has been formed by simple precipitation in a hot crater lake. In this water, microorganisms live and die, and at last their remains accumulated in the bottom of the water mingled with other materials.

Diatoms have lived in the water of this valley. Therefore, we can find them in both the present water and the previous deposit of this valley. The sulphur-bearing sediment is divided into two classes as already said. Subfossil diatoms are mostly found in one class which includes the bluish gray or black muddy sediments.

(a) Diatoms in the bluish gray or black muddy sediments.

In these sediments, the following species are found. (Text-figure **2**)

Pinnularia braunii (GRUN.) CLEVE var. *amphicephala* (A. MAYER) HUST.	Dominant.
Melosira islandica O. MÜLL.	Dominant.
Caloneis bacillum (GRUN.) CLEVE	Rare.

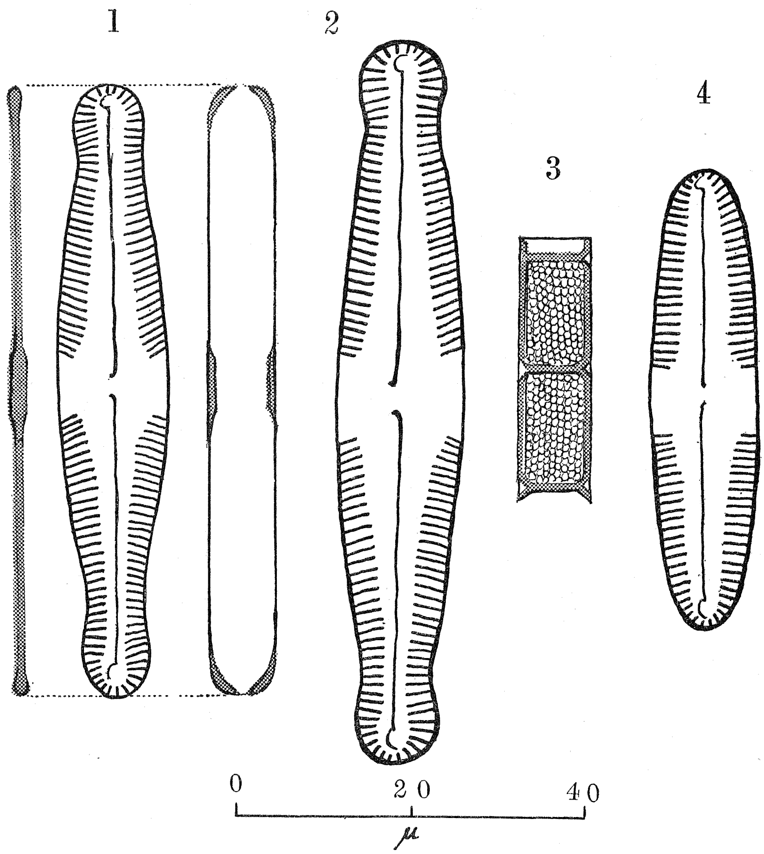
(b) Diatoms in the yellowish white silty sediments.

In this case, the number of species can not bear comparison with the number of the above material. The following one species is rarely found.

Pinnularia braunii (GRUN.) CLEVE var. *amphicephala* (A. MAYER) HUST. Rare.

(2) Diatoms in the thermal spring.

Mineral waters collected from the thermal spring by Fujii contain some suspended impurities. The most part of them composed of a clod of sulphur in which diatoms are frequently found.



Text-figure 2

1, 2. *Pinnularia braunii* (GRUN.) CLEVE var. *amphicephala* (A. MAYER) HUST.

3. *Melosira islandica* O. MÜLL.

4. *Caloneis bacillum* (GRUN.) MERESCHK. var. *inconstantissima* (GRUN.) A. CLEVE

The Fusaji hut admits a thermal spring generating from a land heat of the upper valley. According to Fujii, the temperature of the thermal water shows 78°C and the pH-value 2.8 in the morning of the 10 th, October, 1955. In these samples, diatoms are very small in number, and only one species.

