DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

Principal Facts for 63 Gravity Stations in the Vicinity of Katmai National Park, Alaska

by

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Abstract

This report describes data for 63 gravity measurements made in July 1991 in the vicinity of Katmai National Park and the town of King Salmon, Alaska. The measurements were made with Lacoste and Romberg gravity meter G-17C. Elevation control is from mapped spot elevations and altimetry. Included in this report are base station descriptions for two new gravity bases established in King Salmon. Tables in the report list principal facts and reduced Bouguer and isostatic residual gravity anomalies. Page-sized plots at 1:250,000 scale show the measurement site locations. A page-sized contour plot of the complete Bouguer anomaly in the vicinity of Katmai Pass shows a gravity low that may be caused by low-density magma within the crust.

Gravity data collection and reduction

The tables list 5 gravity base station and 63 field station values for data collected in July 1991. The stations are located in and around the Katmai National Park and King Salmon–Naknek area, Alaska (Figure 1). The data were obtained as part of a cooperative study between the U.S. Geological Survey (USGS) and the University of Alaska, Fairbanks. Field work was performed in conjunction with maintenance of the seismograph network at Katmai National Park (network described in Ward et al., 1991).

Lacoste and Romberg gravity meter G-17C (a rebuilt version of G-17) was used. Elevation control was mapped spot elevations and altimetry. Stations were reached by helicopter, except the traverse along the highway from King Salmon to Naknek that was done by truck.

Gravity values are tied to David Barnes' (USGS) base station ANCW (personal commun., 1991) in Anchorage (at Elmendorf Air Force Base near the NOAA warehouse). Observed gravity values relative to ANCW at other USGS Anchorage bases (ANCG at the Anchorage Airport parking garage and ANCU at the USGS office in Anchorage) are also listed in table 1. Two new bases were established in King Salmon, KS91A at the Post Office (at the Airport) and KS91B at the U.S. Fish and Wildlife Office (near the Naknek river); Base station descriptions are given in the appendix of this report. Table 1 gives the observed gravity values at these base stations. The base station values are on the International Gravity Standardization Network of 1971 datum (Morelli, 1974).

Bouguer gravity anomalies were calculated using the 1967 Geodetic Reference System formula (International Association of Geodesy, 1971) using methods developed by Barnes (1972; 1984) for use in Alaska. A Bouguer reduction density of 2.67 g/cm^3 was used. Terrain corrections were done by computer, using digital topography, from 0.39 km to 166.7 km from the station (Plouff, 1977). Inner zone terrain corrections, estimated in the field, were added to the computer corrections. Isostatic anomalies were calculated assuming a local (Airy) isostatic model (Simpson et al., 1986) with the following parameters: crustal density of 2.67 g/cm^3, root depth of 25 km at sea level, and a density contrast at the root of 0.4 g/cm^3.

The largest potential source of error in the reduced gravity values is from elevation inaccuracy. Elevations were established by altimetry checked against mapped spot elevations on the USGS 1:63,360-scale maps (produced in 1951 with minor revision in 1984). Several of the gravity measurement sites were revisited multiple times during the survey. Based on comparison of repeat altimetry at these sites (mostly USGS seismograph sites as indicated in Table 3), elevations are assumed to be accurate to better than 30 feet. A 30 foot elevation error produces an error in the combined free air and Bouguer correction of about 1.8 mGal.

Table 2 gives principal facts and reduced anomalies for a gravity traverse along the highway from King Salmon to Naknek, Alaska. Elevation control is by altimetry. The first 4 letters of the station name give the name used in the field, the second 4 letters are the name as changed for inclusion in the Alaska gravity data base (field names had to be changed to avoid name duplication in the data base). Figure 2 shows the location of the gravity stations.

Table 3 contains principal facts and reduced gravity values for stations in and around Katmai National Park. Several of the stations are located at sites of the seismograph network (Ward et al., 1991). The three-letter designations listed in the "Loc" column are names of the seismograph stations. In addition, several measurement sites were placed in an attempt to relocate measurement sites of an earlier, local survey in the Novarupta region (Eichelberger et al., 1990). These sites are indicated with site numbers in the "Loc" column. It was not possible to relocate the buried metal bars that marked these sites, so locations were estimated from site descriptions. Figures 2 through 5 show the locations of the stations in and around Katmai National Park.

Table 1: Base Station Values.
OG = Observed Gravity, *FAA* = Free Air Anomaly, *SBA* = Simple Bouguer Anomaly (density 2.67 g/cm^3), *TC* = Terrain Correction, *CBA* = Complete Bouguer Anomaly, * = no terrain correction calculated.

Station	*Latitude*		*Longitude*		*Elev.*	*OG*	*FAA*	*SBA*	*TC*	*CBA*
	deg	*min*	*deg*	*min*	*feet*		*gravity in mGal*			
ANCW	61	14.00	149	46.00	204	981930.17	-63.3	-70.2	.7	-69.5
ANCG	61	11.00	149	59.00	80	981907.49	-93.8	-96.5	*	*
ANCU	61	11.00	149	48.00	200	981930.40	-59.6	-66.4	*	*
KS91A	58	41.00	156	39.74	50	981827.81	20.3	18.6	.0	18.6
KS91B	58	40.78	156	39.84	30	981829.26	20.2	19.2	.0	19.2

Table 2: Katmai to Naknek traverse.
OG = Observed Gravity, *FAA* = Free Air Anomaly, *SBA* = Simple Bouguer Anomaly (density 2.67 g/cm^3), *TC* = Terrain Correction, *CBA* = Complete Bouguer Anomaly, *ISO* = Isostatic Residual Gravity Anomaly.

