ON THE SEDIMENTARY AND CONSERVATIVE ENVIRONMENT RELATED TO TECTONIC MOVEMENT OF KABASAWA FOSSIL PLACER DEPOSIT

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The factors which influence the depositional environment of fossil iron-sand placer deposits are the climate, tectonic regime, general palaeogeographic environments, peculiarities of the source area, and the hydro-dynamic conditions in the front basin. It is obvious that the deposition of fossil iron-sand placer deposit is controlled more or less by these factors.

The author (Saitoh, 1972) has reported on the general geology and tectonic movement near Kabasawa Mine area. The warping movement of Okubushi-Line which is the main tectonic line in this area controlled the differentiation and development of the Pliocene sedimentary basin and the deposition of Pliocene Sendai Group, especially Kabasawa sandstone and conglomerate member intercalated ilmenite placer deposit.

It is the purpose of this paper to point out the fact that Kabasawa ilmenite placer deposit has been built up and kept in a very good condition being controlled by the warping movement of Okubushi-Line.

CHARACTER AND BEHAVIOR OF OKUBUSHI-LINE

As previously pointed out in detail (Saitoh, 1972), the Okubushi-Line appeared to have played the leading role in the tectonic regime of this area in the Pliocene age.

This line, which forms a warping axis, is a tectonic one which reflects the fracture in the basement, and consists of two combinations of cross structure of NW and NE branches meeting at tangent angles to each other behind the Kabasawa Mine. It is the NW branch that was more active, and made such a warping movement as differential upheaval at the southwest side and tilting subsidence at the northeast side. The NE branch made only an additional slight movement.

The warping movement of the NW branch participates in the differentiation and development of the Pliocene sedimentary basin, and controls the deposition of Sendai Group within the basin. This branch apparently made a wide movement over each of the depositional stages of Kameoka, Tatsunokuchi, Kitayama (Kabasawa sandstone and conglomerate member) Formation and Hirosegawa tuff in the Pliocene age, and exerted a great influence on each deposition of these formations (Fig. 1).

After the beginning of the depositional stage of Kitayama Formation, the movements of NW branch, especially, were active concentrically around the point

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Fig. 1. Stratigraphic profile of Sendai Group near Kabasawa Placer Mine.
Fig. 2. Map showing the relation between the depositional place of Kabasawa sandstone and conglomerate member and Okubushi-Line.

intersecting with the NE branch, and thus made a "Kabasawa Warping" movement. That is, the hinterland occupied by Shirasawa Formation upheaved extraordinarily, and the front subsided greatly on a slant. Kabasawa sandstone and conglomerate member, a deltaic deposit, accumulated on this front basin (fig. 2).

Additionally, it can be inferred, from the fact that the sign of Kabasawa Warping had already appeared from the depositional stage of Kameoka to Tatsunokuchi Formations, that this wraping movement was an unusual tectonic movement caused by the fracture of the basement in the area (Fig. 1).

**KABASAWA ILMENITE PLACER DEPOSIT**

Summary of Placer Deposit: Kabasawa placer deposit is an intercalation lying just upon the basal conglomerate in Kabasawa sandstone and conglomerate member. The placer deposit consists of three ore-bodies: the main, first and second ore-bodies. Among these three, only the main body is composed of three ore beds of upper, middle and lower parts, with the upper part being the main ore bed. The upper ore bed of main ore body, the first and second ore-bodies locate on the same horizon. This shows that this ore bed and the two bodies are probably the depositional products of about the same period (Fig. 3).

All these ore-bodies elongate toward N 50°W, are pod-like, and arranged in parallel with each other. The elongations of the ore-bodies intersect diagonally with the general strike N15°E of the mother formation, and thus construct a so-called shoe-string formation (Rich, 1923). The strikes of the main and first ore-body indicate N10°E ~N30°W, and usually intersect diagonally with the direction of the elongation of the ore-body and the general strike of the
mother formation. Only the strike of the second ore-body, however, often conforms to the general strike of the mother formation. The scale and grade of each ore-body are as shown in Table 1.

Micro-cyclothem developing on the Placer Deposit:

The author and others have pointed out that a cyclic succession develops in a fossil iron-sand placer deposit (Onishi and Tomoda, 1962; Saitoh, 1965). Also in the Kabasawa placer deposit, a micro-cyclothem is found which repeats in the following order from the upper to lower part of the ilmenite ore beds:

3'. Cross-bedded ilmenite sand
1', 2' Conglomerate or conglomeratic coarse-grained sandstone
8. Compact fine-grained tuff (pisolitic, bearing fossil plants, rarely pumice tuff)
7. Mudstone or siltstone (intercalated drift-wood and fossil plants at the bottom part)
6. Ilmenite sand bearing tufaceous fine-grained sandstone (rarely alternation of thin clay and fine-grained sandstone)
5. Black massive ilmenite sand
4. Banded ilmenite sand
3. Cross-bedded ilmenite sand
2. Massive coarse-grained sandstone
1. Conglomerate (The basal conglomerate in Kabasawa sandstone and conglomerate member)

Table 1. The scale and grade of ore-bodies.