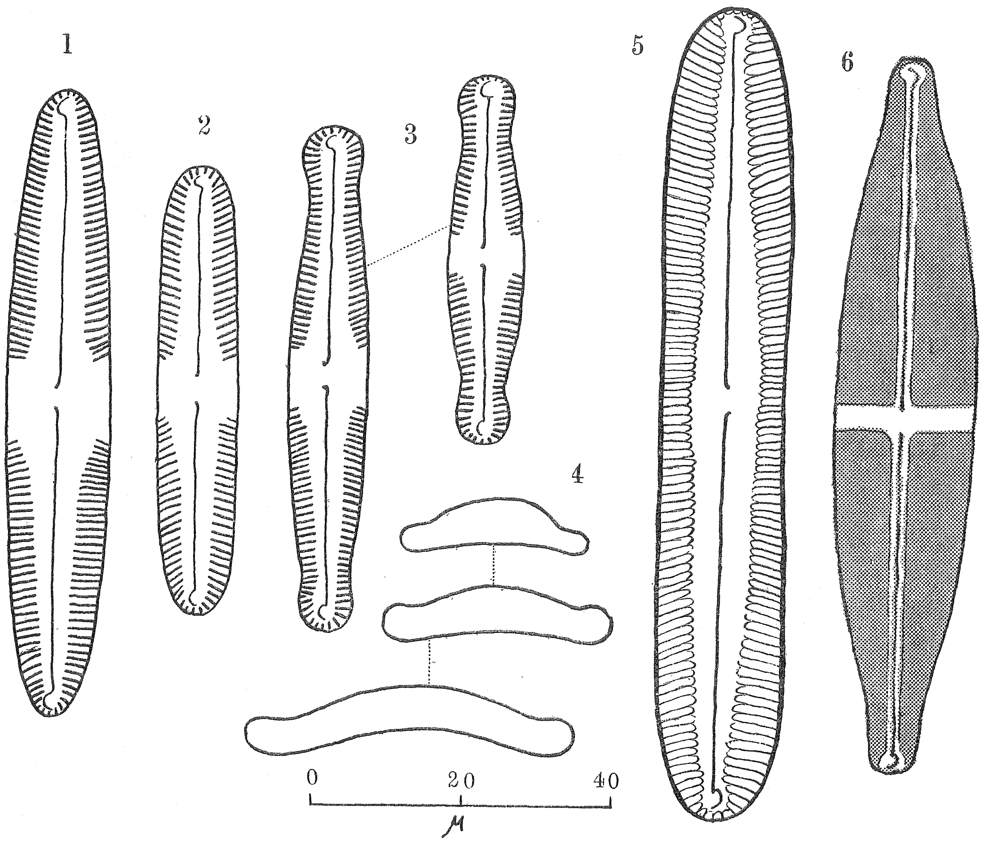
Pinnularia braunii (GRUN.) CLEVE var. *amphicephala* (A. MAYER) HUST. Scarce or rare.

The one pool (T. 62° C ; pH 3.0) dammed up by the water pipe leading to the Raicho hut, and the bath room (T. 52°C ; pH 3.0) of the Fusajii hut are both similarly circumstanced. But it is a question whether all the diatoms found from the impurities belong to living or subfossil. The reasion lies in that the subfossil diatoms contained in the sulphur sediments may be carried with other materials downwards by erosion of the running thermal water.

I must here mention an important fact of living diatoms in this valley. Fujii collected some algae in this valley where the temperature of the water is 10°C and the pH-value 4.4

in the morning of the 10 th, October, 1955. The diatoms attaching to algae are large in number and several in species as follow : (Text-figuse **3**)

Pinnularia braunii (GRUN.) CLEVE var. *amphicephala* (A. MAYER) HUST.	Dominant.
Caloneis bacillum (GRUN.) MERESCHK. var. *incostantissima* (GRUN.) A.CLEVE	Common.
Eunotia septentrionalis ÖSTR.	Common.
Pinnularia superba A. CLEVE.	Rare.
Stauroneis phoenicenteron EHR. var. *intermedia* (DIPP.) A. CLEVE.	Rare
Fragilaria sp.	Scarce or rare.



