The Subsurface Geological Structure of the Alluvial Plain of Muroran, Hokkaido

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Abstract

The general features of the Quaternary sediments and the post-Tertiary valleys buried in the Alluvial plain of Muroran based upon the data from the 94 bore holes, standard sounding tests and geoelectrical observations are summarized below.

1. The Quaternary sediments in the present area can be classified into six units: a-I, a-II, b, c, d-I and d-II, from the younger to the older.

2. a-I unit (Alluvium) consists of soil, clay, silt, fine and medium grained sand and peat which comprises the major part of this unit. The unit is 2–4 meters in thickness. The peat bed is 0.5–4 meters thick and occupies the larger part of the area.

3. a-II unit is the Alluvial river deposits and consists mainly of round or subround boulders and pebbles of andesite, 2–4 meters in thickness, and is distributed along the Washibetsu and Chiribetsu-rivers.

4. b unit, the major part of the Quaternary sediments in this area (Dilluvium?) consists mainly of pumiceous, fine and medium grained sand intercalated with silt layers containing semicarbonaceous matters and indeterminable shell fragments. The age of this unit may be Dilluvium judged from the subsurface stratigraphical features and the N value of the standard sounding test which exceeds 15. The maximum thickness exceeds 24.5 meters in the southern part of the present area, where, the lower limit was not confirmed at the depth of 30 meters from the ground surface.

5. c unit (Dilluvium?) consists mainly of clay and silt. It overlies the basement Tertiary formations with unconformity, and is conformable with b unit. The average thickness is 3–8 meters but attains 10.3 meters in maximum.

6. d-I and d-II units are the weathered part of the Dilluvial Washibetsu-dake agglomerate. The former unit consists mainly of pumiceous silt and the latter mainly of volcanic breccia. In the present area, these units, totaling 4–8 meters in average thickness are distributed in the northern hilly area.

7. One of the notable features of the subsurface relief of the upper bedding plane of the basement Tertiary in the present area is the Y shaped buried valley, the main branch of which extends in NE-SW direction along the Itanki-hama coastal line and opens to the Pacific Ocean. The height of the valley bottom is 20 meters below sea-level, and its depth from the ground surface exceeds 25 meters. Another feature is the subsurface flat plain situated between the two branches of Y shaped buried valley, here, the base of the valley is 0–10 meters in height, and its depth from the ground surface is 3–10 meters.

The pre-peat bed subsurface relief is much different from that of the basement Tertiary. The outstanding feature of this subsurface relief is the buried narrow ridge in the eastern part of this area extending in nearly N-S direction and the soft sediments (a-I unit) are less than one meter in thickness and distributed without the development of the peat-bed. Another feature is the broad subsurface flat plain in the northern part of this area, its average height is about one meter above sea-level, and its average depth is 1–2 meters from the ground surface.

INTRODUCTION

The importance of fundamental studies and surveys of the loose sediments forming the Alluvial flat plains of Muroran, Hokkaido is well known for the purposes of road building, railway construction and the establishment of industrial building site. However, there are very few data concerning the geotechnical works in the present area.

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The general geology of the Muroran area was reported by Sato and the present author in 1952, and in 1953, Osanai and Sako published a geological map of Muroran (scale, 1/50,000) with explanatory text and in the next year Saito, Osanai and Sako, reported on the general geology of the Noboribetsu-onsen in the explanatory text of the geological map of Japan (scale, 1/50,000).

Since a few years ago, the writer has been studying the subsurface geological structures, the distribution and characters of the underground water in the present area based on the subsurface data obtained from many boring works, geoelectrical observations and various sounding tests. In 1969, the present author and Shishido published a detail description of the geology and tectonics of the northeast area of Muroran City, and in the same year, the writer and Tsuzuki reported on the standard load test in the Itanki Alluvial flat area of Muroran City. The writer and his joint investigators made various laboratory experiments on the vertical stress concentration in the sand and clay materials obtained from the present area and reported on the influence of lower rigid base on normal stress (Sawada and Asahi, 1971 and 1972), the relationship between the settlement and thickness of the sand bed on a rigid base (Sawada and Hirano, 1972), and the characters of the soils composed of clay and sand by use of the oedometer (Sawada and Suzuki, 1972).

In this paper, the writer summarizes the subsurface geological structure and sequence of the Quaternary deposits, and also describes the post-Tertiary buried topographic features based upon the data obtained from the 94 bore holes, standard sounding tests and geoelectrical observations.

The writer is deeply indebted to and thanks Professor Kotori Hatai of the Institute of Geology and Paleontology, Tohoku University, who has been a constant source of encouragement and a guide in many ways. Thanks are also due to the members of the Public Works Section, Muroran City Office, Muroran Civil Engineering Works Office, Hokkaido Prefecture and Muroran District Construction Office, Hokkaido Development Bureau who kindly offered valuable subsurface data to his study.