<table>
<thead>
<tr>
<th>ore-body</th>
<th>item</th>
<th>Length of ore-shoot (m)</th>
<th>Width (m)</th>
<th>Thickness (m)</th>
<th>ore grade (% TiO₂)</th>
</tr>
</thead>
<tbody>
<tr>
<td>main ore-body</td>
<td></td>
<td>200</td>
<td>30</td>
<td>2.0</td>
<td>20</td>
</tr>
<tr>
<td>1st ore-body</td>
<td></td>
<td>300</td>
<td>30</td>
<td>2.0</td>
<td>20</td>
</tr>
<tr>
<td>2nd ore-body</td>
<td></td>
<td>400</td>
<td>30-40</td>
<td>2.0</td>
<td>17</td>
</tr>
</tbody>
</table>

* Thickness means the width of excavation.
since its origin seems to be closely related to
the depositional mechanism of the ilmenite
placer deposit.

**THE DEPOSITION OF KABASAWA PLA-
CER DEPOSIT CONTROLLED BY THE
TECTONIC MOVEMENT OF OKUBUSHI-
LINE**

The author has pointed out that Plio-
cene Sokota fossil iron-sand placer deposit
of the Temmabayashi Mine, Aomori Prefec-
ture, is built up under the condition that the
deposit is controlled by “Sokota Warping”
(Saitoh, 1965). This warping is the tecto-
nic movement of the area, namely the
upheaval in the hinterland and the tilting
subsidence in the front basin. In the case
of Kabasawa placer deposit, it seems also
true that the deposit was built up under the
control of “Kabasawa Warping”. This is
very interesting in the meaning that it
suggests the origin of a fossil iron-sand
placer deposit.

At about the end of the depositional
stage of Tatsunokuchi Formation, the area
of Shirasawa Formation distributed all over
the Kabasawa Mine seems to have begun
to uplift to become land, and developed thick
weathered earth-crust there. It seems, with
the beginning of the Kabasawa Warping
movement early in the depositional stage
of Kitayama Formation, that the land
uplifted greatly, and that the products
due to weathering which constructed weath-
ered earth-crust were changed into detrital
materials by highly mechanical weathering.
The abundant erosive products, or the
detrital materials, began to flow into and
were carried by rivers, and were supplied to
the basin with tilting subsidence. Kabasawa
sandstone and conglomerate member might
be formed in the basin through such process.
The member is deltaic deposit, and the fact
that its lithology is composed of such coarse-
grained rock as sandstone and conglomerate,
reflects the violent upheaval facies of the
hinterland. It would be assumed that the
basin subsided on a slant and depressively.
The remarkable thickness of the member
also shows this is the case.

Botvinkina and Yablokov (1967) have
studied the deltaic deposits which originat-
ed, the coal-bearing formations of the Don-
etz Basin and the cupriferous sandstones in
the southern Urals, as follows: “These fossil
deltaic deposits are characteristic for the
regressive series of facies and develop main-
lly during the regressive stage of sedimenta-
tion cycles. This fully agrees with the
concept formulated by Samoilov (1952) for
recent deltas, that the sinking of the coast
hinders, and that uplift favours the forma-
tion of deltas in general and of its submerg-
ed beds in particular. The possibility is not
excluded that in a number of cases the lower
horizons of deltaic deposits begin to get
formed at the end of the transgressive stage.
This happens when uplifts are already tak-
ing place on the continent and abundant
quantities of detrital material begin to be
supplied to the basin by rivers”.

These studies support the author’s in-
sistence on the process of deposition of
Kabasawa sandstone and conglomerate
member; namely the chain of the following
geological phenomena occurred near Kaba-
sawa Mine during the period from the end
of the depositional stage of Tatsunokuchi For-
mation to the beginning of Kitayama Forma-
tion: the indication of uplifts near hinter-
land at the end of Tatsunokuchi deposi-
tional stage— the opening of Kabasawa
Warping movement— the creation of detrital
materials due to the upheaval of hinterland
— the formation of the front basin due to
tilting subsidence— the beginning of the
supply of detrital material to the basin by river—the deposition of deltaic deposit, Kabasawa sandstone and conglomerate member.