Text-figure **3**

1. 2. *Caloneis bacillum*(GRUN.) MERESCHK. var. *incostantissima* (GRUN.) A. CLEVE

3. *Pinnularia braunii* (GRUN.) CLEVE var. *amphicephala* (A. MAYER) HUST.

4. *Eunotia septentrinalis* ÖSTR.

5. *Pinnularia superba* A. CLEVE

6. *Stauroneis phoenicenteron* EHR. var. *intermedia* (DIPP.) A. CLEVE

(3) Diatoms in the water of Mikuriga-ike.

Mikuriga-ike is a small crater lake, and at present, its volcanic activity can not be recognized.

Two sorts of samples are preserved in my hand : one is a muddy material collected by Ueki, dated on July, 1951 and the other similar material collected by Kojima, dated on October, 1955. In an assemblage of diatoms in these samples, there is a difference which can distinguishes one from another. This dues to the discrepancy of dates and the position where the materials were collected by the above two collectors from the same lake.

Following species are found in the former sample : (Text-figure **4**)

Cymbella hebridica (GREGORY) GRUN.	Common.
Eunotia suecica A. CLEVE.	Rare.
Hantzshia amphioxys (EHR.) GRUN. fo. *capitata* O. MÜLL.	Rare.
Pinnularia hemiptera (KTZ.) RABH.	Common.
Pinnularia viridis (NITZSCH) EHR. var. *rupestris* (HANTZSCH) CLEVE.	Rare.
Stauroneis anceps EHR.	Rare.

Following species are found in the latter sample : (Text-figure **4**).

Cymbella hebridica (GREGORY) GRUN.	Common.
Epithemia sp.	Rare.
Eunotia valida HUST. (?)	Rare.
Pinnularia appendiculata (AGARDH) CLEVE.	Common.
Pinnularia borealis EHR.	Rare.
Pinnularia borealis EHR. var. *brevicostata* HUST.	Rare.
Pinnularia hemiptera (KTZ.) RABH.	Common.
Pinnularia microstauron (EHR.) CLEVE fo. *diminuta* GRUN.	Rare.
Stephanodiscus astraea (EHR.) GRUN. var *intermedia* FRICKE.	Rare.

Cymbella hebridica and *Pinnularia hemiptera* are common in both materials.

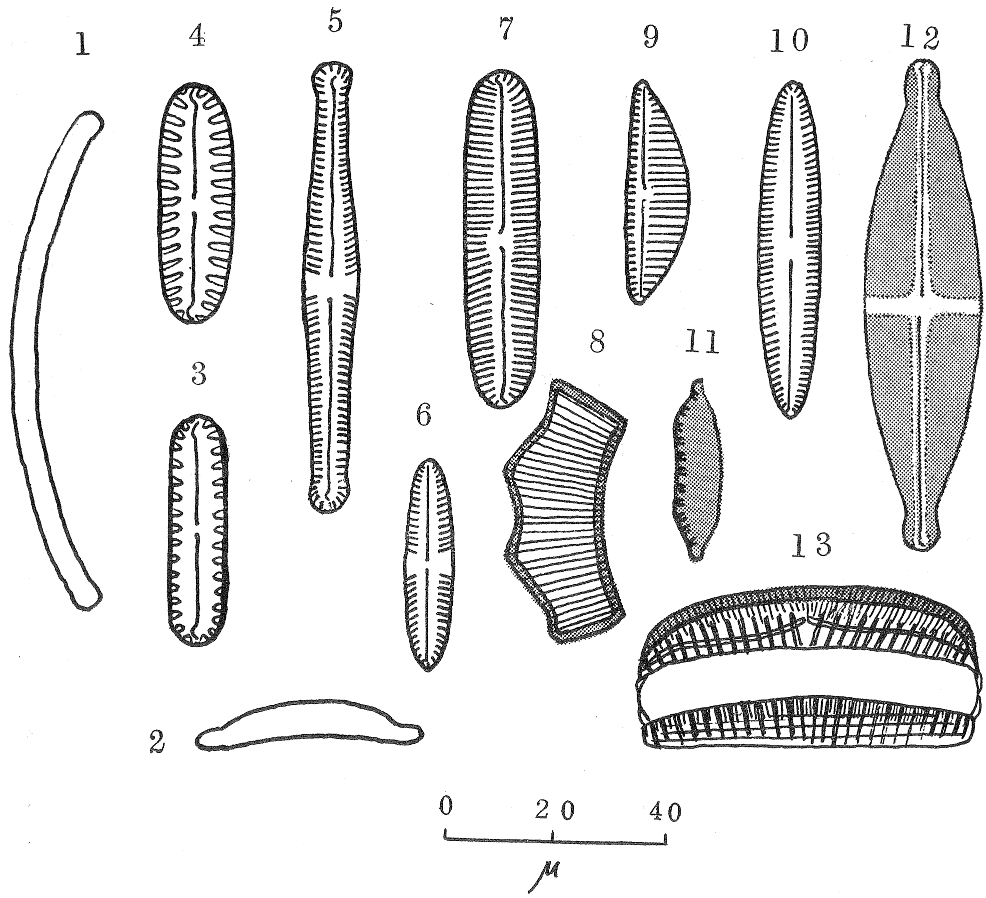
(4) Diatoms in the water of a pool on Tengu-daira.

