Division of Geological & Geophysical Surveys

PRELIMINARY INTERPRETIVE REPORT 2003-2

PRINCIPAL FACTS FOR GRAVITY DATA COLLECTED IN THE COPPER RIVER BASIN AREA, SOUTHCENTRAL ALASKA

by

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December 2003

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3354 College Rd.
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INTRODUCTION

The Copper River basin is a topographic lowland encompassing an area of approximately 3,500 square miles, bordered by the Alaska Range on the north, the Wrangell Mountains on the east , the Chugach Mountains on the south and the Talkeetna Mountains on the west. The area consists of a relatively thin layer of Tertiary rock overlying a more complexly structured Cretaceous and Jurassic marine sedimentary section, which was deposited over massive volcanics in a tectonically active trough. The basin is, in part, geologically related to the Cook Inlet (Jones and Silberling, 1979) and has surficial deposits typically consisting of Quaternary glacial, lacustrine and alluvial sediments with local exposures of undeformed Tertiary continental deposits.

The surficial rocks can be divided into three distinctly different stratigraphic sequences separated by regional unconformities. The topmost Tertiary sequence is approximately 1,200 m thick and consists of sandstone, shale, conglomerate and minor volcanics with numerous low-rank (lignite) coal seams occurring throughout the section. This sequence consists of both Paleogene and Neogene sediments, in part equivalent to the Chickaloon Formation and the Kenai Group of the Cook Inlet basin. Beneath the Tertiary sequence lie rocks of the Upper Cretaceous sequence approximately 4,300 m thick consisting primarily of marine sediments of the Matanuska Formation. The basal sequence consists of a 2,700 m thick Middle Jurassic through Lower Cretaceous (Neocomian) sequence consisting of marine sandstone, siltstone and conglomerate from the Tuxedni Group, the Chinitna Formation and the Naknek Formation. Underlying this sedimentary sequence are Upper Jurassic and older volcanic rocks and metamorphosed volcanic sedimentary rocks (Andreasen, et. al., 1964; Jones and Silberling, 1979; Kirchner, 1986).

This basin has seen a significant exploration effort in the past, and is currently receiving increased interest for its petroleum potential. With relatively organic rich marine sediments providing source rock for the region and a number of gas shows and one tar residue show in the local wells, the petroleum potential is thought to be moderate.

In order to help stimulate interest in this area for petroleum exploration, the Division of Oil and Gas (DO&G) collected 45 additional gravity stations along profiles in the area during June of 2000. This survey was conducted in order to complement and extend the gravity data that is currently available from the U.S. Geological Survey (USGS). The gravity stations are located in the southwest corner of the Gulkana and the southeast corner of the Talkeetna Mountains 1:250,000 scale USGS topographic maps. The study area is bounded by 61° 45’ to 62° 30’ N. latitude and 146° 15’ to 147° 30’ W. longitude. Figure 2 represents a map of the study area showing the newly collected gravity stations in addition to the currently available USGS gravity stations.

GRAVITY-DATA ACQUISITION AND REDUCTION

A LaCoste and Romberg gravity meter (G507) was used to collect the new gravity station data. Conversion of the meter readings to milligals was made using factory calibration constants and a calibration factor determined by Dave Barnes of the USGS. During the field surveys, the gravity meter appeared to function properly, and a maximum drift of 0.48 mgal/day indicates there were no apparent tares in the data. The observed gravity values were based on an assumed linear drift between base station readings throughout the day.

Datum control for all of the gravity values was provided by the USGS Alaskan Gravity Base Station Network (Barnes, 1968; 1972) and was adjusted to the new absolute datum of the International Gravity Standardization Net 1971 (Morelli and others, 1974). The new gravity stations were tied to this network by reoccupying the "/GEB" base station twice each day with survey loops limited to 10 hours or less.

