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Preliminary Report on a Gravimetric Survey on Volcano Hakone, Japan

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Volcano Hakone is situated at a distance of about 80 km from Tokyo and has been fairly well studied from the standpoint of geology. As a series of gravimetric studies on the calderas in Japan, the writers carried out the survey on this volcano which has a caldera measuring about 10 km in diameter. Inside of this caldera, there are Lake Asinoko and 6 central cones which were formed by the post-caldera activities.

In this paper, the gravity values and gravity anomalies observed at each station and the distribution of the Bouguer anomalies are reported as preliminary. Detailed discussions on the subterranean structure of the caldera and comparative studies with other calderas will be postponed to the future papers.

The gravimetric surveys on the volcano were carried out twice, in 1961 and 1963. The former survey was made in co-operation with the Geographical Survey Institute by means of a North American Gravimeter. The latter was supplementary and made by means of a LaCoste & Romberg Gravimeter of the Hokkaido University. Reading accuracies of a single observation by these gravimeters are almost the same, about 0.04 mgal. Both surveys were standardized by the gravity value (g=979.7231 gal) at the pendulum station at the Fujiya Hotel, Miyanosita. As for the observation points, many bench marks for precise levels and spot heights were occupied and heights of many points on the new roads, the "Hakone Bypath" and the "Asinoko Skyline", were determined on reference to their construction elevations. In the former survey, heights of the remaining stations were determined by photogrametric method and in the latter, by a precise microbarometer of the American Paulin System, both accuracies being within about 3 meters at worst. The number of the observation points reached 120. Their distribution is shown in Fig. 1.

To obtain the gravity anomalies, the authors take the density of the earth-crust as 2.67 gr./cc and the vertical gradient of gravity as 0.3086 mgal/

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Fig. 1. Distribution of the gravity stations on and around Volcano Hakone. Hollow circles denote the stations of the present survey.

meter and neglect the topographic corrections. The results are tabulated in Table I where "Observed value" is the gravity value at the height given in column under the designation "Height" and the distribution of the Bouguer anomalies is shown in Figs. 2 and 3. At some stations along the "Asinoko Skyline" which runs the caldera rim at the west of Lake Asinoko, on the central cones, and at the eastern caldera rim, topographical effects on the gravity values .

Chation	ø	λ	Height	Normal value	Observed value	Free-air anomaly	Bouguer anomaly
Station	35°N	139°E	(m)	(mgal) 979,	(mgal) 979,	(mgal)	(mgal)
BM II 12177 II 12179 II 12180 II 12181 II 12181 II 12182	14/6 13.8 13.9 14.2 14.4	$\begin{array}{c} 08/2 \\ 06.4 \\ 05.4 \\ 04.6 \\ 03.8 \end{array}$	34.29 94.59 184.61 328.63 420.26	$766.20 \\ 765.07 \\ 765.21 \\ 765.63 \\ 765.91$	791.68 786.03 770.53 740.80 724.90	36.1 50.2 62.3 76.6 88.7	32.2 39.6 41.6 39.8 41.6
II 12178 No. 1 駒沢橋 2 独標 3 新千鳥橋 4 旧道彎曲点	14.2 13.3 13.0 12.6 12.0	$\begin{array}{c} 07.5 \\ 05.7 \\ 04.6 \\ 04.1 \\ 03.4 \end{array}$	50.66 198 258.2 378 642	765.63764.36763.94763.37762.52	791.48 773.88 757.59 733.08 676.06	41.5 70.6 73.3 86.4 111.7	35.8 48.5 44.4 44.1 39.8
BM II 12183 No. 5 学園前 6 慶巣山入口 7 芦之湯入口 8 六地蔵	14.2 13.7 13.1 13.0 12.6	03.0 03.3 03.3 02.7 02.4	614.00 673 802 844 858	765.63 764.93 764.08 763.94 763.37	683.00 670.62 639.78 628.63 626.65	106.8 113.4 123.2 125.2 128.1	38.1 38.1 33.5 30.7 32.0
9 薺池 10 独標 11 金波館 12 箱根町 13 孫助山南彎曲点	12.1 11.8 12.0 11.1 10.5	02.6 02.0 02.1 01.7 02.1	755 726 718 722 890	762.66762.24762.52761.24760.39	652.50 660.62 660.21 659.86 625.05	122.8122.4119.3121.4139.3	38.4 41.2 38.9 40.6 39.7
14 中継所入口 15 彎曲点 16 <i>"</i> 17 <i>"</i> 18 <i>"</i>	10.8 10.6 10.6 09.5 09.6	$\begin{array}{c} 03.1 \\ 04.0 \\ 03.5 \\ 04.6 \\ 04.2 \end{array}$	990 858 840 586 528	760.82 760.54 760.54 758.98 759.13	602.70 635.18 652.62 694.81 712.49	147.4 139.4 151.3 116.7 116.3	36.6 43.4 57.3 51.1 57.2
19 <i>"</i> 20 <i>"</i> 21 広河原 22 湯河原入口 23 小学校	$\begin{array}{c} 09.2 \\ 09.2 \\ 09.4 \\ 08.8 \\ 08.3 \end{array}$	$\begin{array}{c} 04.9 \\ 04.3 \\ 03.8 \\ 04.3 \\ 05.6 \end{array}$	398 286 216 137 37	758.56 758.56 758.84 758.00 757.29	736.93 765.34 778.20 797.05 811.62	101.2 95.0 86.0 81.3 65.8	56.6 63.0 61.8 66.0 61.6
BM I 50 No.24 穴部独標 25 沼田独標 26 関本 27 関場トンネル	08.5 16.5 17.5 19.1 19.5	$\begin{array}{c} 06.8\\ 09.3\\ 08.1\\ 06.4\\ 03.6 \end{array}$	4.75 18 23 52 246	757.57 768.89 770.31 772.57 773.14	810.89 790.86 797.61 795.68 748.03	54.8 27.5 34.4 39.2 50.8	54.2 25.5 31.8 33.4 23.3
28 地蔵堂 29 竹之下 30 独標 BM 仿11 No.31 東山	18.9 19.9 18.9 18.0 16.9	02.5 58.8* 57.1* 57.7* 57.9*	356 333 435.6 472.79 500	772.29 773.71 772.29 771.02 769.46	$726.40 \\718.78 \\695.97 \\688.84 \\688.21$	64.0 47.8 58.2 63.7 73.0	24.1 10.6 9.4 10.8 17.1
32 寒沢橋 33 展望台 34 長尾峠 35 峠道 36 姥ケ茶屋	16.4 16.2 15.3 15.7 16.4	58.1* 57.7* 58.6* 59.4* 59.8*	685 767 902 810 726	768.75 768.46 767.19 767.75 768.75	650.87 631.84 610.10 628.47 655.86	93.5 100.1 121.5 110.7 112.4	16.9 14.2 20.5 20.0 30.7

Table I. Observed values and the anomalies.



Fig. 2. Distribution of the Bouguer anomalies on and around Volcano Hakone. Unit is *mgal*. Small solid circles denote the height in *meters*.

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Fig. 3. Distribution of the Bouguer anomalies on Hakone Caldera. Unit is mgal. Small solid circles denote the height in meters.

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