**A VIEW OF THE TOPOGRAPHIC FEATURES OF THE PRESENT AREA AND ITS VICINITY**

The main part of the Muroran area is a hilly land, extending southwestward for some distance, and then curves toward northwest. At the southeast part of the area is Muroran bay, an embayment at the eastern side of Uchiura-wan (so-called volcanic bay). The peninsula is connected with the main land by a low alluvial flat. The main hilly part of the peninsula, divided into two blocks by a structural line trending N-S, is formed of the Neogene and Quaternary formations, the former accompanying pyroclastic and igneous rocks, which occur as extrusive and dykes. Topographically the axial ridge of the peninsula, about 100 meters above sea-level is close to the southern side with a rather gentle slope toward the north. The slope is dotted with monadnocks due to the resistance of igneous dykes reaching to the height of 80 to 90 meters above sea level.

As shown in Fig. 1, the eastern coastal line is simple and can be divided by the small capes of Itanki-misaki and Washibetsu-misaki into two parts, the Itanki-kita-hama and Itanki-minami-hama.

The average height of the Alluvial plain where the Muroran Peninsula and the main land are in contact is 2–7 meters above sea-level, and the maximum height of this plain in the area along the Washibetsu-gawa is about 100 meters above sea level, but it is 20 meters along the Chiribetsu-gawa.

The main streams in the present area are the Washibetsu-gawa and the Chiribetsu-gawa, the former is larger than the latter and both of them originate in the southern part of
Fig. 2. Explanation on bottom of p. 481.
Muroran-dake (911 meters) and flow southward to drain into the Pacific Ocean and the Muroran port.

The basement of Tertiary rocks surrounds this flat plain with cliffs or slopes of ten odd or scores of meters in height.

**SUMMARY OF THE BASEMENT FORMATIONS DISTRIBUTED AROUND THE PRESENT AREA**

The stratigraphical successions of the basement formations distributed in the present area and its vicinity are shown in the following table.

<table>
<thead>
<tr>
<th>Quaternary</th>
<th>Dilluvium</th>
<th>Terrace deposits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muroran-dake agglomerate</td>
<td>Washibetsu sand and gravel deposits</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Neogene Tertiary</th>
<th>Pliocene</th>
<th>Muroran Formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andesite Motowanishi sandstone shale member</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Washibetsu tuff member</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Muroran Formation

This formation consists of two members: the lower comprises tuff, tuff-breccia and sandstone, about 200 meters in thickness, and the upper of alternations of sandstone, shale and conglomerate and less amounts of pyroclastic sediments and volcanic rocks. The former is called the Washibetsu tuff member, and the latter the Motowanishi sandstone shale member by Saito and others (Saito, Osanai and Sako, 1954).

In this area the formation is about 230 meters in thickness and the base is not exposed. Although it is wholly lacking in fossil evidence, the age of this formation may be regarded to be Pliocene from the relation between this formation and the Horobetsu Forma-

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**Fig. 2.** General distribution of the basement formations around the Alluvial plain of Muroran.

**LEGEND**

- Alluvial deposits: sand, gravel, clay, volcanic ash
- Sand-dune deposits: sand
- River terrace deposits: sand, gravel, clay
- Lower terrace deposits: gravel, sand
- Middle terrace deposits: gravel, sand, volcanic ash, clay
- Muroran-dake agglomerate: tuffaceous agglomerate, agglomeratic mud lava
- Washibetsu sand and gravel deposits: sand, gravel, volcanic sand
- Andesite dyke: augite hyperthene andesite
- Motowanishi sandstone, shale alternation member: sandstone, shale, tuffaceous mudstone, tuff, tuff breccia
- Washibetsu tuff member: agglomerate, sandstone, tuff, tuff breccia
tion (Miocene) of tuff and tuff-breccia, their relation is an unconformity.

2. Washibetsu Sand and Gravel deposits

The type locality of this deposits is the sea cliff of Cape Washibetsu-misaki in Muroran City. In the present area it overlies the Motowanishi sandstone shale member of the Muroran Formation with unconformity, and is conformable with the Muroran-dake agglomerate. At the type locality it is about 12 meters in thickness and consists of coarse grained sand and round pebbles of Tertiary rocks.

3. Muroran-dake Agglomerate

This agglomerate is distributed in the southern foot-hill area of Muroran-dake and Washibetsu-dake, typically exposed at the sea cliff of Cape Washibetsu-misaki and the river cliff of the Washibetsu-gawa. This agglomerate lies upon the Washibetsu sand and gravel deposits with conformity and underlies various altitude Terrace deposits or Alluvial deposits. The thickness of this agglomerate is unknown.

