UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Principal facts for gravity data in the Ten Lakes Wilderness
Study Area, Lincoln County, Montana

by

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature. Any use of trade names is for descriptive purposes only and does not imply endorsement by the USGS.

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Studies related to Wilderness

The Wilderness Act (Public Law 88-577, September 3, 1964) and related acts require the U.S. Geological Survey and the U.S. Bureau of Mines to survey certain areas on Federal lands to determine their mineral resource potential. Results must be made available to the public and be submitted to the President and the Congress. This report presents the data from a gravity survey of the Ten Lakes Proposed Wilderness and vicinity in Kootenai National Forest, Montana. The Ten Lakes Wilderness was classified as a further planning area during the Second Roadless area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

Introduction

This report presents part of the work undertaken by the U.S. Geological Survey to evaluate the mineral-resource potential of the Ten Lakes Wilderness study area. During the summer field seasons of 1981 and 1982, 53 gravity stations were established in the Ten Lakes Wilderness study area, Lincoln County, Montana. The Ten Lakes Wilderness study area is located in Kootenai National Forest and covers approximately 500 sq. mi (fig. 1). This report presents the principal facts for these data.

Data Collection

Gravity observations were made using LaCoste-Romberg gravity meter G-550. The gravity stations were referenced to the U.S. Department of Defense (DOD) base at Kalispell, Montana (appendix A), which is part of the International Gravity Standardization Net (IGSN-71). A secondary base was established in Eureka, Montana (appendix B), and was tied to the Kalispell DOD base. Gravity loops were started and closed daily by making repeat observations at the secondary base. Access was by helicopter and ground traverses into the roadless areas and by vehicle along highways and secondary roads outside of the wilderness area.

Elevation Control

The survey area is bound by lat. $48^{\circ}45'-49^{\circ}0'N$ and long. $114^{\circ}45'-115^{\circ}05'W$. The station elevations were obtained from benchmarks, spot elevations, and section corners on 1:24,000-scale USGS topographic maps. The uncertainty of elevations based on benchmarks is assumed to be 0.5 ft. For spot elevations and section corners with elevations in black, on 1:24,000-scale maps with a 40-ft contour interval, the uncertainty is assumed to be 3 ft. At a density of 2.67 g/cm^3 , this elevation uncertainty translates to a maximum uncertainty in the Bouguer anomaly value of 0.18 mgals.

However, errors in the estimation of terrain corrections give rise to the greatest uncertainty in Bouguer values. Computer-generated terrain corrections in mountainous areas like the Ten Lakes Wilderness study area are believed generally accurate to within 1 mgal.

Data Reduction

Computer programs existing on the USGS Honeywell Multics computer system were used to obtain principal facts and terrain-corrected gravity values. A program written by D. Dansereau and R. Wahl (USGS, unpub. program, 1979) was used to reduce gravity meter readings to observed gravity values by calculating and correcting for earth-tide and linear meter drift. The theoretical gravity value was calculated using the 1967 formula of the Geodetic Reference System (International Association of Geodesy, 1967). Complete terrain corrections were computed using a program by R. H. Godson (USGS, unpub. program, 1978), which corrects for the gravity effects of terrain from each station to a radius 166.7 km away using the method of Plouff (1977). Godson's program also calculates earth curvature corrections and complete (terrain-corrected) Bouguer anomaly values. These computed terrain corrections use mean elevation data digitized on a 15-second grid for corrections from 0 to 5 km, 1-minute terrain data for corrections from 5 to 21 km, and 3-minute terrain data for corrections from 21 to 166.7 km. Densities of 2.67 g/cm^3 and 2.72 g/cm^3 were used to calculate terrain corrections, giving two complete Bouguer anomaly values per station. The corrections and anomaly values are listed in Appendix C.

References

- Defense Mapping Agency Aerospace Center, 1974, World Relative Gravity Reference Network, North America, Part 2: DMAAC Reference Publication 25, with supplement updating gravity values to the International Gravity Standardization Net 1971, 1635 p.
- International Association of Geodesy, 1967, Geodetic Reference System, 1967: International Association of Geodesy Special Publication 3, 74 p.
- Plouff, Donald, 1977, Preliminary documentation for a FORTRAN program to compute gravity terrain corrections based on topography digitized on a geographic grid: U.S. Geological Survey Open-File Report 77-535.

Figure 1: Map showing location of the Ten Lakes Proposed Wilderness gravity survey area.