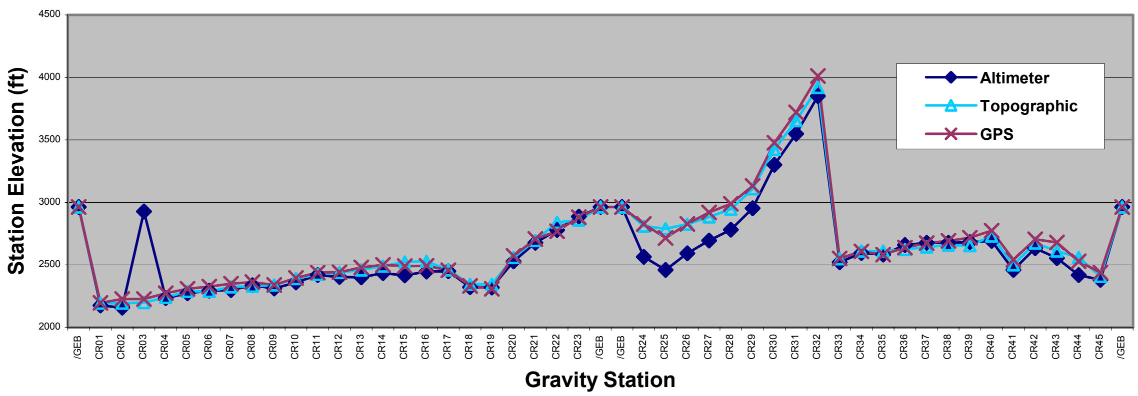

Figure 1. Graph comparing the altimetry, GPS and topographic station elevations.

Horizontal control was obtained using a Trimble Pathfinder Basic Plus portable Global Positioning System (GPS) unit and USGS topographic maps at a scale of 1:63,360. The station locations were located on USGS topographic maps in the field and digitized for comparison to the reduced GPS data. The GPS locations were processed using the Trimble GPS Pathfinder Office software and base station data obtained from the NOAA Continuously Operating Reference Stations (CORS) in Talkeetna and Glenallen. Standard processing techniques were applied to the GPS data by averaging the corrected data after applying differential corrections and selecting the best-corrected locations within the 68% confidence level. The accuracies for the corrected GPS locations were found to be ±6 feet, and in all but a few cases, were found to be of a higher accuracy, compared to the digitized locations. In a few cases, the GPS base station data did not collect enough information to get reasonable locations and the digitized values were used.

Vertical control was obtained using a Trimble Pathfinder Basic Plus portable GPS unit, American Paulin Model T-5 altimeters and USGS topographic maps at a scale of 1:63,360. The altimetry data was collected using three meters with the readings averaged at each station and corrected for diurnal barometric variations. Where feasible, the gravity stations were located at U.S. Coast and Geodetic Survey Vertical Angle Benchmarks (VABM) for comparison. Temperature and drift corrections were also applied and yielded elevations with an accuracy of ±30 feet. Elevations were also digitized from USGS topographic maps with an accuracy of ±50 feet and the GPS data was processed as described above and yielded data with an accuracy of ±10 feet. A comparison of the three elevations was made (Figure 1) and it was determined that for most of the stations, the GPS values provided the most accurate and consistent values for use in reducing the data.

Gravity reductions were run on all of the data (including the data obtained from the USGS) using standard techniques. Corrections for the variation of gravity with latitude at each station were computed based on the Geodetic Reference System 1967 (International Association of Geodesy, 1971) using the International Gravity Standardization Net 1971 gravity datum (Morelli and others, 1974). The observed gravity values were calculated by adding the meter drift and earth-tide corrections to the meter readings converted to milligals. Free-air anomalies were calculated by subtracting the theoretical gravity from the observed gravity and adding a free-air correction. Simple Bouguer anomalies were calculated by subtracting the Bouguer correction from the free-air anomaly, calculated using a gravitational constant of $6.67 \times 10^{-11}\ m^3\ kg^{-1}\ s^{-2}$ and a standard density of 2.67 gm/cc. Complete Bouguer anomalies were calculated by adding the terrain correction to the simple Bouguer anomaly and isostatic anomalies were calculated by adding the isostatic correction to the complete Bouguer anomaly.