There are some small depressions on Tengu-daira which are 5–10 m around. The bed rock is a decomposed andesite, namely – a clay. Some diatoms are found in the muddy sediment at the bottom of the pool.

The chief species are as follows : (Text-figure **5**).

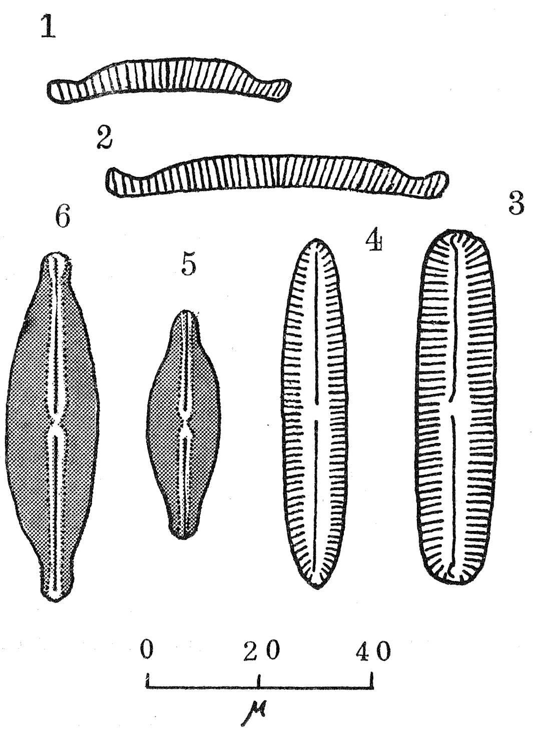
Eunotia flallax A. CLEVE var. *lapponica* A. CLEVE	Common.
Eunotia nymanniana GRUN.	Rare.
Frustulia saxonica RABH. var. *leptocephala* (ÖSTR.) A. CLEVE	Rare.
Pinnularia hemiptera (KTZ.) RABH.	Rare.
Pinnularia viridis (NITZSCH) EHR. var. *rupestris* (HANTZSCH) CLEVE	Rare.

Pinnularia hemiptera and *Pinnularia viridis* var. *rupestris* are already found in the former sample of Mikuiriga-ike. Mikuriga-ike is a small crater lake, but the pool on Tengu-daira is different from that. Such a pool is also here and there in this place as if it were a eroded relic of the past.



Text-figure 4

1. *Eunotia lunaris* (Ehr.) Grun.
2. *Eunotia valida* Hust. (?)
3. *Pinnularia borealis* Ehr. var. *brevicostata* Hust.
4. *Pinnularia borealis* Ehr.
5. *Pinnularia appendiculata* (Agardh) Cleve
6. *Pinnularia microstauron* (Ehr.) Cleve fo. *diminuta* Grun.
7. *Pinnularia viridis* (Nitzsch) Ehr. var. *rupestris* (Hantzsch) Cleve.
8. *Eunotia suecica* A. Cleve
9. *Cymbella hebridica* (Greg.) Grun.
10. *Pinnularia hemiptera* (Ktz.) Rabh.
11. *Hantzschia amphioxys* (Ehr.) Grun. fo. *capitata* O. Müll.
12. *Stauroneis anceps* Ehr.
13. *Epithemia* sp.