KALISPELL

scale = 1:250,000
contour interval 200'

Appendix A: Kalispell gravity base station location and description

APPENDIX 3 GRAVITY BASE STATION			
LATITUDE		STATION DESIGNATION	
48° 18.50' N (1)		KALISPELL	
LONGITUDE			
114° 15.00' W (1)		COUNTRY/STATE	
ELEVATION		USA/Montana	
905.6 m (1)			
REFERENCE CODE NUMBERS		ADOPTED GRAVITY VALUE	
ACIC 0441-0		g = 980 567.39 mgals	
IGC 15684 J			
WA 32			
		ESTIMATED ACCURACY	DATE
		± 0.1 mgals	MONTH/YEAR
			1971
DESCRIPTION AND/OR SKETCH			
<p>Station is located at the Flathead Airport, six miles north of Kalispell, Mont., on the west side of St.Hwy. #206, inside the airport lobby, on the floor, at the west side of the entrance to the apron and loading area. (1)</p>			
REFERENCE SOURCE			
(1) 01355 (2) 05100			

Appendix B: Eureka gravity base station location and description

U.S. GEOLOGICAL SURVEY
GRAVITY BASE STATION

STATE/COUNTRY		STATION DESIGNATION		OBSERVED GRAVITY
Montana		Eureka Post Office		980660.70 mgals
NEAREST TOWN		LONGITUDE		LATITUDE
Eureka		115° 03.07'		48° 52.85'
ELEVATION		TOPOGRAPHIC MAP(S)		
786.4 m (2580')		Eureka North 1/24000 Kalispell 1/250,000		
DATE	OBSERVER	METER	REFERENCE STATION	REFERENCE VALUE
8/25/78	Howard/Kleinkopf	G-235	Kalispell DOD	980567.39 mgals

DESCRIPTION/SKETCH

Meter read on concrete sidewalk in front of eastern-most of 4 brick pillars, in front of the Eureka Post Office, located on the corner of 1st Ave. E. and 3rd Street.

Appendix C: Principal Facts of Gravity Data

Explanation of headings

Identification

proj	Project name.
sta id	Gravity station identification number.

Location

latitude	North latitude in degrees, decimal minutes.
longitude	West longitude in degrees, decimal minutes.
ele	Station elevation in feet.
st	State where station is located.

Gravity

observed	Observed gravity in milligals.
theoretical	Theoretical gravity in milligals.

Corrections

Terrain	Terrain correction, 166.7 km radius, in milligals.
Bouguer	Simple Bouguer slab correction in milligals.
curv	Curvature correction in milligals.
special	Not used.

Anomalies

free-air	Free-air anomaly in milligals.
complete-Bouguer	Complete Bouguer anomaly in milligals for designated densities d_1 and d_2 .
spec fields	Not used.