Bob Morin of the USGS computed the terrain corrections for this data by using a computer program (Plouff, 1966, 1977; Godson and Plouff, 1988) and a digital terrain model. This program calculated the gravity effects of the surrounding terrain for each station from a radial distance of 0.39 km to a distance of 166.7 km using the standard Hammer technique (Hammer, 1939), in which average elevation estimates within zones surrounding the station are used to compute the gravity effect of each zone. The station elevations used for this correction were taken from the digitized USGS topographic maps at a scale of 1:63,360 in order to be consistent with the elevation model used for the terrain. No inner zone correction was applied due to the flat topography surrounding the stations.

Bob Morin also processed these data with an isostatic reduction program (Jachens and Roberts, 1981) to compensate for the effects of crustal roots that buoyantly support topography. The isostatic reduction assumes an Airy-Heiskanen model with a density of topography above sea level of 2.6 gm/cc and a crustal thickness at sea level of 25 km.

The locations of the gravity data collected in this survey as well as the data collected and available by the USGS can be seen in Figure 2. The data locations have been plotted on a topographic base with the new stations plotted in red while the USGS data are plotted in black. Figure 3 shows the contoured free-air anomaly values, Figure 4 shows the contoured complete Bouguer anomaly values and Figure 5 shows the contoured isostatic anomaly values. Table 1 lists the principal facts for the gravity stations collected during this survey.

ACKNOWLEDGMENTS

The authors gratefully acknowledge Tim Ryherd and Don Krouskop of the Division of Oil and Gas for reviewing the manuscript and providing many helpful suggestions. We also want to thank Kent Richter and Sunny Remmy with the Division of Oil and Gas for their assistance in collecting and reducing this data and Bob Morin with the USGS for computing all of the terrain and isostatic corrections.

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Table 1. Principal facts for the gravity stations collected during this survey. Topo represents the topographic elevation taken from USGS topographic maps at 1:63,360 scale. Elev represents the GPS station elevation used for reducing the data. FAA is the free-air anomaly, SBA is the simple Bouguer anomaly, CBA is the complete Bouguer anomaly and IA is the isostatic anomaly.

