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# Offshore Detrital Heavy Minerals in Japan*

By

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## Brief historical outline of the use of heavy sands in Japan

Iron sands are the only heavy sand which have been used in Japan. Residual iron sands from granitic rocks and beach sands were used since the ancient times as raw materials for swords and other weapons. The use of these sands decreased considerably, however, with the introduction of modern iron production techniques about 80 years ago. After 1945, the development of steel making process by electric furnace which enabled large scale production of steel from iron sands together with the development of techniques for pelletizing powder ores stimulated the use of iron sands and pyrite cinder.

The Japanese Government initiated an exhaustive survey of iron sands in 1954. At that time, iron sand mining industry had already mined out the major high grade portions of iron sands of beaches and alluvial plains, and was about to begin prospecting and test mining of the iron sands in diluvium beds. And the development and survey of iron sands in very shallow seas were started at about that time.

In 1953, suction tests by sand pumps for offshore sands were carried out at Yamakawa Harbor of Kagoshima Prefecture and obtained 3.5 tons of high grade ores with 30 percent magnetic concentrates. Later, offshore drilling (1954) and geophysical prospecting (1955) methods were applied and offshore iron sands were prospected in various localities of Japan. The survey and mining operations are outlined in Table 1 and Figure 1.

## Occurrence of iron sands

The mineral composition of sands reflect the mineralogy of the source rocks. Thus sands abundant in useful minerals such as zircon, monazite, rutile, cassiterite and others all occur in areas with favorable source rocks. But in the case of Japan, such source rocks are scarce and the common ore minerals are magnetite, titanomagnetite, and ilmenite. These are believed to have come from intermediate rocks, mainly andesitic Quaternary volcanics.

The crude iron sands of Japan which are being mined contain small amounts of hematite, ilmenite, limonite, pyrite, native gold, chromite, together with rock forming minerals such as feldspars, quartz, pyroxenes, olivine, rutile, spinel,

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urvospinel, and rock and shell fragments. They usually contain 3-20 percent iron sand and in some areas, stringers with over 50 percent iron sands occur.

Data on the iron and titanium contents of the offshore iron sands are scarce, but the grade of the alluvial beach sands ranges from Fe 48 to 68 percent, $TiO_2$ 4 to 27 percent.

Chromite occurs in the beach sands in Hokkaido but they are not common, native gold occurs in minor amounts at Hazaki (Locality 6, Fig. 1), zircon and monazite are, in general, very scarce.

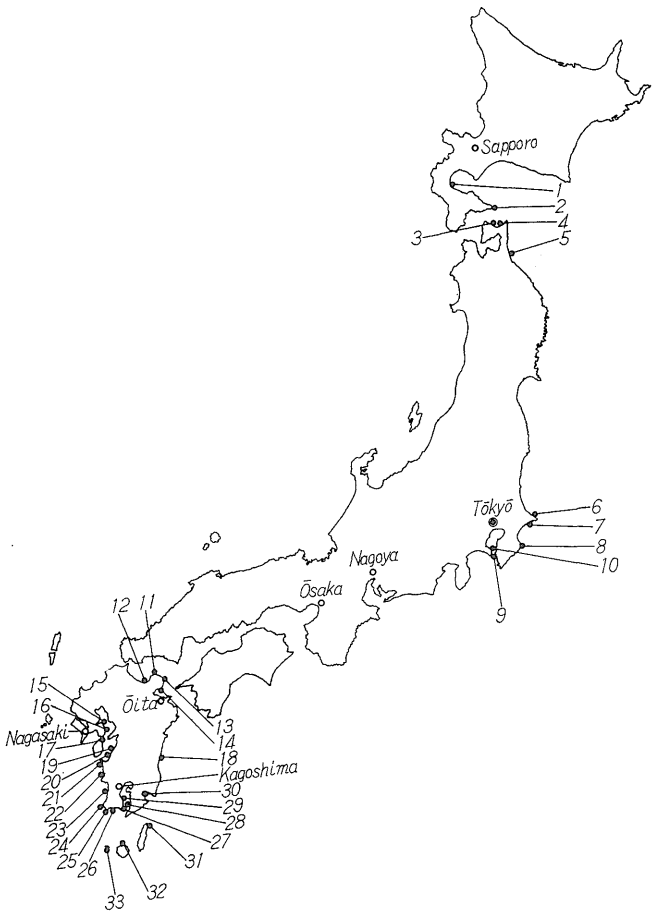


Fig. 1 Localities of offshore iron sands in Japan

1. Hokkaido, Southwestern Area of Funka Bay
2. Hokkaido, Shirikishinai-Kobui
3. Aomori Pref., Ohata Area
4. Aomori Pref., Noushi Area
5. Aomori Pref., Momoishi Area
6. Ibaraki Pref., Hazaki Area
7. Chiba Pref., Iioka Area, Chōshi Area
8. Chiba Pref., Ichinomiya-Ohara Area