Station	*Latitude*		*Longitude*		*Elev.*	*OG*	*FAA*	*SBA*	*TC*	*CBA*	*ISO*
	deg	*min*	*deg*	*min*	*feet*		*gravity in mGal*				
KS01KA41	58	42.36	156	38.01	65	981829.49	21.6	19.4	.0	19.4	23.8
KS02KA42	58	43.11	156	39.14	75	981829.97	22.0	19.5	.0	19.5	23.7
KS03KA43	58	44.08	156	41.33	65	981827.88	17.7	15.5	.0	15.5	19.5
KS04KA44	58	44.60	156	44.31	80	981821.97	12.5	9.8	.0	9.8	13.5
KS05KA45	58	44.80	156	49.24	125	981820.19	14.7	10.4	.0	10.4	13.5
KS06KA46	58	45.00	156	54.13	135	981829.99	25.1	20.5	.0	20.5	23.1
KS07KA47	58	44.99	156	56.95	90	981836.01	26.9	23.9	.0	23.9	26.2
KS08KA48	58	43.49	157	3.23	85	981831.29	23.8	20.9	.0	20.9	22.6
KS09KA49	58	43.66	157	1.04	70	981833.76	24.6	22.2	.0	22.2	24.1

Table 3: Katmai Region Gravity Data.
OG = Observed Gravity, *FAA* = Free Air Anomaly, *SBA* = Simple Bouguer Anomaly (density 2.67 g/cm^3),
TC = Terrain Correction, *CBA* = Complete Bouguer Anomaly, *ISO* = Isostatic Residual Gravity Anomaly.

Station	*Loc*	*Latitude*		*Longitude*		*Elev.*	*OG*	*FAA*	*SBA*	*TC*	*CBA*	*ISO*
		deg	*min*	*deg*	*min*	*feet*	*gravity in mGal*					
WWW KA0A	WWW	58	20.75	156	20.68	1363	981730.52	73.9	27.4	6.0	33.4	40.8
GRANKA0B		58	22.78	156	16.32	1683	981718.91	89.6	32.2	8.4	40.6	49.1
KSM KA0C	KSM	58	50.80	156	12.93	1840	981724.52	72.4	9.6	16.2	25.8	35.7
KM01KA51		58	17.15	155	8.85	3786	981510.53	86.8	-42.3	15.0	-27.3	-2.4
KM02KA52	250	58	16.36	155	8.95	3235	981544.04	69.5	-40.8	5.7	-35.1	-10.2
KM03KA53		58	16.87	155	5.04	2310	981611.98	49.7	-29.1	7.2	-21.9	3.4
KM04KA54	KCG	58	18.52	155	6.43	2130	981628.48	47.0	-25.6	7.5	-18.1	7.8
KM05KA55		58	15.59	155	16.27	2110	981623.34	44.0	-28.0	4.6	-23.4	.6
KM06KA56		58	13.63	155	14.75	3690	981515.01	87.0	-38.9	13.6	-25.3	-2.3
KM07KA57		58	14.63	155	12.43	3102	981550.92	66.2	-39.6	6.6	-33.0	-9.0
KM08KA58	KVT	58	22.91	155	17.72	1615	981670.89	35.0	-20.0	3.5	-16.5	8.3
KM09KA59		58	17.32	155	11.71	2540	981601.40	60.2	-26.5	3.9	-22.6	2.4
KM10KA60	KBM	58	16.11	155	12.27	2240	981616.87	49.0	-27.4	3.4	-24.0	.6
KM11KA61	KKP	58	13.05	155	9.63	2175	981599.51	29.7	-44.5	6.4	-38.1	-14.7
KM12KA62		58	17.56	155	19.25	1250	981684.50	21.5	-21.1	5.8	-15.3	9.1
KM13KA63		58	15.49	155	19.32	1395	981672.10	25.6	-22.0	8.0	-14.0	9.8
KM14KA64		58	20.33	155	20.78	960	981708.41	14.4	-18.3	4.0	-14.3	10.1
KM15KA65		58	17.09	155	41.62	1355	981693.72	41.3	-4.9	1.8	-3.1	16.1
KM16KA66		58	10.12	155	7.87	3115	981557.03	79.7	-26.6	14.7	-11.9	8.9
KM17KA67		58	8.43	155	10.98	2865	981565.28	66.7	-31.0	16.6	-14.4	5.1
KM18KA68		58	8.70	155	15.39	2490	981600.10	65.8	-19.1	7.3	-11.8	8.1
KM19KA69		58	9.32	155	17.93	3905	981514.51	112.6	-20.6	10.9	-9.7	10.3
KM20KA70		58	10.18	155	19.63	4980	981444.01	142.1	-27.8	17.5	-10.3	10.0
KM21KA71	KTR	58	12.51	155	4.67	2350	981607.14	54.5	-25.6	6.7	-18.9	3.8
KM22KA72	KMC	58	11.18	155	9.08	1620	981643.07	23.6	-31.7	5.3	-26.4	-4.3
KM23KA73	KTP	58	5.54	155	9.84	2675	981586.14	73.6	-17.7	11.8	-5.9	10.9
KM24KA74		58	8.33	155	21.16	3810	981518.68	109.1	-20.8	12.1	-8.7	10.5
KM25KA75		58	6.01	155	23.15	2670	981584.03	70.3	-20.7	12.5	-8.2	9.3
KM26KA76		58	7.43	155	26.24	3855	981511.48	107.4	-24.1	17.1	-7.0	11.2
KM27KA77		58	13.81	155	2.09	3880	981516.03	105.7	-26.7	8.5	-18.2	4.9
KM28KA78		58	16.19	154	52.85	3540	981544.02	98.4	-22.3	8.6	-13.7	10.4
KM29KA79	KKC	58	13.86	154	53.96	1850	981654.08	52.6	-10.5	7.4	-3.1	19.8
KM30KA80	KRB	58	31.74	154	43.30	1630	981674.27	27.9	-27.7	6.0	-21.7	6.4
KM31KA81	KNE	58	20.29	154	50.11	2950	981583.92	77.3	-23.4	6.7	-16.7	9.4
KM32KA82		58	35.63	155	19.44	1585	981694.38	38.6	-15.5	7.1	-8.4	14.1
KM33KA83	KEL	58	26.44	155	44.24	3195	981602.17	110.3	1.3	17.2	18.5	35.9
KM34KA84	74	58	16.42	155	8.81	3290	981539.95	70.5	-41.7	5.9	-35.8	-10.9
KM35KA85	113	58	16.33	155	8.22	2976	981568.63	69.8	-31.7	4.1	-27.6	-2.7
KM36KA86	71	58	15.79	155	9.94	2352	981604.58	47.7	-32.5	4.8	-27.7	-3.0
KM37KA87	KCE	58	14.54	155	11.23	2570	981582.40	47.7	-39.9	4.1	-35.8	-11.8
KM38KA88	KKR	58	5.62	155	30.27	3340	981539.37	89.3	-24.6	15.3	-9.3	7.3