Further, it has been found that sedimentary deposit including iron-sand placer deposit are built up generally at the time when the supply of detrital material into rivers decreases, or when the tectonic condition of the area is inactive (Strakov, 1963). Kabasawa placer deposit, also, was probably the depositional product of the early stage when Kabasawa Warping movement was relatively inactive. The movement of Okubushi NW branch at the stage of formation of Kabasawa placer deposit seems to have once been keenly active, but soon resumed inactiveness, as is shown by the basal conglomerate of Kabasawa sandstone and conglomerate member. It seems that a faint fluctuation went on for a while during which small upheaval and subsidence appeared repeatedly. It is conceivable that Kabasawa placer deposit was formed under such environment, and that micro-cyclothem developing in the ilmenite placer deposit shows the comparative inactivity of tectonic condition or a faint fluctuation occurred a little while.

On the other hand, the state of the basin in the front mouth of the river reflects the inactive tectonic condition, and seems to have repeated such fluctuations as the invasion of sea on one occasion, and the appearance of land, lagoon or swamp on another occasion. Under such environment, the depth of the basin would be so shallow that it must have been very favorable for the development of barrier spit at the mouth of the river. The author infers that Kabasawa placer deposit is "the estuarine barrier spit type placer deposit" built up on the barrier spit thus grown up.

Compared with general seacoast, an estuary has topographically special features, and is a peculiar place where the violent exchange of the energy of land and sea takes place. The place possesses advantageous conditions for itself to become the ideal place for an iron-sand placer deposit to built up after concentration. In fact, many iron-sand placer deposits in the Philippines (Saitoh, 1969), and the recent seacoast iron-sand placer deposits distributed on the west coasts of the north island of New Zealand (Williams, 1965) belong to estuarine barrier spit type placer deposit, and demonstrate the fact that barrier spits near the mouth of rivers are the places where iron-sand placer deposits are grown up.

THE CONSERVATION OF KABASAWA PLACER DEPOSIT CONTROLLED BY THE TECTONIC MOVEMENT OF OKUBUSHI-LINE

In this country, many Pleistocene fossil iron-sand placer deposits (so-called "terrace iron-sand placer deposit") are distributed, in the coast of Eruptive Bays of Hokkaido and the Shimokita Peninsula, Aomori Prefecture, for example. But there are very few pre-Pleistocene fossil iron-sand placer deposits formed in the period from Palaeozoic up to Pliocene age in Neogene Tertiary. The reason would be that almost all pre-Pleistocene fossil iron-sand placer deposits were eroded away and extinguished because they had been land for a long period of geological time scale, while many Pleistocene fossil iron-sand placer deposits remained not eroded, because it had not been so long time after these deposits emerged on the land. It is easily conceivable that still existent pre-Pleistocene fossil iron-sand placer deposits saved from weathering were under some
special conservative environment.

As stated before, Kabasawa placer deposit was the depositional product in the period when Kabasawa Warping movement was of temporary slight fluctuation before its full-scale activity began. But this equilibrium was destroyed and the warping turned into real action soon after the placer deposit built up. The hinterland of the Kabasawa Mine upheaved with increasing violence, and the front basin subsided rapidly, though intermittently. Thus, much detrital material which came into the basin accumulated thickly on the upper part of the ilmenite placer deposit, and the deposit was buried deep in the ground. Subsequently, new sediments deposited on the upper part of the covered rock of the placer deposit, in the order of Hirosegawa tuff, Imozawagawa shell bed, and Doyabara Formation, and the placer was buried still deeper in the ground.

In connection with Quaternary Tectonic Group (1968), the present large topographic undulation of the Japan Island, above all one half to one third of the altitude of mountain regions, is said to have been caused by the crustal movement in Quaternary. The surrounding area of Kabasawa placer deposit must have become land with this violent upheaval in Quaternary, and then suffered from heavy weathering. It seems, however, that Kabasawa placer deposit has been preserved and survived as its upper part was protected with thick covered rock, though subject to heavy weathering since Quaternary.

In general, pre-Quaternary fossil iron-sand placer deposits distributed today probably received rapid tilting subsidence after accumulation, and were protected with covered rock which deposited on the deposit, so that they have been conserved, resisting weathering after they emerged on the surface of the ground. Both placer deposits of Kabasawa and Sokota at the Temmabayashi Mine, Aomori Prefecture, are excellent examples signifying the typical conservative environment of pre-Quaternary fossil iron-sand placer deposits.

