Rectified Images of Selected Geologic Maps of the Northern Rockies Area, Idaho, Montana, Washington, and Wyoming

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Abstract

Selected geologic maps covering parts of the Northern Rocky Mountains and adjacent areas were converted to raster images and georeferenced (rectified) for use in a geographic information system (GIS). These rectified images were created for the purpose of visually comparing published geologic maps with other geospatial information. However, they cannot be queried or used for spatial analysis thus limiting their use in a GIS. The 42 georeferenced images included in this report range in scale from 1:250,000 to 1:100,000.

Tagged Image Format (TIFF) images of the maps were generated by scanning an original paper map or converting previously published Portable Document Format (PDF) images or Encapsulated PostScript (EPS) files. To reduce file size and minimize image overlap, the TIFF images were cropped, and then rectified using ArcMap® 8 and converted to MrSID® images. Information in the explanation and cross sections can be viewed in un-rectified images of the original publications that are included with this report. In addition, the text in the map unit description along with the unit name, map label, and a citation are organized in a searchable PDF file.

Introduction

Geologic maps published by the U.S. Geological Survey (USGS) between 1972 and 2004 were obtained for an area surrounding and including the northern Rocky Mountains, extending from about Spokane in eastern Washington to the Beartooth Mountains in western Montana, and from the U.S.-Canadian border south to the vicinity of the Snake River Plain in southern Idaho. The extent of the rectified images with respect to federally managed land is shown in figure 1. The 42 rectified images in this report include geologic and tectonic maps of 1:250,000-scale and 1:100,000-scale quadrangles (figs. 2 and 3) as well as maps of national forests and parks, and wilderness and study areas (figs. 4, 5, and 6). In 1999, the USGS began production of a spatial database of geology for the northern Rockies that could be used by the U.S. Forest Service for planning and research activities. This spatial database is a vector representation of the polygons and lines that make up geologic maps and is accompanied by attribute information in related tables. These rectified images of published maps were created to assist with the production of the vector spatial database. We found them extremely useful to check the quality and consistency of our work. They also allowed us to quickly compare geologic information to other datasets without having to query or symbolize the vector database.

These previously published geologic maps have been scanned or otherwise converted to images and georeferenced. The georeferencing process associates map coordinate information with the image and allows their use in a GIS. Individual rectified images can be viewed along with other digital data, or combined to form one large mosaic of map images for the entire area. Furthermore, the rectified images can be compared to vector representations of the same map to ensure that features are coded correctly and that all geologic information on the published map was captured in the vector files. Each image also quickly illustrates how the author intended to symbolize the map.

Before they were georeferenced, the images were cropped to reduce file size and limit overlap between maps. The geologic map and coordinate information along the edge of the map was retained in the rectified image. Other information typically published with a geologic map (such as the explanation, cross sections, title, and scale bars) were cropped or partially cropped. In order to understand map symbolization and units, we have included un-rectified TIFF or MrSID® images of the complete map sheet and a text-searchable PDF file created from the map unit descriptions.

Additional map images for the study area that are not included in this report are available from state geological surveys. Montana Bureau of Mines and Geology (MBMG), accessible at http://www.mbmg.mtech.edu/, and the Idaho Geological Survey (IGS), accessible at http://www.idahogeology.org, both provide online geologic map products that cover additional portions of this study area.

