U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

Merged Aeromagnetic Data for Washington: A Web Site for Distribution of Gridded Data and Plot Files

by

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Open-File report 98-241

1998

Abstract

This report is a listing of the primary information pages in the following web site:

http://minerals.cr.usgs.gov/publications/ofr/98-241/wash.html

This web site describes the results of a USGS project to merge the best available aeromagnetic data into a consistent 500-m grid spanning the state of Washington. The website allows users to download (via FTP) data files (in several formats) and plot files. The anonymous FTP sites are:

ftp://minerals.cr.usgs.gov/minerals/ofr/98-241/data

and

ftp://minerals.cr.usgs.gov/minerals/oft/98-241/plots

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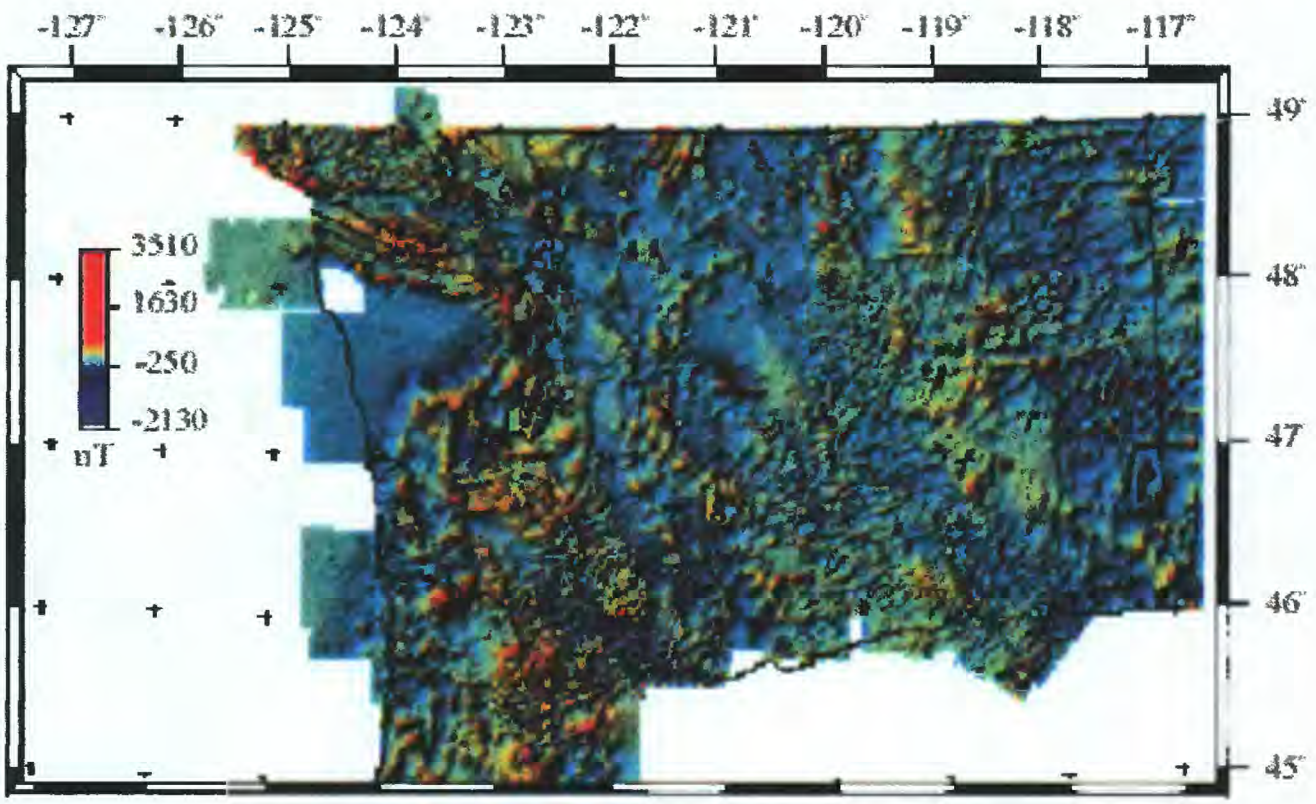
Washington Aeromagnetic Maps and Data



Get Map Info...

Get Processing Info...

Get Survey Info...

Get Gravity Map...

Get Plots...

Get Data...