Table 3 (continued)

Station	*Loc*	*Latitude*		*Longitude*		*Elev.*	*OG*	*FAA*	*SBA*	*TC*	*CBA*	*ISO*
		deg	*min*	*deg*	*min*	*feet*		*gravity in mGal*				
KM39KA89		58	11.94	155	29.37	2888	981578.24	77.0	-21.5	16.0	-5.5	15.0
KM40KA90		58	12.99	155	24.46	1900	981644.76	49.1	-15.7	4.1	-11.6	10.3
KM41KA91		58	11.81	155	16.90	5970	981352.55	141.6	-62.0	31.6	-30.4	-8.9
KM42KA92		58	16.47	155	1.54	4725	981460.40	126.0	-35.2	11.0	-24.2	.4
KM43KA93		58	17.44	154	56.23	5070	981439.52	136.2	-36.7	17.0	-19.7	5.1
KM44KA94		58	20.16	155	2.37	4980	981443.33	127.9	-42.0	22.7	-19.3	6.5
KM45KA95		58	21.61	155	3.49	4830	981459.51	128.0	-36.7	18.3	-18.4	7.7
KM46KA96		58	23.82	155	5.79	3205	981568.66	81.2	-28.1	9.2	-18.9	7.6
KM47KA97		58	24.42	155	8.70	3655	981537.94	92.1	-32.6	13.7	-18.9	7.1
KM48KA98		58	24.67	155	11.59	4535	981468.80	105.4	-49.3	30.6	-18.7	6.5
KM49KA99		58	23.22	155	13.52	4505	981472.35	108.1	-45.6	29.2	-16.4	8.6
KM50KA50		58	26.61	155	15.77	2542	981608.89	55.3	-31.4	12.2	-19.2	5.4
KM51KA0D		58	22.16	155	25.56	945	981718.87	21.0	-11.3	2.3	-9.0	14.3

Bouguer gravity in the vicinity of Katmai Pass

The gravity data reported here were collected to investigate the boundaries of the gravity low identified by previous studies in the vicinity of Katmai National Park (Kienle, 1969; David Barnes, written communication, 1990). Figure 6 shows the contoured Bouguer gravity combining the new and old data. The gravity low centered on Katmai Pass spans approximately 400 square km, extends 24 km along the strike of the magmatic arc (NE-SW) and 16 km in the perpendicular direction, and reaches a minimum of -27 mGal. Both Novarupta (the vent for the 1912 Valley of Ten Thousand Smokes ash flow) and the contemporaneously formed Katmai Caldera are on the flanks of this gravity low. Mt Trident, the source of 1949 to 1963 (and later) lava flows, also lies along the margin of this low. Based on teleseismic delays observed in the local seismic network, Ward et al. (1991) concluded that the gravity low may be related to magma within the crust beneath Katmai Pass. The gravity and teleseismic anomalies at Katmai Pass are analogous to similar anomalies at the Geysers-Clear Lake region in California, an active geothermal area (Saltus et al., 1991). The correlation of low-density and low-velocity sources in a region of (presumed) high heat flow and recent volcanism strongly suggests that the anomalies are caused by magma bodies within the crust (Saltus et al., 1991).

Acknowledgements

The helicopter time for gravity data collection was paid for by the University of Alaska, Fairbanks, as part of their on-going work in the Katmai region. David Stone and Jurgen Kienle coordinated this support and provided important advice for the planning of this survey. David Barnes, USGS, Menlo Park, pointed out the need for more data in the Katmai Pass region and suggested that we should take advantage of the helicopter support already planned for seismic network maintenance. Pete Ward, USGS, Menlo Park, was the field chief for the seismic network maintenance. Mel Nading, Trans Alaska Helicopters, Anchorage, Alaska, was the expert pilot for this survey. We thank the U.S. Fish and Wildlife Office in King Salmon, Alaska, for lodging and vehicle support, and the National Park Service Office for logistical support.

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Appendix - Base station descriptions

GRAVITY BASE STATION
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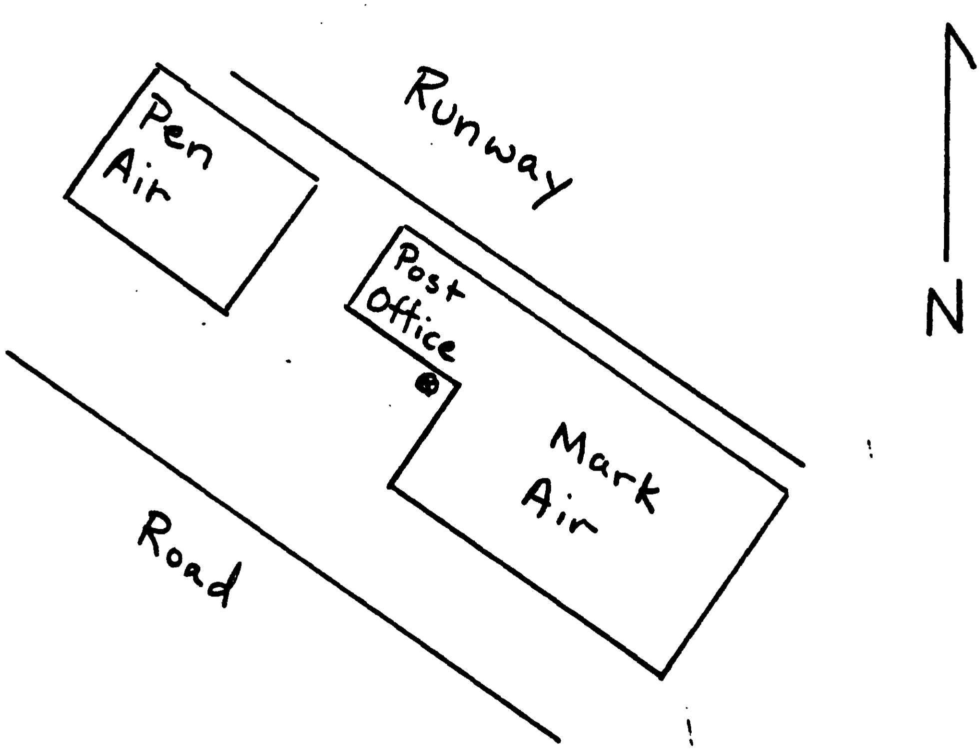
STATE/COUNTRY	STATION DESIGNATION	OBSERVED GRAVITY
Alaska/USA	KS91A	981827.81
NEAREST TOWN	**LONGITUDE**	**LATITUDE**
King Salmon	-156 39.74	58 41.00
ELEVATION	**TOPOGRAPHIC MAP(S)**	
50 feet	Naknek (C-2) 1:63,360	