Then, are there any placer deposits, among recent seacoast iron-sand placer deposits, that are to be preserved in the future as fossil iron-sand placer deposit for a long period of geological time scale? Generally, recent seacoast iron-sand placer deposits exist on the uplift seacoast, and are distributed under the dune behind the beach (outer beach type), or under the plain of the inland (inner beach type) (Hattori, 1960). This type of iron-sand placer deposit, however, will be eroded out sooner or later, and there will hardly be a possibility of these deposits being conserved as fossil iron-sand placer deposits in the future. Judging inductively from the preservation of pre-Quaternary fossil iron-sand placer deposits, the conservative conditions of iron-sand will be as follows: It is necessary that warping movement and rapid tilting subsidence take place soon after the deposition of recent seacoast iron-sand placer deposits, and the upper part of the deposits be protected with thick covered rock. Only the iron-sand placer deposits which build up on the place satisfying this condition must be conserved as fossil iron-sand placer deposit.

There may exist some recent seacoast iron-sand placer deposits which are now being build up under such conservative conditions, and which will be preserved for a long period in the future as fossil iron-sand placer deposits. But, as the present time is a very short moment of geological time, it will probably be impossible, granted that there does exist a deposit of this type, to decide...
whether a given iron-sand placer deposit of the recent deposits building up now will be conserved as a fossil iron-sand placer deposit under special tectonic conditions.

SUMMARY

Kabasawa ilmenite placer deposit is an intercalation lying just upon the basal conglomerate of Kabasawa sandstone and conglomerate member belong to Pliocene Sendai Group. The member is a deltaic deposit controlled and formed by the warping movement of the Okubushi NW, branch, “Kabasawa Warping,” which is the main tectonic line in this area.

Micro-cyclothem developing in Kabasawa placer deposit is supposed to have been formed by the interaction of the two factors of stratigraphic relationship and tectonic control (intermittent subsidence). Taking the origin of the micro-cyclothem into consideration as a cue, it is conceivable that Kabasawa placer deposit was formed in the early stage of Kabasawa Warping, while the movement was relatively inactive and small fluctuations were taking place.

Kabasawa Warping probably began its full-scale activity after the accumulation of Kabasawa placer deposit. The hinterland upheaved and the front basin subsided greatly on a slant. The abundant detrital materials produced with the upheaval flowed into the basin, and covered thickly the upper part of the placer deposit. It seems that, though this area upheaved violently in Quaternary, Kabasawa placer deposit has been saved from heavy weathering and has survived as its upper part was protected with thick covered rock.

While a number of Pleistocene fossil iron-sand placer deposits (terrace iron-sand placer deposits) are distributed in this country, there are very few pre-Quaternary fossil iron-sand placer deposits of the period from the Palaeozoic up to the Pliocene age in Neogene Tertiary. The reason would be that, while many Pleistocene fossil iron-sand placer deposits have been conserved because it was not long period that these deposits emerged on the land after its accumulation and were subject to relatively short-term weathering, almost all pre-Quaternary fossil iron-sand placer deposits were eroded out as they were exposed on the land for a long period. It is conceivable that still existent pre-Quaternary fossil iron-sand placer deposits are limited to those that were under the special conservative environment mentioned before.

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化石イルメネイト砂鉱床の形成および保存を規定する造景要素
——宮城県蒲沢鶴山周辺の地質鉱床——

齋藤 洋彦

蒲沢イルメネイト砂鉱床は、第三紀鮮新世の仙台層群に属する蒲沢砂礫岩層の、基底礫岩の直上部に挟在する。本部層は、地域の主要構造線である。奥武士 MW 分岐線の横曲運動（蒲沢横曲）に規定されて堆積した、三角洲堆積物である。蒲沢横曲運動は、その初期段階では、比較的静穏で小規模を保った期間があった。蒲沢砂鉱床は、このような時期に生成した、三角洲堆積物に関連のある堆積産物と推定される。砂鉱床には、発達する微堆積層の成立から、このような事実が読みとれる。

蒲沢砂鉱床形成の後、暫くして蒲沢横曲の本格的な運動が始まり、後背地の激しい隆起、前線水盆の著しい顕著沈降が起こった。かくして砂鉱床は、後背地の浸食産物である碎屑物と、更にその後引続いて堆積した後期鮮新統により厚く被覆されることになった。

第四紀に入って、鶴山周辺地域は著しく隆起したため、鶴化して、激しい浸食作用に曝された。しかしながら、蒲沢砂鉱床は、上部を厚く被覆する岩石により保護されており、削剥を免がれ、現在まで保存されていると考える。

わが国において、更新世段丘鉱床の数は、極めて多い。一方古生代から第三紀鮮新世に至る先第四紀化石砂鉱床の数は、激減する。この理由は、砂鉱床が海浜で堆積してから、陸上に出現した後、浸食作用に曝された期間の短縮に起因する。したがって、先第四紀化石砂鉱床は、「河口性砂礫型砂鉱床」に属し、蒲沢および青森県天城郡蒲沢町底田砂鉱床（鮮新世）にみられる如く、横曲運動に規定された、特殊な堆積および保存環境にあったものと推定される。