Ten Lakes Wilderness Gravity
Bankey and Mancinelli 1982

STATION IDENTIFICATION proj sta-id	L O C		A T I LONGITUDE deg min	O N S ELE (in ft)	G R A V I T Y ST OBSERVED	T E R R A I N BOUGUER CURV (d1=2.67)	C O R R E C T I O N S SPECIAL	F R E E A I R	A N O M A L I E S COMPLETE-BOUGUER d1=2.67 d2=2.72	S P E C F I E L D S				
	LATITUDE deg min	deg min												
eureka	48 52.85	-115	3.07	2580.00	mt	980660.70	980969.34	2.23	-88.00	-0.93	0.00	-66.06	-152.76	-154.38
eu1	48 56.41	-114	29.13	4187.00	mt	980549.90	980974.66	3.10	-142.81	-1.29	0.00	-31.14	-172.14	-174.78
eu2	48 56.23	-114	27.85	4115.00	mt	980552.07	980974.39	2.39	-140.35	-1.28	0.00	-35.47	-174.71	-177.32
eu3	48 55.60	-114	26.40	4041.00	mt	980552.45	980973.45	1.58	-137.83	-1.27	0.00	-41.10	-178.61	-181.19
eu4	48 55.13	-114	24.38	3898.00	mt	980557.54	980972.74	1.78	-132.95	-1.24	0.00	-48.75	-181.16	-183.64
eu5	48 53.96	-114	23.26	3771.00	mt	980559.23	980970.99	1.80	-128.62	-1.22	0.00	-57.25	-185.28	-187.68
eu6	48 52.57	-114	23.75	3984.00	mt	980545.43	980968.91	1.26	-135.88	-1.26	0.00	-48.95	-184.83	-187.37
eu7	48 52.68	-114	25.19	4058.00	mt	980545.82	980969.08	1.42	-138.41	-1.27	0.00	-41.77	-180.02	-182.61
eu8	48 53.74	-114	25.55	4125.00	mt	980544.64	980970.66	1.39	-140.69	-1.28	0.00	-38.23	-178.82	-181.45
eu9	48 54.11	-114	27.13	4310.00	mt	980537.08	980971.22	2.49	-147.00	-1.31	0.00	-28.97	-174.79	-177.52
eu10	48 54.03	-114	28.89	4490.00	mt	980527.02	980971.10	7.10	-153.14	-1.34	0.00	-21.99	-169.37	-172.13
eu11	48 53.83	-114	30.18	4747.00	mt	980507.22	980970.80	11.71	-161.91	-1.38	0.00	-17.34	-168.91	-171.75
eu12	48 53.51	-114	30.84	4937.00	mt	980496.44	980970.32	11.33	-168.39	-1.40	0.00	-9.79	-168.25	-171.21
eu13	48 52.96	-114	31.88	5153.00	mt	980487.47	980969.50	8.62	-175.75	-1.43	0.00	2.36	-166.20	-169.35
eu14	48 52.81	-114	32.96	5292.00	mt	980479.83	980969.27	6.75	-180.49	-1.44	0.00	8.01	-167.18	-170.46
eu15	48 52.51	-114	26.72	4244.00	mt	980540.18	980968.83	1.75	-144.75	-1.30	0.00	-29.68	-173.98	-176.68
eu16	48 52.93	-114	28.38	4666.00	mt	980517.01	980969.45	4.80	-159.14	-1.37	0.00	-13.81	-169.53	-172.44
eu17	48 51.74	-114	28.19	4228.00	mt	980542.57	980967.67	3.44	-144.20	-1.30	0.00	-27.63	-169.70	-172.36
eureka	48 52.85	-115	3.07	2580.00	mt	980660.70	980969.34	2.23	-88.00	-0.93	0.00	-66.06	-152.76	-154.38
eureka	48 52.85	-115	3.07	2580.00	mt	980660.70	980969.34	2.23	-88.00	-0.93	0.00	-66.06	-152.76	-154.38
eu18	48 50.98	-114	54.57	3226.00	mt	980609.90	980966.54	3.74	-110.03	-1.10	0.00	-53.35	-160.73	-162.75
eu19	48 51.71	-114	54.58	3286.00	mt	980606.59	980967.63	4.71	-112.08	-1.11	0.00	-52.11	-160.58	-162.61
eu20	48 51.95	-114	56.28	3037.00	mt	980618.54	980967.99	3.56	-103.58	-1.05	0.00	-63.92	-165.00	-166.89
eu21	48 51.55	-114	56.33	3021.00	mt	980618.09	980967.39	3.04	-103.04	-1.05	0.00	-65.27	-166.32	-168.21
eu22	48 50.88	-114	56.88	2886.00	mt	980627.92	980966.39	3.14	-98.43	-1.01	0.00	-67.13	-163.44	-165.24
eu23	48 50.58	-114	58.27	2785.00	mt	980638.85	980965.94	2.19	-94.99	-0.99	0.00	-65.24	-159.03	-160.79
eu24	48 49.72	-114	57.46	2736.00	mt	980640.00	980964.66	2.31	-93.32	-0.98	0.00	-67.42	-159.40	-161.13
eu25	48 50.11	-114	56.14	2841.00	mt	980627.95	980965.23	2.65	-96.90	-1.00	0.00	-70.18	-165.43	-167.21
eureka	48 52.85	-115	3.07	2580.00	mt	980660.70	980969.34	2.23	-88.00	-0.93	0.00	-66.06	-152.76	-154.38
eureka	48 52.85	-115	3.07	2580.00	mt	980660.70	980969.34	2.23	-88.00	-0.93	0.00	-66.06	-152.76	-154.38
eu26	48 54.92	-114	53.15	7225.00	mt	980368.62	980972.43	28.62	-246.42	-1.51	0.00	75.25	-144.06	-148.17
eu27	48 59.10	-114	50.53	5988.00	mt	980430.27	980978.68	14.38	-204.23	-1.50	0.00	34.45	-156.90	-160.49
eu28	48 58.21	-114	52.49	5532.00	mt	980484.50	980977.35	5.78	-188.68	-1.46	0.00	27.16	-157.21	-160.66
eu29	48 56.71	-114	49.14	6851.00	mt	980391.22	980975.11	14.13	-233.67	-1.52	0.00	60.04	-161.01	-165.15
eu31	48 56.63	-114	47.09	5797.00	mt	980461.93	980974.98	3.66	-197.72	-1.48	0.00	31.85	-163.69	-167.35
eu32	48 56.69	-114	45.85	5444.00	mt	980482.17	980975.08	4.17	-185.68	-1.46	0.00	18.83	-164.13	-167.56
eureka	48 52.85	-115	3.07	2580.00	mt	980660.70	980969.34	2.23	-88.00	-0.93	0.00	-66.06	-152.76	-154.38
eureka	48 52.85	-115	3.07	2580.00	mt	980660.70	980969.34	2.23	-88.00	-0.93	0.00	-66.06	-152.76	-154.38
eu33	48 56.93	-114	56.15	7614.00	mt	980342.01	980975.44	23.84	-259.69	-1.50	0.00	82.18	-155.17	-159.61