DATE	OBSERVER	METER	REFERENCE STATION	REFERENCE VALUE
7/91	Saltus	G17C	ANCW	981930.17

DESCRIPTION/SKETCH

The station is located on the south porch of the King Salmon Post Office (at the airport in the west part of the building that houses the Mark Air terminal). The site is in the east corner of the porch, just outside an employee service door. An aluminum USGS gravity disk stamped "KS91A" was cemented to the concrete.



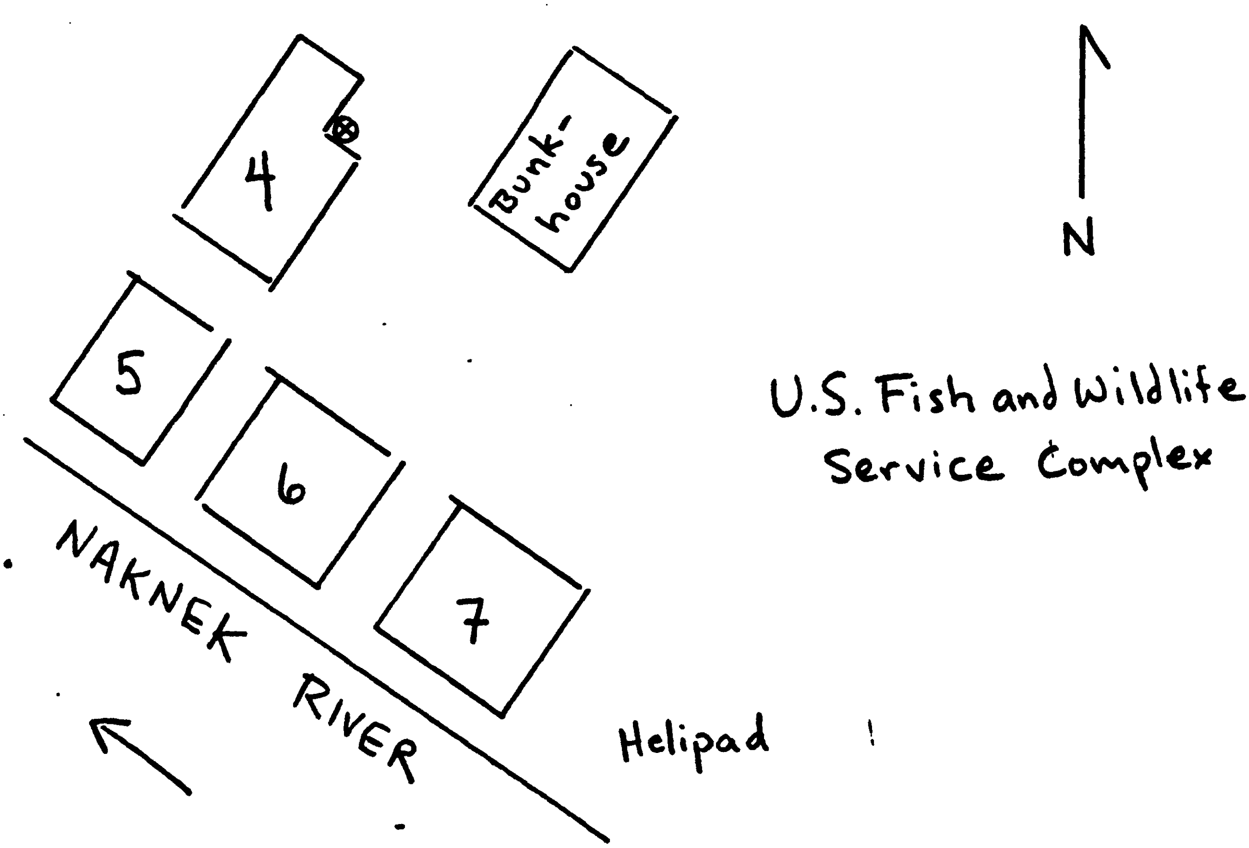
GRAVITY BASE STATION
U.S. GEOLOGICAL SURVEY

STATE/COUNTRY	STATION DESIGNATION	OBSERVED GRAVITY
Alaska/USA	KS91B	981829:26
NEAREST TOWN	LONGITUDE	LATITUDE
King Salmon	-156 39.84	58 40.78
ELEVATION	TOPOGRAPHIC MAP(S)	
30 feet	Naknek (C-2) 1:63,360	

DATE	OBSERVER	METER	REFERENCE STATION	REFERENCE VALUE
7/91	Saltus	G17C	ANCW	981930.17

DESCRIPTION/SKETCH

The station is located on a concrete step just outside the main entrance to Building #4 of the U.S. Fish and Wildlife Service complex next to the Naknek river in King Salmon. The site is marked with an aluminum USGS gravity disk stamped "KS91B".



