# II-9. GEOPHYSICAL PRELIMINARY SURVEY OF KAGOSHIMA BAY

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## Introduction

In Kagoshima Bay, preliminary geophysical surveys of gravity, magnetics and seismic profiling were made. The gravity measurement was carried out over 120 km covered in this cruise and compiled with other onboard gravity data and land gravity recorded by YOKOYAMA (1961). The magnetic data was used as an auxiliary in order to aid interpretation, because it is already compiled and published by MATSUZAKI *et al.* (1966) and YOSHIKAWA *et al.* (1973). The subbottom profile was used throughout the cruise. The airgun seismic profiling was applied over 39 km in the northern part of Kagoshima Bay, which is characterized by the Aira Caldera, over 67 km in the middle part of Kakoshima Bay, which has a graben structure and in the southern part of the bay, also characterized by the Ata Caldera. Fig. II-9-1 shows the airgun traverse tracks.

## Gravity Anomalies

Gravity anomalies are calculated as a Bouguer reduction assuming a rock density of 2.4 g/cm$^3$ (YOKOYAMA, 1961). The results of the gravity survey are shown in Fig. II-9-2. The most notable features of the gravity data are as follows.

1) A low gravity anomaly is observed in the center of the northern part of Kagoshima Bay with a minimum value of $-25$ mgal. The relative gravity value for the adjacent area is about $-35$ mgal.

Considering the large absorption of the explosion seismic waves recorded by ITO *et al.* (1975), the low gravity anomaly suggests presence of a magma reservoir beneath the center of the Aira Caldera.

2) A low gravity anomaly is present along the deepest axis of topography in the centeral area of Kagoshima Bay. The relative value is some $-40$ mgal, and the axis of low gravity is the direction of about N10°W. A graben-type structure is assumed to exist which agrees with the geological and gravity data.

3) The iso-gal map of the Ata Caldera shows the presence of a minimum value $-12$ mgal SE of Yamakawa Harbour, the center of the Caldera according to MATSUMOTO (1943). The relative value of this minimum is about $-40$ mgal, which is a large negative anomaly in comparison with those recorded from other Japanese calderas.

The negative anomaly is not closed in the inside of the caldera, as the north branch extends and connects to the minimum axis of the graben and the southwest one connects with the negative anomaly outside of the Kagoshima Bay area.

4) In the SW area of Kagoshima Bay a low gravity anomaly is present. The center of this low anomaly is $+4$ mgal, and the relative value is about $-25$ mgal. The area of this anomaly is larger than that of the Ata Caldera, although the gravity gradients of the circumference are smaller.