9. Tokyo, Tokyo Bay
10. Tokyo, Uraga Strait Area
11. Oita Pref., Himeshima Area
12. Oita Pref., Nagasu Area
13. Oita Pref., Kunisaki Area
14. Oita Pref., Beppu Bay Area
15. Kumamoto Pref., Ariake Bay Area
16. Kumamoto Pref., Shimabara Bay Area
17. Kumamoto Pref., Hondo Area
18. Miyazaki Pref., Akae-Nada Area
19. Kagoshima Pref., Southern Area of Yatsushiro Bay
20. Kagoshima Pref., Nagashima Area
21. Kagoshima Pref., Akune Area
22. Kagoshima Pref., Sendai-Kushikino Area
23. Kagoshima Pref., Fukiage Area
24. Kagoshima Pref., Noma-Bonotsu Area
25. Kagoshima Pref., Makurazaki Area
26. Kagoshima Pref., Ei Area
27. Kagoshima Pref., Ibusuki-Yamakawa Area
28. Kagoshima Pref., Onejime Area
29. Kagoshima Pref., Kiire Area
30. Kagoshima Pref., Shibushi Bay Area
31. Kagoshima Pref., Tanegashima Area
32. Kagoshima Pref., Yakushima Area
33. Kagoshima Pref., Kuchinoerabu-jima Area

The distribution of offshore iron sand deposits is shown in Figure 1, several more localities would probably be added to this in the near future.

The following four mines recovered offshore iron sands in 1965.

1) Saeki Kogyo Co., Amakusa mine, Kumamoto Prefecture.
2) Toho-Kinzoku Co., Ibusuki mine, Kagoshima Prefecture.
3) 〃 Nejime mine, 〃 〃
4) 〃 Shinkai-Yamakawa mine, 〃

Amakusa mine ceased operations in 1966.

Table 1 Offshore iron sand operation in Japan

| Year | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| 1953 | 27 | prospect. | sand pump | 3－4 | | |
| 1954 | 27 | 〃 | 〃 | 5 | | |
| | 29 | 〃 | 〃 | <20 | 400×400 | 0.4－1.4 |
| 1955 | 27 | 〃 | sand pump, diver | | | |
| | 29 | 〃 | magnetic survey | | | |
| 1956 | 27 | mining | magnetic separator on ship | | | |
| | 12, 13 | prospect. | drilling | 6－12 | | |
| 1957 | 8 | 〃 | magnetic method | | | |
| 1958 | 7 | 〃 | 〃 | | | |
| 1959 | 6 | 〃 | 〃 | | | |
| 1960 | 27, 28, 1 | 〃 | 〃 | | | |

Tab. 1 cont.

| Year | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| 1960 | 13, 11 | prospect. | magnetic survey, dredging, diver | 3.5–40 | | 0.7–0.8 |
| | 28 | mining | | | | |
| | 6, 7, 9, 10 | test mining and prospect. | sand pump | | | |
| | 27 | prospect. | | | | |
| 1961 | 5 | 〃 | magnetic survey | | | |
| | 11, 12, 13 | 〃 | sampling by dredge | | 1,000×1,000 | |
| | 14 | 〃 | magnetic, sampling, dressing test | 3–30 | | |
| | 14 | mining | | | | |
| | 15 | prospect. | magnetic, sampling | | | |
| | 18 | 〃 | magnetic survey | 2.5–30 | | |
| | 22 | 〃 | dredging | <40 | 500×500 | |
| | 28 | 〃 | drilling | | | |
| 1962 | 10 | 〃 | sampling | <40 | 500×250 | <1.5 |
| | 19, 20, 24, 25 26, 30, 31 | 〃 | dredging | 30–50 | 500×500 | |
| | 23, 27, 29 | 〃 | sand pump | 10–30 | | 2–5 |
| | 28 | mining | sand pump and diver | | | |
| | 33 | prospect. | dredging | <40 | 200×200 | |
| | 2 | 〃 | sand pump and diver | | 100×100 | |
| | 15 | test mining | | | | |
| 1962 | 16 | prospect. | sampling | | | |
| 1963 | 10 | 〃 | drilling, underwater TV | <35 | | |
| | 16 | test mining | | | | |
| | 21, 32, 3, 4 | prospect. | sand pump and diver | | 200×200 | |
| | 13 | 〃 | dredging | <50 | 500×250 | 0.75 |
| 1964 | 3, 4, 5, | 〃 | sand pump | 10–30 | | |
| | 1 | 〃 | dredging | 10 | | |
| | 2 | 〃 | sand pump | | | |
| | 13 | 〃 | dredging, rotary drilling | <50 | 500×250 | 0.75 |
| 1965 | 1 | 〃 | dredging, drilling, sparker | | | |
| 1966 | 1 | 〃 | 〃 | | | |