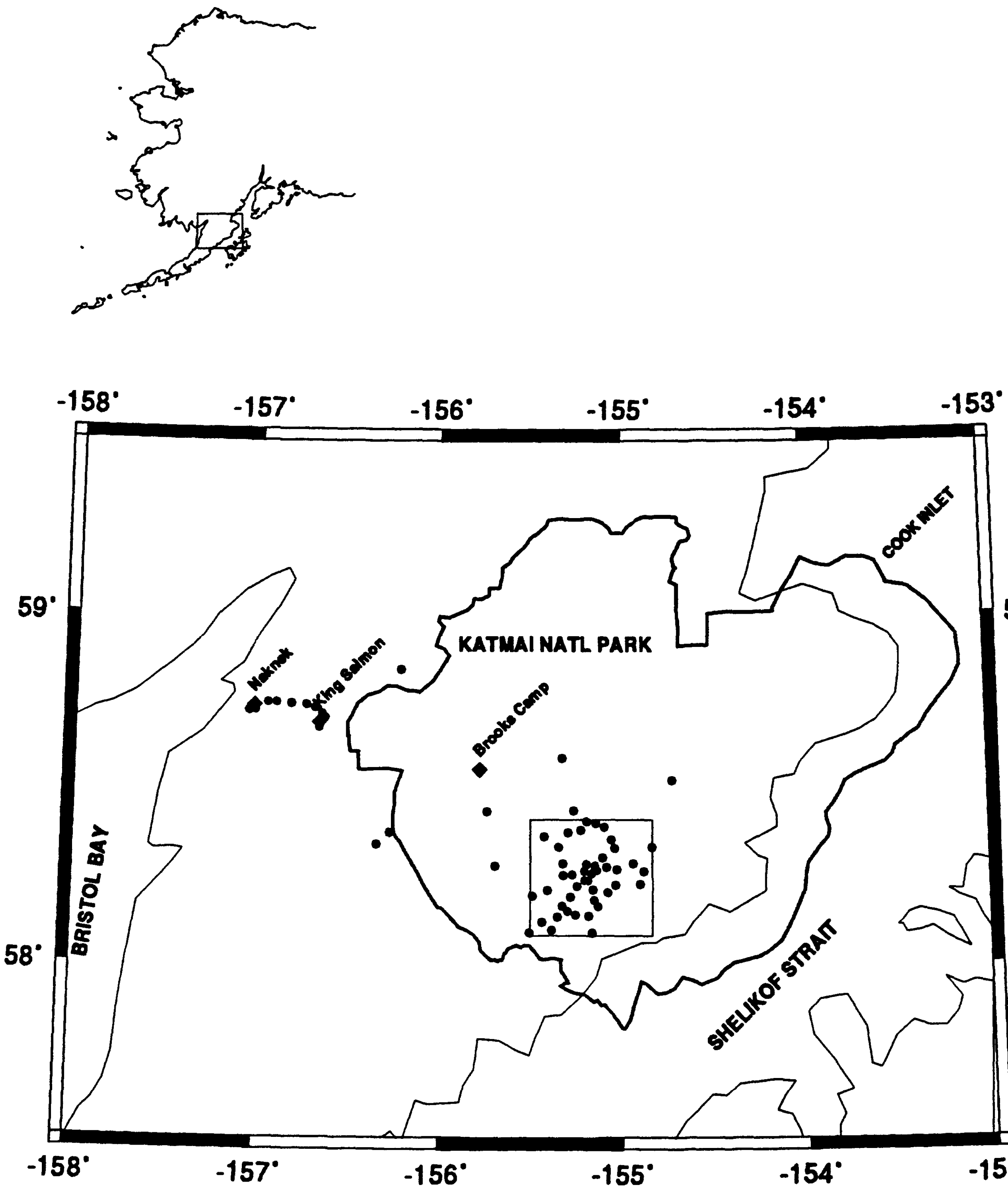


Figure 1: Location of study area in southwest Alaska. Dots show the locations of gravity measurements described in this report. The heavy line is the approximate boundary of Katmai National Park. The box shows the area of the gravity map in Figure 7.