Text-figure 5

1. *Eunotia fallax* A. CLEVE var. *lapponica* A. CLEVE
2. *Eunotia nymanniana* GRUN. *Syn. E. exigua* (BRÉB.) RABH. var. *gibba* HUST.
3. *Pinnularia viridis* (NITZSCH) EHR. var. *rupestris* (HANTZSCH) CLEVE
4. *Pinnularia hemiptera* (KTZ.) RABH.
5, 6. *Frustulia saxonica* RABH. var. *leptocephala* (ÖSTR.) A. CLEVE.

Description on Species

The following each species describes according to its frequent occurrence and its order of the above habitats.

(1) 1. *Pinnularia braunii* (GRUN.) CLEVE var. *amphicephala* (A. MAYER) HUST.
Text-figure 2, 1,2

HUSTEDT 1930, p. 319, fig. 578

Length, 40–80μ ; breadth (in broad part), 10–18μ ; striae, 10–12 in 10μ.

Common.

This form has been mentioned by several authors such as F. Hustedt (1930 ; 1938–'39), K. Negoro (1941;1942), M. Saito(1949), N. Foged (1953), A. Cleve-Euler(1955) etc.

Hustedt (1938–'39) points out that *Pinnularia braunii* is prolific in the acidic water of the botanical garden of Buitenzorg in Java, and the spring form preferably occurring in acidic water found in the temperature 20–35°C and in the pH-value 6–7. But the general limit of this form lies in the temperature 30–40° C and in the pH-value 7–8. He also shows that the form found in the thermal spring of Bukit kili kerül near Singkaraksee in Middle Sumatra occurs in the water of 50°C in the temperature and 7.5 in the pH-value.

According to Negoro (1941;1942), the form is widely distributed and occurs in abundance as a characteristic leading form in mineral-acidic waters of volcanic regions in Japan. The pH-values of waters range from 1.7 to 7.3, yet the luxuriant growth is generally found in acidic enviroment found in the pH-values 1.7–nearly 4.0. He also considers that the uppermost limit of temperatures of the cited water is 48°C, but the favorable range for existance of this form seems to lie below 35°C.

Foged (1953) finds that the form in Menyanth Lake which is situated on the inland of Sdr. Strømfjord, West Greenland, is common in the water where the pH-values range from 5 to 7.

In the samples of the Jigoku valley, this form is common, and not only large in number, but also found in both hot and cold water. If *Pinnularia braunii* var. *amphicephala* obtained from the materials which were gathered from the source of the Fusaji thermal spring is a living form, it will be true that the form occurs in the water of 78°C in the temperature and 2.5 in the pH-value.

2. *Melosira islandica* O. MÜLL.
Text-figure **2**, 3

HUBER-PESTALOZZI 1942, p. 384, Taf. CXII, Abb. 460 a

Diameter, 8μ.

Dominant.

According to Fustedt (1938–'39), the form is usually found in a wide limit, and especially from mesohalob to eutrophe water of the interior among mountains as if the form has a breeding season in winters.

In the Jigoku valley, the form is dominant, and not still found in the thermal spring.

3. *Caloneis bacillum* (GRUN.) MERESCHK. var. *incostantissima* (GRUN.) A. CLEVE
Text-figure **2**, 4

A. CLEVE-EULER 1955, p. 102, Fig. 1147 a-c

Length, 55–85μ ; breadth (in broad part), 10–15μ ; striae, 10–11 in 10μ.

Rare.

The form is quite alike to *Caloneis bacillum*. But according to the classification of A. Cleve-Euler (1955), the form fits *Caloneis bacillum* var. *incostantissima* exactly. *Caloneis bacillum* is generally found in the water of oligohalob to krenophil.

(2) 1. *Pinnularia braunii* (GRUN.) CLEVE var. *amphicephala* (A. MAYER) HUST.
Text-figure **3**, 3

Dominant. Already described in (1), 1.