Non-graphical version of this page

URL: http://minerals.cr.usgs.gov/publications/ofr/98-241/wash.html
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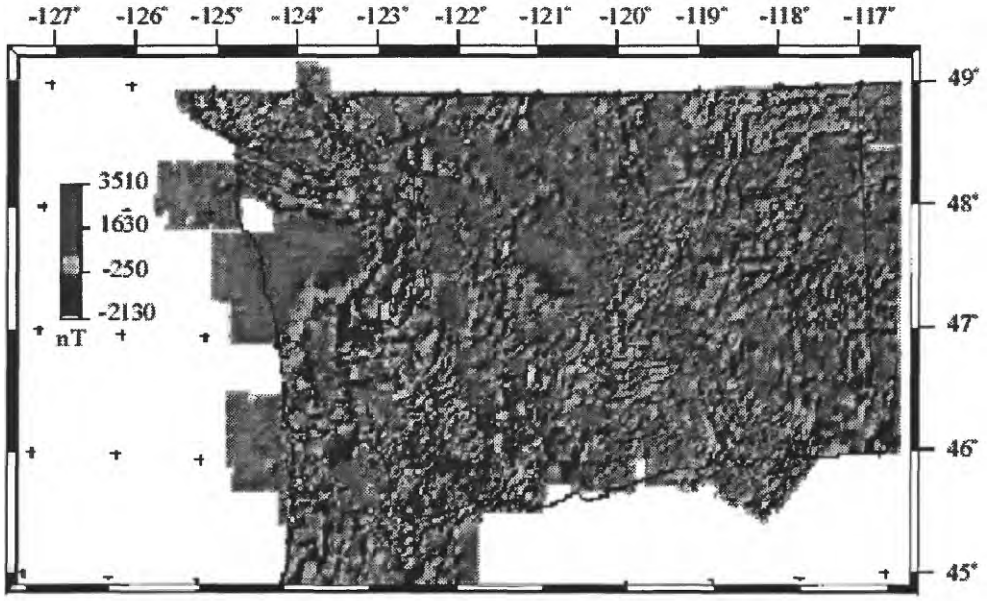
Washington Aeromagnetic Maps and Data

This is a non-image-mapped page to allow folks with older browsers to access all the individual pages that make up the Washington Aeromagnetic web site (USGS Open-file report 98-241).
Pick a destination from the list below:

Read map text
Read project details
Examples of the aeromagnetic map utility
Isostatic gravity map
Aeromagnetic survey index map
Aeromagnetic survey table
Reference list
Download gridded data via FTP
Download binary plot files via FTP



URL: http://minerals.cr.usgs.gov/publications/ofr/98-241/wash_nograph.html

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Washington Aeromagnetic Compilation

These maps show variations in the Earth's magnetic field caused primarily by the uneven distribution of the mineral magnetite in the rocks that make up the upper part of the Earth's crust. The features and patterns of the maps reveal details of subsurface geology including the locations of buried faults, the location of magnetite-bearing rocks (which include many kinds of rocks of interest to mineral exploration), and the thickness of surficial sedimentary rocks (see examples).

The map is constructed from grids that combine information (see data processing details) collected in 41 separate aeromagnetic surveys conducted over the past 35 years. The data from these surveys are of varying quality; the southeastern region of Washington are covered only by very coarse surveys. An index plot (see plot) gives an overview of the flightline spacing of the original surveys. A data table (see table) summarizes the detailed specifications of the surveys.

HPGL plot files for the image can be downloaded (see download plots) for plotting at true scale (1:1,000,000) for the overview map.

We thank Lisle Exploration for help with the Hanford aeromagnetic data. This project was supported by the Mineral Resource, Energy Resource, and Earthquake Hazards Programs of the U.S. Geological Survey.

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URL: http://minerals.cr.usgs.gov/publications/ofr/98-241/wash_desc.html
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Washington Aeromagnetic Data Processing

The assembly of 41 individual aeromagnetic surveys and grids to build the Washington state-wide compilation was done in several steps.

DATA PROCESSING STEPS

1. Grids were constructed from the original aeromagnetic survey data with a cell size of between 1/3 and 1/5 of the flightline spacing of the survey, using a bidirectional gridding algorithm when necessary due to wide flightline spacing. For digitized contour line data, the initial grid was constructed using a minimum curvature algorithm and a spacing appropriate for the scale of the digitized map.
2. Data quality problems were addressed.
3. The Definitive Geomagnetic Reference Field (DGRF), in conjunction with the International Geomagnetic Reference Field (IGRF) 1990, was applied for the date of the original survey (in some cases this required the determination and correction for the original reference field applied).
4. The survey grids were regridded, as necessary, to the final grid cell size of 500 m using a minimum curvature algorithm.
5. The original survey grids were upward or downward continued and converted from level to drape as necessary to produce a consistent survey specification of 1000 ft above ground. Upward continuation of the NURE surveys was by standard 2D FFT filtering techniques. Downward continuation and level-to-drape was performed (Cordell and others, 1992).
6. The datum levels of the converted grids were then adjusted to minimize differences at the boundaries.
7. These adjusted grids were combined into a single merged grid.

