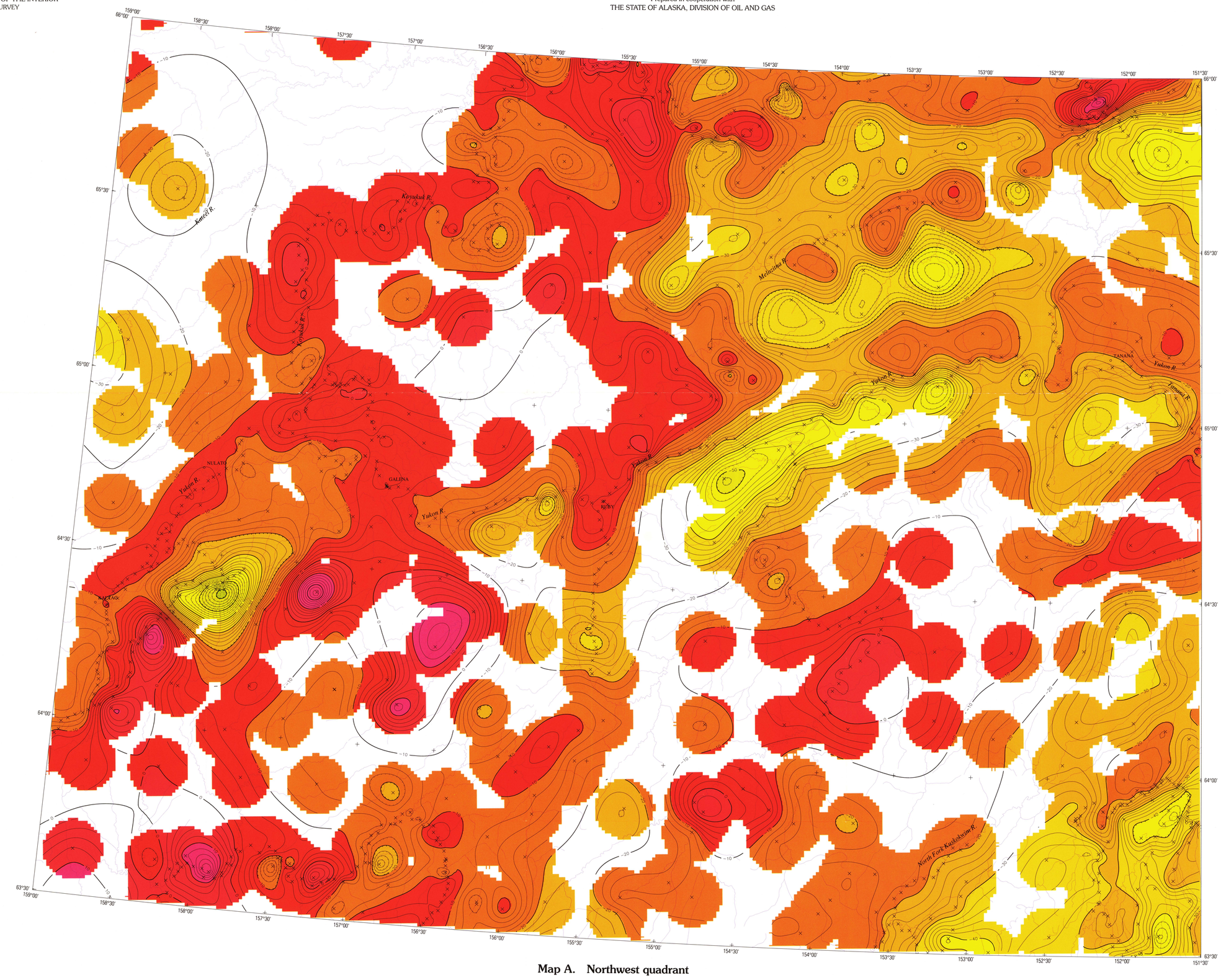
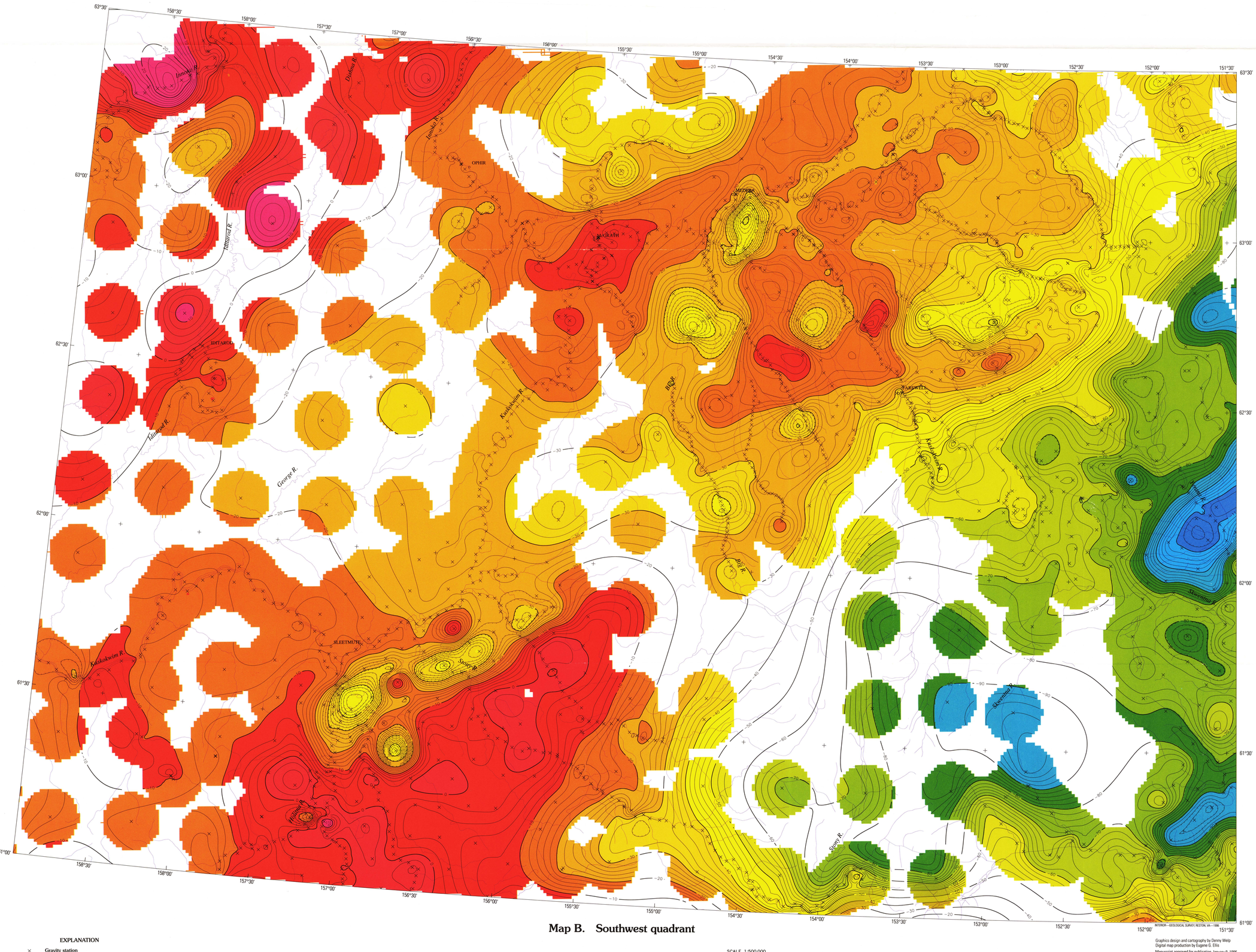
Prepared in cooperation with
THE STATE OF ALASKA, DIVISION OF OIL AND GAS