5) A high gravity anomaly $+50$ mgal lied around Cape Sata-Misaki of the Osumi

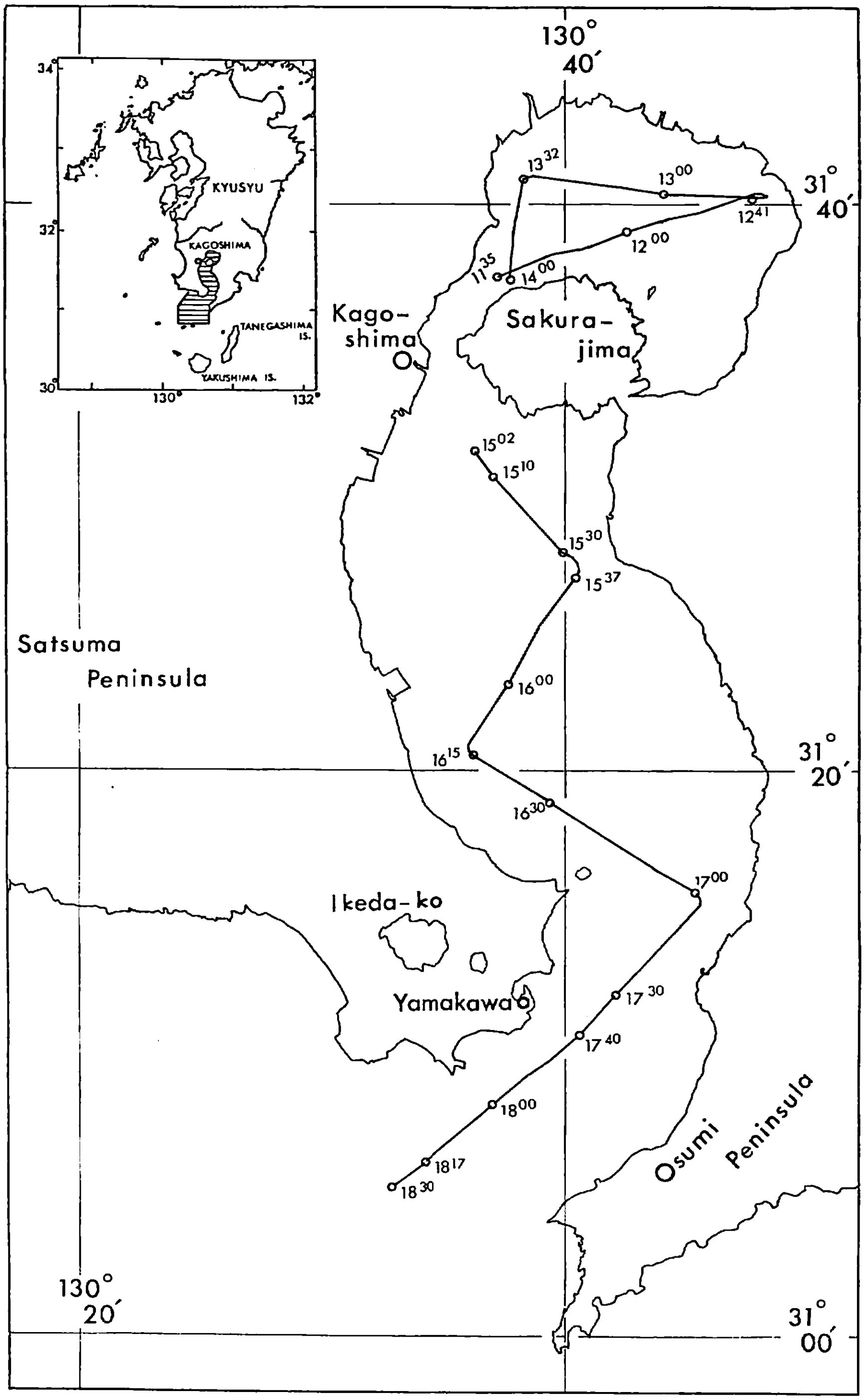


Fig. II-9-1 The traverse in Kagoshima Bay.