GRID PROJECTION SPECIFICATIONS

- Projection = Lambert conformal conic
- Central meridian = 122 W
- Base latitude = 45 N
- Standard parallels = 33 and 45 N

- Semi-major ellipsoid axis = 6378206.4 m
- Eccentricity squared = 0.0067686579973

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URL: http://minerals.cr.usgs.gov/publications/ofr/98-241/wash_proc.html
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Examples of the Utility of the Washington Magnetic Map

Positive magnetic anomalies (shown in red colors) are produced by normally magnetized rocks; negative anomalies (shown in blue colors) are related to rocks less magnetic than adjacent rocks or to reversely magnetized volcanic rocks. Positive anomalies in the Coast Range reflect exposed and buried Eocene basalts. Negative anomalies in the Coast Range result from several sources: 1. sedimentary basins, 2. reversely magnetized Eocene basalts and 3. tectonically overturned normally magnetized basalts. High frequency anomalies typical of young volcanic rocks occur over the Cascade Range. Linear positive and negative magnetic anomalies extending several hundred kilometers are associated with normal and reversed dikes and folds in the Columbia Plateau. Interpreted buried plutons in the Cascade Range and northeastern part of the state are associated with positive magnetic anomalies. One of the highest ampitude positive anomalies on the map is associated with the serpentinized pre-Tertiary Ingalls ophiolite.

Several faults in western Washington are easily seen on the magnetic map: 1. the Seattle Fault; 2. the South Whidbey Island fault; 3. the Leach River fault; 4. the San Juan Island fault. In northeastern Washington linear anomalies are associated with the Toroda Creek and Republic grabens and the Pasayten fault, which bounds the eastern edge of the Methow trough.

Many prominent anomlies are not associated with the mapped geology. The aeromagnetic, combined with other geophysical data, can be used to delineate the buried sources of these anomalies.

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URL: http://minerals.cr.usgs.gov/publications/ofr/98-241/wash_examp.html
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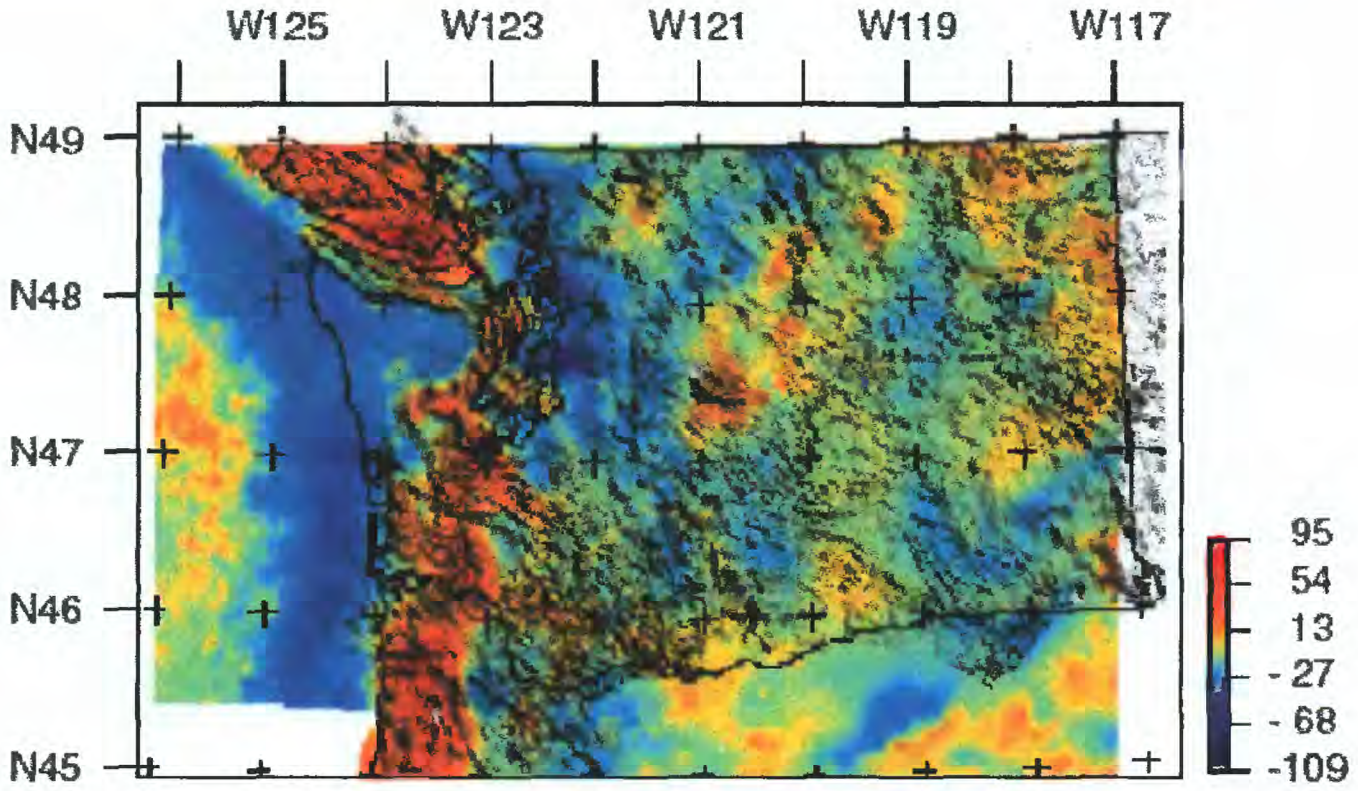
Washington Isostatic Gravity Map