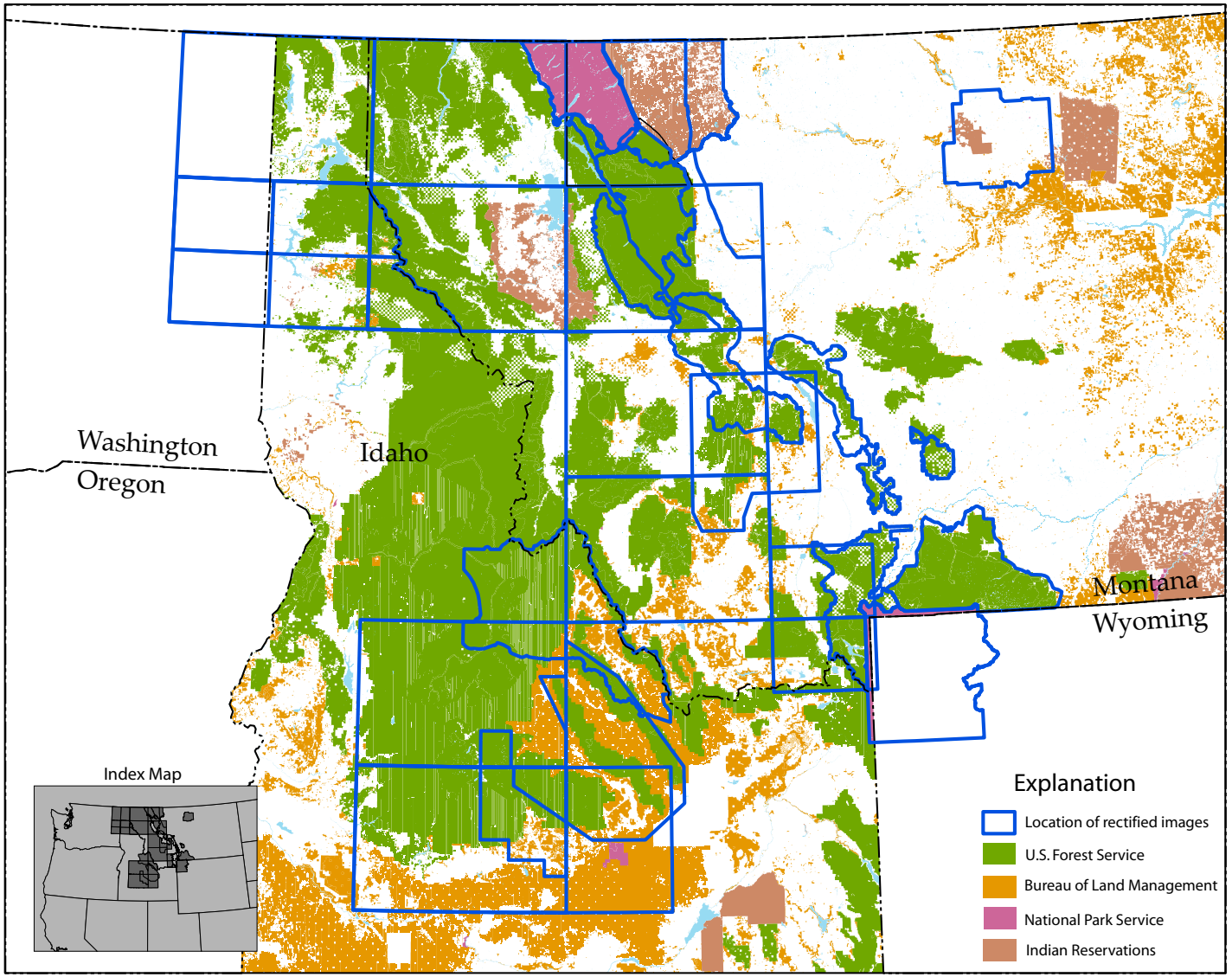

Figure 1. Map showing the outlines of the rectified geologic maps included in this report and and federally managed land in Idaho and Montana.