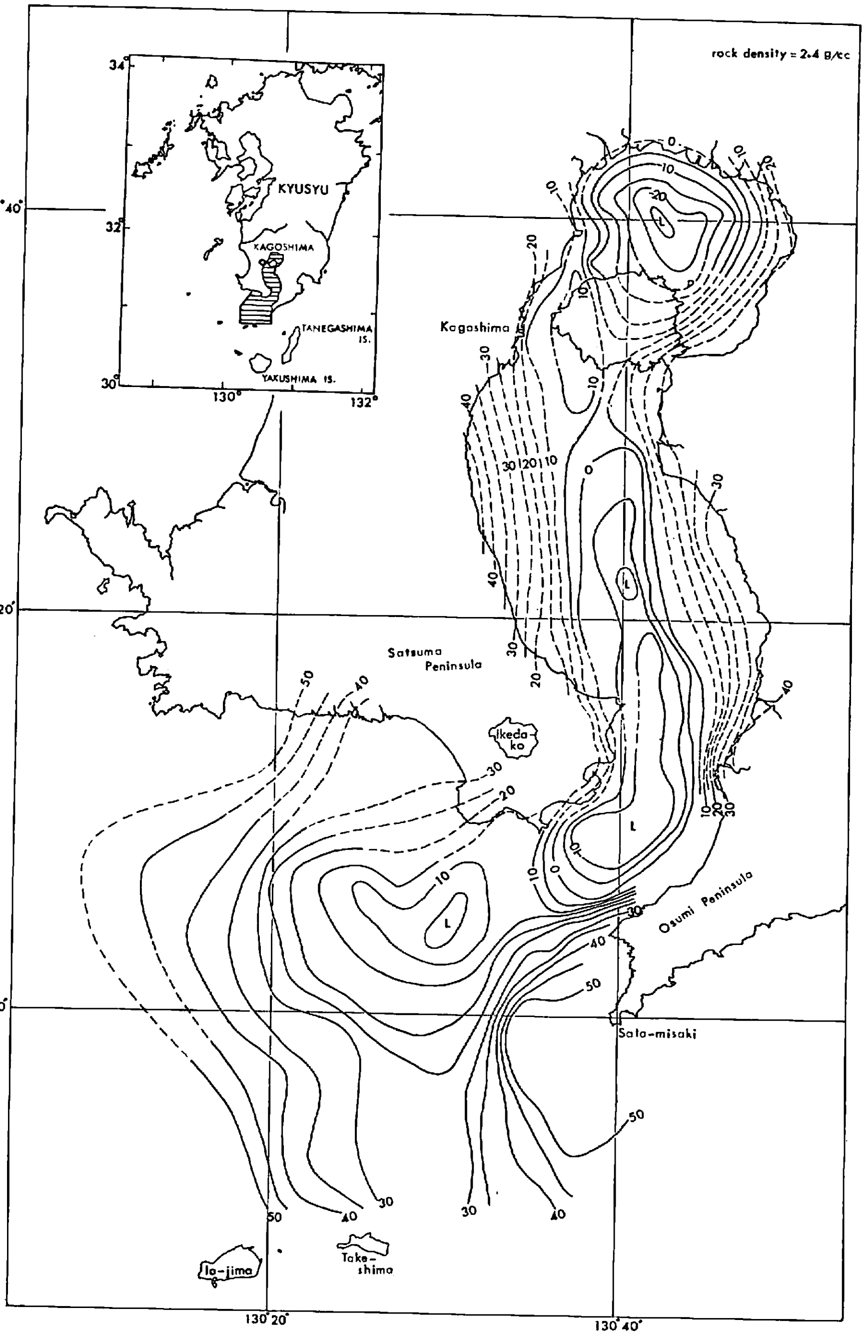


Fig. II-9-2 Bouguer anomaly of Kagoshima Bay.
The rock density used for the Bouguer reduction is assumed to be 2.4 g/cm$^3$. For the compilation of this iso-gal map the writers used data from this survey, data from other cruises and on-shore gravity data by YOKOYAMA (1961).

peninsula, where the Shimanto Formation is deposited.

**Aira Caldera**

The NE part of Aira Caldera consists of the Wakamiko Caldera (KUWASHIRO, 1969) which is considered to be the source of pyroclastic flows. The subbottom profiler record shows the profile of the Wakamiko Caldera. Fig. II–9–3 illustrates the subbottom profiler record and Fig. II–9–4 illustrated the section. The average depth of the Caldera bottom (B) is about 200 m, and the highest point on the surrounding ridge (T) is 136 m. The shoulder of the caldera wall (K) is 150m. Therefore, the specific depth of the Caldera

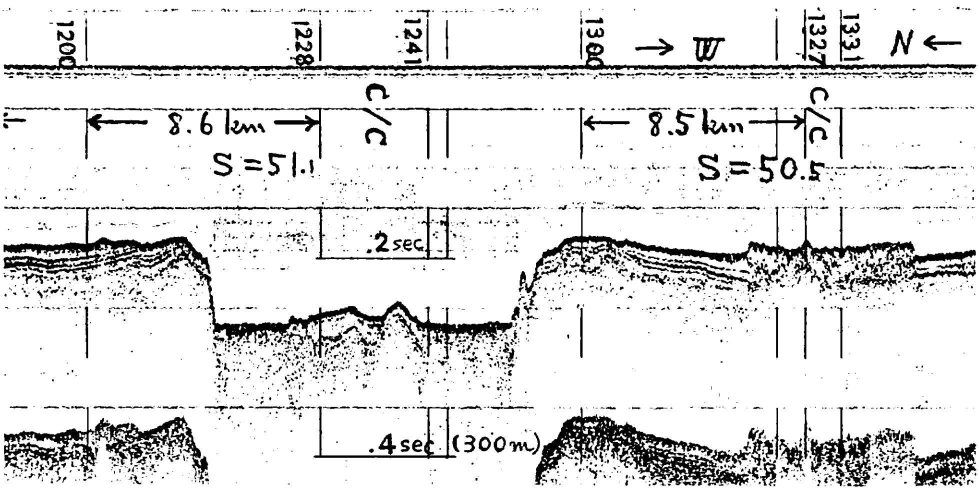


Fig. II–9–3 The subbottom profiler record.
The pulse width is 50 m-sec. The transmitting wave is FM modulated between 2.5 to 5 kHz. The CESP (correlation echo sounder processor) is applied.