The colors on this map reflect variations in the Earth's gravity field caused primarily by lateral variations in density in the rocks that make up the upper part of the Earth's crust. This map is known as an isostatic gravity map and was derived from Bouguer and Free-Air anomaly maps (Finn and others, 1984). The features and patterns of the maps reveals details of subsurface geology including the location of buried faults, sedimentary basins, plutons, uplifted oceanic rocks, etc. Positive anomalies (red colors) delineate rocks denser than the surrounding rocks. Negative anomalies (blue colors) delineate rocks less dense than the surrounding rocks. The gravity map is superimposed on the magnetic map (shading).

The gravity data are available from the National Geophysical Data Center (NGDC). HPGL plot files for the image can be downloaded (see download plots) for plotting at true scale of 1:1,000,000 for the overview map.

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URL: http://minerals.cr.usgs.gov/publications/ofr/98-241/wash_iso.html
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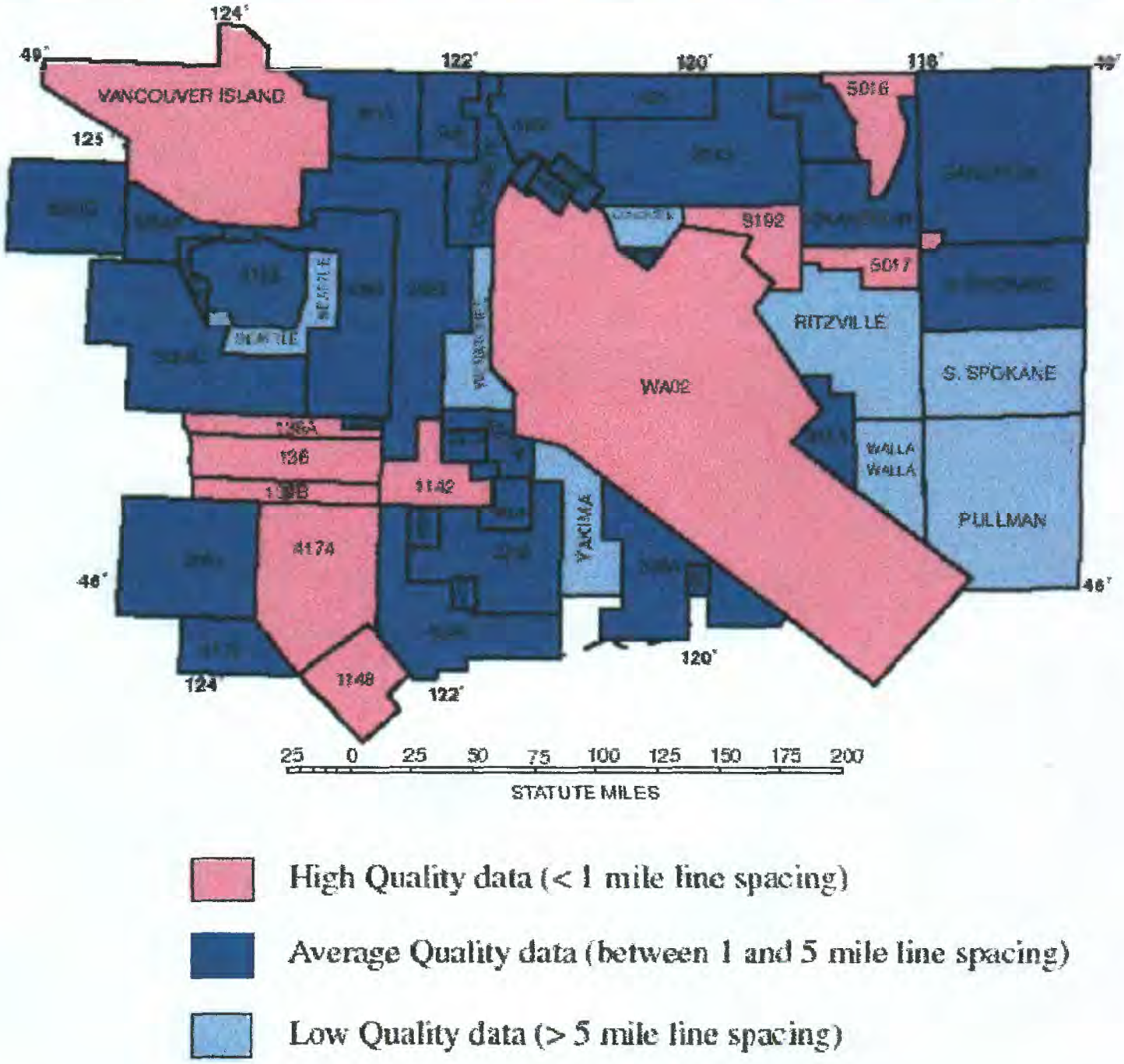
Washington Aeromagnetic Data Index Map