This volcanic ejecta consist of mainly tuffaceous agglomerate and agglomeratic mud lava, and is intercalated with hypersthene andesite flow, tuff-breccia and pumiceous tuff. The tuffaceous agglomerate comprises breccia of augite andesite, sandstone, slate and green tuff cemented with porous andesite lava. The agglomeratic mud lava consists of augite and hypersthene andesite; the breccia range from ten to about 30 centimeters in diameter and is cemented with andesite mud lava.

THE QUATERNARY SEDIMENTS IN THE PRESENT AREA

The Quaternary sediments in the Muroran Alluvial plain based upon detailed examination of the cores from 94 wells drilled to a maximum depth of 30 meters and 14 geoelectrical data, can be subdivided into six lithostratigraphical units (named from the upper, a-I, a-II, b, c, d-I and d-II).

Figures 3-5 shows that these deposits fill the pre-Dilluvial buried valleys situated at 15-25 meters below sea-level, and the subsurface platform developed at 4-10 meters under sea-level, at the depth of 7-13 meters from the ground surface.

The notable features of these sediments is the distribution of a-II, d-I and d-II units which are limited to the northern area, the slope along the Washibetsu-gawa and the hilly flat plain, and it must be mentioned that a peat bed is distributed in the major part of the present area.

1. a-I unit

This uppermost unit consists of soil, clay, silt, fine and medium grained sand and peat, the latter of which comprises the major part of this unit. The thickness of this unit is less than 2 meters and the average thickness is 1-1.5 meters in the northern area, but in the southern area, its maximum thickness attains 5.6 meters and the average thickness is 2-4 meters.

The thickness of the peat bed which is divided into two layers by clay, silt and fine grained sand layers of from 50 centimeters to one meter in thickness, is influenced by the total thickness of a-I unit which is from 1 to 4 meters, and the depth from the ground surface is from 50 centimeters to 1.5 meters. This unit is not distributed in the northern area of Takasago-cho along the Washibetsu-gawa and Chiribetsu-cho along the Chiribetsu-gawa, and its northern limit is the east-west line through Miyanomori-cho by which the peat area is divided into two parts of the western peat area which is the major part of the present area and the eastern one; its northward extension was not confirmed by lack of subsurface data.
Fig. 3. Geological profiles of the Quaternary sediments. Full lines show the boring points.
①: basement formation (Tertiary). Horizontal scale: 1/10,000 Vertical scale: 1/1,000.
Fig. 4. Heights above sea-level of the upper bedding plane of the basement formations in meters (contour lines) and the boring (dots) points (○).
Fig. 5. Heights of the peat-bed lower bedding plane above sea-level in meters.
1. distribution of the peat bed
2. distribution of the basement formations
3. boring point
4. section line of geological profile AA’
2. a-II unit

This unit consists of alluvial river deposits and consists of mainly round and subround boulders of andesite from ten odd or scores of centimeters to 1.5 meters in diameter, and large round pebbles of several centimeters in diameter cemented with coarse grained sand. The distribution of this unit is limited to the area along the Washibetsu-gawa, and the thickness is 4 meters in maximum and 2 meters in average. It becomes thicker in the downstream (southeast) than at the upper course (northward), but is absent in the southern area of Hinode-cho and Chiribetsu-cho.

3. b unit

This unit consists of pumiceous fine and medium grained sand and volcanic ash intercalated with rounded granules and from 1–1.5 meters thick silt layers with subcarbonaceous organic matters and indeterminable shell fragments.

This distribution agrees with that of a-I unit, the major part of the present area. This unit comprises the major part of the Quaternary deposits in this area and the maximum thickness exceeds 24.5 meters in the southern area, Hinode-cho, Higashi-machi and Itanki minami-hama. Here, the lower plane of this unit was not confirmed to the depth of 30 meters from the ground surface, however, at the northern area it becomes thinner than at other parts, and measures less than one meter at Nakajima-cho, and thins out northward along the Washibetsu-gawa and Chiribetsu-gawa rivers.

4. c unit

This unit consists of mainly clay and silt intercalated with thin sand layers and is spattered with subcarbonaceous organic fragments in the upper part. The distribution of this unit is the same as b unit; the maximum thickness is 10.3 meters in the so-called Higashi-machi peat area, and at other areas 6–8 meters thick, but at Nakajima-cho it is less than 3 meters.

5. d-I and d-II units

These units are correlated with the Muroran-dake agglomerate. The d-I unit consists of mainly pumiceous silt (weathered fine volcanic ash of the Muroran-dake agglomerate) and its distribution is limited to the northern hilly area; the maximum thickness is 11.9 meters, but 4–8 meters in average. The d-II unit consists of mainly volcanic breccia and overlies the members of Muroran Formation in the northern hilly areas, but it lies without break upon the Washibetsu sand and gravel deposits at Cape Washibetsu-misaki, and it is conformable with d-I unit.