Station	Topo		Elev		Lat	Lon	Obs Grav	FAA	SBA	CBA	IA
/GEB	2963.00	F	2963.00	F	61.81702357	-147.46674953	981835.990	57.691	-43.365	-37.895	73.685
CR01	2195.00	F	2196.69	F	62.05564933	-146.54405128	981869.067	0.712	-74.209	-74.129	18.101
CR02	2195.00	F	2227.50	F	62.06685294	-146.55708591	981867.504	1.206	-74.765	-74.685	17.515
CR03	2200.00	F	2228.22	F	62.07950030	-146.56925434	981865.141	-2.039	-78.035	-77.935	14.255
CR04	2240.00	F	2273.61	F	62.09221959	-146.59922192	981861.192	-2.674	-80.217	-80.127	12.353
CR05	2290.00	F	2310.53	F	62.10879739	-146.61410844	981858.125	-3.512	-82.315	-82.255	10.265
CR06	2290.00	F	2328.42	F	62.12877528	-146.62053478	981855.822	-5.630	-85.043	-84.973	7.347
CR07	2325.00	F	2350.16	F	62.14542343	-146.63652646	981856.493	-4.163	-84.318	-84.298	8.122
CR08	2330.00	F	2363.35	F	62.16216670	-146.63836178	981854.675	-5.995	-86.600	-86.580	5.710
CR09	2340.00	F	2340.56	F	62.17934879	-146.65799387	981857.487	-6.615	-86.442	-86.442	6.018
CR10	2390.00	F	2396.59	F	62.19680718	-146.67601647	981857.133	-3.006	-84.744	-84.774	7.836
CR11	2425.00	F	2440.10	F	62.21078985	-146.69132782	981855.979	-1.114	-84.337	-84.387	8.393
CR12	2440.00	F	2442.30	F	62.22234117	-146.70897176	981858.759	1.008	-82.289	-82.339	10.591
CR13	2460.00	F	2481.60	F	62.23981545	-146.73166151	981865.116	9.755	-74.883	-74.943	18.247
CR14	2490.00	F	2500.18	F	62.25576285	-146.73703968	981867.844	13.038	-72.233	-72.293	20.867
CR15	2525.00	F	2489.60	F	62.27189324	-146.75658765	981871.465	14.459	-70.452	-70.502	22.868
CR16	2530.00	F	2493.47	F	62.28682146	-146.76915016	981873.530	15.772	-69.271	-69.311	24.179
CR17	2460.00	F	2457.96	F	62.18215350	-146.61463598	981849.342	-3.927	-87.758	-87.758	3.972
CR18	2345.00	F	2331.57	F	62.16308857	-146.68706507	981856.322	-7.406	-86.927	-86.917	6.183
CR19	2345.00	F	2309.75	F	62.15483529	-146.71563539	981856.318	-8.845	-87.621	-87.561	6.119
CR20	2560.00	F	2572.76	F	62.14812714	-146.76358147	981844.396	4.475	-83.272	-83.172	11.348
CR21	2695.00	F	2707.35	F	62.13572628	-146.80329527	981835.945	9.613	-82.724	-82.544	12.826
CR22	2840.00	F	2769.75	F	62.12503933	-146.84333128	981831.837	12.176	-82.290	-82.070	14.130
CR23	2860.00	F	2882.65	F	62.11620863	-146.87656254	981825.276	16.897	-81.419	-81.179	15.761
CR24	2810.00	F	2828.37	F	62.11236731	-146.93987061	981834.000	20.803	-75.661	-75.451	22.779
CR25	2790.00	F	2715.50	F	62.09710391	-146.97794033	981841.771	19.103	-73.512	-73.222	26.018
CR26	2825.00	F	2828.91	F	62.08214695	-147.00425881	981837.264	26.387	-70.097	-69.757	30.163
CR27	2885.00	F	2921.41	F	62.07082716	-147.03971506	981834.298	32.971	-66.667	-66.297	34.483
CR28	2945.00	F	2990.41	F	62.07037674	-147.06052909	981831.232	36.429	-65.562	-65.152	36.058
CR29	3110.00	F	3132.27	F	62.06213063	-147.09869133	981825.272	44.432	-62.398	-61.868	40.232
CR30	3425.00	F	3478.76	F	62.04432886	-147.14941991	981806.766	59.853	-58.794	-58.024	45.226
CR31	3655.00	F	3719.52	F	62.04001836	-147.17760769	981793.170	69.228	-57.631	-56.661	47.169
CR32	3920.00	F	4011.92	F	62.03102909	-147.20957719	981775.652	79.888	-56.943	-55.673	48.787
CR33	2550.00	F	2553.07	F	62.29703871	-146.78831697	981876.637	23.721	-63.354	-63.354	30.386
CR34	2610.00	F	2607.98	F	62.30990313	-146.79796650	981875.240	26.528	-62.420	-62.430	31.380
CR35	2610.00	F	2584.06	F	62.32857345	-146.80435240	981881.453	29.097	-59.035	-59.055	34.695
CR36	2625.00	F	2639.14	F	62.34896857	-146.82322900	981882.978	34.282	-55.729	-55.759	38.201
CR37	2645.00	F	2674.62	F	62.36214354	-146.84063852	981887.258	40.916	-50.305	-50.325	43.805

Table 1 (continued)

Station	Topo		Elev		Lat	Lon	Obs Grav	FAA	SBA	CBA	IA
CR38	2660.00	F	2693.41	F	62.37728859	-146.85608769	981888.972	43.268	-48.594	-48.624	45.686
CR39	2655.00	F	2717.88	F	62.39334207	-146.86976123	981895.367	50.768	-41.928	-41.938	52.472
CR40	2730.00	F	2774.00	F	62.41422255	-146.90323182	981902.734	61.859	-32.752	-32.732	62.068
CR41	2500.00	F	2540.84	F	62.19944301	-146.57459752	981850.074	3.306	-83.352	-83.332	7.698
CR42	2675.00	F	2704.82	F	62.20800384	-146.54184716	981840.318	8.333	-83.918	-83.898	6.582
CR43	2610.00	F	2678.73	F	62.22337436	-146.47675015	981843.251	7.662	-83.699	-83.699	5.821
CR44	2560.00	F	2530.14	F	62.23038719	-146.42405784	981862.323	12.232	-74.061	-74.101	14.749
CR45	2410.00	F	2440.58	F	62.24284544	-146.35649328	981862.321	2.875	-80.364	-80.494	7.526