The Washington aeromagnetic compilation map contains data from 41 separate aeromagnetic surveys, digitized maps, and previous gridded compilations. This map is an index to the flightline spacing of the original surveys. A tabular index (see index) provides a summary of the data sources. The raw data for all these surveys are available from the National Geophysical Data Center (NGDC), Boulder, Colorado.

The Vancouver Island survey was provided by the Pacific Geoscience Center of the Geological Survey of Canada and contains three separate sections. Each section was flown in 1976 with north-south flight lines spaced at about 1 km and at barometric elevations of 1000', 4500', and 5500'.

URL: http://minerals.cr.usgs.gov/publications/ofr/98-241/wash_indmap.html
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Washington Aeromagnetic Compilation Index

No.	State	Type	Name	Flown By	Date	Spacing	Dir	Alt (ft)	MxLat	MnLat	MxLg	MnLg	LnMi	Datum	Publication
0136	WA	M-A	Southwest Washington '51	USGS	09/51	0.5 mi.	E-W	1000 AG	46.88	46.62	122.50	124.12	2542	Tot.field, arb.datum	GP-176-189
0139A	WA	M-A	S.W. Washington North '53	USGS	07/53-08/53	0.5 mi.	E-W	1000 AG	47.00	46.88	122.50	124.12	1250	Tot.field, arb.datum	GP-176-182
0139B	WA	M-A	S.W. Washington South '53	USGS	07/53-08/53	0.5 mi.	E-W	1000 AG	46.62	46.50	122.50	124.08	1375	Tot.field, arb.datum	GP-183-189
0335A	WA-OR	M/R-A	Hanford ARMS	USGS	06/59	1 mi.	N-S	500 AG	47.25	45.75	118.55	120.63	8335	Tot.field, arb.datum	GP-917,307r
0335B	WA	M/R-A	Hanford ARMS Northwest	USGS	06/59	1 mi.	N-S	500 AG	47.15	46.90	120.38	120.63	165	Tot.field, arb.datum	GP-917,307r
1142	WA	M/EM/V-D	Morton	USGS	06/90-08/90	0.5 mi.	E-W	1000 AG	47.00	46.50	121.58	122.50	1677	DIGRF	unpub
3036	WA	M-D	Puget Sound	Expl.Tech	06/73-09/73	1 mi.	N-S	3000 B	48.25	47.00	122.40	123.88	3050	IGRF65, +1000	74-1106
3064A	WA	M-D	Olympic Peninsula '75	Geoterrex	01/75-02/75	2 mi.	N-S	4200 B	48.40	47.83	123.72	124.72	638	IGRF65	80-950
3064B	WA	M-D	Olympic Pen.-Offshore	Geoterrex	01/75-02/75	1-2 mi.	E-W	500 B	48.40	47.88	124.62	125.75	900	IGRF65	80-976
3064C	WA	M-D	Olympic Pen.-South	Geoterrex	01/75-02/75	2 mi.	E-W	2500 B	47.83	47.00	123.12	125.00	1536	IGRF65	80-948,977
3081	WA-OR	M-D	S.W. Washington-NW Oregon	GeoMet.	03/76-05/76	2 mi.	E-W	3000 B	46.50	45.83	123.50	124.62	1395	IGRF75, 54619	84-205
3082	WA	M-D	East Puget Sound	GeoMet.	03/76-05/76	2 mi.	N-S	3000 B	48.50	46.75	121.75	123.33	1865	IGRF75, 56210	77-034
3083	WA-OR	M-D	Walla Walla (Pendleton)	GeoMet.	03/76	1 mi.	N-S	500 AG	46.28	45.50	117.72	119.00	2468	IGRF75, 56108	79-278
3115	WA	M-D	Bellingham	LKB	12/77	2 mi.	E-W	3000 B	49.00	48.25	122.00	123.50	1465	IGRF75	78-354
3152	WA	M-D	Glacier Peak '79	LKB	03/79-05/79	1 mi.	NE-SW	1000 AG	48.55	48.23	120.68	121.50	440	IGRF75, 58000	79-1645
3192	WA	M-D	Coulee Dam	Geodata	08/80	0.5-1 mi.	E-W	7000 B	48.25	47.75	119.00	120.00	2515	IGRF75	82-661
4001	WA	M-D	Mt. Baker	Applied	08/81	0.62 mi.	E-W	12,500 B	48.85	48.70	121.70	121.90	175	IGRF75, 56575	82-540
4002	WA	M-D	Glacier Peak '81	Applied	08/81	0.62 mi.	E-W	12,500 B	48.18	48.05	121.00	121.22	175	IGRF75, 56590	82-541
4003	WA	M-D	Mt. Adams	Applied	10/79	0.62 mi.	E-W	14,500 B	46.27	46.12	121.38	121.52	175	IGRF75	81-929
4007	WA	M-D	Mt. Rainier	Applied	09/79	0.62 mi.	E-W	8-16,500 B	47.05	46.62	121.25	122.00	2020	IGRF75, 55846	82-547
4008	WA-OR	M-D	S. Washington Cascades	Applied	09/81	0.62 mi.	E-W	8000 B	46.50	45.50	121.00	122.50	4325	IGRF75, +5000	82-663
4009	WA	M-D	Goat Rocks	Applied	10/81	0.5 mi.	E-W	1000 AG	46.75	46.38	121.25	121.65	1065	IGRF75, 55455	82-662
4021	WA	M-D	Mt. Margaret	Geodata	08/80	0.5 mi.	E-W	1000 AG	46.50	46.25	121.98	122.27	680	IGRF75	81-926
4022	WA	M-D	Indian Heaven	Geodata	08/80	0.5 mi.	E-W	1000 AG	46.10	45.90	121.68	121.88	290	IGRF75	81-928

