A Gravity Database of Southwest Japan: Application to Bouguer Gravity Imaging in Kyushu District, Southwest Japan

R. Shichi

College of Engineering, Chubu University, Kasugai, Aichi 487-8501, Japan

A. Yamamoto

Graduate School of Science, Hokkaido University, N10S8, Kita-ku, Sapporo 060-0810, Japan

T. Kudo

Tono Geoscience Center, Japan Nuclear Cycle Development Institute, 1-63, Yamanouchi, Akeyo, Mizunami 509-6132, Japan

Y. Murata, K. Nawa, M. Komazawa

The Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, Tsukuba Central 7, 1-1, Higashi 1-Chome Tsukuba, Ibaraki 305-8567, Japan

M. Nakada

Graduate School of Science, Kyshu University, 6-10-1 Hakozaki, Fukuoka 812-8581, Japan

H. Miyamachi

Faculty of Science, Kagoshima University, 1-21-35 Korimoto, Kagoshima 890-0065, Japan

H. Komuro

Interdisciplinary Faculty of Science and Engineering, Shimane University, 1060 Nishikawatsu, Matsue 690-8504, Japan

Y. Fukuda, T. Higashi, Y. Yusa

Graduate School of Science, Kyoto University, Kyoto 606-8502, JAPAN

I. Nakagawa

Daiichi Fukken Engineering Co., Ltd., 3-5-28 Fukuokaeki-minami, Fukuoka 812-0016, Japan

H. Watanabe, J. Oikawa

Earthquake Research Institute, University of Tokyo, 1-1-1 Yayoi, Bunkyo-ku, Tokyo 113-0032, Japan

S. Kobayashi
Space and Earth Information Technology, School of Engineering, Kyushu Tokai University, Kumamoto 865-8652, Japan

I. Ohno
Department of Earth Sciences, Faculty of Science, Ehime University, 10-13, Dogo-Himata, Matsuyama 790-8577, Japan

Abstract. In order to investigate subsurface density structures with the highest precision, two major gravity databases and some unpublished data files, which cover Southwest Japan, are recompiled. This paper presents some examples of the detailed gravity anomaly maps in Kyushu District, southwest Japan. These maps indicate various fine subsurface structures, which may arose with tectonic movements and/or volcanic activities of this region. With an aid of geological and topographical information, we discussed relationships between characteristic patterns of the detailed gravity anomalies and subsurface structures in this region. The most conspicuous feature is an existence of a steep horizontal gradient zone of gravity anomalies running through the Aso Caldera in the ENE-WSW direction. Although the location of the westward extension of the Median Tectonic Line (MTL) in this region is still debatable, this zone seems to be the westernmost part of MTL.

Keywords. Gravity database, Gravity anomaly, Kyushu district, Southwest Japan

1 Introduction

Two large gravity databases in Japan have been successively issued for public use in 2000 and 2001. One is the "Gravity CD-ROM of Japan" (GSJDB) published by the Geological Survey of Japan (GSJ) (GSJ, 2000). The other is the "Gravity Database of Southwest Japan" (SWJDB) published by the Gravity Research Group in Southwest Japan (GRGSWJ) (2001). Total number of original gravity data published by these two databases amounts to 136,698 and 90,298 points, respectively. Data coverage of the GSJDB extends to whole Japanese Islands, while the SWJDB covers largely southwest Japan. Both databases were formed mutually complementary in their distributions of gravity data. Consequently, by combining these two databases, gravity data of southwestern area of the Japanese Islands lose their non-closely-spaced character and spread evenly over the area. By adding unpublished gravity data provided by the Geographical Survey Institute (GSIDB), we compiled a gravity database in southwest Japan. Thus, southwest Japan is successfully covered by uniformly- distributed dense gravity data with no blank area of observation left.

2 Recompiling of the gravity databases

Although the databases above have been compiled

with a higher precision of about 1 mgal, they still contain gravity data with a precision no better than a few milligals or more which are not accurate enough for a detailed mapping. We (members of GRGSWJ) are now executing further revisions to remove those poorly-calibrated data by careful scrutiny. We have accomplished this revision in the area of Kyushu District, southwest Japan, and it becomes possible to draw very precise gravity anomaly atlas which fully guarantees a precision of 1 mgal in the whole area.