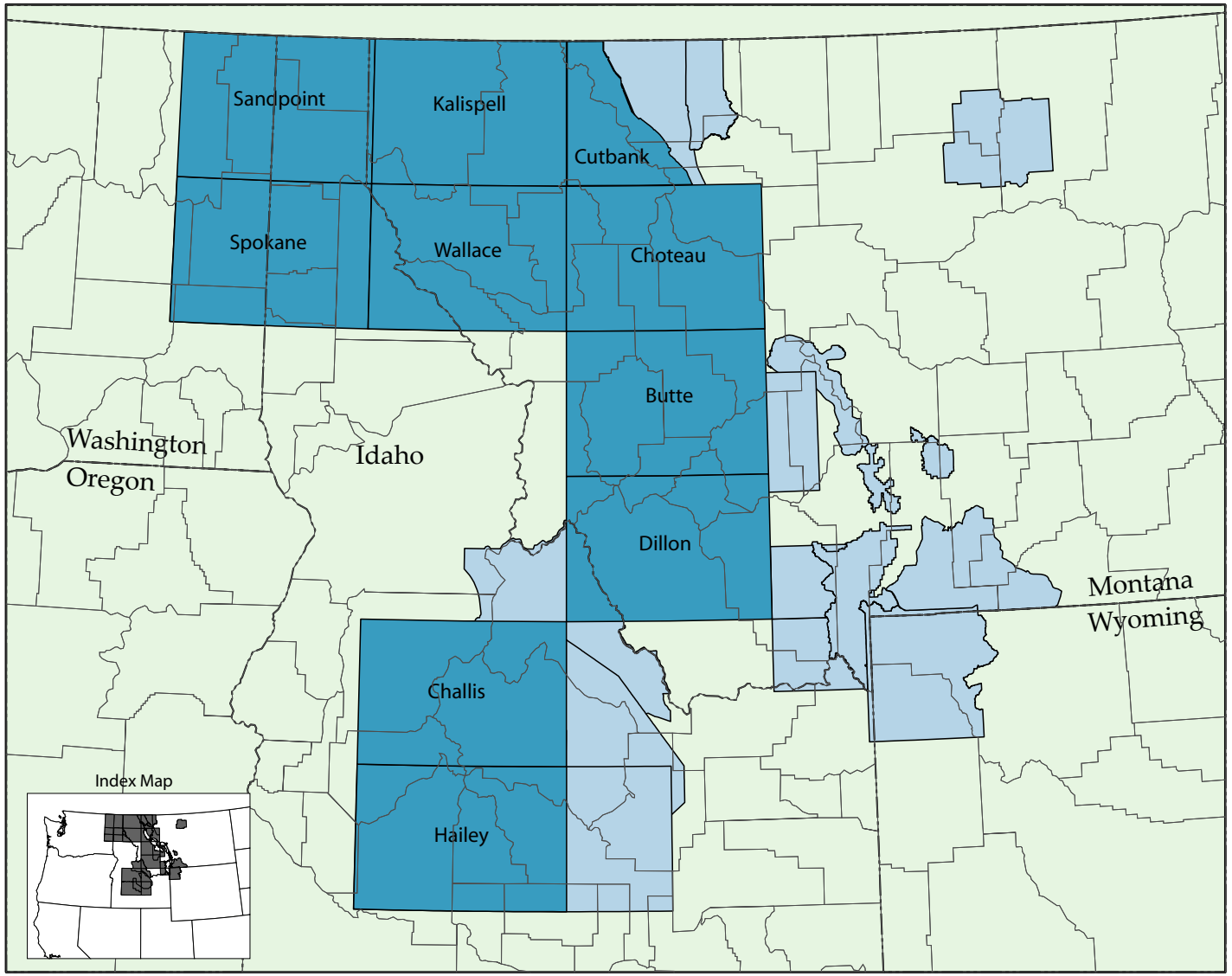

Figure 2. Index map showing the locations of the georeferenced 1:250,000-scale geologic map labeled and colored dark blue. Location of other map images shown in pale blue

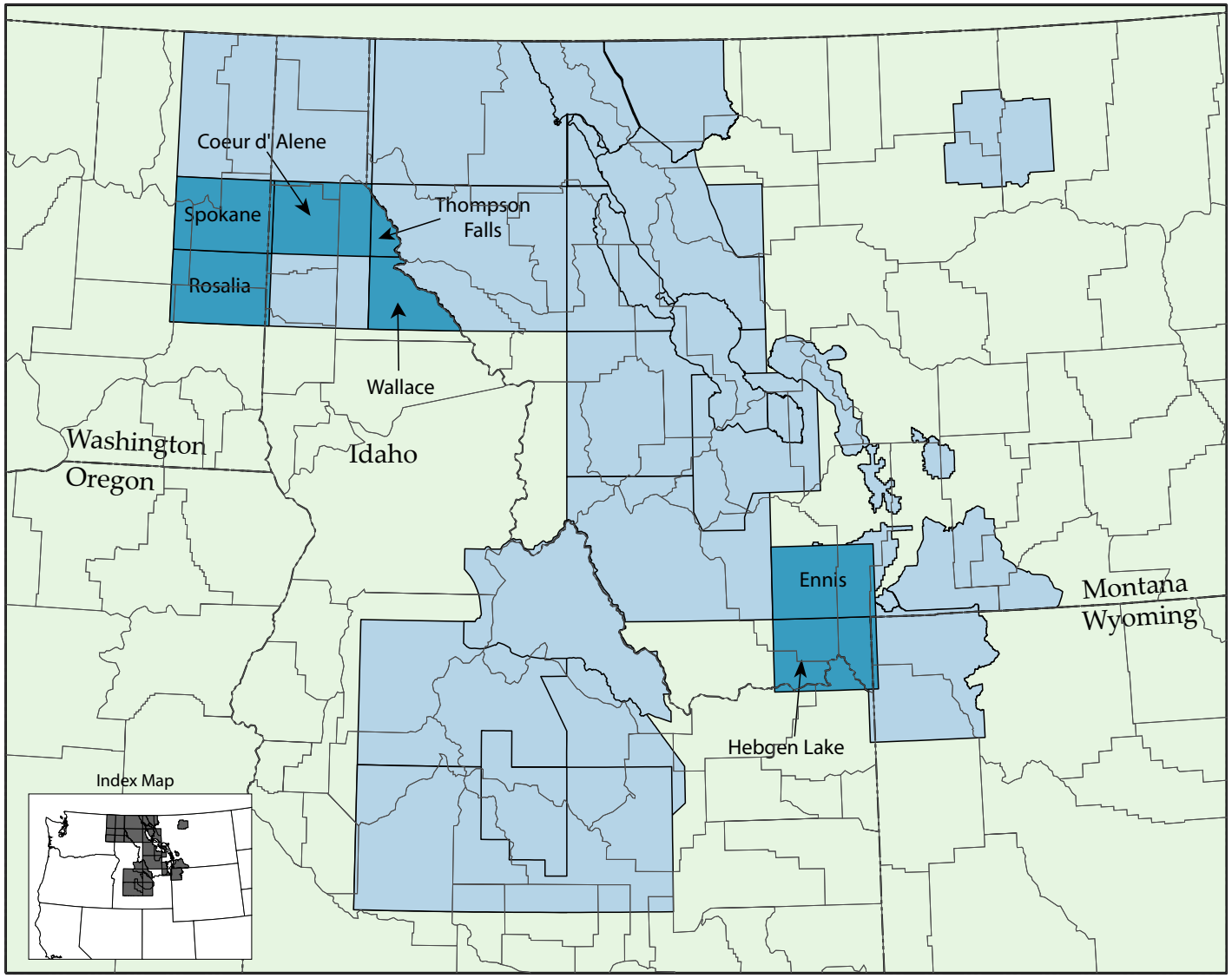

Figure 3. Index map showing the location of the georeferenced 1:100,000-scale geologic maps labeled and colored dark blue. Location of other map images shown in pale blue.