4025	WA	M-D	Dome Peak	Applied	08/81	0.5 mi.	NE-SW	1000 AG	48.45	48.20	120.90	121.33	425	IGRF75, 56846	82-548
4088	WA	M-D	Mt. St. Helens Refly	Applied	09/81	0.62 mi.	E-W	11,500 B	46.25	46.12	122.08	122.30	175	IGRF75, 55364	82-659
4105	WA	M-D	Olympic Mountains	Div.Tech	04/83	3 mi.	E-W	7000 B	48.07	47.50	123.17	124.17	635	IGRF75	84-510
4106	WA	M-D	North Cascades Nat. Park	Div.Tech	04/83	3 mi.	E-W	9000 B	49.00	48.42	120.75	121.67	505	IGRF75	84-511
4174	OR-WA	M-D	Longview North	Aerodat		0.31 mi.	E-W	1000 AG	46.50	45.52	122.50	123.50			
4179	OR-WA	M-D	Hillsboro Northwest	Airmag		0.33 mi.	NE-SW	1000 AG	45.83	45.47	122.60	123.22			
5016	WA	M/R-D	Mt. Leona-Nancy Creek	LKB-Car.	09/79-10/79	0.25 mi.	E-W	400 AG	49.00	48.30	118.00	118.83	4057	IGRF75	GJBX-001(82)
5017	WA	M/R-D	Midnite-Sherwood Mines	LKB-Car.	09/79-10/79	0.5-0.25 mi.	E-W	400 AG	48.08	47.75	117.80	119.00	2145	IGRF75	GJBX-001(82)
6045	WA-ID	M/R-D	Spokane-Sandpoint	LKB	08/77-09/77	3 mi.	E-W	400 AG	48.50	47.00	116.00	118.00	2855	IGRF65	GJBX-121(78)+
6046	WA-ID	M/R-D	Northeast Washington	LKB	09/77-10/77	1 mi.	E-W	400 AG	49.00	47.50	116.00	119.00	10650	IGRF65	GJBX-142(79)
6047	WA	M/R-D	Western Okanogan	LKB	09/77-10/77	3 mi.	E-W	400 AG	49.00	48.00	119.00	120.00	1350	IGRF65	GJBX-142(79)
6091	WA	M/R-D	Ritzville	T.I.	09/78-10/78	3 mi.	E-W	400 AG	48.00	47.00	118.00	120.00	2700	IGRF?	GJBX-126(79)
6161	WA-OR	M/R-D	Washington-Oregon	HighLife	03/80-08/80	6 mi.	E-W	400 AG	47.00	43.00	118.00	124.08	14575	IGRF75	GJBX-240(81)+
6178	WA	M/R-D	Northwest Washington	HighLife	08/80	6 mi.	E-W	400 AG	49.00	47.00	120.00	124.75	4125	IGRF75	GJBX-135(81)+
6179	ID-OR-WA	M/R-D	Grangeville-Pullman	GeoData	08/80-09/80	6 mi.	E-W	400 AG	47.00	45.00	116.00	118.00	3133	IGRF75	GJBX-098(81)+
WA01	WA	M-A	Northeast Washington '59	Hunting.	09/59-10/59	0.25 mi.	E-W	500 AG	49.00	48.50	118.50	119.25	3945	?	WA RI-20
WA02	WA-OR	M-D	Central Washington '77	Weston	?/77	0.5 mi.	NE-SW	1000-1500 AG	48.42	45.48	117.53	121.72	40000	?	WPPSS