3 Bouguer gravity imaging in Kyushu District, Southwest Japan

In constructing Bouguer anomaly atlas, we used several reduction density values, ranging from 2.2 to 2.67 g/cm^3, to remove the correlation between gravity anomaly and surface topography particularly in volcanic areas. Examples of the results obtained through this procedure are shown in Figs. 1 and 2. Fig. 1 is a Bouguer anomaly map contoured at 2 mgal interval for a density 2.67 g/cm^3 and superposed on the active faults in Kyushu District. Fig. 2 is one for a density 2.3 g/cm^3 contoured by the same manner as Fig.1. Gravity features of the whole Kyushu District are delineated very precisely on those figures. It is reasonable to adopt a density value of 2.67 g/cm^3 for an overview of the whole Kyushu area, while a density value of around 2.3 g/cm^3 is best fit for the local area of volcanic zones. A low density yields artificial complicated patterns in the mountainous area other than volcanic zones (cf. Kyushu Mountains area in Fig.2).

4 Characteristic features shown in the detailed gravity anomaly maps of Kyushu District

The Median Tectonic Line (MTL) is extending more than 800 km in the median zone of Southwest Japan. The northern Kyushu, in the geologic sense, have characteristic of the northern side (Inner Zone) of the MTL, and southern Kyushu have that of the southern side (Outer zone) (Huzita, 1980). Nevertheless, only the central Kyushu is characterized by many normal faults, huge active volcanoes, and active seismicity in the crust (e.g., Kakuta et al., 1992). Characteristic features found from the new precise gravity anomalies in Kyushu District are summarized as follows;

(1) The Aso volcano, located in the central Kyushu, has one of the largest craters (caldera) in the world. Yokoyama (1963) initially pointed out that the Aso Caldera is characterized by a prominent low gravity anomaly. Further gravity investigations made sure that this gravity depression is nearly circular shaped, with a steep rim and a flat bottom accompanying several closed minima (e.g., Komazawa, 1995). The new Bouguer anomaly map shows that gravity changes along the rim have the amplitude of more than 10 mgal/km. This feature implies that the Aso Caldera has not the funnel-shaped structure, which is suggested by Yokoyama (1963), but a piston-shaped cylinder structure.

(2) A dominant steep gravity gradient zone which is running through the Aso Caldera is observed along the ENE-WSW trending The Oita-Kumamoto Tectonic Line (OKTL). OKTL is running nearly along the Tertiary-PreTertiary geologic boundary in central Kyushu. The eastward extension of this gradient zone corresponds to the location of the MTL at Shikoku District. Therefore, it is strongly

suggested that the westward extension of the MTL is along the gradient zone. On the other hand, southwestward continuation of this gradient zone is passing through the northern coast of the Uto Peninsula and can be traced to Hondo (central Amakusa, southern part of the Inner Zone of Kyushu). Adjacent to the north of this steep gradient zone lies a huge and strong low anomaly belt, which is passing through Iyonada - Beppu Bay - Kuju Volcano - Kumamoto - Unzen Volcano - Tachibana Bay - Amakusanada from east to west.

(3) A strong negative Bouguer anomaly is observed over the Hyuganada Basin, southeastern Kyushu, and characterized by a sharp inland ward increase of Bouguer anomaly. This gravity low forms arcuate depression whose northwestern boundary is sharply cut by Pre-Tertiary volcanic rocks. This implies that subsurface structure beneath the basin may be correlated to the tectonic drug caused by subduction of the Philippine-Sea Plate.

(4) Trend-reduced Bouguer anomaly shows a large positive anomaly over the Pre-Tertiary formations in the northern part of Kyushu. In contrast, negative anomalies are dominant over the Pre-Tertiary formations in the southern part of Kyushu, particularly around the Kyushu Mountains. While the Amakusa Islands in western central Kyushu, probably the westernmost part of MTL, are characterized by a strong gravity high in detrended Bouguer map, which is well corresponded with Paleogene formations.

(5) Locations of active faults (Nakada and Imaizumi, 2002) are also depicted in Fig. 1. It is obvious that many parts of active faults correspond with narrow gravity cliff or ridge. Moreover, some of these gravity lineaments are much longer than the corresponding active faults. These parts of lineament presumably indicate subsurface extensions of the fault structures.

5 Conclusions

Detailed gravity anomaly maps in Kyushu District are presented. Characteristic patterns and geometries in the gravity anomaly distributions in this region provided much helpful information for exploring hidden faults and other subsurface geologic structures. Especially, Bouguer anomaly maps derived from the revised database might be some useful constraints for understanding of the tectonics at the western end of the MTL.

Acknowledgments

We would like to express our thanks to the Geographical Survey Institute, Japan and Nihon Chinetsu Kaihatsu Sokushin Center, Japan for the permission to use the gravity data.

References

The Geological Survey of Japan (ed.) (2000), Gravity CD-ROM of Japan, Digital Geoscience Map P-2, Geological Survey of Japan.