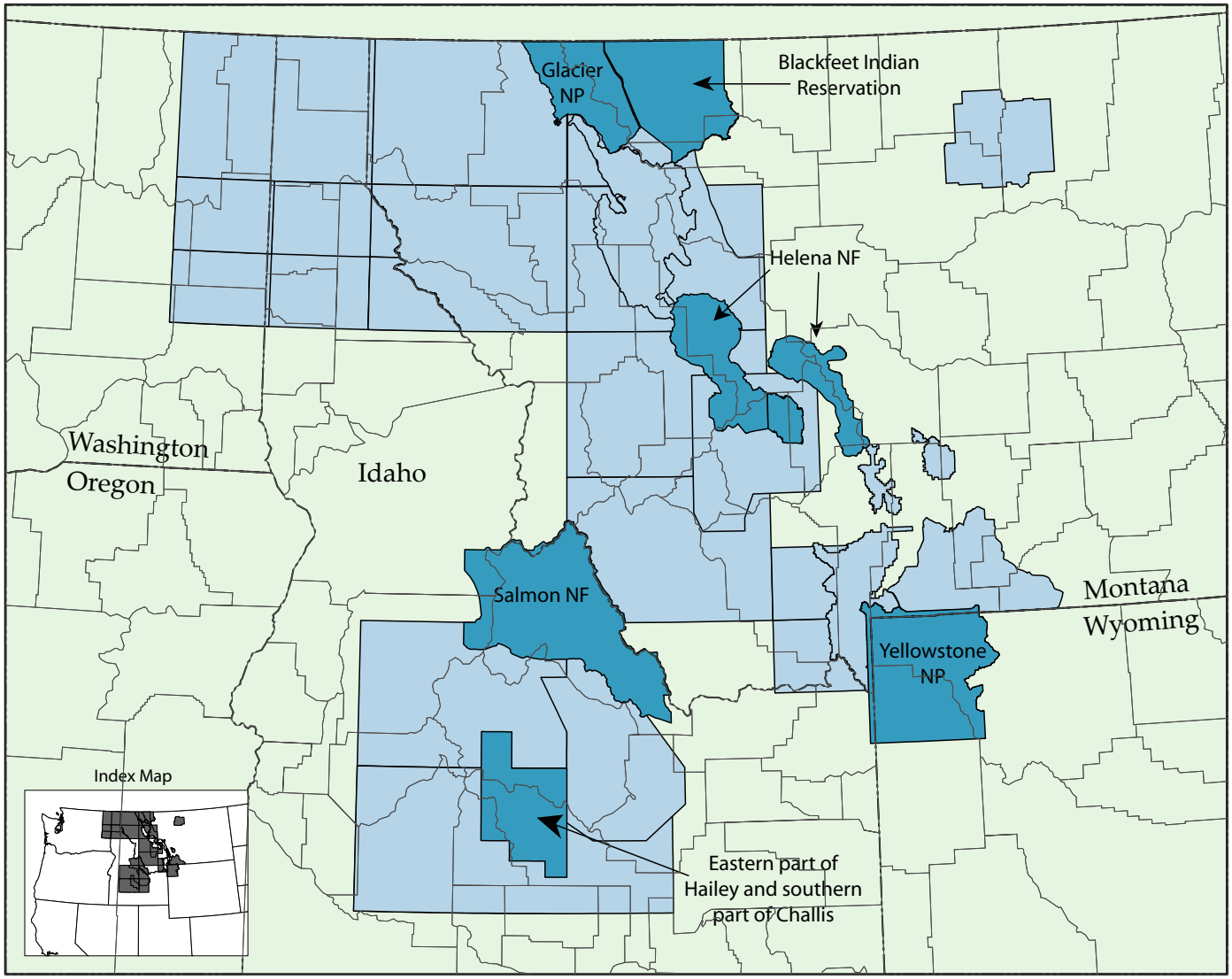

Figure 4. Index map showing the locations of the National Forest (NF), National Park (NP), and other geologic maps labeled and colored in dark blue. Other rectified map images are shown in pale blue.