2. *Caloneis bacillum* (GRUN.) MERESCHK. var. *incostantissima* (GRUN.) A. CLEVE.
Text-figure **3**, 1, 2

Common. Already described in (1), 3.

3. *Eunotia septentrionalis* ÖSTR.
Text-figure **3**, 4

FOGED 1953, p. 34, PL. II, 7, 8

Length, 24–45μ ; breadth, 5μ.

Common.

According to Foged (1953), the form belongs to acidophilous. A. Cleve-Euler (1953) points out that the form is found in fresh water here and there in Sweden and Finland.

4. *Pinnularia superba* A. CLEVE

Text-figure 3, 5

A. CLEVE-EULER 1955, p. 71, Fig. 1096

Length, 110μ ; breadth, 18μ ; striae, 8–9 in 10μ.

Very rare.

A. Cleve-Euler (1955) shows that the form is found in brooks of mountains (minerotraphent!).

5. *Stauroneis phoenicenteron* EHR. var. *intermedia* (DIPP.) A. CLEVE

Text-figure 3, 6

A. CLEVE-EULER 1953, p. 210, Fig. 944, e

Length, 95μ ; breadth (in central part), 20μ ; striae, lack clearness.

Rare.

In general, the form is cosmopolitan in fresh water.

(3) Recent diatoms in Mikuriga-ike are large in number and several in species. Although Mikuriga-ike is situated near the Jigoku valley, there is no connection with the water of the valley.

1. *Cymbella hebridica* (GREGORY) GRUN.

Text-figure 4, 9

HUSTEDT 1930, p. 359, Fig. 662

Length, 40μ ; breadth, 9–10μ ; striae, 9–10 in 10μ.

Common.

According to Hustedt (1930), the form is a Northern alpine type. Foged (1953) shows that the form is boreal species and belongs to acidophilous. A. Cleve-Euler (1955) points out that the form occurs in fresh water as in the limit from mesohalob to eutrophe water. Therefore the form is common in lakes and brooks of mountains.

2. *Pinnularia hemiptera* (KTZ.) RABH.

Text-figure 4, 10

A. CLEVE-EULER 1955, p. 35, Fig. 1042 a, b

Length, 60μ ; breadth, 16μ ; striae, 9–10 in 10μ.

Common.

According to Hustedt (1938–'39), the form occurs in the water of the pH-values 4 to 7.

3. *Pinnularia appendiculata* (AGARDH) CLEVE

Text-figure 4, 5

HUSTEDT 1930, p. 317, Fig. 570

Length, 80μ ; breadth, 8–10μ ; striae, 8–9 in 10μ.

Common.

According to Hustedt (1930), the form is not small in number in mountains. He (1938–'39) also indicates that the pH-values of water range from 4.3 to 8.

4. *Eunotia suecica* A. CLEVE

Text-figure 4, 8

HUSTEDT 1930, p. 174, Fig. 210

Length, 45μ ; striae, 9–10 in 10μ.

Rare.

Hustedt (1930) shows that the form is a Northern alpine type.

5. *Hantzschia amphioxys* (EHR.) GRUN. fo. *capitata* O. MÜLL.
Text-figure 4, 11

A. CLEVE-EULER 1952, p. 49, Fig. 1419 t

Length, 36μ ; breadth, 8μ.

Rare.

The form is common in fresh water.

6. *Pinnularia viridis* (NITZSCH) EHR. var. *rupestris* (HANTZSCH) CLEVE
Text-figure 4, 7

HUSTEDT 1930, p. 334 ,Fig. 617 a

Length, 67μ ; breadth, 16μ ; striae, 7–9 in 10μ.

Rare.

The form is generally common in mountains. According to Hustedt (1938–'39), *Pinnularia viridis* is common in the water of the pH-valves 6.6 to 8.53.

7. *Stauroneis anceps* EHR.
Text-figure 4, 12

HUSTED 1930, p. 256, Fig. 405

Length, 90μ; breadth, 20μ.

Rare.

The form is cosmopolitan in general (Indiffirent).

8. *Eunotia lunaris* (EHR.) GRUN.
Text-figure 4, 1

HUSTED 1930, p. 183, Fig. 249

Length, 90–100μ ; breadth, 4μ.