(1) Locality shown in Fig. 1
(2) Objective of survey (prospecting or mining)
(3) Method used (4) Water depth (m)
(5) Sampling or test point grid interval (m)
(6) Sampled depth under sea bottom (m)

## Mining methods of offshore iron sands

Research work on the methods of mining offshore iron sands was started in 1954. At first, separators were set on shore with suction pipes in the sea water, but later, sand pumps and magnetic separators have been equipped on vessels (about 100 tons) for these operations. The flow sheet of the operation is laid out in Figure 2. It is now possible to mine sands under water depths of up to 30 m.

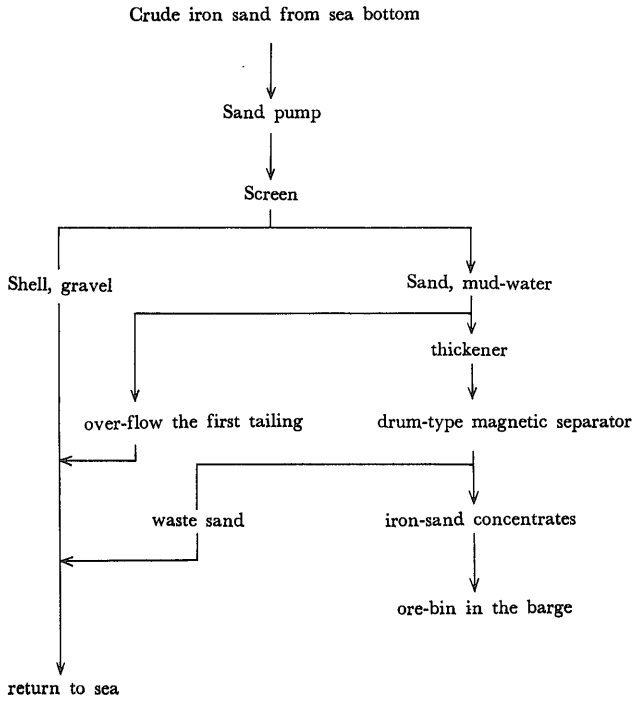


Fig. 2 Flow-sheet of iron sand separation on mining barges

An example of a mining vessel used for offshore iron sand mining by Toho-Kogyo Co. is shown in Figure 3.

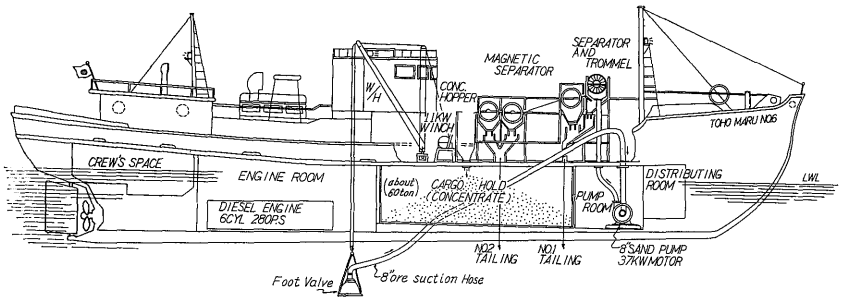


Fig. 3 The mining facilities of "Tohomaru No. 6"

The details of "Tohomaru No. 6", Toho-Kogyo Co.

Iron sand ores are pumped up together with sea water by a sand pump equipped with a special foot-valve. These ores pass through a trommel which removes gravel, shells and other material. The crude ore is then fed into the magnetic concentrator.

1. The vessel.
   Dimensions ; 89.37 t., 26.3 m long, 5 m wide, steel hull.
   Engine ; Diesel engine 6 cyl., 280 HP
2. Mining equipment.
   Sand pump ; NS–B 8″ 37 kW.
   Suction and delivery ; 8″
   Foot-valve ; Toho Co.
3. Concentration equipment.
   Concentrator ; TY–8 wet 3 drums, permanent magnet.
   Trommel ; steel bars 1.8 m long, inlet 0.3 m diameter, outlet 0.6 m diameter.
4. Generator.
   3 PH., AC., 220 V, 100 KVA.