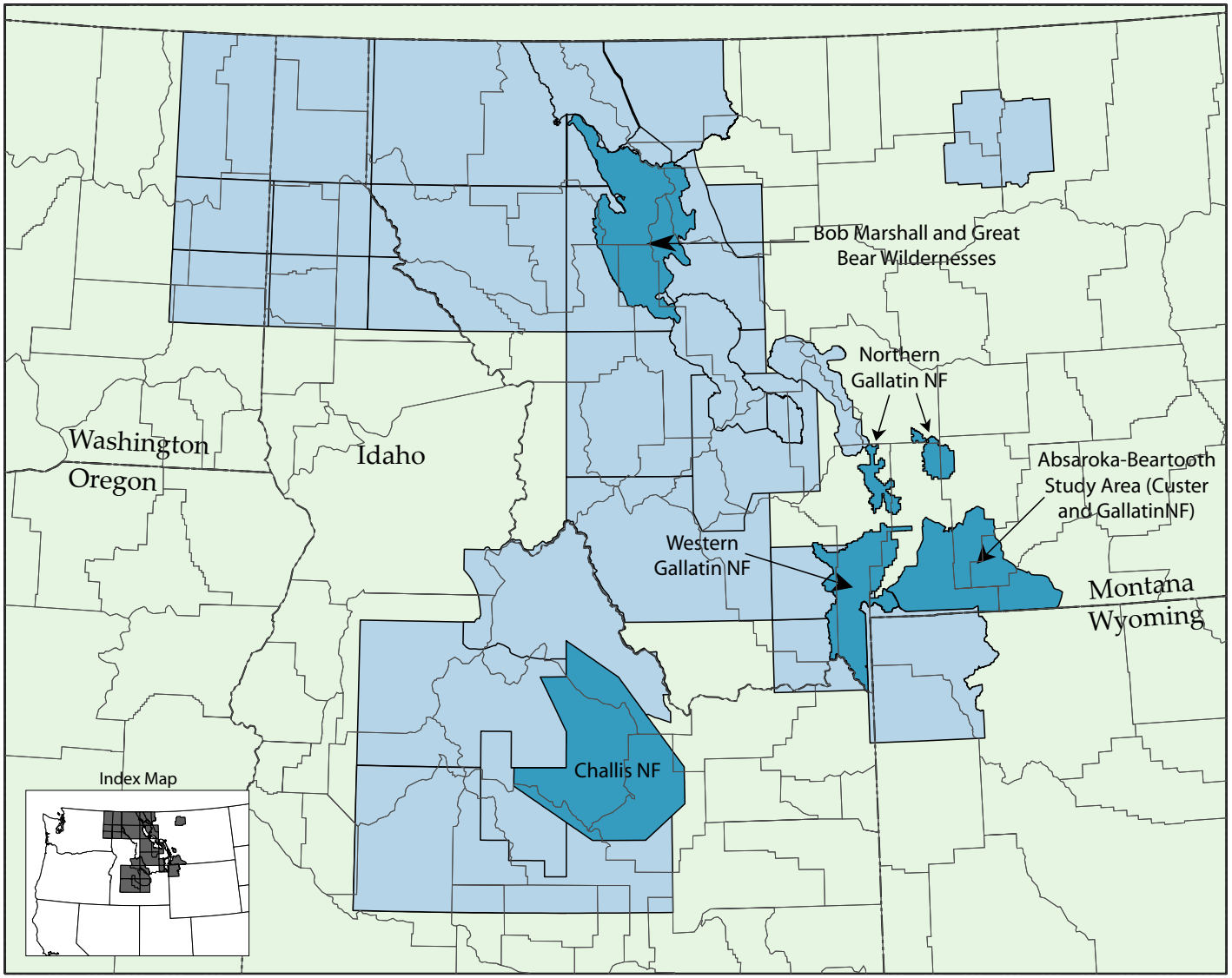

Figure 5. Index map showing the location of additional National Forests (NF) and wilderness areas labeled and colored in dark blue. Other images shown in pale blue.