Map A. Northwest quadrant



Map B. Southwest quadrant

INTRODUCTION

These complete Bouguer gravity maps of interior Alaska are part of a cooperative effort by the State of Alaska Division of Oil and Gas and the U.S. Geological Survey (USGS) to provide background information for future Alaskan petroleum and mineral exploration. Along with an accompanying set of aeromagnetic maps (Meyer and Saltus, 1995) they provide a compilation of all publicly available potential-field geophysical data covering the primary Cenozoic structural basins within the state-controlled lands of the Alaskan interior. The maps are 1:500,000 scale and are prepared from digital data sets using an Albers equal-area projection.

GRAVITY DATA

The gravity maps summarize about 9,800 measurements made by the U.S. Geological Survey, the State of Alaska, and other groups between 1958 and 1992. Most of the data are contained in previous compilations, but this report contains the first digitally compiled maps that have terrain corrections on all measurements. Previous map compilations covering the same area and using much of the same data are a simple Bouguer gravity map of Alaska (Barnes, 1977) and the state isostatic gravity map (Barnes and others, 1994). Previous larger scale compilations of specific sedimentary basins covered the Minto Flats (Barnes, 1962), the Copper River Basin (Andreasen and others, 1964), the Medfra-McGrath Lowlands (Barnes, 1973), and the Beluga Basin (Hackett, 1977). These early maps used the 1930 international ellipsoid and the Potsdam gravity datum and have a resulting anomaly difference of about +8 mGal from the present maps. More recent, detailed compilations using the present IGSN-71 datum and 1967 ellipsoid cover the Holitna Basin and the Minchumina Basin (Meyer and Krouskop, 1984, 1986) and the Nenana Basin (Valin and others, 1991; Frost and others, in press). Sources of data used for more mountainous parts of the maps are summarized by Barnes (1977). Those sources are now supplemented by the surveys of Hackett (1981 a, b), Burns (1982), Burns and others (1985), Cady and Weber (1983), Cady and Morin (1988), and Wescott and others (1983). The maps also include unreduced data contributions received as unpublished written communications from U.S. Geological Survey investigators William F. Isherwood (1976), David L. Campbell (1982, 1983, 1984), and Michael A. Fisher (1984–92) and the University of Alaska's Ronald G. Cothren (November 1993). Unpublished data from the U.S. Department of Defense Gravity Library (Kenneth E. Burke, written commun., 1994) provide additional control.

DATA COMPILATION AND REDUCTION

The gravity values are complete Bouguer anomalies, which show the variation of gravitational attraction after the removal of a theoretical value calculated for the effects of latitude and elevation differences on the earth surface (Heiskanen and Vening Meinesz, 1958). The latitude effects were calculated by the 1967 Geodetic Reference System (International Association of Geodesy, 1971), and the elevation effects were derived from the standard free-air gradient of 0.3086 mGal/m (neglecting second order terms) and a standard density of 2.67 g/cm^3. The gravity datum was established from the IGSN-71 network values at Fairbanks and Anchorage (Morelli and others, 1974). Other data reduction steps followed the procedures for Alaskan gravity data as outlined by Barnes (1972). Terrain corrections between an inner radius of 0.39 km (zone E of Hammer, 1934) through 166.7 km (Hayford's zone O from Swick, 1942) were calculated by the terrain correction program of Plouff (1977) using digitized mean elevations. The primary sources of the terrain data were the USGS digital-elevation model (DEM) tapes (Elassal and Caruso, 1983), which were read and gridded into three files of 1/4 × 1/2-minute, 1 × 2-minute, and 3 × 6-minute mean elevations for the terrain correction program (Barnes, 1984). The accuracy of these terrain files has not been carefully evaluated, but small errors are known to exist for data in the Anchorage, Russian Mission, Bethel, Goodnews, Seward and possibly other quadrangles. The DEM data do not include bathymetric or ice-thickness data for lake, ocean and glacier areas; only the elevations of the upper surfaces of most such areas were used for the terrain corrections. However, the 3 × 6-minute mean-elevation file, which was used for outer-zone corrections, included oceanic bathymetric data derived by regridding the 5 × 5-minute topographic data set of the world (National Geophysical Data Center, 1986).