Rare.

According to Foged (1953), the form is a rather eurytopic species, which, however, seems to prefer oligotrophic localities, as its optimum undoubtedly occurs in a humic acid milieu.

9. *Pinnularia borealis* EHR.
Text-figure 4, 4

HUSTEDT 1930, p. 326, Fig. 597

Length. 40μ ; breadth, 10μ ; striae, 4–5 in 10μ.

Rare.

According to Hustedt (1930 ; 1938–'39), the form is common in mountains, and found in the pH-values about 4 to 8. Foged (1953) shows that this is widely distributed in most acidic and neutral samples, rare in the alkalic samples, and often occurring as an aerophilous form in West greenland.

10. *Pinnularia borealis* EHR. var. *brevicostata* HUST.
Text-figure 4, 3

HUSTEDT 1930, p. 326, Fig. 598

Length, 40μ ; breadth, 16μ ; striae, 4–5 in 10μ.

Rare.

According to Hustedt (1938–'39), the form is cosmopolitan, and has the same chracters of the above said species *P. borealis.*

11. *Pinnularia microstauron* (Ehr.) Cleve fo. *diminuta* Grun.
    Text-figure 4, 6

    Hustedt 1930, p. 321, Fig. 585

    Length, 37μ; breadth, 7μ; striae, 9–10 in 10μ.

    Rare.

According to Hustedt (1938–'39), the form occurs from alkalic to light acidic water in mountains.

12. *Stephanodiscus astraea* (Ehr.) Grun. var. *intermedia* Fricke

    Hustedt 1930, p. 110, Fig. 85

    Diameter, 23μ.

    Very rare (Fragments).

The form is found in every fresh water sediment in our country.

(4) Diatoms found in the muddy materials in a pool on Tengudaira is not large in number. The chief diatoms are as follows:

1. *Eunotia flallax* A. Cleve var. *lapponica* A. Cleve
    Text-figure 5, 1

    A. Cleve-Euler 1053, p. 100. Fig. 427 a-b

    Length, 43μ; breadth, 5μ.

    Common.

The form is especially common in mountains (acidophilous).

2. *Eunotia nymanniana* Grun. Syn., *E. exigua* (Bréb.) Rabh. var. *gibba* Hust.
    Text-figure 5, 2

    A. Cleve-Euler 1953, p. 108, Fig. 445 a-d

    Length, 60μ; breadth, 5μ.

The form is common in springs of mountains. According to Hustedt (1938–'39), its pH-values of water range from 4.8 to 7.7.

3. *Frustulia saxonica* Rabh. var. *leptocephala* (Östr.) A. Cleve
    Text-figure 5, 5, 6

    A. Cleve-Euler 1952, p. 8, Fig. 1327 c-e

    Length, 40–60μ; breadth, 12–17μ.

    Rare.

According to Hustedt (1938–'39), the form is common in streams and springs of the pH-values 4.8 to 7.7. Especially, this is a dominant form in humic acidic water with the pH-values under 7. A. Cleve-Euler (1953) shows that the form is common in fresh water or in such acidic ill-feeded water, as swamps and mossy places everywhere.

4. *Pinnularia viridis* (Nitzsch) Ehr. var. *rupestris* (Hantzsch) Cleve
    Text-figure 5, 3

    Rare. Already described in (3), 6.

5. *Pinnularia hemiptera* (Ktz.) Rabh.
    Text-figure 5, 4

Rare. Already described in (3), 2.

Ecological Notes

Species of diatom show in a broad way the natural enviroment of its habitat. A detailed report concerning to each species, recent or in fossil, is required for the interpretation of a geological occurrence in field, but it is still difficult to meet with one satisfying fully this requirement at present.

Some of species which were found in a certain area are of important in their ecological chracters. For example, *Pinnularia braunii* var. *amphicephala* is worth special mention.

The form is found in the sulphur-bearing muddy sediments and also in the water of this valley. The former belongs to a subfossil, and the latter to a recent in the same form. The sulpher-bearing materials are now settling on the bottom of this valley. This fact shows that the completed layers have also occurred in such a way in the near-Recent.