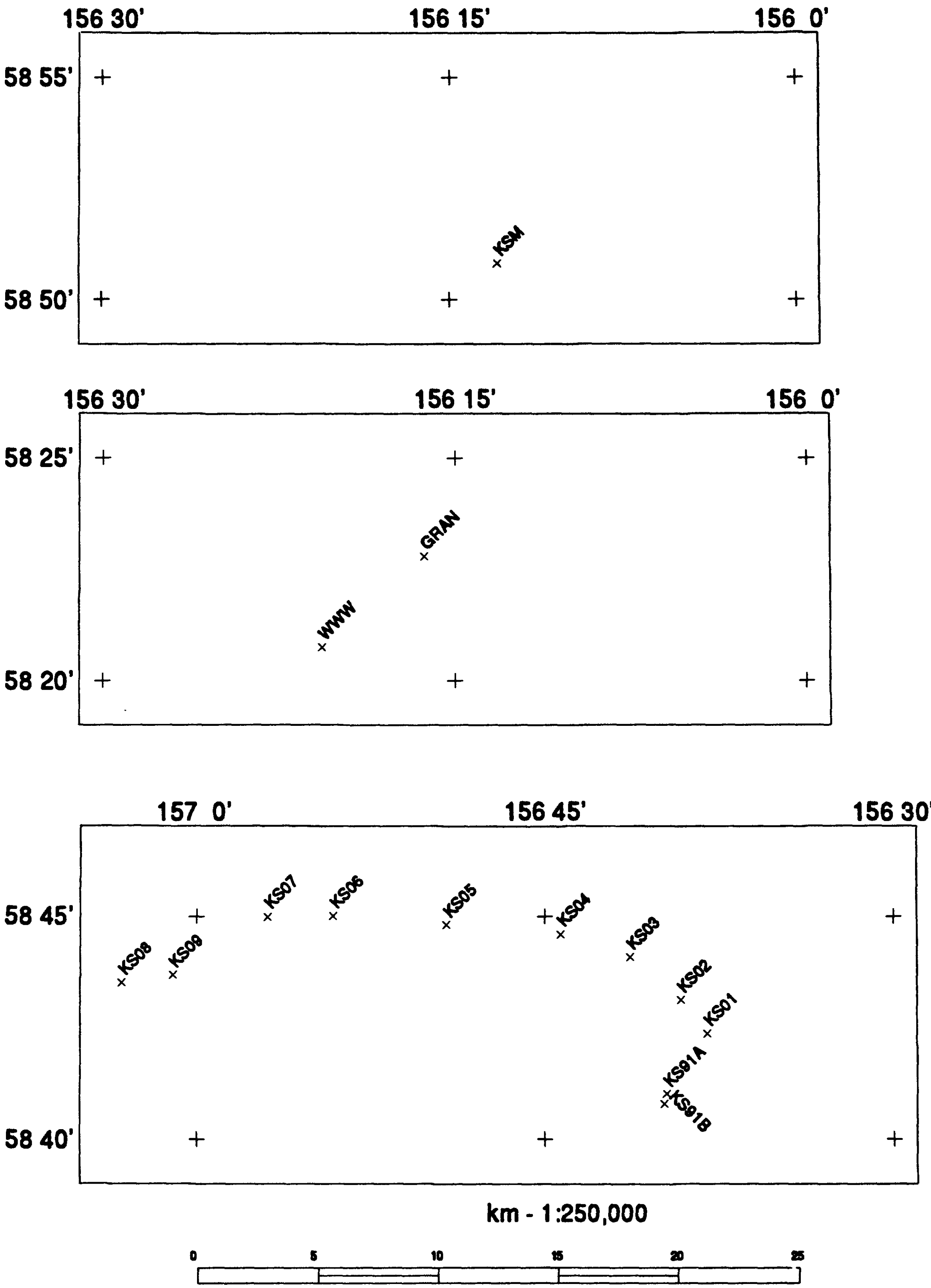


Figure 2: Gravity station locations, King Salmon to Naknek, Alaska, and western edge of Katmai National Park.

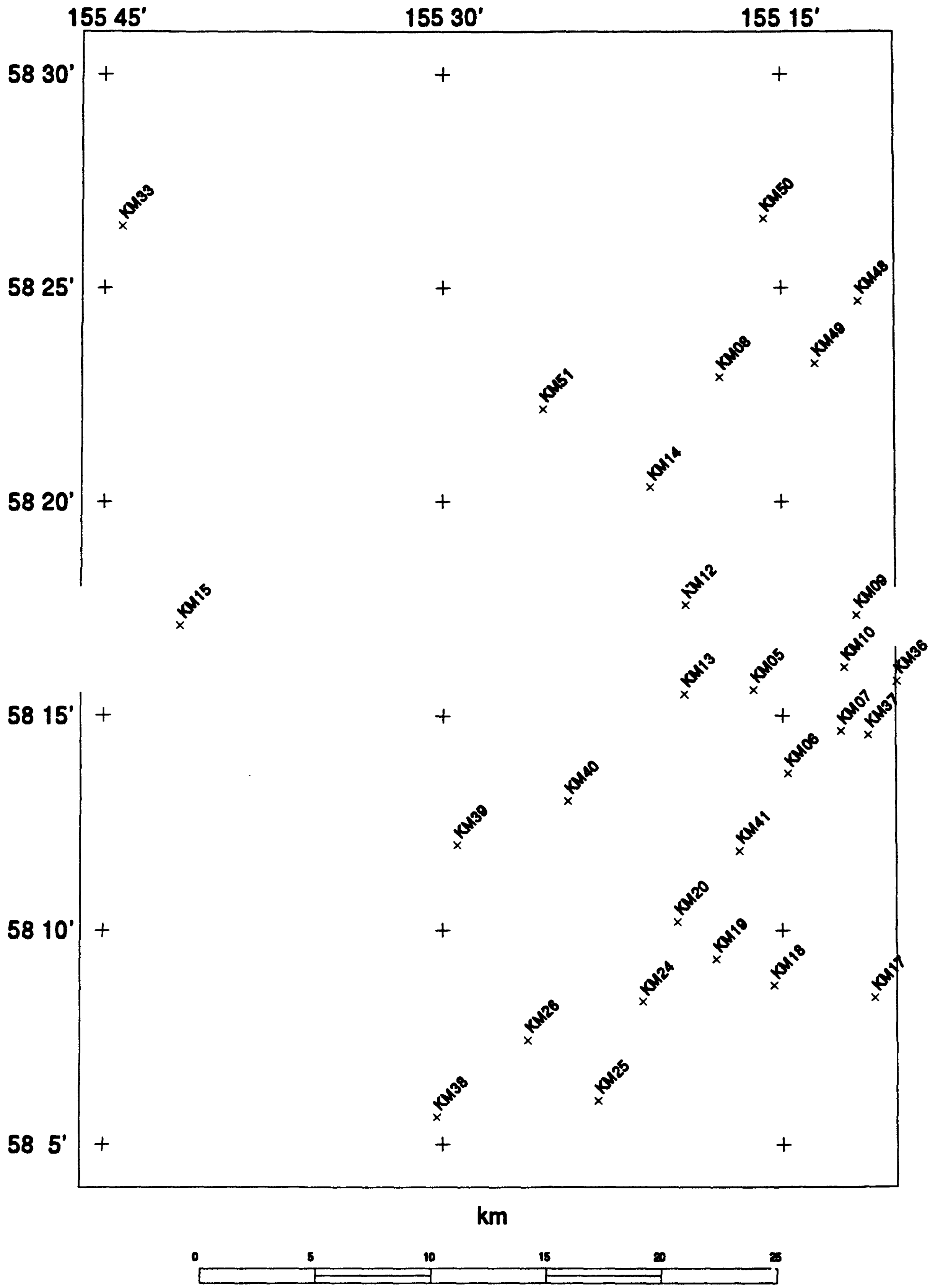


Figure 3: Gravity station locations, west Katmai National Park and vicinity.