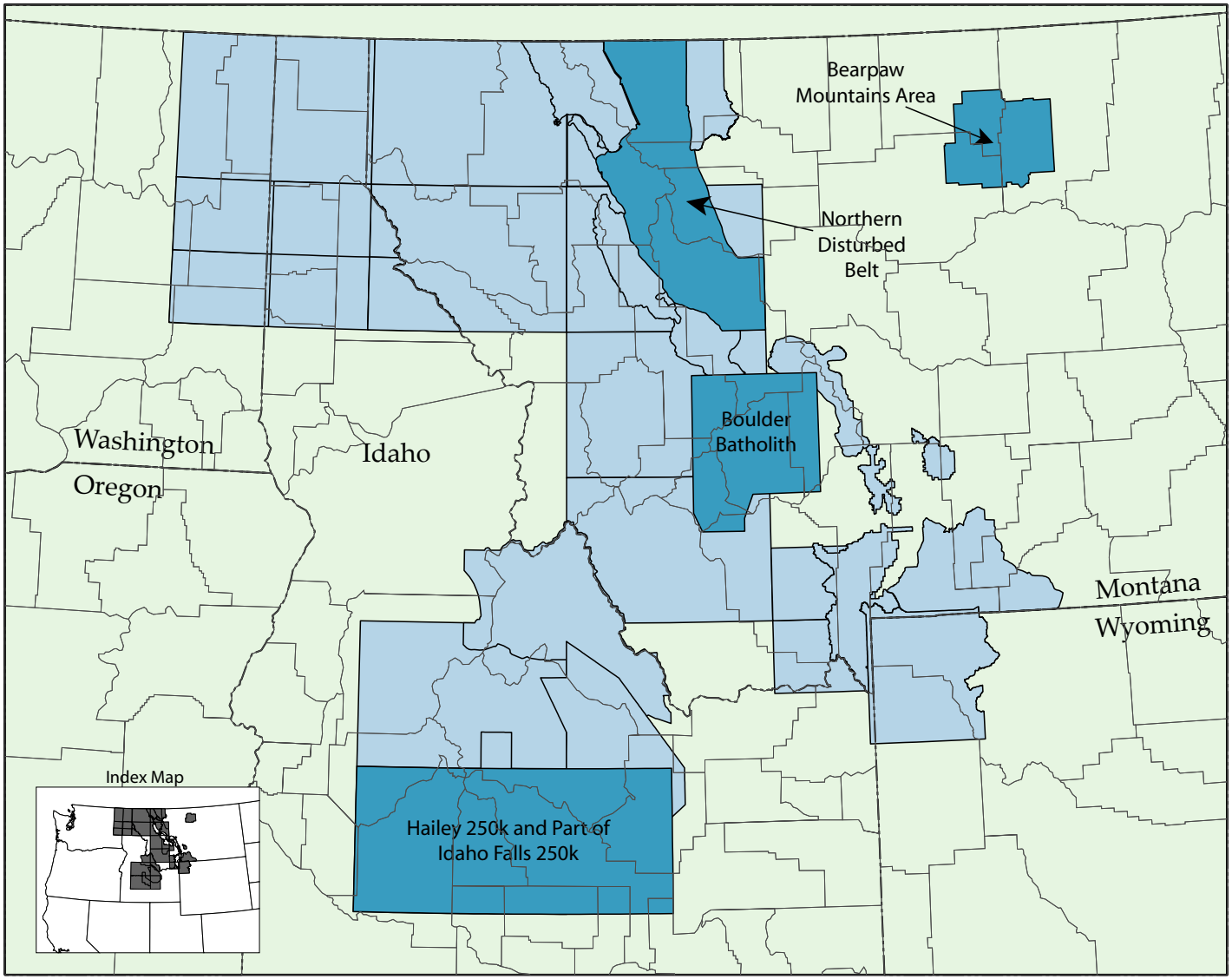

Figure 6. Index map showing the locations of additional geologic maps included in this report labeled and colored dark blue. The location of other images are shown in pale blue.

Digital Conversion of Maps

Two distinct types of map publications were used to generate the images in this report. Most of the maps were printed on paper following the conventions used by the USGS for formal geological map publications. These cartographic products show the geology on appropriate base materials and include a map explanation and cross sections. Maps released recently may be accompanied by PDF images of the map or a vector spatial database that can be used in a GIS. For this report, maps printed in color were scanned as a 300 dpi, 24-bit color TIFF image, while black-and-white maps were scanned either as 400 dpi 8-bit grayscale or 400 dpi bitmap TIFF images. Maps available as PDF files were downloaded from USGS servers and converted to a TIFF image. Some map sheets were too wide for the scanner and had to be cut in two. The suffixes "N" and "S", "E" and "W", or "a" and "b" are used to differentiate these sheets.

Some of the maps were only released as spatial databases to be used in a GIS. A formal cartographic product was not prepared for these maps; however, an image of a plot file derived from the digital files of the spatial database was prepared for the original publication. These plot file images do not show the geology in relation to base materials and do not include cross-sections or elaborate explanations. However, they do show how the authors intended to symbolize the spatial database. These plot file images were released as EPS files and, similar to the PDF files, were converted to TIFF images. Rectified images derived from EPS plot files include: the Sandpoint 1:250,000-scale quadrangle; the portion of the Thompson Falls 1:100,000-scale quadrangle in Idaho; the portion of the Wallace 1:100,000-scale quadrangle in Idaho; the Coeur d'Alene 1:100,000-scale quadrangle; the Spokane 1:100,000-scale quadrangle; and the Rosalia 1:100,000-scale quadrangle.

As discussed earlier, the TIFF images were cropped before they were rectified. After they were cropped, an auto color correction filter was applied to the image using Adobe® Photoshop® Elements 2.0. The TIFF images were georeferenced using ESRI® ArcMap® 8. Due to the variances in map scale, image shape, or the abundance of coordinate labels, it was not possible to use only one reference source to georeference all types of geologic maps. Therefore, the images were georeferenced to one or any of three reference sources: a grid tic coverage of latitude and longitude coordinate points mathematically generated using ARC/INFO®, a mathematically-generated shapefile of 1:100,000-scale quadrangles obtained from ESRI®, and/or a GeoTIFF of 1:100,000-scale USGS Digital Raster Graphic (DRG) maps. Once rectified, the color geologic map TIFF images were opened in LizardTech ™ GeoExpress 3.0 or 4.0 and converted to MrSID® image format using a 10:1 compression ratio. The resulting MrSID® image files (*.sid) are accompanied by a world file (*.sdw). The MrSID® compression algorithm only works effectively with color or grayscale images. Bitmap images created for this report are in TIFF format and have the TIFF (*.tif) file extension.

Georeferenced TIFF images retain the coordinate information that is set in the data frame properties in ArcMap® by creating a world file (*.tfw). However, when the TIFF images are converted to MrSID® images, ArcMap® does not recognize the coordinate information stored in the image or the new world file (*.sdw). For this reason, the RAster Georeferencing Enabler tool (RAGE) from 3001, Inc. (available at: http://www.3001data.com/3001website/main/downloads_files/rage/geotiff_header_repair.htm) was used to write coordinate information to the header of the MrSID® map images. The projection used for images are Universal Transverse Mercator (UTM, North American Datum of 1927), Zone 11 or 12.

Rectified images were tested to ensure they were projected and georeferenced properly by overlying each image with mathematically-generated vector polygon spatial databases, grid tic coverages, or other rectified images. For example, quadrangle map images were compared to a shapefile of 1:100,000-scale quadrangles, while other geologic map images were overlain with a latitude and longitude tic point coverage that was mathematically generated using ARC/INFO®. At the scale of publication, the images fall within the boundaries of the corresponding 1:100,000-scale quadrangle, or reference points on the images coincide with corresponding reference points of the tic file.