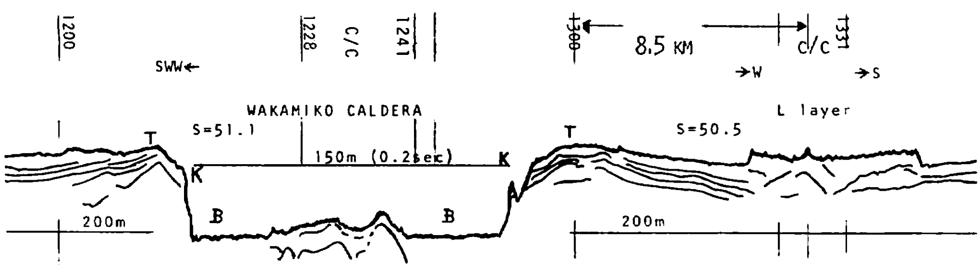


Fig. II–9–4 The time section of Aira Caldera by the subbottom profiler. Showing the Wakamiko Caldera and L layer. The vertical to horizontal scale ratio is 50.5, and c/c means course change. The marginal bottom of the Wakamiko Caldera (B) is about 200 m, and the average dip angle of the wall is 9.°3 The L layer has 9 to 10 m of specific height around the circumference. The surface of the L layer is fairly rough.

bottom is 65 m for (T) and 53 m for (K). The apparent angle of the wall slope of the Wakamiko Caldera is 9.°3 on the SW traverse. Although the record shows a very steep wall for the large vertical to horizontal scale ratio of 51, the caldera's actual shape has the appearance of tray. The Aburatsubo central cone is located at the center of the Wakamiko Caldera, and a subbottom central cone is observed under the topographic central cone. The margin bottom (B) is flat and lies at about 200 m, and the sea bottom has a strong reflection. Here, there is no reflection beds below the surface and therefore may consist of different material from that of the cone. On the outside of the Wakamiko Caldera (T), the highest point is that mentioned above. On the westward traverse four reflection beds are observed. If these beds are pyroclastics, such reflections may not represent different eruptions because one eruption may comprise several layers. The topography slopes deeper westward by 2.5 m-rad (milli-radian) as do the reflection beds i.e., the first layer by 3.2 m-rad, the second by 3.7 m-rad, the third by 3.8 m-rad while the fourth is poorly defined. The lower layers have 30 to 50 percent larger slope angles.

The airgun record shows deeper reflection layers, and they have the same tendency. An example is that of 13h 20 m where the sea bottom at 148 m dips westward by 2.6 m-rad. The reflection bed at 176 m dips by 3.5 m-rad and that at 793 m by 16.2 m-rad.

In the northwest part of the Aira Caldera a distinctive sea bottom reflection is observed, tentatively named the L layer. The characteristics of the L layer are

1) It is topographically higher by some 10 m from the surrounding layers.
2) The surface has about 5 m of relief. The L layer does not connect with the Mt.

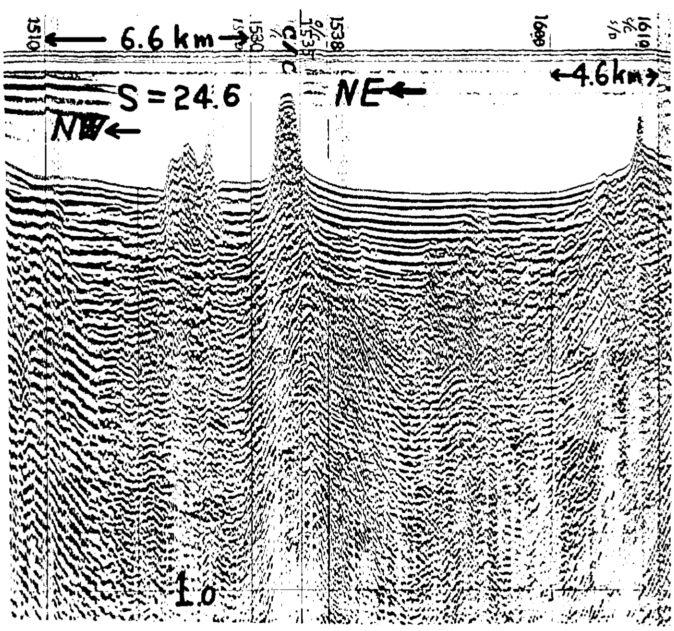


Fig. II–9–5 The airgun seismic profiling record of the middle part of Kagoshima Bay. The airgun is single and 40 cubic inch in volume, with 1300 pounds per square inch in pressure. The pop interval is 4 sec. The receiver is 50 m hydrostreamer of 100 elements for one channel. The filter is 50 to 160 Hz.