Mining capacity

1. Amount of ore treatment.
   Iron sand ore ; 20,000 t/month
   MP ; 5% (MP : wet percent, standard grade magnetic concentrate to ore).
2. Amount of product.
   Iron sand concentrates ; 1,000 t/month, Fe 56%.

## Prospecting methods for offshore iron sands

### Drilling methods

Percussion drilling, rotary drilling, pump suction and other methods have been used for determining the columnar section of the sediments. Recently, sand pump vessels are used for this purpose, it is possible to determine the conditions of the iron sand deposition for 3–4 meters in thickness under 20 meters of water with this method and data useful for the mining operation can be obtained at the same time.

**Geophysical prospecting methods**

Geophysical prospecting methods used for iron sand deposits are magnetic and sonic methods. Proton magnetometer is used for the magnetic prospecting and sparker, sonoprobe, and other equipment are used for sonic prospecting.

**An example of offshore iron sand prospecting**

Prospecting for iron sands was carried out in 1966 at Funka-wan (Crater Bay) in southwest Hokkaido (Locality 1, Fig. 1) using all available methods. The area surveyed was in water depth range of 10–25 m and was 20 km in north-south direction (parallel to the shore line) and 1.5 km in east-west direction. Cores were obtained for depths of up to 3.0 m under the sea bottom (average 2.0 m). The grade of iron sand by magnetic separator was 1–21 percent and the average was 2.5 percent.

The results of this survey showed that minable deposits with over 3 percent iron sand by magnetic separators were in lense shaped bodies of 1.5–2.0 km north-south, 500–1,000 m east-west, and 1.5–2 m thick. Ten such bodies were discovered and each body is calculated to have reserves of approximately 120,000 tons of iron sand concentrates.

Areas of this bay in shallower water than 10 m and the northern and southern parts are not yet surveyed, and there are good possibilities of further discovery of large iron sand reserves in this bay.

## Production

The production of iron sands in Japan during the period of 1956–1966 is shown in Table 2. The production has not shown increase since 1960, and its fluctuation is considerable. But the ratio of the offshore iron sands to the total iron production is increasing and it is believed that it will constitute considerable portion of the total iron sand production in the future.

The development of engineering techniques concerning offshore mining operations is the most important factor for the exploitation of offshore iron sands in Japan.

The writers are indebted to Toho-Kogyo Co., for kindly offering data used in this report.

Table 2 Production of offshore iron sand concentrates in Japan
1955～1966

| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|
| 1955 | 967 | 56.1 | 25.6 | — | — | — |
| 1956 | 967 | 56.9 | 22.1 | 0.5 | 0.05 | 1 |
| 1957 | 1,142 | 56.0 | 17.3 | 0.7 | 0.06 | 1 |
| 1958 | 955 | 56.9 | 14.3 | 4 | 0.4 | 1 |
| 1959 | 1,357 | 56.7 | 13.5 | 8 | 0.6 | 1 |
| 1960 | 1,751 | 56.3 | 13 | 2 | 0.1 | 2 |
| 1961 | 1,712 | 56.6 | 12.9 | 32 | 1.9 | 4 |
| 1962 | 1,443 | 57 | 12 | 40 | 2.8 | 4 |
| 1963 | 1,295 | 57 | 13 | 33 | 2.5 | 3 |
| 1964 | 1,425 | 56 | 11 | 39 | 2.7 | 4 |
| 1965 | 1,389 | 56 | 11 | 47 | 3.4 | 4 |
| 1966 | 1,289 | 57 | 10 | 41 | 3.2 | 3 |

(1) Year
(2) Total production of iron sand concentrate in Japan (1,000 tons)
(3) Fe content of concentrates (%)
(4) Fe content of crude ore (%)
(5) Production of offshore iron sands (1,000 tons)
(6) Percentage of offshore iron sand to total iron sand production
(7) Numbers of operating mines

## 要　旨

わが国の海底重砂は磁鉄鉱・含チタン磁鉄鉱・チタン鉄鉱（これらを総称して砂鉄と呼んでいる）に富み，その他のものは量的に少ない。海底砂は3～20％，ときに50％の砂鉄を含有する。海底砂から砂鉄を回収しているのは，鹿児島県3，熊本県1（1966年には鹿児島3）で全砂鉄生産量の3.2％（1966）である。第1図，第1表に日本の海底砂鉄の調査地・調査方法，第2図　海底砂鉄採取船における系統図，第3図　海底砂鉄採取船の一例，第2表に1955～1966年の砂鉄の生産量を示してある。