Digital data and files

Text and data for this report is contained within three subdirectories: GEOREFERENCED, ORIGINAL, and METADATA. A README.txt file briefly describes the information in the subdirectories. Georeferenced MrSID® and TIFF map images listed in table 1 are in the GEOREFERENCED subdirectory. All georeferenced images are identified with the image file name followed by "_rect" to denote rectification.

Table 1. List of rectified image files in the GEOREFERENCED subdirectory that accompanies this report. Unrectified images of the original published maps are in the ORIGINAL subdirectory.

File name	Description (map title)	Format	UTM zone	Scale	File size	Reference
Absk_Beartooth_rect	Generalized geologic map of the Absaroka-Beartooth Study Area, south-central Montana	SID	12	1:126,720	15.6 Mb	Van Gosen and others (2000)
Bearpaw_geo_rect	Geologic map of the Bearpaw Mountains area, north-central Montana	SID	12	1:125,000	20.0 Mb	Hearn (1976)
Bearpaw_tec_rect	Tectonic map of the Bearpaw Mountains area, north-central Montana	SID	12	1:125,000	26.0 Mb	Hearn (1976)
Blkfeet_bed_rect	Geologic map for the Blackfeet Indian Reservation bedrock geology, Montana	SID	12	1:125,000	18.8 Mb	Cannon (1996)
Blkfeet_sur_rect	Geologic map for the Blackfeet Indian Reservation surficial geology, Montana	SID	12	1:125,000	20.0 Mb	Cannon (1996)
BobMarshall_rect	Geologic map for the Bob Marshall and Great Bear Wildernesses, Montana	SID	12	1:125,000	37.5 Mb	Mudge and Earhart (1991)
BoulderBath_rect	Preliminary map of plutonic units of the Boulder Batholith, Montana	TIFF	12	1:200,000	10.3 Mb	Smedes and others (1988)
Butte_MF1925_rect	Generalized geologic map of the Butte quadrangle, Montana	SID	12	1:250,000	6.5 Mb	Wallace (1987)
Butte_OF86_292_rect	Preliminary geologic map of the Butte quadrangle, Montana	SID	12	1:250,000	5.4 Mb	Wallace and others (1986)
CDAlene_rect [1]	Digital geologic map for the Coeur d' Alene quadrangle, Idaho and Montana	SID	11	1:100,000	6.8 Mb	Munts (2000)
Challis_rect [2]	Geologic map for the Challis quadrangle, Idaho	SID	11	1:250,000	12.2 Mb	Fisher and others (1992)
ChallisNF_rect	Geologic map for the eastern part of the Challis National Forest and vicinity, Idaho	SID	12	1:250,000	14.4 Mb	Wilson and Skipp (1994)
Choteau_geo_rect	Geologic map for the Choteau quadrangle, western Montana	SID	12	1:250,000	11.5 Mb	Mudge and others (1982)
Choteau_str_rect	Structure map for the Choteau quadrangle, western Montana	SID	12	1:250,000	11.6 Mb	Mudge and others (1982)
Cutbank_rect	Geologic map for the western part of the Cut Bank quadrangle, northwestern Montana	SID	12	1:250,000	7.6 Mb	Harrison and others (1998)
Dillon_rect	Geologic map for the Dillon quadrangle, Idaho and Montana	SID	12	1:250,000	11.5 Mb	Ruppel and others (1993)
Dist_belt_N_rect	Bedrock geologic map of the northern part of the northern disturbed belt, Montana	SID	12	1:250,000	23.5 Mb	Mudge and Earhart (1983)
Dist_belt_S_rect	Bedrock geologic map of the southern part of the northern disturbed belt, Montana	SID	12	1:250,000	28.4 Mb	Mudge and Earhart (1983)
Ennis_I2690_rect	Geologic map for the Ennis quadrangle, Montana	SID	12	1:100,000	8.3 Mb	Kellogg and Williams (2000)
Ennis_OF97_851_rect	Geologic map for the Ennis quadrangle, Montana	SID	12	1:100,000	17.8 Mb	Kellogg and Williams (1998)
GallatinNF_N_rect	Geologic map for the northern part of the Gallatin National Forest, Montana	SID	12	1:126,720	11.0 Mb	Wilson and Elliott (1997)
GallatinNF_W_rect	Geologic map for the western part of the Gallatin National Forest, Montana	SID	12	1:126,720	20.0 Mb	Wilson and Elliott (1997)
GlacierNP_bed_rect	Bedrock geologic map for Glacier National Park, Montana	SID	12	1:100,000	33.4 Mb	Whipple (1992)
GlacierNP_sur_rect	Surficial geologic map for Glacier National Park, Montana	SID	12	1:100,000	32.5 Mb	Carrara (1990)
Hail_Chal_rect	Geologic map for parts of Hailey and parts of Challis 1:250,000-scale quadrangles, south-central Idaho	SID	11	1:100,000	26.8 Mb	Link and others (1995)