THE PRE-QUATERNARY BURIED VALLEY

In the present area, the boundary between the basement Tertiary formations and the Quaternary sediments is confirmed by many boring data, but it is difficult to certify the base of the alluvial sediments by the subsurface data. Therefore, the writer checked the depth from the ground surface of the lower bedding plane of the Quaternary sediments and its relief is shown in Fig. 4, and in Fig. 5 is shown that the depth from the ground surface of the lower bedding plane of the peat bed agrees with that of a-unit which is of very soft sediments and of bearing power less than 4 N.

1. The subsurface relief of the upper bedding plane of the basement Tertiary

Fig. 4 shows the thickness variation of the Quaternary deposits, namely the subsurface relief of the upper bedding plane of the basement Tertiary formations. By the
data obtained from many boring works and geoelectrical observations, the maximum depth of the basement surface exceeds 24.5 meters at Itanki-minami-hama. The notable features of the subsurface relief in the present area, are the buried valley courses on the northern side of Cape Washibetsu-misaki extending in NE-SW direction and opened to the Pacific Ocean, here the height of the plane is 20 meters below sea level, and the depth from the ground surface exceeds 25 meters.

The eastern branch of the Y-shaped valley diverges to the southern part of Higashi-machi, extending in SW-NE direction, passing Kotobuki-cho and Hinode-cho, and here, the base of this branch is about 10 meters below sea level, and about 13–15 meters in depth from the ground surface. The western branch runs in SE-NW direction and opens to the Muroran Port. In the northern part of Kotobuki-cho, the branch of the valley extends northward and is about 20 meters in height below sea level, and the maximum depth of the base is 24.5 meters from the ground surface, in the southern area of Miyanomori-cho, it forms a subsurface cliff of 20 meters in height.

The subsurface flat plain in the area from Nakajima-cho to Higashi-machi and between the two branches of the Y-shaped valley extends from sea level down to 10 meters below sea level, and the depth of the plain is 3–10 meters from the ground surface. The western extension of this subsurface relief is unknown because of the lack of data.

2. The pre-peat bed subsurface relief

The depth of the lower bedding plane of the uppermost soft sediments nearly agrees with that of the peat-bed, and the subsurface relief of this lower bedding plane is different from that of the basement.

The distribution of the peat bed is divided into three areas of western, middle and eastern by the narrow two subsurface ridges which extend in nearly NW-SE direction from Miyanomori-cho to Hinode-cho in the eastern part, and in the same direction from Nakajima-cho to Itanki-kita-hama in the western part of the area as shown in Fig. 5.

In the area where the subsurface ridge of the pre-peat bed is developed from Miyanomori-cho to Hinode-cho, ten odd or scores of centimeters or less than one meter thick soft sediments (a-I unit) are distributed without development of the peat-bed, and the a-I unit without peat and about 2 meters in thickness is distributed in the area from Nakajima-cho to Itanki-kita-hama.

These subsurface ridges, developed in nearly N-S direction, traverse the buried valley extending in SW-NE direction of the basement formations, in other words, in areas of the ridges and valley the thickness of the Quaternary sediments without soft and loose a-I unit is thicker than in other areas, and knowledge of the relief of the lower bedding plane of the pre-peat bed is important for the purpose of road building and establishment of industrial building-site.

The variations of the depth from the ground surface of the lower bedding plane of the peat-bed, its height above sea level and the thickness of the peat bed in the three peat areas are shown in the following table.

<table>
<thead>
<tr>
<th>peat-bed areas</th>
<th>eastern</th>
<th>middle</th>
<th>western</th>
</tr>
</thead>
<tbody>
<tr>
<td>average height above sea-level, in meter</td>
<td></td>
<td>0-1</td>
<td></td>
</tr>
<tr>
<td>depth from ground-surface, in meter, ( ): maximum</td>
<td>3-4 (4.6)</td>
<td>4-5 (5.7)</td>
<td></td>
</tr>
<tr>
<td>thickness of peat-bed, in meter, ( ): maximum</td>
<td>1-2 (4.0)</td>
<td></td>
<td>(2.7)</td>
</tr>
</tbody>
</table>
As shown in this table, the average height of the peat-bed base is 0–1 meters above sea-level and the average depth is 3–5 meters from the ground surface and it is deeper by only one meter in the eastern area than in the other areas, and the difference between the maximum depth in the eastern area and the other areas is also about one meter.

The peat distributed in these areas is 1–2 meters in average thickness and the maximum thickness is 2.7 meters in the eastern area and 4.0 meters in the other areas. These facts indicate that the eastern peat basin is rather small and deeper than the others.

REFERENCES