First-order level lines and triangulation networks cover only small parts of the Alaskan interior, so the vertical control is very limited. Photogrammetric mapping at 1:63,360 scale now covers most of the state, but primarily because of poor vertical control this mapping does not conform to national map-accuracy standards. The local relief is well portrayed, but broad areas (covering thousands of square kilometers) that have absolute elevation errors exceeding 30 m have been found on some maps. Thus, altimetry measurements have supported almost all Alaskan gravity measurements. The data files for most stations also contain a second elevation, if possible a surveyed elevation, perhaps a spot elevation, and otherwise a contour-interpolation elevation. Initially, comparison between the altimetry and the second elevation was used primarily as a check on the accuracy of both the altimetry and the station location. After the digital-elevation-model (DEM) data made routine terrain corrections possible, the second elevation proved useful because it almost always agrees with the relative terrain data. In Alaskan gravity data reduction, all surveyed elevations and many river-gradient elevations have been used as station elevations for the entire Bouguer correction. Otherwise, the altimeter elevation (usually considered preferable) is used for the infinite-slab part of the Bouguer correction, and the second (map) elevation is used for the terrain correction. In limited tests this system seems to produce the most consistent results. Inner-zone corrections (within 0.39 km) were not made, because a large sampling (Barnes, 1981, and unpublished data) shows that these inner-zone corrections seldom exceed 1.0 mGal. One milligal is also approximately equivalent to a 5-m elevation error, the estimated accuracy of most altimetry and one half the smallest contour interval on these maps.

The bulk of the gravity data are probably accurate to about 1.0 mGal, but a few larger errors are undoubtedly still present in the data. Possible sources of these larger errors include extreme altimetry errors caused by misread scales or abnormal weather, inaccurate field locations, and data processing mistakes. Poor data coverage over much of the study area makes it difficult to evaluate accuracy by comparison to nearby measurements. As highlighted by the uncolored areas of these maps, there is a clear need for additional gravity data in interior Alaska.

The 1-km gravity data grids for these maps are available from the National Geophysical Data Center in Boulder, Colorado; most of the principal facts are available on a CD-ROM (Hittleman and others, 1994).

MAP PRODUCTION

The locations of all the gravity measurements were projected from their latitude and longitude coordinates to an Albers Conical Equal-Area projection defined by a base latitude of 55° and central meridian of 151° (Snyder, 1983). Once the data were projected, the complete Bouguer anomalies were gridded using a proprietary gridding code (Surface Gridding Library by Dynamic Graphics, Inc., Berkeley, CA). Two grids with row and column spacing of 1 km were constructed: a complete grid contains interpolated and extrapolated values for the entire study area, and a limited grid contains interpolated and extrapolated values for regions of the study area within 10 km of an observation point. The two grids were then split into four subgrids. These subgrids were converted to postscript images as follows: they were interpolated to 0.25-km row and column spacing. Color images (10 mGal color interval; reds are gravity highs and blues are gravity lows) and 2-mGal contour lines were generated from the limited grid for regions within 10 km of an observation point. Ten-mGal computer generated contour lines, generated from the complete grid were then superimposed on the color image. River and town locations are from the digital line graph (DLG) data set (Domeratz and others, 1983, and U.S. Geological Survey, 1992). The color images and linework for the maps were combined into single PostScript files for each map sheet, and the files were imported into Adobe Illustrator for map annotation. The files were then converted to the Scitex format, which was used to create the color-separation negatives.

MAP USAGE

The maps were planned as an attempt to show the size of the interior basins and the availability of pertinent data, but they should be used with caution. The many colorless areas clearly show where additional data are needed, but even the colored areas may give a deceptive indication of basin size. The gridding routine employed attempts to fit the smoothest possible surface between the data points. In some cases this technique may produce circular contours around widely spaced measurements so that linear anomalies may appear as chains of circles instead of continuous features.

Hand contouring aided by knowledge of available geologic and aeromagnetic data was used to draw the earlier state gravity maps (for example, Barnes, 1962; Barnes, 1973; Barnes, 1977). The initial Bouguer map of Alaska (Barnes, 1977) contained an interpretive index that outlined the principle Cenozoic-basin anomalies. In areas of low topography the simple Bouguer anomalies should be similar to the complete Bouguer anomalies on this map. The isostatic anomaly map (Barnes and others, 1994) shows the extensions of some of these anomalies into adjacent mountainous areas, and its interpretive inset and table references other sources of geophysical data. For example, interpretive contouring of the 1977 map used evidence of a southward decrease in gravity across the meander belt of the Yukon River west of the town of Tanana. This gradient was combined with geologic knowledge of Tertiary outcrops along the Yukon River Palisades to suggest a narrow Tertiary trough south of the river, which was interpreted as evidence for the Lower Tanana Basin proposed by Miller and others (1959). The present map shows a smaller, more discontinuous trend for this feature and thus indicates the need for much additional data to clearly define the anomaly and size of this possible petroleum basin.