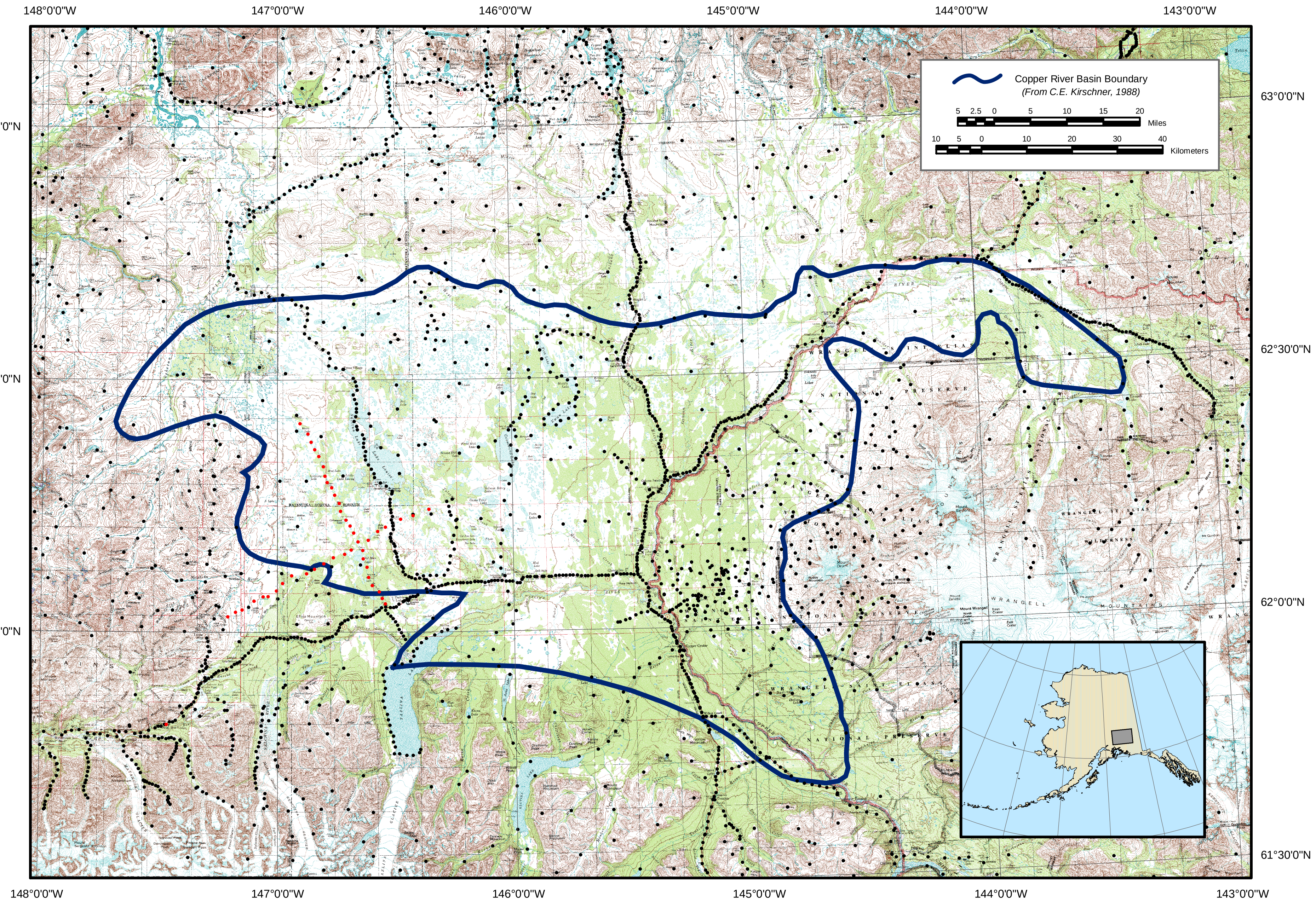

Figure 2. Index map of the study area showing the locations of the gravity data collected for this study in red. The previously collected data is shown in black. The map base is a composite of USGS 1:250,000 scale topographic maps.