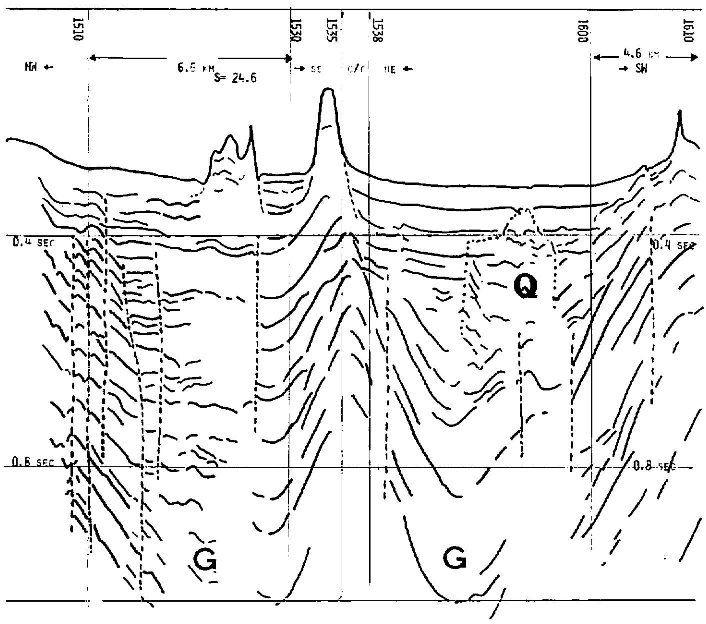


Fig. II–9–6 The time section of the airgun in the middle part of Kagoshima Bay. The left half shows the section of the graben from NW to SE. After course change (c/c) the airgun line crossed the graben again NE to SW. The vertical to horizontal scale ratio is about 25, assuming sound velocity as water. Both sections show the grabens of which the centers are denoted G, and they are subsided in centers and their sides are bordered by normal faults. The dip angles of the deeper layers increase with depth. The portion denoted Q has disturbed reflections and its topography is undulating a little.

Sakurajima volcano and is not considered to be a recent sedimentary deposition layer. It is composed of very young material, probably younger than Ito pyroclastic flow of 23 k-year B.P. If uplift has not been large, the L layer might be formed on the sea bottom without relation to the eustatic change of sea level.

**The Middle Part of Kagoshima Bay**

The airgun traverse begins from the south of Sakurajima Volcano 15 h 02 m to the SE. Running 10 km in 35 min, the traverse turns SW at the 1537 marking c/c on the time section and runs 14 km up to 1610. Fig. II–9–5 shows the airgun record along this line, and Fig. II–9–6 shows this time section. Two G mean the center of the graben, and Q is a problem part. The traverse twice crosses the middle part of Kagoshima Bay. On the left crossing of the bay, five faults were observed on the west side and one fault on the east side. All of them show that the central part (G) has subsided and that the faults are normal. These features indicate that the middle part of Kagoshima Bay has the form of a graben. The fourth fault from the NW is very gentle with an apparent fault plane angle of 28.4°. Under an assumed velocity of 2.0 km/sec the true angle is 33.3°. In general, with increasing depth the dip angle of the layer increase. For example on 1532 a good reflection bed at 374 m dips NW at 5.4° and a moderate reflection bed at 617 m dips at 6.2° using 2.0 km/sec as the average velocity. It is suggested that the graben has been subsiding continuously contemporaneous with deposition.

The portion denoted as Q has disturbed reflections which may, in part, be affected by topography. It appears to be on intrusion, although the magnetic data of YOSHIKAWA (1973) shows anomaly quiet the adjacent area.