The Gravity Research Group in Southwest Japan (Representatives: Ryuichi Shichi and Akihiko Yamamoto) (2001), Gravity Measurements and Database in Southwest Japan, Gravity Database of Southwest Japan (CD-ROM), Bull. Nagoya University Museum, Special Rept., No.9.

Huzita, K. (1980). Role of the Median Tectonic Line in the Quaternary Tectonics if the Japanese Islands. Mem. Geological Soc. Japan, 18, pp. 129-153.

Kakuta, T., H. Miyamachi, H. Kubota and A. Takagi (1992). Crustal Earthquakes in Kyushu. Zisin. Journal of the Seismological Society of Japan, 45, pp. 229-237.

Komazawa, M. (1995). Gravimetric Analysis of Aso Volcano and its Interpretation. J. Geod. Soc. Japan, 41, 17-46.

Nakada, T. and T. Imaizumi (ed.) (2002). Digital Active Fault Map of Japan. Univ. of Tokyo Press.

Yokoyama, I. (1965). Structure of caldera and gravity anomaly. Bull. Volcanol., 26, pp. 67-72.

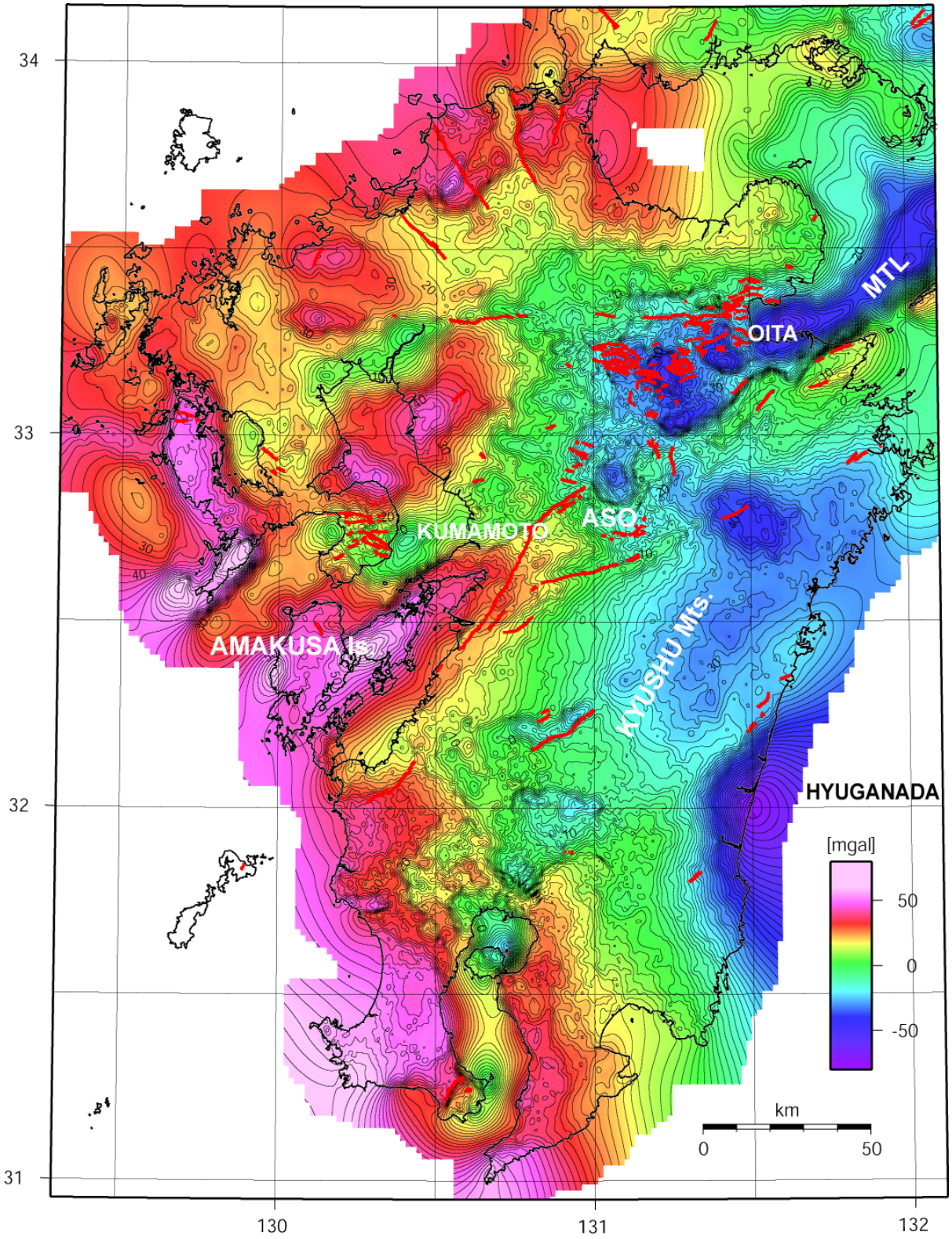

Fig. 1. Bouguer anomaly map of Kyushu District. Assumed density: 2.67. Contour interval: 2 mgal. Red line segments: Active faults.