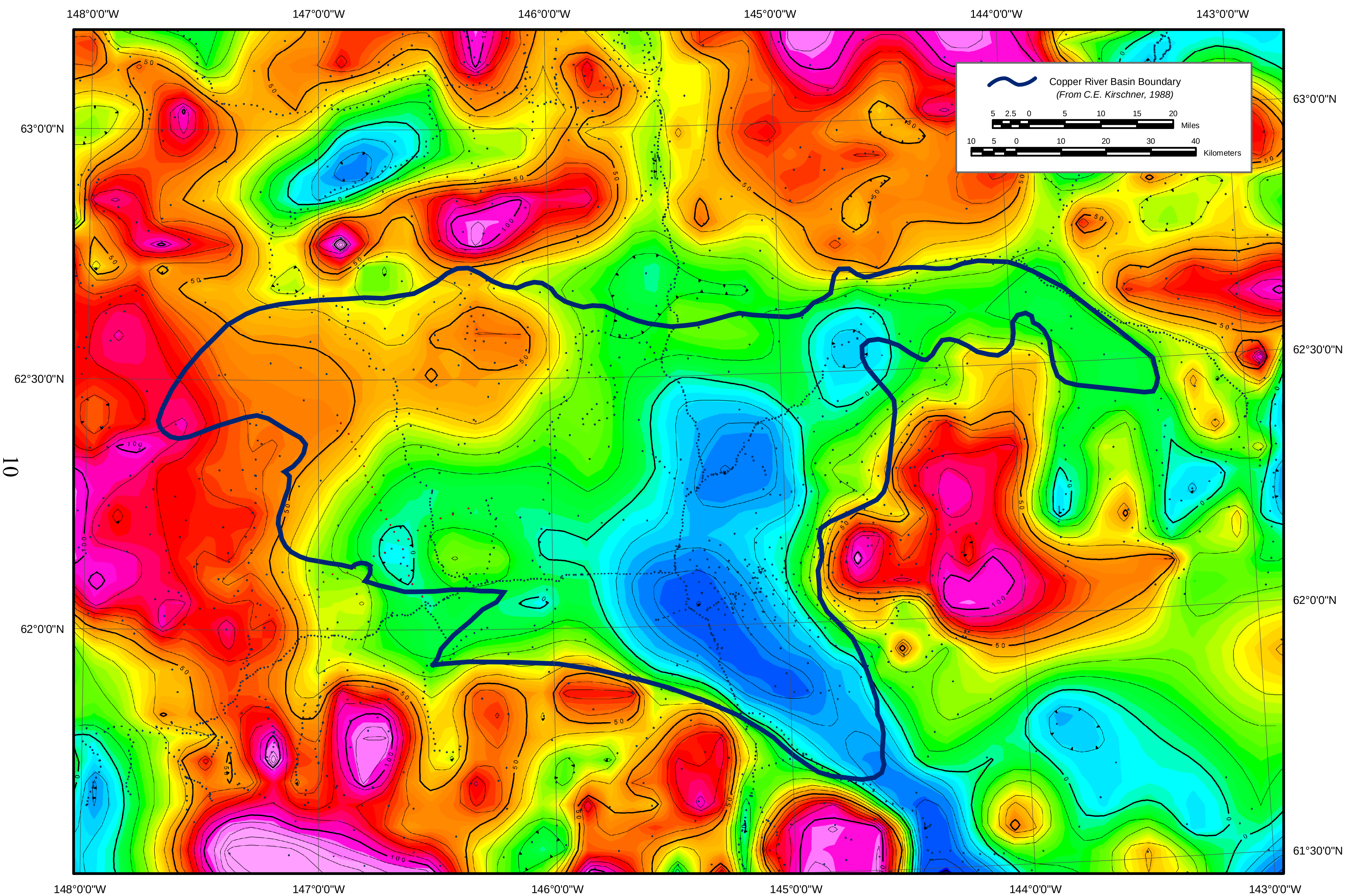

Figure 3. Free-air gravity map of the Copper River Basin with a contour interval of 10 mGal.