### Ata Caldera

The subbottom profiler only weakly records the bottom sediments in the Ata Caldera except in topographic depressions where up to 13 m thickness of sediment are present. The western half of the caldera around Ibusuki and Mt. Kaimon-dake is buried and emergent. The eastern half comprises the sea bottom and is topographically higher than both the central and western periphery of the Bay. The sea bottom mainly consists of outcrops of thin, coarse sediment. The geological structure revealed by the airgun profiling is complicated by disturbances. The time section of the airgun is illustrated in Fig. II–9–7. The observing point 1736, written as C, where, east of Yamakawa Harbour, may be the center of Ata Caldera. Both the SW and NE flanks are bordered by faults in places, the 1801 on SW side and 1725 on the NE side. The special features of the beds are the strong reflections, which are short, and disturbed. These features are different from those in the Aira Caldera although they have almost the same tendency as those of the deeper reflection beds with steeper angle of dip.

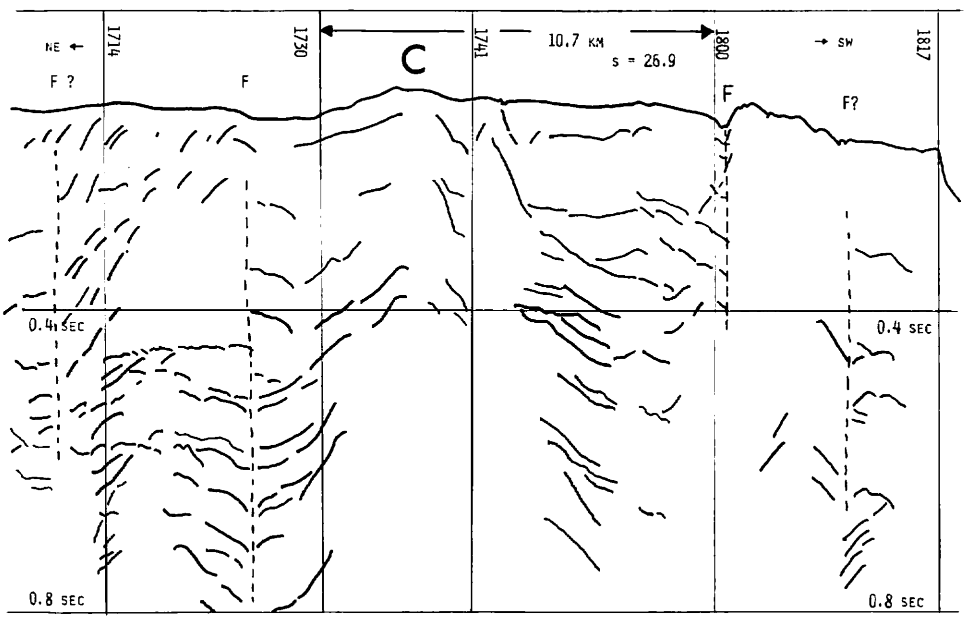


Fig. II–9–7 The time section of the airgun across Ata Caldera, NE to SW. C is the center of the Ata Caldera, east of Yamakawa Harbour. The reflection beds dip down from both sides of C, and they are bordered by faults (F).

**Comparison between the Aira Caldera and Ata Caldera**

The Aira Caldera and Ata Caldera are separated by only 60 km, and are aligned on the volcanic belt of south Kyushu. However, their geological and geophysical features are somewhat different.

1) The topography of the Aira Caldera is generally deeper than the surroundings relief. That of the Ata Caldera is shallower, i.e., the west half of the caldera is buried and emerged and the east half is shallower than both the graben the northern side and that outside of Kagoshima Bay to the west side.

2) In the Aira Caldera the presumed vent of pyroclastic flows is the Wakamiko Caldera, which remains topographically as the crater and central cone. Reflection beds are present beneath the bottom of the Wakamiko Caldera. The vent of the Ata Caldera cannot be observed or even located in the current survey.

3) In the central part of the NW part of Aira Caldera three reflection beds are observed, which are flat and continuous with a thickness of some 20 m. The topography of Ata Caldera is complicated and coarse material covers the caldera bottom. Sediments are only deposited in the concaved area.

4) The airgun record of Aira Caldera shows almost flat and continuous reflection beds up to 0.8 sec in thickness, with a dip of less than 0.9°. With the Ata Caldera the reflection pattern of the beds changes rapidly and they have up to 5°.

5) The low gravity anomaly of the Aira Caldera has its center on the center of the caldera, and iso-gal contours are concentric. Although the lowest gravity anomalies are on the center of the caldera, their contour shape is different from that of the caldera. One of the branches of the low anomaly axis extends north and coincides with the low axis of the graben of the middle part of Kagoshima Bay. Another branch extends SW and connects with the low anomaly of the region outside of Kagoshima Bay.