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STATION IDENTIFICATION proj sta-id	L O C A T I O N S		ELE (in ft)	ST	G R A V I T Y		C O R R E C T I O N S		A N O M A L I E S				
	LATITUDE deg min	LONGITUDE deg min			OBSERVED THEORETICAL	TERRAIN BOUGUER CURV (dl=2.67)	FREE AIR	COMPLETE-ROUGHER SPEC dl=2.67 dl2=2.72 FIELDS					
eu34	48 57.40	-114 57.41	7314.00	mt	980360.55	980976.14	23.21	-249.46	-1.51	0.00	71.85	-155.91	-160.17
eu35	48 58.94	-114 55.09	7623.00	mt	980351.85	980978.44	19.37	-260.00	-1.49	0.00	89.87	-152.26	-156.79
eu37	48 54.30	-114 52.28	6950.00	mt	980376.97	980971.50	21.50	-237.04	-1.52	0.00	58.70	-158.36	-162.42
eu38	48 54.77	-114 52.43	7002.00	mt	980377.59	980972.20	21.13	-238.82	-1.52	0.00	63.51	-155.69	-159.80
eu39	48 52.98	-114 51.01	7131.00	mt	980361.31	980969.53	23.95	-243.22	-1.51	0.00	62.02	-158.76	-162.90
eureka	48 52.85	-115 3.07	2580.00	mt	980660.70	980969.34	2.23	-88.00	-0.93	0.00	-66.06	-152.76	-154.38
eu40	48 55.51	-114 59.12	3786.00	mt	980582.42	980973.31	7.47	-129.13	-1.22	0.00	-34.96	-157.84	-160.14
eu41	48 55.77	-114 59.08	4004.00	mt	980568.73	980973.70	9.36	-136.56	-1.26	0.00	-28.56	-157.03	-159.43
eu42	48 52.09	-115 5.97	2917.00	mt	980643.20	980968.20	1.93	-99.49	-1.02	0.00	-50.74	-149.33	-151.17
eu43	48 51.42	-115 6.97	3090.00	mt	980633.14	980967.20	2.77	-105.39	-1.07	0.00	-43.54	-147.23	-149.17
eu44	48 48.95	-115 7.23	3348.00	mt	980617.24	980963.50	2.36	-114.19	-1.13	0.00	-31.50	-144.45	-146.57
eu45	48 47.42	-115 8.14	3474.00	mt	980608.09	980961.21	4.25	-118.49	-1.15	0.00	-26.51	-141.90	-144.07
eu46	48 46.90	-115 7.37	3612.00	mt	980599.31	980960.44	3.12	-123.19	-1.18	0.00	-21.55	-142.81	-145.08
eu47	48 46.70	-115 6.33	3714.00	mt	980592.49	980960.13	3.24	-126.67	-1.20	0.00	-18.48	-143.12	-145.45
eu48	48 46.06	-115 5.36	3760.00	mt	980588.69	980959.18	3.08	-128.24	-1.21	0.00	-17.01	-143.38	-145.75
eu49	48 45.30	-115 4.44	3824.00	mt	980583.27	980958.04	3.97	-130.43	-1.23	0.00	-15.26	-142.95	-145.34
eu50	48 49.80	-115 1.60	2993.00	mt	980632.91	980964.77	1.73	-102.08	-1.04	0.00	-50.47	-151.87	-153.77
eu51	48 48.93	-115 0.87	3126.00	mt	980623.58	980963.47	1.91	-106.62	-1.07	0.00	-46.00	-151.78	-153.76
eu52	48 47.87	-115 1.17	3457.00	mt	980603.65	980961.88	1.47	-117.91	-1.15	0.00	-33.23	-150.82	-153.02
eu53	48 46.61	-115 1.17	3583.00	mt	980594.00	980960.00	1.40	-122.21	-1.18	0.00	-29.15	-151.13	-153.42
eureka	48 52.85	-115 3.07	2580.00	mt	980660.70	980969.34	2.23	-88.00	-0.93	0.00	-66.06	-152.76	-154.38