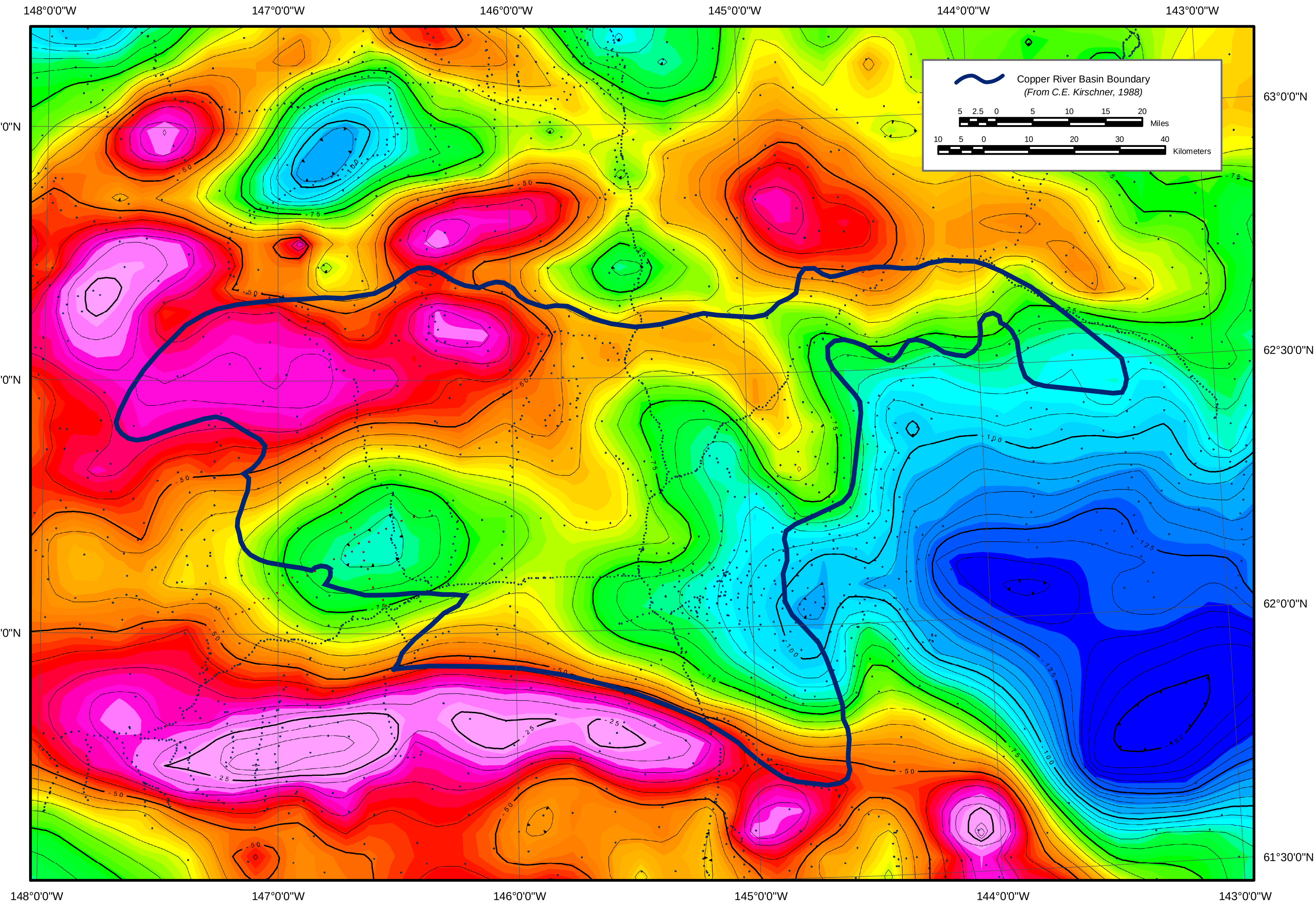

Figure 4. Complete Bouguer gravity map of the Copper River Basin with a contour interval of 5 mGal.