REFERENCES CITED

Andreasen, G.E., Grantz, Arthur, Zietz, Isidore, and Barnes, D.F., 1964, Geologic interpretation of magnetic and gravity data in the Copper River Basin, Alaska: U.S. Geological Survey Professional Paper 316–H, 153p, 2 plates.

Barnes, D.F., 1962, Gravity low at Minto Flats, Alaska, *in* Geological Survey Research 1961: U.S. Geological Survey Professional Paper 424–D, p. 254–257.

———1972, Notes on processing and presentation of U.S. Geological Survey Alaskan gravity data: U.S. Geological Survey Open-File Report 72–16, 25 p.

———1973, U.S.G.S. gravity data maps of Medfra and McGrath quadrangles: U.S. Geological Survey open-file report, 2 sheets, scale 1:250,000.

———1977, Bouguer gravity map of Alaska: U.S. Geological Survey Geophysical Investigations Map GP–913, 1 sheet, scale 1:2,500,000.

———1981, Supplementary terrain corrections for gravity data from the National Petroleum Reserve in Alaska: National Geophysical Data Center NPRA data set TGR–0230, 10 p.

———1984, Digital elevation models improve processing of Alaskan gravity data, *in* Coonrad, W.L. and Elliott, R.L., eds., U.S. Geological Survey in Alaska—Accomplishments during 1981: U.S. Geological Survey Circular 868, p. 5–7.

Barnes, D.F., Mariano, John, Morin, R.L., Roberts, C.W., and Jachens, R.C., 1994, Incomplete isostatic gravity map of Alaska, *in* Plafker, George, and Berg, H.C., eds., The geology of Alaska: Boulder, Colorado, Geological Society of America, The Geology of North America v. G1, plate 9, scale 1:2,500,000

Burns, L.E., 1982, Gravity and aeromagnetic modeling of a large gabbroic body near the Border Ranges fault, southern Alaska: U.S. Geological Survey Open-File Report 82–466, 59 p.

Burns, L.E., Pessel, G.H., and Fazmigala, G.J., 1985, Simple Bouguer gravity map of part of the northwest Chugach Mountains, Anchorage quadrangle, south central Alaska: Alaska Division of Geological and Geophysical Surveys Public Data File 85–44, 1 sheet.

Cady, J.W., and Weber, F.R., 1983, Aeromagnetic map and interpretation of aeromagnetic and gravity data, Circle quadrangle, Alaska: U.S. Geological Survey Open-File Report 83–170–C, 38 p.

Cady, J.W., and Morin, R.L., 1988, Aeromagnetic and gravity data, *in* Weber, F.R., McCammon, R.B., Rinehart, C.R., Light, T.D., and Wheeler, K.L., eds., Geology and mineral resources of the White Mountains National Recreation Area, east central Alaska: U.S. Geological Survey Open-File Report 88–284, p. 59–77.

Domeratz, M.A., Hallam, C.A., Schmidt, W.E., and Calkins, H.W., 1983, Digital line graphs from 1:2,000,000-scale maps: U.S. Geological Survey Circular 895–D, 38 p.

Elassal, A.A., and Caruso, V.M., 1983, Digital elevation models: U.S. Geological Survey Circular 895–B, 40 p.

Frost, G.M., Barnes, D.F., and Stanley, R.G., 1996, Geologic and isostatic gravity map of the Nenana basin area, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I–2543, 3 sheets, scale 1:250,000.

Hackett, S.W., 1977, Gravity survey of Beluga basin and adjacent area, Cook Inlet region, south central Alaska: Alaska Division of Geological and Geophysical Surveys Geologic Report 49, 26 p., 1 plate.

———1981a, Tabulated gravity field data, north flank of the Alaska Range, Alaska: Alaska Division of Geological and Geophysical Surveys Open-File Report 138, 6 p.

———1981b, Tabulated gravity field data, Cook Inlet, south central Alaska: Alaska Division of Geological and Geophysical Surveys Open-File Report 139, 15 p.