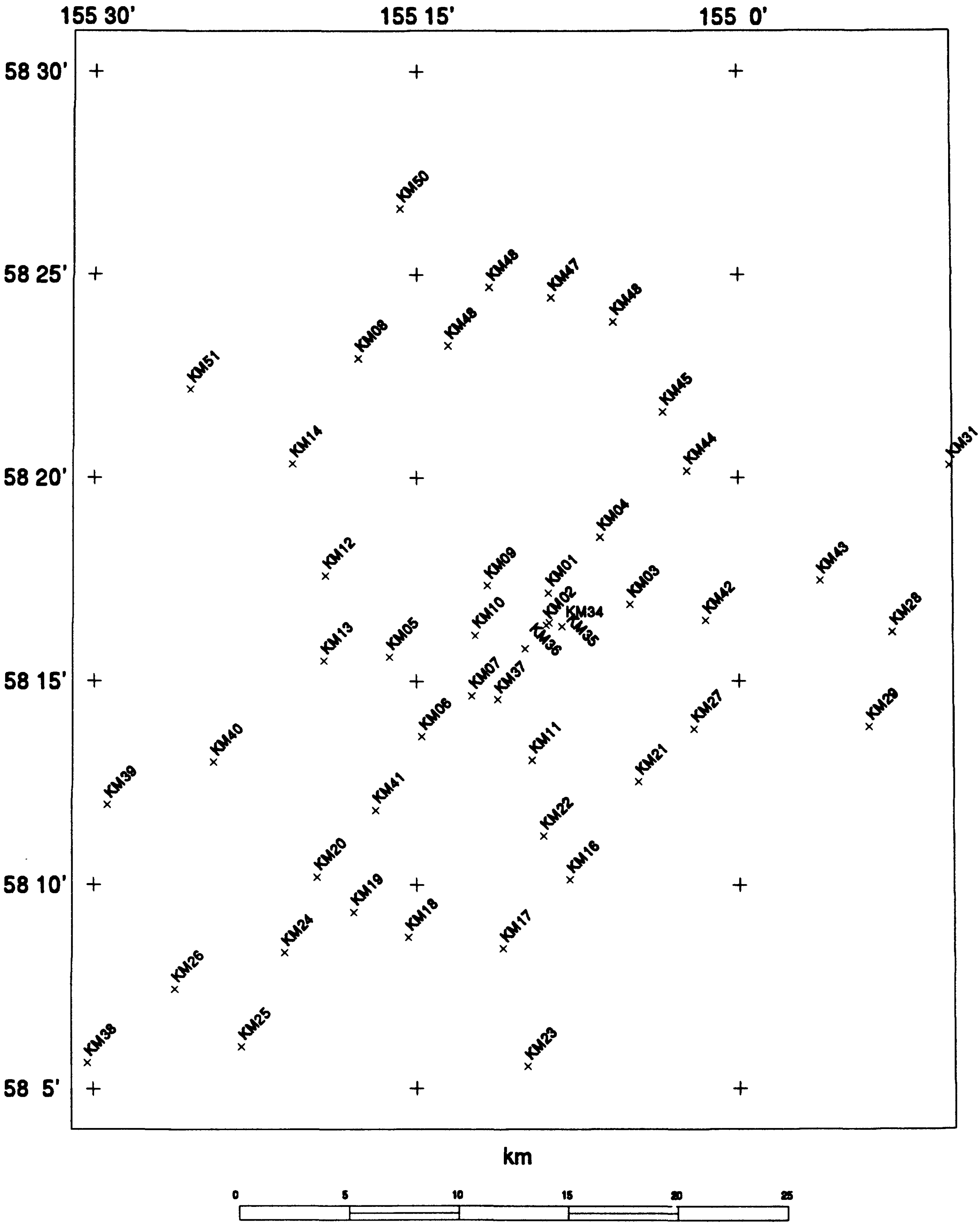


Figure 4: Gravity station locations, central Katmai National Park and vicinity.