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URL: http://minerals.cr.usgs.gov/publications/ofr/98-241/wash_indtab.html
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README.TXT FILE FOR PLOT TRANSFER DIRECTORY

This directory contains binary HPGL format plot files for the aeromagnetic and gravity maps that span the state of Washington. See the web site for index maps and more information. These plot files will plot on plotters such as the HP750. The sizes of the resulting maps vary, but are mostly about 2 ft x 3 ft.

These plot files have been compressed using the "gzip" public-domain utility. Before plotting these files you will need to uncompress them. Information on gzip is available at:

http://www.maths.lancs.ac.uk/~smithdm1/GNU/GNUWeb/gzip.html
(unix and PC DOS versions)

http://www.winzip.com/
(PC windows version)

http://www.1source.com/tools/compress.html
(contains link to download Mac gzip)

Listing of plot files:

Aeromagnetic Maps

mag_pub_HP750_1mil_plot.gz	(plot at 1:1,000,000 scale in rtl format)
mag_pub_HP750_plot.gz	(page sized plot in rtl format)
mag_pub_ps_plot.gz	(page sized plot in postscript format)

Isostatic Gravity Maps

iso_mag_web_HP750_1mil_plot.gz	(plot at 1:1,000,000 scale in rtl format)
iso_mag_web_HP750_plot.gz	(page sized plot in rtl format)
iso_mag_web_ps_plot.gz	(page sized plot in postscript format)

Carol Finn
3 June 1998

README.TXT FILE FOR GRIDDED DATA TRANSFER DIRECTORY

This directory contains ascii and binary gridded files for
the Washington merged (wam*) aeromagnetic and gravity data.
Each data grid is available in four different data formats:

1. GeoSoft GXF format (an ascii grid transfer format)
2. ER Mapper grid format (a two-file transfer format)
3. ARC/INFO grid export format (a binary format)
4. USGS ODDF grid format (a binary format)

Each of these formats is discussed briefly below.
If none of these formats are directly readable by software on your
system, then your best bet is probably to write a program to input
and translate the GXF format. Extensive description of this format
is given below.

The data grids in this directory have been compressed using the public-
domain "gzip" compression utility. Information on gzip is available at:

http://www.maths.lancs.ac.uk/~smithdm1/GNU/GNUWeb/gzip.html
(unix and PC DOS versions)

http://www.winzip.com/
(PC windows version)

http://www.1source.com/tools/compress.html
(contains link to download Mac gzip)

To avoid file name problems on older PC systems, I have replaced the
original "." in the filenames with an "_" (underscore) character.
For example:

original filename: wa_mag.e00
changed to: wa_mag_e00
compressed file name: wa_mag_e00.gz

After you transfer and uncompress the files, you should rename them
to replace the "_" with a "." again.

Projection	Lambert Conformal Conic	
Parameters:		
1st standard parallel		33 0 0.000
2nd standard parallel		45 0 0.000
central meridian		-122 0 0.00
latitude of projection's origin		45 0 0.000
false easting (meters)		0.00000
false northing (meters)		0.00000

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1. Grid eXchange Format (*.gxf)

GXF (Grid eXchange File) is a standard ASCII file format for exchanging
gridded data among different software systems. Software that supports the GXF
standard will be able to import properly formatted GXF files and export grids
in GXF format.