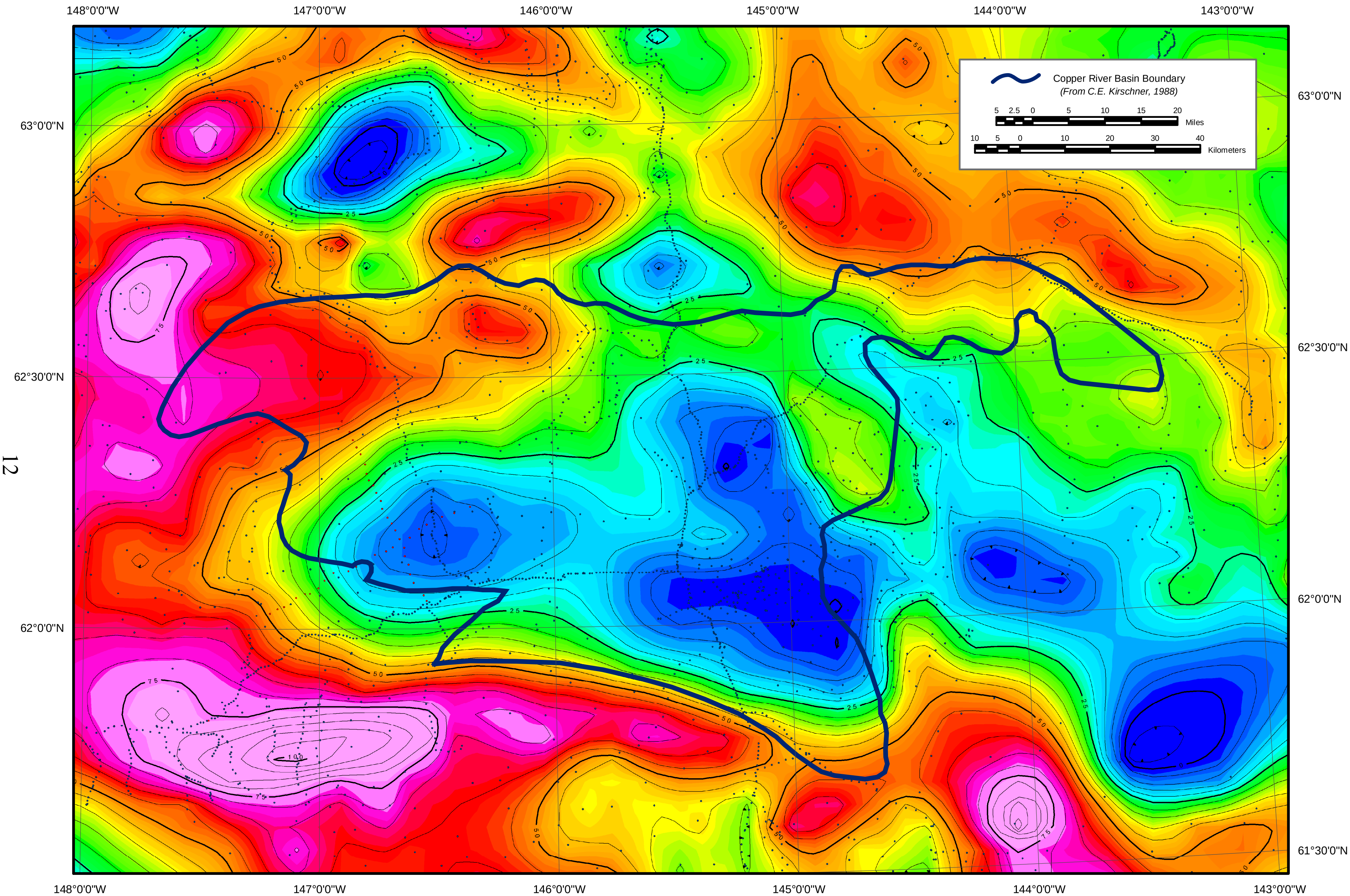

Figure 5. Isostatic gravity map of the Copper River Basin with a contour interval of 5 mGal.