Pinnularia braunii var. *amphicephala* is prolific in the acidic waters of which the pH-values show about 4.5. Although the uppermost limit of the temperature of the origin of the Fusagi thermal spring is 78°C but the favorable limit for existence of the form seems to exist from 20 to 35°C.

Other species such as *Melosira islandica* and *Pinnularia superba* are found in mountains like other places of our and foreign countries. *Caloneis bacillum, Caloneis bacillum* var. *incostantissima, Eunotia septentrionalis* and *Stauroneis phoenicenteron* var. *intermedia* are respectively rare form in this valley, and the above two species of *Caloneis* sometimes known as indifferent and alkaliphilous.

Next problem is to show that whether the recent diatoms in Mikurigaike are independent or not with other organisms of such places as the Jigoku-valley and the pool on Tengu-daira.

Cymbella hebridica is a common form in Mikuriga-ike, and yet not small in general in lakes and brooks of mountains. *Pinnularia appendiculata* is found in all parts of our country, especially large in mountains. *Pinnularia hemiptera* occurs in the pH-values of water from 4 to 8 as well as those of *Pinnularia appendiculata.* These two species are common and large in number in Mikuriga-ike. *Pinnularia microstauron* is also found as a rare species, but the form as the above two species is one of dwellers in mountains. A few rare species such as *Eunotia suecica, Pinnularia viridis* var. *rupestris* are chracteristic in mountains, and the former is a Northern alpine type, and the latter common in acidic water. *Eunotia lunaris* occurs in a humic acidic milieu. *Pinnularia borealis* and *Pinnularia borealis* var. *brevicostata* are also recognized as a dweller in acidic water of mountains, but these species are rare forms in Mikuriga-ike. *Hantzschia amphioxys* and *Stauroneis anceps* are rare, but the former is most common in the water on alkalic soil.

Diatoms gathered from a pool on Tengu-daira contains two forms of the same kind found in Mikuriga-ike, that is, *Pinnularia hemiptera* and *Pinnularia viridis* var. *rupestris.* Each species is a rare form in this pool. As a common form, *Eunotia flallax* var.

lapponica generally occurs in mountains, and belongs to acidophilous. *Eunotia nymanniana* is a rare form in this pool, but known commonly in springs of mountains. *Frustulia saxonica* var. *leptocephala* is a chracteristic form found in acidic humic waters with pH-value under 7.

Generally speaking, diatoms found from all samples collected in this area chiefly belong to acidophilous, and a few to alkaliphilous. As a chracteristic leading form in the thermal spring of the Jigoku valley, *Pinnularia braunii* var. *amphicephala* is of importance. Next, *Pinnularia hemiptera* and *Pinnularia viridis* var. *rupestris* are only two common forms in the both waters of Mikuriga-ike and the pool of Tengu-daira.

Summary

Diatoms from the Jigoku valley and its neighbourhood are divided into four classes due to their geological and geographical occurrences. (1) Subfossil diatoms in the sulphur-bearing sediments. (2) Diatoms in the thermal spring. (3) Diatoms in the water of Mikuriga-ike (4) Diatoms in the water of a pool on Tengu-daira.

(1) and (2) have a deep connection with each other in their occurrences. As a chracteristic leading form found in the samples, *Pinnularia braunii* var. *amphicephala* is a very important form. (3) is a small crater lake, and (4) a small pool. The waters of (3) and (4) are of fresh, and the forms which was found in these waters are all recent. Acidophilous types are generally common, and some of them are also known as dwellers in mountains. *Pinnularia hemiptera* and *Pinnularia viridis* var. *rupestris* are only two common species in (3) and (4).

A problem lies in the Jigoku valley and its neighbourhood, but as far as I observe, there exists a fact that diatoms are not confused with each other in the two groups of habitas ((1), (2) and (3), (4)) of this area, and that rather a distinct boundary stands in the differences of the two natural enviroments. In conclusion, I may say that *Pinnularia braunii* var. *amphicephala* is common in some acidic mineral-water deposits such as sulphur, jarosite and limonite deposits distributed in our county.

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