Grid Description:
A grid is a rectangular array of points at which single data values define a two dimensional function. Grid point locations are related to a Grid Coordinate System (GCS), which is a right handed Cartesian system with X and Y axis defined by the bottom and left sides of a grid array. The grid point at the bottom, left corner of the array is the origin of the GCS. All distances are in meters.

GCS coordinates are related to a Base Coordinate System (BCS) through a plane translation and rotation.
The origin of the GCS is located at point
(x0,y0) in the BCS, and the X and Y grid indices are related to BCS units through the separation between points in the GCS X and Y directions.

Labeled Data Objects and Comments

A GXF file is an ASCII file made up of a number of labeled data objects and comments. Each labeled data object has a label line followed by one or more data lines. A label line is identified by a '#' character in the first column followed immediately by an upper-case label. The data associated with that label are found on one or more lines that follow the label.

Lines

All lines in a GXF file must be less than or equal to 80 characters in length. Any lines that are not part of a labeled data object are ignored and can be used to place comments within a GXF file. Programs that read GXF files will skip such comment lines while they search for the next GXF data object.

GXF Object Definitions

#TITLE
A one line descriptive title of the grid. Some grid formats include textual descriptions of the grid, and this information can be placed in a #TITLE object.
Default: blank title

#POINTS
The number of points in each grid row (horizontal or vertical as defined by the #SENSE object).
Default: no default - this object is required.

#ROWS
The number of rows in the grid. A grid row (or vector) is a collection of consecutive grid points that represent the grid values along a horizontal or vertical line in the grid. The complete grid is then defined by a consecutive sequence of grid rows.
Default: no default - this object is required.

#PTSEPARATION
The separation between points in the grid. This should be in Base Coordinate System units (ground units for geographically based grids).
Default: 1.0

#RWSEPARATION
The separation between rows in the grid. These should be in Base Coordinate System units (ground units for geographically based grids).
Default: 1.0

#XORIGIN
The X location of the bottom left corner of the grid in the Base Coordinate

System.
Default: 0.0

#YORIGIN
The Y location of the bottom left corner of the grid in the Base Coordinate System.
Default: 0.0

#ROTATION
The rotation angle of the grid. This is the counter-clockwise angle of the bottom edge of the grid with respect to the Base Coordinate System X axis. Rotation only has meaning for Base Coordinate Systems that use the same units on the X and Y axis.
Default: 0.0

#SENSE
The first point of the first row of the stored grid can be at any corner of the grid rectangle, and the grid rows can be run vertically or horizontally. The SENSE object defines this storage sense as follows:

±1	first point at bottom left of grid
±2	first point at upper left of grid
±3	first point at upper right of grid
±4	first point at bottom right of grid

A positive SENSE stores rows in a right-handed sense; a negative SENSE stores rows in a left-handed sense. This means that if you were standing at the first grid point and looking into the grid, the first grid row would extend to your right for a right handed grid (positive sense), or to your left for a left handed sense (left-handed grid):
(All grids on this CD have SENSE=+1.)
Default: 1 (first point at bottom left, rows left to right)

#TRANSFORM
This keyword is followed by two numbers on the same line: SCALE and OFFSET, which are used to transform the grid data to desired units:
Z = G * SCALE + OFFSET
where

Z	grid value in the desired unit
G	are grid values as specified in the #GRID object

Default: SCALE = 1.0, OFFSET = 0.0

#DUMMY
The grid must be rectangular (every row must have the same number of points). The dummy value defined by this object is used to define blank areas of the grid. Any grids that include blank areas must define a dummy value.
Default: no dummy value.

#GRID
The grid data is listed point by point and row by row. The #GRID object and data is always the last object in a GXF file.
The first data point is at the location indicated by #SENSE, and is followed by successive points in that row of points (either horizontal or vertical), then the points in the next row, and so on. The points in a row can follow on to the next data line, although each new row must start on a new data line. A GXF reading program can expect #ROWS of #POINTS for a total of #ROWS times

#POINTS data values.
Default: none, must be included as the last object in a GXF file.

---

2. ER Mapper grid format (*.ers)

The ER Mapper grid format consists of two files: a binary data file (no file suffix) and a ascii header file (*.ers). These files can be read directly by the ER Mapper software or by other packages such as ERDAS IMAGINE.

---

3. ARC/INFO Grid Export format (*.e00)

This format is readable by ARC/INFO, ERDAS IMAGINE, and other packages. When imported into ARC/INFO, this file will unpack into a directory containing all the components of the registered grid coverage.

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4. USGS ODDF binary grid format (*.gd)

This is a binary format with an included ascii header. This format is used by the USGS Geophysics Group within the Minerals Program of the Geologic Division.

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Washington Aeromagnetic References

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