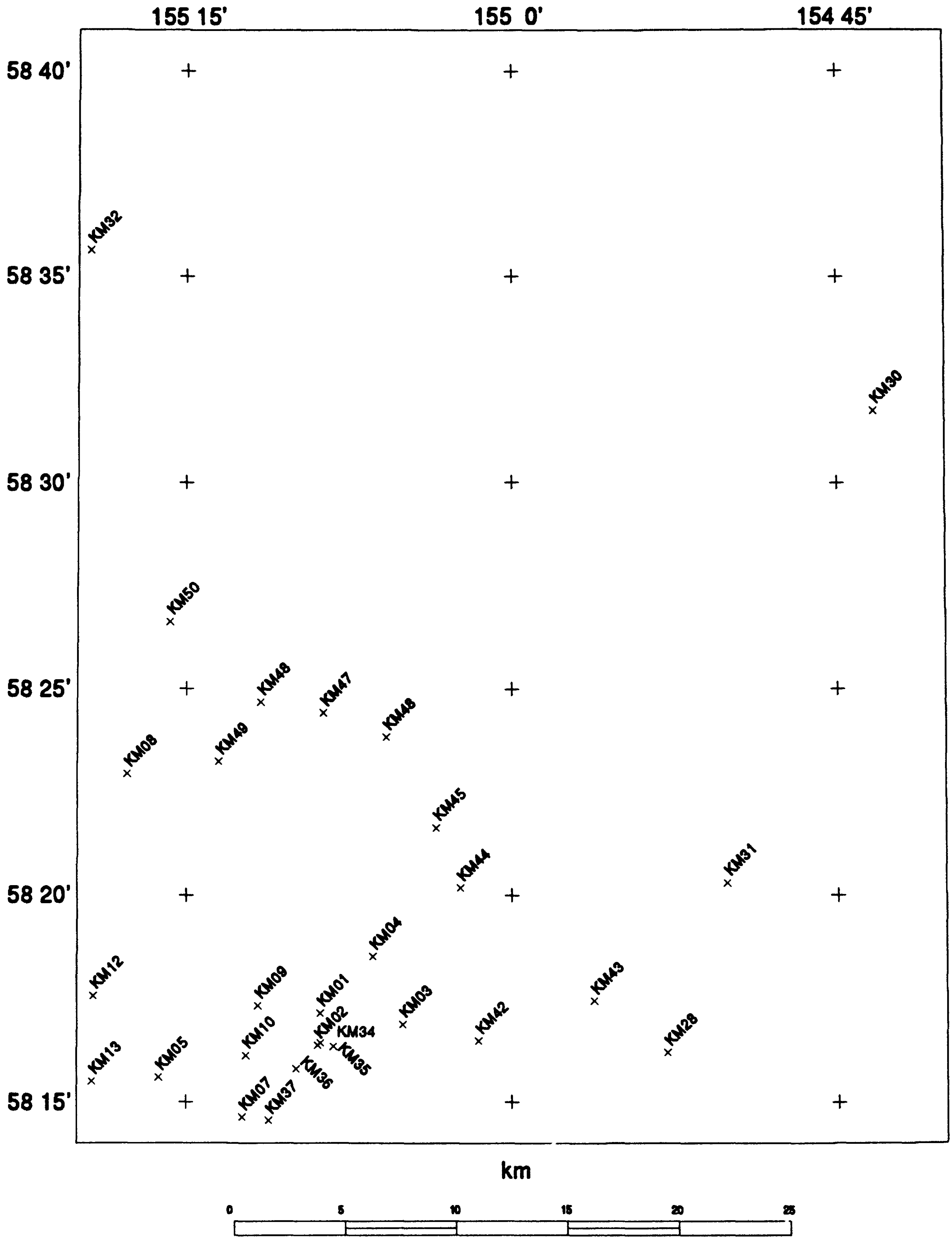


Figure 5: Gravity station locations, northeast Katmai National Park and vicinity.

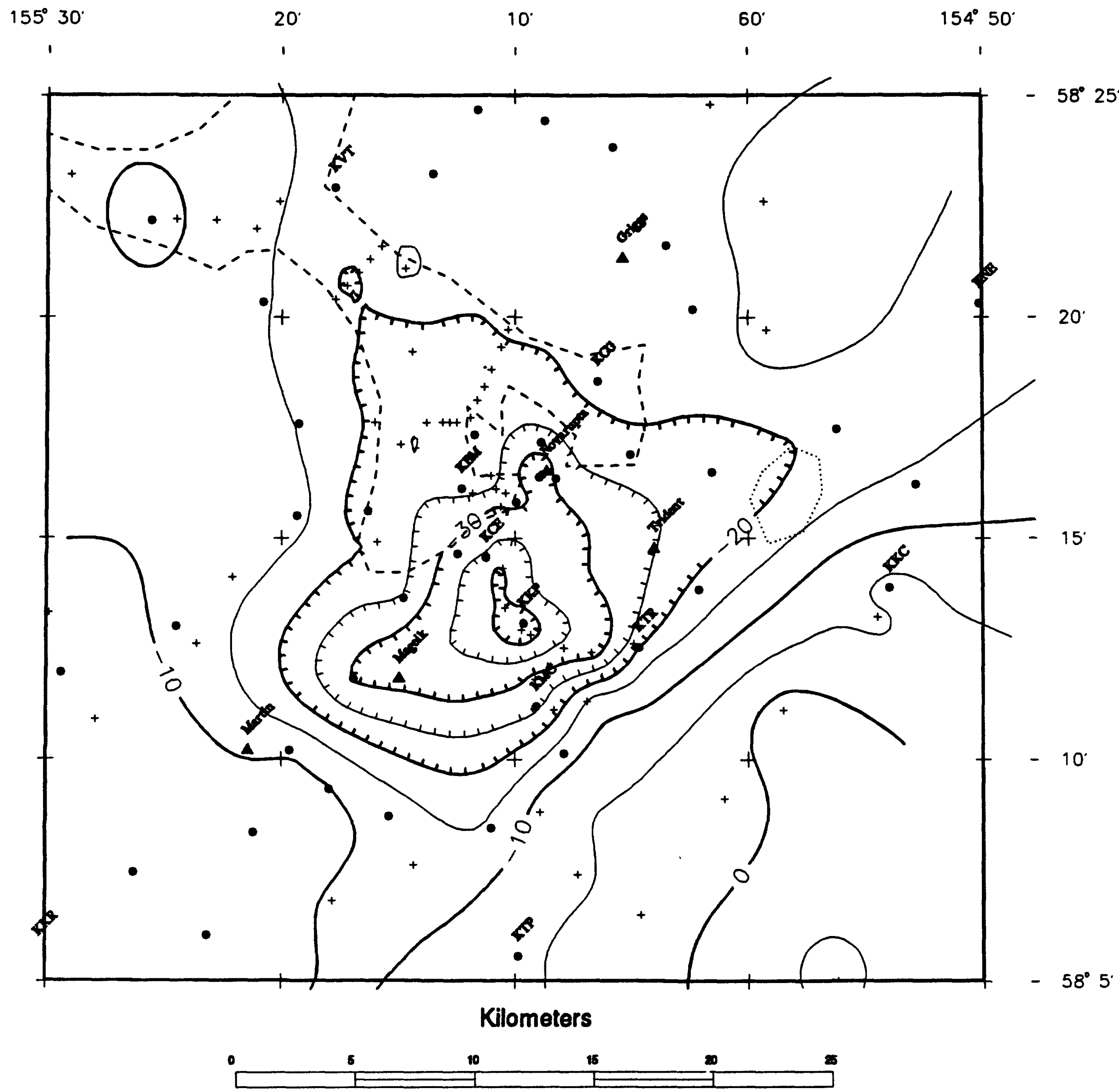


Figure 6: Complete Bouguer gravity anomaly in the vicinity of Katmai Pass, Katmai National Park, Alaska. Contour interval is 5 mGal. Dashed line traces the Valley of Ten Thousand Smokes, dotted line outlines Katmai Caldera. Triangles mark major volcanos. Filled circles are the locations of new gravity measurements from July 1991, pluses mark previous measurements (Keinle, 1969; David Barnes, written communication, 1990). Three-letter labels identify stations of the seismic network (Ward et al., 1991). Station KKP is located at Katmai Pass.