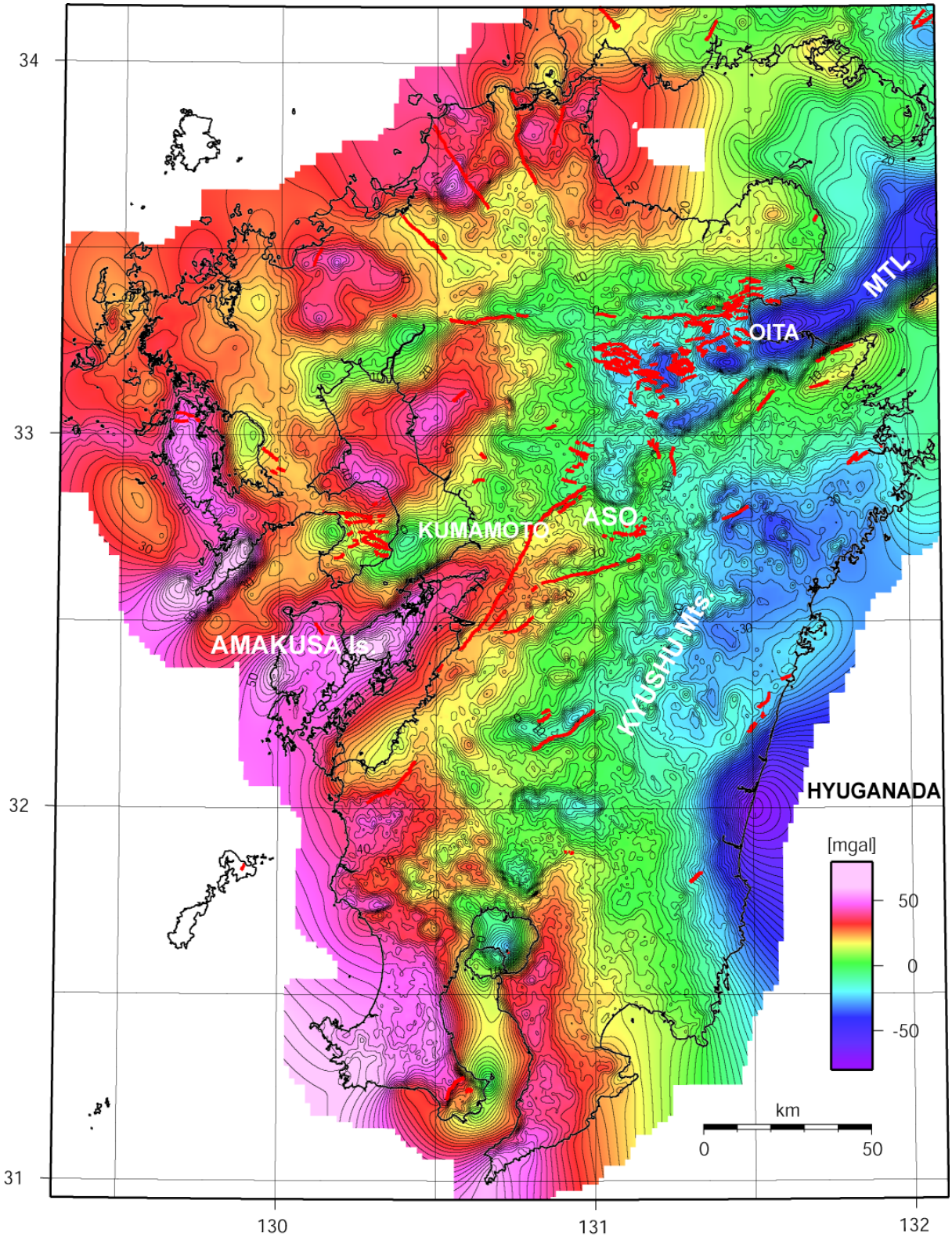

Fig. 2. Bouguer anomaly map of Kyushu District. Assumed density: 2.30. Contour interval: 2 mgal. Red line segments: Active faults.