Hailey_rect	Geologic map for the Hailey quadrangle, Idaho	TIFF	11	1:250,000	9.2 Mb	Worl and others (1991)
Hailey_IDFalls_rect	Geologic map for the Hailey and western part of Idaho Falls 1:250,000-scale quadrangles, Idaho	SID	11	1:250,000	15.4 Mb	Worl and Johnson (1995)
HebgenLake_rect	Geologic map for the Hebgen Lake quadrangle, Montana	SID	12	1:100,000	19.3 Mb	O'Neill and Christiansen (2004)
HelenaNF_E_rect	Eastern part of the geologic map for the Helena National Forest, Montana	SID	12	1:126,720	8.0 Mb	Tysdal (1996)
HelenaNF_W_rect	Western part of the geologic map for the Helena National Forest, Montana	SID	12	1:126,720	9.9 Mb	Tysdal (1996)
Kalispell_rect	Geologic and structure map for the Kalispell quadrangle, Montana	SID	11	1:250,000	11.0 Mb	Harrison and others (1992)
Rosalia_rect [1]	Geologic map for the Rosalia quadrangle, Washington and Idaho	SID	11	1:100,000	5.6 Mb	Derkey and others (1998)
SalmonNF_E_rect	Geologic map for the eastern part of the Salmon National Forest, Idaho	SID	12	1:100,000	18.0 Mb	Evans and Green (2003)
SalmonNF_W_rect	Geologic map for the western part of the Salmon National Forest, Idaho	SID	11	1:100,000	17.7 Mb	Evans and Green (2003)
Sandpoint_rect [1]	Digital geologic map for the Sandpoint quadrangle, Washington, Idaho, and Montana	SID	11	1:250,000	6.8 Mb	Miller and others (1999)
Spokane_I768_rect	Geologic map for the Spokane quadrangle, Washington, Idaho, and Montana	SID	11	1:250,000	11.9 Mb	Griggs (1973)
Spokane_OF98_115_rect [1]	Digital geologic map for the Spokane quadrangle, Washington and Idaho	SID	11	1:100,000	15.9 Mb	Johnson and Derkey (1998)
ThompsonFallsID_rect [1]	Digital geologic map for the Thompson Falls quadrangle, Idaho	SID	11	1:100,000	2.3 Mb	Lewis and Derkey (1999)
Wallace_geo_rect	Geologic map for the Wallace quadrangle, Montana and Idaho	SID	11	1:250,000	11.5 Mb	Harrison and others (1986)
Wallace_str_rect	Structure map for the Wallace quadrangle, Montana and Idaho	SID	11	1:250,000	10.4 Mb	Harrison and others (1986)
WallaceID_rect [1]	Digital geologic map for the Wallace quadrangle, Idaho	SID	11	1:100,000	4.6 Mb	Lewis and others (1999)
YellowstoneNP_rect	Geologic map for the Yellowstone National Park, Wyoming	SID	12	1:125,000	32.7 Mb	USGS (1972)

[1] Indicat

[2] Indicates additional descriptive information about the map (a pamphlet) is included in the ORIGINAL subdirectory.

MrSID® images of the uncropped published maps can be found in the ORIGINAL subdirectory. The images in this folder are not georeferenced. These images are not modified from their original appearance and are presented with all information (collar information, titles, map unit descriptions, cross-sections, and so on) that originally appeared the published map. Some maps were accompanied by pamphlets or reports describing the geologic map units, instead of displaying the descriptions on the face of the map. If this information is not available online, these pamphlets or reports were scanned and saved as PDF files. They are named using the same file nomenclature as the images. A MrSID® viewer, such as ExpressView Browser Plugin, can be used to view these MrSID® images. This plug-in may be obtained free of charge at http://www.lizardtech.com/download.

The PDF file, NR_map_units.pdf, contains the unit names, unit labels, and map unit descriptions for all geologic map images. This information was captured in a text-searchable format from the original map publications, pamphlets, and reports. In some cases, this information came to us as digital files (that accompanied the map or were provided by the author). However, for most maps, the text was scanned and converted to editable and searchable text using optical character recognition (OCR) software. This information was collated to create a searchable text PDF containing a complete list of all map unit descriptions from the maps in this report. To maintain the searchable text feature, the unit labels in the PDF do not use geologic font symbols as they appear in the original maps, but use a standard text equivalent. For example, the letter "C" is used for Cambrian instead of the special symbol Ꞓ. Most of the citations found within the map unit description PDF will not appear in the reference list for this report. These citations in the map unit descriptions are associated with individual map publications and are too numerous to list here. Please refer to the reference list that appears on the scanned image of the publication in ORIGINAL subdirectory, a PDF of a pamphlet or report in the ORIGINAL subdirectory, or to online reports or pamphlets (table 1).

FGDC compliant metadata was created for all rectified files using ArcCatalog® and exported as HTML documents in frequently asked questions (FAQ) format. The HTML metadata files are located within folders in the METADATA subdirectory and are organized by the coordinate system of the associated image, either UTM zone 11, or UTM zone 12. The METADATA subdirectory also contains two master metadata files (UTM_zone_11_metadata.xml and UTM_zone_12_metadata.xml) that describe images in a more general form. Additionally, metadata for individual images is also directly associated with each image in the GEOREFERENCED subdirectory as an XML format file.

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