Hammer, Sigmund, 1934, Terrain corrections for gravimeter stations: Geophysics, v. 4, p. 184–194.

Heiskanen, W.K., and Vening Meinesz, F.A., 1958, The earth and its gravity field: New York City, N. Y., McGraw Hill, 470 p.

Hittleman, A.M., Dater, D.T., Bohman, R.W., and Racey, S.D., 1994, Gravity—1994 edition CD ROM and users' Manual: National Geophysical Data Center, 29 p.

International Association of Geodesy, 1971, Geodetic Reference System 1967: International Association of Geodesy Special Publication 3, 116 p.

Meyer, J.F., and Krouskop, D.L., 1984, Preliminary gravity data, Holitna basin, south central Alaska: Alaska Division of Geological and Geophysical Surveys Report of Investigations 84–25, 6 p., 2 plates, scale 1: 500,000.

———1986, Preliminary gravity data of the Minchumina basin, south central Alaska: Alaska Division of Geological and Geophysical Surveys Report of Investigations 86–1, 14 p., 2 plates, scale 1:500,000.

Meyer, J.F., and Saltus, R.W., 1995, Merged aeromagnetic map of interior Alaska: U.S. Geological Survey Geophysical Investigations Map GP–1014; 2 sheets, scale 1:500,000.

Morelli, Carlo, Gantar, C., Honkasal, Tauno, McConnell, R.K., Tanner, J.G., Szabo, Bela, Uotila, V.A., and Whalen, C.T., 1974, The international gravity standardization net 1971 (I.G.S.N. 71): Paris Bureau Central de l'Association International de Geodesie Special Publication 4, 174 p.

National Geophysical Data Center, 1986, Digital relief of the surface of the earth, 5′ × 5′ gridded data: National Geophysical Data Center magnetic tape ETOPO–5.

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, 44 p.

Snyder, J.P., 1983, Map projections used by the U.S. Geological Survey: U.S. Geological Survey Bulletin 1532, 313 p.

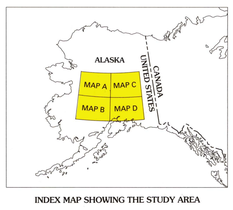
Swain, C.J., 1976, A FORTRAN IV program for interpolating irregularly spaced data using the difference equations for minimum curvature: Computers and Geosciences, v. 1, p. 231–240.

Swick, C.H., 1942, Pendulum gravity measurements and isostatic reductions: U.S. Coast and Geodetic Survey Special Publication no. 232, 82 p.

U.S. Geological Survey, 1992, 1:2,000,000-scale digital line graph (DLG) data CD–ROM: U.S. Geological Survey.

Valin, Z.C., Bader, J.W., Barnes, D.F., Fisher, M.A., and Stanley, R.G., 1991, Simple Bouguer anomaly map of the Nenana basin area, Alaska: U.S. Geological Survey Open-File Report 91–33, scale 1:250,000, 5 sheets.

Westcott, E.M., Petzinger, Betty, Witte, William, Turner, R.L., and Bender, Gary, 1983, A gravity survey of part of the eastern Copper River Basin, Alaska, *in* Wescott, E.M., and Turner, D.L., eds., Final report on the investigation of the geothermal energy resources potential of the eastern Copper River Basin, Alaska: University of Alaska report RSA82–5X–670, 127 p., 2 plates.



INDEX MAP SHOWING THE STUDY AREA

EXPLANATION

Gravity station

Gravity contour—Contour interval 2 mGal

CONVERSION FACTORS

Multiply	By	To obtain
centimeters (cm)	0.3937	inches (in)
meters (m)	3.281	feet (ft)
kilometers (km)	0.6214	miles (mi)

SCALE 1:500 000

10 0 10 20 30 40 50 MILES

10 0 10 20 30 40 50 KILOMETERS

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA—1996

Graphics design and cartography by Denny Welp
Digital map production by Eugene G. Ellis
Manuscript approved for publication January 8, 1996

BOUGUER GRAVITY MAP OF INTERIOR ALASKA

By
John F. Meyer, Jr., Richard W. Saltus, David F. Barnes, and Robert L. Morin

1996

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U.S. Government Printing Office: 1996—774-067